LAT Flight Software Quick Look Review Recommendations – Responses & Forward Plans

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Contents

0. 0 Introduction

A Quick Look Review for the GLAST LAT FSW was held via Telecon on November 21. The recommendations of the Review team have been passed on to the GLAST Project Office. The GPO has worked these reponses with their SLAC team members. Some of these recommendations have been grouped and all are addressed in the sixteen responses below in Section 1. In section 2, the ten questions asked by the committee are responded to.

The QLR committee's raw feedback on recommendations is included in tabular format in Appendix A. Appendix B contains the full writing of the emails provided by the QLR. This may be helpful in providing context for some of the recommendations and responses.

Note: The number(s) in parentheses preceding each Section heading references back to the raw inputs recommendation numbers provided in the QL Review Team summary.

1. 0 Glast Project (GPO and SLAC) Actions

(1) Requirements Detail, Location, Control:

Summary:

The requirements in the FSW SRS are at a high level. More detailed requirements on *design* are captured in package level design documentation and are not well controlled. These are functional 'objectives' of the package. More detailed requirements on *interfacing* to the LAT hardware and the Spacecraft are documented in controlled ICDs (Interfaces to the LAT Hardware are controlled internally while the S/C-LATinterface document is controlled by Spectrum Astro).

Project can/should gain added insight by participating in design/code walkthru's where they exist.

Action Plan:

Action 1A: SLAC, GPO. Rework the FSW SRS to include either the text of or pointers to all FSW requirements that are not contained in the SRS itself. If multiple documents, link these requirements documents in DOORS so that when changes are made, all affected requirements are readily identified. Include Project Office personnel as signature to the document, and as a member on the CCB. All documents containing FSW requirements must be under CCB control. Test cases identified in the Test Plan must map to all FSW requirements, regardless of document location.

SLAC/GSFC to identify locations of requirements and strategy for including the appropriate references/text into document. This will include identifying signature and change control on SRS and the other documents.

Target Date for requirements update: End of January for the EM2 Peer Review.

Likewise, SLAC is implementing a plan for FSW CCB to be in place by the end of January 2004. Implemented before/for FU development.

Action 1B: SLAC. Review development schedule for opportunities for design/code reviews. As a part of the weekly FSW team meeting, identify working-group level design/code reviews which are scheduled for the coming weeks. These may be joined by project. Project: Ensure that working group level meetings are being held. Target Completion date for implementing process with updated schedule and meeting topic:End of January for EM2 Peer Design Review.

Action 1C: SLAC. Identify schedule and manpower to generate the LAT FSW Maintenance Plan document sometime in the schedule. Create placeholder in PMCS to author a Software Maintenance Plan sometime in project schedule. Intend to include in plan during schedule updates in January 2004.

(2 / 14) Flight Software Schedule Margin

Summary:

There seems to be limited schedule margin in the current schedule between the software completion date and the Instrument System Test (or Instrument Environmentals)

Action Plan:

Action 2A: SLAC, GPO. Work a detailed schedule with LAT FSW and LAT Project Management **ASAP**. Ensure that the schedule addresses completing tasks/packages on a priority basis such that the highest priority tasks/functions are implemented in the earliest possible builds while the lowest priority tasks are held until the final builds.

Once the requirements are identified more completely (see Action 1), identify the priority and build/release for the required capability.

Addressing 14: (Notion of planning FSW into the on-orbit/operations phase). The GPO will ensure that no software planned for LAT (or SC or GBM) will be planned or scheduled to be tested and completed on-orbit. Two notes: (1) Since GLAST is a 'discovery' mission, the capability to support 'discovery' in the manner of uploading a new science algorithm is planned. (2) Software to meet all requirements is currently scheduled to be tested and thru FQT in preparation for System Test (before Instrument Environmentals in 7/05) .

We've built in a bit of margin already – by adding bandwidth coming out of the LAT. This added margin eliminates one of the cuts that's needed in the filter (that hadn't been written yet)…

Action 2B: GPO – CCR to the LAT Science Data Rate. Ensure the LAT Science Data Rate CCR (CCR# 218) gets approved at GLAST Project CCB.

(3 / 16) Code Metrics. Identify and agree on them. Use them.

Summary:

Identify productivity metrics and definition of Source Line Of Code

Action Plan –

Action 3A: GPO, SLAC. Develop a mutually understood and agreed upon definition for metrics measurement. Specifically for SLOC and SLOC/day. Use this to put the IRT concerns to rest. Report on these metrics to GPO as well. (See Test Process Action (#4/5) for more on Test Metrics.)

We don't believe that there is adequate validity to providing productivity metrics (SLOC/day) at interim milestones. Will utilize measurements of functionality and requirements demonstrated and tested during the development/test cycle.

Action 3B: GPO, SLAC. Work a baseline to report out. Using that baseline on our overall LAT FSW SLOC estimates. Initial SLOC reports provided at dPDR (July 2002). At milestones (EM1 delivery, EM2 Peer Design Review , ISIS delivery, etc) provide updates to the initial estimates comparing 'estimated' vs. 'actual'.

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(4 / 5) Test Process

Summary:

Implement a more complete and formal test process.

Action Plan:

Action 4A: SLAC, GPO. As described in the LAT SMP, hold Test Ready Reviews for all the coming build (EM2, Next) and release (ISIS, Flight, Next) testing. Hold Test Results Reviews to ensure team understands where tests went awry and how. GPO closely monitor testing plan and process.

- ? Make distinction between "Integration" (informal) activities and "Test" (formal) activities. Know what the difference is.
- ? Take a notional "Test" process and flesh it out based on an example. Implement for ISIS, EM2, Flight, Next.
- ? Timeframe:By EM2 Peer Review.

Action 4B: SLAC. Definitions. Clearly articulate Build Testing and Release testing. Describe how are they relate to the functional requirements. Present to GPO what test metrics are used by the SLAC FSW team. Work with GPO to agree on test metrics to use.

(6) FPGA (and ASIC) Peer Review.

Summary:

Have all FPGA (and ASIC) designs Peer Review'd by GSFC reviewers.

Action Plan:

Action 6: SLAC. Plan/Coordinate delivery of FPGA designs to GSFC for review. GPO will coordinate the internal GSFC reviews. Timeframe ASAP, Plan in place NLT January 30, 2004. .

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(7) Software Configuration Management and Control.

Summary:

Differentiate between Code Management tool (CVS/CMT/CMX) and the process of Requirements and Code Control via a Change Control Board. Implement a code control and CCB process and define when it will take effect and on what.

Action Plan:

Action 7: SLAC, GPO. GPO work with SLAC to establish the timetable and process for Requirements & Code Control. SLAC create the FSW CCB with GPO involvement and identify the timeline to establish its implementation. Document processes in the LAT FSW SMP.

(8) Software Schedule Detail.

Summary:

GLAST Project Office and SLAC need to understand the software schedule in detail.

Action Plan:

Action 8A: GPO, SLAC: GPO work with LAT FSW Mgmt to identify detail to the schedule sufficient to monitor progress on both a functionality and a unit/task/package basis. With an adequate schedule, productivity and progress can be assessed. By EM2 Design Peer Review, establish more detail on what's needed in the various build/releases/demos on the schedule. Ensure that the schedule includes at least one to two FSW Level 3 milestones per month. Schedule updates to be completed by EM2 Design Peer Review.

Action 8B: SLAC: One term used in the software testing approach was Demo. Provide Definition of Demo. Associated with the Action 4B, identify the relationship between "demo" and requirements in the SRS or to formal tests from the FSW Test Plan.

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(9) Software Resource Usage.

Summary:

Report the Software resources regularly.

Action Plan:

Action 9: SLAC: Report their CPU/RAM/PROM/EEPROM/DL margin. Resource Usage - both "Expected/Planned" and "Actual" at 'Build' and 'Release' milestones.

(10 / 11) Software Reviews.

Summary:

Identify Reviews to be held during development cycle.

