Facilities Management During Construction, Fabrication, Installation

Mark Coles

Topics covered:

- Plans and activities related to transition from design to construction and installation
  - >> Civil Construction
  - >> Vacuum Equipment
  - >> Beam Tube
- Overview of field activities planned and how they will be implemented:
  - >> QA
  - >> Safety
  - >> Contract management
- Steps taken to insure that FDR designs (and ETC costs) are stable.
- Discussion of exposure to labor and material cost variances.

LIGO-G960063-00-F

Basic Philosophy

- Management approach to major facilities contracts:
  - >> maximize visibility into contractor activities:
    - very frequent teleconferences between LIGO technical manager and contractor.
    - contractors are required to supply detailed, resource loaded schedules with milestones one level lower than deliverable milestones.
    - monthly status meetings are held at contractor locations to review technical, schedule, cost status. Attended by LIGO technical manager and other LIGO staff as appropriate.
    - all contractor payments are based on progress milestones.

BI

PARTIAL PAYM 'SCHEDULE

Contract No. PC1
LIGO-C951080-00-B
December 8, 1995

Payment Milestones for LIGO Beam Tube Modules	Milestone Value	% of Total	Projected Wk ARA	Portion of Value Subject to Escalation		
				Coil Material	WA Craft	LA Craft
Design and Spiral Mill						
1 Contract Award	$ 1,500,000	3.79%	0	$ 0	$ 0	$ 0
2 Design Review	$ 1,780,000	4.50%	15	$ 0	$ 0	$ 0
3 Qualify Spiral Mill	$ 1,718,000	4.34%	28	$ 0	$ 0	$ 0
Hanford, WA Fabrication						
4 Complete Batch #1 Ready to Ship (at mill)	$ 891,000	2.25%	25	$ 891,000	$ 0	$ 0
5 Complete Batch #2 Ready to Ship (at mill)	$ 891,000	2.25%	33	$ 891,000	$ 0	$ 0
6 Complete Batch #3 Ready to Ship (at mill)	$ 891,000	2.25%	40	$ 891,000	$ 0	$ 0
7 Fabrication Readiness Review	$ 4,013,000	10.15%	36	$ 322,168	$ 0	$ 0
8 Complete Leak Check of Tube Assys. 1-50	$ 859,000	2.17%	47	$ 0	$ 434,000	$ 0
9 Complete Leak Check of Tube Assys. 51-100	$ 859,000	2.17%	53	$ 0	$ 420,000	$ 0
10 Complete Leak Check of Tube Assys. 101-150	$ 859,000	2.17%	59	$ 0	$ 420,000	$ 0
11 Complete Leak Check of Tube Assys. 151-200	$ 859,000	2.17%	63	$ 0	$ 420,000	$ 0
12 Complete Leak Check of Tube Assys. 201-250	$ 859,000	2.17%	67	$ 0	$ 420,000	$ 0
13 Complete Leak Check of Tube Assys. 251-300	$ 859,000	2.17%	73	$ 0	$ 420,000	$ 0
14 Complete Leak Check of Tube Assys. 301-350	$ 859,000	2.17%	79	$ 0	$ 420,000	$ 0
15 Complete Leak Check of Tube Assys. 351-400	$ 859,000	2.17%	85	$ 0	$ 420,000	$ 0
Hanford, WA Installation						
16 Installation Readiness Review	$ 1,932,000	4.89%	43	$ 0	$ 0	$ 0
17 Install & Circumf. Leak Check Tube Assys. 1-50	$ 300,000	0.76%	51	$ 0	$ 299,000	$ 0
18 Install & Circumf. Leak Check Tube Assys. 51-100	$ 300,000	0.76%	58	$ 0	$ 299,000	$ 0
19 Install & Circumf. Leak Check Tube Assys. 101-150	$ 300,000	0.76%	63	$ 0	$ 299,000	$ 0
20 Install & Circumf. Leak Check Tube Assys. 151-200	$ 300,000	0.76%	68	$ 0	$ 299,000	$ 0
21 Install & Circumf. Leak Check Tube Assys. 201-250	$ 300,000	0.76%	73	$ 0	$ 299,000	$ 0
22 Install & Circumf. Leak Check Tube Assys. 251-300	$ 300,000	0.76%	78	$ 0	$ 299,000	$ 0
23 Install & Circumf. Leak Check Tube Assys. 301-350	$ 300,000	0.76%	83	$ 0	$ 299,000	$ 0
24 Install & Circumf. Leak Check Tube Assys. 351-400	$ 300,000	0.76%	88	$ 0	$ 299,000	$ 0

