PHOTON SCIENCE at STANFORD LINEAR ACCELERATOR CENTER

LUSI LCLS Ultrafast Science Instruments

DESIGN REVIEW REPORT	Report No. TR-391-003-09
The Design Review Report Shall include at a minimum: ▪ The title of the item or system; ▪ A description of the item; ▪ Design Review Report Number; ▪ The type of design review; ▪ The date of the review; ▪ The names of the presenters ▪ The names, institutions and department of the reviewers ▪ The names of all the attendees	▪ Findings/List of Action Items – these are items that require formal action and closure in writing for the review to be approved. ▪ Concerns – these are comments that require action by the design/engineering team, but a response is not required to approve the review ▪ Observations – these are general comments and require no response

TYPE OF REVIEW: **Advanced Procurement Technical Review**

WBS: 1.2 X-ray Pump Probe

Title of the Review	XPP Diffractometer and Detector Mover Advanced Procurement Technical Review	
Presented By:	David Fritz, J. Langton	
Report Prepared By:	Tom Rabedeau, SLAC	**Date:** 4 November 2008
Reviewers/Lab :	Dan Harrington/SLAC, Nicholas Kelez/LBL, Thomas Rabedeau/SLAC, Deming Shu/ANL	
Distribution:		
Attachments:	☐Review Slides ☐Design Checklist ☐Calculations ☒Other Robot Quotation	

Purpose/Goal of the Review:

Provide a technical review of the procurement specifications, statements of work and procurement strategy for the XPP Diffractometer and Detector Mover System.

This document presents the report from the reviewers along with the XPP responses. The XPP responses are shown in red.

Attendees:

David Fritz, Tom Fornek, J. Langton

XPP Diffractometer System Advance Procurement Technical Review
Review Date: 11/4/08
Committee: Dan Harrington, Nicholas Kelez, Thomas Rabedeau, Deming Shu
Presenters: Dave Fritz, Jay Langton

Review Charge: DOE-BES mandated review to assess the advance procurement readiness of the XPP diffractometer system including the sample goniometer and detector positioning system.

Summary: Dave Fritz presented XPP project over view followed by a general discussion of performance requirements of the detector positioning system. Jay Langton and Dave Fritz then examined in more detail the detector positioning system engineering specification document sp-391-00-62 r0 and associated statement of work (SOW) documents ps-391-000-86 r0 (robot test) and ps-391-000-95 r0 (robot mount). Following this presentation the sample goniometer engineering specification sp-391-000-57 r1 and associated procurement specification ps-391-001-55 r0 were examined in detail.

Detector Positioning System

Observations:

o Advance procurement prior to CD3 is required in order to meet early science schedule (summer 2010).

o The favored solution for the detector positioning system involves a multi-axis commercial robot system capable of positioning a 20kg load with accuracy and stability of a fraction of the detector 90um pixel size.

The detector mover ESD specifies the accuracy and stability of the detector positioning system at 140 µm and 25 µm per hour respectively. Indeed it is desirable to have the detector mover achieve a fraction of a pixel performance. In fact, this level of performance now seems plausible after analyzing the results of the robotic arm test (TR-391-003-06-0 Staubli RX160 Test). However, this is a design goal but not a strict requirement for the detector positioning system to be functional. This misunderstanding may have triggered many of the subsequent reviewer concerns.

o The detector operating envelope is demanding with both forward and back scattering geometries envisioned for two different sample positions separated by 600mm. The forward scattering detector positioning envelope exceeds $\pi/2$ steradians with 100-1000mm sample to detector distance. The back scattering detector positioning envelope is some what reduced relative to the forward scattering positioning envelope. The positioning requirements include all six degrees of freedom of the detector.

o The detector positioning system is independent of the sample positioning system to minimize detector influence on the sample manipulator sphere of confusion.

o In the presentation the hutch temperature control was reputed to be +/-1.0deg F though this information is not contained in the engineering specification document. The vibration spectrum and longer term stability of the hutch floor, walls, and roof were not presented.