Action Plan:

Action 10A – GPO: Given where we are in the project life cycle (CDR + 6 months, EM1 past, EM2/ISIS coming), determine not just what reviews need to be performed at a system level (EM2/ISIS CDRs, TRRs, etc), but also evaluate the package level reviews required to move from one phase of development (ie. design to code or code-to-test). Also, what, if any, reviews (and scope) should accompany a 'build' test or a 'release' test.
Once Project determines what's needed to support reporting up, work with LAT FSW Mgmt to implement, starting in Jan 2004.

Action 10B – GPO, SLAC. Schedule the LAT EM2 CDR-level Peer Design Review for January 29, 2004

Action 10C – GPO / SLAC. GPO and SLAC discuss what reviews are deemed necessary to provide adequate insight and reporting up the chain to satisfy management.

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(12 / 13) Project Software Staffing.

Summary:

GLAST Project Office support to LAT should be dedicated and possibly enhanced.

Action Plan:

Action 12: GPO. GLAST Project Office to provide direction to Staff (Erik, others) to ensure complete coverage of the SLAC FSW effort. Project Office plans to evaluate oversight and technical support requirements based on schedule, development and testing plans being worked in response to the QLR.

(15) GSE / Test Stand Support

Summary:

Test stand production (60 count) and maintenance could distract the FSW team.

Action Plan

Action 15: SLAC: SLAC LAT Project management to identify the individuals who will manufacture, build, assemble, populate, test, ship, and maintain the multiple test stands and configurations that will exist on the project. Understand the timeline for this support: some 20 or so are fielded now. How long with maintaining these be necessary. Understand the upgrade process for the test stands, and who's responsible for it.

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(17) Software Scalability.

Summary:

Effort associated with scaling up from 1 to 16 towers and getting the configurations optimized may not be readily assessed. Is configuration of multiple towers or the whole instrument easy/hard to modify/update/test?

Action Plan :

Note:The primary goal of the EM2 build is to verify that multiple tower configuration and control can be performed.

Action 17: SLAC: Provide information, potentially as a demonstration/test, that the software can perform multiple tower configuration or control. If necessary, adjust schedules accordingly to reflect uncertainty in scaling of configuration control from a single tower to sixteen towers. .

Secondly, present testing strategy that shows complete testing coverage of multiple configurations of multiple towers.

(18) Front-End Simulator and Software Test Bed (STB) Definition.

Summary:

Recommend documenting (and controlling) requirements for the simulators, peer reviews, and approval/acceptance.

Description: The FES and STB are being worked by a dedicated simulator team of hardware and software engineers, separate from the FSW team (consulatation is of course common and expected). GPO must investigate to what extent the requirements for the simulators are documented.

The FES simulates the TKR, CAL, and ACD, providing the signal stimulus to the DAQ system. (It really is a simulator to test all of DAQ, not just software.) This may mean that the test bed will have difficulty injecting faults into the system to be detected by software down the line.

The interface requirements from the software perspective are not different, since the software interface is actually to EM DAQ hardware – the simulation is in front of the electronics. The software sees the same interface from the Front End Simulator and the STB.

ActionPlan:

Action 18: SLAC. Present approach to managing the requirements/functionality of the FES and STB. Present approach on how fault/error testing is accomplished. Does simulator provide the necessary capability to perform it? Does the FES allow the STB to inject errors and test limit conditions in the FSW? These questions to be addressed as part of the EM2 Design Peer Review in the end of January 2004.

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(19) ISIS Plan & Capability Definition

Summary:

ISIS may only be good for interface checkout. Limited capability to inject errors with EM equipment.

Action Plan:

The ISIS is for interface testing only.

Action 19: SLAC- Establish ISIS release schedule, delivery plan, tests, milestones. Have ISIS schedule included with the January updates to the schedule. Where they are different from the EM2/FU milestones, ensure that the ISIS milestones appear as Level 3 milestones.

(20) Reporting

Summary:

Have software report independently of the hardware.

ActionPlan -

The SLAC WBS and PMCS system have the two budgeted together as part of the Data Acquisistion system. Technical reporting can be done independently.

Action 20: GPO/SLAC. Continue to have explicitly planned (separate) times for hardware and software during the course of reviews and management briefings.

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(21) LAT FSW Staffing

Summary:

What is the LAT Project contingency for losing key FSW personnel?

Action Plan –

Action 21: SLAC. LAT IPO to contemplate contingency plans for loss of key personnel from the project.

2. 0 Questions

The following questions were also provided by the Committee. The GPO/SLAC response to them is included here.

Q ##	Question	Author
1	There seems to be a discrepancy in the documentation for the ISIS delivery date. The Management Plan and Process presentation package on page 10 shows a 6/1/04 delivery date for the ISIS Formal Release. In the schedule package listed on the web page, the EM2 formal test is completed in mid-July 2004 (see page 5 of 10 in the FSW schedule package). Since EM2 forms the basis of the ISIS delivery, these dates seem inconsistent. [Q#1] **Response**: The ISIS delivery is a subset of EM2. Not all of EM2, which does science as well as C&DH, is required for ISIS. As for the dates discrepancy, 6/1/04 is the date that the tested FSW is delivered to allow two-three weeks of formal testing of an integrated full-up ISIS prior to its delivery to Spectrum in late June. Note: This date is predicated on an updated CDRL list being currently worked with the SC and SLAC, so this is a bit up in the air right now.	Ed R.
2	EM1 and future EM2 development are "prototype" code to test the HW. Do the diagnostic codes(test code) for the HW stay embedded in the FSW codes? Are we flying all the HW diagnostic codes? If so are these codes going to be system tested? [Q#2] **Response**: LAT makes a clear distinction between 'diagnostic' and 'test' code. Test code does not fly. Diagnostic FSW does. The LAT instrument provides a level of diagnostics to assist in troubleshooting anomalies that occur in the instrument. This diagnostic code will run built-in-test (upon command) and produce diagnostic telemetry packets to assist in problem resolution. It will be fully tested as part of the FSW.	Martha C.
3	Currently the FSW is on schedule; however, the schedule has been recently updated. Looking at the schedule, these are my questions: [Q#3a thru 3e] A- The development cycles overlap each other (slide 10 of Management Plan & Process). The design/development for FU overlaps with EM2. Does LAT have two development teams?	Martha C.

Q ##	Question	Author
	One for EMS/ISIS and one for the FU ? If not the resource is double booked. **Response**: Slide 10 is a notional slide. The details of the schedules needs to be clarified so that it's clear who's doing what during the various phases of EM1, EM2/ISIS and FU. There is not a second development team; there is however a test team that is tasked with doing testing beyond the unit/package level. B - There are schedule inconsistencies between the slide 10 of Management Plan & Process and PMCS Schedule (review related documents). Using the PMCS schedule EM1 delivery is due on Jan 22, 2004 instead of September 1, 2003 ? **Response:** SLAC is doing some follow-up documentation to support EM1 thru January 2004. The work associated with the actual tower and electronics has been completed. There are further schedule modifications due to the rebaselining that are now a part of the schedule as well. C - The ISIS release planned on 6/1/04 to Astro and the FU release planned on 12/15/04 to I&T are before the System level testing completes on 7/15/04 and 2/18/05, respectively. **Response:** The ISIS-related Flight Software release is a subset of the EM-2 FSW build. It will be a separate delivery of FSW to the ISIS team which will be formally sold off. For the FU, the FSW team plans to deliver their code on an 'interim' basis to support some early I&T, and then proceed with the FQT until Feb 2005, at which time it will be delivered formally to I&T for System Test. D - Looking at the PMCS Schedule, EM2 design, development, and unit test occur at same time and the design review is currently scheduled on Jan. 04. This is a high risk if the design proves unacceptable. **Response**: The EM-2 Design Review has unfortunately been delayed from its initial schedule of early fall due to a number of reasons. It is currently scheduled for Jan 29, 2004 E - The EM2 Formal test (19 tests/FSW Test Plan) and the FU Formal Test (19 tests/FSW Test Plan) . . . are they the same 19 tests?	

