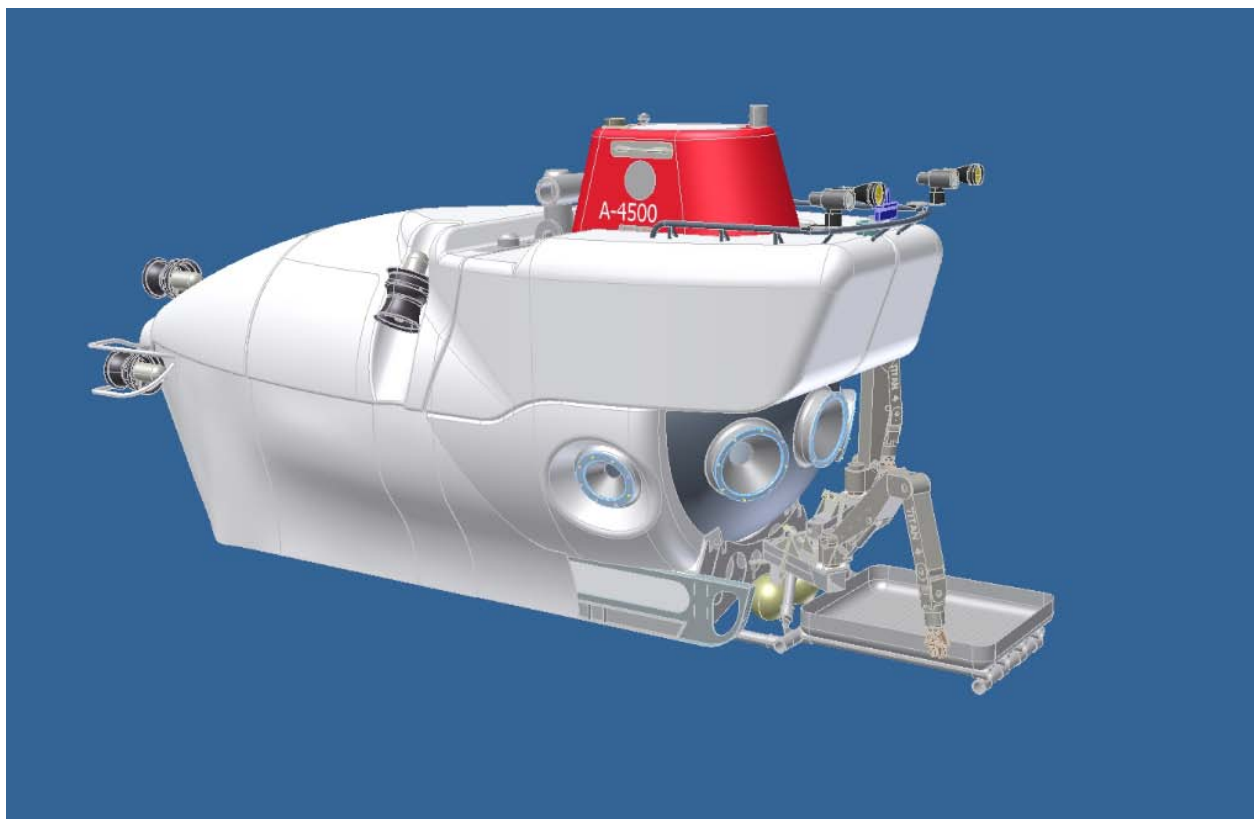


6500m HOV Project Stage 1: A-4500 HOV

Work Breakdown Structure and Dictionary

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