



LIGO Laboratory / LIGO Scientific Collaboration

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Advanced LIGO

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Facility Modifications and Preparations
Conceptual Design

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Distribution of this document:
LIGO Science Collaboration

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of the LIGO Project.

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1 Scope

The FMP (Facilities Modifications and Preparations) task includes the following scope:

- provide clean workspace and parts storage for ADL subsystem assembly,
- procure cleanrooms for assembly and installation,
- provide additional bake facilities,
- procure assemble and install fixtures,
- modify vacuum systems

2 Site Layouts

2.1 Hanford Facilities

Much of the SEI and SUS assembly work will take place in the Staging building.

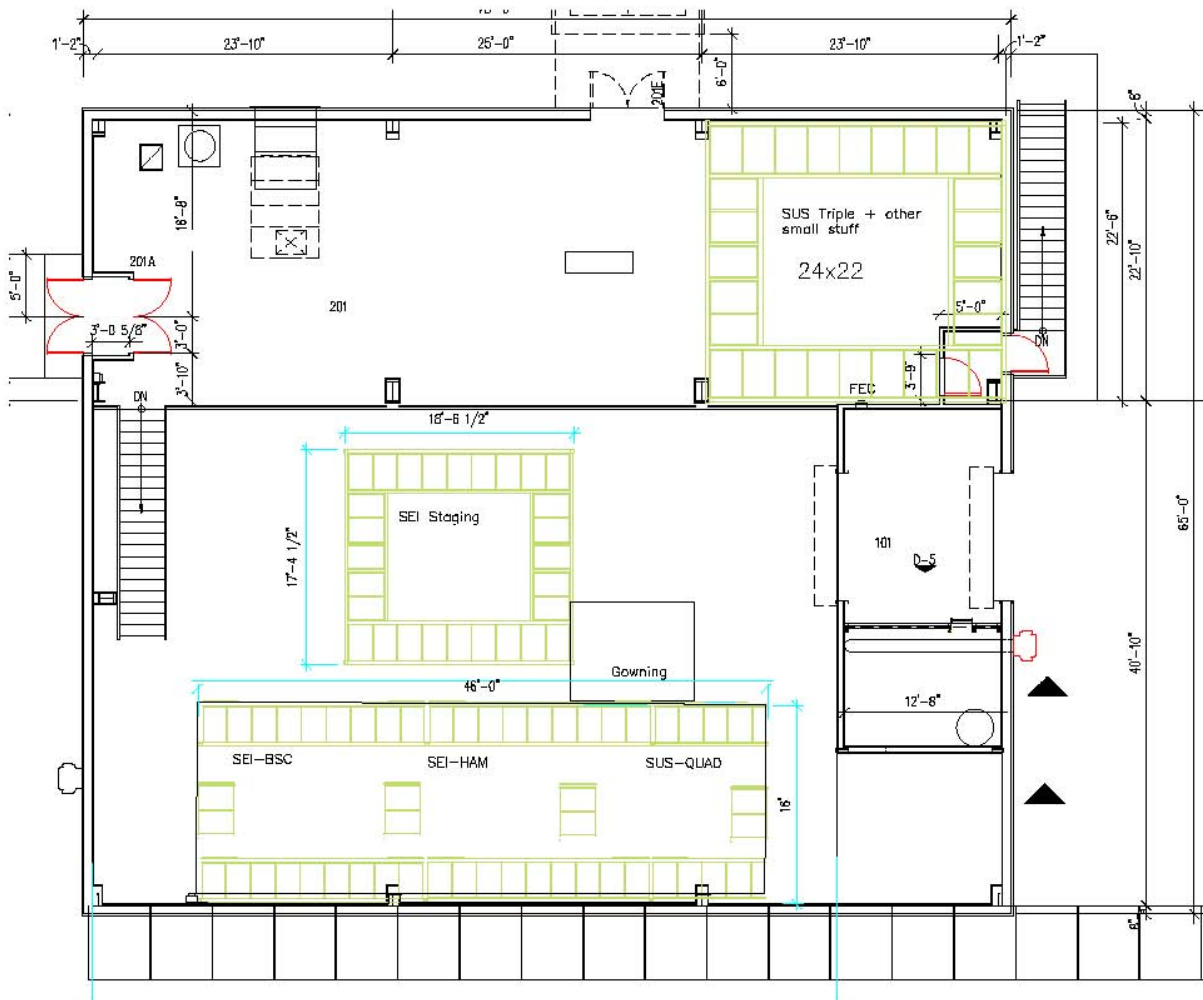
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2.1.1 Hanford Staging Building

The layout shown contains cleanroom space allocated for both SEI and SUS assembly. The lower high bay has 5 ton crane access. The cleanrooms will be similar to our existing portable cleanrooms used in the LVEAs. There will be 2 lab spaces – a lower lab and a mezzanine lab in the staging building.