Q ##	Question	Author
	Response: The simple answer is yes, however, SLAC is aware that this schedule and test plan need further definition in this area.	
4	Up until the QLR, the FSW development process was presented to IV&V as incremental, that is FU (Flight) Build = EM1 + EM2 + a few additions. During the QLR Erik Andrews (GSFC) stated that EM1 and EM2 were test only builds for hardware/systems checkout and that a Flight Ready Build with formal controls and testing would occur later. This is a significant departure from the prior information. [Q#4] **Response**: As the GPO understanding of SLAC's process has improved, so has our ability to describe the process.	IVV
5	EM1 supports one Tower Electronics Module (TEM) fully. This software will be "cloned" and used to manage all 16 TEMs in the FSW. Therefore, EM1 software is essential to the success of the LAT. IV&V has attempted, on several occasions, to obtain and evaluate the EM1 Source Code to provide feedback early in the development lifecycle. We have been rebuffed on each attempt. IV&V efforts are a software risk mitigation approach and the analysis will be done without interference in the software development process. However, the analysis cannot be completed without the delivery of the EM1 Source Code. [Q#5] **Response**: The LAT IV&V MOA does not include code analysis.	IVV
6	EPU filtering software is currently stated at 98. 4% efficient at filtering out real events from the background data. What is meant by the phrase "99% non-idle CPU to do physics" on Slide 8? What is the estimate of CPU use at the greater than 99% level that is required on orbit? During the QLR, at least three different flight CPU use numbers were discussed. Erik Andrews stated 70-80% of both CPUs would be needed, the current single CPU is 99% utilized, and the CPU estimate charts presented during the review showed 15% across two processors. The expected CPU use for both EPUs in on-orbit conditions should be clearly stated. A minimum reserve of 25% CPU cycles for both EPUs is a common requirement. [Q#6] **Response:** The CPU usage for both processors was clearly shown as 15% in each EPU and 25% in the SIU. 99% of the 15% of the EPU CPU utilized is taken by the filter.	IVV
7	There does not appear to be an SQA function within the development organization. The "Independent" Test Team shown	IVV

Q ##	Question	Author
	on Slide 21 does not appear to be truly "independent" as they report to the SLAC Software Project Manager instead of to the GLAST LAT Program Manager. During the QLR, it was also mentioned that the Independent Test Team members could be asked to write FSW and they were partially included in the Effort estimations on Slide 35. [Q#7] **Response**: Not quite sure of the question. It's not intended to be an independent test team. It iss intended to be separate from the developers. They should be included in the estimation since they'll be doing the testing.	
8	This approach is contrary to industry best practice where Software is developed from detailed requirements and designs, unit tested, integration tested, and deployed to the hardware for hardware/software integration testing. [Q#8] **Response**: While varying somewhat from Goddard's standard software development approach, we've deemed it a good risk – to use a software development process that the core flight software team has used multiple times with success. GPO continues to work with SLAC to modify the development approach when we identify shortcomings.	IVV
9	Is the System Testing indicated for February 05 (Slide 7) the formal qualification testing of the software on flight level hardware? If so, does this take 4 months? Or does this include tests other than those involving software? [Q#9] **Response**: System Testing refers to Instrument System Test. The FSW is tested and sold off before that.	IVV
10	Are timing characteristics, configurability and reconfigurability being addressed completely for all 16? [Q#10] **Response:** Generally, configuration is done "in advance" of a "run" (taking science), so it is an 'off-line' function. It would be good to know the issues associated with multiple tower configuration. . We've taken action to understand the timing and issues/constraints with configuring the LAT. Much more of this will be learned during EM-2 build testing since there will be four towers in the configuration.	Elaine S.

Appendix A:Raw Comments Provided by the QLR Team

As compiled and provided to GLAST by Review Team Chair, Joe Hennessey.

Rec ##	Recommendation	Author
1A	**Review the FSW requirements and ICDs to ensure the full job is defined well enough to produce and test quality code, on schedule. [R#1A]**	Ann M.
1B	**I would recommend that an inclusivesingle requirements document be generated, reviewed and signed off. [R#1B]**	Joe H.
1C	**SLAC needs to provide a consolidated Software Requirements Specification that captures all the software requirements and their sources. All the software requirements need to be captured in one place and they need to be traced to their parents (ICD's, systems specs, whatever). ICD's could, at the very least be referenced in the SRS so people know where to go to find the requirements. Currently the 67 requirements in the SRS do not define a system and present a maintenance nightmare if anyone other than the original team tries to work on this thing. [R#1C]**	Steve S.
1D	**I recommend that the project assess the flight software requirements specification along with the ICD's for overall adequacy. If they haven't already, I recommend that the project attend design and code walkthroughs to see how the requirements are implemented. This would provide another good way to assess the situation. [R#1D]**	Ed R.
1E	**The 67 requirements they have now are level 2 or 3. They write level 4 requirements when they sit down to start writing code; they call them "objectives" rather than "requirements". Unit testing is done to those "objectives". [R#1E]**	Stephe L.
1F	**Not having all the requirements defined in one place and that there are no references from the SRS to the ICDs, obviously has everyone a little concerned. I'm not too worried about SLAC since this seems to be their standard operating procedure, which we shouldn't change, but possibly the project (in particular Erik Andrews) needs to pay a little more attention to this area to ensure there is proper traceability between the SRS and ICDs. . The other area the project needs to worry about is preparing for on-orbit maintenance later on in the project life cycle. If the goal of the mission is to last up to 10 years, during this time there will be software changes. I don't know who will be operating GLAST or maintaining it, but even if SLAC is involved the same people**	Bill O.

Rec ##	Recommendation	Author
	won't be and the software maintenance plan needs to address how all these distributed requirements will be maintained for future reference. [R#1F]	
1G	**The spread of requirements into the ICDs will make the Requirements Management Process difficult. ICDs do not contain clearly defined software requirements, so in order to derive the proper FSW requirements, the developer will have to sift through the information to identify the necessary software functions. FSW requirements should be fully and completely identified in the FSW Software Requirements Specification (SRS). [R#1G]**	IVV
1H	**Dedicate someone to maturing the FSW requirements into a single product that is reviewable and controllable as the driving document of LAT FSW capabilities. It sounds like a waste now, but once done everyone will be thankful. [R#1H]**	Elaine S.
1I	**Put the reqmts. doc. under CCB control in the near future. It doesn't mean that you can't change requirements. It just means that communications are solid and documented. Informality creates huge risk in regards to FSW maturity. [R#1I]**	Elaine S.

Rec ##	Recommendation	Author
2A	**Add margin to the schedule either by overstaffing or identifying requirements which can be deleted or deferred. (If all the code is required, the earlier additional staff are brought on board, the better.) [R#2A]**	Ann M.
2B	**The current plan has the Software Test-Bed assembled by February 04 and commissioned by late spring of 04. Late spring is late for a June '04 ISIS release. In a worse case scenario (are there other kinds ?) this means that the FSW group will only have this stable system for two months before Qualification testing begins for the ISIS delivery ? [R#2B]**	Joe H.
2C	**. The Project should consider options to create some FSW delivery slack for the full FSW(deliver first needs first in Dec. 04 and add a second FSWflight delivery in April) ? [R#2C]**	Joe H.
2D	**The project should be working with SLAC now to develop work arounds, plans, etc. to provide from margin to the schedule [R#2D].**	Bill O.

