6500m HOV Project
Stage 1: A-4500 HOV

Transition to Operations Plan

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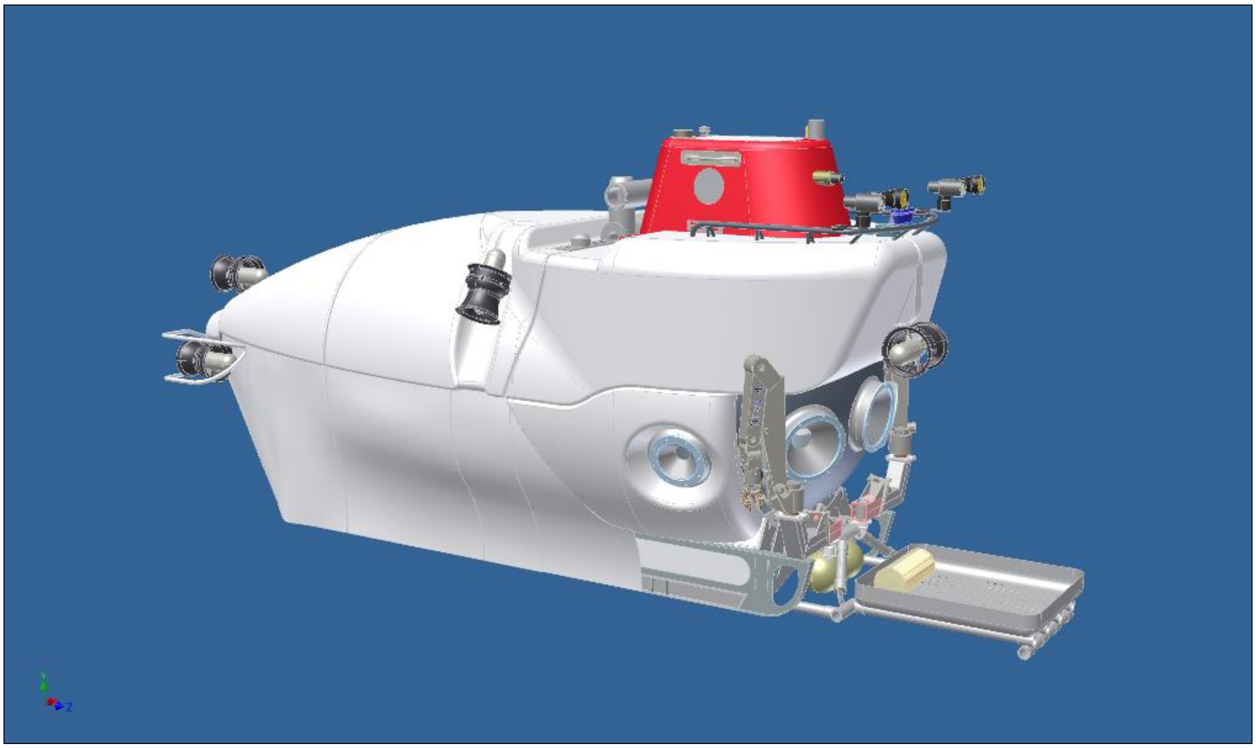

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1.0 Introduction

This Plan for Transition to Operational Status establishes the methodology, procedures and processes by which the A-4500 HOV will be brought into operations for the scientific community. Transition to operations will commence following the completion of the construction stage of this project when acceptance trials for ABS classification and science acceptance trials take place.

Abbreviations used in this document can be found in Appendix 1.

2.0 Definitions

Acceptance
The act of acceptance constitutes written acknowledgment by an authorized Woods Hole Oceanographic Institution (WHOI) representative that the equipment/materials and supplies and/or services offered to WHOI conform with applicable contract or sub-award quality, quantity, performance, and specification requirements and are subject to, and conform with other terms and conditions of the contract or sub-award. Acceptance may take place before delivery, at the time of delivery, or after delivery, depending on the provisions of the terms and conditions of the contract or sub-award. Equipment/materials and supplies and/or services shall ordinarily not be accepted before completion of all quality assurance actions. Acceptance shall be evidenced by execution of an acceptance certification letter signed by a duly authorized representative from WHOI. (Note: for complete contractual requirements, see sub-award agreement.)

Activation
The point in time when A-4500 HOV systems are fully integrated with interfaces, tested and accepted by the American Bureau of Shipping (ABS) and/or Director of Contracts and Grants, and the system is in use by user personnel. Activation is normally the final phase of the sea trials operations.

Commissioning
A systematic process (milestone event/test) of ensuring through validation and verification that new integrated systems perform according to the documented design and the operational needs, and that specified system documentation and training are provided to the operations and maintenance staff. It also defines the transfer of responsibility from the engineering domain to the operations domain.

