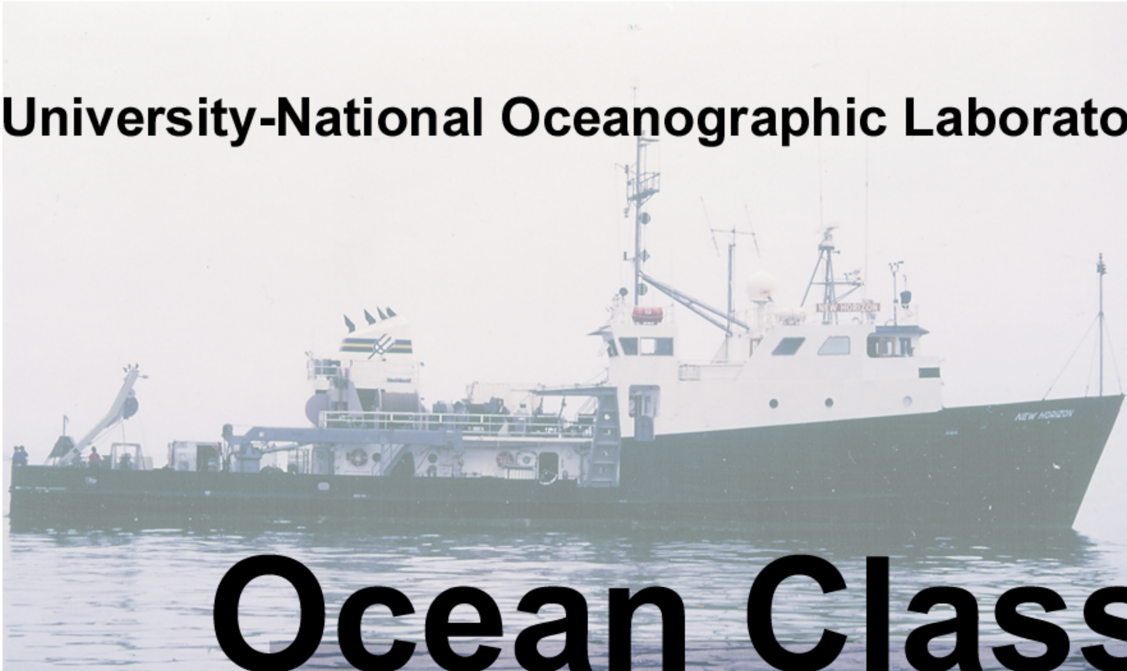
University-National Oceanographic Laboratory System



Ocean Class

Science Mission Requirements

March 2003

University-National Oceanographic Laboratory System (UNOLS)

Science Mission Requirements for Ocean Class Oceanographic Research Vessels

These Science Mission Requirements (SMR) were developed as part of the Academic Fleet Renewal effort outlined in the Federal Oceanographic Facilities Committee (FOFC) report: *Charting the Future for the National Academic Research Fleet – A Long-Range Plan for Renewal* published in December 2001. Funding for development of the SMR was provided to UNOLS through NSF Co-operative agreement number OCE 9988593 and through ONR Grant number N000140010742. Support and guidance for this project was provided by the following agencies:

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Preface – Ocean Class Research Vessel Science Mission Requirements

The timely replacement of the academic research fleet is vital to oceanographic research in the United States. The ships age and become more expensive to operate and they become less capable as scientific missions evolve. The Fleet Improvement Committee has over the past few years presented to the community compelling data showing that systematic replacement of the fleet must begin soon. If not, we will be using old and possibly unsafe ships and certainly ships that are not as capable as is needed.

The process used to construct new ships is many faceted, but a fundamental action is the formulation of the Science Mission Requirement: the SMR. The SMR states with as much specificity as possible what attributes the ship must have to perform the science envisioned. For example “What is the maximum sea state that a CTD cast can be taken in?” or “Is a core storage freezer needed and how big should it be?” The SMR provides a science capability framework for the steps between community input, vessel concept design, and final construction. It is not meant to serve as a final list of specifications, but as a list of science needs that may face prioritization during the funding and construction phase for the Ocean Class vessels.

This document gives the best estimate of what the Science Mission Requirements are for a Ocean Class Research Vessel. The document represents the work of over 70 people over the past 12 months. A meeting was held in Salt Lake City on July 23 and 24, 2002. Later the draft SMR was posted for public comment. Finally the Fleet Improvement Committee reviewed and finalized the document. The final document is then submitted to the UNOLS Council for approval, which it has received.

Although Mission Requirements and technology change with time this SMR represents a community consensus of what a Ocean Class vessel should be capable of in the coming years. This document should be considered a living document that should be updated as new science requirements are identified and as new technical solutions become available.

