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Date:	3 June 2008
Refer to:	L080058-00-F
Subject:	Review committee report on FMP building modifications and cleanroom
To:	David Shoemaker, Carol Wilkinson
From:	Zucker, Coyne, King, Mason, McCarthy, Romie, O'Reilly
cc:	Worden, Sibley, Lubinski, Bland, Giaime, Raab, Wooley

## Response to the review committee's report

The report recommendation to proceed with RFQs for specific elements of the FMP plan as presented is accepted. For those in the FMP current scope, procurement activity should proceed at full speed.

A CCB is required for the increased volume of in-house, in-vacuum, parts cleaning, and elimination of some obsolete scope; that CCB should be pursued immediately. However, the CCB for roll-up doors and associated work should be deferred until a later time.

FMP should respond to the recommendations in the report. Systems, and other impacted subsystems, should consider the relevant recommendations.

The financial analysis in this report has been superseded, leading to a smaller deviation from the cost book, making the approach and impact acceptable.

David Shoemaker  
14 June 2008

## **Scope of review**

On 5/28 we reviewed FMP plans for physical modifications to lab facilities at LHO and LLO, and for portable softwall cleanrooms to be installed in those locations. These items are under schedule pressure to insure readiness for impending SEI and SUS hardware deliveries, and to minimize construction interference during the planned S6 science run. Other FMP components (including inventory control software, vacuum equipment modifications, and installation support equipment) are on less aggressive schedules, and were NOT reviewed at this time.

## Documents

We discussed the overall program of modifications by site/building, described in C080058-00<sup>1</sup>. Proposed building layouts for the LHO and LLO staging buildings<sup>2,3</sup>, LHO and LLO warehouses<sup>4,5</sup>, the LHO vertex MER<sup>6</sup>, and the LLO LVEA<sup>7</sup> were consulted as necessary.

The LHO staging building floor plan also incorporates the improved/simplified softwall cleanroom concept<sup>8</sup> developed by Mason, Worden, and Zucker. This drawing thus also served as the basis for reviewing the cleanroom design.

Finally a cost spreadsheet was presented incorporating preliminary quotes and engineering estimates for the proposed work, organized to correspond with C080058. The spreadsheet was being actively updated with new information as of the meeting time, but gave a sense of how estimates for the proposed scope compared to the AdL baseline budget for each cost element.

## Summary result

The Committee found the proposed facility modifications to be comprehensive, well conceived and properly attuned to the needs of site-based AdL system fabrication and assembly tasks. We particularly commend measures incorporated for flexibility and reserve capacity in the arrangements, to support adaptation as workflow or schedule contingencies unfold. At the same time, we note that detailed consideration of requirements has permitted descoping or deletion of some elements foreseen at the prior concept stage, thereby keeping overall costs under control.

Preliminary cost estimates, as updated after the review meeting, exceed escalated baseline budgets at the ~ 20% level (whereas the AdL cost book assigns about 14% average contingency). However, given the maturity of the requirements basis presented, and the evident attention to economy in the subject proposal, reconsideration of the scope is not recommended at this time.

We recommend proceeding to issue commercial Requests for Proposal/Quotation on each element reviewed, either as reviewed, or with minor modifications detailed below.

## Comments and recommendations directed to FMP

- C080058 indicated a mixture of sealed concrete (e.g., existing floor in the LLO staging high bay), vinyl composition tile, and seamless vinyl flooring. While more costly, experience indicates it is significantly easier to maintain cleanliness with seamless over the facility life. *The Committee strongly recommends considering installation of seamless vinyl in all clean assembly workspaces.*
- *HVAC refit specifications should explicitly require internal overpressurization of clean workspaces.*

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1 [http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility\\_Modifications\\_and\\_Preparations?action=AttachFile&do=get&target=AdL\\_FMP\\_ZUCKER\\_C080058-00-F.doc](http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility_Modifications_and_Preparations?action=AttachFile&do=get&target=AdL_FMP_ZUCKER_C080058-00-F.doc)

2 [http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility\\_Modifications\\_and\\_Preparations?action=AttachFile&do=get&target=LHO\\_Staging\\_Bldg\\_v1.pdf](http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility_Modifications_and_Preparations?action=AttachFile&do=get&target=LHO_Staging_Bldg_v1.pdf)

