6500m HOV Project
Stage 1: A-4500 HOV

Vehicle Construction Plan

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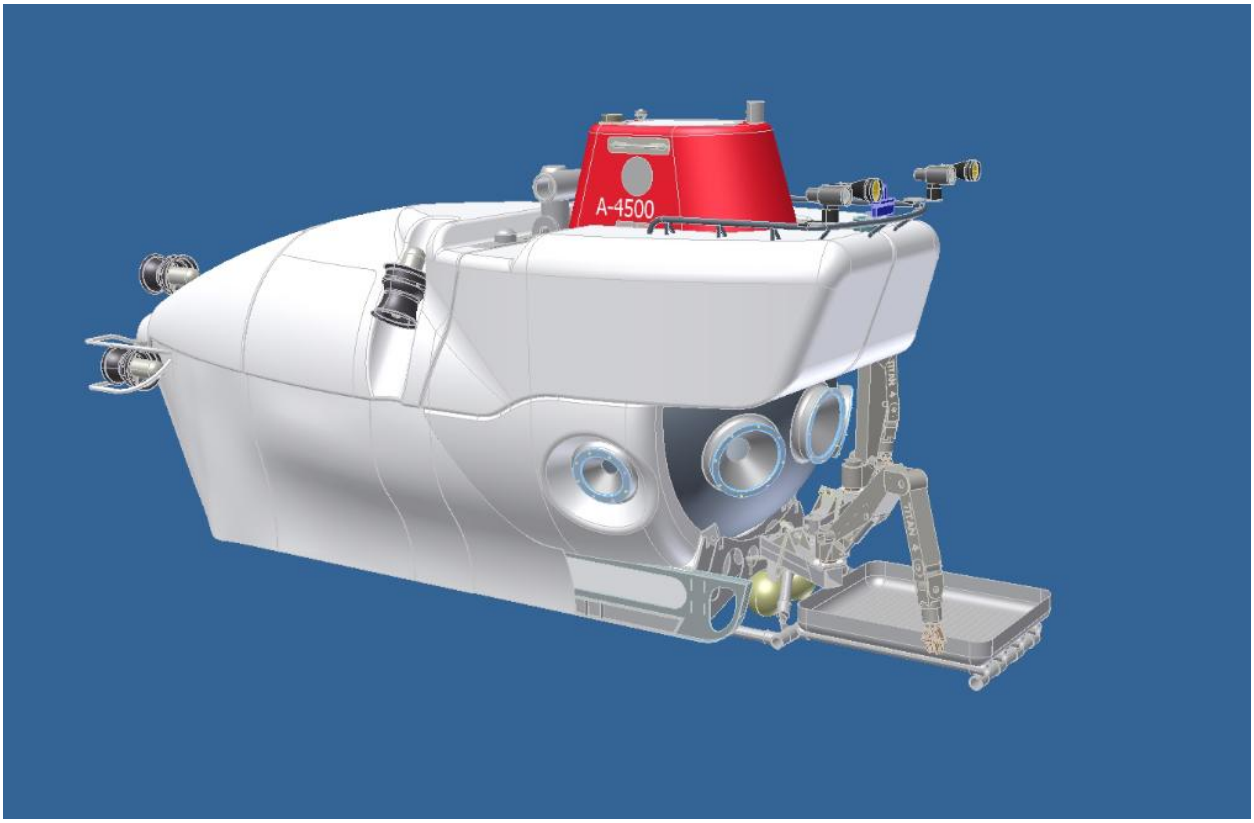

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Date	Originator	Description
08-31-09	P. Hickey	Initial Draft
09-01-09	P. Hickey	Edit incorporating Fig. 1 baseline Gantt Chart and Org. Chart
10-19-09	P. Hickey	Draft 2 incorporating Construction Gantt Chart, originally Fig. 2, now Fig. 3
10-29-09	P. Hickey	Draft 3 incorporating 1.2 re-write and changed draft number
11-02-09	P. Hickey, S. Humphris	Revised Draft 3 incorporating Pre-construction Fabrication Gantt Chart, Fig. 2, & edits

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1.0 Introduction

Since the human occupied submersible *Alvin* was commissioned in 1964, it has undergone a series of refits and overhauls that have transformed it from the basic vehicle delivered, to a diverse and adaptable system that has benefited the science community worldwide with its versatility for over 45 years. The *Alvin* operations team (ALOPS) and the shore-based engineers, who collectively make up the Submersible Engineering and Operations Group (SE&OG), have been solely responsible for conducting overhauls of *Alvin* every 3.5 to 5 years, and for completing all in-house work done during these maintenance periods. This group will be responsible for the assembly of the new A-4500 HOV.

The *A-4500 HOV Construction Plan* describes the team, the tasks, and schedule for fabrication of components, tear-down of the *Alvin*, and assembly of the A-4500 HOV. In this document, "pre-construction fabrication" is the term used to describe those procurement and fabrication activities that can be completed prior to the arrival of the HOV *Alvin* in Woods Hole. The term "construction" is used to include three distinct activities: demobilization and disassembly of the HOV *Alvin*, refurbishing and servicing of existing equipment to be utilized on the A-4500 HOV, and assembly of the new A-4500 HOV. The A-4500 HOV testing plans and sea trials are described in the *Transition to Operations Plan*, but will be briefly summarized in this document for completeness.

Note: Referenced documents cited throughout are available for viewing on the secure password protected website ftp://A4500HOV@ftp.whoi.edu

2.0 Project Team

The SE&OG, which includes the ALOPS and the shore-based engineers, will be responsible for construction of the A-4500 HOV under the direction of the Manager of the SE&OG, who is also the Integration Lead, Operations Liaison, and Safety Manger for the A-4500 HOV project.

Since the project's inception, the SE&OG has been informed and involved with review of science community polls, hull designs and viewport placements, the vendor bid process and initial award, Lockheed preliminary designs and design reviews, and re-scoping to the staged approach. WHOI has regularly updated the operational crew on the status and progress of the project. These updates have been in the form of presentations to the crew at sea by shore-based engineering personnel when they have made operational cruises as part of SE&OG requirements.