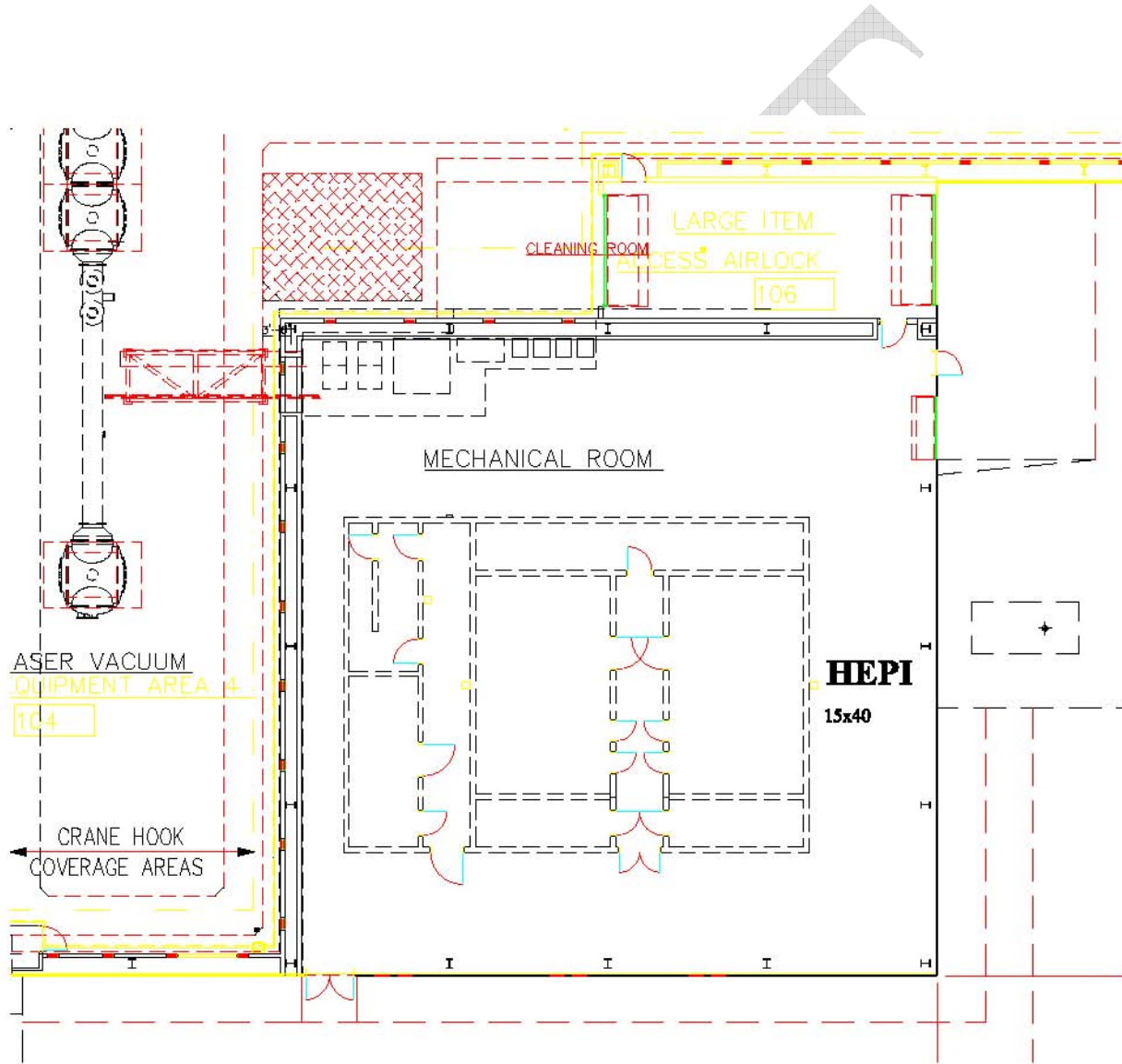
Some modifications to the staging building are planned to improve the cleanliness of the building:

- Hepa filtration will be installed in the building HVAC.
- One exit door will be outfitted with an airlock to help control building pressurization.
- Flooring will be replaced or improved and a thorough cleaning of the interior will be performed prior to installation of the new cleanrooms.