The NEH was not built to any particular temperature or vibration specifications. It is expected that the temperature stability of the hutch will be +/-1.0 deg F. However, the only thing we can do now is measure the as built performance of the NEH hutch 3. Measurements of the thermal and vibrational stability will be made in the field once all of the HVAC systems are running and the hutch doors are installed.

o Testing of a commercial robot as described in SOW ps-391-000-86 r0 is complete and results were presented.

o A second SOW ps-391-000-95 r0 will be issued shortly to examine mounting solutions for the robot employed in the robot testing SOW. Completion of this SOW is anticipated 2/09. The hutch roof is the preferred robot mount location in order to minimize conflicts with other XPP equipment.

Findings:

o The robotic solution to detector positioning offers an extremely adaptable positioning system. This adaptability is essential to accommodate the demanding detector positioning envelope and avoid conflicts with sample positioning and pump laser systems as well as accommodate evolution in detector positioning requirements as the XPP user community expands and matures.

o The demanding detector positioning envelope is appropriate given the diverse character of the XPP science and associated instrumentation requirements.

o Separation of the detector positioning system from the sample manipulation system is warranted to minimize adverse influences of the detector on the sample positioning system.

o The results of the robot testing SOW provide confidence that a commercial robot system can provide the required performance.

o Two detector positioning system procurement strategies are plausible. (a) An integrated solution procurement strategy utilizes a single RFP for the entire system including robot, robot mount, control software, and protection systems. (b) A subsystem procurement strategy involves multiple RFP for the different subsystems of the detector positioning system.

o The primary advantage of the integrated solution is a single vendor assumes responsibility for the entire system, so definition of performance requirements and assessment of vendor product performance is relatively straight forward. The primary concern is no one vendor may have the requisite mix of capabilities. The detector positioning engineering specification document provides a reasonably complete description of the detector positioning requirements subject to some qualification as noted below. As such, with some modification, it could serve as the requirements document for the integrated solution procurement.

o The subsystem procurement strategy may allow a better match of vendor competency to subsystem requirements. A subsystem procurement strategy, however, demands clear definitions of subsystem performance requirements that avoid coupling of performance assessment between the various subsystems. Thus the documentation and specification burden on project staff is much more significant with this procurement strategy as compared to the integrated solution strategy. Additionally, more of the system integration effort falls to the project staff. As presently written the detector positioning engineering specification does not provide an adequate basis document for a subsystem procurement strategy.

The ESD is intended to give overall complete system requirements. This document will be included as part of the procurement package but will not be the only documentation included. The numbers that have come from the robot measurements are consistent with an integrated system since the measurements of the robot motion were good enough to adequately allow for additional tolerance stack-up from the support system. The XPP team can, and will have to, address the precision and tolerance budgets due to the various sources and explicitly allocate numbers to the various subsystems. This will be done when we have a more mature design and obtain measurements of the hutch environment.

o The software requirements, instrumentation and controls requirements, and machine protection and personnel protection system requirements sections of the engineering specification document sp-391-00-62 r0 are insufficiently developed. The review panel would have benefitted from inclusion of a software and controls expert.

The engineering specification document is intended to only state our requirements of the detector mover system. It is not intended to prescribe a solution and in fact it is not assumed in the document that a robot system be used. The software, safety system, and controls specifications will be described in future statements of work.

Nevertheless, the XPP team arranged a meeting (May 15, 2008) with a robotics integration firm and both the SLAC ES&H and LCLS Photon Controls and Data Systems groups. Both groups were satisfied with the many safety system and control options available to them.

o Sole source procurement of a robot was not adequately justified. In particular, the performance differences between the Staubli RX160 robot and the ABB IRB 2400-16 robot are minor (ie., 10um in positioning reproducibility).