Steps to ensure design stability

- mature specifications developed prior to procurement
  - >> LIGO wide reviews of specifications and SOW
  - >> Technical review board evaluation with external participation prior to procurement
- attention to system interface requirements - technical fit up of equipment to building (Systems Engineering Interface Control Docs.)
- close monitoring of contractor activities
- A formal LIGO review process is required prior to authorization of significant change orders:
  - >> LIGO Technical Review Board evaluation of technical impacts
  - >> Change Control Board authorization required for items with cost or schedule impact

PROCESS SYSTEMS INTERNATIONAL, INC.
20 Walkup Drive, Westborough, MA 01581

Fax No.: (818) 304-9834

January 18, 1996
V049-PL-064

Mr. E.J. Jasnow c/o Ms Linda Turner
CALIFORNIA INSTITUTE OF TECHNOLOGY
LIGO Project
102-33 East Bridge Laboratory
Pasadena, CA 91125

Reference: Technical Information Memorandum No. 10, Dated December 21, 1995
LIGO Document No. LIGO-C951471-00-V
LIGO Vacuum Equipment - Contact PC175730

Subject: **Change Order Request No. 11**
Washington Corner Station Beam Manifold Spool Changes

Gentlemen:

Attached for your review and approval, is Process Systems International's firm fixed price price proposal for Change Order No. 11, for a net credit to LIGO in the amount of ($200,557.00), for deleting two A-8 spools, six B-1 spools, six BE-1 spools and replacing them with two BE-5 spools in the Washington Corner Station. This change order covers all vendor, subcontractor, and direct costs associated with implementing the new scope. The credit is primarily associated with the savings in flange costs, expansion joint costs, and related testing. Also included is the engineering and design rework which will be resultant from changing the spool configuration at this point in the project. The equipment arrangement for the Washington Corner Station is scheduled to be completed in mid-February.

There is no overall schedule impact anticipated as a result of this change order, however the completion of the final design may be delayed if a decision is not made by January 26, 1996. Design of the Washington Corner Station is well underway and the section of beam manifold impacted by this change is currently being held pending the resolution of this change.

Excluded from this change order is sales tax, which will be invoiced separately in accordance with established billing procedures.

The pricing of this change order is valid for 30 days from the date of this letter, and we respectfully request LIGO's approval within that time frame. Proposed payment terms are a net credit to LIGO by PSI on the invoice for Payment Milestone 17A, Major Vessel Delivery for the Washington Corner Station.

Please indicate your authorization of this change by issuing PSI a change order to the Contract, so that, we may proceed with this scope change.

CALIFORNIA INSTITUTE OF TECHNOLOGY

Laser Interferometer Gravitational Wave Observatory (LIGO) Project

To/Mail Code: Distribution
From/Mail Code: J. Worden/M. Zucker
Phone/FAX: 395-4438
Refer to: LIGO-L90928-00-V
Date: November 29, 1995

Subject: Vacuum Equipment Corner Station Beam Manifolds:

Attached are two PSI drawings which show the VE configuration in the corner stations. Mike and I would like to have project consensus on reducing the scope of the beam manifold in WA to the same as that in LA. Each WA beam manifold was originally provided with 3 removable 20 foot spool pieces, to accommodate rapid and seamless addition of TMC chambers in a future upgrade. Revisions to the scope of the buildings necessarily make the civil aspects of this future upgrade significantly more disruptive and time consuming than originally envisioned, negating the advantage of rapid reconfiguration to the vacuum envelope. Procurement of a replacement manifold section with the proper design details would not be a significant perturbation on the expansion project, and would not force us to freeze in our primitive expansion concept at this stage. So, in summary;

-Potential cost savings could be used to offset the cost of other changes such as selecting all electric valves.
-The presence of 3 additional removable spools (per arm) does not provide a significant step towards expansion. This pipe is readily replaced or modified at the time of expansion to 4 or more interferometers.
-The presence of these removable spools actually puts unnecessary constraints on the dimension and location of additional interferometers.
-Reducing the number of removable spools would reduce the number of large Viton O-ring sealed flanges with the associated annulus pumping support. Reliability of the initial configuration will be greater.

The potential cost savings (direct costs) are ~$200k.
Please respond by December 8 to Mike or John.

Thanks

Attachments: V049-5-001, V049-5-003.

Distribution: M. Coles, G. Stapfer, A. Sibley, L. Jones, W. Althouse, R. Vogt, S. Whitcomb, D. Shoemaker, A. Lazzarini, D. Coyne, R. Weiss, G. Sanders, M. Zucker, B. Barish, P. Lindquist, F. Raab, Chronological File, Document Control Center

Change Request

Change Request No.: 96.0002 Date: 1/23/96

WBS Element and Title: 1.1.1 Vacuum Equipment - WA Beam Manifold

Originator: J. Worden Ext: 4438 CCB Sponsor: _____

Technical Change Description:

Delete unnecessary spools from the WA Corner Station Beam Manifolds. Replace two A-8 spools, six B-1 spools, six BE-1 spools with two BE-5 spools as used in the LA corner station. These spools were intended for use with TMC chambers and would only be useful if used in the predetermined positions. See the attachments for more detail.

Cost Impact:

The change will result in a net credit to LIGO of $200,557.
Decrease Milestone 17a of the VE contract by this amount. (C/N 5A522).

Schedule Impact:

No schedule impact anticipated.

Concurrence Signatures:

Facilities Group Leader: _____ Date: 26 Jan 1996

Deputy Facilities Group Leader: _____ Date: _____

Detector Group Leader: _____ Date: 26 JAN 96

R&D Group Leader: _____ Date: 26 JAN 96

System Engineer: _____ Date: 1/26/96

Integration Scientist: On File Date: _____

Project Controls Manager: _____ Date: 1/26/96

CCB Approval/Disposition: Tech Config. W.E. Approved, returning $ 200,557 to contingency. 1/26/96

CCB Chairman: _____ Date: 1/26/96

The role of Quality Assurance

Three tiers of QA:

- LIGO Project Office:
  - Broad policy responsibility with respect to overall project.
  - headed by Bill Tyler - QA specialist
- Facilities Group implementation of QA policies
  - QA oversight and responsibilities carried out by technical personnel that will become part of site operating staff.
  - direction and guidance in conduct of QA provided by Bill Tyler
- Contractor QA
  - >> Each contractor required to submit QA plan.
  - >> Evaluation by Bill Tyler and contract technical manager
  - >> Audits of QA plan implementation by Tyler and Facilities Group staff

I. GENERAL

A. All personnel who participate in the handling and fabrication of LIGO electronic and mechanical hardware must be familiar with the technical requirements and be fully certified. Certification is obtained by successfully completing training or familiarization classes, whichever is appropriate. These classes are intended for the development of personnel capabilities in specific techniques to ensure a continuous high level of quality.

1. TRAINING must be completed by all personnel who work on or handle flight electronic and mechanical hardware, such as technicians and inspectors. Training will consist of lesson demonstrations by Quality Assurance instructors, and the practical work of individual students practicing what they have been taught. A Certificate of Training will be issued upon successful completion of the Quality Assurance training classes.