The following criteria are required for commissioning:

– Configuration item(s) delivered and fully accepted.
– All support systems for operations and maintenance of the configuration item(s) are in place.
– System capable of operating in a "steady state" mode.

Determination of Operational Readiness (DOR)
Period of time after acceptance and before commissioning when the A-4500 HOV system, or subsystems, are in use for purposes of user, operator and maintenance personnel training and familiarization, and for its evaluation against established commissioning evaluation criteria. A science non-critical cruise following the sea trials will be conducted to test all regimes of operations and serve as the platform for DOR prior to science critical cruises.

Responsibility for Acceptance
Acceptance of supplies or services is the responsibility of the Contracting Officer Technical Representative (COTR). When this responsibility is delegated to a COTR or to another person or entity, acceptance by that person is binding.

Transfer of Title and Risk of Loss
Title to supplies shall pass to National Science Foundation (NSF) upon formal acceptance, regardless of when or where WHOI takes physical possession. Unless the contract or sub-award specifically provides otherwise, risk of loss of, or damage to, supplies shall remain with the contractor until, and shall pass to WHOI upon, formal acceptance by WHOI.

3.0 Overview

The transition to operational status for the A-4500 HOV will begin well before the actual construction phase of the project begins. Transition of itself dictates that current operational crew members be continually informed and have an opportunity the express views and offer opinions of the A-4500 HOV in the design stage as it relates to future operational requirements, maintainability and reliability. Since the project’s inception, the operational team 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 make operational cruises as part of the Submersible Engineering & Operations Group (SE&OG) requirements. Shore-based staff make, at a minimum, yearly cruises to stay current with operational philosophies and methods. Additionally, when opportunities are available, the operations crew has, and will continue to review designs, and make vendor facility visits during component construction and testing phases. Actual visits to vendors currently involved in hull construction have been limited because of operational commitments but, to date, operations team members have participated in Lockheed design reviews and visited Ladish Forging to see the facilities and witness the hull forging. It is hoped, and planned, that operation team members will also have the time and opportunity to attend phases of the hull welding, annealing and pressure testing.

Under the original transition concept, Lockheed Martin Riviera Beach would have built and delivered an operable submersible. Because members of the operations crew would not have been involved in the construction of the vehicle, a six month transition and training period would have been necessary to allow the operations crew to learn new systems and equipment maintenance requirements prior to the start of science operations.

Based on our experience with the time it takes to complete *Alvin* overhauls, assembly of the A-4500 HOV at WHOI is scheduled to take six months, with the transition to operations taking an additional two months for trials and testing. However, because 1) the operations team will be the primary source of manpower during the construction, and 2) many of *Alvin's* systems will be utilized on the A-4500 HOV, the operations team will, in essence, be doing the same kinds of transitional training as would have been required for a vendor-constructed vehicle. In addition, they already have an advanced working knowledge of the existing systems. A significant advantage of this plan is that the experience and knowledge gained by having the operations team doing the construction will be invaluable to the future science needs and safe operations.

Experience in the past has demonstrated that the NAVSEA certification process after an *Alvin* overhaul takes about 14 days, but because of new ABS classification and new systems integration, we estimate that 30 days will be warranted and required. Additionally, following the formal ABS classification, a science acceptance and shakedown cruise will take place and will require an additional 21 to 28 days.

The SE&OG, the eventual operators of the vehicle for the National Deep Submergence Facility, consists of a shore-based management and engineering team, and an at-sea operations team. The shore-based personnel structure consists of a Program Director, Operations Manager, Submersible Operations 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. From this pool of shore-based and at-sea personnel, more than 80% of the SE&OG have participated in the last six overhauls spanning more than 20 years.

Because the operations team will eventually be solely responsible for the repair, maintenance and operations of the vehicle, it is intended that they will perform the majority of the vehicle assembly. This philosophy in past overhauls has made the team extremely knowledgeable about the vehicle on a system and sub-system level. Such knowledge has been critical to *Alvin*'s past operational and reliability record and will significantly shorten the Transition to Operations period that would have otherwise been required.