3 [http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility\\_Modifications\\_and\\_Preparations?action=AttachFile&do=get&target=LLO\\_Stage\\_AssemblyBldg.pdf](http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility_Modifications_and_Preparations?action=AttachFile&do=get&target=LLO_Stage_AssemblyBldg.pdf)

4 [http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility\\_Modifications\\_and\\_Preparations?action=AttachFile&do=get&target=LHO\\_Warehouse\\_D080245-C.pdf](http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility_Modifications_and_Preparations?action=AttachFile&do=get&target=LHO_Warehouse_D080245-C.pdf)

5 [http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility\\_Modifications\\_and\\_Preparations?action=AttachFile&do=get&target=LLO\\_Warehouse.pdf](http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility_Modifications_and_Preparations?action=AttachFile&do=get&target=LLO_Warehouse.pdf)

6 [http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility\\_Modifications\\_and\\_Preparations?action=AttachFile&do=get&target=LHO\\_MechanicalRM\\_HEPI.pdf](http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility_Modifications_and_Preparations?action=AttachFile&do=get&target=LHO_MechanicalRM_HEPI.pdf)

7 [http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility\\_Modifications\\_and\\_Preparations?action=AttachFile&do=get&target=LLO\\_LVEA\\_StoragePlan.pdf](http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility_Modifications_and_Preparations?action=AttachFile&do=get&target=LLO_LVEA_StoragePlan.pdf)

<sup>8</sup> [http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility\\_Modifications\\_and\\_Preparations?action=AttachFile&do=get&target=cleanroom\\_notes\\_22May08.pdf](http://hocds.ligo-wa.caltech.edu:8000/advlgo/Facility_Modifications_and_Preparations?action=AttachFile&do=get&target=cleanroom_notes_22May08.pdf)

- HVAC humidity and temperature requirements were not specified. The committee understood the primary drivers to be worker comfort, electronics operation and preventing mildew and corrosion (particularly of cleaned maraging alloys). As a result, typical office or laboratory requirements, about  $\pm 2^\circ$  F and 40% relative humidity, appear appropriate. *FMP should verify this with SEI, SUS, AOS, PSL etc. and incorporate the resolution in bid specifications.*
- The proposed “back door” and paved exterior access ramp into the Livingston LVEA inside corner offers a useful contingency for clean storage, staging and installation access with comparatively modest investment. Although LVEA storage floorspace is more limited at LHO, staging and installation logistics are even more difficult. *The Committee recommends Hanford also consider adding a rollup door and approach ramp to the back side of the LVEA.*
- Articulated exterior rollup doors, such as the proposed LVEA back door and the Hanford warehouse equipment entrance(s), are typically difficult to seal against dust. *Since these do not have an internal vestibule/airlock like other large equipment access points, we recommend backing them up with an interior rollup curtain or equivalent sealed barrier. An example is the fabric rolling curtain installed in the LASTI high bay at MIT.*
- LLO warehouse layouts show detailed storage for SUS components in process, insuring adequate stay-clears and reserved space. *Storage for quad and triple assemblies should also be shown on the LHO arrangement plans to insure these zones are not oversubscribed in the future.*
- The LHO warehouse arrangement plan showed three more HAM ISI assemblies in storage than will be required. In addition, LLO is currently expected to build some of the LHO HAM ISI assemblies, so the final “storage” requirement is unlikely to be a full site complement. *The LHO layout should be updated to relieve unnecessary congestion.*
- The LHO staging building mezzanine lab layout inadvertently shows a single access door; *this should be updated to show a double-width entry for rolling equipment.*
- *Electronics bays for alignment and test of SEI and SUS assemblies should be depicted in the LHO staging high bay as shown for LLO.*
- *Layouts should explicitly show required stay-clears around electrical panels (or indicate that they will be relocated).*
- The LHO warehouse will require new electrical service as existing transformers were not intended for the new HVAC and equipment loads. *Include transformer upgrade in the written scope of work and in cost estimate.*