2. FAMILIARIZATION, an abbreviated training, must be completed by all personnel who participate in the development, quality, and handling of LIGO electronic and mechanical hardware, such as engineers and supervisors who are responsible for LIGO hardware. Familiarization will consist of definition of specifications, an insight into what is happening technically when a specific process is being used, what to be alert for, and the reasons and explanations of why things do what they do. A Certificate of Familiarization will be issued upon successful completion of the engineering familiarization classes.

3. RECERTIFICATION is obtained by continuous demonstration of quality work as determined by the responsible Group or Task Leader. Requalification will be required if:

   a. The operator's proficiency level falls to the point where the necessary quality of hardware is not maintained, or

   b. Process/requirements have undergone major changes, or

   c. A time period as designated for each course has elapsed since an individual passed a training course or was recertified.

B. The training and familiarization classes include qualified instructors, training facilities and equipment, lesson plans and instructions, quality and engineering specifications, and video tapes which are applicable to appropriate LIGO and contractor employees.

18.0 TRAINING

18.1 Scope

This section establishes the requirements for training, qualification and certification.

18.2 Training and Qualification Requirements

18.2.1 CBI controlled training, qualification and certification procedures, standards and programs shall be used, when applicable to the activities of assigned personnel.

18.2.2 Each organization (department, group, etc.) shall develop documented training and qualification procedures (or QAPs) that include references to CBI controlled procedures, standards and programs as applied, for personnel performing activities affecting quality. These procedures shall follow the guidelines of ISO 9004 Article 18, applicable to the scope of activities performed. As a minimum, the procedures shall include:

A. Identification of qualification requirements for individuals performing specialized operations, processes, tests, audits or inspections.

1. Personnel required by applicable codes or contract specifications to be formally qualified shall be qualified prior to performing the work.

2. Evidence of qualification shall be maintained.

B. Identification of training requirements for all personnel as appropriate to the activities performed.

1. Personnel shall be given sufficient training to enable them to understand and perform their work.

2. Personnel responsible for implementation and control of this manual and associated QAPs shall be trained in this manual and appropriate QAPs.

4.4 All individuals (except craftsman) shall be trained in the Quality Management System requirements, including subsequent revisions related to their activities. This training shall include familiarization with the QA Manual, QAP's and references applicable to the activities they are performing.

5.0 RECORDS

5.1 Records of Qualification:

5.1.1 The General Manager of Corporate Welding & QA is responsible for verifying the qualification requirements of 3.0 as documented in department personnel files, except that NDE Technicians records shall be contained in their NDE file.

5.2 Records of Training:

5.2.1 Training in the QAM, applicable QAP's and any other required references as given in 4.4 shall be documented. Documentation shall consist of a record of the individual's name(s), date(s) of training, QAM, QAP's or references covered in the training and the name & signature of the individual conducting the training session. Training records may be grouped, and separate training records for each individual are not required.

5.2.2 If previous training of a transferring individual is deemed acceptable by the Manager or Supervisor, this conclusion shall be documented and placed in the individual's records.

5.2.3 Documentation of other training required by 4.0 is optional.

9.0 PROCESS CONTROL

9.1 Scope

This section identifies the controls required to effectively perform fabrication, installation and servicing processes.

9.2 General

Work on a contract is executed in accordance with detail drawings, written requisitions and procedures. Work is controlled, as required, by the use of process control documents .

9.3 Controlled Conditions

Fabrication, installation, and service activities directly affecting the quality of the product shall be identified and planned to ensure that these processes are performed under suitably controlled conditions. Controlled conditions shall include:

A. Approved procedures which include acceptance criteria when applicable and which comply with referenced standards or Codes and quality plans (when used).

B. Efficient utilization of fabrication and installation equipment and suitable working environment.

C. Monitoring and control of process parameters and product characteristics throughout the fabrication and installation processes.