The organization structure of the SE&OG, which is part of the National Deep Submergence Facility based at WHOI, is shown in Figure 1. The shore-based personnel include a Program

Director, SE&OG Manager, SE&OG Coordinator, Mechanical and Electrical Engineers, Drafting and Documentation Control Department and an Administrative Assistant. The at-sea group is led by the Expedition Leader who oversees and manages the Mechanical, Electrical and Electronic Section Leaders who, in turn, manage a pool of technicians. The Pilot pool is drawn from these personnel who have trained and attained Pilot Certification. More than 80% of the SE&OG have participated in the last six overhauls spanning more than 20 years.

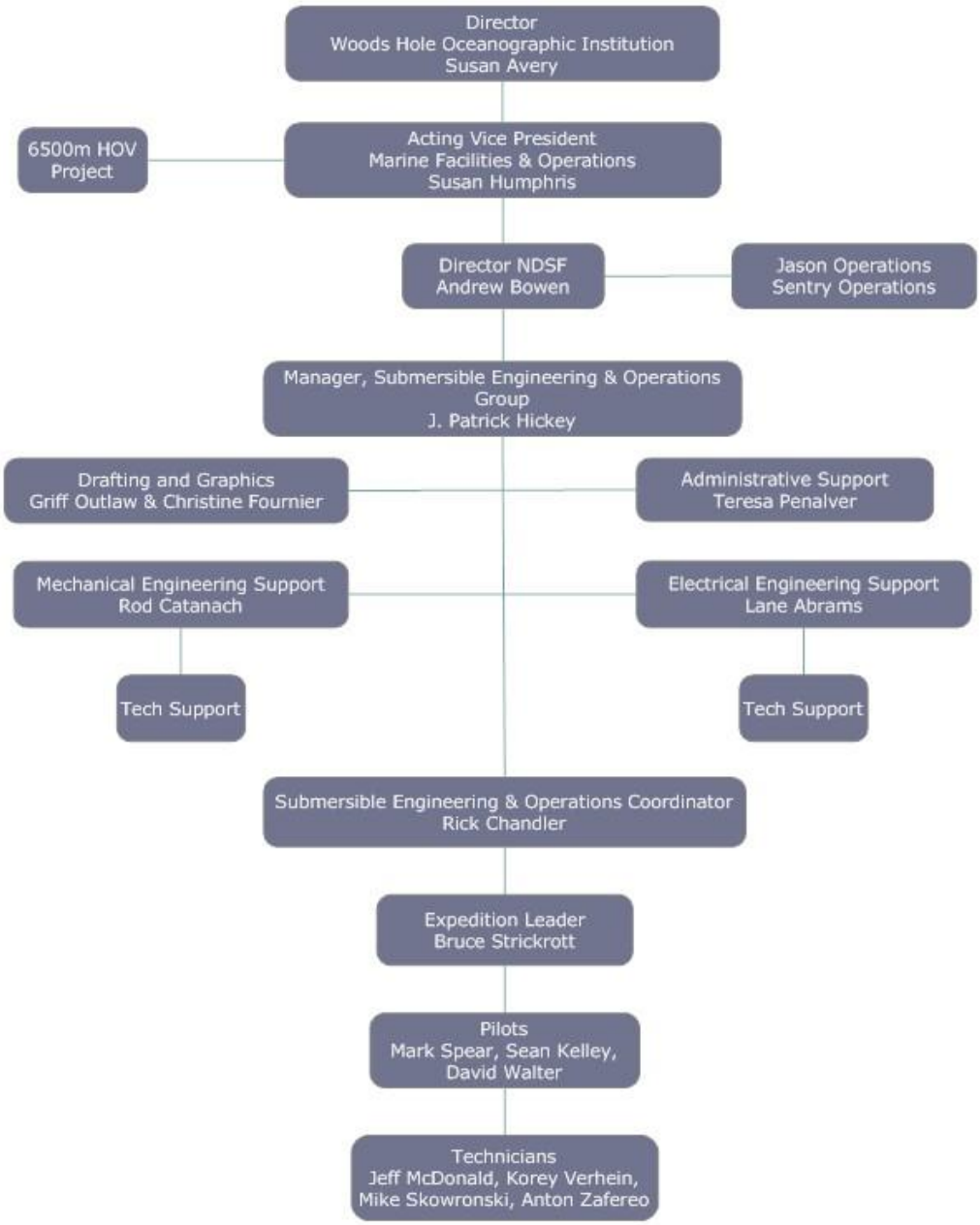

Figure 1. Organizational Structure of the Submersible Engineering and Operations Group

Because the operations team will eventually be solely responsible for the repair, maintenance and operations of the vehicle, they will perform the majority of the construction. This philosophy in past overhauls has made the team extremely knowledgeable with the vehicle on a system and sub-system level. Such knowledge has been critical in *Alvin*'s past operational and reliability record, and will significantly shorten the transition to operations period that would have been required if the HOV had been built under contract by an outside party.

3.0 Construction Schedule, Testing Acceptance and Criteria

3.1 Construction Schedule

Much of the pre-construction fabrication and construction of the A-4500 HOV will be conducted in facilities at WHOI with the majority of the work being done by WHOI personnel. Figure 2 illustrates the currently expected gross breakdown of tasking and servicing requirements on a timeline basis. This is based on our experience with the time it has taken in the past to do similar tasks for *Alvin*. In the following sections, we discuss the tasks to be accomplished and provide more detailed timelines for all activities required in the construction of the A-4500 HOV.

