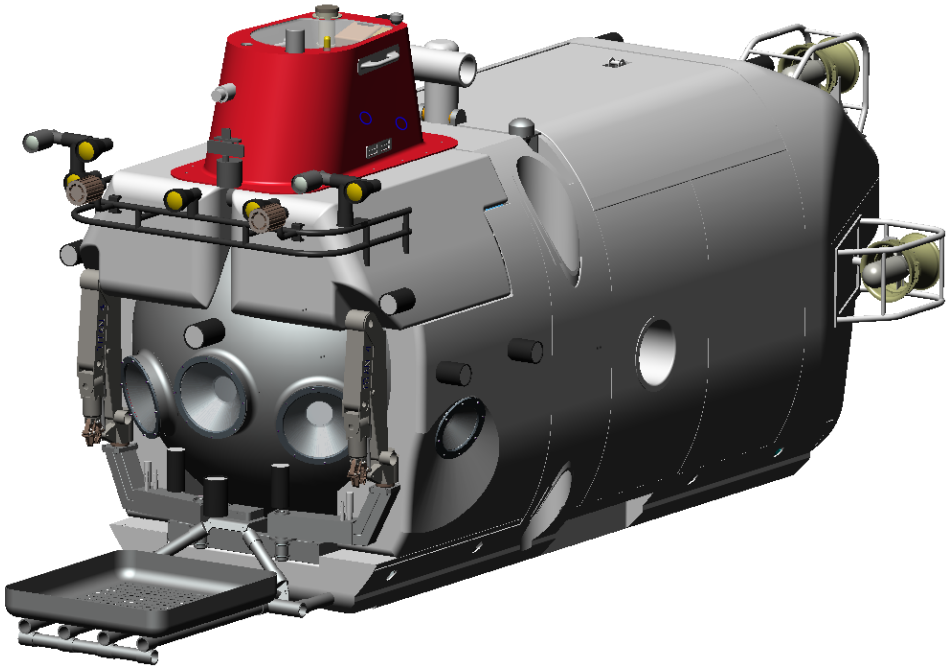
Replacement Human Occupied Vehicle

DESSC Update

December 9, 2007



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Replacement HOV Update

Outline

- RHOV Management Team
- Personnel Sphere Updates
- Vehicle Updates
- Vehicle Cost Drivers
- Integrated Sphere and Vehicle Schedule

Replacement HOV Update

Changes to the Management Team

Program Manager

Tom Lewis

Naval Sea Systems Command 1983 - 2007

- Special Operating Forces Undersea Mobility Office
- Deep Submergence Program Office
- Submarine Safety and Quality Assurance Division
- TRIDENT Submarine Program

Assistant Program Manager

Anthony Tarantino

STS International Inc. 2006 - 2007

- In water Security Systems

Woods Hole Oceanographic Institution 2000-2006

- DSV Alvin Operations Group

Bruker Federal Systems Inc. 1994-2000

- Production/Final Test /Support Group
- Technical Transfer Team
- Prototype Service Group