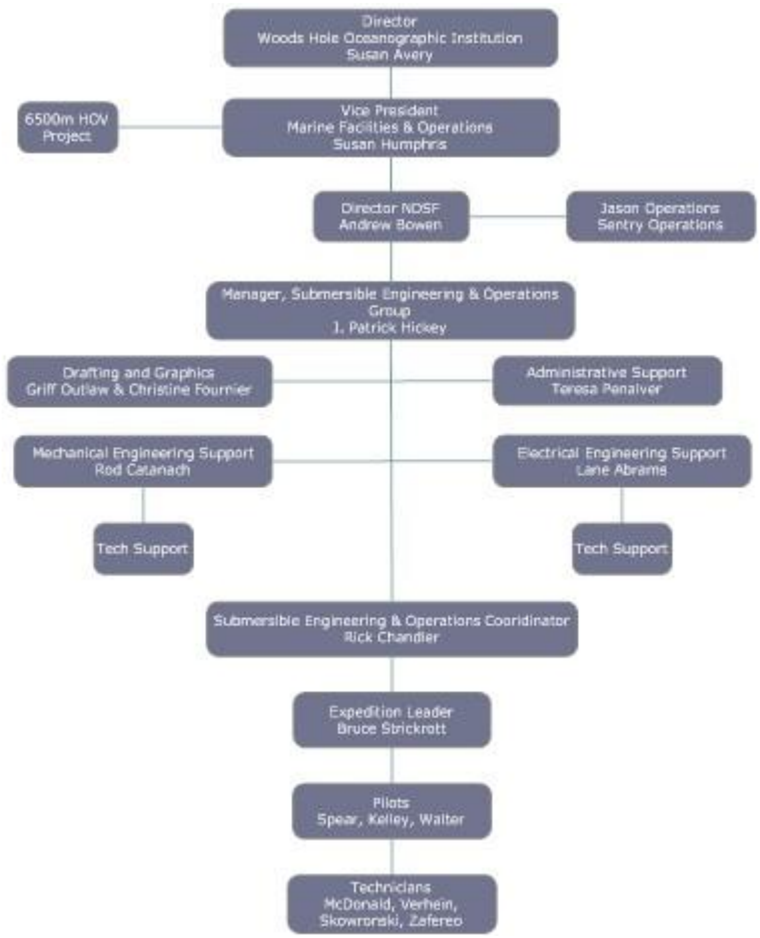

Figure 1. Organizational Structure of the Submersible Engineering and Operations Group

3.1 Initial Transition and Testing

At approximately the 90% point of physical completion of the A-4500 HOV, the full submersible Post Overhaul Electrical Check Out (POELCO) is started. This is expected to be during Month 6 of the assembly period. Once completed, the vehicle moves into the sea trial phase of classification. This process begins with detailed unmanned testing in the High Bay 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 the 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 classification inspectors will be allowed in the submersible during the testing program. The culmination of the High Bay test program will be ABS approval to begin tethered wet testing from the WHOI pier.

The tethered program will begin with surface trials to energize and run systems in a salt water environment. Progressively, tests will move towards shallow tethered trim dives and inclining experiments. With ABS approval, shallow water untethered dives will be done to test and prove systems integration and operations. It is anticipated that dock side trials will take 5 to 7 days before being ready to take the submersible away from the dock for harbor and shallow water trials. 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 five to seven days of the sea trial program with a three day transit from Woods Hole to Bermuda.

3.2 Transition Testing Acceptance and Criteria

As dictated by engineering and ABS classification requirements, a comprehensive testing program will be carried out as part of the transition program. Individual test criteria for systems and sub systems will be detailed in the classification 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 Program Execution Plan (PEP) develops.

3.2.1 Component Testing

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

3.2.2 Sub-Assembly Testing

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

3.2.3 System Testing

Successful testing of the complete hardware systems, sensors systems and associated software that make up the entire system; e.g., the VB system.

3.2.4 System Monitoring and Support

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

3.2.5 Physical and Configuration Audits

A designated body (TBD) will perform either or both of these audits during the testing and sea trial phase in order to establish or confirm the initial system baseline.

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 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 and/or WHOI's 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.

3.3 Operational Crew Training

Crew situational awareness and training is constantly carried out at sea and during overhaul periods. Not only is this good practice, but also is mandated by the certification agencies so that operational personnel can, and do, maintain a level of knowledge and skill cognizant with the need to operate the vehicle and associated systems in a safe and effective manner. Based on our experience with *Alvin* overhauls, the crew and engineering staff for the A-4500 HOV will meet once a week and have formal training on specific subjects. As completion nears, those sessions may be broken into smaller groups with emphasis on specific subjects. All training is mandatory and failure to attend can and will result in a particular individual's loss of piloting privileges. As the system designs develop and progress during the pre-construction process, system engineers will be required to develop training guides and curricula specific to those new systems as part of the overall engineering package.

During harbor and open water sea trials, the SE&OG Manager and *Alvin* Expedition Leader will be designated as the Chief Test Pilots because of their combined operational experience and time. It will be their responsibility to ensure that the remaining pilots are adequately prepared to operate the vehicle as Pilot in Command. Until such time that the sea trials are completed, accepted and the vehicle is ABS classified, all diving operations will have one of the Chief Test Pilots and either a qualified pilot or advanced pilot-in-training present in the submersible. The third seat will be designated for a systems engineer, classifying agency inspector, operations or design team member.

