Replacement Human Occupied Vehicle

DESSC Update
December 9, 2007
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
- 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
- Production/Final Test /Support Group
- Technical Transfer Team
- Prototype Service Group
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
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 \textit{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
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
  - +/-10° 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
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
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
<table>
<thead>
<tr>
<th></th>
<th>Alvin</th>
<th>RHOV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Depth</strong></td>
<td>4,500 m</td>
<td>6,500 m</td>
</tr>
<tr>
<td><strong>Sphere Volume</strong></td>
<td>144.2 ft³</td>
<td>170.8 ft³</td>
</tr>
<tr>
<td><strong>External Science Payload</strong></td>
<td>275 lbs</td>
<td>400 lbs</td>
</tr>
<tr>
<td><strong>Internal Science Payload</strong></td>
<td>6,630 in³ 19” rack space</td>
<td>12,300 in³ 19” rack space</td>
</tr>
<tr>
<td><strong>Max Speed (fwd)</strong></td>
<td>2 kts</td>
<td>3 kts</td>
</tr>
<tr>
<td><strong>Max speed (lateral)</strong></td>
<td>Minimal lateral ability</td>
<td>0.5 kts</td>
</tr>
<tr>
<td><strong>Max Speed (vertical)</strong></td>
<td>30 m/min</td>
<td>48 m/min</td>
</tr>
<tr>
<td><strong>Trim Angle</strong></td>
<td>+/- 7.5 deg</td>
<td>+/- 15 deg</td>
</tr>
<tr>
<td><strong>Positioning Control</strong></td>
<td>Manual w/ auto heading</td>
<td>Auto heading, DP, track and following control</td>
</tr>
</tbody>
</table>
### Replacement HOV Update

#### Power Comparison

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

*Lead acid battery designed to meet RHOV requirements would exceed 10,000 lbs and 70 ft³*
Cost Drivers

• **Power Consumption**
  Battery is a custom application: as power increases, battery capacity and weight increase

• **Weight**
  300 ft³ 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
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
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