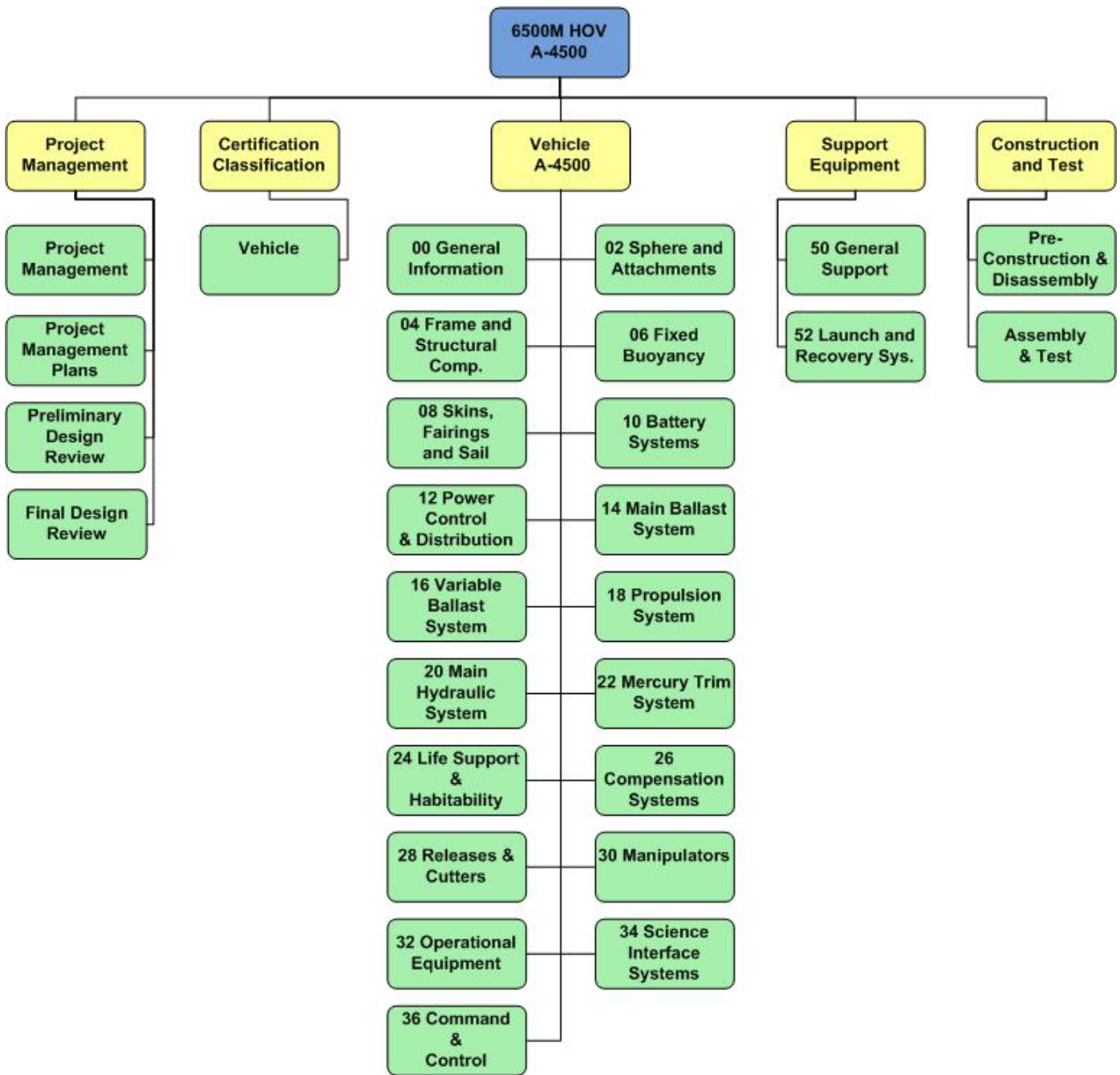
Document Control Sheet

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1.0 Work Breakdown Structure Chart



