

# Pressurized Rescue Module System (PRMS)

U.S. Navy's Future Submarine Rescue Vehicle

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### **ABSTRACT**

The Submarine Rescue Diving Recompression System (SRDRS) is the U.S. Navy's next generation submarine rescue system. The SRDRS is a rapid assessment, global response system for the rescue and controlled decompression of personnel from a disabled submarine (DISSUB). The Pressurized Rescue Module System (PRMS) contains the elements of the SRDRS that constitute a remotely operated submarine rescue vehicle.

The Pressurized Rescue Module (PRM), an element of the PRMS, is a tethered, manned Remotely Operated Rescue Vehicle (RORV) used to transfer personnel from the DISSUB to the surface Vessel of Opportunity (VOO). The PRM will have the capability to navigate, descend in the water column, maneuver in submarine currents up to 2.5 kts, and mate with a DISSUB as deep as 2000 ft and at a deck angle as much as 45 deg from horizontal while maintaining a normal horizontal vehicle orientation. It can then conduct a transfer of personnel to the surface while maintaining up to 6 ATA of elevated cabin pressure.

Other PRMS elements include:

- The Transfer Skirt
- Control Van
- Umbilical Winch
- PRMS Air Transport Interfaces
- PRMS Auxiliary Equipment

This paper describes the PRMS capabilities and discusses the evolution of a proven design concept and the challenges associated with the development of this new generation rescue vehicle.

### **INTRODUCTION**

OceanWorks International's subsidiary, OceanWorks International Corporation (OWC) of North Vancouver Canada was selected by the US Navy to design and fabricate the PRMS, a segment of the SRDRS. The

contract was awarded in September of 2000. Final Design Review is scheduled for April 2002 and system delivery for September 2003.

In order to execute the PRMS project, Team Hard Suits (THS) was formed. OceanWorks International Corporation has the lead role as prime contractor and system integrator. Southwest Research Institute. (SwRI) is responsible for the pressure hull and frame structural component design, analysis, fabrication and testing. International Submarine Engineering (ISE) is responsible for vehicle control and navigation systems and a number of related ROV components. Systems engineering and integrated logistics support products are being provided by Resource Consultants Inc (RCI).

The world's first RORV system was developed by OceanWorks International in 1995 to meet urgent operational requirements of the Royal Australian Navy (RAN). REMORA-1 is considered to be a "proof of concept" vehicle that clearly illustrates the potential for RORV technology. The concepts pioneered with REMORA have since evolved into configurations that incorporate many "lessons learned" from the RAN project. The new designs are now the foundation on which the custom configuration for the US Navy PRMS is being based.

The PRMS advancements include greater depth and personnel capacity, improved propulsion, navigation and control systems and significantly improved deployment and operational response capability due to full integration with the SRDRS deck decompression and launch and recovery systems.

The integration of the PRMS into the SRDRS program is a co-operative effort between Team Hard Suits, the United States Navy and its Technical Authority for SRDRS, Oceaneering International.

### **OVERVIEW - SUBMARINE RESCUE DIVING AND RECOMPRESSION SYSTEM (SRDRS)**

The U.S. Navy Submarine Rescue Diving and Recompression System (SRDRS) is a fully integrated submarine rescue system to provide a rapid response submarine rescue system using 21<sup>st</sup> century technology. The SRDRS is composed of three distinct systems and one integration segment.

The first system is the Assessment/Underwater Work System (AUWS). It consists of Atmospheric Diving Suits (the ADS is provided by OceanWorks International), Remotely Operated Vehicles (ROVs), and associated AUWS Support Equipment that will be used with both the ADS and ROV. AUWS is the first SRDRS system mobilized in response to a SUBMISS/SUBSUNK event. It will provide capability for DISSUB localization and marking, rapid assessment of conditions, hatch clearance activities, and Emergency Life Support Stores (ELSS) Pod replenishment.

The second system is the Submarine Decompression System (SDS). The SDS comprises two large Submarine Decompression Chambers (SDCs) and associated SDS Mission Support Equipment (SDS-MSE). The SDS provides controlled decompression for personnel who have escaped or been rescued from the DISSUB.