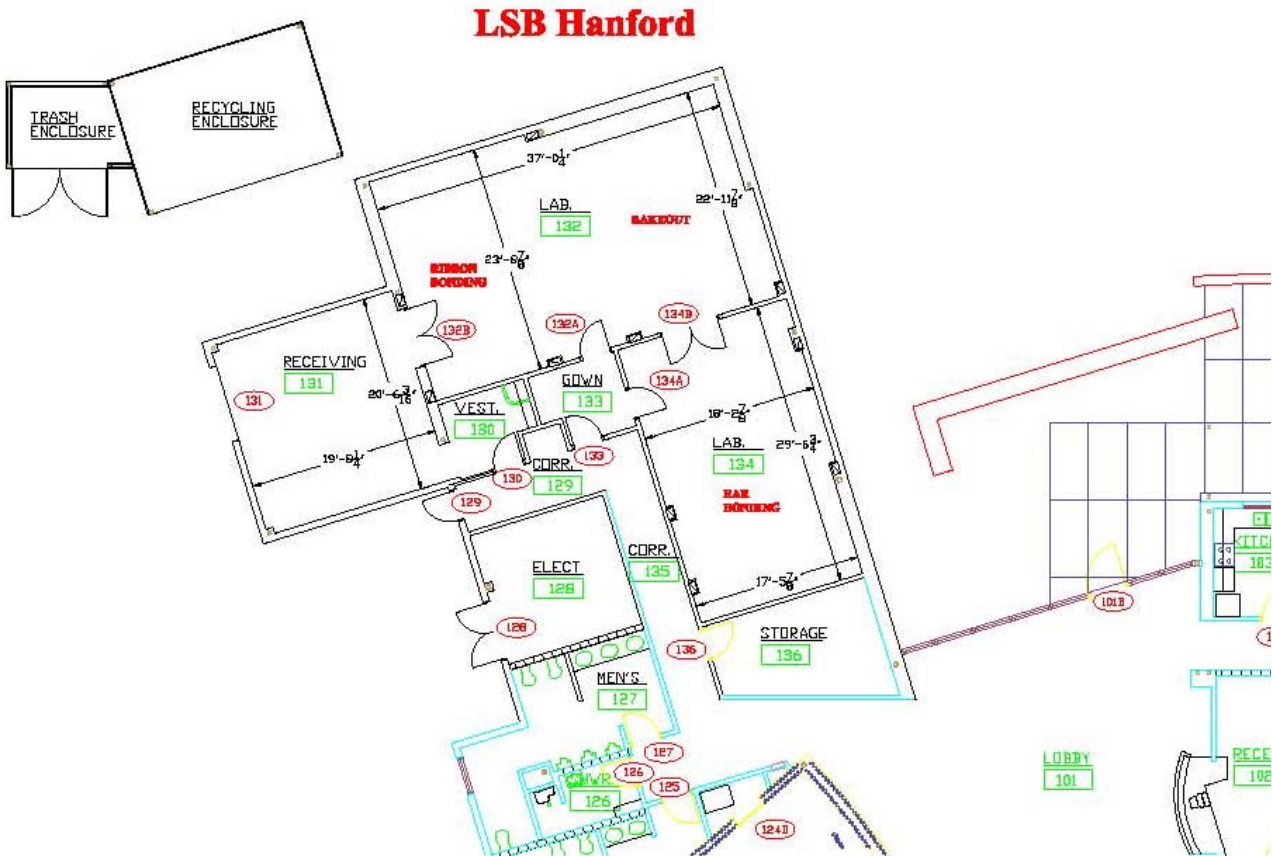


2.1.2 Hanford Mechanical Room

The HEPI system will be installed at Hanford as was done at Livingston. This system does not require cleanroom space for assembly and a possible location for this work is the mechanical room. Bench space and a gantry crane or engine hoist will be required.



