U.S. Department of Transportation
Maritime Administration
Office of Marine Asset Construction and Technology

New Generation Polar Research Vessel

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These Newsletters can be found online at the PRV Web site (see page 8).

Feasibility Study Nears Completion

A milestone nears in the Polar Research Vessel (PRV) project with the completion of the most recent science and technical efforts for the vessel.

The achievements to date reflect the considerable time and effort expended by over 250 U.S. scientific experts at the request of the Antarctic Research Vessel Oversight Committee (ARVOC) and its Scientific Standing Committee for the PRV (SSC-PRV).

These experts provided information, comments, and opinions that lead to a well defined set of science and operational requirements. Furthermore, they provided timely guidance to the project team responsible for translating those requirements to a feasible vessel.

While there are many components to the feasibility study, this Newsletter focuses on the "science platform" aspect and how the PRV will satisfy the national needs.

These efforts began in 2003 when the National Science Foundation, Office of Polar Programs initiated a program to determine the national requirements for polar marine science in the Antarctic and to determine the approximate vessel characteristics.

Figure 1. Artist's Rendering of the Polar Research Vessel

Science and Operational Requirements

While the *Nathaniel B. Palmer* (*NBP*) has served the science community well, there are compelling reasons to plan for a new polar research icebreaker. Under the auspices of the Antarctic Research Vessel Oversight Committee (ARVOC), the list of critical research requirements, as developed by the U.S. scientific community, mandates a new vessel for future scientific exploration of the Antarctic seas.

Critical New Research Requirements

- Enhanced icebreaking capabilities 1.4 m (4.5 ft) at 3 kts
- Increased endurance to 80 days and 20,000 miles at 12 kts
- Increased accommodation and lab space for 50 scientists
- Moon pool (an opening from the main deck to the bottom of the vessel) for geotechnical drilling and provides access to the water column
- Ability to tow nets and research instrumentation from the stern during icebreaking
- Acoustically quiet
- Hull form designed for the installation and operation of remote sensing instruments during icebreaking

The first two critical requirements are directed towards increasing the ability of U.S. researchers to operate in a greater portion of Antarctica's ice-covered seas as well as throughout the Southern Ocean during all four seasons. The third requirement, increased accommodation space and lab space, will foster comprehensive and integrative approaches to Antarctic marine research.

The moon pool, ice-shedding stern, and acoustic/hull properties are required to take advantage of new tools that have become important for many types of Antarctic research. An example of this is the use of a box keel as described in Newsletter No. 2.

While the icebreaking capabilities are defined in terms of transiting 1.4 m (4.5 ft) thick level ice at 3 kts, the vessel must also be able to encounter and transit pressure ridges with a sail height of at least 2.4 m (8 ft) and a corresponding keel depth of 7.9 m (26 ft). [The sail is the area that is above the level ice surface and is visible. The keel is below the sail and is not visible.]

Transits through these ice conditions, as well as level ice thicknesses greater than 1.4 m (4.5 ft), will require the vessel to back and ram. Periodic impacts with multiyear ice fragments should also be expected as well as higher resistance from lateral pressure in the ice sheet which is caused by winds and currents.

Additional requirements were also identified by the scientific community and some of these are described below.

Additional Science and Operational Requirements

- Capability to conduct autonomous underwater vehicle remotely operated vehicle (AUV/ROV) operations
- Jumbo piston coring (JPC) capacity for 50 m
- Compliance with International Maritime Organization (IMO) guidelines for Arctic vessels
- Reduced air emission from diesel engines and incinerator and other features for a "greener" ship
- Provision for a helicopter flight deck and hangar
- Space for 6 portable lab containers
- 2.4 m (8 ft) wide passageway on the Main Deck and inter-deck elevator
- Aloft, enclosed platform for science observations

Taken together, these requirements dictate that the next generation PRV will be larger and have a different hull shape than many of the existing icebreaking research vessels.

An example of the benefits to be realized with the

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Advancing Toward Ultra Green -
Developing an Environmentally Sensitive PRV

Recent advances in marine engineering are providing an opportunity to make significant improvements in the environmental quality of ships. With this in mind, an "ultra-green" strategy was developed for the PRV with the objective of addressing all ship systems including air emissions, water discharges, and possible oil leakages.