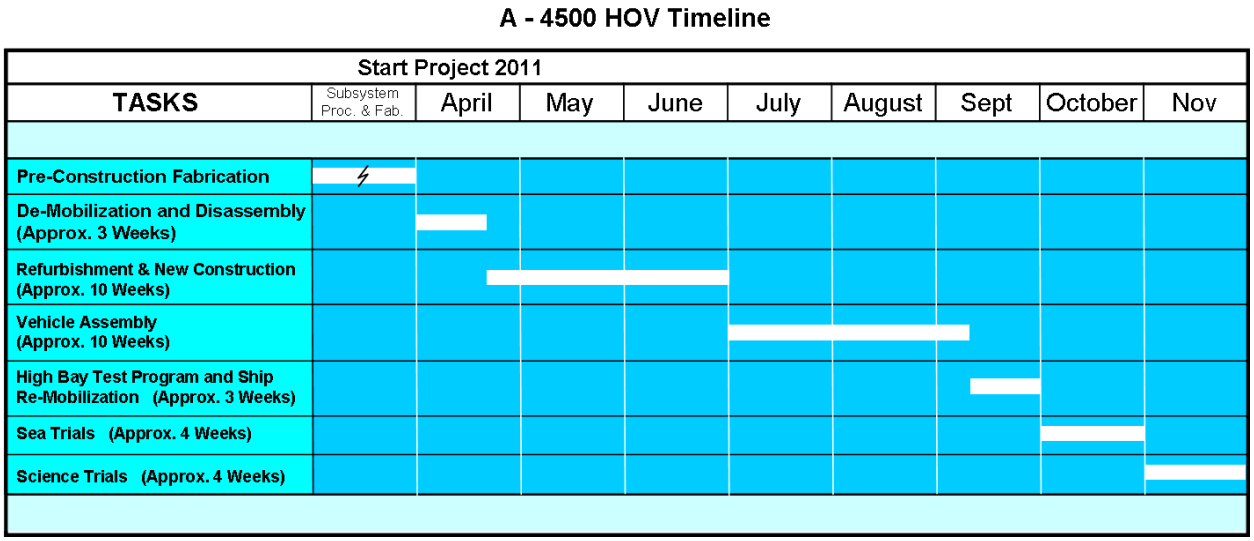

Figure 2. Gross Breakdown of the Fabrication and Construction of the A-4500 HOV

3.1.1 Pre-construction Procurement and Fabrication

Pre-construction procurement and fabrication is defined as the period of time that starts immediately following the Final Design Review, and extends until the HOV *Alvin* returns to Woods Hole – a period of about seven months. Preconstruction fabrication includes purchase,

assembly, and testing of items such as data and power bottle assemblies, fixed and soft ballast system components, command and control hardware, frame modification components and wiring harnesses. Completion of some of these tasks to schedule will require approval of funding for long lead time items, such as syntactic foam, prior to the Final Design Review.

In addition to these activities, the ALOPS in concert with selected shore-based engineering personnel will, as operational commitments allow, attend pressure hull testing as the personnel sphere fabrication progresses. Various operations crew members with particular technical expertise will also be brought back to Woods Hole to participate in planning and scheduling meetings.

WHOI has acquired a fiberglass sphere mock-up of the new 6500m personnel sphere. Members of the ALOPS team with the required technical expertise will be brought back to WHOI to assist with the layout and configuration of the internal layout of the personnel sphere mock-up. The sphere mock-up will have an equipment frame on which existing and new internal sphere electrical panels and equipment will be attached. This equipment frame, commonly known as the bird cage, has been an integral part of previous *Alvin* overhauls, and enables work and wiring to easily be done on major in-hull components and panels that are normally inaccessible when installed in the sphere.

Internal design of the personnel sphere is already underway using the mock-up. We plan to have approximately 80% of the required sphere outfit completed in the mock-up sphere, including support frame structure (bird cage), life support systems, control and data systems, and interior wiring harness. In-hull components fabricated during pre-construction will be installed into the sphere mock-up, wired and functionally tested as part of an initial Sphere Electrical Check Out (SPELCO and Post-Overhaul Electrical Checkout. An example of the *Alvin* POELCO from the 2006 overhaul, which details staged end-to end-wiring and electrical verification, is available for viewing at the secured online website. These checkouts will verify the correctness and operability of system designs without the restrictions of the equipment physically installed into the actual personnel sphere. Both of these procedures, as yet to be developed, will be required because of the changes that will take place in sphere and overall vehicle configuration and wiring.

Figure 3 shows the timeline and tasks for the pre-construction activities that include but are not limited to:

<u>Interior arrangement</u>

- Purchase new interior Command & Control and video equipment
- Finalize interior mock-up based upon availability of actual hardware
- Purchase bird-cage materials and pre-construct components to the extent possible

- Populate interior mock-up with all available equipment
- Construct interior wiring harnesses and test cables
- Test available interior equipment as installed

Main frame

- Pre-fabrication of main frame modification components to the extent possible

Exterior Command & Control

- Purchase required hardware
- Verify chassis and pressure housing designs
- Manufacture chassis and pressure housings
- Build Command and Control assemblies and test component integration
- Install Command and Control assembly chassis in pressure housings and conduct burn-in tests.

Exterior Wiring

- Manufacture cable junction boxes

Fixed Buoyancy

- Bond and shape new syntactic foam modules
- Fit to mock-up sphere and correct as required
- Apply final protective exterior coatings as required

Main Ballast Tanks

- Construct new ballast tanks
- Fit to mock-up sphere and correct as required
- Apply final protective exterior coatings as required

Sphere Interior Equipment

- Transfer required interior equipment to replacement sphere mock-up
- Complete testing of interior equipment utilizing the mock-up installation

Mechanical outfit of the new personnel sphere, once received, will take place in parallel with this effort should the new sphere arrive prior to the submersible support ship delivers the current vehicle system to Woods Hole.