Rec ##	Recommendation	Author
3A	**Select metrics that both LAT and the Project can agree will be true indicators of FSW progress (or the lack there of). Update these at least monthly and report them to management. [R#3A]**	Ann M.
3B	**Over the next several weeks the Project should work with SLAC and Code 582 to better establish a valid basis of comparison. [R#3B]**	Joe H
3C	**We need a standardized definition for Verified Source Lines of Code (VSLOC) for SLAC so we are all using the same terminology and calculations. Erik Andrews will provide a definition based on standard GSFC and JPL practice and run it past the team for agreement prior to sending it to SLAC. Right now we are not making apples-to-apples comparisons of VSLOC and this is causing confusion and misrepresenting the required aggressiveness of the SLAC Software development schedule. Once normalized to a standard approach, these numbers should not look like the five to eight times the IRT is criticizing in its chart. [R#3C]**	Steve S
3D	**We need updated SLOC/VSLOC charts from SLAC. [R#3D]**	Steve S
3E	**I find it difficult to say "21 lines of code per man per day is too high" since we don't have a written, accepted definition of how to measure that number, nor a history of measuring it on our own projects. [R#3E]**	Stephe L.
3F	**Not having a whole lot of background on LAT, I gathered that the review spawned out of concerns on their productivity and I agree with the general consensus that they need to get to an apples to apples comparison. If the numbers still seem a little high, the project should be able to justify them by examining SLACs working environment, processes, etc. If they don't make an apples to apples comparison, they will be addressing this issue at every review. [R#3F]**	Bill O.
3G	The post-CDR **software productivity metrics (LOC/day) are skewed by the fact that the "Real-Time Toolbox" development was minimal. IV&V was told that this software was written for the Balloon Test Flight and moved over with minimal changes. SLAC is not hitting 21 LOC/day even at present. [R#3G]**	IVV

Rec ##	Recommendation	Author
4A	**Concurrent with this I would recommend that a EM1 test plan be created, tests conducted, and a test results review held. Information learned in this will help better size the effort to conduct formal release testing, as well as provide a leg up for actually doing the ISIS tests. [R#4A]**	Joe H.
4B	**we need to be very clear what we think they should do, and review their test plans carefully [R#4B & R#5B].**	Stephe L
4C	**Have FSW build test reviews prior to and after each build to be sure that the testers fully understand what they're testing and that the developers fully understand the problems the testers had testing. [R#4C & R#5D]**	Elaine S.
5A	**The Project should hold ISIS and I&T Flight release Test Readiness and Test Results reviews. [R#5A]**	Joe H
5B	**we need to be very clear what we think they should do, and review their test plans carefully [R#4B & R#5B].**	Stephe L
5C	**Towards the end of the review, it was stated that "specificity" was being added to formal tests for FU and that meant that requirements from the ICDs will be incorporated into the verification matrix. Where this gives me some confidence, it would benefit the project pay close attention to this activity and possibility double check these activities (tie into the concern in #3 above) or have the IV&V group look at it. [R#5C]**	Bill O.
5D	**Have FSW build test reviews prior to and after each build to be sure that the testers fully understand what they're testing and that the developers fully understand the problems the testers had testing. [R#4C & R#5D]**	Elaine S.
5E	**Document FSW test scenarios and walk-through the scenarios before commiting to test procedures. [R#5E]**	Elaine S.

Rec ##	Recommendation	Author
6	**The GASU is critical to LAT success and it consists of some number of FPGAs. The Project should consider a detailed GASU review with FPGA peer reviews, if not already completed. [R#6]**	Joe H

Rec ##	Recommendation	Author
7A	**The actual code management is done using CMX/CMT/CVS. Thought needs to be given about the mangement process to decide on what changes are incorporated when (LAT CCB process). If a problem is found in test of a release how is change authorized, incorporated, and what are the implications for retest ? [R#7A]**	Joe H
7B	**Configuration Management is a concern - particularly, when it starts and how rigorously it is enforced. GSFC should be on top of this. [R#7B]**	Steve S.
7C	**The Configuration Management of the software seemed a little up in the air. At first it seemed that none of the s/w was really under CM control as of yet where changes were being documented, but in the testing presentation that software delivered for testing was under CM control. The project needs to pay particular attention to this area to ensure SLAC is maintaining proper CM and is enforcing it at the right time. [R#7C]**	Bill O.
7D	**Formal control over software using a managed process involving Quality Assurance, Configuration Management and the use of an SCCB is missing (Ref: Slide 27). It is our opinion that the process described in Slide 27 for use in the "development builds (EM1 and EM2)" has the potential for significant requirements creep [R#7D].**	IVV
8A	**We need a full software schedule breakdown from SLAC. The schedules we saw were too high level and do not have the necessary credibility to eliminate the concerns. [R#8A]**	Steve S.
8B	**…more importantly the LAT team productivity should be used to project and monitor the future schedule [R#8B].**	Martha C.
8C	**Except for the examples of their tracking schedules, a comprehensive s/w schedule was not presented [R#8C].**	Bill O.
8D	**Define FSW builds [R#8D]**	Elaine S.
9A	**GSFC Software Management needs to track Flight Software Resource usage estimates/actuals monthly. [R#9A]**	Steve S
9B	**CPU performance and data downlink (compression) may be a limiting factor. This needs to be monitored and reported periodically. [R#9B]**	Martha C.

Rec ##	Recommendation	Author
10	**A GSFC/SLAC review/walkthrough of the ISIS requirements and design should be conducted for obvious reasons. [R#10]**	Steve S.
11	**The Project could proceed with the LAT EM2 Review because it is ready. [R#11]**	Steve S.
12	**Erik Andrews needs to devote his full time energies to Software Systems Management and Engineering of the GLAST Project or else the Project should make him a Systems Engineer and find someone else to do the Software Systems job [R#12].**	Steve S.
13	**GSFC should consider adding another Software Engineer to monitor and help this effort [R#13].**	Steve S.
14	**The Project seems to be holding a dangerous vision of work that could be completed after Software Delivery or even on-orbit - this idea should be completely eliminated [R#14].**	Steve S.
15A	**SLAC needs to hand the daily production of simulators over to less critically skilled people so that their top developers do not end up becoming a "Help Desk" for production level development of simulators. Students could handle this task very well. [R#15A]**	Steve S.
15B	**About 60 Instrument test stands will be distributed in mid December. After the distribution, support is going to be an issue. Who is going to do support? The experienced software engineers need to be shielded from this activity. [R#15B]**	Martha C
16	**The next major milestone is the ISIS release scheduled for June 1, 2004 delivery. The project should derive the productivity rate required to meet this delivery [R#16].**	Ed R.
17	**This may be a time consuming process and the project may want to closely monitor this activity. Since it is an iterative process, the earned value system ("credits") and software productivity rates may not be useful in revealing a schedule problem in this type of flight software development activity. [R#17]**	Ed R.
18	**Define detailed requirements for each simulator and get the reqmts. reviewed by appropriate subsystem and systems staff. Be very sure that all possible error, anomaly,**	Elaine S.

Rec ##	Recommendation	Author
	contingency situations, timing criteria, etc. can be created using the simulated test environments. [R#18]	
19	**Review the practicality of using EM hardware at the s/c. Will the s/c FSW team be able to configure the LAT EM hardware to fail or have an incomplete interface transfer or content, fail a timing event, etc. ?EM hardware is great for interface tests, but not great for functional tests between two CPU. [R#19]**	Elaine S.
20	**The FSW team lead should report to upper mgmt. independent of the hardware group. [R#20]**	Elaine S.
21	**Does staffing accommodate losing a key person from FSW productivity?If not, hire now [R#21]**	Elaine S.