There are other issues with regard to specifying the robot than just repeatability (reach, payload, mounting aspect, relative lengths between joints, weight). We chose the robot with the best performance and characteristics for our application to test (Staubli RX160). The test measurements were exceptional and we have now proceeded with the robot reach and basing design study. A robot choice had to be made for this study to be performed. This work would have to be redone for a different robot model and would significantly impact the cost and schedule of the project. We believe this is sufficient justification for a sole source procurement of this size (see attached quotation) and we will follow SLAC purchase procedures accordingly.

o The robot mount SOW does not provide adequate information regarding hutch vibration spectra as well as longer term drift to assess the relative stability of various robot mount locations (eg., floor mount vs. roof mount).

The robot basing SOW is only intended to address the robot work envelope and mounting location options. Once the optimal mounting location is determined, the XPP team will proceed with the preliminary design of the mount. The relative stability of the design will be analyzed at that time but the team is confident that a solution will be designed that meets the system requirements.

o Real time correction of detector position drift using optical tooling for detector position monitoring is difficult owing to the demanding detector positioning envelope and interrupted lines of sight associated with the XPP experimental equipment. Consequently such correction while conceptually plausible may prove practically infeasible. Certainly a very large contingency should be reserved for such a scheme if real time correction is a likely outcome of the procurement.

At this time we do not anticipate the need for real time correction. However, we have included this in the LUSI risk registry.

Recommendations:

o Prior to issuing detector positioning system RFP(s), hutch environmental effects on detector stability need to be analyzed in particular as applies to a roof mounted solution.

The XPP team agrees and these measurements will be performed as soon as possible.

o If an integrated system procurement strategy is employed, then the engineering specification document should be embellished to define unambiguous software requirements, instrumentation and controls requirements, and machine and personnel protection requirements. Additionally, relevant environmental information such as hutch floor, wall, and roof vibration spectra and longer term stability as well as hutch temperature control should be provided.

The ESD is only intended to address the overall technical requirements, not the specifics of procurement or subsystem design. The topics raised by the reviewers will be addressed in the subsequent procurement document(s) or additional ESD's for the robot subsystems.

o If a subsystem procurement strategy is utilized, then the specification documentation requires substantial modification and re-review prior to release for procurement. Complete and self contained specifications must be developed for each subsystem of the detector positioning system prior to the procurement of any individual subsystem. The position tolerance budget established in detector positioning system engineering specification document sp-391-00-62 r0 must be apportioned amongst the subsystems. Performance requirements and delivery acceptance criteria for each subsystem must permit unambiguous assessment of subsystem performance despite potential performance coupling to other detector positioner subsystems. The revised documentation should address the software, instrumentation and control, machine and personnel protection issues noted above as well as the hutch environmental parameters. Re-review of the system specification should be accompanied by a proof of principle solution to the detector positioning system requirements which utilizes the results of the two robot SOW currently in process or complete.

Again, the detector mover ESD is not intended to be the only document describing the overall system. Additional documentation will be written to complete the various subsystem procurements when appropriate. At a minimum, the XPP team will author engineering specification documents for the support structure (which would address the hutch dynamics and tolerance budget issues as engineering design inputs for analysis) and for the software (that would address safety system and controls requirements, etc).

The review committee recognized that the results of the robot testing SOW provides confidence that a commercial robot system can provide the required performance and indeed there is little risk associated with the robot. The next task is to design a base for the robot. The robot basing SOW will determine the best location to mount the robot. At that point, the team will design a base that will satisfy XPP requirements. We strongly believe that we have the engineering expertise to accomplish this task and like all LUSI components this effort will be formally evaluated by critical reviewers via the LCLS design review process. Once the base is designed, the last remaining task is to integrate the robot control and safety system into the XPP instrument control and safety systems. This activity is not a particularly challenging task and was determined to be relatively straightforward at the May meeting between the robotics integrator and the ES&H and controls groups.

