Arctic Research Vessel

Preliminary Design Report

(Abridged Version)

August 1994

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Preliminary Design Report

(Abridged Version)

Conducted pursuant to the research ship requirements of the University National Oceanographic Laboratory System (UNOLS), Fleet Improvement Committee (FIC)

Under the direction of:

University of Alaska

Fairbanks, Alaska

Supported by a grant from the Ocean Sciences Division of the National Science Foundation

UNIVERSITY-NATIONAL OCEANOGRAPHIC LABORATORY SYSTEM

An association of institutions for the coordination and support of university oceanographic facilities.

18 August 1994

Dear Colleague,

The enclosed UNOLS Fleet Improvement Committee (FIC) report on the Arctic Research Vessel (ARV) is offered for your review and comments. The report represents the work of the UNOLS FIC ARV subcommittee and their primary contractor, The Glosten Associates, Inc. of Seattle. This design responds to the ARV Scientific Mission Requirements (SMR) that were circulated in August 1992. It is designed to work throughout the year in the seasonal ice zone of the Arctic and to carry out expeditionary work anywhere in the Arctic during the summer in company with an escort. While the vessel in this design will be the largest in the UNOLS fleet, it is the minimum sized vessel that is capable of satisfying the SMR. The addition of this vessel to the academic fleet has been endorsed by UNOLS. This ARV design has also been presented to the Polar Research Board, the Arctic Research Commission and to program managers from agencies that will use the vessel, ONR, NSF, NOAA, NASA and MMS.

The acquisition of a capable, well designed Arctic Research Vessel will allow access to the Arctic on the same regular basis available to our international colleagues. This will allow U.S. scientists to plan and execute scientific programs in the same manner as do users of other UNOLS vessels.

This ship will become a reality only if there are funds available for its construction and operation. UNOLS and the federal funding agencies are committed to the proposition that the ARV should only be added to the fleet if other UNOLS fleet operations are not adversely affected. If the Arctic and Oceanographic science community want this platform, then their collective voices must be heard. Comments on this design process, the design itself and the finances should be directed to UNOLS and federal funding agencies. Political support by interested scientists can only help the process.

Sincerely,

Garrett W. Brass
Chair
UNOLS

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Chair
UNOLS Fleet Improvement Committee

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ARCTIC RESEARCH VESSEL

PRELIMINARY DESIGN REPORT

(ABRIDGED VERSION)

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ABBREVIATIONS AND ACRONYMS

(Abbreviations for units on page v below)

ABL	above baseline
ABS	American Bureau of Shipping
AC	alternating current
ARC	Arctic Research Commission
ARV	Arctic Research Vessel
BL	baseline
CAC3	Canadian Arctic Class 3
CASPPR	Canadian Arctic Shipping Pollution Prevention Regulations
CFM	cubic feet per minute
CFR	Code of Federal Regulations
CL	centerline
COR	Circular of Requirements
DC	direct current
DNV	Det Norske Veritas
DWL	design waterline
EOS	Engineers Operating Station
ESWBS	Expanded Ship's Work Breakdown Structure
FIC	Fleet Improvement Committee
FP	forward perpendicular
FR	frame
GM & Gm_t	metacentric height
HP	horsepower
HSVA	The Hamburg Ship Model Basin
Ht.	height
HVAC	heating, ventilation and air conditioning
ISO	International Standards Organization
KG	vertical center of gravity above baseline
KML	longitudinal metacentric height, from baseline
KMT	transverse metacentric height, from baseline

lav.	lavatory
LCB	longitudinal center of buoyancy
LCDR	Lieutenant Commander
LCF	longitudinal center of flotation
LCG	longitudinal center of gravity
Long'l	longitudinal
L_{pp}	length between perpendiculars
maint.	maintenance
MIZ	Marginal Ice Zone
MSD	Marine Sanitation Device
NSF	National Science Foundation
NSMB	Netherlands Ship Model Basin
prop.	propeller
PTO	power-take-off
RH	relative humidity
Rev.	revision
S.S.	sea state
Sht.	sheet(s)
SMP	Ship Motion Prediction Program
SMR	Science Mission Requirements
SNAME	The Society of Naval Architects and Marine Engineers
SOLAS	Safety of Life at Sea
S.W.	salt water
SWBS	ship's work breakdown structure
SWBD	switchboard
TGA	The Glosten Associates
UAF	University of Alaska Fairbanks
UNOLS	University-National Oceanographic Laboratory System
VAC	volts, AC
VCB	vertical center of buoyancy
VCG	vertical center of gravity
WL	waterline

UNITS

Bhp	brake horsepower
g	gravity
gal	gallon
gpd	gallons per day
GPM	gallons per minute
kg	kilogram(s)
kHz	kilohertz
kPa	kilo-Pascals
ksi	kips per square inch
kW	kilowatt
L	liter(s)
lb	pound(s)
LTSW	long tons, salt water
LT	long tons
m	meter(s)
M	million(s)
min	minute
mm	millimeter(s)
psi	pounds per square inch
RPM	revolutions per minute
scfm	specific cubic feet per minute
sec	second(s)
SHP	shaft horsepower

1 - INTRODUCTION

1.1 General

The new Arctic Research Vessel (ARV) design commissioned by the University-National Oceanographic Laboratory System (UNOLS) under a grant from the National Science Foundation (NSF) is intended to support science missions in the Arctic well into the next century. The vessel described in this report and in the attached preliminary design package is primarily an ice-breaking research vessel. The design reflects the perceived needs of the arctic science community as communicated through the Arctic Research Vessel Subcommittee of the UNOLS Fleet Improvement Committee (FIC).

On behalf of the UNOLS Subcommittee, this project was overseen by three principal investigators from the University of Alaska Fairbanks, Institute of Marine Science:

Dr. Thomas Royer, Chair

Dr. Vera Alexander

Dr. Robert Elsner

The other members of the Subcommittee are:

Dr. Knut Aagaard, University of Washington

Dr. Garrett. Brass, University of Miami, UNOLS Chair

LCDR William Davis, United States Coast Guard

Ms. Emma Dieter, National Science Foundation

Capt. Robertson Dinsmore, Woods Hole Oceanographic Institution

Dr. Marcus Langseth, Columbia University, UNOLS FIC Chair

Dr. Sharon Smith, University of Miami

Mr. Al Sutherland, National Science Foundation

1.2 Project History

The arctic science community has been attempting to procure an Arctic Research Vessel for the United States since 1975. In 1975, UNOLS published "Needs for an Alaskan Arctic Research Vessel," which resulted in a conceptual design published for The National Science Foundation (ref. 1.1).

This conceptual design later evolved into a preliminary design, the details of which were published in "Polar Research Vessel, Preliminary Design" (ref. 1.2). That early design was based on science requirements of the '70s and '80s and resulted in a vessel of relatively modest size and ice capability. The need for this vessel, and an indication of the growing importance of the Arctic as a subject of research, was addressed in a report to the President from the U.S. Arctic Research Commission (ARC) in 1987 entitled "The United States: An Arctic Nation" (ref. 1.3). This report outlined the commission's highest priority: research of the sea ice atmosphere interface. Further definition of the need for an Arctic Research Vessel was given in the 1990 article "An Arctic Nation without an Arctic Research Vessel" by Elsner and Dieter (ref. 1.4).

As a result of the ARC report, UNOLS issued, in 1989, "Scientific Mission for an Intermediate Ice-Capable Research Vessel" (ref. 1.5). Those requirements described a vessel capable of working in the marginal ice zone. It was to be a UNOLS Class III vessel, 150' to 199'. In September 1990 The Glosten Associates began work on the concept design of a vessel meeting those requirements.