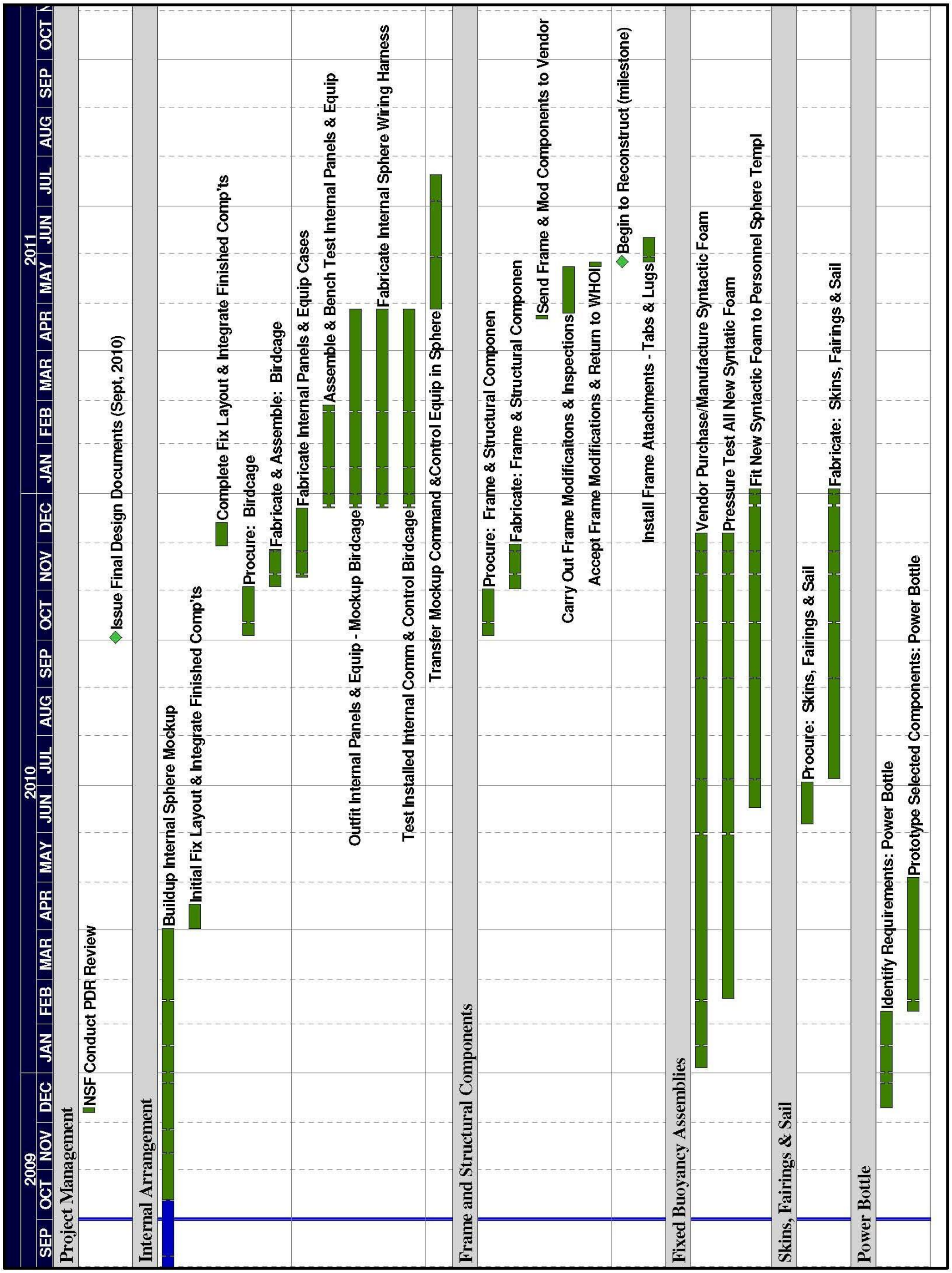

Figure 3. Schedule of Pre-Construction Procurement and Fabrication Tasks

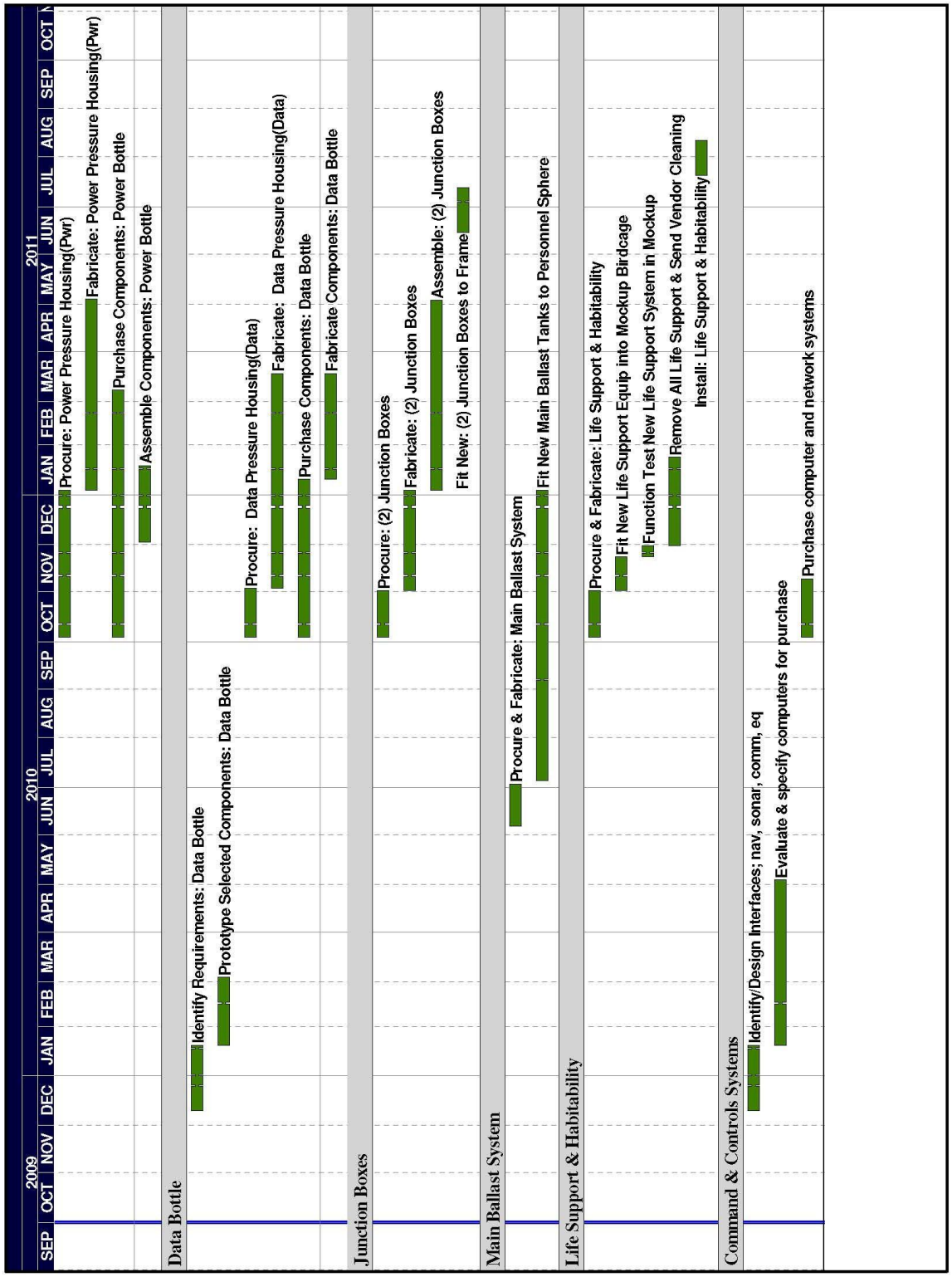

Figure 3 (contd). Schedule of Pre-Construction Procurement and Fabrication Tasks

3.1.2 Construction

Construction is divided into three distinct activities:

1. Demobilization and disassembly of *Alvin*
2. Continuation of pre-construction new equipment assembly and testing, as well as refurbishment and servicing of existing equipment to be utilized on the A-4500 HOV.
3. Assembly of the A-4500 HOV and end-to-end testing prior to sea trials.