The third system is PRMS as introduced above.

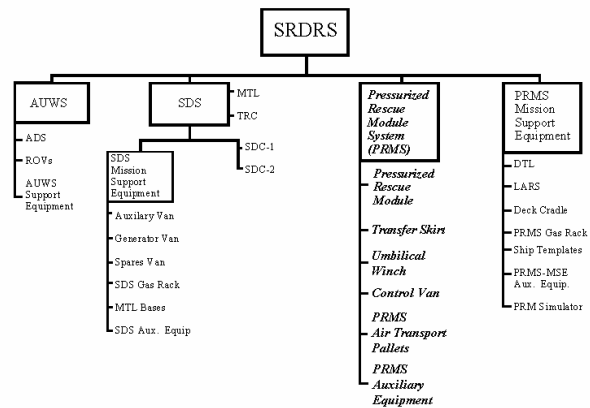
The PRMS Mission Support Equipment (PRMS-MSE) integrates the other segments through the Deck Transfer Lock (DTL), the Launch and Recovery System (LARS), the Ship Interface Templates and a number of other smaller but key elements.

All SRDRS segments are designed for rapid deployment via air and ground transport and for mobilization aboard military or commercial vessels of opportunity (VOO). This configuration eliminates the current USN rescue system's dependence on specially configured mother submarines (MOSUBs) or dedicated surface support ships.

## OPERATIONS SEQUENCE

The SRDRS is designed to be mobilized, installed on the VOO, transit to site and mate to the DISSUB within a maximum time of 72 hours from first notification to first rescue.

The PRMS LARS is a stern mounted A-frame configuration. The PRM is commanded and controlled remotely from the surface. The pilot and navigator in the control van navigate, descend, maneuver and mate the PRM with the bottomed DISSUB. The Integrated Navigation System (INS) is configured to support target location and mating in one foot of visibility. The topside dive supervisor oversees all PRM operations, including pressurization and decompression if required. The PRM has two attendants onboard to assist with the transfer of up to sixteen rescued DISSUB personnel.



Elements controlled in this document are listed in *bold italic* type.

The attendants also control and monitor life support functions.

The PRM umbilical is routed through an active load alleviator system on the LARS that compensates for vessel motion and prevents high impulse loads from occurring. The umbilical includes a buoyancy package to provide a maneuvering loop for the PRM. A syntactic float string is installed on the PRM end of the umbilical such that the PRM does not have to pause during deployment or recovery for float attachment or removal. The pilot controls the umbilical winch during the dive and can select winch auto and feedback functions as needed.

After rescued personnel transfer is complete, the PRM ascends and latches into a submerged Cursor Frame suspended from the LARS A-frame. The cursor, with its failsafe latch mechanism, can mate to the PRM with a misalignment of +/- 30 degrees. The cursor is connected to a dual winch, two wire heave compensated recovery system mounted on the A-frame arms. The vehicle and cursor are lifted into the Launch Latch Assembly that actively controls pitch to allow controlled and precise landing of the PRM on the deck cradle. A pressurized flexible man way connects the PRM horizontal man way on the PRM to the Deck Transfer Lock to permit the transfer under pressure of rescues and attendants into the SDS decompression chambers.

PRM life support and mission supplies are replenished in less than 30 minutes between dives. Each rescue sortie from launch to launch takes less than 5 hours.

## PRMS - DESIGN

The Navy's specification of a very small minimum size for the VOO (Auxiliary fleet tug T-ATF – 2,260 ton ) and the requirement for air transportation has placed significant size and weight limitations on the PRMS. These constraints, combined with stringent military

certification standards, have driven the design to a highly refined compact and lightweight configuration that requires the use of high strength to weight ratio materials and more complex fabrication methods.

For example, the control van operational weight limit of 11,115 lb necessitated the use of custom aluminum structural extrusions and Arimid fiber composite honeycomb wall panels to limit the weight while withstanding significant transportation and wave slap loads. Titanium HY-100 components are used to minimize the weight of high strength components of the PRM to keep the total operational air weight of the vehicle, occupants and supplies under 45,242 lbs.