### **Related comments directed to AdL Systems and end users**

- Clean lab space adequate for adding 1-3 nominal 24” vacuum bake ovens has been provided in the refurbished warehouse arrangements at each site. However, detailed cleaning schedules are not yet firm enough to say how many will actually be required at peak production.
- The committee generally endorses provision of redundant vacuum prep capacity at each site, given substantial delays, shipping faults and logistic consequences experienced in iL and ELI tasks.
- Facility plans implicitly depend on an aqueous detergent cleaning process being adopted for Class A processing of small parts (as currently accepted for large parts), and furthermore that this process be compatible with commercial batch washing machines. An aggressive program is urgently needed to develop and validate such a process to meet LIGO SYS standards.
- Presuming automated washing is feasible, the wash cycle time will be short enough that one or two machines will easily keep up with the vacuum ovens. The washing machine spaces laid out in the LLO and LHO warehouses are therefore adequate.
- If the selected wash process requires DI water or other special facility infrastructure, this need should be communicated to FMP planners ASAP. Tankage space has been tentatively identified at both sites.
- More detailed planning is needed regarding how and where large SEI components will be machined and cleaned. Difficulty and costs of shipping should be balanced against feasibility of undertaking operations in house. The current baseline, found to be the only feasible path for ELI, has all large parts cleaned at a single California vendor and shipped to the observatory site in a clean state for air bakeout.
- AOS asserted minimal demands on site vacuum prep and bakeout, indicating its needs can be met at CIT with shipping of clean subassemblies “just in time” for integration. This scenario needs to be reviewed to insure it is robust and justified.
- To help define storage height requirements, it should be clarified whether SUS plans to store upper and lower quad sections assembled or apart.

- FMP should be aware that LHO will require laser enclosures comparable to the one currently installed at LLO; and that the one at LLO will need to be modified or demolished and rebuilt to accommodate the revised HAM arrangement. This change cannot be undertaken until the respective interferometers are decommissioned.
- FMP should be aware that H1 and H2 electronics racks will be relocated to the OSB clean storage area, which may require installation of a mezzanine. It is not immediately apparent to the Committee if or where budget for this task has been incorporated in the baseline.

## ***Top level budget comparison***

As of 6/3/08<sup>9</sup> the cost estimate for the scope described came to M\$2.01, vs. escalated AdL budget of M\$1.66 (M\$1.90 with assigned contingency).

Considerable savings, about \$380k, were achieved by simplifying the design of the assembly cleanrooms. Also required renovations to the LLO staging building were less extensive than originally budgeted.

However these reductions are more than offset by the requirement to retrofit both site warehouses as clean process and storage facilities. This is driven bottom-up by the volume of SEI and SUS assembly tasks currently envisioned (now informed by R&D and ELI assembly experience with each type of hardware). At LLO, refitting of the warehouse also triggers substantial exterior paving to gain viable forklift access.

Other requirements unforeseen in the cost book include:

- an air bake oven for LHO, due to vulnerability of large Class A assemblies in shipment and overall production pipeline capacity
- SEI weights require added expense for appropriate material-handling equipment
- a new laser laboratory is to be partitioned inside the LLO staging building, to accommodate the SUS fiber pulling and welding operations (insufficient space exists elsewhere)
- redundant vacuum bake capacity, to maintain production given realistic equipment downtime
- dual SEI assembly stations, plus separate staging cleanroom, to achieve required production at each site without serializing assembly and test phases for each build
- SEI laminar-flow “pod factory” at LLO to process and test vacuum sensor pods for both sites
- dedicated cleanroom spaces at each site for SUS assembly (as SEI stations are fully and continuously occupied)

The phasing for SEI builds assumed production rate of 0.75 HAM ISI or 0.5 BSC ISI per month averaged over the full production. This just meets schedule requirements, given no supply or processing delays (adding to pressure on vacuum prep infrastructure). Given LASTI and ELI experience, this schedule is characterized as “success-oriented” by members of the SEI team. It therefore appears that compromising the above additions could severely impair AdL installation readiness, in particular for SEI and (by consequen

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<sup>9</sup> 6/3/08 emailed spreadsheet by John Worden, incorporating recent budgetary estimates from LHO and LLO architects