Based on previous experience with major *Alvin* overhauls, we have planned six months (excluding sea trials) for this phase of the project. A detailed timeline of tasks is presented in Figure 4.

Throughout the construction process, crew training is conducted on a minimum of a weekly basis. These training sessions review work progress, new installations, and operational principles as they apply to the work being carried out and future anticipated science needs.

3.1.2.1 Demobilization and Disassembly of *Alvin*

Demobilization and disassembly will essentially mirror activities that are done during every *Alvin* major overhaul period. Once *R/V Atlantis* arrives in Woods Hole, *Alvin* and its shipboard shop and support equipment will be moved from the ship into WHOI's High Bay facility on the dock. Once setup is completed, a total strip down of the vehicle will begin. An 8 minute time-lapse movie is available for viewing at http://www.whoi.edu/page.do?pid=12775&tid=1061&cid=20837&cl=16857). Total strip down in 2006 took approximately ten working days. Activities include, but are not limited to:

- Relocation of support ship shops to temporary work vans in High Bay
- Relocation of all system spares to storage vans and High Bay
- Setup of temporary shops
- Removal of all skins and fairings
- Removal of all syntactic foam
- Strip out all internal sphere components
- Removal of all battery systems
- Removal of all VB system components
- Removal of all hydraulic system components
- Removal of all mercury and mercury trim components
- Removal of all pressure housings and cabling
- Removal of all j-boxes and cabling
- Removal of all propulsion system components

- Removal of all science sensors
- Removal and storage of old personnel sphere
- Removal of all other associated materials and fixtures to the bare frame
- Cleaning of the frame in preparations for transport to vendor service facility
- Storage of the old 4500 m personnel sphere
- Work package control documentation generation.

Once disassembled, the frame would normally undergo and complete inspection but, because significant frame modifications will be required to accommodate the new personnel sphere, the vendor performing those modifications will also do the general inspection as well.

3.1.2.2 Refurbishment, Servicing and New Construction

Following the complete disassembly of the vehicle, maintenance and servicing of reusable system components will begin. This includes but is not limited to:

- Teardown, servicing and reassembly of the VB system
- Teardown, servicing and reassembly of the Hydraulic system
- Teardown, servicing and reassembly of the Hg trim system
- Teardown, servicing and reassembly of the Main battery tanks and cells
- Teardown, servicing and reassembly of the Main ballast system components to be reused
- Teardown, servicing and reassembly of the life support system inspection and cleaning
- Teardown, servicing and reassembly of the ISE manipulator
- Teardown, servicing and reassembly of the Propulsion
- Unmodified frame section inspection and repair
- Lifting tee inspection and repair
- Service and emergency system releases
- Vendor service of Schilling manipulator
- Miscellaneous frame fixtures and bracket inspections and repairs
- Periodic ABS survey inspections and testing as required.

Other activities include:
- New hull birdcage fabrication and installation
- New skin fit ups
- New foam fit ups
- New main ballast system component fit up
- New sphere to frame modification fit up.

Inspection Reports (see IR's in the QA manual) are used as the controlling work package document and define the extent and compliance criteria of the system and sub-system work to be carried out, the Maintenance Manual procedure criteria to be used, and post-maintenance testing requirements. The ABS classification plan will also mandate any additional requirements for the scope of work that may be required over and above the established maintenance procedures.

Based on the maturity of the in-hull design, and the completeness of the mock-up, the ALOPS team electrical section will complete the assembly and wiring of the new sphere internals onto the bird cage. We plan to have the electrical wiring and panel installation complete and tested well in advance of the sphere installation onto the modified frame. Construction of new, and refurbishment of old, junction boxes and wiring runs will also be underway at this time. Once the sphere SPELCO is complete and tested, we will then have the capability to connect the bird cage, either via the new penetrators, or by penetrator adapters, to the external junction boxes and housings and perform a preliminary system "ring out".

Because we intend to have the in-hull layout fixed, and a majority of the in-hull mechanically outfitted in the mock-up prior to start of construction, the mechanical team will begin to duplicate and install frame structure into the new sphere. In concert with this effort, other team members will begin the refurbishment process of equipment intended to be cross-decked from the current systems to the upgrade. It is also anticipated that ABS will require a significant amount of pressure testing of existing housings for classification, as well as witnessing specific systems tests for acceptance as yet to be determined.

3.1.2.3 Assembly of the A-4500 HOV

Once the frame has been modified, accepted and returned by the vendor, we will begin the process of reassembly of the system components onto the vehicle. The assembly schedule will be dictated by many factors but the most significant will be ABS witnessed inspections. A clearer understanding of those requirements will be realized in the next several months. Dependent on the progress of bird cage electrical testing, the internal sphere systems may be fully installed prior to mating the new hull to the frame.

The assembly approach includes installing individual components on to the frame, as well as sub-assembly of systems that are then installed as a single unit. A SPELCO will be completed during this period so that final sphere component assembly (penetrators, viewports and fixtures) can be installed.

Activities include, but are not limited to:

- Installation of all skins and fairings

- Installation of all syntactic foam
- Installation of all internal sphere components
- Installation of all VB system components
- Installation of all hydraulic system components
- Installation of all mercury and mercury trim components
- Installation of all pressure housings and cabling
- Installation of all J-boxes and cabling, install all propulsion system components
- Installation of all science and submersible sensors
- Installation of new personnel sphere
- Installation of all other associated materials and fixtures to the bare frame
- Installation of all manipulators
- Installation of all viewports
- Installation of all penetrators
- Periodic ABS survey inspections and testing as required
- Completion and closure of work package control documentation.