Appendix B: Email Response from the QLR Team

Date: Wed, 26 Nov 2003 09:27:15 -0500
To: Kevin. J. Grady@nasa. gov, Albert. G. Vernacchio@nasa. gov, Jack. E. Leibee@nasa. gov
From: Joseph Hennessy <Joseph. F. Hennessy@nasa. gov>
Subject: 9AM 12/1 Meeting: LAT FSW QLR Team Inputs
Cc: Steven. S. Scott@nasa. gov, William. R. Ochs@nasa. gov, Edward. O. Ruitberg@nasa. gov, Elaine. M. Shell@nasa. gov, Raymond. Whitley-1@nasa. gov,Stephen. Leake@gsfc. nasa. gov, Martha. I. Chu@nasa. gov, AMerwarth@hst. nasa. gov, Stephen. M. Pukansky@nasa. gov

On behalf of the LAT Quick Look Review (QLR) Team and other participants I would like to thank the Project and the SLAC presenters for providing a very good overview of this challenging LAT flight software development effort. As mentioned throughout a number of the comments provided below, the Project and the SLAC development team look to be skilled, knowledgeable, and dedicated. It is obvious that a great deal of work lies ahead, even while some real accomplishments have been made to date (such as the reported EM1 success).
Raw EMail inputs are included below, approximately ordered by time of receipt.
Recommendations for Project consideration are shown in **bolded blue text**, numbered as R#1 through R#21. Different aspects of the same basic concern reflected in the recommendations are tied through letter suffix notation. For example, requirements concerns and some approaches to this are found in R#1A through R#1I (recommendation #1 with twists A through H). Some additional questions listed are shown in **green text**, numbered as Q#1 through Q#10.
As we discussed at the review, let's plan on a **1 hour tag up discussion at 9AM this coming Monday (12/1) in B23 room S412.** We hope that you find these inputs useful in helping LAT meet mission requirements.

joe

##
#####**Ann Merwarth Inputs** #######
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From:Ann Merwarth

Subject:Report from the GLAST LAT Quick Look FSW Review

I attended a LAT FSW Quick Look Review via telecon from 12:00 PM-4:30 PM on Nov. 21, 2003. The meeting was a video-con between GSFC and LAT. I was tied in via telecon from Fort Myers. There was considerable static on the line so it was difficult to follow the presentations at times.
The LAT presenters were technically competent, confident, and showed good ownership of their effort. They are also a very experience team. I was impressed with their presentation. I was also impressed with the Project personnel and their plan to mange this difficult effort. I am very pleased that the Project has been able to augment the LAT FSW staff.
The LAT SW development methodology is somewhat different from the GSFC norm. The

requirements for the FSW are at a high level (A total of 67) and distributed in multiple documents. In order to understand what needs to be done a person needs to look at ICDs and design documentation as well as the requirements. This raises the question of what is used to drive the test plan. Steve Scott indicated that there needs to be a review of the requirements document to evaluate its adequacy for supporting test plans and to determine if the requirements are written in sufficient detail to convey the full scope of the effort.
The LAT FSW has builds and releases. Builds are unit and hardware tested but no formal testing is done on them. There are 2 releases of the LAT FSW on which unit, HW and formal testing is done. The first release with formal testing will be for the ISIS SW delivery and then the full I&T delivery. The LAT definition of formal testing is: testing done to the requirements mapping using approved test procedures and followed by a report. The test plan needs to be updated. Since the requirements are at a high level LAT plans to augment the test plan with information from ICDs and other documents.
One of the triggers for this review was concern regarding LAT FSW productivity. At an earlier review LAT indicated that their code productivity was around 45-50 LOCs/person /day. GSFC uses a figure of 5 LOCs/person/day for FSW. In the last 6 months, LAT has measured their productivity at 21 LOCS/person/day. This has been their productivity for 6 persons working 6 months and producing 15000 LOC. This productivity is for writing code, unit testing the code and running it on flight HW. They have no productivity measures as yet for producing code which has undergone unit, hardware and formal testing. GSFC's 5 LOC/person/day is for producing fully tested code. So comparing LAT's productivity of 21 LOC/person/day to GSFC's 5 LOC/person/day is comparing apples to oranges.
LAT claimed at their earlier review that they did not need additional people to do this job, and that the special skills that would be needed for their FSW could not be found even if they wished to increase the size of their staff. LAT has, however, with help from the project found additional people to augment their staff. With these additional people and with maintaining a productivity rate of 21 LOC/person/ day, LAT estimates that they can produce the additional 77K LOCs on the needed date. I have the following concerns:
1. Additional people will have to be trained and may not start out as productive as the original 6
2. The high level of the requirements may make it difficult for new people to work at a high productivity rate
3. There are no metrics of productivity which apply to formally tested code, as yet
4. There is no measure of difficulty of the 15K LOCS compared to the 77K LOCS -(maybe adding the controls for multiple towers is more difficult to test even on the HW, not to mention formal testing)
5. There is no margin other than reducing the system test time.
6. Formal testing and the writing of test SW, procedures, etc may prove to be a more labor intensive process than LAT imagines-

The LAT FSW development approach involves SW developers working closely with the HW developers in producing "prototype like" code builds which are generated in an informal process and run on the HW. Formal testing is only done on the 2 builds which are being delivered to an outside entity like I&T. LAT claims that LOCs is not a measure that they have used in the past. They mentioned a LAT earned value system which they participate in. Perhaps the Project needs to look for metrics that both the LAT FSW and the Project can agree are better able to track progress against their plan. Whatever is chosen needs to be fully understood and accepted by

both the Project and LAT and needs to be updated on a regular basis. (at least once/month) The high level schedule in the presentation was not very usable in this regard since all the activities spanned the same critical period of time. I assume there are at least lower level milestones, detailed release content definitions, as well as other standard SW measures that are in use and could be used to judge if progress is as planned.

Recommendations to the Project:
Review the FSW requirements and ICDs to ensure the full job is defined well enough to produce and test quality code, on schedule. [R#1A]
Add margin to the schedule either by overstaffing or identifying requirements which can be deleted or deferred. (If all the code is required, the earlier additional staff are brought on board, the better.) [R#2A]
Select metrics that both LAT and the Project can agree will be true indicators of FSW progress (or the lack there of). Update these at least monthly and report them to management. [R#3A]
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Joe Hennessy Inputs#########
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My observations and tentative recommendations from the LAT flight software Quick Look Review held on 11/21/03.

1. The existing requirements document is at a high level (under 70 total FSW requirements) and contingent on other detailed information spread across a number of ICDs and related technical information. Testing to date on the single tower EM1 build has been exercised as a functional prototype, without a formal test plan. Current plans show the first LAT FSW formal release in June '04 (ISIS release), with the I&T formal release set for December '04.

To assess the completeness of the requirements and the effort actually required to conduct formal testing, **I would recommend that an inclusivesingle requirements document be generated, reviewed and signed off. [R#1B]Concurrent with this I would recommend that a EM1 test plan be created, tests conducted, and a test results review held. Information learned in this will help better size the effort to conduct formal release testing, as well as provide a leg up for actually doing the ISIS tests. [R#4A]**

2. Recent additions to the FSW Staff (3) and the addition of a dedicated test team (4) are sound moves, as is the addition of another person to help in FSW Management.
3. SLAC reported a FSW productivity of 20 to 25 source lines of code per day vs. a more generally accepted JPL & GSFC range of 5 to 10. However, this SLAC productivity figure seems more like a programming rate through integration testing only. This doesn't seem to account for the SW management & systems engineering associated labor, nor does it include formal test efforts at least through final delivery to launch. Historically, my experience is that requirements definition through PDR also account for about 20% of the total development effort and this isn't being accounted for as well. **Over the next several weeks the Project should work with SLAC and Code 582 to better establish a valid basis of comparison. [R#3B]**

4. **The Project should hold ISIS and I&T Flight release Test Readiness and Test Results reviews. [R#5A]**

5. **The GASU is critical to LAT success and it consists of some number of FPGAs. The Project should consider a detailed GASU review with FPGA peer reviews, if not already completed. [R#6]**
6. **The actual code management is done using CMX/CMT/CVS. Thought needs to be given about the mangement process to decide on what changes are incorporated when (LAT CCB process). If a problem is found in test of a release how is change authorized, incorporated, and what are the implications for retest ? [R#7A]**

7. **The current plan has the Software Test-Bed assembled by February 04 and commissioned by late spring of 04. Late spring is late for a June '04 ISIS release. In a worse case scenario (are there other kinds ?) this means that the FSW group will only have this stable system for two months before Qualification testing begins for the ISIS delivery ? [R#2B]**