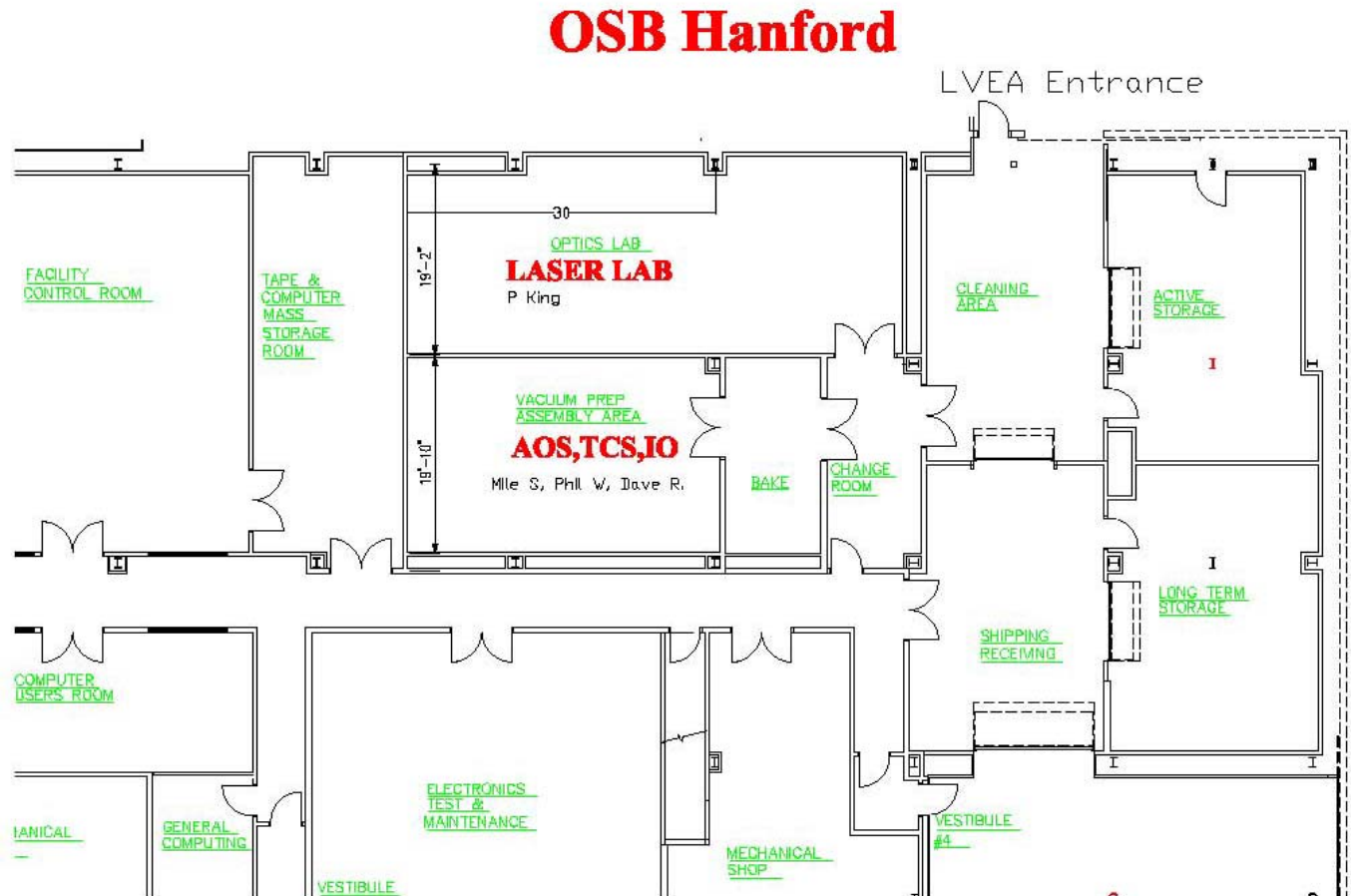
2.1.3 Hanford LSB Lab Space



The lab space in this building is currently earmarked for the following activities:

- Receipt and inventory of all adLIGO hardware.
- Cleaning and baking of the adLIGO hardware (SUS, SEI, AOS, etc) which has not been done elsewhere already. It would be best if the parts handling was kept to a minimum. This would require the existing vacuum bake oven from the OSB be moved to this building for processing parts. Currently, there are also thoughts of procuring an airbake oven for this lab space to handle processing of large parts (airbake inner dimensions of around 8x4x8 feet, duplicate of the one currently at the 40m lab at CIT).
- Ear Bonding of optics and Fiber pulling of ribbons for suspension assemblies. These 2 tasks will be performed in the same lab room hopefully in series. If these tasks overlap in time, the lab space is large enough to accommodate both activities. This room is already equip for laser safety if either task needs to use lasers (fiber welding requires a CO2 laser, but this activity will probably take place at installation in the LVEA).

2.1.4 Hanford OSB Lab Space



The lab space in this building is designated for the preparation of non in-vacuum IFO components. These activities include:

- PSL
- AOS – optical levers, photon calibrators, TCS
- IO – PSL table layout components

Assembly which involves handling of Class A UHV optics should probably be done in the Staging Building SUS assembly cleanrooms. This includes AOS BS pickoff assemblies, baffles, etc.

Possibly, some parts processing could be done in this building if parts arrive before the AOS, TCS, PSL, IO teams begin to occupy the space. Many of the tasks designated for this space are likely to be scheduled in series.