The THS design team is using state of the art 3D solid modeling and finite element analysis on every element of the system to optimize weight with respect to the necessary configuration and the allowable stresses. This project relies on sophisticated design and management tools to provide requirements tracking, test and analysis verification, configuration control, data base BOMs, quality verification steps and process control tracking and of course, cost and schedule control. Software tools in use include Pro Engineer, Pro Pipe, Intralink, Ansys, Working Model, Mathcad, Orcaflex, Baan, Paradox, AutoCad, Doors, MS Project and others.

Design control and quality assurance is managed using the OWC ISO 9001 Quality System, which has been tailored to provide full compliance with certification to US military standards. The requirements include provision of complete and accurate documentation on both the design and delivered hardware to verify that system requirements are met and all systems are in compliance with the principles of the USN SUBSAFE program

The PRMS and SRDRS components are ultimately being certified by NAVSEA OOC in accordance with SS521-AA-MAN-010, US Navy Diving and Hyperbaric Systems Safety Certification Manual (referred to as MAN-010).

To facilitate commercial design and fabrication, the Navy has applied a combination of commercial and military design practices to the pressure hull. Based primarily on the American Bureau of Shipping Rules for Building and Classing Underwater Vehicles, Facilities and Hyperbaric Systems, 1990, these criteria are combined with US Navy submarine hull design rules. The resulting composite requirements are what has been termed "ABS+" Rules, whereby ABS will provide independent design verification of the hull components. In addition, sections of rules from Det

Norske Veritas are being applied to appropriate components of the LARS and umbilical design.

The application of blended military and commercial rules results in some unique opportunities. It is anticipated that this effort will lead to future systems enjoying the cost and time benefits of a more commercial approach to military systems development.

## **PRM ELEMENT**

The PRM is an open frame vehicle with principal buoyancy provided by the displacement of the pressure hull. The hull is a horizontal cylinder with hemispherical ends. Navigation, video, hydraulic, propulsion, de-watering and gas storage cylinders for the life support systems are mounted externally on the frame and hull with open access for maintenance and repair. The skirt is offset towards the bow to allow mating to the DISSUB at angles up to 45 degrees with approach from any direction.

The life support, power, communications, navigation, propulsion and telemetry control systems are fully redundant with dual independent main power supply busses to insure continued operation in the event of any single system failure.

The following are the key specifications of the PRM element.

### Dimensions

Transport	25' x 8' x 8'
Operational c/w skirt	25' x 8' x 14.5'

### Weight

Transport	38,000 lbs
Operational (air)	45,242 lbs
Operational (water)	200 lbs +ve

### Depth

Operational	2,000 fsw
Test	3,000 fsw

### Temperature

Transport & Storage	-10 <sup>0</sup> to + 150 <sup>0</sup> F
Operational (air)	0 <sup>0</sup> to + 110 <sup>0</sup> F
Operational (water)	+28 <sup>0</sup> to + 85 <sup>0</sup> F

### Personnel Capacity

Attendants	2
Rescued Personnel	16

### Performance

0 to 853 fsw	2.5 knot current
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854 to 1509 fsw	2.3 knot current
1510 to 2000 fsw	2.0 knot current
locate and mate	1 foot visibility
life cycle	25 years

Depth  
 USBL acoustic tracking beacon  
 USBL – pinger deployment system  
 Directional listening hydrophone

Pressure Hull Material

HY100 steel  
 INCONEL penetrator bosses, brackets  
 Monel and stainless penetrator inserts  
 Titanium lift  
 INCONEL cladding of all seal surfaces

Video & Lights

Video and lighting are arranged to provide the pilot and navigator with a clear view in all directions. All pan, tilt and rotate systems include position feedback and display. Video output display and recording is fully integrated in the control van.