As described in Newsletter No. 2, the potential exists to significantly reduce diesel air emission rates aboard the PRV by approximately 90 percent compared to the *NBP's* 1990 diesel engines. Recent advances in shipboard equipment and systems now allow major improvements in a number of other areas that could have an impact on the environment. All of the approaches employ proven technology some of which are shown in Figure 2.

In addition to the environmental benefits previously noted, there are a number of others that are significant.

- Use of the latest incinerator technology to reduce particulate matter and other emissions
- Installation of electric-powered science winches in lieu of hydraulic powered to reduce potential of oil leakage
- Availability of ultra low sulfur marine diesel fuel in 2012 (99 percent lower sulfur content than today's marine diesel fuel). Note that on-highway use begins in 2006.

While the strategic framework for the PRV has been developed, there remains a number of aspects that require further definition before they can be incorporated in the guidance specification for the vessel.

Ultimately, the PRV may serve as a catalyst for others in the international community to further reduce environmental impacts from marine operations in the Polar Regions.

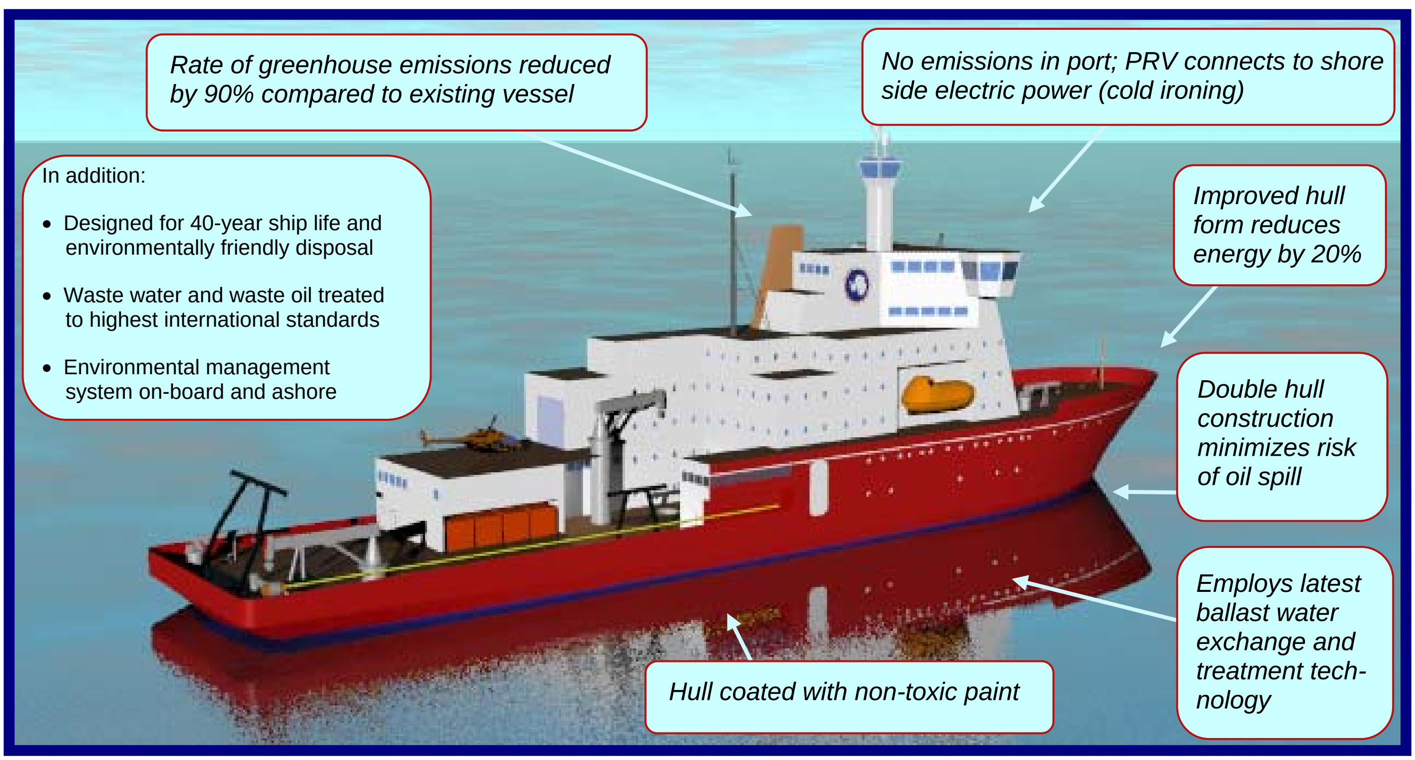

Figure 2. Some of the Environmental Features Incorporated in the PRV

Arrangement of Primary Science Decks

The PRV must be multi-functional with modular designed components that can be mobilized or de-mobilized for specific projects. As an example, investigations in the Polar Regions require not only the ability of a vessel to enter the ice, but also to be equipped with Autonomous Underwater Vehicles (AUVs) or Remotely Operated Vehicles (ROVs) to facilitate investigations under the ice, in the water column, and on the sea floor. There are rapid advances being made in these technologies and it is anticipated that these instruments will become standard in all areas of marine science. Storage, deployment, operation, and recovery of modular systems and instruments need to be fully reviewed.