Replacement HOV Update

Personnel Sphere Progress

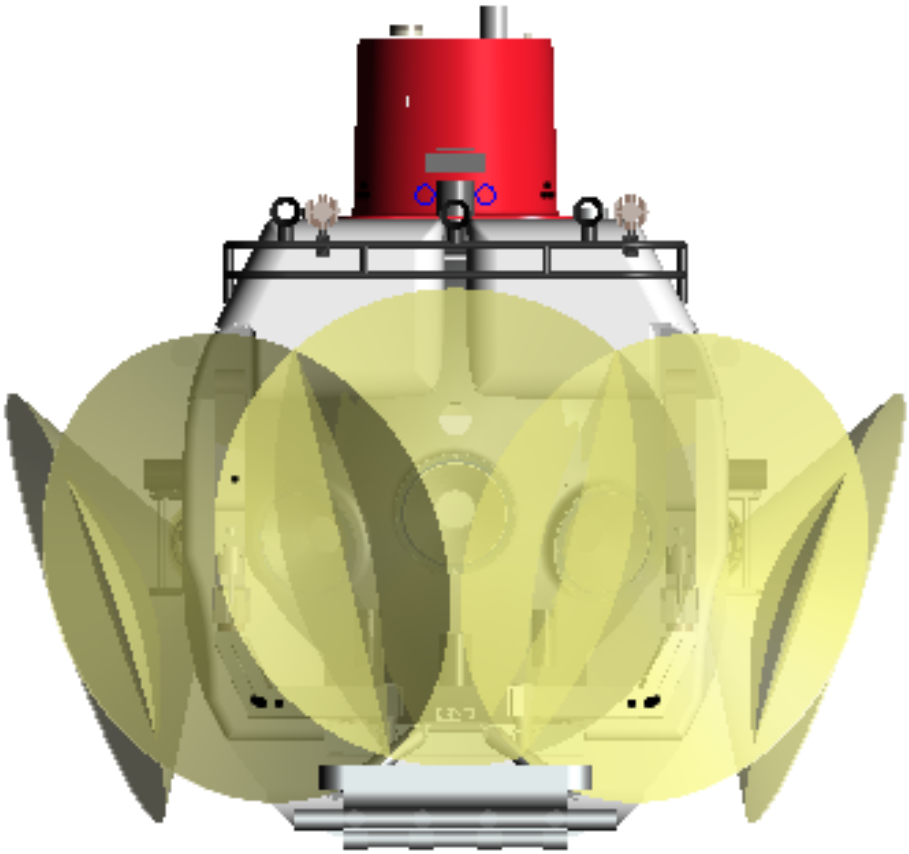
- 5-6 Sep 2007: Southwest Research Institute (SwRI) submitted Detailed Design Review (DDR) for RHOV personnel sphere
- The design was reviewed and accepted by ABS and received concurrence by NAVSEA
- Subcontracts in place:
  - Ladish Forge (forging)
  - STADCO (machining and welding)
  - Bodycote Inc. (heat treatment and stress relief)
  - ABS America (certification)
- **Titanium ingots delivered, fabrication phase started!**

Replacement HOV Update

SwRI Personnel Sphere

Final Design based on
NADAC/RHOC/DESSC input

Three 18-inch forward viewports
Two 13-inch side viewports



Overlapping Viewing Area

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Replacement HOV Update

Vehicle Contracting

8 June 2007: Lockheed Martin (LM) awarded contract for vehicle design and fabrication

Contracting Methodology

- Collaborative effort to develop scope of work, specs, and cost estimates
- Allows both parties to develop a clear understanding of the requirements
- Will reduce risk to contractor and mitigate potential cost overruns

Contract Structure

Two Phase Contract

- Preliminary Design and Detailed Cost Estimate of Vehicle (CLIN 1)
- Detailed Design, Fabrication, and Test of Vehicle (CLIN 2)

In order to close CLIN1, LM must provide detailed costing for CLIN 2 six weeks after completion of Preliminary Design Review (PDR), at which time price negotiations begin.

Based on the cost estimate, WHOI/NSF has the option to execute CLIN 2 or cancel contract.