D. Maintenance of equipment used to assure continued process capability.

9.4 Special Processes

9.4.1 Contract procedures for special processes (e.g., concrete, earthwork, welding, NDE, testing, heat treatment, etc.) shall be generated when required to verify characteristics of an item when subsequent inspections, tests or examinations cannot be performed.

9.4.2 Procedures shall be qualified when required and shall contain acceptance criteria as specified in applicable codes and contract documents.

The role of Safety

- Implementation is similar to approach with QA:
  - >> Ben Lucas is Safety Specialist in LIGO Project Office - develops LIGO site safety plan
  - >> LIGO requires each contractor to have an effective safety plan in place. Ben Lucas and other LIGO staff audit these plans.
  - >> Site Construction Manager is responsible for conduct of site LIGO safety procedures
  - >> Internal site hazards Analysis Review planned for July 96 to identify possible hazards and appropriate mitigation

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LIGO Project System Safety Plan

LIGO-M950046-A-M

November 1995

November 3, 1995

LIGO-M950046-A-M

LIGO PROJECT SYSTEM SAFETY PLAN

November, 1995

LIGO PROJECT

CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Here is a link to the Signature page.

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Figures

LIGO-M950046-A-M -- last modified 05 Mar 96

Standard Forms

SAF 20A	Managing an Incident for CBI Projects
SAF 21	Safety Rules for Construction (Worldwide)
SAF 22	Safety Rules for Shops/Warehouses (Worldwide)
SAF 23	US. Safety Questionnaire
SAF 25	CBI Accident Analysis Worksheet
SAF 26	Supervisor's Accident & Incident Investigation Report
SAF 27A	Capacity of Slings Poster
SAF 29A	Hazard Communication Checklist-Facilities
SAF 29B	Hazard Communication Checklist-Construction
SAF 34	Medical Questionnaire for Crane Operator
SAF 35	Operator Functional Test
SAF 36	Crane Safety Certification Check List
SAF 37	Isolation of Structures, Systems & Pipelines
SAF 38	CBI Employee Safety Orientation Program Attendance Form
SAF 38S	Shop/Warehouse Safety Orientation Program Attendance Form
SAF 39	Project Information Pamphlets
SAF 40	Field Employee Safety Orientation Program Open-Book Test (Field)
SAF 40SW	Field Employee Safety Orientation Program Open-Book Test (Shop/Warehouse)
SAF 41	Automobile Incident Report Form
SAF 42	CBI Employee Orientation Train Program-Part II Score Card
SAF 43	CBI Construction Safety Audits
SAF 44	Confined Space Entry Permit
SAF 45	Non-Permit Required Confined Space Certificate
SAF 46	Confined Space Entry Log
SAF 49C	Overhead & Gantry Crane Inspection Schedule and Report
SAF 50S	CBI Services Constructive Discipline for Safety Program Violations
SAF 52	Avoid Powerline Contact Poster
SAF 105	Extra Hazardous and Repair Work Report
WL 30	NDE Certification of Qualification
WL 40	NRC-5 Current Occupational External Radiation Exposure
WL 44	CBI Physical Inventory, Leak Test and Maintenance-RT Source
WL 46	CBI Safety/Training Metering Report-RT Source
WL 188	CBI Assistant Radiographer Qualification
WL 189	CBI Radioactive Isotope Shipping/Receiving Report
WL 236	CBI Quarterly Dosimeter Report
WL 238	CBI Radiography Internal Inspection Checklist
WL 250	Daily X-Ray Exposure Data
N/A	CBI Basic Safety Rules Booklet-Construction
N/A	CBI Basic Safety Rules Booklet-Shop

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Section 1 Accident Prevention Program