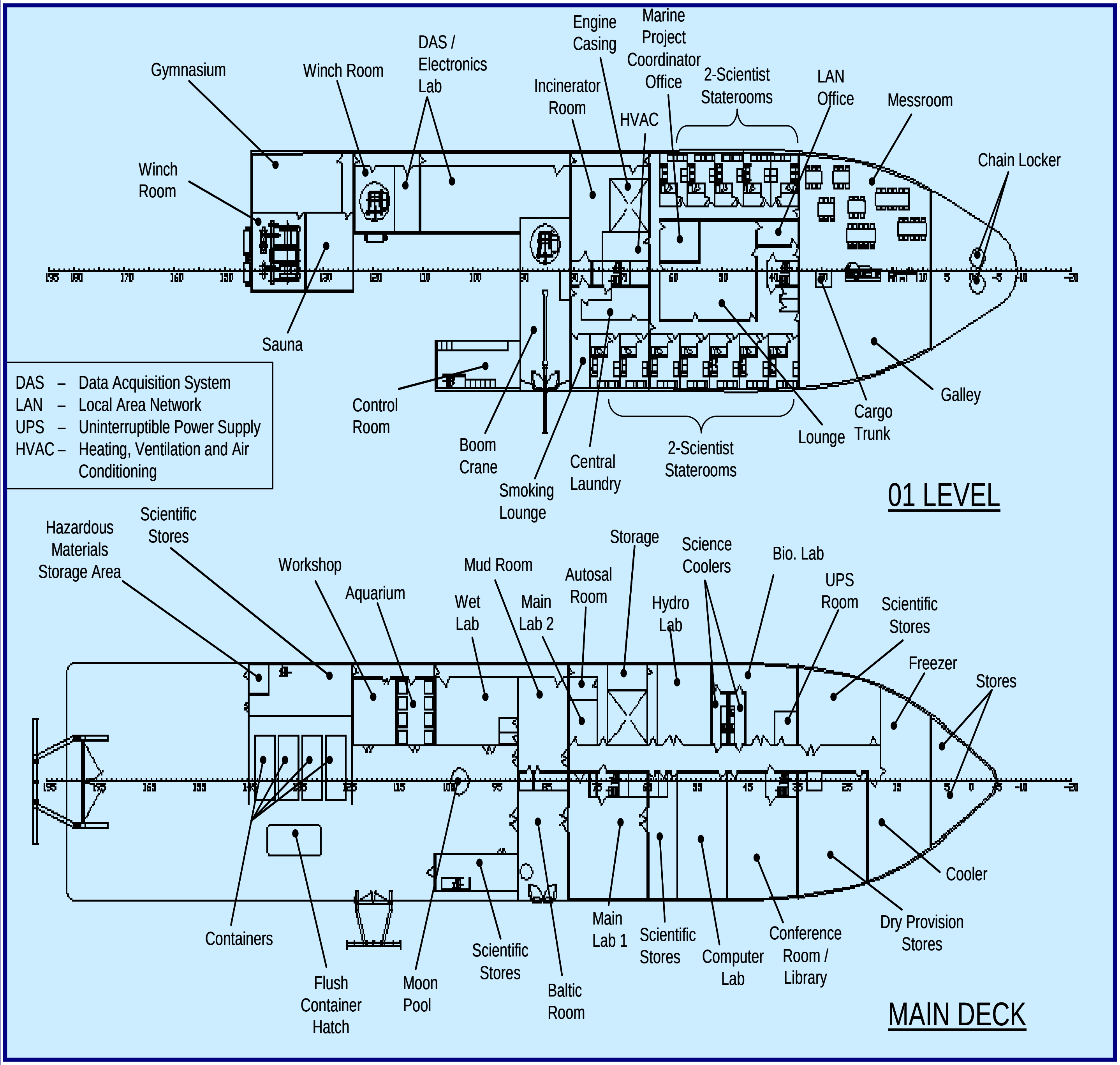

Figure 3. PRV Arrangements for the Main Deck and 01 Deck

Moreover, similar consideration needs to be given to accommodate new geotechnical drilling and sediment coring. Here again, storage and deployment of drill rigs require careful analysis of their capabilities, planning of deck layout and superstructure as well as ship maneuverability. In addition, biological investigations are rapidly evolving to rely more and more on molecular-based methods for evaluation of taxonomy and physiology. Sterile lab conditions and motion sensitive instruments are routine components of many research projects.

Therefore, considerable time and effort have been spent by ARVOC and others in the science community on the current arrangement of scientific spaces on the Main and 01 Decks. These Decks are the primary work areas of the vessel and are shown to the left. The arrangement is somewhat similar to the *NBP*, but incorporates changes to reflect operational experience and new needs. Of particular interest, please note the new arrangements.