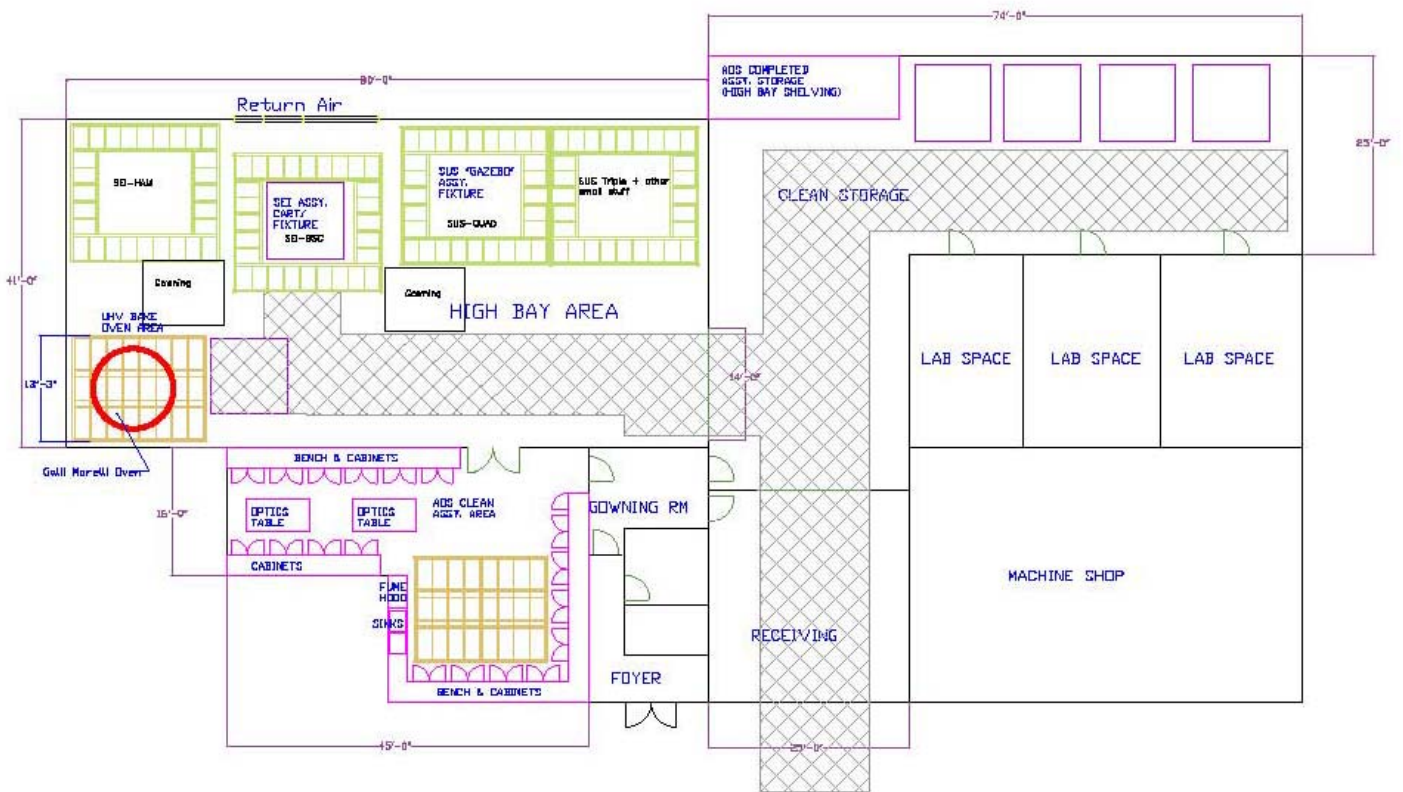
2.1.5 Hanford Warehouse

The warehouse is not shown but the intent is to convert ~2000 square feet of this building to temperature controlled semi-clean storage for completed SEI assemblies. Existing iLIGO parts and equipment will be moved to offsite storage if necessary or disposed of via GSA surplus. Additional storage space is available in the LVEA and VEAs.

2.2 Livingston Facilities

2.2.1 Livingston Staging Building

The proposed layout for cleanroom activities in the LLO staging building is shown below. Completed SEI components may need to be stored in the LVEA or VEAs. The High Bay has a 5 ton crane available. Building HVAC modifications or improvements are TBD.



LLO STAGING BUILDING



LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

3 Preparation Requirements

3.1 **Matrices** (Duty Cycle is currently a guess only designated to show how tasks will need to share the space in series or parallel.)

SUB SYSTEM	Contact	TASK	LHO SPACE	LLO SPACE	UTILITIES	HANDLING EQUIPMENT	PERIOD NEEDED	DUTY CYCLE
SEI	Ken Mason	BSC	Staging Build Lower Lab			Crane, Forklift		100%
		HAM	Staging Build Lower Lab			Crane, Forklift		100%
		HEPI	Mechanical Room			Gantry Crane		100%
SUS	Janeen Romie	QUAD	Staging Build Lower Lab		DI Water			100%
		Triple	Staging Build Mezz Lab		DI Water			20%
COC	Garilynn Billingsley	Cleaning Ear bonding Fiber pulling	LSB Labs		DI Water			
PSL	Peter King		OSB Labs		208vac			25%
AOS	Mike Smith	Viewports OptLevers PhotonCals	OSB Labs		Laser Hazard Zone			25%
	Phil Willems	TCS	OSB Labs		Laser Hazard Zone			25%
	Mike	Baffle	Staging Build					20%

	Smith		Mezz Lab				
	Mike Smith	PO Assys	Staging Build Mezz Lab				20%
		Output MMT	Staging Build Mezz Lab		Laser Hazard Zone		20%
ISC	Peter Fritschel						
IOO	David Reitze	PSL Table Components	OSB Labs		Laser Hazard Zone		25%
	David Reitze	In-vac Components	Staging Build Mezz Lab				20%
PEM	Mark Lubinski						
DAQ	Dave Barker						
Vacuum Prep	Kyle Ryan	Clean Bake	LSB Labs		DI Water Airbake Oven OSA vent Vacuum Oven Dishwasher Drain		
Storage			Warehouse				



3.2 Relevant Documentation

A fair amount of documentation must be in place before assembly work begins in the labs. Such documentation includes:

(Items with a √ indicate document has been written.)

Laser Specifications and SOPS in the Lab

- CO2 Laser SOP for fiber welding
- Fiber Welding Procedure

Equipment Safety Procedures and Specifications in the Lab

- Fork Lift Safety
- Ergo Arm User Manual
- Autocollimator/theodolite User Manual

CDS Support in the Lab

- √ LIGO-T060242 Sections on [LabView](#) cards, computer and controller software

Handling Specifications

- √ LIGO-E960022 LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures
- √ LIGO-T060132 Overview of Tooling

Assembly Procedures

- √ LIGO-T050213 ETM/ITM Monolithic Stage Fabrication and Assembly
 - √ LIGO-T060040 Advanced LIGO ETM Noise Prototype Assembly Procedure
 - √ LIGO-T060039 Caltech Controls Method/Prototype 3&1 Assembly Technique
- Quad Lab Test Specification – violin mode baselines, etc.