After a review of the requirements for arctic science support capability, the National Science Foundation in January 1991 recommended increasing the capability of the vessel as follows:

- Ice capability, 3 ft. of ice @ 3 knots
- Accommodations for 30 scientists
- Lab area of 3000 square feet

In May of 1991 The Glosten Associates submitted to UNOLS a concept design of an Arctic Research Vessel meeting the revised requirements of the National Science Foundation (ref. 1.6). The design report was subsequently distributed for comments throughout the arctic science community in the United States. The majority of comments received by the UNOLS FIC indicated the need for an even larger, more capable vessel.

Responding to those comments, the UNOLS FIC published, in July 1991, a revised Science Mission Requirements (SMR) for a larger, more ice capable research vessel. Those requirements were further modified during the course of preliminary design and resulted in the August 1993 SMR (ref. 1.7) on which the current preliminary design effort is based. The SMR contains the following basic requirements:

- Ice capability, 4 ft. of ice @ 3 knots
- Accommodations for 36 scientists
- Lab Area of 4000 square feet

1.3 Design Philosophy

Throughout the evolution of this preliminary design, the UNOLS ARV Subcommittee, headed by Dr. Tom Royer of the University of Alaska Fairbanks, has taken an active role in virtually every major design decision. We believe that, due to the input of the Subcommittee, the vessel described herein is representative of an advanced concept that will effectively meet the needs of the arctic science community for many years.

From the very beginning of the design evolution, the Subcommittee encouraged the design team to investigate newer, more effective hull forms and ice-breaking techniques in an effort to arrive at the most efficient vessel possible. They stressed the need for a platform that could realistically and economically attain the desired science goals in the Arctic.

With this in mind, the design team subcontracted the services of several recognized experts in the field of ice-breaking vessel design. Early in the design process there was considerable interest in a new ice-breaking hull form developed in Germany; the Thyssen/Waas form. The claimed advantages of this hull form were its reduced resistance in level ice, which reduced required horsepower by as much as 40% compared with traditional ice-breaking hull forms and its ice-free wake. The latter was seen as an advantage in handling science packages over the stern in ice covered waters.

In the spring of 1992 two members of the design team and three members of the UNOLS Subcommittee took part in a voyage on the Russian Thyssen/Waas ice-breaker *Kapitan Sorokin* from Murmansk to Dixon at the mouth of the Yenisey River in the Kara Sea. The return voyage was on a sister vessel whose bow had recently been modified by the Wartsila shipyard in Finland. This bow was also representative of modern ice-breaking hull forms. A complete description of the team's impressions from these voyages is contained in references 1.8 and 1.9.

The design team, with the concurrence of the Subcommittee, endorsed the concept of using a "modern", efficient ice-breaking hull form for the ARV similar to those recently developed for vessels such as the IB *Oden*, IB *Kapitan Sorokin*, and the new Finnish multi-purpose vessels M/V *Fennica* and M/V *Nordica*. However, The Glosten Associates felt that the Thyssen/Waas hull form, although promising, presented a higher technological risk than should be undertaken by the Subcommittee for this design.

Subsequently The Glosten Associates subcontracted The Hamburg Ship Model Basin (HSVA) to develop alternative hull forms. HSVA had been involved with the development of Thyssen/Waas hull forms and with other advanced ice-breaking hull forms. As a leading ship testing facility, and only one of five in the world with ice testing capability, HSVA had the depth of knowledge in the field of ice-breaking technology to be well suited to developing a hull form for the ARV.

The Glosten Associates subcontracted Dr. Arno Keinonen of AKAC, Incorporated, in Calgary, Alberta to further strengthen the design team's capability for assessing the hull form alternatives. Dr. Keinonen was involved with the development of such modern icebreakers as CANMAR's M/V *Kigoriak*, the Swedish icebreaker IB *Oden* and the Finnish vessels M/V *Fennica* and M/V *Nordica*.

His input in the areas of analytical performance prediction and his oversight of the ice model testing complemented the work of HSVA and, in the opinion of the design team, resulted in the development of a uniquely capable hull form for the ARV.

1.4 The Preliminary Design

The preliminary design described in this report meets or exceeds all the requirements set forth in the SMR. Additionally, it represents the smallest vessel that will fulfill the specified endurance and transit requirements. The vessel meets the double hull requirements of the proposed Canadian Arctic Pollution Prevention Regulations (CASPPR).

The objective of the preliminary design has been to verify, to the extent possible within time and budget constraints, the feasibility of producing a vessel that meets the Science Mission Requirements. Summarizing, the goals supporting the design objective are as follows (in order of importance).

- Verify the minimum size vessel able to meet the performance requirements.
- Establish a realistic construction and operating cost estimate.
- Produce a report and drawing package describing the salient features of the preliminary vessel design.

The vessel is designed to withstand the harsh environment of the Arctic and is capable of transit in first year ice. The vessel also has limited capabilities in multiyear ice, an important consideration for a vessel that will undertake voyages into the Central Arctic Basin in the company of an escort icebreaker.

These goals were met and the feasibility of an Arctic Research Vessel that meets the identified science mission requirements was confirmed. This design report and the attached drawing package summarize the preliminary design. Detailed engineering reports, upon which the conclusions are based, are available in the appendices.

Aspects of the preliminary design have been published in several papers and articles referenced below:

"Ice Breaking and Open Water Performance Prediction of the New UNOLS/NSF Arctic Research Vessel," Dirk H. Kristensen, Bruce L. Hutchison, Arno Keinonen, and Karl-Heinz Rupp, presented at SNAME ICETECH '94, Calgary, Alberta, Canada, March 1994.

"Design of an Arctic Research Vessel for the National Science Foundation," John Springer III, Dirk H. Kristensen, and Duane H. Laible, Marine Technology Society, MTS '93 Conference & Exposition Proceedings, September 1993, pp. 237-243.

"Arctic Research Vessel Design Would Expand Science Prospects," Robert Elsner and Dirk H. Kristensen, EOS, Transactions, American Geophysical Union, Vol. 74, No. 45, November 9, 1993, pp. 523-525.

2 - DESIGN REQUIREMENTS

2.1 UNOLS Requirements

The mission requirements for this vessel (SMR) are contained in the UNOLS publication of August 1993: "Scientific Mission for an Ice-Capable Research Vessel" (ref. 1.7). This document, supplemented by considerable input from the Subcommittee during periodic review meetings, formed the base requirements for the design.

The two requirements having the greatest influence on the overall vessel characteristics are the operating environment and the vessel's endurance. Both of these requirements significantly affect the size of the vessel.

2.2 Operating Environment

Although the Subcommittee has identified the entire Arctic as a potential operating area, the following specific areas and seasons are identified in the SMR:

- Central Arctic Basin
  During the Arctic "summer", i.e., July through September

- Arctic Offshore Shelf
  July through December

- Arctic Marginal Ice Zone (MIZ)
  Year-round

Included within the areas identified above are the "Western Arctic". This area includes the waters of the Bering, Chukchi and Beaufort Seas that surround Alaska, and constitutes the most difficult of all operating areas identified in the SMR with the exception of the Central Arctic Basin.

What makes this area so challenging is the irregularity of ice features and the high ridge frequency found in the northern Beaufort and Chukchi Seas.

These diverse conditions require a vessel with considerable ridge transiting capabilities in addition to efficient "level" ice, rubble field and broken floe transiting capability. Implied within the "efficient ridge transiting" capability is a minimum displacement (or mass) appropriate for effective operation. The current ARV design is believed to be the minimum size vessel that can effectively operate in this environment.

2.3 Endurance

In addition to the operational demands placed on it by an exceedingly harsh environment, the vessel is required to have an endurance of 90 days. This was seen by the Subcommittee as essential to the economical operation of the platform since it allows the vessel to remain in the Arctic for up to two 45–day science cruises eliminating the need for long transits for refueling and resupply. Personnel would be transferred either in the Arctic or in a subarctic port, such as Dutch Harbor in the Aleutians or Tromsø, Norway, in the Eastern Arctic.