Approximately 90 percent of the Main Deck area is dedicated to science operations and of that, over 25 percent is a clear, unobstructed open area with tie-down fittings. This clear deck area also contains a 2 m (6 ft) moon pool located approximately at midship and will have flush watertight closures at the top and bottom. On the starboard side, space has been provided for a 50 m jumbo piston core *as shown in yellow on page 3.*

In addition, from the outside deck area, direct access is provided to the wet lab, Baltic room (a room from which scientific equipment can be deployed over the side through large water-

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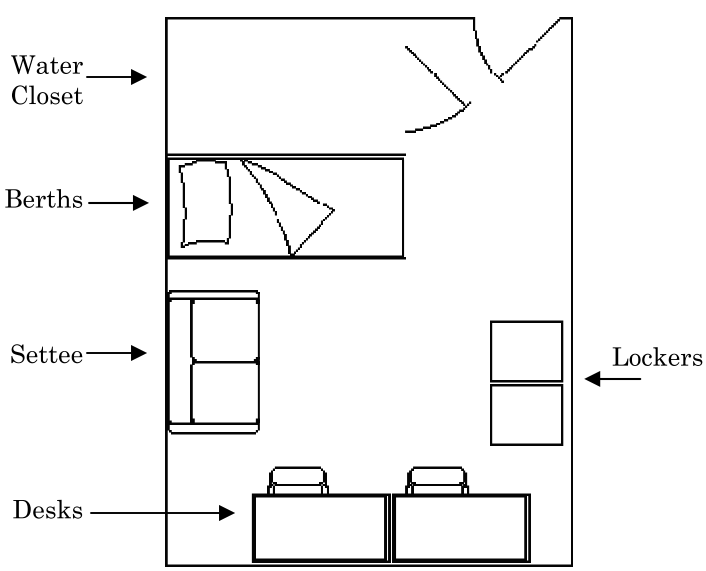
Features of Two-Person Science Cabin

The PRV is configured to accommodate a total of 50 scientific personnel in 26 cabins. Of this total, two are single cabins (staterooms) and the remaining are two person cabins. As these comprise the majority, a number of cabin arrangements were considered and the configuration shown below was selected. It has approximate dimensions of 3.7 by 4.9 m (12 by 16 ft) or 17.8 sq m (192 sq ft). Some of the features of this arrangement are described in the adjoining table.