Drawings

- √ LIGO-D040401 ETM Quad Assembly (for example)
- √ LIGO-D020700 MC Overall Assembly

Non-QUAD Documents:

- √ LIGO-D030518 Ad. LIGO Mode Cleaner Triple Pend Susp Assy Specification
- AOS PO Mirror Double Suspension Assembly and Installation Procedures - MSmith
- AOS Telescope Suspension Assembly and Installation Procedures - MSmith
- AOS ETM Telescope Double Suspension Assembly and Installation Procedures - MSmith
- AOS ETM Stepper Motor Assembly and Installation Procedures - MSmith

Installation Documents:

- Counterweight Payload Layout diagrams

New Traveler System – WIKI, or other online form

3.3 Lab Support Fixtures

Items which will need to be stocked and or built in the Lab Spaces at the sites in order to facilitate SUS/SEI/AOS assembly work are listed below. In iLIGO, these items/systems were procured via on-site accounts (meaning, they were not brought to the sites as part of the sub-system assembly tooling).

iLIGO assembly fixtures which will need rework modifications in order to adapt to AOS use:

- LOS suspension Assembly Fixtures mods
 - Magnet Gluing Fixtures
 - Guide Rod Gluing Fixtures
- SOS suspension Assembly Fixtures mods

Fixtures which have yet to be documented:

- Triple suspension Assembly Fixtures
- QUAD suspension Assembly Fixtures
 - Gaussmeter large magnet holder
 - ...
- Fabrication of tooling and fixtures as needed (Beam Height Targets)
- Indoor Transport Carts w/shocks for Non-Quad Suspension Hardware
- Indoor Transport Carts w/shocks for Quad Suspension Hardware - Qty 2
- Outdoor Transport Carts/Cases for between buildings

Lab Storage and Workbenches

- Large Shelving Units - Qty 6 (Metro 5 shelf 24"x120", for example)
- Cabinets - Staging
- Laminar flows - Qty 5 (2 Non-Quad SUS Staging, 1 Quad SUS Staging, 1 Fiber LSB, 1 Ears LSB) (Ears already has 1 flow, no bench - will add breadboard)
- Workbenches
 - 1 Non-Quad SUS Staging laminate top
 - 1 Non-Quad SUS Staging breadboard top
 - 1 Quad SUS Staging laminate top
 - 1 Quad SUS Staging breadboard top
 - 1 SEI Staging laminate top
 - 1 Fiber LSB laminate top
 - 1 Ear LSB breadboard top

Other Lab necessities

- 1 Ear Fume Hood
- 1 Inst-a-hot hot water heater LSB
- DI Water Skid LSB
- DI Water Skid Staging
- 1 Air Bake Oven w/Vacuum Pump
- Pallet Jack for Staging Bldg
- Fork lift for Staging Bldg
- Flow Bench Ion Bars - Qty 6
- 3 Tool Boxes/Sets
- Particle Counters for Staging/LSB Bought as a "Complete Canned System" xx per system (8 monitors per system)
- Upgrade Particle Counters for LVEA and VEAs(Installation and Operation)
- Convection/Vacuum Bake Oven - (Larry Jones develop??)
- Large Volume Ultrasonic cleaner

- Barcode tracking system for parts, shipping/receiving containers, assemblies, electronics
- Large volume HEPA Vacuum. Quantity: minimum of 1

Lab Equipment which possibly will fall under a lab acct, but will be needed 1-3 labs: (We will need to stock all 3 labs with some, or all, of this list.)

- Fab Optic Holders for day to day storage of optics (SOS, LOS, QUAD, 2" sizes)
- Height Guages
- Translation Stages
- Newport Stock of Mounts, etc.
- Optic Stock - flats, BS, etc.
- Illuminators
- Microscopes
- Oscilloscopes
- Autocollimators
- Weigh Scales

Possible Lab Upgrades:

- N2 Backfill System for bagging Class A parts...
- Dishwasher for Glassware ClassA/B Support stock, solvent bottles, etc.

3.4 Installation Support Fixtures

Installation fixtures which do not yet have much documentation (and therefore may fall under development at the sites) are listed below. Possibly, some of this has been developed by the sub-system design groups. As well, some items may come from iLIGO and may just need modifications to adapt for aLIGO use.

3.5.1 AdvSEI Installation Fixtures

The AdvSEI BSC ISI (In-Vacuum 2-Stage Seismic Isolation) System is currently installed at LASTI. This system is what will be installed in BSCs at the sites. Assembly, Testing, & Installation consists of building a "pod" on a Granite Table & testing the "pod" on the Test Stand. The major components will be assembled on the granite table. On the Test Stand one will conduct Performance Tests for the Assembled Pod. It will then get "locked" for storage or transport. At LASTI, a Cartridge is used for craning the "pod" into place in a clean manner (this may not be

needed at sites since there are no space constraints). This method of assembly is still in development.