Frame & Accessories

steel main structure  
 titanium lift and braces  
 aluminum & INCONEL brackets  
 plastic and other adapters

lights (ext)	13 variable intensity
lights (int)	4 hyperbaric
lights (skirt int)	2 wet dry hyperbaric
SIT equivalent	1 bow – pan & tilt
	1 stern – pan & tilt
	1 landing – pan & tilt
	1 skirt – bore mount

Power

Propulsion:	3000 vac, 60 hz
Hotel:	1900 vac, 60 hz
Battery:	12, 24 VDC silver zinc

Color CCD	2 umbilical/latch
	1 port
	1 starboard
	2 PRM interior
	1 skirt (int) – tilt rotate

Propulsion & Hydraulics

The PRM uses a conventional hydraulic system for thruster power and control. Hydraulic systems are also used for skirt de-watering and position controls. Servo and solenoid valve packs distribute the hydraulic flow. All systems are pressure compensated with oil status and water alarms. The prime movers are:

HPU (2):	230 HP total
Thrusters:	Lateral 4 x 19.5” Trans 4 x 19.5” Vertical 4 x 12”
Speed:	3.5+ knots fwd 1.5+ knots descent 1.5+ knots ascent

Life Support Capacity

Total system capacity is specified to support the rescue mission sortie time of 5 hours or less with consumable re-supply between sorties. All primary and secondary gas is stored in bottle banks mounted external to the PRM. There is full crossover between primary and secondary supplies.

Primary O <sub>2</sub>	6 hr
Secondary O <sub>2</sub>	12 hr
Primary CO <sub>2</sub> Removal	7.5 hr
Secondary CO <sub>2</sub> Removal	18 hr
Blow down air capacity	to 5 ata

Navigation & Control Sensors

Redundant sensors and feedback systems are installed on the PRM for processing in the Control Van Integrated Navigation System (INS). All pan, tilt and rotate systems include position feedback and display. The control and navigation system is designed to allow the PRM to mate in 1 foot of visibility. Sensor inputs to the INS include:

Forward scanning sonar – pan & rotate  
 Aft scanning sonar – pan & rotate  
 Forward profiling sonar  
 Doppler sonar  
 Fiber optic gyrocompass  
 Fluxgate compass

Life Support Monitoring

All life support functions are monitored and displayed on board with data transmission to the surface for display and recording. Redundant electronic and analogue systems are provided for:

Primary O<sub>2</sub> HP supply pressure  
 Secondary O<sub>2</sub> HP supply pressure  
 Primary O<sub>2</sub> LP supply pressure  
 Secondary O<sub>2</sub> LP supply pressure  
 Primary HP air supply pressure  
 Secondary HP air supply pressure  
 Ballast HP air supply pressure

O<sub>2</sub> percent  
 CO<sub>2</sub> percent  
 Internal depth  
 External depth  
 Skirt depth  
 Internal temperature  
 Humidity

Monitors:        redundant O<sub>2</sub> & CO<sub>2</sub>  
                       on board display  
                       transmit to surface  
 Control:            redundant, manual

Communications

A fully integrated communications system is provided to allow round robin, multi channel communication between the surface elements, the PRM, the DISSUB and the support vessels. PRM components include:

Hardwire main intercom  
 UQC acoustic u/w telephone  
 Sound powered phone  
 VHF (surface)  
 EBS mask connections

Environmental Control

The personnel capacity range (2 to 18 people), operating environment temperature range (-10 to +110<sup>0</sup>F in air and 28 to 85<sup>0</sup> F in water) and size, weight, and power limitations created the demand for a highly efficient system to maintain cabin temperature. An active heat exchanger system with high flow forced air circulation has been developed to maintain cabin temperature within limits when operating at extreme environmental temperatures. Features of the system include:

Heat exchangers: aluminum fin baffles  
 High flow fans: 2 x 840 scfm

Emergency Breathing System

The relatively small volume of the PRM, combined with high number of personnel, requires the use of a fully closed circuit EBS to prevent cabin pressure build up associated with use of open circuit demand systems typically used in manned submersibles. The EBS features:

Duration (18 man)        4 hours  
 Masks:                    full face c/w comms (2)  
 Scrubbers:                2 – lung powered  
                               rapid replacement  
 System:                    air purge of contaminated  
                               gas  
                               auto pressure –  
                               compensation  
                               light weight  
                               low breathing resistance

Ballast System

The PRM is designed to operate like an ROV and is positively buoyant with all personnel, full consumable payload and all ballast tanks flooded. Vertical thrust is used to descend. Principal buoyancy is provided by the hull displacement and no syntactic foam is used.