4.0 Sea Trials Agenda and Acceptance

Formulation of a Sea Trials Agenda Plan will be based on historically successful previous sea trials, mandatory ABS Classification Plan requirements, and any other requirements of Federal, State or Local requirements that might be applicable.

In water Sea Trials will commence following successful completion of all prerequisite testing as a result of the maintenance, system modifications, and successful controlled dry environment testing conducted in the High Bay and with ABS concurrence.

A sample Sea Trials Agenda Plan, developed and utilized for the 2006 *Alvin* overhaul, will serve as the template for this project. It is available at the Preliminary Design Review secure website.

4.1 Woods Hole Harbor Trials

The new A-4500 HOV will be moved back aboard R/V *Atlantis* following the dry High Bay testing and confirmation of vehicle fit, both to the vessel's A-frame and the service hangar, will be made. The main batteries will then be re-installed and, while still tied to the WHOI pier, a series of controlled tethered lowerings from the submersible's launch and recovery A-frame will be made. Foremost among these first dives is to conduct inclining experiments to verify the weight and stability calculations, both surfaced and submerged, before the submersible is allowed to "free swim". Also conducted during these first tethered dives is a full operational power up and systems operation of the vehicle.

With ABS approval, the vehicle will continue with a series of shallow untethered harbor dives in Woods Hole to continue testing of the systems and to familiarize the pilots with new devices and equipment. As stated in Section 3.3, the SE&OG Manager and ALVIN Expedition Leader, will be designated as the Chief Test Pilots.

In concert with these dock trials, the A-4500 HOV shops and system spares will be re-mobilized back aboard R/V *Atlantis*.

4.2 Bermuda (St. Georges) Harbor Trials

Once a determination is made that the vehicle is performing as expected, sea trial operations will then move to Bermuda in preparation for open ocean testing. Bermuda is the test port of choice because it has sheltered water locations around the island, easy and quick access to progressively deeper water up to the required depths for classification, and regular international airline flights so that parts and personnel can be acquired as needed during the trials process.

On arrival in Bermuda, untethered harbor testing will be continued in the slightly deeper depths of that location, primarily for sonar and acoustic communications tests. Additional stability testing, as required by ABS, will also continue as needed.

At the same time, the rescue vehicle will begin a series of trials and proof of concept in a progressively deeper series of tests which will be parallel to, or slightly deeper than, test depths of the submersible at any given time.

4.3 Bermuda Open Water Trials

On completion of the harbor testing phase, trials will move into open water beginning with day trips from St. Georges to shallow water (25 to 100 meters) on the northern end of the island in relatively sheltered waters. The primary goal in the shallow water phase is to verify complete system operability in "safe haven" depths while also allowing oil-compensated components and cabling to acclimate to progressively high ambient water pressures. It also allows progressive testing of the watertight integrity of pressure vessel seals.

Following a short number of shallow water dives, the submersible will be moved to slightly deeper water on the island slopes (200 – 250 meters). From this point, the vehicle will be driven down slope to deeper waters during the course of any particular dive, typically 750 – 1000 meter depth gains per dive. At specific intervals during the down slope excursions, the vehicle will be stopped and a full systems operational check will be performed. Subsequent dives will start at a slightly shallower depth than the ending depth of the previous dive, and the incremental depth increase will continue. At specific depth benchmarks, it is anticipated that ABS inspector(s) will be required to observe and agree that testing requirements to that point have been met before continuing as part of the open water classification plan.

Once dives to water depths of 3,000 to 3,500 meters have been accomplished, multi-day excursions from St. George will be required because of support ship transit times to the deep water areas.

Final culmination of the sea trials will involve dives to operational depth by ABS and the issuance of a classing certificate for the vehicle. Receipt of the class certificate from ABS will be considered the milestone point of the Activation process.

Once this requirement has been met, additional diving will be done as part of the pilot currency and certification process. The Chief Test Pilots will observe dives made by the remaining certified pilots, and certify them as qualified to operate the new vehicle as Pilot in Command for single pilot operations. Any remaining open water test time will be utilized for further systems operability verification, commencement of science equipment interface verification, navigation testing, pilot in training dives, and continued support ship personnel training.

5.0 Rescue Vehicle Training and Operations

A key design factor of the new personnel sphere is that it will no longer be releasable from the main submersible structure as a final emergency personnel recovery measure in case of vehicle stranding on the sea floor. Because of this, a rescue system vehicle is currently in design and fabrication at WHOI. Funded under NSF Grant #OCE-0513945, the preliminary vehicle design has been completed and multiple components purchased (Figure 2). While it is anticipated that this rescue system will be in operation well before the start of the assembly phase of the A-4500 HOV, it will be required to be tested as part of the final ABS classification requirements; thus, it is included in the Transition to Operations Plan.