ASSEMBLING THE TEST STAND / TESTING THE PODS TOOLING

- (1 or 2) Test Stand Assembly ([T050113](#))
- Brunson optical transit square [we have (2)!]
- Unisorb RK1 Alignment wedges
- 96" straight-edge
- 24" combo square
- plumb bob
- plumb bob stand
- Hilti anchors 3/4"
- Precision cross level

BSC/HAM POD ASSEMBLY TOOLING

- (1 or 2) Granite Table (5'x5')
- (8) 2-4-6 Tool Blocks
- (3) 48" 3pt slings
- (6) 10-150ft-lb torque wrench
- (9) Hoist rings
- 1000lb load cells
- Height gauge
- machinists levels
- Tooling pin
- Leak Testing Equipment
- Testing Equipment (i.e. Spectrum Analyzer, oscilloscope, etc.)
- Pod Storage/Transport Container

3.4.1 SUS Installation Fixtures

BSC Quad installation fixtures are currently under development by SUS groups.

- Roller Table
- Lift Cart
- Straddle
- 3 Point Lifting Hardware
- Prisms/Retroreflecting Hardware
- Locating Fixtures for Structures (LOS, SOS, Triples, etc.)
- Plank - redesign, or a better idea altogether.
- Rigging...

3.4.2 Improved Contamination Control

- HAM/BSC SEI "Pod" Clean Cans
- Make all cleanrooms/garbrooms fitted with HEPA flows
- Improve Junctions between cleanrooms and chamber entrance points
 - BSC Dome Platform to Cleanroom junction
 - BSC Door to Cleanroom junction
 - HAM Door to Cleanroom junction
- Fabricate new chamber entrance stairs

Additional/Improved Safety and Laser Safety Equipment

- Steel toed shoes
- Laser Safety - ...

3.5 TO DO LIST

To be developed by either the subsystem or a site:

- Long term storage and transport container for QUAD assemblies.
- Long term storage and transport container for SEI assemblies.

- Long term storage and transport container for other SUS assemblies. (These will probably be stored in Staging Building instead of warehouse, but should be better stored than "foil wrapped" on a bench for many months.)

Misc

- Retro-fit non-HEPA cleanroom and garbrooms with HEPAs. (Might be completed for eLIGO.)
- Add PSL facilities support (where do new racks go, chillers, etc.)
- Add Laser Safety improvements and stock for additional lab spaces if needed.

4 Facility Modifications

Advanced LIGO incorporates a larger diameter mode cleaner vacuum tube, and a conversion of the Hanford 2 km IFO to 4 km. We expect the contract for these major components to be a design and fabricate contract. Installation is not in the FMP scope.

This section is for information only – there will be a separate PDR at a later date to address the vacuum equipment modifications.

Figure 1. aLIGO LVEA Layout (H1, H2, L1)