Replacement HOV Update

Key Events

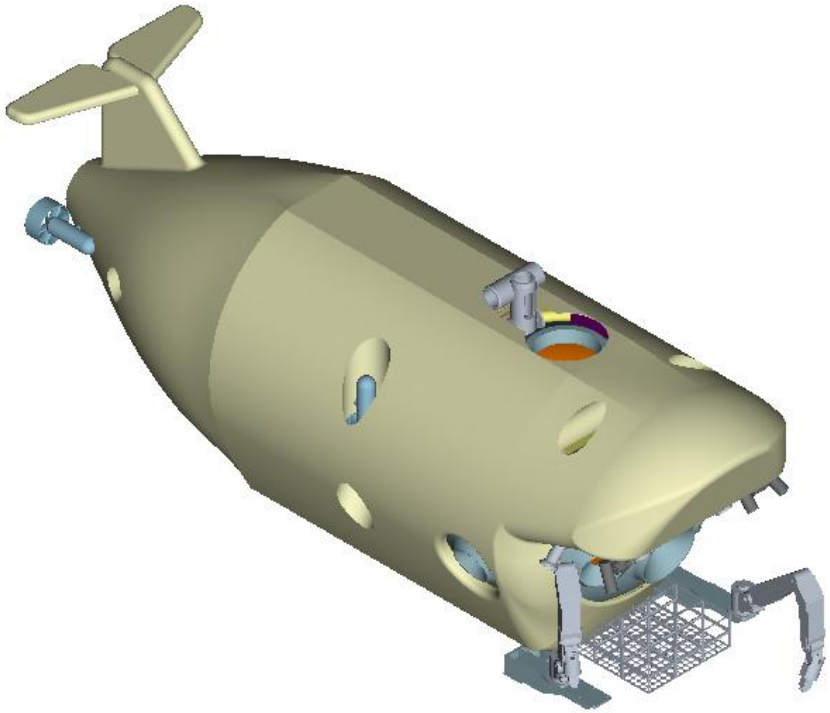
2007

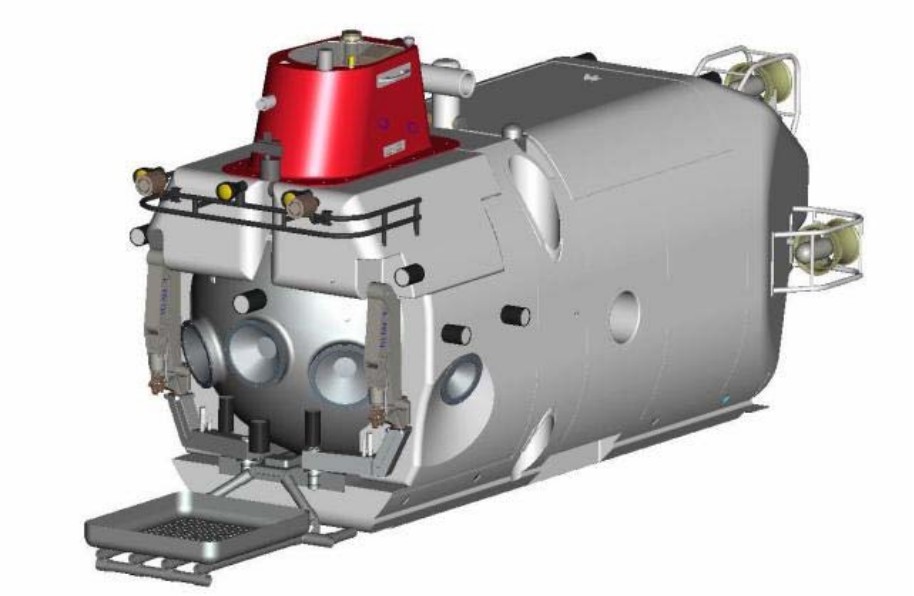
8 June	Vehicle contract executed
27 June - 1 July	LM engineers observed operations during *Atlantis* engineering cruise
24 - 25 July	System Requirement Review / System Design Review conducted at LM
15 - 17 October	Design Team meeting with Alvin Pilots
13 - 15 November	Preliminary Design Review
Ongoing	WHOI-LM Technical Exchange

Replacement HOV Update

LM / Vehicle

Concept vs. PDR





Replacement HOV Update

Vehicle Characteristics

- 43,419 lbs air weight (heaviest state)
- 24’ L x 7.5’ W x 11.0’ H
- Descent time to 2,500m = 73 min
- 7-8 hr bottom time (2,500m)
- 6 thruster configuration
- Movable manipulator mounts

- Flat top and bottom surfaces
- Low profile sail
- Compatible with current A-Frame
- Limited ship modifications
- Maintain *Atlantis/Alvin* launch & recovery procedures