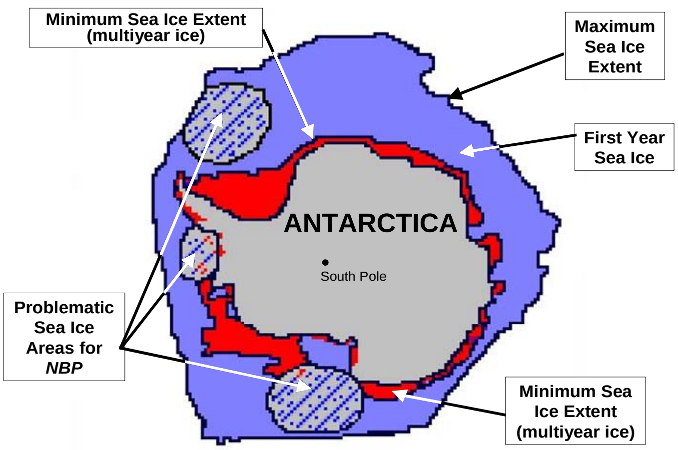


- Berths
  - Positioned fore and aft
  - Upper of Pullman type that can fold against the bulkhead
  - Bottom to have drawers below
  - Draw curtains to close off light
  - Lighting and shelving at the head
- Carpeting on the floor
- Desks for each occupant, various electrical and electronic outlets, extra lighting at each desk, one phone
- Flat panel TV/monitor suspended from wall or ceiling
- Porthole in each stateroom with plexiglas sheet covering to act as insulator
- Electronic in-room safe
- Water closet (shower, toilet, wash basin)
- Two lockers sized for hanging bulky clothing with drawers plus suitable space for life preservers
- Two-person settee
- Magnetic stripe card for access to room
- Outside of cabin, next to door, name card holders to identify occupants in upper and lower berths

(Continued from page 2)

Science and Operational Requirements

PRV's 50 percent increase in icebreaking capability is depicted in the adjacent figure. It shows the minimum and maximum sea ice extent in year 2000, first year and multiyear ice areas, and hatched areas where *NBP* vessel operations have been problematic during multiple cruises. With the increased capability of the PRV, it will have access to 90 percent of the ice covered areas of the Antarctic margin.



Minimum and Maximum Sea Ice Extent during Calendar Year 2000

To aid in all of these conditions, the PRV will have a low friction hull coating and a heeling system that permit the vessel to roll from one side to the other by pumping fluid to and from the outboard ballast tanks. With the double hull construction, the vessel will have many ballast tanks. This will permit the vessel to take on sea water and maintain a near constant draft throughout the mission as fuel is consumed. It is likely that IMO regulations will be in effect to reduce potential harmful exchanges of ballast water and marine organisms from native to non-native habitats and seas.

A notional annual operating profile for the PRV is shown. This is considered very representative as it reflects the operational experience of the *NBP* during the last 14 years.

Of the 265 days conducting science and in-transit, the majority of the time will be spent in the ice environment, although much of the science will still be conducted in ice free waters. These latter science activities, as well as approximately 66 days in open water transit, make the sea kindliness characteristics of the vessel (gentle motions in waves) extremely important.

Notional Operating Profile	
Activity	**Days**
Science operations away from port and in-transit	265
In-port preparations for science op-	35
Repair and maintenance	65
Total Days	365

The need to minimize transit days to 66 per year, and maximize science operations at 265 days, is based on having the principal base of operation in the southern latitudes. It should be noted that there is an additional requirement for the PRV to have the capability to operate independently, away from any port, for a three-month time period.

Operationally, the PRV may face a wide range of environmental conditions. As such, the vessel will be designed and built for a minimum winter air temperature of –46°C (-50° F) and have the capability of enduring a maximum sustained wind speed of 100 kts. Additionally, the combination of cold sea water and air temperatures with high sea states can cause severe topside icing at times. Icing rates of 1.3 cm/hr (0.5 in/hr) can be expected in extreme events.

From a vessel life cycle perspective, the technology is available today to design and build for a service life of 40 years. This requirement for the PRV must be factored into the detail design phase by the shipyard (after contract award) to avoid the unnecessary cutting of cabling, piping, and other systems when the need arises for possible replacement of machinery and other components. A preventative maintenance plan and thorough half-life refit at the 20-year mark may be some of the methods used to meet the requirement.

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Arrangement of Primary Science Decks

tight doors), aquarium, scientific stores, workshop, hazardous materials storage area, four containers and the mud room. Access to the mud room is through 8 ft wide doors and this allows, when the vessel is in port, equipment and supplies to be moved on pallets to the other science spaces.