The ultimate goal is to have the vehicle ready to commence Post-Overhaul Electrical Checkout (POELCO) by the end of the fifth month of the construction period.

3.1.2.4 High Bay Testing and Remobilization

Once a complete end-to-end submersible systems ring out with fully powered test (POELCO) is completed, detailed unmanned testing in the High Bay will commence to verify the habitability of the submersible prior to human occupancy. Once approved for human testing, a series of short and long "deck dives" are then conducted in High Bay. All testing is carried out by a qualified pilot in the sphere with either the Expedition Leader or Operations Group Manager in overall charge of the program. Only pilots, system engineers and certification inspectors will be allowed in the submersible during the sea trials program. The culmination of the High Bay test program will be ABS approval to begin tethered wet testing from the WHOI pier.

At this point, the A-4500 HOV, together with its shops and support equipment, will be loaded on to R/V *Atlantis*. Once everything is secure, the main battery tanks will be installed in the A-4500 HOV.

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float
Pre-Construction & Alvin Tear Down					
5200	Set Up High Bay	5	01APR11	07APR11	2
5210	Load Test High Bay Crane	5	01APR11	07APR11	2
5220	Set Up Outside Storage, Decking & Stairs	2	01APR11	04APR11	5
5230	Design Fixture for Personal Sphere	5	11DEC09	17DEC09	323
5240	Fabricate Fixture for Personal Sphere	10	01APR11	14APR11	2
5250	Offload Submersible & Complete High Bay Setup	5	08APR11	14APR11	2
5260	Tear Down Submersible	10	15APR11	28APR11	2
5270	Fabricate VB Storage Sphere	2	01APR11	04APR11	20
5280	Store Old VB Sphere	3	29APR11	03MAY11	2
5290	Store Old Personnel Sphere	3	29APR11	03MAY11	2
Maintenance, Construction & Refurbishment					
5300	Begin Maintenance	0	04MAY11		2
5302	Service Crossdeck Internal Components	30	04MAY11	15JUN11	7
5305	Refurbish: Power Pressure Housing (Bottle)	10	04MAY11	17MAY11	32
5310	Refurbish: Data Pressure Housing (Bottle)	10	04MAY11	17MAY11	32
5315	Refurbish: Existing Junction Boxes	25	04MAY11	08JUN11	32
5320	Refurbish: Main Ballast Tanks	30	04MAY11	15JUN11	12
5325	Refurbish: Existing Variable Ballast Spheres	30	04MAY11	15JUN11	31
5330	Refurbish Propulsion System	30	04MAY11	15JUN11	32
5335	Refurbish: Main Hydraulic System	30	04MAY11	15JUN11	32
5340	Refurbish: Mercury Trim System	30	04MAY11	15JUN11	12
5345	Refurbish Lead Acid Battery Box	30	04MAY11	15JUN11	2
5350	Refurbish: Manipulators	20	04MAY11	01JUN11	2
5355	Refurbish: Imaging Systems	30	04MAY11	15JUN11	32
5360	Refurbish: Science Interface Systems	30	04MAY11	15JUN11	32

Figure 4. Detailed Task Timeline for Construction of the A-4500 HOV

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float
5500	Inspect, Modify & Weld Frame	10	04MAY11	17MAY11	29
5510	Refurbish: Frame & Structural Components	10	04MAY11	17MAY11	29
Vehicle Assembly					
5440	Install Penetrators & Test Sphere	84	01SEP10	04JAN11	0
5520	Begin to Reconstruct (milestone)	0	18MAY11		29
5530	Install Frame Attachments - Tabs & Lugs	10	18MAY11	01JUN11	29
5540	Mount Sphere/Hull	2	02JUN11	03JUN11	29
5550	Schedule Contingency (if sphere doesn't fit)	10	06JUN11	17JUN11	29
5575	Test Fit New Variable Ballast Sphere	1	20JUN11	20JUN11	29
5580	Test Fit Foam	5	20JUN11	24JUN11	35
5590	Test Fit Main Ballast Tanks	5	20JUN11	24JUN11	35
5600	Test Fit Sail & Bath Tub	5	20JUN11	24JUN11	35
5605	Fit Up Skins	10	01JUN09	12JUN09	692
5610	Install Syntactic Foam	10	27JUN11	11JUL11	35
5711	Install: Existing Variable Ballast Spheres	20	21JUN11	19JUL11	29
5715	Install Crossdeck Internal Components in Birdcag	20	16JUN11	14JUL11	7
5800	Install: Power Pressure Housing (Bottle)	20	16JUN11	14JUL11	32
5900	Install: Data Pressure Housing (Bottle)	20	16JUN11	14JUL11	32
6000	Install: Junction Boxes	20	16JUN11	14JUL11	32
6100	Install: Main Ballast Tanks	20	16JUN11	14JUL11	12
6105	Install: Skins	10	15JUL11	28JUL11	22
6107	Install: Fairings	5	01JUN09	05JUN09	697
6109	Install: Sail	5	01JUN09	05JUN09	697
6200	Install: New Variable Ballast Spheres	20	15JUL11	11AUG11	12
6300	Install Propulsion System	20	16JUN11	14JUL11	32
6513	Disassemble (3) Lead Acid Cells	6	01JUN09	08JUN09	509
6515	Service Lead Acid Cells into Battery Box	45	16JUN11	18AUG11	2
6525	Assemble Lead Acid Batteries Into Alvin	5	19AUG11	25AUG11	2
7000	Install: Manipulators	20	02JUN11	29JUN11	2
7010	Install: Mercury Trim System	20	30JUN11	28JUL11	2