The personnel payload varies from 2 to 18 people. 16 individual water bags, each equivalent to the weight of one man, are drained into the DISSUB to compensate for total payload changes as personnel are transferred into the PRM.

Bags:        NOMEX covered MYLAR  
                       2.83 cu ft each  
 Fittings: Fill, drain, vent

A simple soft tank ballast system is used to provide additional stability at the surface and to allow for adjustment in total payload. The system includes:

Tanks: 4 x 250 lb net displacement each  
 Control: HP air - blow  
           Pilot (air) operated - flood  
           Tank level sensors and display

The PRM can also carry life support stores, food and medical supplies for delivery to DISSUB personnel. Water ballast bags are adjusted to maintain total payload limit.

In addition, the PRM is fitted with a forward and aft clump weight (500 lb each) system. These are sized to provide final adjustment of vehicle trim and can be jettisoned to provide additional positive ascent buoyancy in the emergency mode.

Safety & Emergency Systems

The PRM is fitted with a number of emergency systems. These supplement the already redundant power, control and monitoring systems.

Rations                18 men, food & fluids  
 First aid                comprehensive kits  
 Stretcher for injured personnel  
                               (includes hoist)  
 Fire suppression     hyperbaric water  
 Seat belts                harness for all personnel  
 Strobe light            surface SAR  
 Pinger                    37.5 kHz

Secondary lift Jettison	2 <sup>nd</sup> lift point attachment main umbilical termination umbilical core cut forward clump weight aft clump weight
Batteries	critical life support and communication functions are supplied by silver zinc battery packs external to the hull for power backup.

At launch, a high flow vent system allows the skirt to be flooded in less than 15 seconds. After aligning with the mating ring, the skirt is de-watered at depth in 2 stages. The LP high volume pump creates a flow to assist in landing and provides the initial seal. Two HP low volume pumps are provided to completely de-water the skirt in less than 15 minutes.

LP Pump	450 gpm @ 12 psig
HP pump	2 x 35 gpm @ 900 psig

#### Seals

The main seal at the DISSUB mating ring is identical to current USN DSRV design. Each rotary joint in the skirt has a primary and secondary seal. The skirt is attached to the PRM using a bolted flange. The flange incorporates a dual seal and a test port to allow pressure testing of the flange seals after installation.

#### Angle Control

The skirt rotation is controlled by hydraulic motors, a toothed belt drive and position feedback. The upper (horizontal) rotary joint adjusts for angle of approach of the PRM relative to current and target. Rotation is +/- 330 degrees. The lower (diagonal) rotary joint adjusts the angle of the skirt from 0 to 45 degrees. Rotation is +/- 220 degrees.

#### Control & Sensors

Rotate position feedback is provided from the hydraulic motors. The PRM profiling sonar is used to provide long range DISSUB orientation and deck angle input. Four high-resolution altimeters on the skirt are used to provide accurate altitude data. The bore mounted SIT Equivalent camera and upper skirt mounted internal tilt, rotate camera provide optical data. All inputs are integrated to create a graphic and digital data feedback display for the pilot, indicating the skirt geometry and alignment with the DISSUB mating seat. This feedback is displayed at the pilot and navigator consoles. Manually activated switches adjust skirt orientation. An "Auto Skirt Angle Reset" function is provided for subsequent sorties.

#### **CONTROL VAN ELEMENT**

The Control Van (CV) element includes the control van structure, the PRM control system, and van and PRM power distribution systems.

The structure meets all ISO standard dimensions. Due to significant weight and operational load limits imposed, the structure of the CV has been highly engineered to optimize strength and minimize weight. The van is divided into two sections: the pilot control

#### **TRANSFER SKIRT ELEMENT**

A key feature of the PRMS system is the OWC-patented articulated mating skirt that allows the PRM to mate to the deck of the DISSUB at angles up to 45 degrees while maintaining a normal horizontal vehicle attitude. The hydraulic powered skirt rotation and alignment allows the vehicle to be flown at optimum angles of attack with respect to sub sea current, DISSUB axial orientation, and angle of repose on the sea floor. The need for costly, heavy, and complex ballast and trim control systems is eliminated. Operation time, pilot training time and associated training cost is greatly reduced over fixed skirt rescue system technology.