The 90–day endurance coupled with highly variable ice conditions results in a relatively conservative fuel consumption profile. The amount of fuel that must be carried to meet the endurance requirement is considerable. It not only affects vessel size due to the weight and volume of fuel, but also calls for the selection of fuel efficient propulsion machinery.

2.4 Regulatory Body Requirements

As with other vessels in the UNOLS fleet, this vessel will be inspected by the United States Coast Guard under the requirements of 46 CFR Subchapter U "Oceanographic Vessels". The impact of these requirements on the preliminary design are primarily in the areas of intact and damaged stability criteria and in the extent of fire protection and lifesaving equipment.

The vessel's structure, machinery, helicopter outfit and lifting appliances will be classed by an internationally recognized classification society such as the American Bureau of Shipping (ABS) or Det Norske Veritas (DNV).

In the case of ABS classification, the hull structure will be in accordance with their requirements for Ice Class A3. A DNV Classification of Ice Class Polar 10 would be comparable. In any event, a "first-principles" analysis of the hull structure will be required. The assigned ice class will be negotiated with the classification society selected.

2.5 CASPPR Requirements

The CASPPR regulations used for guidance in this preliminary design effort are those contained in "Proposals for the Revision of the Arctic Shipping Pollution Prevention Regulations" (ref. 2.1).

The Subcommittee recognizes that the vessel's operating area will include portions of the Canadian Arctic within the jurisdiction of the Canadian Arctic Shipping Pollution Prevention Regulations (CASPPR).

The regulations embodied within CASPPR include structural and subdivision requirements. Due to relatively recent commercial interest in the Canadian Arctic, these regulations have resulted from an extensive research and development program sponsored by the Canadian Government. The structural requirements relating to the ice worthiness of the hull are on the leading edge of technology. Additionally, the subdivision requirements contained in these regulations are very demanding.

Compliance with these regulations was found to be in keeping with the goals of the Subcommittee in taking advantage of the latest safeguards to protect the sensitive arctic environment.

3 - DIMENSIONS AND GENERAL ARRANGEMENTS

3.1 General

The ARV's principal dimensions have been primarily dictated by vessel endurance, ice transit capability and, to a lesser extent, the double hull requirements of the proposed CASPPR regulations. In meeting these requirements, the principal dimensions of the vessel result in all of the other space and volume requirements contained in the SMR being met or exceeded.

3.2 Principal Dimensions

The principal dimensions resulting from the preliminary design cycle are given below:

Principal Dimensions		
Length:		
Overall	103.6 m	340'-0"
Design Load Waterline (DWL)	93.9 m	308'-0"
Beam:		
Maximum, main deck at reamer	27.1 m	89'-0"
Amidships, main deck	23.2 m	76'-0"
Depth	12.2 m	40'-0"
Draft At DWL	9.1 m	30'-0"
Displacement At DWL	11,684 tonne	11,500 LTSW

3.3 Capacities

The largest quantity of consumable liquid carried aboard the vessel is fuel. The amount of fuel required to meet the endurance requirements contained in the SMR is approximately 3,556 tonne (3,500 LT). The fuel requirement is derived from the 90-day mission profile, that is, 14 days free transit, 20 days full ice breaking, 30 days half power ice breaking and 26 days on station.

The efficiency of ships optimized around ice performance is relatively sensitive to maintaining constant draft and trim at the design waterline. To facilitate this, a considerable amount of ballast capacity, approximately equal to the fuel capacity, is incorporated. This ballast capacity includes approximately 1,215 tonne (1,200 LT) of heeling water as part of the rapid heeling system.

Potable water storage sufficient for 76 days of operation is installed. This assumes a potable water consumption at 22 L/man-day (5.36 gal/man-day). Note, however, that the potable water will be replenished from on-board, evaporator type water makers at an approximate rate of 14,000 L/man-day (3,500 gal/day). The amount of potable water, and the ratio of storage tank volume to water maker capacity, is proportional (by size of complement) to existing large vessels in the UNOLS fleet, e.g., R/V *Melville* and *Knorr* (AGOR 14 & 15).

The table below shows the consumable liquids, and ballast/heeling water capacities of the preliminary design.

Consumable Liquids Capacities					
	m^3	ft^3	gal	tonne	LT
Fuel Oil Storage (No. 2 Diesel)	3,800	134,650	1,007,182	3,312	3,260
Fuel Oil Day Tanks	240	8,497	63,558	209	206
Total	**4,040**	**143,147**	**1,070,740**	**3,521**	**3,466**
Salt Water Ballast	1,220	43,228	323,345	1,255	1,235
Heeling Tanks	1,250	44,061	329,576	1,279	1,259
Trim Tanks	1,125	39,740	297,255	1,153	1,135
Total	**3,595**	**127,029**	**950,176**	**3,687**	**3,629**
Main Engine Lube Oil	34	1,216	9,096	32	31
Reduction Gear Lube Oil	15	532	3,979	14	14
Generator Engine Lube Oil	17	608	4,548	16	16
Total	**66**	**2,356**	**17,623**	**61**	**61**
Hydraulic Oil	19	684	5,116	18	18
JP-5 (Helicopter Fuel)	36	1,282	9,589	34	33
Potable Water	100	3,562	26,644	101	9

Space allocations for dry stores, reefer/chill stores and general maintenance stores are based on the endurance calculations of 90 days.

The spaces allocated for provisions are located, to the extent possible, in areas of the vessel not conducive to sustained human occupancy in severe open water conditions. The space characteristics are summarized in the following table.

Ship's Consumables Stores (Non-Liquid)				
	Area		Volume	
	m^2	(ft^2)	m^2	(ft^2)
Engineer's Stores (1st Platform)	80	(860)	244	(8,600)
Dry Stores (Main Deck)	130	(1,397)	396	(13,970)
Reefer Stores (550 ft^2 + 650 ft^2)	112	(1,200)	340	(12,000)
Pantry	13	(140)	36	(1,260)
Total	**335**	**(3,597)**	**1,016**	**(35,830)**

3.4 General Arrangements

The general arrangements of the vessel are dictated by the science requirements; i.e., all science spaces have been located in areas where they will provide maximum utility for conducting science operations.

Generally, all main science work areas are located on the main deck, providing good access between labs and the covered and exterior working decks.

Public spaces and accommodations are located on the 01 deck and above. This is in order to keep these spaces as far removed from sources of machinery and ice-breaking noise as possible.

3.5 Deck Working Areas

The 409 m^2 (4,400 ft^2) aft working deck has a 10 ft freeboard above the design waterline (the maximum freeboard allowed by the SMR). This working deck is accessible from the labs through double watertight doors, with fold-down sills, to the main longitudinal passageway. There is also direct access to the deck via similar doors from the science workshop to port. The staging bay has direct access via a weathertight roller door. The deck loading capability will be 7,300 kg/m^2 (1,500 lb/ft^2). At the request of the Subcommittee, all exterior working decks are cambered to allow water to drain quickly from the working surfaces. The entire deck will be heated by utilizing waste heat from the main propulsion engines.

Removable bulwarks in 1.5 m (5 ft) sections are provided. The bulwark panels are secured by utilizing a flush bolt-down grid. A 25 mm (1 in) diameter bolt-down system is shown on a 600 mm (2 ft) grid.

A flush, hydraulically actuated, 3.7 m by 7.3 m (12 ft x 24 ft) hatch to the science hold is provided on centerline. The hatchway is sized to allow a standard 20 ft ISO container to be placed in the hold. The hatch cover will contain a flush bolt-down grid in the same pattern as the surrounding deck. The freight elevator at frame 98 has a car area of 1.8 m by 1.8 m (6 ft x 6 ft), allowing standard size pallets to be transported between the main deck and the science hold. The elevator can be arranged to open onto the aft deck as an option.