Construction, Fabrication, and Installation Management

- Draft construction management plan for site activities has been written.
- Roles of Site Construction Manager and relationships to Parsons and other site contractors defined.
- Flowdown of responsibility:
  - LIGO construction manager (Otto Matherny):
    - on site May 96
    - coordination of site activities
    - initiate field change orders with $50K of approval authority, also petty cash expenditures.
    - oversight of Parsons (civil construction manager)
    - coordinate PSI & CBI site access needs and joint occupancy requirements
    - prepare punch list items

Construction, Fabrication, and Installation Management (ctd)

- Parsons Construction Manager:
  - on site Feb. 96
  - ensures construction in compliance with design documents, coordinates approval of shop drawings, test results.
  - verifies invoices
  - responsible for daily reports, construction records management, & photo history
  - accepts completed civil construction
  - assist with change orders and punch list preparation
- Vacuum Equipment Manager (John Worden):
  - on site July 96
  - oversight of site specific vacuum system (beam tube and vacuum equipment) activities
- additional Facilities Group Staff support John and Otto (Cecil Franklin - on site May 96, Allan Sibley...)

Site related QA responsibilities

- LIGO approach:
  - >> witness all critical QC activities
  - >> selectively delegate implementation of non-critical QC activities to contractors.
  - >> audit contractors to insure QA compliance
  - >> Train/motivate LIGO staff to conduct active oversight of contractors.
- Areas of special importance:
  - >> Insure that a well defined interface between contractor and lower tier suppliers exists:
    - Verify proper implementation of receiving and inspection processes between contractors and lower tier suppliers
    - Verify that subs are maintaining traceability of materials - example: CBI materials segregation
  - >> Verify use by contractor of approved and released drawings, specifications, and procedures
  - >> oversight of acceptance testing of LIGO deliverables

Supplemental help from QA-specific contractors:

- soil compaction
  - >> PSI' - LA
- surveying
  - >> ABMB - LA
  - >> Rodgers Surveying - WA
- BTE fab
  - >> Shannon and Wilson - WA
  - >> TBD - LA
- concrete work
  - >> Shannon and Wilson - WA
  - >> TBD - LA

Civil Construction Transition Plans

- There is a very short period between FDR and issuance of the Invitation To Bid - we want to make sure all goes smoothly
- We have completed individual table top reviews in the following areas:
  - >> OSB
  - >> LVEA
  - >> Mid and end stations
  - >> science related requirements
  - >> site work and out buildings
  - >> design option for 3 interferometers at Hanford
- table top reviews included participation of appropriate technical staff and LIGO met.

Civil Construction Transition Plans (ctd)

- detailed review comments incorporated for FDR
- aim for FDR (April 26) with very few surprises
- we have also held a 3-way interface meeting between CBI, PSI, and RMP to promote communication of contractor interface requirements
- FDR participation includes outside reviewers in following areas:
  - >> Hal Amick - acoustics & vib. - Acentech
  - >> John Hall - structural eng. - Caltech Prof.
  - >> Bert Sweetser - general constr. - consult.
  - >> Paul Weickert - civil and struct. eng. - consult.

Civil Construction Transition Plans (ctd)

- FDR deliverables:
  - >> design drawings
  - >> specifications
  - >> design narrative (design configuration control document)
  - >> calculations
  - >> cost estimate

General Construction IFB package

Features of the bid package:

- using general provisions approved by NSF
- using special provisions provided by Parsons
- using very complete plans, specifications and drawings suitable for formally advertised procurements
- bids will be opened publicly - apparent low bidder determined
- All bids will be bonded
- require performance to be bonded
- require payments to lower tier subs be bonded

Response to October NSF Review - Conventional Construction

- Continue preconsolidation plan now underway in LA. Monitor consolidation and report findings.
  - » Professional Service Industries, Inc. provides quality assurances testing for the rough-grading. ABMB Engineering, Inc.provides field survey support and monitors berm consolidation
- The building systems and designs may be more cost effective if they are selected specific to site.
  - » Site specific condition has been considered in the design of the building systems for two sites.
    - Examples: Beam tube slab foundation, technical foundations, WA vs. LA HVAC etc.