This rescue system will be installed aboard R/V *Atlantis* and become a permanent part of the submersible system support equipment. It will be operated and maintained by the A-4500 HOV operations crew and be purpose-specific – that is, ABS will require that the rescue vehicle be operable at all times in order to conduct submersible diving operations. Hence, no other use of the rescue vehicle will be allowed. Pre-cruise and weekly checks of this rescue vehicle system will be required as part of the overall submersible periodic checks.

In concert with the detailed submersible sea trials and acceptance, demonstration of the rescue vehicle capabilities will be held in parallel with the open water sea trials of the submersible. These tests and trials will be conducted as part of night operations and will establish the rescue system's operability on deployed test bed weights up to full classification depth.

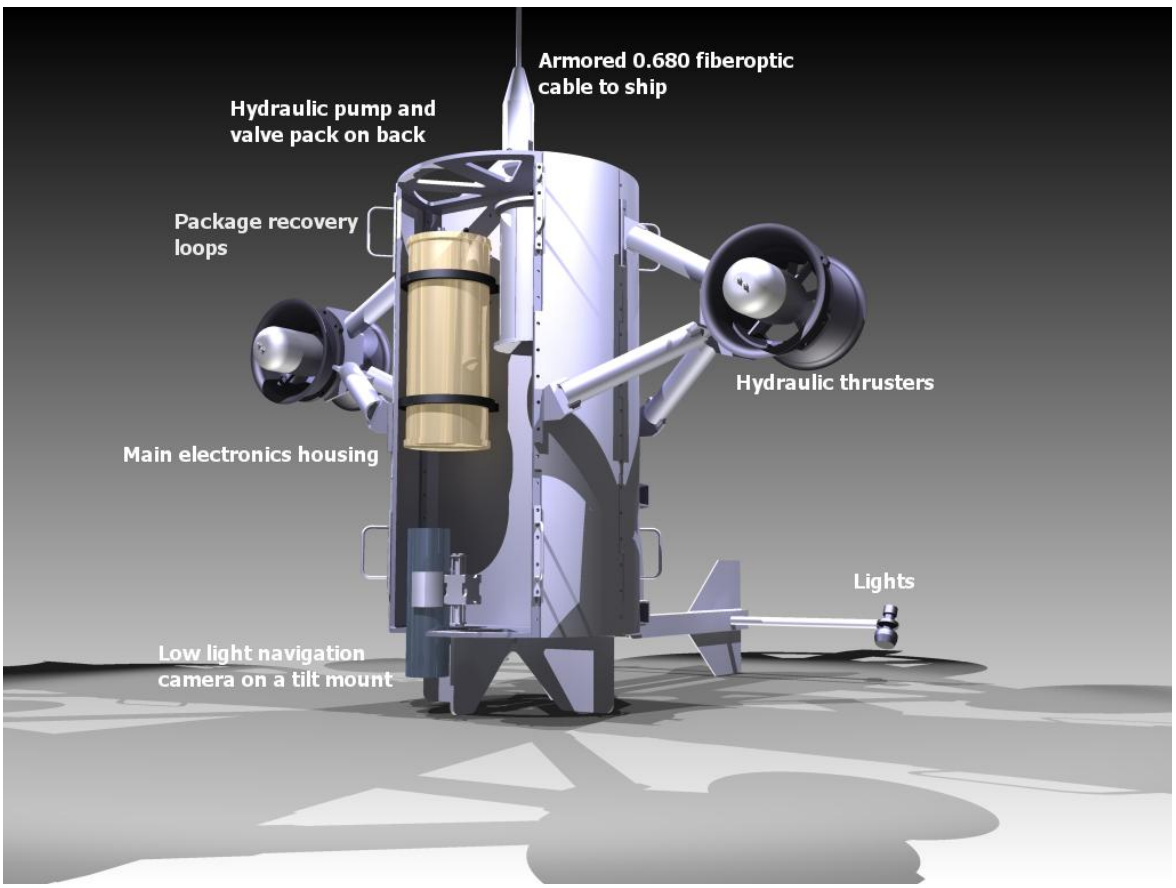

Figure 2. Preliminary Design of the Rescue Vehicle

6.0 Science Acceptance Trials

Following ABS Sea Trials and system classification, a comprehensive science Sea Trials program will be carried out to verify the operability and viability of the submersible systems to support the science user end goals. WHOI's Chief Scientist for Deep Submergence will lead the effort to design and propose a research cruise that tests the seven scientific capabilities identified as critical to science operations (i.e. observations, imaging, exploration, surveying, sampling, interacting with instrumentation, transiting). These trials will be multidisciplinary in nature to ensure the full spectrum of past and future science users and their requirements can be supported. This will also serve as a means for further practice and training in an operational environment for the pilots and technicians who will operate and maintain the vehicle system on behalf of the NDSF. The culmination of this Acceptance Trials program will be a Determination and Statement of Operational Readiness, at which time the vehicle and all support systems will be commissioned.