2.0 Work Breakdown Structure Dictionary

Element Level	WBS Title	Description
1	6500M HOV A-4500	
2	Project Management	
3	Project Management	This work package includes all work required to generate, administer and implement project control functions and reporting tasks including risk mitigation, scheduling, budgeting, earned value management and reporting for the duration of the project. This includes work required to maintain (but not develop and write) project documents i.e.: <i>Project Execution Plan, Configuration Management Plan, Risk Management Plan, Quality Management Plan</i> , etc. This work package also includes all efforts required to plan organize, administer and attend project meetings including all regularly scheduled team meetings.
3	Project Management Plans	This work package includes activities to prepare and review project management plans. Activities include the draft and final for (9) PM plans for the <i>Project Execution Plan, Vehicle Design Plan, Project Management Plan, Risk Management Plan, Contingency Management Plan, Procurement Plan, Quality Management Plan, Environmental Health and Safety Plan, and Transition to Operations Plan</i> .
3	Preliminary Design Report	This work package is to prepare and review documents presentations and data for the Preliminary Design Review. Activities include engineering reviews, preparation of presentations, dry run sessions and revisions with the internal and external advisory boards.
3	Final Design Report	This work package is to prepare and review documents presentations and data for the Final Design Review. Activities include engineering reviews, preparation of presentations, dry run sessions and revisions with the internal and external advisory boards.
2	Certification/Classification	
3	Vehicle ABS classification	This work package includes all work required to support vehicle classification during the preliminary design, final design, procurement & overhaul phases of the project. This includes meetings with ABS and effort required to generate all reports and information required by the <i>ABS Classification Plan</i> including all drafts and final submissions. This task includes any billing by ABS engineering and surveying groups and any WHOI labor required to classify the vehicle.
2	Vehicle	

Element Level	WBS Title	Description
3	00 General Information	
4	General Information/System Engineering	This work package includes all electrical engineering, planning, prototyping and documentation required to generate a top level electrical system design. This WP effort covers design and build of the pilots' joystick, control hardware, submarine specific controls and any testing and analysis required to develop a system architecture including data, high and low power distribution system with circuit protection analysis and component selection. This WP includes all efforts required to maintain instrument list, I/O list, wire list, cable and connector list and vehicle wiring schematic and design of ground and leak detection systems, emergency power plan and junction box allocation. The work package includes work required to generate ABS support documentation to be included in ABS classification submission. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.
3	02 Sphere & Attachments	
4	Sphere & Attachments	This work package includes all engineering, planning, prototyping and documentation required to support the SwRI sphere fabrication process including all interface and integration required to generate an interface document indicating size and placement of external lugs and hull to frame attachment points on the personnel sphere. This budget includes SwRI sphere costs and all outside services required to support the project.
4	Penetrators	This work package includes all engineering, planning, and documentation required to develop a purchase specification and define a final test procedure for verification of production units. The WP included vendor site visits, procurement of vendor quotations and selection of a penetrator vendor. This WP includes procurement of prototype copper and fiber penetrators and production units and effort to complete final testing to be performed by WHOI.

Element Level	WBS Title	Description
4	Internal Arrangement	This work package includes all engineering, planning, prototyping and documentation required to design an ergonomically correct internal arrangement. This includes all Lockheed Martin contract services and any WHOI costs required to generate internal mock-ups of sphere internal hardware and components. Also included are WHOI maintenance of a master equipment list (MEL), switch list and panel list, and all efforts needed to generate an interface document for SwRI indicating the placement of personnel sphere mounting studs that are needed to attach internal structure. This will include all WHOI procurement costs and fabrication effort required to build and test the mock-up and actual birdcage and internal arrangement components and spares.
4	Internal Arrangement Electrical	This work package includes all engineering, planning, prototyping and documentation required to design internal panels, penetrator enclosures and wiring harness. This will include all WHOI procurement costs and fabrication effort required to build and test components and spares.
3	04 Frame & Structural Components	
4	Frame & Structural Components	This work package includes all engineering, planning, prototyping and documentation required to design the vehicle frame including modifications to the existing frame and design of new structure required to attach the new personnel sphere and all subsystems. The work package includes structural analysis and verification of compliance with ABS rules and guidelines. All detail design, external services, fabrication cost and unit testing is included. Vendor site visits, development of purchase specifications and procurement of vendor quotations required to identify and select a fabrication and weld shop are included in this WP.
3	06 Fixed Buoyancy Assemblies	
4	Fixed Buoyancy Assemblies	This work package includes all engineering, planning, and documentation required to develop a syntactic foam purchase specification. This includes efforts to determine minimum foam density requirements, foam qualification test procedures, and accurate estimates of quantity needed. Foam block size, shape, placement and attachment method should be determined as well as identification of shaping facility. The work package includes work required to generate ABS support documentation to be included in ABS classification submission. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.
3	08 Skins, Fairings and Sail	