The 01 Deck has control rooms, winch rooms, 12 two-person staterooms, a large lounge, a smaller smoker's lounge, wash rooms outside of the mess-room and galley, the Marine Project Coordinators Office, laundry room, gymnasium, sauna, in addition to a large data acquisition system (DAS)/ electronics laboratory. The messroom was relocated to the 01 Deck from the Main Deck, because it was felt that the noise level from icebreaking operations would be significantly reduced at the new location.

Although not shown in the Newsletter, the 02 Deck provides cabins for 24 scientists including single staterooms for the Chief Scientist and the Marine Projects Coordinator. It is also the deck where a hangar is provided for the storage of two helicopters and an associated service workshop. The 03 Deck is also the location of the hospital and easy access is provided from the hospital to the lifeboat. The 03 and 04 Decks provide 21 cabins for officers and crew.

The bridge deck is configured for primary pilothouse control from the starboard bridge wing, which affords a clear view of the open starboard and fantail area (see Figures 1 and 2). As such, there is no need for a centerline control station as the redundant station will be located on the port bridge wing.

All of the science and operational requirements are satisfied in a vessel having the principal characteristics as shown.

Principal Characteristics

Length, Overall	**119.7 m**	**392.8 ft**
Length, Waterline	**108.3 m**	**355.4 ft**
Beam	**22.8 m**	**74.8 ft**
Draft	**10.2 m**	**33.5 ft**
Displacement	**14,100 MT**	**13,900 LT**
Propulsion Horsepower (total, twin propellers)	**16.8 MW**	**22,400 HP**

Additional Readings

1. Sutherland, A., "United States Antarctic Program Research Vessels," *Marine Technology Society Journal*, Fall 2001
2. Dunbar, R. (on behalf of the Antarctic Research Vessel Oversight Committee), "Advancing U.S. Polar Research through the Acquisition of a New Polar Research Icebreaker," June 2006
3. Voelker, R., Sutherland, A., Owen, H., Olsgaard, P., Holik, J., St. James, J.W., Iyerusalimskiy, A., and Karnes, D.B., "New Generation Polar Research Vessel," Society of Naval Architects and Marine Engineers, ICETECH 2006, July 2006

Figure 4. Portside View of PRV

Next Phase

To date, the PRV's basic science and operational missions have been determined, as well as the vessel size, characteristics, and a construction cost estimate. Should a decision be made to proceed, the next phase needs to fine tune aspects of the program and vessel such that guidance plans and specifications can be developed for a PRV Request for Proposals (RFP).

PROCUREMENT ACTIVITIES

Some of the key activities include an analysis of the lease-versus-buy alternatives, the development of a procurement plan of action including schedules, the conduct of meetings with industry on the procurement, and a wide set of activities related to preparation of the RFP.

SCIENCE ACTIVITIES

A great deal of time and effort is needed on the arrangement of laboratory and science spaces such that there is proper integration with winches, cranes, storage, and cargo handling equipment. In addition, some of the laboratories will require a more detailed study to assure that they provide the desired flexibility of use for multiple science disciplines. All of these activities will require considerable deliberation and coordination.

TECHNICAL ACTIVITIES

There is a need to refine the hull and propulsion plant so that a series of model tests (seakeeping, icebreaking, calm water speed/power, and station keeping) can be conducted. The objective of these tests would be to demonstrate or verify, not optimize, that the guidance drawings of the hull and propulsion plant satisfy the requirements. Prospective bidders will then have the option of using this information or attempting to further optimize the configuration as they respond to the RFP. Several additional studies will need to be conducted and these include: the reliability of podded propulsors in ice, acoustic studies, and general refinement of the machinery plant.

Acronyms

ARVOC	Antarctic Research Vessel Oversight Committee
AUV	Autonomous Underwater Vehicle
HP	Horsepower
JPC	Jumbo Piston Core
MARAD	Maritime Administration
MW	Megawatt
NBP	*Nathaniel B. Palmer*
NSF	National Science Foundation
OPP	Office of Polar Programs
PRV	Polar Research Vessel
RFP	Request for Proposals
ROV	Remotely Operated Vehicle
RPSC	Raytheon Polar Services Company
STC	Science and Technology Corporation

Visit the PRV Web site at:

www.usap.gov/vesselscienceandoperations/prvsection.cfm

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