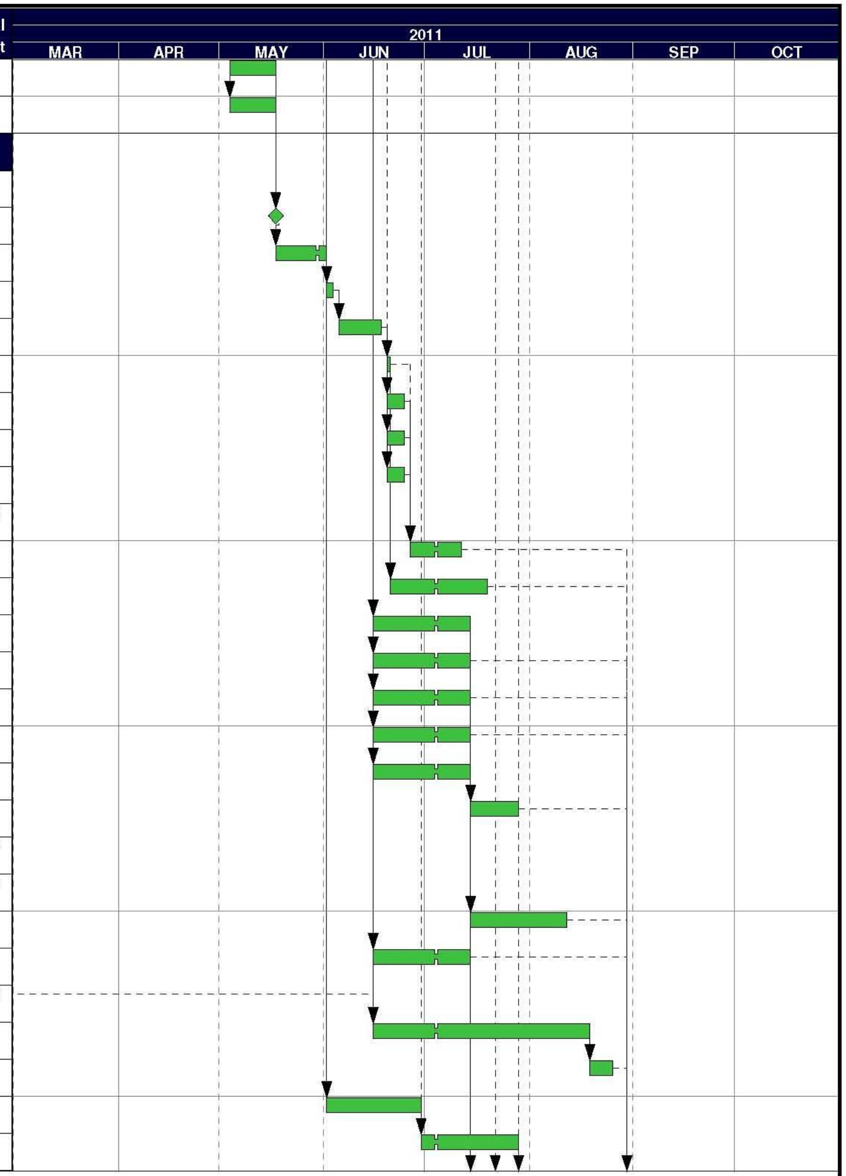

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Figure 4 (contd). Detailed Task Timeline for Construction of the A-4500 HOV

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float
7020	Install: Main Hydraulic System	20	29JUL11	25AUG11	2
7090	Fabricate Birdcage	10	01JUN09	12JUN09	530
7100	Load Birdcage in Hull	5	15JUL11	21JUL11	7
7200	Install: Life Support & Habitability	20	22JUL11	18AUG11	7
7300	Install: Imaging Systems	20	22JUL11	18AUG11	7
7400	Install: Science Interface Systems	20	22JUL11	18AUG11	7
7500	Complete Testing NEW 4500m Alvin Vehicle Systems	20	30AUG11	27SEP11	0

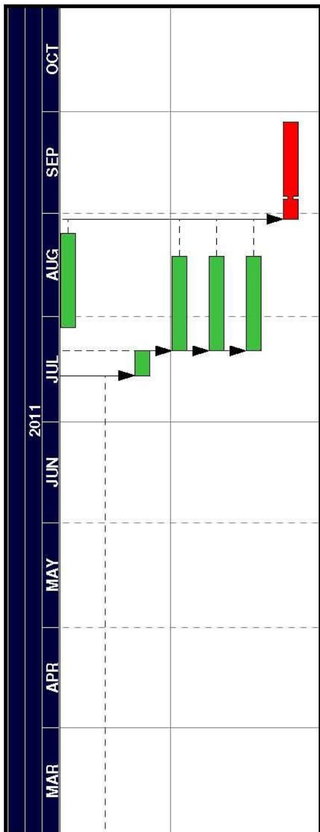

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Figure 4 (contd). Detailed Task Timeline for Construction of the A-4500 HOV

3.2 Testing Acceptance and Criteria

As dictated by engineering and ABS certification requirements, a comprehensive testing program will be carried out as part of the overhaul and transition program. Individual test criteria for systems and sub systems will be detailed in the certification plan or as part of the Inspection Report work package requirements. Testing definitions and requirements are detailed below. These will be revised and additional requirements added as the *A-4500 HOV Program Execution Plan (PEP)* develops.

3.2.1 Component Testing

Successful testing of an individual component piece, vendor unit assemble or joint assembly that will be incorporated into a unit sub-assembly, i.e., VB hydraulic control valves.

3.2.2 Sub-Assembly Testing

Successful testing of a series components assembled to form, but not necessarily comprise, a system assembly, i.e., the VB hydraulic valve box and pump.

3.2.3 System Testing

Successful testing of the complete hardware systems, sensors systems and associated software which makes up the entire system, i.e., the VB system.

3.2.4 System Monitoring and Support

Successful demonstrations of the system, or subsystem monitoring and support capabilities.

3.2.5 Certification Audits

Periodic audits by an independent internal committee will be conducted throughout the construction, testing and sea trial period in order to establish and confirm the initial system baseline will meet certification requirements.

3.2.6 Archive Capability

Archival of data products for legal and data retention purposes, as well as the WHOI system's ability to process data and replay products, must be demonstrated before commencing science operations.

3.2.7 Policies, Plans and Handbooks

Relevant user policies, various plans, maintenance and related documentation will be updated to incorporate changes related to the implementation of the A-4500 HOV Project and must be finalized before commencing science operations.

3.2.8 Technical Manuals

WHOI or contractor supplied technical manuals will be finalized and approved by Project Engineering, ABS or SE&OG before science operations begin.

3.2.9 Commissioning Software

The software version(s), revision number or the date of the software load, release, or build will be established to identify the commissioning software. The software release or build is defined as the minimum software required to meet the commissioning criteria of the WHOI system.