Element Level	WBS Title	Description
4	Skins, Fairings and Sail	This work package includes all engineering, planning, and documentation required to develop skin, bathtub and sail designs. Efforts to select a fabrication shop are included in this WP including vendor site visits, development of purchase specifications and procurement of vendor quotations. All design, external labor and services, fabrication costs, unit testing and WHOI rework is included.
3	10 Battery Systems	
4	Main Battery Systems	This work package includes all electrical engineering, planning, prototyping and documentation required to cross deck the existing lead acid main battery design. Activities include the procurement of replacement cells.
3	12 Power Control and Distribution	
4	Junction Boxes Mechanical	This work package includes all engineering, planning, prototyping and documentation required to generate new mechanical designs for four (4) new electrical junction boxes. This task includes any procurement costs and fabrication effort required to build and test the mechanical boxes, covers and gaskets only. Electrical stuffing tubes and internal hardware will be covered by the electrical effort.
4	Junction Boxes Electrical	This work package includes all engineering, planning, prototyping and documentation required to determine the number of junction boxes the new vehicle will need and determine the physical requirements of each. This work will also determine if any existing boxes will be reused. This effort includes the design and build of any new internal assemblies for reused and new external electrical junction boxes. This will include any procurement costs and fabrication effort required to build and test the necessary components required to assemble fully functional units and spares.
4	Power Bottle Mechanical	This work package includes all engineering, planning, prototyping and documentation required to design the power pressure vessels. Component layout, chassis design and thermal analysis is included. The work package includes structural analysis and generation of ABS support documentation to be included in ABS classification submission. All detail design, external labor and services, fabrication costs and unit testing is included.

Element Level	WBS Title	Description
4	Power Bottle Electrical	This work package includes all engineering, planning, and documentation required to develop a detailed power bottle schematic. This WP includes procurement of prototypes for validating designs and development of test procedures for functional units. This will include any procurement costs and fabrication effort required to build and test all components of three functional systems and spares.
4	Data Bottle Mechanical	This work package includes all engineering, planning, prototyping and documentation required to design the data bottle pressure vessels. Component layout, chassis design and thermal analysis is included. The work package includes structural analysis and generation of ABS support documentation to be included in ABS classification submission. All detail design, external labor and services, fabrication costs and unit testing is included.
4	Data Bottle Electrical	This work package includes all engineering, planning, and documentation required to develop a detailed data bottle schematic. This WP includes procurement of prototypes for validating designs and development of test procedures for functional units. This will include any procurement costs and fabrication effort required to build and test all components of three functional systems and spares.
3	14 Main Ballast System	
4	Main Ballast System Mechanical	This work package includes all engineering planning, prototyping and documentation required to design the main ballast system. This includes a study to determine the buoyancy requirements of the vehicle and the design of new soft ballast tanks. This WP will also include any effort required to modify hard and soft piping. The work package includes ABS support documentation to be included in ABS classification submission. This will include any procurement costs and fabrication effort required to build and test all components of the system.
4	Main Ballast System Electrical	This work package includes all electrical engineering planning, prototyping and documentation required to cross deck the <i>Alvin</i> Main Ballast system and design the electrical interface schematic and electronics. The work package includes work required to generate ABS support documentation to be included in ABS classification submission. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.
3	16 Variable Ballast System	

Element Level	WBS Title	Description
4	Variable Ballast System Electrical	This work package includes all engineering planning, prototyping and documentation required to cross deck the <i>Alvin</i> VB system and construct the electrical interface schematic and electronics. The work package includes work required to generate ABS support documentation to be included in ABS classification submission. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.
4	Variable Ballast System Piping	This work package includes all engineering planning, prototyping and documentation required to make any high pressure piping modifications to the VB system to accommodate the new sphere design. The work package includes work required to generate ABS support documentation to be included in ABS classification submission. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.
4	Variable Ballast System High Pressure Spheres	This work package includes all engineering planning, prototyping and documentation required to design and integrate new Variable Ballast Spheres into the existing system. The work package includes work required to generate ABS support documentation to be included in ABS classification submission. This will include procurement costs for 2 new spheres. Replacement of VB Hydraulic system is not included in the scope of this task.
3	18 Propulsion System	
4	Propulsion Control System	This work package includes all engineering, planning, prototyping and documentation required to design the propulsion system electrical interface schematic and electronics. All detail design, external labor and services, fabrication costs and unit testing is included. The work package includes generation of ABS support documentation to be included in ABS classification submission. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.
3	20 Main Hydraulic System	
4	Main Hydraulic System	This work package includes all engineering, planning, prototyping and documentation required to cross deck the <i>Alvin</i> Main Hydraulic system and construct the electrical interface schematic and electronics. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.
3	22 Mercury Trim System	