This SMR should serve as the guiding document for concept designs, preliminary designs, and construction of new Ocean Class Research Vessels.

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UNOLS Chair
Committee
March 6, 2003

Dr. Larry Atkinson, Chair
UNOLS Fleet Improvement

March 6, 2003

Ocean Class Research Vessel

Science Mission Requirements

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Executive summary

This new class of general purpose research vessel, designed to support integrated, interdisciplinary research, should have many of the capabilities of modern Global class vessels, though Ocean class vessels will not be globally ranging. The primary requirement is a maximum capability commensurate with ship size to support science, educational, and engineering operations in all oceans, with improved over-the-side equipment handling, station keeping, and acoustic system performance while providing a stable laboratory environment for precision measurements. These vessels should be designed to be reliable, cost effective, and flexible.

These vessels will support scientific (non-crew) parties as large as 25. Attention to the details of habitability and the design of crew and technician berthing should promote crew retention and the resulting expertise for supporting the scientific missions. The vessel should support expeditions up to 40 days and a total range up to 10,800 nautical miles (20,000 km) at optimal transit speeds. The ship should be able to sustain 12 knots through sea state 4 with fine speed control. The vessel must have effective dynamic positioning relative to a fixed position in a 35 knots wind, sea state 5 and 2 knot current.

The design should maximize the sea-kindliness of these vessels and maximize their ability to work in sea states 5 and higher. It is desirable for these vessels to operate 75% of the time in the winter in the Pacific Northwest and in the North Atlantic. In sea state 4 the vessel should be fully operational for all but the most demanding deployments and recoveries.

The stern working area, with a minimum of 1,500 sq ft aft of deckhouses and total space equal to at least 2,000 sq ft, should be open and as clear as possible from one side of the ship to the other and highly flexible to accommodate large and heavy temporary equipment. In addition, a contiguous work area along one side should provide a minimum of 80 ft clear deck area along the rail. The area should be designed to provide a dry working deck with provisions for allowing safe access for deployment and recovery of free-floating equipment to and from the water.

Additional deck areas should be provided with the means for flexible and effective installation of incubators, vans, workboats and temporary equipment. There should be maximum visibility of deck work areas and alongside during science operations and especially during deployment and retrieval of equipment. Voice communications systems between the bridge, labs, working decks and machinery spaces should be designed to effectively enhance ship control during science operations.

The design of weight handling appliances to safely and effectively deploy, recover, and sometimes tow a wide variety of scientific equipment should be considered at the earliest stages of the design cycle. The entire suite of over the side handling equipment including winches, wires, cranes, frames, booms and other appliances should be considered as a system. Designs for over the side appliances and equipment should include innovative thinking and consider ideas that will reduce the amount of human intervention necessary for launch and recovery of equipment, both on wires and un-tethered, and that will control packages from the water to the deck. This will enhance personnel safety, reduce manning level requirements, increase operability in heavier weather and protect science and ship's equipment. The winches should provide fine control and have maximum speeds of at least 100 m/min. The ship should be capable of towing large scientific packages continuously for extended periods of time. A suite of modern cranes should be provided to handle heavy and large equipment and that can reach all working deck areas. The capability of offloading vans and equipment weighing up to 20,000 lbs to a pier or vehicle in port is desirable.

Total lab space should be approximately 2,000 sq ft including: Main (dry) lab area designed to be flexible for frequent subdivision providing smaller specialized labs; separate wet lab/hydro lab located contiguous to sampling areas; climate controlled work space or chamber and an electronics/computer lab. A high bay/hanger space for multiple purposes adjacent to the aft main deck should support protected set up and repair of equipment, sample sorting and other related functions. Flexibility and support for different types of science operations within limited space are the important design criteria for these vessels. Benches and cabinetry should be flexible and reconfigurable. A separate electronics repair shop/work space for resident technicians should be included. Storage space for resident technician spares and tools should be defined in the design and not part of useable laboratory space. There should be some provision of dedicated storage/ workshop space for science and ship use. There should be accessible safe storage for chemical reagents and hazardous (non-radioactive) materials.

Lab areas need to have separate electrical circuits on a clean bus with un-interruptible power available wherever needed. Seawater systems should be designed to provide uncontaminated seawater to all science work areas and higher volume seawater to maintain incubation experiments at ambient surface temperatures. The best available navigation systems will be provided for geo-referencing of all data, for dynamic positioning and ship control as part of an integrated information system. Internal and external communications systems will provide high-quality voice communications and continuous high-speed data communications throughout the ship and with shore stations, other ships, aircraft, and data sources.