6.1 Science Trials Agenda Outline

As part of demonstrating the vehicle's readiness for science operations following sea trials and ABS classification, certain specific goals will be completed as part of a separately funded science acceptance program.

1. Reach the maximum depth of 4500 m.
2. Demonstrate the capabilities of the vehicle – from simplest tasks up to, and including, the most complex for which it has been designed.
3. Explore the operational capabilities from the simplest flat bottom locations up to seafloor hydrothermal vent sites – some of the most demanding locales for deep submersible science.
4. Conduct initial science trials close to WHOI, as well as Bermuda or other commercially accessible (airline) port, in a setting that allows easy returns to port both for (a) costs of participating science party and (b) in case of unanticipated technical needs.

To accommodate all of the above, we plan to build upon a proven cruise scenario that was developed for the UK's *Isis* ROV program which enabled both pilots and scientists to become familiar with that vehicle's capabilities following the technical trials cruise on R/V *Atlantis* in the Tongue of the Ocean (2003). The ship will sail from Bermuda towards the Azores and known vent sites at similar latitudes. Rainbow hydrothermal vent area at 36°N and, alternatively, Lucky Strike at 37°N, are both viable and useful to visit scientifically for time-series studies.

While still on Bermuda's outer flanks, and then continuing to water depths of <4500 m, the A-4500 HOV will be deployed on flat, featureless sedimented abyssal terrain. This will allow:

- Scientists their first opportunity to trial in-ball ergonomics
- Observations through front and side viewports, including first-ever overlap in field of view on an unvisited site. This will allow assessment of the exploration capability.

- Assessment of cameras and other sensors in terms of science controls and interfaces in a non-critical setting with time for trial and error without missing something exciting as might be the case at a more dynamic site (e.g., a vent).
- Collection of metadata for post-dive QC processing of *in situ* sensors, video and still camera data, and submersible systems data.
- Completion of a RESON bathymetric survey on flat terrain so that artifact interference is minimized, in concert with both long baseline (LBL) and ultra-short baseline (USBL) submersible and support ship navigation systems.
- Testing of manipulator envelopes for science by push coring, suction slurps, and science equipment deployments and retrievals.
- If biology is present, testing of manipulators to collect animals and place in bio-boxes or samplers as appropriate.

Following successful completion of abyssal plain dives, diving will move closer to the ridge crest onto rocky terrain or the flanks of a seamount. The science testing program will continue demonstrating further abilities to:

- Work in hard substrates more typical of seamount and ridge environments and margins. Sediments found here are more familiar for people working on margins and, in future, on abyssal plains.
- Conduct mapping over more complex terrain.
- Collect a wider range of biological organisms by additional use of slurp-pumps.
- Collect rocks for first time.
- Continue trials of cameras on sites that have more complex topography and, probably, more photogenic biology.

The final phase of the science acceptance trials will take place at previously well-explored hydrothermal vent sites where already proven and now familiar tasks completed on the abyssal plains and rocky terrain will be repeated in addition to the following:

- Conduct further maneuvering tests and operations around difficult terrain (chimneys).
- Ascertain how well new in-hull navigation and control systems work to drive the submersible to known geographic locations, and to return to specific sites.
- Check additional standard equipment from NDSF not already demonstrated – notably T-probes, but also other bio-samplers not as yet used, and further manipulate scoops and different slurp samplers.
- Collect hydrothermal vent fluid samples using standard *Alvin* procedures and science-supplied samplers.
- Demonstrate the manipulators' ability to collect friable chimney samples.

At the completion of the science trials cruise, the submersible will be commissioned into science operational readiness status. The support vessel, R/V *Atlantis*, will return to a port of convenience and the submersible will be ready to commence science operations for the U.S. scientific community.

7.0 Current and Future Budgetary Considerations

Throughout the 45+ years of operations, the *Alvin* Submersible Engineering and Operations Group (SE&OG), under the auspices of the National Deep Submergence Facility, has provided the science community deep oceanographic access with economy. While *Alvin* has aged gracefully over the last 45+ years, a poll of science community users conducted beginning in 1999 (Summary of Deep Submergence Community Questionnaire on Improved Submersible Capabilities), set the baseline for future use, needs and capabilities of a Human Occupied Vehicle (http://www.unols.org/committees/dessc/replacement_HOV_/replacement_hov.html). A second study published in 2004 (Future Needs In Deep Submergence Science by the National Research Council) stated "NSF/OCE should construct a new, more capable HOV…. Capable of operating at significantly greater depths (6,000 meters plus) should be undertaken only if additional design studies demonstrate that this capability can be delivered for a relatively small increase in cost and risk".