The PRM specifications require that the skirt be of sufficient size that mating, hatch opening and personnel transfer can be achieved without removal of any streamline fairing that may be fitted to the submarine hatches. This results in a skirt size and configuration much larger than that now required under current NATO STANAG agreements. Principal features of the PRM skirt are:

#### Dimensions

Clear ID	76+ inches
Height (flat)	63+ inches
Height (45 <sup>0</sup> )	79+ inches

#### Mating Angle Capability

DISSUB deck	45 degrees
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#### Weight

7,946 lbs

#### Pressure Hull Material

HY100 steel  
INCONEL penetrator bosses, brackets  
Monel and stainless penetrator inserts  
HY 100 turnbuckle adapters  
INCONEL cladding of all seal surfaces

#### De-watering System

area and the power distribution and HVAC equipment area. All system interconnect cables are connected via a D-mark panel using gender and size specific watertight quick connect fittings to ensure rapid, trouble free mobilization.

Dimensions

Length	240 inches
Width	96 inches
Height	96 inches

Weight

Maximum operational	11,115 lb
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Construction

Frame Structure	custom aluminum extrusions
Panels	laminated aluminum skin with honeycomb Arimid fiber composite core
Assembly	welded, bolted and sealed
Lift	Bottom ISO corners
Doors	1 x personnel 1 x equipment 1 x escape hatch
HVAC	6 ton, ducted
Main power	input - dual bus, 440, 460, 480 vac, 60 hz, 3 phase distribution – 220/110 vac

Control System - Power

Input power from the SRDRS Generator Van is provided on two independent buses with dedicated cables and discrete power loads assigned to each bus. This dual system distribution is maintained from source to the PRM sub sea. The PRM power is divided between the surface control system, the high voltage sub sea HPU motor power and the sub sea hotel load power. Power conductors in the umbilical are also split between bus 1 and bus 2 to ensure redundancy.

Features of the power system include:

Boost transformers	2 x 122 kva, multi-tap input to multi-tap output (3000 vac) – main hydraulic power units 2 x 5 kva, multi-tap input to multi-tap output (1900 vac) – sub sea hotel load
Ground Fault Protection	On primary and secondary bus supplies
Uninterrupted Power Supplies	Split on system CPU's, monitors, controls and

recording systems ensuring full function is maintained in event of power loss on either bus.

Control System - Signal

The PRM control and telemetry data is transmitted over a fiber optic network. It features 2 fully redundant sub sea telemetry cans and related surface CPU's operating over 2 fibers and an Ethernet system that shares all the PRM functions and provides for automatic transfer of control in the event of signal loss or fiber failure. The CPU's in the control van are also configured for full interchangeability and cross-over control from any of the personnel stations.

There are 6 main consoles that support the PRM controls, signal processing, data display and data recording functions. All components in the control van are selected, housed, tested and evaluated to withstand the severe transport and operational shock and vibration loads imposed.

PRM control features include auto depth, auto heading, auto altitude, auto station keeping, auto skirt angle reset, cruise control, pitch, roll and yaw control, and trim adjust. The status of the vehicle systems is displayed on the main Graphical User Interface (GUI) screen with video overlay on any of the displays selected by the pilot or navigator. The GUI is multi page and has pop up menus for system adjustment, alarms and trouble shooting. Maneuvering and camera functions are controlled through the pilot's joy stick, mounted in the arm of the ergonomically designed chair. Touch screens and keyboards with track balls are used for menu selection, system manipulation and display control.

Command and Control - Consoles & Video

The CV is the hub of the SRDRS system. It is sized and equipped to provide space for the Operations Supervisor, the Life Support System Supervisor, the PRM Navigator and the PRM Pilot. Interfaces are provided for communication and remote displays for the ships Captain and the Rescue Forces Coordinator.