Element Level	WBS Title	Description
4	Mercury Trim System	This work package includes all engineering, planning, prototyping and documentation required to cross deck the <i>Alvin</i> Mercury Trim system and develop the electrical interface schematic and electronics. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.
3	24 Life Support & Habitability	
4	Life Support Systems	This work package includes all engineering, planning, prototyping and documentation required to design the life support system. This includes all outsourced work to the LM corporation and all WHOI efforts to support outsourced work and complete the ABS submission. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.
3	26 Compensation Systems	
4	Compensation Systems	This work package includes all engineering, planning, prototyping and documentation required to design fabricate and test the oil compensation system. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.
3	28 Releases and Cutters	
4	Service Releases Mechanical	This work package includes all engineering, planning, prototyping and documentation required to cross deck the <i>Alvin</i> Service Weight Release System electrical components. This includes a system schematic and effort required to generate ABS support documentation to be included in ABS classification submission. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.
4	Service Releases Mechanical	This work package includes all engineering, planning, prototyping and documentation required to cross deck the <i>Alvin</i> Service Weight Release System. This includes analysis to determine placement based on weight and balance criteria and designs for dropper mounting plate. The work package includes work required to generate ABS support documentation to be included in ABS classification submission. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.

Element Level	WBS Title	Description
4	Emergency Releases and Cutters Electrical	This work package includes all engineering, planning, prototyping and documentation required to cross deck the <i>Alvin</i> Emergency Release System electrical components. The work package includes work required to generate ABS support documentation to be included in ABS classification submission. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.
4	Emergency Releases and Cutters Mechanical	This work package includes all engineering, planning, prototyping and documentation required to design the Emergency Release and Hydraulic Disconnect system. This includes all work required to design a new basket and manipulator electrical, mechanical and hydraulic release mechanism. The work package includes work required to generate ABS support documentation to be included in ABS classification submission. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.
3	30 Manipulators	
4	Manipulators	This work package includes all engineering, planning, prototyping and documentation required to cross deck the <i>Alvin</i> Manipulator system and construct a four-wire interface system schematic and electronics. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.
3	32 Operational Equipment	
4	Operational Equipment & Controls	This work package covers design, development, and building of the equipment the pilot and observers use to control the submarine and evaluate its real-time performance. Specifically, it includes the pilots' joystick/hand box, the head-down display, and other submarine specific controls and indicators.
3	34 Science Interface Systems	
4	Science Data Systems	This work package includes all engineering, planning, prototyping and documentation of the science interface system required to provide power and through hull communications to science gear located outside the vehicle. This effort includes science basket electrical, hydraulic and optical fiber interface and disconnect system. This WP includes a pressure bottle to house all electronics. This will include any procurement costs and fabrication effort required to build and test all components of functional system and spares.

Element Level	WBS Title	Description
4	External Arrangement - Workspace Design	This work package includes all engineering, planning, prototyping and documentation required to design an efficient pilot and observer workspace layout including the design and build of the manipulator mounting system, sample basket, and light/camera mounting system. This includes a kinematic analysis of the manipulator and considers the emergency release system and hydraulic and electrical disconnect system. This includes any procurement costs and fabrication effort required to build and test the manipulator mounting system, sample basket and light/camera mounting system.
4	Imaging	This work package includes all engineering, planning, prototyping and documentation required to design the vehicle's imaging and recording plant. This includes high intensity (ramped and strobed) LED lighting. New internal Infrastructure hardware including camera displays, Pan Tilt Zoom and Focus control, video routing and switching, audio, data and time code integration. Cross decking of several existing Alvin cameras, an upgrade to the existing HD camera from Analog to Digital output and replacement of imager with new. Addition of second HD Camera and external still image storage capability. Digital Upgrade to the Shipboard Science Support Group duplication station. Retooling of the Science Processing Station tools and addition of Non-Linear Editing capabilities to allow HD conversion to PC or Mac format. To include the integration of these new tools and functions with the existing SDTV conversion tools. This will include any procurement and fabrication effort required to build and test all components of functional system and spares.
4	Illumination	This work package includes all engineering, planning, prototyping and documentation required to design the vehicle's lighting plant. This includes high intensity (ramped and strobed) LED lighting. This will include any procurement and fabrication effort required to build and test all components of functional system and spares.
3	36 Command and Control	