8. **The Project should consider options to create some FSW delivery slack for the full FSW(deliver first needs first in Dec. 04 and add a second FSWflight delivery in April) ? [R#2C]**

joe

##
Steve Scott Inputs##########
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As you know the GLAST LAT Flight Software Quick Look Review was conducted on Friday, November 21, 2003. Attendance was excellent. Joe Hennessy, in his usual prompt and excellent manner, has already provided insightful preliminary comments which pretty much capture everything. At the risk of repeating some of them, I provide my comments below:
1. **We need a standardized definition for Verified Source Lines of Code (VSLOC) for SLAC so we are all using the same terminology and calculations. Erik Andrews will provide a definition based on standard GSFC and JPL practice and run it past the team for agreement prior to sending it to SLAC. Right now we are not making apples-to-apples comparisons of VSLOC and this is causing confusion and misrepresenting the required aggressiveness of the SLAC Software development schedule. Once normalized to a standard approach, these numbers should not look like the five to eight times the IRT is criticizing in its chart. [R#3C]**
2. **SLAC needs to provide a consolidated Software Requirements Specification that captures all the software requirements and their sources. All the software requirements need to be captured in one place and they need to be traced to their parents (ICD's, systems specs, whatever). ICD's could, at the very least be referenced in the SRS so people know where to go to find the requirements. Currently the 67 requirements in the SRS do not**

define a system and present a maintenance nightmare if anyone other than the original team tries to work on this thing. [R#1C]

3. **We need a full software schedule breakdown from SLAC. The schedules we saw were too high level and do not have the necessary credibility to eliminate the concerns. [R#8A]**
4. **We need updated SLOC/VSLOC charts from SLAC. [R#3D]**
5. **GSFC Software Management needs to track Flight Software Resource usage estimates/actuals monthly. [R#9A]**
6. **A GSFC/SLAC review/walkthrough of the ISIS requirements and design should be conducted for obvious reasons. [R#10]**

7. **The Project could proceed with the LAT EM2 Review because it is ready. [R#11]**
8. **Erik Andrews needs to devote his full time energies to Software Systems Management and Engineering of the GLAST Project or else the Project should make him a Systems Engineer and find someone else to do the Software Systems job [R#12]**. We cannot afford gaps in Software Systems coverage on GLAST - it will be fatal to this project. We had weaknesses in systems too long to have Erik doing both jobs. Hopefully, Jack Leibee completely mitigates this problem.

Additional Comments:
1. The required LAT software productivity requirements are not as high as advertised once the numbers are normalized to the typical GSFC/JPL way of tracking these numbers. It may be high and aggressive but I do not think it will be unreasonable nor unsustainable given SLAC's past performance based on comparison to their own numbers. GSFC is going to need to watch this a lot more carefully than it has been doing. GSFC has Software Systems responsibility and it needs to assert this - otherwise a SWIFT is in the making. **GSFC should consider adding another Software Engineer to monitor and help this effort [R#13].** The Project seems to be holding a dangerous **vision of work that could be completed after Software Delivery or even on-orbit - this idea should be completely eliminated [R#14]**. The LAT FSW needs to be completed by the start of I&T and needs to be essentially stable (except maybe for some parameter changes) for launch.

2. SLAC has added 3+ people in the past three months (since CDR) to the software development effort. The software test team will consist of four people (two already in place, two more to be added. SLAC is slowly adding qualified people who do not have a huge learning curve, which is exactly the right way to do this.

3. SLAC will perform a Formal Software Qualification/Acceptance Test of the LAT FSW before release to System Integration and Testing.
4. **Configuration Management is a concern - particularly, when it starts and how rigorously it is enforced. GSFC should be on top of this. [R#7B]**
5. **SLAC needs to hand the daily production of simulators over to less critically skilled people so that their top developers do not end up becoming a "Help Desk" for production level development of simulators. Students could handle this task very well. [R#15A]**

6. Finally, SLAC has a terrific team and they seem to have a complete understanding of what is

required. I think they have a much better chance of getting this job done correctly than the SWIFT Science Team.

Respectfully Yours for GLAST LAT Mission Success,
Steve Scott

##
Ed RuitbergInputs#########
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Joe,
Here's my comments from the LAT flight software review:

LAT Flight Software Team Organization
The most positive thing I observed in the review was the strong LAT team organization. The flight software and hardware development team work together in the LAT development environment. The team size seems manageable to operate this way. The team is also well experienced. Some of the issues noted at the review are mitigated by this team organization.

Requirements definition
The LAT Flight Software Specification is at a high level. There was substantial discussion of this at the review and I expect there will be many written comments on this issue. The SLAC team said that many of the requirements are detailed in the ICD's. This may be the case, however, many requirements are internal to the LAT, therefore, I expect that even including the ICD's there remains a high level specification of many requirements.

There are several mitigating factors to offset this. The LAT flight software team is well experienced and has operated successfully under similar conditions in the past. The EM1 delivery has been successful, indicating that the requirements definition so far, has not been an issue.

I recommend that the project assess the flight software requirements specification along with the ICD's for overall adequacy. If they haven't already, I recommend that the project attend design and code walkthroughs to see how the requirements are implemented. This would provide another good way to assess the situation. [R#1D]

ISIS delivery
The next major milestone is the ISIS release scheduled for June 1, 2004 delivery. The project should derive the productivity rate required to meet this delivery [R#16]. 21 lines of code seems to be the standard, however, it was not known at the review what the required rate is to meet the June 2004 delivery. The metric will be useful, especially since this is the first release of the LAT software external to SLAC, and will likely have high visibility.

There seems to be a discrepancy in the documentation for the ISIS delivery date. The Management Plan and Process presentation package on page 10 shows a 6/1/04 delivery date for the ISIS Formal Release. In the schedule package listed on the web page, the EM2 formal test is

completed in mid-July 2004 (see page 5 of 10 in the FSW schedule package). Since EM2 forms the basis of the ISIS delivery, these dates seem inconsistent. [Q#1]

Instrument configuration tables

The flight software contains large tables (configuration bits) that define the parameters required for instrument operation, e. g. , scan parameters. Each of the 16 towers has a unique set of configuration bits. The process of specifying these parameters may be complex although this wasn't discussed at the review. This process must be tightly coupled between flight software and hardware for this is likely an iterative process. The SLAC LAT development team's organization appears to be well suited to address this type of problem. **This may be a time consuming process and the project may want to closely monitor this activity. Since it is an iterative process, the earned value system ("credits") and software productivity rates may not be useful in revealing a schedule problem in this type of flight software development activity. [R#17]**

Ed Ruitberg

##
Martha Chu Inputs
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These are my observations and recommendations from the LAT flight software Quick Look Review held on 11/21/03

The LAT team is technically competent. They are also a very experienced team.

1. I agree with the recommendation on requirements documents from Steve Scott and Joe Hennessy
2. The productivity numbers of 21 LOC/day/person is only measured during last 6 months not the whole software life cycle and it is an orange to apple comparison to GSFC/JPL productivity. The conversion needs to be done but **more importantly the LAT team productivity should be used to project and monitor the future schedule [R#8B].**
3. EM1 and future EM2 development are "prototype" code to test the HW. Do the diagnostic codes(test code) for the HW stay embedded in the FSW codes?Are we flying all the HW diagnostic codes?If so are these codes going to be system tested? [Q#2]
4. Currently the FSW is on schedule; however, the schedule has been recently updated. Looking at the schedule, these are my questions: [Q#3a thru3e]

- The development cycles overlap each other (slide 10 of Management Plan & Process). The design/development for FU overlaps with EM2. Does LAT have two development teams? One for EMS/ISIS and one for the FU ?If not the resource is double booked.
- There are schedule inconsistencies between the slide 10 of Management Plan & Process and PMCS Schedule (review related documents). Using the PMCS schedule EM1 delivery is due on Jan 22, 2004 instead of September 1, 2003 ?
- The ISIS release planned on 6/1/04 to Astro and the FU release planned on 12/15/04 to I&T are before the System level testing completes on 7/15/04 and 2/18/05, respectively.