4.0 Testing and Sea Trials

It is anticipated that dockside trials will take 5-7 days before being ready to take the submersible away from the dock for harbor and shallow water trials. The tethered program will begin with surface trials to energize and run systems in a saltwater environment. Progressively, tests will move towards shallow tethered trim dives and inclining experiments. Again, with ABS approval, shallow water untethered dives will be done to test and prove systems integration and operations. Initial shallow dives will be conducted in Woods Hole harbor.

Open ocean trials, will take place in Bermuda, beginning with a series of shallow water dives of 50 to 300 meters. This allows easy tracking and works the oil compensated systems prior to deeper depths. It will also allow the pilots additional training and familiarization time in a relatively controlled environment prior to proceeding to deeper water. We expect this to take about 5-7 days of the sea trial program following a 3-day transit from Woods Hole to Bermuda.

Deepwater testing and trials, 300 to 4500 meters, off Bermuda begins with a series of progressively deeper dives. Two qualified pilots, or a qualified pilot and highly experienced pilot in training, are required to be in the submersible during this phase of testing. The third dive seat will be either an engineer or ABS observer. The submersible is launched in relatively shallow water (300 to 500 meters) and is driven slowly down slope stopping at pre-determined depth intervals to conduct atmospheric and system tests. The start point for the next dive is

generally a depth slightly shallower that the end point of the previous dive. Barring unforeseen problems with these test dives, we would expect to achieve final certification depth in 7-10 days. Once reaching the Stage 1 classification depth of 4500 meters, the remainder of the program will revolve around final ABS classification and deep water submersible and science system testing. A more detailed sea trials description can be found in the Transition To Operations Plan.

5.0 WHOI In House Shop Facilities

5.1 Shop Capabilities

The WHOI Mechanical Services Group is located on the Iselin Pier with over 16,000 square feet of floor space, plus a smaller satellite shop on the Quissett Campus.

Working with other engineering groups at WHOI, this shop has taken many underwater vehicle systems from concept to completion. This includes: *Jason 2*, *ISIS*, *ABE*, *Sentry*, *Nereus*, and numerous REMUS vehicles. The WHOI Mechanical Services Group will be utilized throughout the overhaul period in support of this project.

5.2 Weld & Fabrication Shop

This shop has four full time certified welders, and one apprentice welder. In addition to the equipment listed below. The shop has an extensive range of specialty titanium welding gear, including vacuum chambers, flooded argon tables and portable argon purge blocks.

Fabricating Equipment:

Marvel series 8 Mark 3 Vertical Band saw with 18” x 22” capacity
Ercolina 3 wheel pipe and angle roll
Hossfield Pipe and Tube bender
Cincinnati 150 ton press Brake
Cincinnati 48” Hydraulic Plate Shear
Cincinnati 48” plate roller
Demler 500 x 1000 precision Weld fixturing tables (two each)

5.3 Machine Shop

This shop is staffed by eight full time machinists and specializes in prototype machining with some emphasis on light to moderate production work.

Machining equipment:

Stratasys Titan FDM rapid prototyping machine
OMAX 55 x 110 waterjet cutting machine
CNC 3 axis Bed Mill (two each)
CNC 2 axis Knee Mills (three each)
Manual Bridgeport milling machines (two each)
CNC lathes (two each)
Manual Lathes (six each)
Hardinge precision Tool Room lathes (three each)
CMM inspection arm on 36” x 48” precision granite Table

5.4 Mechanical Technicians

Staffed by four technicians, these personnel, who specialize in the assembly and maintenance of underwater vehicles and handling systems along with other complex mechanical equipment, are well equipped to measure, make and install hydraulic hose and tube assemblies. This group also offers at-sea support of mechanical systems.

6.0 Abbreviations

AE	Architect and Engineering Firm
ALOPS	ALVIN At Sea Operations Group
CDRL	Contract Data Requirements List
CFR	Code of Federal Regulations
COTS	Commercial Off The Shelf
CSP	Certified Safety Professional
DID	Data Item Description
DOD	Department of Defense
DoDI	DOD Instruction
DOR	Determination of Readiness
DOT	Department of Transportation
ECP	Engineering Change Proposal
ECA	Engineering Change Authorization
ECPSHSR	Engineering Change Proposal System Health and Safety Report
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
EH&S	Environmental Health & Safety
FDR	Final Design Review
GFE	Government-Furnished Equipment
GFP	Government-Furnished Property
GIDEP	Government-Industry Data Exchange Program
HHA	Health Hazard Assessment
HHAR	Health Hazard Assessment Report
HRI	Hazard Risk Index
IRS	Interface Requirements Specifications
IO	Integrating Organization
ISSPP	Integrated System Safety Program Plan
MA	Managing Activity
MIL-STD	Military Standard
MRAR	Mishap Risk Assessment Report
NavSea	Naval Sea Systems Command
NDI	Non-developmental Item
NSF	National Science Foundation
O&SHA	Operating & Support Hazard Analysis
OPR	Office of Primary Responsibility
OSHA	Occupational Safety and Health Administration

OSSE	Operational Site Support Equipment
PDR	Preliminary Design Review
PE	Professional Engineer
PHA	Preliminary Hazard Analysis
PHL	Preliminary Hazard List
PM	Program Manager
P/N	Part Number
POELCO	Post Overhaul Electrical Check Out
RFP	Request for Proposal
R/V	Research Vessel
SAR	Safety Assessment Report
SCCSC	Safety Critical Computer Software Components
SCN	Specification Change Notice
SDR	System Design Review
SE&OG	Submersible Engineering & Operations Group
SHA	System Hazard Analysis
SHRI	Software Hazard Risk Index
SOW	Statement/Scope of Work
SPR	Software Problem Report
SRCA	Safety Requirements/Criteria Analysis
SRR	System Requirements Review
SRS	Software Requirements Specifications
SSG	System Safety Group
SSHA	Subsystem Hazard Analysis
SSPP	System Safety Program Plan
SSPPR	System Safety Program Progress Report
SSR	Software Specification Review
SSS	System/Segment Specification
SSWG	System Safety Working Group
TBD	To Be Determined
TLV	Threshold Limit Value
WDSSR	Waiver or Deviation System Safety Report
WHOI	Woods Hole Oceanographic Institution