7.1 Historical Budgetary Information

Since 2000, the ten year average operational cost, as shown in Figure 3, has been $2.2M. Figure 4 shows the number of funded days for each of those years.

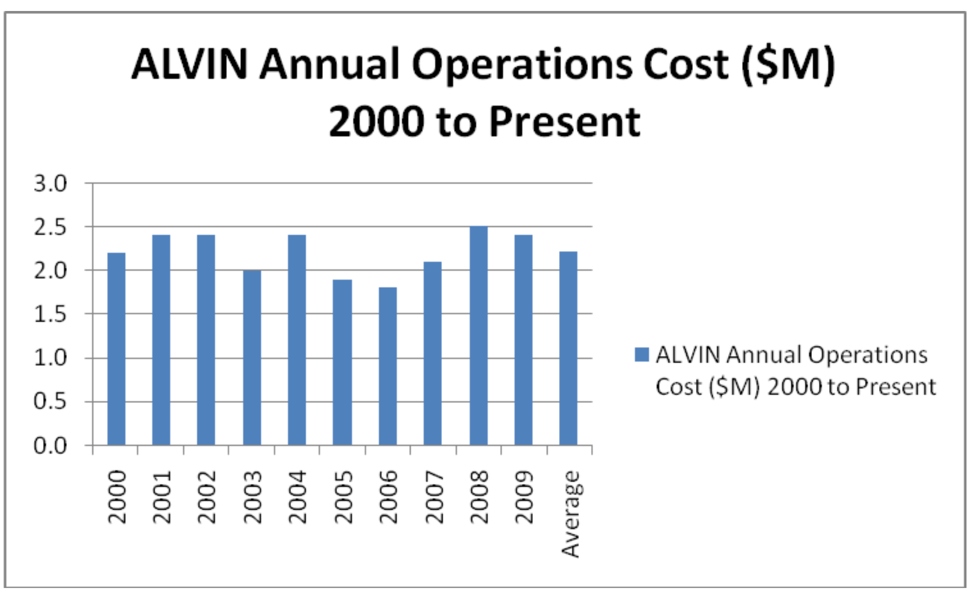

Figure 3. Annual Operations Costs for HOV *Alvin*

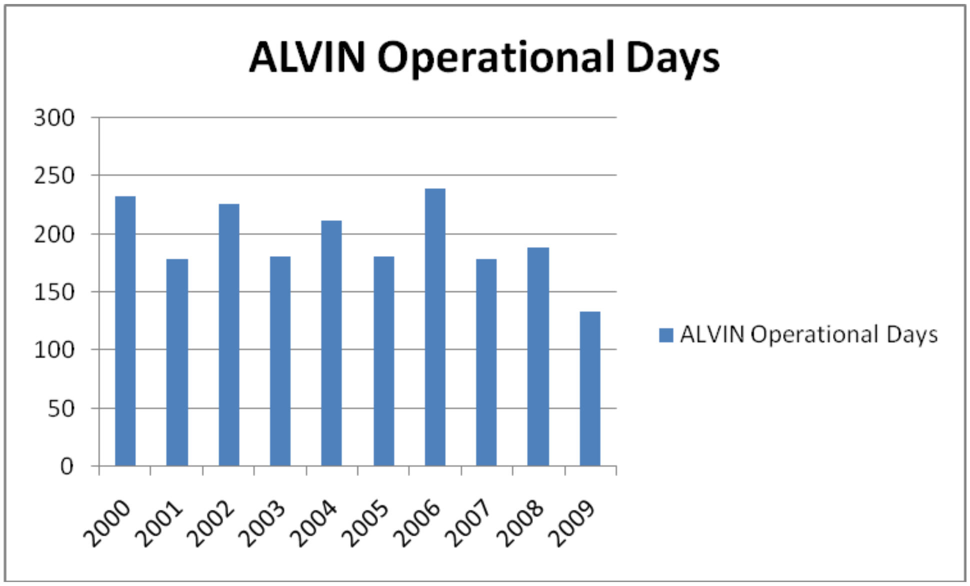

Figure 4. Annual *Alvin* Operational Days

This historical data is used in the section below to develop an estimated operating budget for the A-4500 HOV beginning in 2012.

7.2 Future Budgetary Estimate Information

Table 1 below presents an estimated annual operating budget for the A-4500 HOV. One of the operational requirements of the new vehicle was an operational support team similar in size to that for *Alvin* so that future operations would incur cost and logistical levels similar to those for the current vehicle. This goal is achieved, and personnel costs continue to make up the major portion of the budget.