Space should be available to carry two standardized 8 ft by 20 ft portable deck vans that may be laboratory, berthing, storage, or other specialized use and up to two additional portable, possibly non-standard size, vans on superstructure and working decks is required. At least one 16-ft or larger inflatable boat located for ease of launching and recovery is also required. The variable science load should be between 100 and 200 LT.

The ship should be as acoustically quiet as practicable in the choice of all shipboard systems, their location, and installation. Propeller(s) are to be designed for minimal cavitation, and hull form should attempt to minimize bubble sweep down. Design criteria for noise reduction should take into account reducing radiated noise into the water that may affect biological research objectives, acoustic system performance and habitability.

Heating, ventilation, air conditioning and lighting appropriate to berthing, laboratories, vans, and other interior spaces being served should be carefully engineered and designed to be effective in all potential operating areas.

A thorough evaluation of construction costs, outfitting costs, annual operating costs and long-term maintenance costs should be conducted during the design cycle in order to determine the impact of design features on the total life cycle cost. The design should ensure that the vessel could be effectively and safely operated in support of science by a well-trained but relatively small number of crew. The regional conditions, available ports and shore side services should be considered during the design process.

Summary of Ocean Class Science Mission Requirements

Parameter	Capability or Characteristic
Accommodations and habitability	
Accommodations	20 to 25 non-crew personnel
Habitability	Attention to details that ensure effective work and living spaces.
Operational characteristics	
Endurance	40 days (20 transit and 20 station)
Range	Up to 10,800 nautical miles at optimal transit speeds.
Speed	12 knots sustainable through sea state 4
Sea keeping	Maximize ability to work in sea states 5 (2.5 to 4 m wave heights) and higher.
Station keeping	Dynamic positioning relative to a fixed position in 35 knot wind, sea state 5, and 2 knot current
Track line following	Maintain a track line within ± 5 meters of intended track and with a heading deviation (crab angle) of less than 45 degrees with 30 knots of wind, up to sea state 5 (2.5 - 4 m wave heights), and 2 knots of current.
Ship control	Design for maximum visibility and effective ship control
Ice strengthening	May be needed for two vessels – work near 1st year ice
Over-the-side and weight handling	
Winches, wires, frames, and cranes	New generation oceanographic winches, frames, cranes, and other weight handling equipment that are integral parts of an equipment handling and deployment system. Winches should provide fine control (0.1 m/min under full load); maximum winch speeds should be at least 100 meters/min. A crane that can reach all working deck areas and that is capable of offloading vans and equipment weighing up to 20,000 lbs to a pier or vehicle in port is desirable.
Towing	The ship should be capable of towing large scientific packages up to 10,000 lbs tension at 6 knots, and 25,000 lbs at 4 knots. Winches should be capable of sustaining towing operations continuously for days at a time.
Science working spaces	
Working deck	Stern working area - 1,500 sq ft minimum aft of deck houses open as possible. Contiguous waist work area along one side that provides a minimum of 80 ft clear deck area. Total amount of clear working area available on the main deck aft should be at least 2,000 sq ft.

Laboratories	Total lab space should be approximately 2,000 sq ft including: Main (dry) lab area (1,000 sq ft) designed to be flexible for frequent subdivision; Separate wet lab/hydro lab (400 sq ft) located contiguous to sampling areas; An electronics/computer lab (300 sq ft); A separate electronics repair shop/work space for resident technicians; High bay/hanger space for multiple purposes adjacent to the aft main deck; Climate controlled work space or chamber (approx.100 sq ft)
Vans	Carry two standardized 8 ft by 20 ft portable deck vans and the capability to carry up to two additional portable, possibly non-standard size, vans (500 sq ft total);
Storage	Approximately 5,000 cubic feet of storage space that could also be used as shop or workspace when needed would be desirable.
Science load	Variable science load should be 200 LT.
Workboats	At least one 16-ft or larger inflatable boat located for ease of launching and recovery
Masts	Design criteria are presented so these science operation areas are not overlooked
On deck incubations	
Marine mammal & bird observations	
Science and shipboard systems	
Navigation	Navigation, computing, voice and data communications through the best available systems using current expert advice. Systems should be specified as close to actual delivery as possible.
Data network and onboard computing	
Real time acquisition	
Comms – internal	
Comms – external	
Underway data collection & sampling	Promotes design of flexible and functional systems for data collection and sampling using advice from experts at the time of design and specification.
Acoustic systems	
Visiting science systems	Build in capability to accommodate a variety of equipment
Discharges	Ensure discharges do not impact science, health and environment.
Construction, operation & maintenance	
Maintainability	Statements to ensure that the design and construction of these vessels take into account the ability to maintain and operate within domestic and international regulations in a reliable and cost effective manner.
Operability	
Life cycle costs	
Regulatory issues	