Element Level	WBS Title	Description
4	Command, Control & Computing	This work package includes all engineering, planning, prototyping and documentation required to develop the processing platform, network facilities, and processing code to support all hotel, navigation and control processes of the vehicle including bus and operating system. This includes development of a computer system and network topology, hardware, human interface devices, networking systems and displays. Data offload plans and protocols, processing hardware and network facilities used for offloading daily data from submarine dives and test procedures should be included. This will include any procurement and fabrication effort required to build and test all components of functional system and spares.
2	Support Equipment	
3	50 General Support	
4	Ship Space Modifications	This work package includes all engineering planning, prototyping and documentation required to modify the existing hangar or shop spaces to accommodate the A-4500 HOV. This includes modifications to the lower hangar, upper hangar catwalk, and hangar door. This portion of the project will be performed separate funds and will not be included in the overall budget estimate.
3	52 Launch and Recovery System	
4	A-Frame	This work package includes all engineering planning, prototyping and documentation required to modify the existing vehicle launch and recovery system. This includes the A-Frame, tow winch, related HPU's and ship wiring. This will include any procurement costs and fabrication effort required to make modifications to structure or spaces directly resulting from necessary changes. This portion of the project will be performed separate funds and will not be included in the overall budget estimate.
4	Deck Positioning Equipment	This work package includes all engineering planning, prototyping and documentation required to modify the existing vehicle deck positioning system. This includes the sled structure, guide track, HPU, and ship wiring. This will include any procurement costs and fabrication effort required to make modifications to structure or spaces directly resulting from necessary changes. This portion of the project will be performed separate funds and will not be included in the overall budget estimate.
2	Construction and Test	
3	Pre-Construction and	

Element Level	WBS Title	Description
	Disassembly	
4	Pre-Construction	Activities include, but are not limited to: High Bay overhead crane load testing, general area cleanup, additional lighting installation, shop and office van installations, shop and office van decking and stairway installation, outside storage van setup, outside van decking and stairway installation, area work bench assembly and setup, temporary wall structure setup, fabrication of old sphere transport and storage fixture, WHOI safety office inspections, etc. This task also includes design and fabrication of a sphere storage and transport fixture for old <i>ALVIN</i> 4500M personnel sphere.
4	Ship Demobilization and <i>Alvin</i> Disassembly	Activities include, but are not limited to, relocation and set up of support equipment and system spares into temporary work vans in Islen High Bay and the complete disassembly of the existing vehicle and final disposition of all components and systems. This also includes cleaning of the existing vehicle frame and preparations for transport to vendor service facility and all work package control documentation.
4	Service and Refurbishment	This work package includes all work required to teardown, service and reassemble all vehicle subsystems and components to be reused for the A-4500 HOV and includes unmodified frame inspection and repair, lifting tee inspection and repair, and life support system inspection and cleaning. The task also includes new hull bird cage component 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, support of ABS survey inspections and testing as required, etc.
3	Assembly and Test	
4	Assembly	This work package includes all efforts, planning, and documentation required to reassemble all components of the A-4500 vehicle and support periodic ABS survey inspections and testing as required. This task also includes completion and closure of all work package control documentation.
4	Hangar Test and Ship Mobilization	This work package includes all engineering, planning and documentation required to perform all post assembly hangar (dry) testing including complete end-to-end submersible systems ring out with fully-powered test (POELCO), closed-boat unoccupied habitability test, closed-boat occupied habitability test, and support of ABS survey and inspections as required. This task also includes return of support equipment and system spares from the temporary work and storage vans in High Bay to the support ship, setup of shops and stowage of system spares, and return tested submersible to support ship.