- Looking at the PMCS Schedule, EM2 design, development, and unit test occur at same time and the design review is currently scheduled on Jan. 04. This is a high risk if the design proves unacceptable.
- The EM2 Formal test (19tests/FSW Test Plan) and the FU Formal Test (19tests/FSW Test Plan) . . . are they the same 19 tests?
- The schedule needs to be closely tracked to make sure there are no surprises.

5. **About 60 Instrument test stands will be distributed in mid December. After the distribution, support is going to be an issue. Who is going to do support? The experienced software engineers need to be shielded from this activity. [R#15B]**

6. **CPU performance and data downlink (compression) may be a limiting factor. This needs to be monitored and reported periodically. [R#9B]**
Martha

##
Stephen LeakeInputs#######
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Here are my comments.

SLAC has an excellent process that they are used to and works well for them. We should not change that process without very good reason.

The 67 requirements they have now are level 2 or 3. They write level 4 requirements when they sit down to start writing code; they call them "objectives" rather than "requirements". Unit testing is done to those "objectives". [R#1E]

A separate test team is something they are not used to. They have no idea what that team is supposed to do; **we need to be very clear what we think they should do, and review their test plans carefully [R#4B & R#5B]**. The test team needs to capture the "objectives" (ie level 4 requirements) in order to test to them.

I find it difficult to say "21 lines of code per man per day is too high" since we don't have a written, accepted definition of how to measure that number, nor a history of measuring it on our own projects. [R#3E]

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Bill OchsInputs#######
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From: William Ochs <William. R. Ochs@nasa. gov>
Subject: LAT FSW Review

Hi Joe,

My comments to last Friday's review are below.

Bill

1. Overall I think the SLAC folks did a good job at the review. I have some concerns, but they're basically the same ones that every one else on team had with regards to requirements, CM, traceability, etc.

2. **Not having a whole lot of background on LAT, I gathered that the review spawned out of concerns on their productivity and I agree with the general consensus that they need to get to an apples to apples comparison. If the numbers still seem a little high, the project should be able to justify them by examining SLACs working environment, processes, etc. If they don't make an apples to apples comparison, they will be addressing this issue at every review. [R#3F]**

3. **Not having all the requirements defined in one place and that there are no references from the SRS to the ICDs, obviously has everyone a little concerned. I'm not too worried about SLAC since this seems to be their standard operating procedure, which we shouldn't change, but possibly the project (in particular Erik Andrews) needs to pay a little more attention to this area to ensure there is proper traceability between the SRS and ICDs. . The other area the project needs to worry about is preparing for on-orbit maintenance later on in the project life cycle. If the goal of the mission is to last up to 10 years, during this time there will be software changes. I don't know who will be operating GLAST or maintaining it, but even if SLAC is involved the same people won't be and the software maintenance plan needs to address how all these distributed requirements will be maintained for future reference. [R#1F]**

4. **Towards the end of the review, it was stated that "specificity" was being added to formal tests for FU and that meant that requirements from the ICDs will be incorporated into the verification matrix. Where this gives me some confidence, it would benefit the project pay close attention to this activity and possibility double check these activities (tie into the concern in #3 above) or have the IV&V group look at it. [R#5C]**

5. **The Configuration Management of the software seemed a little up in the air. At first it seemed that none of the s/w was really under CM control as of yet where changes were being documented, but in the testing presentation that software delivered for testing was under CM control. The project needs to pay particular attention to this area to ensure SLAC in maintaining proper CM and is enforcing it at the right time. [R#7C]**

6. Except for the examples of their tracking schedules, **a comprehensive s/w schedule was not presented [R#8C].** Based on the work left to complete, there seems to be no schedule margin in their plan. At this point in time, that's just adding risk to what seems to be an already medium to

high risk development. **The project should be working with SLAC now to develop work arounds, plans, etc. to provide from margin to the schedule [R#2D].**

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#####**IV&V TeamInputs** ########
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NASA-IV&V Attendees:
Steve Pukansky (GSFC, NASA-IV&V)
Eric Sylvania (SAIC)
Ed Tadlock (SAIC)

Comments from NASA-IV&V:
IV&V appreciates the opportunity to participate in the GLAST LAT FSW QLR and respectfully submits the following comments. If additional information to support these comments is required, please do not hesitate to contact IV&V.

1) **Flight Software (FSW) Development Process**
Up until the QLR, the FSW development process was presented to IV&V as incremental, that is FU (Flight) Build = EM1 + EM2 + a few additions. During the QLR Erik Andrews (GSFC) stated that EM1 and EM2 were test only builds for hardware/systems checkout and that a Flight Ready Build with formal controls and testing would occur later. This is a significant departure from the prior information. [Q#4]

2) **EM1 Software Release - IV&V Code Analysis**
EM1 supports one Tower Electronics Module (TEM) fully. This software will be "cloned" and used to manage all 16 TEMs in the FSW. Therefore, EM1 software is essential to the success of the LAT. IV&V has attempted, on several occasions, to obtain and evaluate the EM1 Source Code to provide feedback early in the development lifecycle. We have been rebuffed on each attempt. IV&V efforts are a software risk mitigation approach and the analysis will be done without interference in the software development process. However, the analysis cannot be completed without the delivery of the EM1 Source Code. [Q#5]

3) **EPU Filtering Software**
EPU filtering software is currently stated at 98. 4% efficient at filtering out real events from the background data. What is meant by the phrase "99% non-idle CPU to do physics" on Slide 8?What is the estimate of CPU use at the greater than 99% level that is required on orbit?During the QLR, at least three different flight CPU use numbers were discussed. Erik Andrews stated 70-80% of both CPUs would be needed, the current single CPU is 99% utilized, and the CPU estimate charts presented during the review showed 15% across two processors. The expected CPU use for both EPUs in on-orbit conditions should be clearly stated. A minimum reserve of 25% CPU cycles for both EPUs is a common requirement. [Q#6]

4) **IV&V Requirements Analysis Statistics**
IV&V provided an evaluation of the software requirements, interfaces, and testing forGLAST LAT. However, the results of our efforts, as presented on Slide 13 of the Introduction, are

reported incorrectly and are misleading.
In the area of the GLAST LAT software requirements, the IV&V Requirements Analysis Report stated that 65-70 requirements were too few to adequately define what the LAT software would be doing, and in many cases these requirements were a very high level of abstraction. IV&V wrote 29 software requirements related issues and communicated these to the project office during June and July 2003. The status of these issues is as follows:
? Closed - None
? Resolved - 19; "Resolved" means an action plan is agreed to, but the results have not been verified
? Open - 4
? Withdrawn - 6
In the area of the GLAST LAT traceability, here is the status of the 19 reported issues:
? Closed - 4
? Resolved - 11
? Open - 4
In the area of GLAST LAT testing, IV&V did not have any technical concerns on theinformation provided in the LAT Test Plan, however IV&V had numerous concerns related to the LAT test processes which were communicated in an informal manner.

5) **"Build" vs. "Release" Concept & Development Process**
There appears to be some confusion regarding what constitutes a "build" and a "release" as well as what the differences are in the control and testing of the software for each. **Formal control over software using a managed process involving Quality Assurance, Configuration Management and the use of an SCCB is missing (Ref: Slide 27). It is our opinion that the process described in Slide 27 for use in the "development builds (EM1 and EM2)" has the potential for significant requirements creep [R#7D].** In addition, given that the software requirements are written at a very high level, this creep would be difficult to track and to manage.
There also exists the potential for serious differences between the "design to" documents and the "as-built" system, as there appears to be no provision in place to keep the design and the as-built details in sync. The SCCB process does not start until the ISIS is delivered to the Spacecraft developer.