The XPP team strongly believes that the subsystem strategy described in the previous paragraph is the approach that effectively reduces the risks associated with the detector mover system and does not simply re-allocate the risks. We are confident in our capabilities and accept the responsibility of successfully interfacing all subsystems to each other to ensure that we have a working system at the initial operations of the XPP instrument. In addition, it is highly beneficial to the XPP instrument and LCLS facility to develop the in-house expertise for controlling the robot and implementing a safety system.

Sample Goniometer System

Observations:

o Advance procurement prior to CD3 is required in order to meet early science schedule (summer 2010).

o Two systems are envisioned which share some common elements. One system ("sample translation platform") is specified for large (100kg) loads with arc segments whereas a kappa system is specified for lighter (1kg) loads with more complete rotations. Removal of x-y-z translation stages from the large load system provides the platform for the kappa mount of the lighter load system.

o The two systems are defined to permit stacking of stock catalogue translation and rotation stages.

o The goniometer support base will be designed at SLAC.

o The performance specification for each stage is provided in isolation from the perturbing influences other stages.

The ESD was written with the intent that the stated motion specifications are applicable for a complete assembled goniometer system, measured with respect to the sample (IE: goniometer center of rotation). The vendor that quoted our system (Huber) understood this point, but we will clarify the ESD to specifically state our assumptions.

o For many of the degrees of freedom reproducibility and resolution requirements are identical.

The XPP team recognizes that in practice the reproducibility of a motion is typically larger than the resolution of the stage. However, we just stated our requirements in the document. This does not preclude a vendor from designing a system with a reproducibility that is larger than the resolution.

o Limit switch and hard stop requirements are not specified.

Limit switches and hard stops will be added to the specification.

o No hutch environmental information is provided.

We anticipate the thermal stability of the hutch to be +/-1.0 deg F. This will be verified as soon as possible. The XPP team is responsible for improving the thermal performance of the hutch if +/-1.0 deg F is not reached. The XPP team believes that it is our responsibility to create a laboratory environment in the hutch (temperature, vibration) suitable for the experiments. We cannot expect the sample goniometer system to perform with the desired level of stability unless we do so.

o Goniometer acceptance testing is performed with the goniometer mounted to the SLAC provided support base.

This will be changed, per the committee's recommendation, and the bottom of the lowest vendor procured items will be the test datum.

o A detailed RFP evaluation matrix was presented.

Findings:

o Two goniometer systems sharing many common elements yet servicing very different experimental needs appears to be a cost effective solution to the diverse experimental requirements of the XPP goinometer system.

o Utilization of stock stages is a cost effective approach.

o Specification of the performance of each stage in isolation does not properly account the errors introduced by coupling multiple stages. A more robust specification would tolerance the degrees of freedom at the sample interaction point for each of the two complete goniometer system configurations.

See comment above.

o Acceptance testing of the goniometer when mounted to the SLAC provided mounting base couples vendor hardware performance with SLAC hardware performance. This may result in ambiguous acceptance test data.

See comment above.

o The RFP evaluation matrix appropriately weights the various vendor selection criteria.

Recommendations:

o Specify the performance of each degree of freedom at sample interaction point for each of the two complete goniometer system configurations in the absence of the SLAC mounting base.

The ESD is organized in a manner to prevent different or duplicate specifications for the same hardware. As stated above, a section that specifically states that the performance criteria apply to completed goniometer assemblies (either configuration) and the measurement datum is at the sample goniometer center of rotation will be included in the ESD.

o Add hutch environmental information to the engineering specification document. Add limit switch and hard stop requirements as applicable to the engineering specification document.

Limit switch and hard stop information will be added. Environmental information will be included when we perform the measurements. Nonetheless, a +/-1.0 deg F hutch stability is what will be communicated to the vendors.

o Specify the SLAC mounting base requirements with appropriate consideration for the aggregate base plus goniometer system stability at the sample interaction point for each degree of freedom.