The side working deck (including the starboard portion of the aft working deck) is arranged to handle cores of over 30 m (100 ft) in length. The side deck is 3 m (10 ft) wide and is unencumbered by side frames due to the use of hydro-booms located well above the deck.

The foredeck area has approximately 280 m^2 (3,000 ft^2) of working area. This deck is also fitted with 25 mm (1 in) diameter, flush, bolt-down fittings. Two articulated electro-hydraulic cranes are located port and starboard. These cranes may be utilized for over-side science operations. Two outlet stations containing electrical and/or hydraulic connections for portable winches, capstans or other deck machinery will be located on this deck.

A foremast holds navigation lights and a portable instrument platform (IMET).

Due to the harsh environment in which the vessel will operate, several covered working deck areas are provided. The primary covered space, the midship Baltic room, (about 47 m^2 (500 ft^2) with 4.6 m (15 ft) clear overhead below the hydro-boom) can be accessed from the main lab, the wet lab, and the interior longitudinal passageway via double doors (with fold-down sills). The Baltic room doors open directly to the starboard side of the vessel. These hydraulically operated bi-fold doors provide an opening to the exterior, either 2 m or 4 m (7 ft or 14 ft) wide depending on the size of package being handled. A 6.8 tonne (7.5 ton) capacity hydro-boom, extending 4 m (13 ft) over the side of the vessel serves this space. A grid of flush, 25 mm (1 in) tie-downs is arranged over the entire Baltic room deck. The deck will be fitted with over-size deck drains for rapid removal of water and ice. A watertight door on the aft side of the Baltic room provides access to the side working deck.

The forward Baltic room, to port, has an area of approximately 65^2 (700 ft^2) with 4 m (13 ft) clear overhead. This space is arranged to provide direct access through a 5.5 m x 3 m (18 ft x 10 ft), hydraulically actuated, side port door to the ice surface. An articulated, high load capacity ramp will be deployed from the space to facilitate access to the ice surface. Ramp deployment will be assisted by the hydraulic deck crane on the 01 deck directly above. The space is also arranged to accommodate two lab vans with direct access to the vessel's interior. Van utility stations are located in the vestibule immediately forward of the bulkhead at frame 13. Vans, snowmobiles and mission equipment can be loaded into this space via the 3.7 m by 6.7 m (12 ft x 22 ft) deck hatch directly above in the 01 deck (note the direct access possible to the interior of the vessel). The deck is fitted with tie-downs similar to those described for the midship Baltic room. A hydro-winch is located in an alcove on the inboard side of the space.

A heated, 46 m^2 (490 ft^2) staging bay, with 5.8 m (19 ft) clear overhead, is located on the main deck, aft. Large, 4.3 m by 4.9 m (14 ft x 16 ft) weather-tight roller doors provide access to both the side and aft working deck areas. This space is ideal for staging ROVs, seismic equipment, dive equipment, etc. Alternatively, this space may be used for lab or storage vans.

Additional exterior working deck space is available on the upper decks; specifically about 316 m^2 (3,400 ft^2) of deck area fitted with tie-downs, is available on the 05 deck. This would primarily serve the meterology lab which is also located at this level.

When not in use for helicopter operations, the landing pad on the 03 deck provides 307 m^2 (3,300 ft^2) of deck space. The interior of the hangar provides an additional 578 m^3 (20,400 ft^3) of storage volume.

An upper instrument platform, located above the upper conning station, provides about 5.3 m^2 (100 ft^2) of area.

As can be seen in the following tables, the SMR requirements are met and exceeded in the preliminary design.

Covered Working Decks				
	Area		SMR Rqmt (ft^2)	% of Rqmt
	m^2	(ft^2)		
Forward Baltic Room (Port Side)	66	(711)		
Midship Baltic Room	48	(515)		
Staging Bay (Starboard Side)	46	(490)		
Total	**160**	**(1,716)**	**1,000**	**172**

Exterior Working Decks				
	Area		SMR Rqmt (ft^2)	% of Rqmt
	m^2	(ft^2)		
Main Deck:				
Aft Working Deck	380	(4,081)	3,000	136
Side Working Deck	93	(1,000)	1,000	100
01 Level:				
Forward Working Deck	282	(3,034)		
05 Level:				
Available Deck Area	321	(3,453)		
Total	**1,076**	**(11,568)**		

3.6 Cranes

A complete suite of cranes, able to reach all areas of the primary working decks and to provide loading and unloading capability for vans and other science payload, are shown on the arrangement plans. The cranes will be made suitable for use in extreme low temperatures by the use of special construction materials, operating fluids, and heaters.

The large, articulated jib-boom crane, located to starboard at frame 79, provides a maximum lift capacity of 13.6 tonne (15 ton). This crane is motion compensated to allow handling of loads close to the water/ice surface. The crane is arranged to assist in coring operations and is also able to load vans and equipment to the upper decks.

Two articulated hydraulic deck cranes are arranged on the aft working deck providing full coverage of the fantail. These cranes can also work in tandem over a portion of the deck. The cranes are rated at 9.1 tonne (10 ton) at a radius of 7.6 m (25 ft) (5.2 m [17 ft] over the side) and 2.3 tonne (2.5 ton) at 12.2 m (40 ft) radius (9.8 m [32 ft] over the side).

Two cranes, similar to the cranes on the aft working deck, are located on the foredeck (01 level). These cranes are able to support over-side science operations port and starboard, stores handling, science payload handling into the forward science hold and Baltic room, and to assist with the deployment of the ice access ramp.

3.7 Winches

The fully enclosed oceanographic winch complex on the 01 level includes a traction winch with two storage drums (refer to dwg. 9243-4, sht. 2). The winch and storage reels shown on the plans are representative of a system capable of handling 9,144 m (30,000 ft) of 9/16 in wire and 9,144 m (30,000 ft) of 0.68 electro-mechanical cable. Sheaves are of large diameter, as required for use of fiber-optic cable.

The trawl winch is a traction winch arranged to lead either to the aft A-frame or to the large hydro-boom at frame 82 on the starboard side.

Two hydrographic winches, capable of handling 9,144 m (30,000 ft) of 3/8 in wire rope, are located adjacent to the traction winch. Both winches are situated on moveable turntables allowing each winch to lead to either the aft A-frame or either of the two starboard side hydro-booms.

An additional hydrographic winch, similar to those described above, is located in the forward Baltic room on the main deck (refer to dwg. 9243-4, sht. 2).

Both the aft working deck and the foredeck will be equipped with air/electrical/hydraulic outlet stations to facilitate the use of portable winches at any location on these two decks.

Two portable capstans are located on the aft working deck. The foundations of these capstans would be secured to the deck using a flush bolt-downs system.

The winches will be controlled locally as well as remotely from the aft control room on the 01 deck. Each winch will be capable of fine speed control from a minimum 1/2 meter per minute and will provide constant parameter (iso-follower), auto slow-down to preset speed at near surface, and target scope slow-down and/or stop. These features can be provided with electro-hydraulic or direct current electric motor drives and appropriate sensors. Control features will include a wire monitoring system with input to ship's data net, alarms and automatic remote as well as local winch control.

To achieve the performance noted above, motion compensation (constant tensioning) will be provided, but the compensating equipment would most likely be separate from the winch package. The goal is to achieve a constant rate of ascent or descent or a constant location of a package in the water column. Use of a dithering winch, one solution, has not yet been successfully accomplished and a hydraulic ram tensioner, either passive or active, is the practical solution at this time. The active tensioner requires a separate source of hydraulic power and is the better choice of the two.