NSF

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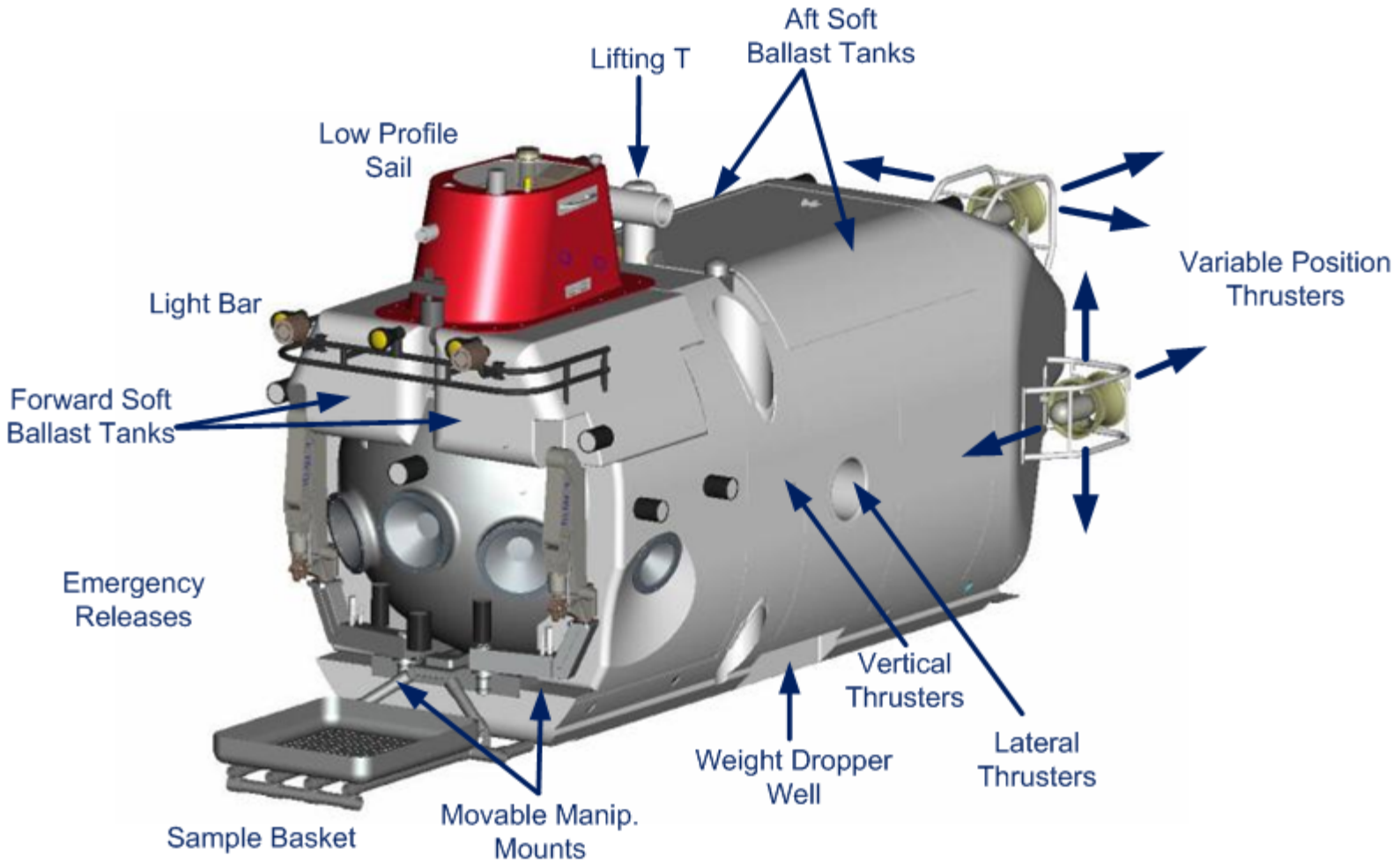
SRI