The contribution of the mounting base to the overall performance of the goniometer is only via deflections of the mounting base due to rotations of unbalanced loads about the goniometer center. These deflections are manifested as motion of the location of the goniometer center of rotation during the from one rotation angle to a different rotation angle. If the load / goniometer is balanced there is no motion. Using the loading criteria of section 7.3 of the ESD these deflections are predicted to be <<1 micron. Angular precision and repeatability due to these deflections are a function of the level arm over the height of the goniometer and the values are negligible.

o Perform acceptance testing of each degree of freedom at sample interaction point for each of the two complete goniometer system configurations in the absence of the SLAC mounting base.

We will incorporate this into our plan.

Arnett, Donald W.

From: Rabedeau, Thomas
Sent: Thursday, December 11, 2008 1:27 PM
To: Fornek, Thomas E.
Cc: Rabedeau, Thomas
Subject: RE: Review Responses

Tom,

I have the following observations with respect to the XPP Advance Procurement Design Review Report (ref. TR-391-003-09). Please let me know if you have any questions. Thanks

Tom

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Robot Detector Manipulator:

(1) It is essential that measurements of the NEH environmental stability include not only temperature and vibration but diurnal motion. This is particularly important if a roof mount is employed for the robot detector manipulator. Specifically, laser tracking of targets affixed to the NEH roof should be conducted over at least a 48 hour period. While such measurements would not provide an absolute motion characterization, they would provide essential information regarding the roof motion with respect to the foundation of the sample goniometer and beam conditioning hardware. Ideally such measurements would also be conducted during a period of unsettled weather to ascertain the effect of ground water absorption on the NEH wall hence roof stability.

(2) Responses to the review report indicate that the documentation was not intended to provide a complete and detailed procurement ready specification. Accepting this at face value, I encourage detailed technical review of the specification prior to RFP release. I believe such a review will encourage the careful consideration of the system requirements and bring greater clarity to the system specification. The advance procurement review would have benefitted had these documents been complete and available at the time of the review.

(3) I agree without any reservation that design of the robot mount is well within the capabilities of the XPP engineering staff.

Goniometer:

(1) I believe the clarity of the goniometer specification would be enhanced if the specification provided a tabulated summary of the performance requirements of each degree of freedom for each of the two gonimeter configurations. It is inevitable that this will result in some repetition of specifications as the two different configurations share some degrees of freedom. Nonetheless the benefit in clarity is worth the redundancy. Such a table will facilitate more direct comparison of performance specification of the two goniometer configurations to QC results per the last bullet in the review report.

-----Original Message-----
From: Fornek, Thomas E.
Sent: Monday, December 08, 2008 2:59 PM
To: Rabedeau, Thomas
Cc: Fritz, David M.; Langton, J. Brian; Joma, Hannibal
Subject: FW: Review Responses

Tom,

I am forwarding LUSI's responses to the XPP Procurement review. Please let me know by December 15, if you have any concerns.

The LUSI project needs to move forward by January with the procurement of the goniometer system and we will be incorporating the changes to the ESD over the next two weeks. I am hoping that our responses to your concerns on the goniometer are sufficient to allow this to occur.

The detector positioner is less time-critical. We are part way through a siting study for the robot arm. This study is scheduled for completion in January. That said, I would still like to include a request for DOE approval for the robot advance procurement along with the request for approval of the XPP Goniometer advance procurement. These XPP approvals could then be processed along with advance procurement approval of CXI procurements. If you feel that we should have a follow-on e-mail review of the outcome of the siting study for the robot arm, we could make that a condition of the robot arm procurement final approval.

Thanks,
Tom F.

-----Original Message-----
From: Fritz, David M.
Sent: Monday, December 08, 2008 11:28 AM
To: Fornek, Thomas E.
Subject: RE: Review Responses

Tom,

Here’s the next version, including J's section. Let me know if you want any additional changes. Also, I wanted to attach the robot quotation since I reference it in the response. I've modified the cover sheet accordingly.

David

-----Original Message-----
From: Fornek, Thomas E.
Sent: Monday, December 08, 2008 10:37 AM
To: Fritz, David M.
Subject: Review Responses

David,

Attached is the draft form.

Tom F.