The total operating cost of $2.54M is not significantly different from the projecting operating costs of the current vehicle *Alvin* of $2.4M assuming inflation of 3%. Because the A-4500 HOV will largely be made up of existing systems, only two factors have any significant impact on current and future budgeting: (1) Sustaining ABS classification and (2) Recording media for upgraded camera and digital multibeam mapping systems.

Currently, Naval Sea Systems Command (NAVSEA) assumes all costs of certification and classing for the *Alvin*. These costs have been transparent in terms of funded costs. Classification by ABS will incur additional costs for annual and special (every three years) sustaining surveys and certification. A poll of other facility operators – HURL, HBOI and Hard Suits International, and others – has shown that there is a great range of costs incurred by them to maintain their ABS classification. A high mean average of those classification costs results in our estimates of $15,000 for an annual survey and $35,000 for the three year special survey following construction. These costs are near transparent when compared with the historical funding levels of the last ten years.

Data media for the multibeam profiler, which generates, on average, 5 GB of data per dive in its simplest configuration, will have some impact. The simplest solution is to download data to portable terabyte hard drives that currently cost on the order of $250 - $300 per drive. This will require supplying three drives per cruise leg: a ship master copy, science copy, and archive copy. In the course of a typical operations year, where 12 cruises are funded, this translates into a cost of approximately $10,000 per year.

The greatest budgetary impact will be seen with the imaging systems. Current upgrade plans are not yet defined as to the format to be used. Current video recording media costs based on 150 dives per year (ten year average) are $52,500 per year. High definition media under consideration for use in the A-4500 HOV is slightly more than twice the present cost.

Table 1. Estimated A-4500 HOV Operations Budget for 2012

I. Salaries and Wages

Personnel	Title	Person Years
A. Bowen	Director, NDSF	0.083
P. Hickey	Manager, SE&OG	0.833
T. Penalver	Project Administrator	0.667
R. Chandler	Submersible Operations Coordinator	0.833
L. Abrams	Lead Electrical Engineer	0.500
R. Catanach	Lead mechanical Engineer	0.500
G. Outlaw	Mechanical Engineer/Designer	0.500
C. Fournier	Drafting Technician/Designer	0.917
A. Billings	Mechanical Technician	0.333
H. Popenoe	Electrical Technician	0.333
S. McCue	Data Manager	0.083
B. Doherty	Drafting Technician/Illustrator	0.250
K. Huang	Computer Specialist	0.250
W. Strickrott	Pilot/Expedition Leader	0.667
M. Spear	Pilot/Mechanical Technician	0.667
S. Kelley	Pilot/Electronic Technician	0.667
D. Walter	Pilot/Mechanical Technician	0.750
J. McDonald	Pilot/Mechanical Technician	0.750
M. Skowronski	Pilot/Electronic Technician	0.750
A. Zafereo	Electrical Technician	0.883
K. Verhein	Electronic Technician	0.883

TBH	Mechanical Technician	0.883	
TBH	Electrical Technician	0.883	
Person Years		12.929	
Total Salaries and Wages adjusted for 2012 rates			$1,548,993
II. Repairs and Maintenance (based on 2008 & 2009 average)			
A. Normal Repairs		$115,000	
B. Major Equipment Repairs & Replacements		$ 25,000	
C. Science Equipment Maintenance		$ 25,000	
Total Repairs and Maintenance		$165,000	
Total Repairs and Maintenance w/inflation 3 yrs @ 3%/Yr			$180,299
III. Other Expenses			
A. Fuel			
B. Food			
C. Insurance P&I		$ 45,000	
D. Consumables (based on 150 dives):			
Ballast Steel		$ 12,000	
CO_2 Removal Chemicals		$ 7,500	
Imaging Media		$113,700	
Data Media		$ 10,000	
Compensation Fluids		$ 10,000	
Acoustic Navigation Supplies		$ 3,500	
E. Travel		$ 72,000	
F. Miscellaneous		$ 41,000	
G. Training		$ 10,000	
H. ABS Survey Fees		$ 15,000	
I. Indirect Costs		$403,000	
Total Other Expenses		$742,700	
Total Other Expenses w/inflation 3 yrs @ 3%/Yr			$811,568
Total Estimated A-4500 HOV Budget			**$2,540,860**

Appendix 1. Abbreviations

AE	Architect and Engineering Firm
ALOPS	*ALVIN* Operations Group
AUP	*ALVIN* Upgrade Project
CDRL	Contract Data Requirements List
CFR	Code of Federal Regulations
COTR	Contracting Officer Technical Representative
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
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
NDSF	National Deep Submergence Facility
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
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