Replacement HOV Update

Vehicle Arrangement



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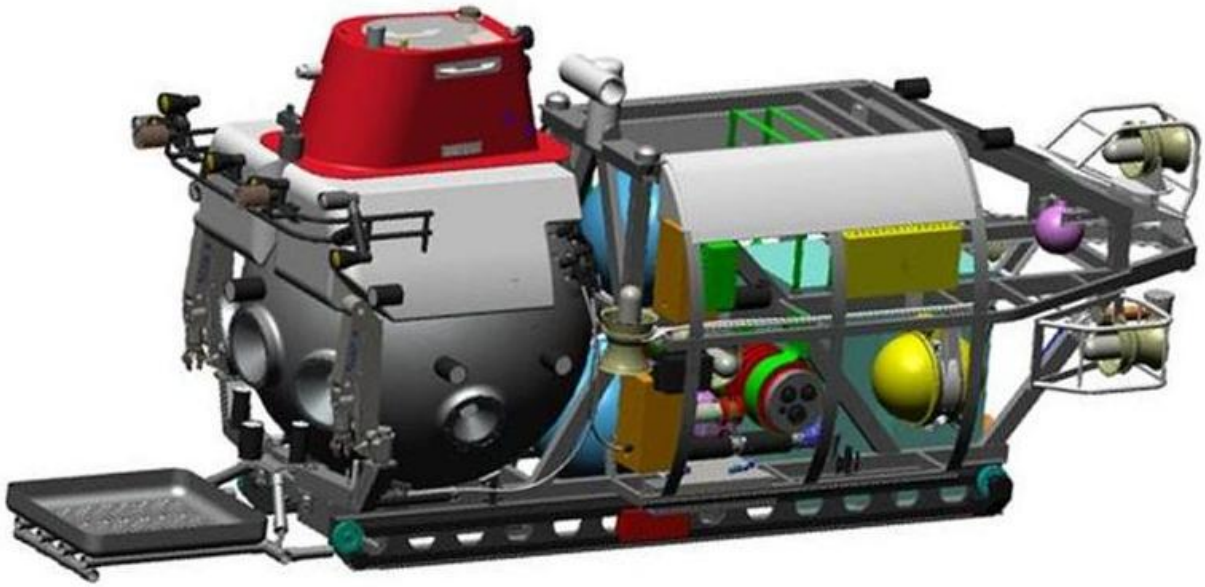
Replacement HOV Update

Vehicle Systems



- **Soft Seawater Ballast System**
  - 4 separate tanks provide extra buoyancy for surface stability
- **Pitch Trim System**
  - 2 independent moveable weights
  - +/-10º pitch trim
- **Port and Starboard Architecture**
  - Eliminates single critical path
  - Increases reliability
- **Main Hydraulic System**
  - Up to 8 science functions
  - Backup for VB system valve actuation

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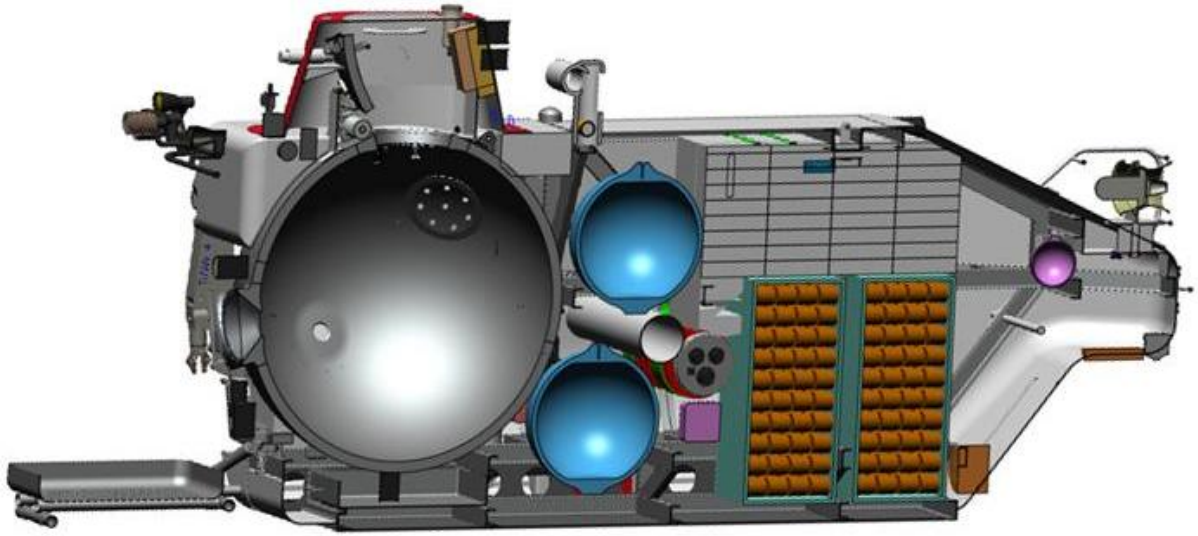
Replacement HOV Update