3.8 Over-side Handling

Two remote operating stations are shown on the arrangement drawings (refer to dwg. 9243-4, sht. 2). The operating stations are located to provide covered and heated areas that allow all over-side handling gear to be controlled from within them. The main control station for fantail and side deck operations is the aft control room situated above the staging bay. This control area will have excellent visibility over the working decks. A full set of engine and maneuvering controls, as well as winch controls, will be furnished in this room. The adjacent scientific command center provides space for chart tables and electronic navigation and recording equipment.

A hydro-boom control room is located at the aft side of the midship Baltic room at the 01 level. Both hydro-booms may be controlled from this room. Excellent visibility of the booms is provided. Additionally, a view of both hydro-winches is provided through windows on the inboard bulkhead. Windows on the forward bulkhead provide visibility into the midship Baltic room.

The hydro-boom located in the overhead of the midship Baltic room is capable of handling a 6.8 tonne (7.5 ton) load and can extend, through the side doors, 4 m (13 ft) over the side of the vessel. In addition to having a lead from the hydrographic winch, a hydraulic or electric hoist of approximately 4.5 tonne (5 ton) capacity will be fitted to the underside of the boom.

The main hydro-boom, located at frame 82 is capable of handling an 18 tonne (20 ton) load. This boom also extends about 4 m (13 ft) over the side of the vessel and, in addition to hydrographic winch leads, will be capable of lifting heavy coring frames.

The aft A-frame is hydraulically actuated and has a lift capacity of 13.6 tonne (15 ton). The frame has a vertical clearance of 7.6 m (25 ft), a horizontal clearance of 6.1 m (20 ft) and is capable of extending 4.9 m (16 ft) inboard and 3.7 m (12 ft) over-the-stern. Two hydraulically actuated bulwark doors are fitted in the transom in way of the A-frame providing a 6.1 m (20 ft) clearance over the stern.

A heavy load capacity, articulated boarding ramp is provided at the forward Baltic room on the port side. This ramp will be capable of handling snowmobiles, personnel and miscellaneous equipment sleds onto the ice surface. The ramp will be deployed with the aid of the hydraulic deck crane located on the 01 level.

3.9 Towing

Towing of scientific packages in ice covered water is facilitated primarily by the relatively ice-free channel created behind the ship. Additionally, a towing hawse pipe is located on centerline in the main deck at frame 119 (Fig. 3.1). This hawse pipe slopes from the deck to the shell plate just above the waterline and is arranged to provide a method of deploying instrument package tow lines in an ice-free area.

3.10 Laboratories

Laboratories have been arranged with extensive input from the Subcommittee. With the exception of the meteorology lab on the 05 level, all laboratories are located on the main deck with excellent access between the labs, aft working deck and forward science stores provided by an 2.4 m (8 ft) wide longitudinal passageway extending the length of the deck (Fig. 3.2). The passageway width allows transporting of pallets (via on-board electric forklift truck) while still providing for personnel passage to one side.

The main and the wet labs have direct access to the midship Baltic room. Additionally, the wet lab has direct access to the side working deck and to the aft staging bay.

An overhead track system is arranged between most of the labs on the main deck allowing the movement of heavy items between the labs, the midship Baltic room, science freezers, etc. All labs have double doors without sills to further facilitate moving items between labs.

A small loading hatch on the 01 level allows equipment to be loaded directly into the main lab. Other loading path options include the midship Baltic room and the longitudinal passageway.

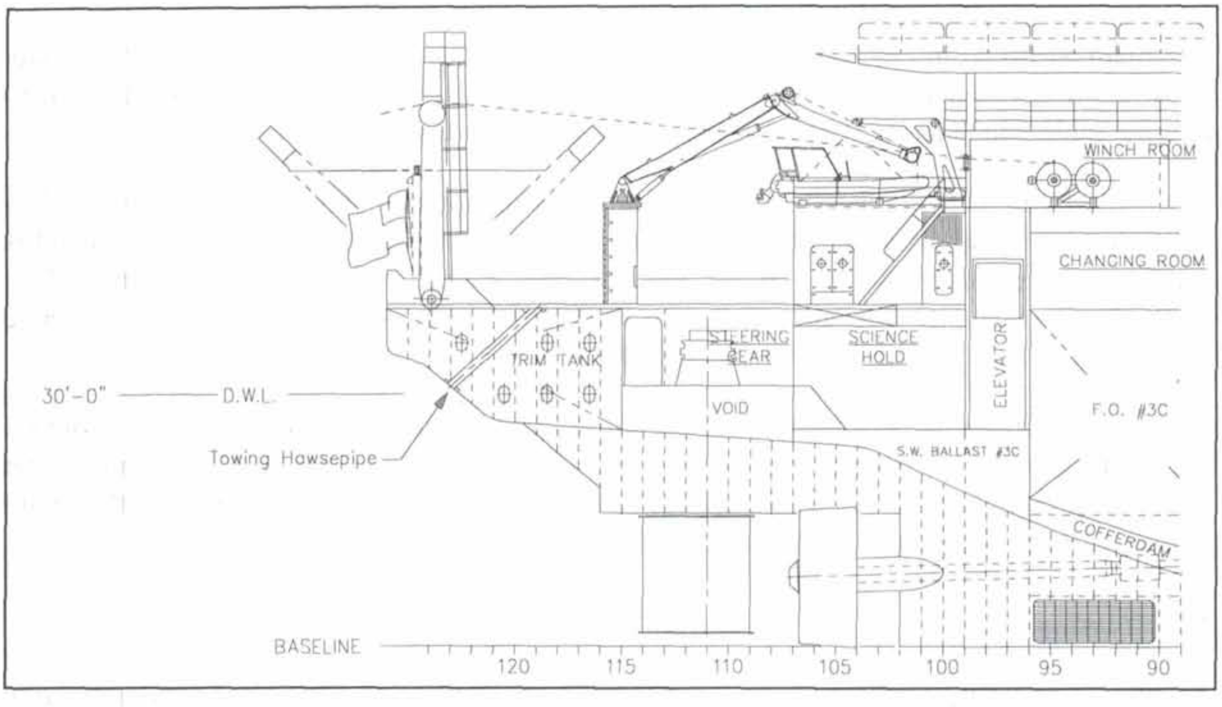

Fig. 3.1
Towing Hawse Pipe

A summary of laboratory areas is shown in the table below. The right hand columns show the areas required by the SMR and the percentage of that area included in the preliminary design.

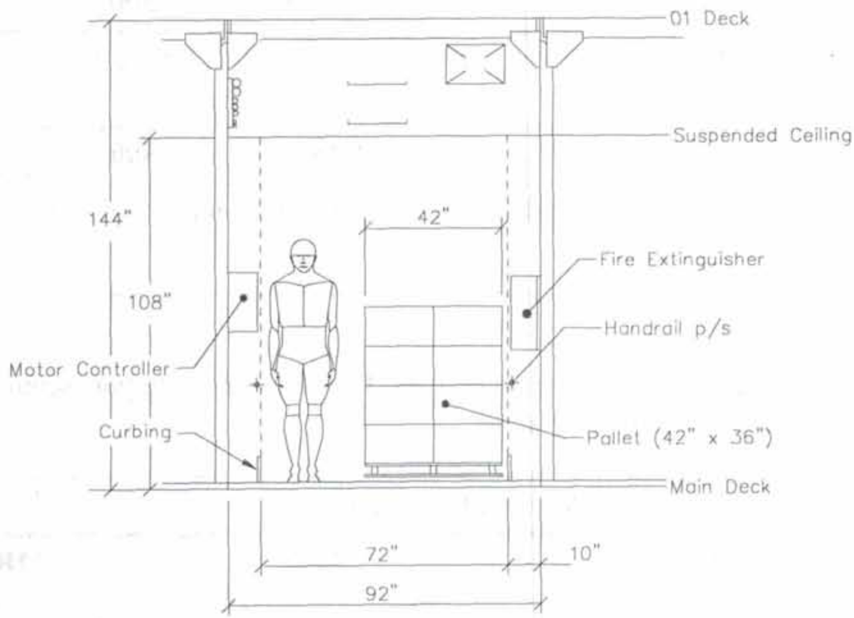

Fig. 3.2
Main "Working" Passageway (Long'l) Dimensions

Science Laboratory Areas, Main Deck				
	Area		SMR Rqmt (ft^2)	% of Rqmt
	m^2	(ft^2)		
Main Lab	208	(2,240)	2,000	112
Computer Lab/Users Lab	86	(927)	600	155
Analytical Lab	44	(470)	300	157
Biology Lab	39	(420)	300	140
Wet Lab	39	(420)	300	140
Climate Cntrl Labs (2)	55	(592)	300	197
Total	**471**	**(5,069)**	**3,800**	