Review for Conventional Construction (continued)

- Consider base bid plus option for large building (more interferometers)
  - done!
- Examine the alternative of two-piece beam tube enclosure with a crown joint.

  >> evaluated by Parsons and ACME. Less cost effective
- Designate site manager and publish Site Manager's Manual.

  >> Otto Matherny designated site manager. Draft of Site Manager's Manual prepared.
- For each site, initiate specific, detailed construction and installation planning.

  >> See Gerry Stapfer's presentation.

Beam Tube

- FFP contract in place
- Contractually incorporated QA monitoring steps by CBI:
  - >> steel coupons
  - >> weld samples
  - >> FTIR samples
- LIGO assesses whether this monitoring is adequate for LIGO performance requirements.
- We can implement changes to process if required (cost implications)

Cost escalation considerations

- stainless steel prices - based on Dept. of Commerce commodity index. - ($600K represents a 10% fluctuation in raw material price)
- labor escalation clause
  - (DOE site labor agreement at Hanford)
  - In LA we are not bound by preset agreements but labor rates are TBD.
- We have made an estimate and included it on our budget to address the likelihood of labor rate increases

Response to October NSF Review - Beam Tube

- Complete formal negotiations with CBI
  - >> Contract was signed 12/11/95.
- Build a mock-up of the beam tube enclosure including sections of the QT beam tube fabricated by CBI.
  - >> A mock-up of a 40' section of the beam tube with enclosure has been installed in the Synchrotron building on the Caltech campus; viewing it is on the agenda for this review.
- Explore alternate methods of beam pipe bakeout
  - >> We have explored alternate methods in the past, including the suggested one. None have approached the method planned in practicality and cost or performance (uniformity of temperature).

Vacuum Equipment

- FFP contract in place
- Contractually incorporated QA monitoring steps;
  - >> material tracking
  - >> acceptance test at vendor of turbo-pump carts
  - >> leak check of all vessels prior to site shipment - optionally witness these tests
  - >> Site acceptance requirements:
    - each isolatable volume subject to 100 hour test to demonstrate outgassing and leak performance
    - acceptance test of LN pump consumption rate
    - demonstrate isolatable volume pump down time requirements
    - purge air purity measurements
    - demonstrate portable clean rooms meet Class 100

VE (ctd)

- LIGO QA audit activities:
  - inspection of workmanship
  - witness UHV cleaning activities
  - witness lower tier contractor qualification and acceptance test procedures
- first article chambers
  - PSI fabrication of prototype BSC chamber:
    - verify design
    - verify fabrication process
    - verify UHV cleaning process
  - similar program initiated for HAM chamber
  - reduces risk of schedule delays by providing earlier look at contract deliverables
  - provides "pathfinder program" to identify lower tier suppliers for specialty machining

Response to October NSF Review - VE

- System Wide Pump Down/Performance:

  >>In progress (Rai Weiss).

- Vacuum System Control and Monitoring:

  >>Design Requirements Document LIGO-T960024-00-CDR.

  >>DRR scheduled for May 1.

- Elimination/control of hydrocarbons:

  >>Use of Oil Free pumps and fail safe valving.

  >>PSI is investigating various cleaning solutions based on DI water (steam) and detergent.

- Noise from bubbling LN2:

  >>PSI has developed a Phase separator which eliminates noise due to gas in the transfer line.

- Feedthrough corrosion:

  >>For the initial LIGO, there will be close to zero devices installed in uncontrolled tunnel atmosphere.

Summary

- Expect stable costs because of mature designs and process of change order review.
- We have established a program with lots of visibility into FFP contractor activities so that we can have early warning of impending problems.
- QA and Safety oversight plans in place. Conducted primarily by technical "stakeholders" in the site operations.
- We are entering a critical implementation phase of the LIGO project - making these plans work is essential.