Vehicle Systems *(cont.)*



- **Battery Distribution System**
  - Li-based battery technology
  - 2 independent battery tanks
- **Variable Ballast System**
  - Dual motor/pump combination
  - Backup motor to drive main hydraulic system pump
- **Flotation Foam**
  - Primary buoyancy
  - 250 cubic feet
- **Profiling Sonar**
  - Reson SeaBat
- **RDI Doppler Velocity Profiler**
  - DVLNav

Replacement HOV Update

Sphere Ergonomics

- Ergonomic design in accordance with US standards where possible (1988 US Army or NASA-STD 3000)
- Volume and interference checks done with three 95th percentile males
- “Reach limits” defined by 5th percentile female
- Adjustable controls
- Observer seating will provide optimized view and better support than pads

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Replacement HOV Update

Specification Comparison

	Alvin	RHOV
Depth	4,500 m	6,500 m
Sphere Volume	144.2 ft^3	170.8 ft^3
External Science Payload	275 lbs	400 lbs
Internal Science Payload	6,630 in^3 19” rack space	12,300 in^3 19” rack space
Max Speed (fwd)	2 kts	3 kts
Max speed (lateral)	Minimal lateral ability	0.5 kts
Max Speed (vertical)	30 m/min	48 m/min
Trim Angle	+/- 7.5 deg	+/- 15 deg
Positioning Control	Manual w/ auto heading	Auto heading, DP, track and following control

Replacement HOV Update

Power Comparison

	Alvin	RHOV
Chemistry	Lead Acid	Lithium
Dive Time	9 hrs (typical)	10.5 hrs
Bottom Time	5-6 hrs	7.5 hrs
Lifetime Cycles	400 total	2,000 total
Maintenance Cycle	60	No scheduled maintenance
Available Energy /Dive	30 kW-Hrs	100 kW-Hrs

Lead acid battery designed to meet RHOV requirements would exceed 10,000 lbs and 70 ft^3

Replacement HOV Update

Cost Drivers

- **Power Consumption**

  Battery is a custom application: as power increases, battery capacity and weight increase

- **Weight**

  300 ft^3 of syntactic foam required at a total cost for raw material of $675,000, with additional costs for shaping, bonding and testing

- **Engineering**

ABS classification and Non Recurring Engineering (NRE) can be very costly

Replacement HOV Update

Cost Improvements

- **Battery**
  - Non-COTs (commercial off the shelf) solution
  - Sizable non-recurring engineering charges
  - Weight and size driver

- **Variable Ballast**
  - Power consumption (battery)
  - Overall weight (foam)
  - ABS classification impact

Replacement HOV Update

Batteries

Design to 3-yr, 600 cycle vs. 10-yr 2000 cycle solution

Pros

- Take advantage of advances in battery technology
- Reduce energy requirement (de-rating factor)
- Reduce size and weight
- Decrease initial costs

Cons

- Increased life-cycle costs

Evaluate vehicle power requirements

Replacement HOV Update

Variable Ballast

Switch to a smaller capacity VB system and use drop weights for descent/ascent

Pros

- Maintain mid-water capabilities
- Increase safety, minimize risk, and reduce ABS requirements
- Simplifies system and reduces weight and power consumption
- Cross-deck *Alvin* seawater pump

Cons

- Will require use of expendable ballast (similar to *Alvin*)

Trade study underway by LM on cost, weight, power implications

Replacement HOV Update

Path Forward

- Evaluate detailed cost estimate for design and fabrication
- Present cost estimate to RHOC/NSF, 20-21 Feb 2008
- Proceed to CLIN2

Replacement HOV Update

SwRI / LM Combined Schedule