Science Laboratory Areas, Other Decks				
	Area m^2	(ft^2)	SMR Rqmt (ft^2)	% of Rqmt
Science Electronics Lab (04 Deck)	48	(516)	Note 1	Note 1
Meteorology Lab (05 Deck)	33	(357)	300	119
Clean Water Lab (Bow Thruster Room)	17	(178)	Note 1	Note 1
Total	**98**	**(1,051)**	**300**	
Note 1: Space is required by SMR but no specific area requirement is given.				

In addition to the laboratories, there are several ancillary spaces to support science activities. These are summarized in the following table.

Science Utility Spaces			
	Area m^2	(ft^2)	SMR Rqmt ft^2
Main Deck:			
Science Office	39	(416)	Note 1
Dark Room	10	(108)	75
Aquaria	22	(240)	Note 2
Science Workshop	47	(510)	Note 1
Dive Locker	6	(67)	Note 3
Gravimeter Room	12	(124)	40
Upper Decks:			
Science Watch Room (04 Deck)	39	(424)	Note 4
Total	**175**	**(1,765)**	

Notes:

1. Space is required by SMR but no specific area requirement is given.
2. Space is required for ten 20 gallon aquariums.
3. Space requirement is to be similar to existing UNOLS standards.
4. This space required during ARV Subcommittee meeting of 13/14 December.

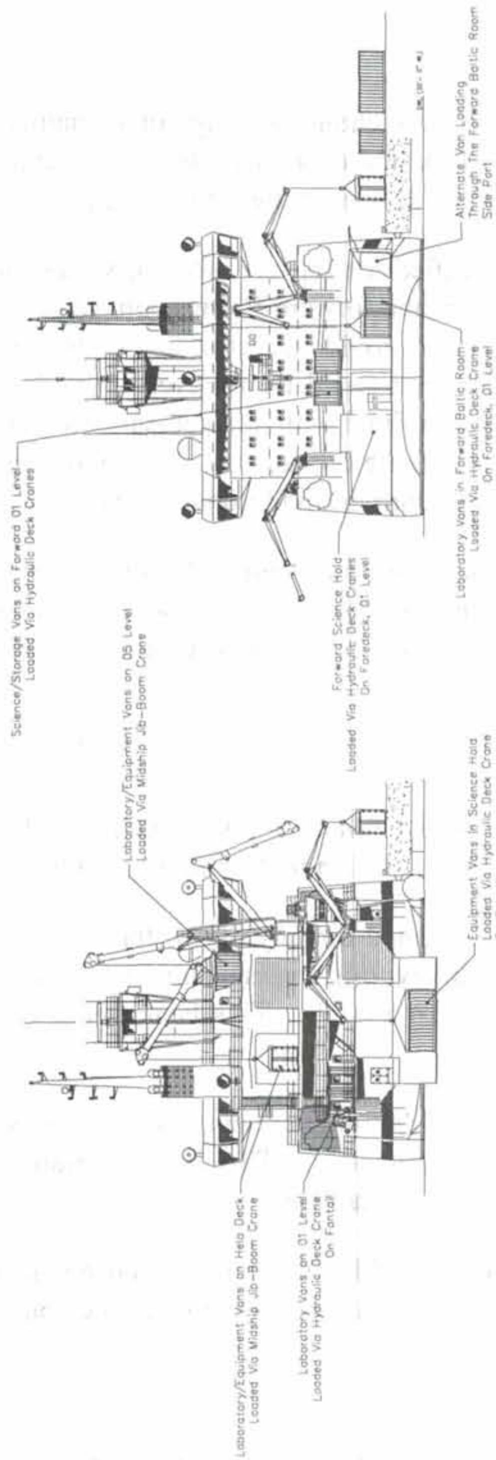

Fig. 3.3
Van Loading Options

Figure 3.3 illustrates the van locations and possible loading options.

3.11 Vans

Several locations are available throughout the ship for container van stowage. Most van locations, with the exception of the foredeck, are either in areas protected from the weather, e.g. in the lee of superstructure, or in interior areas of the ship.

Two areas are specifically identified for science laboratory vans and have direct access into the interior of the ship. These are the forward Baltic room (2 vans) and the aft end of the 01 deck (2 vans). Both of these areas provide direct access to the interior of the ship through a vestibule. The aft 01 deck location could alternatively provide a storage area for isotope van(s). The vestibule would be outfitted with all necessary van connections including water, HVAC, drains, electrical supply, fume hoods, etc. Optionally, the helicopter hangar, when not used for helo operations, could provide additional interior storage for two vans.

Additional locations for science lab vans, although not offering direct connection to the interior of the vessel, include the foredeck (01 deck) where two vans can be accommodated between the hatch covers; the science hold has space for two vans; and the 05 deck offers area for at least three vans.

3.12 Workboats

Two workboats are required by the SMR: a "Norwegian" style workboat, approximately 6.1 m (20 ft) in length and a 6.4 m (21 ft) rigid bottom inflatable.

The 6.1 m (20 ft) workboat is located directly above the midship Baltic room. This boat would be an ice-strengthened survey/utility vessel similar to those used by Rieber Rederi of Norway, who operate several polar vessels. This boat would be launched using the large midship jib-boom crane.

The 6.4 m (21 ft) inflatable rigid bottom rescue/utility boat is stowed above the bosun's locker on the aft working deck, port side. This boat is arranged to be launched from a SOLAS approved davit launching mechanism.

The SMR requires that space be available, in lieu of a science van, for a 7.6–9.1 m (25–30 ft) workboat. In the preliminary design, this boat could be located on the aft working deck.

3.13 Helicopter Facility

Facilities are provided for carrying up to two small helicopters, e.g. MBB BO 105 or Bell 206B. These facilities include a two bay hangar on the 03 deck with a small aviation shop between the two bays. The hangar would be heated.

The 309 m^2 (3,325 ft^2) helicopter pad provides unobstructed landing and takeoff clearance through 280 degrees over the stern. This pad is sized to allow landing a helicopter up to the size of a Bell 212 or the USCG's Jayhawk H60J.

The helicopter crew, when carried, would be included in the science complement and would be accommodated in scientists' staterooms.

3.14 Science Storage

Science storage spaces have been arranged for convenient access to the laboratories. The aft science hold is served by a 3.3 m^2 (36 ft^2) freight elevator that opens directly onto the main longitudinal passageway. This elevator could be arranged to open onto the aft working deck. The science hold offers 374 m^3 (13,200 ft^3) of storage space. The utility of the space is enhanced by the incorporation of 25 mm (1 in) diameter, flush tie-downs installed in a 610 mm (24 in) grid in the hold deck. Portable stanchions will be arranged to facilitate storage. The bulkheads forming the perimeter of the hold will be fitted with heavy-duty "D" rings for securing equipment. Direct access to the hold is provided through a flush 3.7 m by 6.7 m (12 ft x 22 ft) hatch in the main deck. The hatch can be reached by either of the two hydraulic deck cranes located on the aft working deck or by the large jib-boom crane located to starboard.