Element Level	WBS Title	Description
4	Dockside Test and Sea Trials	<p>This work package includes all engineering, planning and documentation required to perform all tests leading to the acceptance and commissioning of the vehicle by the National Science Foundation for regular deep sea operations. This includes all dockside testing activities including, but not limited to: A-frame fit up, tethered powered system testing, inclination and stability tests, untethered surface propulsion testing, and departure and transit to Bermuda. This also includes all sea trial tests including continuation of shallow water test program, initial shallow water harbor dives, communications and obstacle avoidance testing, open water slope dive program to increasing depths, open water deep dive program to full service depth, culminating with ABS survey and inspections and certification class approval and certification of remaining pilots by test pilots.</p>

3.0 Work Breakdown Structure Work Packages and Project Numbers

Element Level	WBS Title	Work Package #	Project #
1	6500M HOV A-4500		
2	Project Management		
3	Project Management	A99	83340911
3	Project Management Plans	A99	83340911
3	Preliminary Design Report	A99	83340940
3	Final Design Report	A99	83340940
2	Certification/Classification		
3	Vehicle ABS classification	A99	83340945
2	Vehicle		
3	00 General Information		
4	General Information/System Engineering	A00	83340913
3	02 Sphere & Attachments		
4	Sphere & Attachments	A02	83340904
4	Penetrators	A02-03	83340917
4	Internal Arrangement	A02-06	83340916
4	Internal Arrangement Electrical	A02-06	83340916
3	04 Frame & Structural Components		
4	Frame & Structural Components	A04	83340918
3	06 Fixed Buoyancy Assemblies		
4	Fixed Buoyancy Assemblies	A06	83340919
3	08 Skins, Fairings and Sail		
4	Skins, Fairings and Sail	A08	83340920
3	10 Battery Systems		
4	Main Battery Systems	A10	83340921
3	12 Power Control and Distribution		
4	Junction Boxes Mechanical	A12-01	83340924
4	Junction Boxes Electrical	A12-01	83340924
4	Power Bottle Mechanical	A12-03	83340922
4	Power Bottle Electrical	A12-03	83340922
4	Data Bottle Mechanical	A12-03	83340923
4	Data Bottle Electrical	A12-04	83340923
3	14 Main Ballast System		
4	Main Ballast System Mechanical	A14	83340925
4	Main Ballast System Electrical	A14	83340925
3	16 Variable Ballast System		
4	Variable Ballast System Electrical	A16	83340926
4	Variable Ballast System Piping	A16	83340926
4	Variable Ballast System High Pressure Spheres	A16	83340926
3	18 Propulsion System		

Element Level	WBS Title	Work Package #	Project #
4	Propulsion Control System	A18	83340927
3	20 Main Hydraulic System		
4	Main Hydraulic System	A20	83340928
3	22 Mercury Trim System		
4	Mercury Trim System	A22	83340929
3	24 Life Support & Habitability		
4	Life Support Systems	A24	83340930
3	26 Compensation Systems		
4	Compensation Systems	A26	83340931
3	28 Releases and Cutters		
4	Service Releases Mechanical	A28	83340932
4	Service Releases Mechanical	A28	83340932
4	Emergency Releases and Cutters Electrical	A28	83340933
4	Emergency Releases and Cutters Mechanical	A28	83340933
3	30 Manipulators		
4	Manipulators	A30	83340934
3	32 Operational Equipment		
4	Operational Equip & Controls	A32	83340935
3	34 Science Interface Systems		
4	Science Data Systems	A34	83340937
4	External Arrangement - Workspace Design	A34	83340937
4	Imaging	A34	83340936
4	Illumination	A34	83340936
3	36 Command and Control		
4	Command, Control & Computing	A36	83340938
2	Support Equipment		
3	50 General Support		
4	Ship Space Modifications	A50	83340939
3	52 Launch and Recovery System		
4	A-Frame	A52	83340939
4	Deck Positioning Equipment	A52	83340939
2	Construction and Test		
3	Pre-Construction and Disassembly		
4	Pre-Construction		83340960
4	Ship Demobilization and <i>Alvin</i> Disassembly		83340960
4	Service and Refurbishment		83340960
3	Assembly and Test		
4	Assembly		83340960
4	Hangar Test and Ship Mobilization		83340970
4	Dockside Test and Sea Trials		83340970