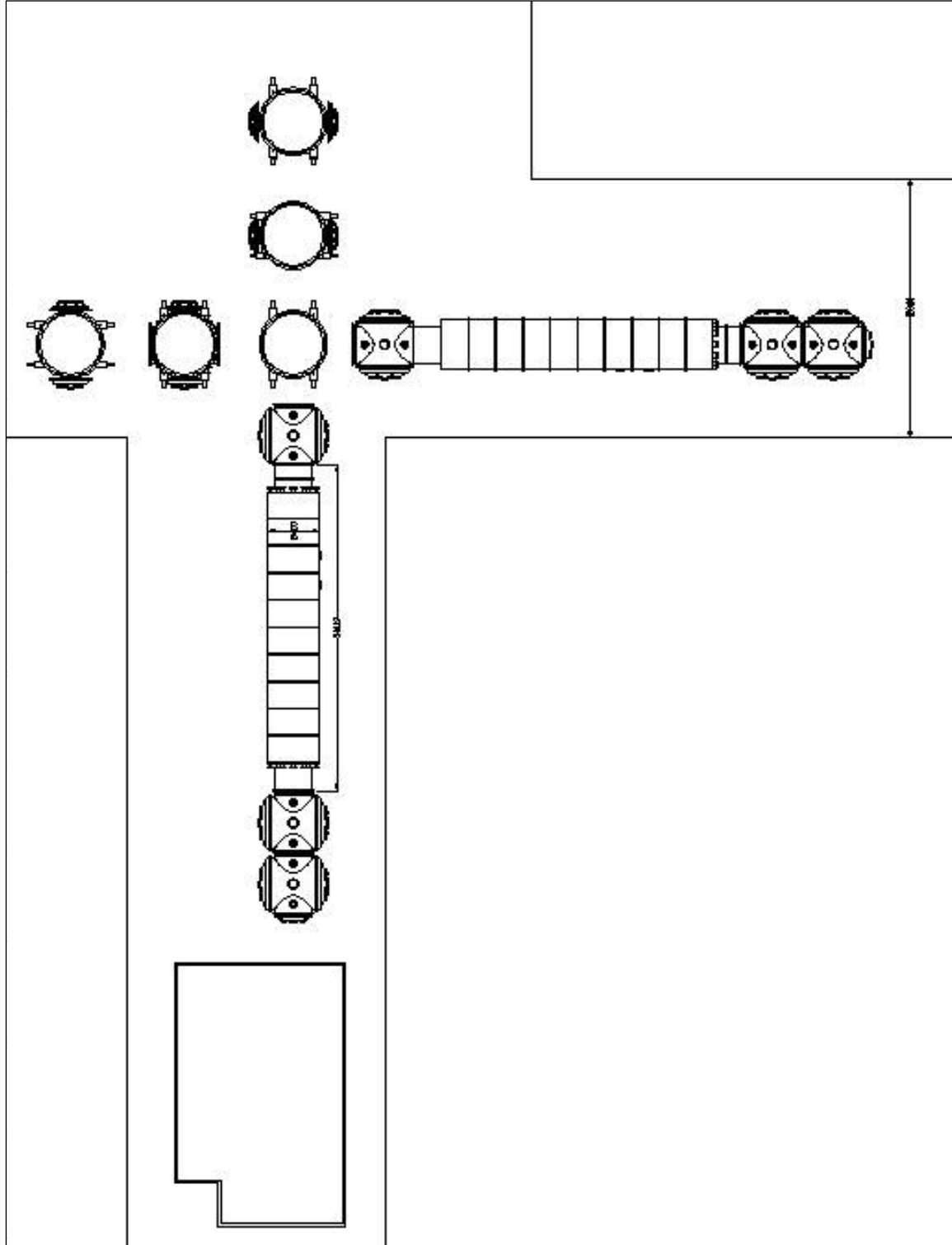


Figure 2. aLIGO End Station VE – Hanford only.

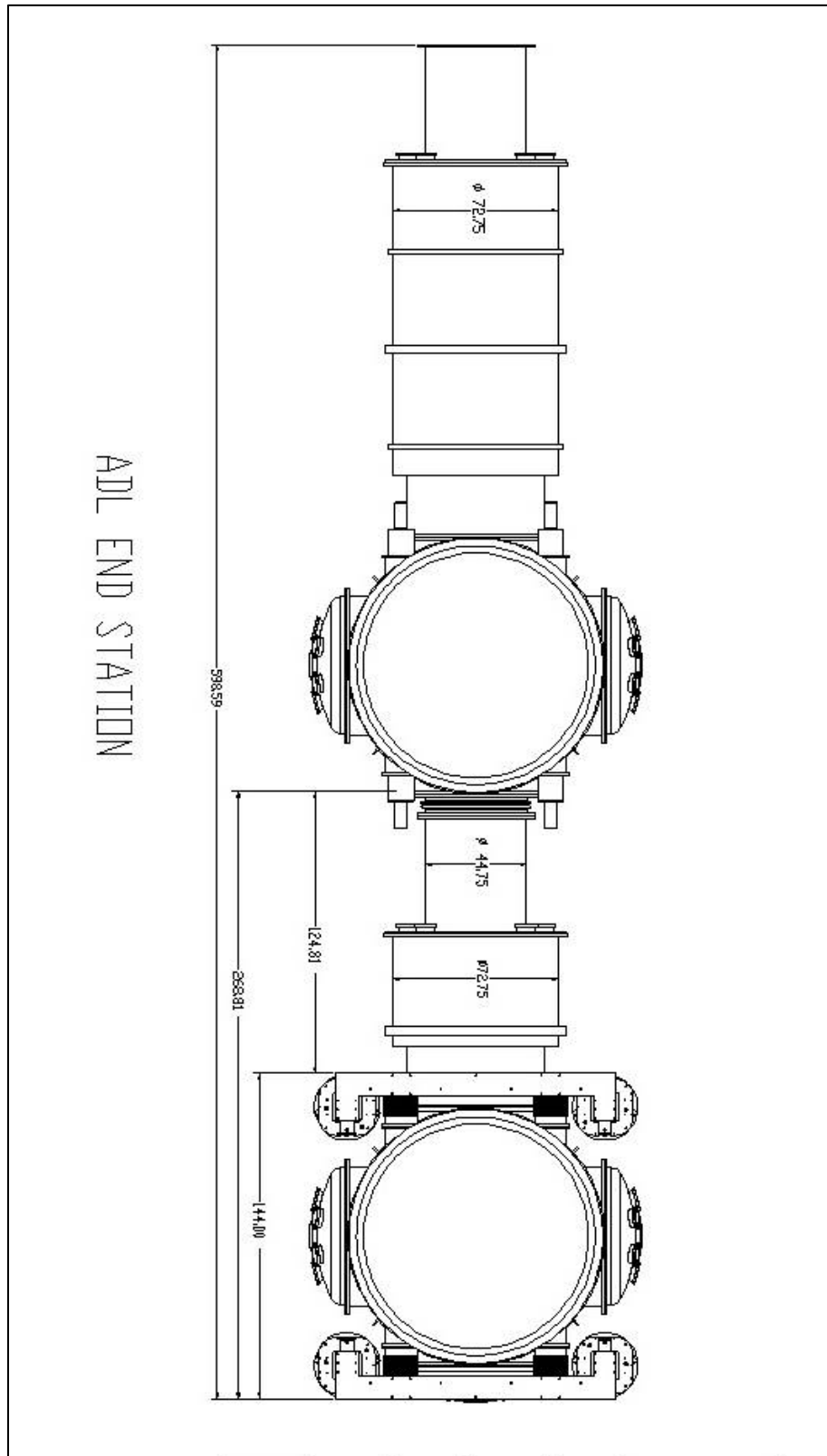


Figure 3: aLIGO MC Spool VE (6 required)