The forward science stores area is on the main deck forward and opens directly onto the longitudinal passageway. This space offers approximately 255 m^3 (9,000 ft^3) of storage volume. The space can be accessed through a large raised hatch, 3.7 m by 6.7 m (12 ft x 22 ft), on the 01 deck.

Specialized science storage is provided for hazardous materials and for chemicals. Both the hazardous materials locker and the chemical locker are located at the aft end of the main deck and provide direct access to the exterior working deck and to the interior science workshop.

An explosives locker is located on the first platform level aft. This locker is to starboard of the steering gear room and is accessible via either the science hold, through a sliding watertight door, or the aft working deck via a vertical ladder and flush hatch. The locker will be outfitted in accordance with the requirements of VAVORD OP 3696 "Explosives Safety Precautions For Research Vessels".

Refrigerated science storage is provided on the main deck, port side. The main science freezer provides 45 m^3 (1,600 ft^3) of storage space. This freezer has direct access to the main longitudinal passageway.

An auxiliary science freezer, arranged for storage of core samples, is located directly athwartships from the wet lab on the port side of the deck. The location of this freezer allows easy transport of long core samples from the side working deck through double doors in the wet lab.

The table below summarizes the science storage spaces.

Science Storage Spaces					
	Area m^2	(ft^2)	Volume m^3	(ft^3)	SMR Rqmt ft^3
Science Hold (1st Platform)	102	(1,100)	374	(13,200)	20,000
Science Storage Room (Mn Dk, Fwd)	70	(752)	255	(9,000)	
Explosives Locker (1st Platform)	12	(130)	42	(1,500)	1,500
Chemicals Locker (Main Deck)	9	(100)	25	(900)	
Hazardous Materials Locker (Main deck)	7	(77)	20	(693)	
Main Science Freezer (Main Deck)	17	(179)	46	(1,611)	
Geology Sample Freezer (Main Deck)	12	(124)	32	(1,116)	
Total	**229**	**(2,462)**	**794**	**(27,560)**	**21,500**

3.15 Acoustical Systems

In accordance with the SMR, the following acoustical systems are required:

- Forward void containing four 508 mm (20 in) wells for two 12 kHz transducers and two spares.
- Aft void containing three 508 mm (20 in) wells for one 12 kHz and two spare transducers.
- Large pressurized seachest, approximately 1.2 m by 2.4 m (4 ft x 8 ft), located at an optimum acoustic location for at sea installation and servicing of transponders and transducers. This space will contain the 3.5 kHz array, two ADCP transducers and two spare 508 mm (20 in) wells. Note, it is anticipated that the pressurized well will only be used "in port".
- A state-of-the-art multi-beam swath mapping system will be installed.
- A state-of-the-art ADCP system, with two hull mounted transducers, will be installed.
- Compressors capable of generating 0.5 m^3/s at 17,240 kPa (1,000 scfm at 2,500 psi) will be installed for single channel seismic work.
- A dual axis Doppler speed log will be installed.

The arrangements show two main areas for the location of transducers: the forward transducer wells between frames 33 and 39, and the aft transducer wells between frames 70 and 73.

The forward transducer well is in the bottom of the ice-breaking wedge. This area was thought to be relatively undisturbed by bubble sweep-down while also relatively far removed from the noise generated by the main propulsion machinery. As reported in section 5 of the unabridged version of this report, model tests showed this area to be free of bubble sweep-down. For this reason, the forward transducer area contains the swath mapping transducers.

Also contained in this space will be the four 508 mm (20 in) wells for two 12 kHz transducers and two spares, as required in the SMR.

The aft transducer void will contain the pressurized sea chest as well as the three 508 mm (20 in) wells and two spares.

A machinery area located on the upper engineroom flat contains 5 seismic compressors capable of generating 0.5 m^3/s at 17,240 kPa (1,000 scfm at 2,500 psi) for single channel seismic work. Compressed air outlets will be located at the staging bay and on the fantail.

3.16 Machinery Spaces

The propulsion and auxiliary machinery is described in detail in section 7 of the unabridged version of this report.

The main machinery spaces are located amidships on three levels: the lower engine room, the 2nd platform level machinery room and the 1st platform level machinery room. Additionally, there are auxiliary machinery spaces located in various areas of the ship as described below.

Principal equipment located in the lower engineroom includes four main propulsion diesel engines, flywheels and two reduction gears. The two propulsion shaft driven generators described in section 7 are located directly aft of the combining reduction gears. Ancillary main engine system components such as lube oil pumps, cooling water pumps, etc. are also located at this level.

The second platform level contains the ship's service generators, the engineer's operating station (EOS), motor control center and two oil fired hot water heaters.

The first platform level contains the seismic air compressors, potable water heating and pressurization equipment and deck de-icing thermal fluid equipment.

The first platform also contains an auxiliary machinery space, forward of the main spaces, between frames 26 and 44. This space is accessible from the main machinery block via a sliding watertight door. The auxiliary machinery room contains the auxiliary ice management systems, e.g., the water wash system pumps, and one of the quick heeling/trimming pumps.

Other machinery spaces include the steering gear flat at the first platform level between frames 107 and 115; and the emergency generator room and HVAC machinery rooms on the 05 level.

3.17 Navigation and Control Spaces

The locations of control spaces on an ice-going vessel are critical to efficient operation. Excellent forward visibility is necessary for ice navigation. With this in mind, we have located the navigation bridge as far forward as practical. The bridge deck is 17 m (56 ft) above the design waterline. Bridge wings extend to the maximum beam of the vessel and contain complete vessel control stations. Good (300°) field of view is provided at each bridge wing control station.

A conning station located above the bridge deck, 27 m (88.5 ft) above the design waterline, provides an additional control station with enhanced visibility for ice navigation.

The aft control station, located on the 02 level to starboard, contains a complete set of ship controls. This area provides complete visibility of the working decks and the over-side handling gear.

Vessel navigation will be facilitated by satellite navigation equipment, including GPS. Additionally, helicopter surveillance and real time satellite ice mapping imagery will enhance ice navigation.

3.18 Public Spaces

Extensive public spaces are provided. The need for a relatively large number of public spaces is due to the anticipated length of voyages. Also, the Subcommittee has expressed a desire to make the arrangement and outfit of the spaces flexible enough to be easily converted to alternative uses, i.e., work/study stations, storage areas, auxiliary labs, etc. Most public spaces are located on the 01 deck where they are far enough removed from the noise associated with ice breaking to be conducive to quiet work.

Food service is cafeteria style with crew and scientists having common seating. When not in use as a mess area this space can be utilized as a lounge, or, with portable partitions, can be made into additional meeting/work spaces.

An 87 m^2 (940 ft^2) library and conference room is located on the 01 deck, adjacent to the mess room, on the starboard side. This space contains a large conference table and extensive bookshelves. This room may also be partitioned, as shown on the plans, into two spaces.

A 45 seat classroom is located in the center of the 01 deck. In addition to its use as a meeting and lecture hall, it may be used as a multi-purpose room.

A fully equipped, 56 m^2 (600 ft^2) gymnasium with adjacent sauna and change room is located on the 01 level aft to port.

Three lounges are located on the vessel providing space for small gatherings, study groups, or project offices, etc.

The public spaces contained in the preliminary design are summarized in the following table.