6) **Lack of SQA Function**
There does not appear to be an SQA function within the development organization. The "Independent" Test Team shown on Slide 21 does not appear to be truly "independent" as they report to the SLAC Software Project Manager instead of to the GLAST LAT Program Manager. During the QLR, it was also mentioned that the Independent Test Team members could be asked to write FSW and they were partially included in the Effort estimations on Slide 35. [Q#7]

7) **Requirements in the Interface Control Documents (ICDs)s**
During the QLR it was mentioned on several occasions that a number of the FSW requirements were contained in the ICDs. **The spread of requirements into the ICDs will make the Requirements Management Process difficult. ICDs do not contain clearly defined software requirements, so in order to derive the proper FSW requirements, the developer will have to sift through the information to identify the necessary software functions. FSW**

requirements should be fully and completely identified in the FSW Software Requirements Specification (SRS). [R#1G]

8) **Hardware and Software Development Integration**
Our perspective on the tight integration of hardware and software development is that SLAC believes that they must have hardware to develop software. This approach is contrary to industry best practice where Software is developed from detailed requirements and designs, unit tested, integration tested, and deployed to the hardware for hardware/software integration testing. [Q#8]

9) **Software Productivity Metrics**
The post-CDR **software productivity metrics (LOC/day) are skewed by the fact that the "Real-Time Toolbox" development was minimal. IV&V was told that this software was written for the Balloon Test Flight and moved over with minimal changes. SLAC is not hitting 21 LOC/day even at present. [R#3G]**
The Remaining Effort software productivity numbers (LOC/day) are skewed by the fact that to reach 14 FTEs at least two test team members must be included in the Development Effort (2 from NRL, 9 Current FTEs, 2 * . 25 for I&T members, . 5 FTE = 12 FTEs; missing 2 FTEs). Potentially, the Test Team could be short on manpower and fall behind schedule. If members of the Test Team are utilized, steps will need to be taken to ensure that the Test Team members who work in Flight Software are notallowed to test their own code.

10) **System Testing**
Is the System Testing indicated for February 05 (Slide 7) the formal qualification testing of the software on flight level hardware?If so, does this take 4 months?Or does this include tests other than those involving software? [Q#9]

##
#####**Elaine ShellInputs** ########
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I found the LAT QLR to be a bit frustrating -- in that I felt a combination of respect for the team and honest fright that the LAT FSW will have many delays between now and launch. The discussions seemed familiar while having a unique flavor.

The talent and dedication of the primary FSW team are clear. However, I worry that even the most dedicated heroism will have major problems meeting the launch schedule based on the current plan. Perhaps I'm worn out from recent problematic instrument development efforts.

What I've heard over and over from 582 Sr. staff is that "the more complex the FSW and the tighter the schedule, the more critical it is to follow proven processes with no short-cuts" -- emphasis on the last phrase. Recovery from short-cuts is much more expensive (in time and energy) than taking the time to follow a process in the first place. The obvious LAT short-cuts include:

* Weak requirements development -- this means that the details of what the FSW is intended to do are not reviewable as a readable list of detailed functional and performance capabilities. The

LAT FSW details are likely fully understood by one or two people, and partly understood by a couple more. But the LAT sounds like it requires a FSW system where many more people should be completely aware of the planned FSW functionality. Determining that the FSW isn't quite what was wanted is much more time consuming and disruptive to change after development than while still a 'paper' exercise. Having the reqmts. spread over a variety of documents, suggests to me that there is no consistent overall review possible by systems engineers, operations staff and the science team. The chances are big that the unwritten and un-itterated derived requirements include omissions and little operational maturity in regards to the full set of commands, parameter types and autonomy details. If there is only one area to step back and mature, it's the reqmts.

* FSW builds seem to be defined to meet hardware integration milestones vs to meet increasing levels of FSW functionality. FSW builds are typically defined quite different from the subset of FSW required to exercise and characterize the flight hardware. Usually we define an early FSW build to meet all the flight hardware I/O requirements to checkout the hardware and its interfaces, plus checkout the interfaces to the ground system. The next builds are defined to incrementally add increasing levels capability that can be tested on a FSW testbed in closed loop fashion. The most complex closed-loop FSW gets put into the earliest builds to get the design of those critical capabilities working early. Additional 'bells and whistles' seem to have less disruption to that complex & validated baseline than adding in the complexity in later builds. It seemed that the LAT FSW builds were not defined for FSW test, repeatability and early retiring of risks to the FSW product (vs the LAT hardware product).

* The highly cohesive hardware/software team sounds smart at first glance. But GSFC has fought hard to separate the teams so that both subsystems report equally to upper management, for the following reasons:
- the hardware/software team lead tends to drive the team toward hardware milestones and issues over FSW processes & issues. The effect is that FSW 'takes a backseat' for a major portion of the project, only to appear as a crisis once the hardware focus diminishes.
- the FSW staff becomes staff for meeting the hardware deadlines -- rather than having dedicated staff to meet FSW deadlines. GSFC tends to plan the staff profile to accommodate hardware integraton and test support demands by the FSW team that will not disrupt the very independent FSW team schedule
- the need to comprehensive and highly capable simulations isn't understood or invested in -- since the hardware is 'the best test environment'. But FSW test requires varieties of fidelity, error generation, anomaly situations, etc. that you can't configure the flight hardware to do. You also lose the repeatability of a simulated test environment so that changes to flight code can be confirmed to have not disrupted previously working code. Plus, from a FSW maintenance point of view, the simulations need to be very high fidelity to troubleshoot and resolve on-orbit problems when the hardware isn't available.
. . . .
I'm starting to just do a tutorial.

Recommendations to LAT team:

1- **Dedicate someone to maturing the FSW requirements into a single product that is reviewable and controllable as the driving document of LAT FSW capabilities. It sounds like a waste now, but once done everyone will be thankful. [R#1H]**

2- **Put the reqmts. doc. under CCB control in the near future. It doesn't mean that you can't change requirements. It just means that communications are solid and documented. Informality creates huge risk in regards to FSW maturity. [R#1I]**

3- **Define detailed requirements for each simulator and get the reqmts. reviewed by appropriate subsystem and systems staff. Be very sure that all possible error, anomaly, contingency situations, timing criteria, etc. can be created using the simulated test environments. [R#18]**
4- **Review the practicality of using EM hardware at the s/c. Will the s/c FSW team be able to configure the LAT EM hardware to fail or have an incomplete interface transfer or content, fail a timing event, etc. ?EM hardware is great for interface tests, but not great for functional tests between two CPU. [R#19]**
5- **Define FSW builds [R#8D]**and test the FSW builds independent of hardware schedules on high fidelity hardware and simulation test facilities. **Have FSW build test reviews prior to and after each build to be sure that the testers fully understand what they're testing and that the developers fully understand the problems the testers had testing. [R#4C & R#5D]**
Informing the whole team is more valuable than informing just the team leads or mgmt.
6- **Document FSW test scenarios and walk-through the scenarios before commiting to test procedures. [R#5E]**
7- It seems that going from one detector system to 16 is a huge jump in functionality likely to have more problems than can be expected. I would have suggested designing for 16 detectors and incrementally adding functionality to handle all the capabilities of the 16. Testing can always configure to use only one detector. Are timing characteristics, configurability and reconfigurability being addressed completely for all 16? [Q#10]
8- **The FSW team lead should report to upper mgmt. independent of the hardware group. [R#20]** If you want to keep the group as a single team, at least encourage the FSW lead to report his status and problems without being 'sanitized' by the hardware team in order to avoid creating attention when the hardware team's preferred focus is still on hardware issues.
9- Recognize that a FSW person is likely to be required more and more often during hardware checkout and test. **Does staffing accommodate losing a key person from FSW productivity? If not, hire now [R#21]** so you'll have a skilled person by the time the intense hardware tests are going on.

That's it for now. Have a nice thanksgiving.
Elaine