There are 5 main consoles for principal PRM control, navigation and life support monitoring, plus a control/power module and a video/communications module. Video and sonar image display is a key feature of the control system. There are 12 cameras and 3 scanning sonars on the PRM, with position feedback on pan, tilt and rotate functions of 6 items. In the control van there are a total of 9 conventional color video/data displays and 3 color flat screen plasma displays that

can be divided into multiple segments. Any operator can select and move any display (video, GUI, INS, sonar etc) to any screen or screen segment using a software based drag and drop video select system.

In addition to the PRM interface, life support and systems status data and video is provided to the CV consoles from the SDC, DTL, LARS, and umbilical winch elements. Remote displays and full deck intercom links are provided from the control van to other stations on the ship, including the bridge.

The Integrated Navigation System (INS) software processes input from the acoustic navigation system, the PRMS sensors, DGPS system, vessel and PRM heading sensors, multiple sub sea beacons and any electronic overlay data that may be appropriate. The integrated display is available in the CV and at remote locations on the bridge or elsewhere on the ship.

The PRM is equipped with a release device that allows it to deploy mini beacons on the DISSUB or other targets of interest. INS data is incorporated with operational procedures and high-resolution sonar data to provide the required feedback to allow mating in one foot of visibility. This includes data on the submarine structure so that landmarks (sail, fins, screw etc) can be identified acoustically and distinctive geometry is used to provide an exact position of the mating seat.

### **UMBILICAL WINCH ELEMENT**

The PRM umbilical winch element consists of the main umbilical winch, the umbilical and the interfaces to the LARS control system and structure. The umbilical winch is mounted on top of the SRDRS Generator Van. Like the control van, the winch weight and dimensions are highly restricted. As a result, significant engineering effort has been applied to produce a lightweight aluminum frame construction providing all operational load handling and control features required. The umbilical winch and umbilical are not used to lift or recover the PRM in air. The LARS incorporates a cursor frame and dual heave compensated recovery winches for lifting and handling the PRM. Umbilical winch controls are interfaced to the LARS controls so that a single operator can complete all launch and recovery control activities.

Principal features of the winch include:

#### Dimensions

Length	96 in
Width	96 in
Height	96 in

#### Weight

Including umbilical, slip rings, hydraulic units, controls and all accessories.

Operational 15,950 lbs

#### Capacity

Umbilical	3,500 ft
Line pull	13,750 lb minimum
Speed	100 fpm minimum
Brakes	27,500 lb minimum

#### Drive & Power

The winch has a dual pump motor hydraulic drive system with redundant power supplies for both prime movers and control systems.

#### Interface & Maintenance

The system is designed for rapid replacement of the umbilical and all system components. Interface features include:

- Slip ring with multi fiber and power rings
- Rotating junction box with pull out access
- Fixed junction box with quick connect power, signal and communications cables
- Rapid depressurization (transport) vent valves on all enclosed spaces
- Dry nitrogen purge and desiccant system on all electronics
- Rapid drum and bearing replacement
- Rapid HPU replacement

#### Control & Operation

The winch has both remote (at control van or LARS) and local controls, selected at the LARS control station. Remote control and data links are RS 485 and RS 422 based. Control features include:

- Fully proportional speed and direction
- Constant tension mode select – 2 tensions
- Level wind adjust
- Level wind engage/disengage
- Fast Render (emergency) pay out

Feedback sensors and control at local and remote stations include:

- Speed and direction display
- Pay in/out display and reset
- Line tension display and alarms
- Hydraulic system status display & alarms
- Electrical system status display & alarms
- Emergency stop control

Provision is made to respond to accidental vessel drive off conditions with the following features:

- Fast render (pay out) mode
- Umbilical cut and release at drum

The winch and umbilical systems are interfaced to the

LARS with features used to mitigate shock and overloads to the winch and the Generator Van structure on which it is mounted to mitigate the potentially hazardous effects of LARS heave compensation or load alleviator failure. These include:

- High speed (900 fpm) render at 20,000 lb
- Umbilical failsafe release at 50,000 lb load

The umbilical selected for the PRM is a contra-helical wound, steel armored cable with power and fiber optic conductors. The armored cable is used to provide weight to help offset drag on the cable in the high environmental current profiles specified for operations. The key features of the umbilical are:

#### Construction

OD	1.36 inches
Weight (air)	2.25 lb/ft
Weight (water)	1.65 lb/ft
Depth Rating	5900 fsw
Minimum bend diameter	43.3 inches
Safe working load	86,000 lb
Breaking strength	84,821 lb
Main power (3000v)	10 x 8mm <sup>2</sup>
Hotel power (2000v)	7 x .82 mm <sup>2</sup>
Drain/earth	6 x .5 mm <sup>2</sup>
Twisted shielded quad	1 x .35 mm <sup>2</sup>
Fibers	8 x SMF

#### Termination

The mechanical termination at the vehicle-end of the umbilical is a titanium docking profile that interfaces to the LARS cursor frame. The umbilical armor is terminated into a mechanical, poured socket assembly secured to the top of the docking profile and designed to release at a load of 50,000 lbs. This requirement is to prevent loads in excess of 50,000 lbs being applied to the Generator Van in the event of a LARS load alleviator assembly failure while the PRM is at depth. The mechanical termination can also be jettisoned in the event that the PRM becomes entangled.

The Electro-optical conductors are terminated in a pressure compensated, oil filled can with distribution to the HPU motors, sub sea hotel load power transformers and two telemetry cans. The core of the umbilical passes through a cable cutter that will automatically cut the cable in the event of a 50,000 lb or greater load (see above) or if umbilical release is mechanically activated for a commanded jettison.

#### **PRMS AIR TRANSPORT INTERFACES**

The PRM, Control Van and Umbilical Winch elements are all designed for air, sea and road transport. Each

element is provided with an air transport pallet compatible with the US Military Aircraft 463L Air Cargo Handling System specifications. Pallets are custom configured and certified to accept the weights and dimensions of the individual elements.

The static and dynamic loads from air, sea and road transport modes have produced significant design developments for the light weight structures of the PRM, Control Van and winch to meet extreme acceleration, deceleration and vibration criteria. These loads are in some cases much higher than the at sea operational loads on the system.

#### **PRMS AUXILIARY EQUIPMENT**

The PRMS is delivered with complete operational support equipment, tools, manuals and documentation. The principal auxiliary equipment includes:

Shop Support Stand – to support the PRM during fabrication, assembly, test sea trials and post delivery depot maintenance and repair.

Auxiliary Hydraulic Power Unit – provides alternative hydraulic power for maintenance and on deck function testing of PRMS equipment and supplemental hydraulic tool operation.

Deck Interconnect Cables – For rapid mobilization a complete PRMS interconnect cables with gender and configuration specific end fittings for quick connect to the PRMS elements is provided.

Engineering Mock ups and Models – Extensive use is made of 3D modeling software. However, a full size mock up of the aft section of the PRM was used to evaluate interior layout and ergonomics. In addition a full size welded assembly of 4 bays of the PRM hull has been fabricated to verify weld procedures prior to committing to the production plan.

## CONCLUSIONS

The PRMS represents a state of the art development in submarine rescue system technology. It applies lessons learned from a previously developed RORV system to create a significantly more powerful and more capable system.

PRMS advancements include greater depth and personnel capacity, improved propulsion, navigation and control systems and significantly improved deployment and operational response capability due to full integration with the SRDRS deck decompression and launch and recovery systems.

To facilitate less costly commercial design and fabrication, the Navy has applied a combination of commercial (ABS, DNV) and military engineering and

design practices to the pressure hull and other system components.

The application of blended military and commercial rules plus the extensive use of COTS components results in interesting opportunities for reduced cost and time design and manufacturing options for a system of this complexity and magnitude. It is anticipated that this effort will lead to future Navy systems enjoying the cost and time benefits of a more commercial approach to military systems development.

The integration of the PRMS into the SRDRS program is a co-operative effort between Team Hard Suits (OceanWorks International Corp, International Submarine Engineering, Southwest Research Institute and Resource Consultants Inc), the United States Navy and its SRDRS Technical Authority, Oceaneering International. We are proud to be a contributing member of this team.