Public Spaces		
Space	**Area**	
	m²	**(ft²)**
Mess Room	103	(1,110)
Library/Conference Room	87	(940)
Lounge (01 Level)	44	(475)
Lounge (02 Level)	37	(400)
Video (Television) Lounge	22	(234)
Classroom	56	(600)
Gymnasium/Hobby Room	56	(600)
Sauna/Change Room/Showers	37	(400)
Total	**442**	**(4,759)**

3.19 Accommodation Spaces

Accommodations spaces are located on the 02 and 03 decks. These decks are far removed from the relatively noisy working areas on the main deck and are convenient to the public services located on the 01 deck.

The basic requirements given in the SMR are as follows:

- Thirty-six scientific personnel in double staterooms.
- Twenty-four to twenty-six crew berths with fourteen being single staterooms.

The Subcommittee requested adequate space in staterooms for desks and computers brought aboard by science personnel.

At the request of the Subcommittee, all scientist staterooms are arranged for double occupancy, including the chief scientist's stateroom. The handicap stateroom located on the 02 level, port side, will be single occupancy when used by a handicapped individual; however it will be arranged for double occupancy when not used as such.

No attempt has been made at this time to finalize the stateroom arrangement, but the space allocated is adequate to fulfill the demands outlined by the Subcommittee. One possible arrangement for a double crew/scientist stateroom is shown in Figure 3.4.

Crew Staterooms			
Space	**Number**	**Area**	
		m^2	**(ft^2)**
Master's Stateroom/Office	1	55	(590)
Chief Engineer's Stateroom/Office	1	49	(530)
Single Crew Staterooms	8	12	(125)
Double Crew Staterooms	8	12	(125)
Total	**18**		
Note: total crew berths =	**26**		

Scientist's Staterooms	
Chief Scientist (possible dbl occupancy)/Office	1 or 2
Handicap Stateroom	1 or 2
Double Scientist's Staterooms	16
Total Scientist's Berths	**34 to 36**

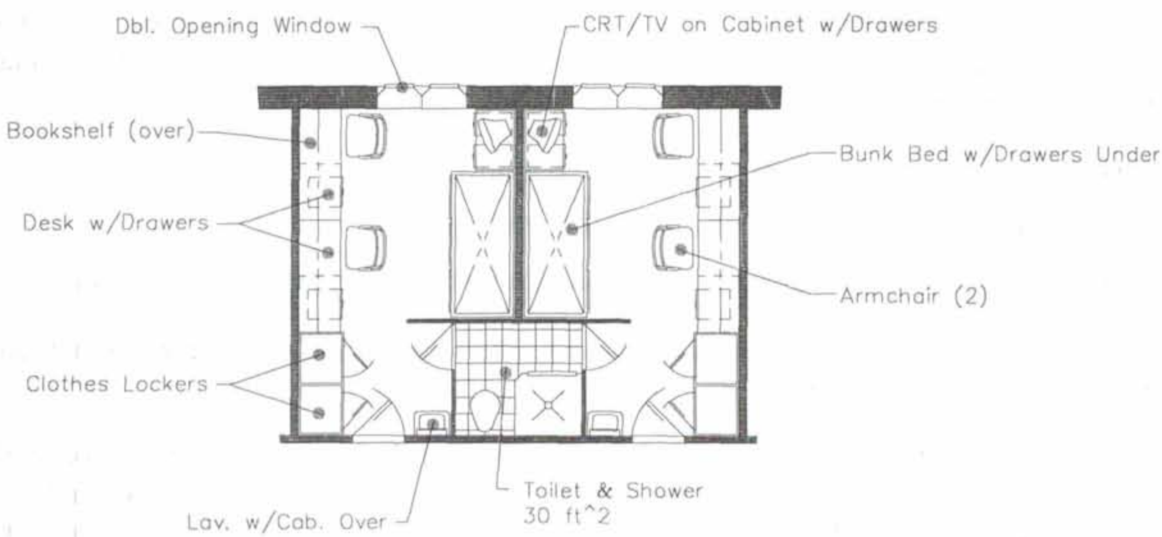

Fig. 3.4
Typical Two-Person Staterooms Area,
Each Stateroom = 127 ft^2
USCG req'd area = 40 ft^2

3.20 Miscellaneous Spaces

Several miscellaneous spaces are shown on the arrangement plans, the location and size of which have resulted from the several design review meetings of the Subcommittee.

Miscellaneous spaces on the main deck include:

- A "mudroom". This space is adjacent to the fantail access at the aft end of the main longitudinal passageway. It includes lockers for arctic work suits as well as a laundry facility.
- Public restrooms are located adjacent to the midship Baltic room and the forward Baltic room.
- A deck locker is located adjacent to the midship Baltic room.

Miscellaneous spaces on the upper decks include:

- Garbage storage and incinerator room aft of the galley on the 01 level.
- A main lounge, with adjacent television/video lounge on the starboard side of the 01 level.
- Two laundry rooms on the 02 level and one on the 03 level.
- Hospital on the starboard side of the 02 level. The hospital is located adjacent to the elevator to facilitate the movement of injured personnel. The elevator is also adjacent to the helicopter hangar on the 03 level facilitating the evacuation of injured personnel.

4 - CONCLUSIONS

As indicated in Chapter 1 of this report, this vessel has been designed to satisfy the UNOLS Arctic Research Vessel Scientific Mission Requirements of August 1993. This is the minimum sized vessel which can meet the Science Mission Requirements. The design has been accomplished using modern ice breaker technology. The cost of the materials for the vessel laid out in these plans is about $43 million in 1993 dollars. Material markups might range from 10 to 20% and labor costs vary from $35/hour in southern and some east coast ship yards, while the 1993 rate is closer to $40/hour in west coast and northeast ship yards. Using a 15% markup and a 20% margin for error, this ship should cost between $113 and $126 million to construct. The operating costs, based on current UNOLS fleet estimates, would be about $34,000/day in 1994. The greatest differences in the operating costs are for repair, maintenance and overhaul (about 5 times those of either *Ewing*, *Thompson* or *Melville*), fuel and lube oil (about 5 times those of either *Ewing*, *Thompson* or *Melville*) and insurance (about 4 times the average of the others). Details of these cost analyses are contained in the unabridged version of the ARV Preliminary Design Report that is available from the UNOLS office. In addition to a more detailed economic analysis, the unabridged Arctic Research Vessel Preliminary Design Report contains chapters dealing with resistance and power, seakeeping, structural design, propulsion and auxiliary machinery, and hydrostatics and stability.

Arctic oceanographic studies are a vital part of a global ecosystem perspective. Potential anthropogenic impacts on this region include global climate change, radionuclide, heavy metal and hydrocarbon pollution and increases in other activities in the Arctic Ocean. It remains the least known of our mediterranean seas.

The Arctic Research Vessel will be a part of a coordinated effort to carry out studies in this high latitude ocean. For expeditions into the permanent multi-year arctic ice pack, multiple ship operations will be required that will involve the U.S. Coast Guard and/or ice breaking vessels of other nations. The U.S. Coast Guard vessels that might be available include the polar class vessels, *Polar Sea* and *Polar Star*, and the new ice breaker presently under construction. Arctic work from surface vessels will also be complemented with under ice nuclear submarine activities. Easy access to the Arctic Ocean beneath the ice is important for acoustic, bathymetry, and magnetic studies, but multidisciplinary sampling, deep profiling and moorings require a surface vessel. Similarly, remotely sensed information will become increasingly important to arctic studies, both scientifically and for ice navigation. A multiple platform approach is necessary to accomplish arctic oceanographic studies and the ARV is a prominent component of this program.

5 - REFERENCES

Section 1

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Section 2

2.1 Subcommittee on the update of the Arctic Shipping Pollution Prevention Regulations, "Proposals for Revision of the Arctic Shipping Pollution Prevention Regulations."