OCEAN CLASS RESEARCH VESSEL

UNOLS Science Mission Requirements

Mission statement and overall characteristics

This is a new class of vessel proposed by the Federal Oceanographic Facilities Committee (FOFC) Long-Range Plan for Academic Fleet Renewal and further defined by these science mission requirements. Designed to support integrated, interdisciplinary research, Ocean Class ships will be ocean going, with many of the capabilities of modern Global Class vessels, though not globally ranging. They will be somewhat smaller and more efficient to operate than the Global Class vessels. However, they will substantially expand the existing capabilities provided by most of the older Intermediate Class UNOLS ships.

These ships are to serve as general-purpose research vessels. The primary requirement is a maximum capability commensurate with ship size in order to support science, educational, and engineering operations in all oceans, with improved over-the-side equipment handling, station keeping, and acoustic system performance while providing a stable laboratory environment for precision measurements. These vessels will provide for larger scientific parties and greater flexibility in use of laboratory/deck spaces than are now available aboard intermediate-size ships. Some may be configured to accommodate ice-margin research, fisheries related oceanography, underway survey operations or other specialized missions.

To accomplish these goals there are several features that should receive high priority during the early design cycle phases. These vessels should be acoustically quiet in terms of radiated noise and so that hull mounted acoustic systems can function at their maximum capability. Sea-keeping and station-keeping capabilities will be important design drivers as well. Education and public outreach is becoming an important function during research cruises and the personnel and equipment to carry out this mission should be considered during design. Paying attention to habitability issues such as noise control, vibration, ventilation, lighting, and aesthetics will also increase the effectiveness and health of the crew and science party.

The specification of scientific and operational equipment outfitting should be carefully planned so that the delivered vessel is equipped with the currently best available equipment. Expert scientific, technical, and operational groups should provide guidance and advice on design criteria for all key scientific and operational systems. Experience with the design of past research vessels as well as innovative new approaches should be used to provide designs that will serve the community well for three decades.

These vessels should be designed to be reliable, cost effective, and flexible. The ability to easily maintain these vessels with minimal manning during full operating years should be a design criterion. Designs should also anticipate major machinery overhaul and replacement, as well as future improvements. Fuel efficiency and reliability of machinery and equipment will serve to reduce the life cycle cost of these vessels. The design cycle should consider carefully the tradeoffs between initial acquisition costs and long term operating costs.

Science Mission Requirements (SMR) - Overview

The purpose of the science mission requirements is to set down design features and parameters that should be used as guidelines during the various design phases. There are some areas where there will be tradeoffs between two or more desired capabilities. By allowing more than one concept design, the possibility of finding ways to minimize these tradeoffs will be enhanced. A key concept is that ship systems are completely integrated with the science mission for these vessels. Sample mission profiles are included in Appendix I to provide examples of how these vessels might be used. It is possible that not all requirements can be fully realized in any one design and it will be necessary to refine priorities during the design phases. Concept, Preliminary, and Construction design efforts should consider all elements in these requirements and make conscious decisions on how and if they can be addressed. These science mission requirements are organized with the following elements.

Mission statement

Overview of SMRs

Size, cost, and general requirements

Accommodations and habitability
- Accommodations
- Habitability

Operational characteristics
- Endurance
- Range
- Speed
- Sea keeping
- Station keeping
- Track line following
- Ship control
- Ice strengthening

Over-the-side and weight handling
- Over the side handling
- Winches
- Wires
- Cranes
- Towing

Science working spaces
- Working deck area
- Laboratories
  - Type & number
  - Layout & construction
  - Electrical
  - Water & air

Science working spaces (cont.)
- Vans
- Storage
- Science load
- Workboats
- Masts
- On deck incubations
- Marine mammal & bird observations

Science and shipboard systems
- Navigation
- Data network and onboard computing
- Real time data acquisition system
- Communications - internal
- Communications – external
- U/W data collection & sampling
- Acoustic systems
- Project science system installation and power
- Discharges

Construction, operation & maintenance
- Maintainability
- Operability
- Life cycle costs
- Regulatory issues

Mission Scenarios

Science Mission Requirements - Details

Size and cost constraints (FOFC fleet renewal parameters)

The design phases will determine the overall size and cost of this vessel. However, the target size and cost were set in the FOFC Academic Fleet Renewal Plan and serve as a benchmark for the design of this class of vessel. In general, these vessels will serve the science demands falling between those services provided by the existing Global Class vessels and the new Regional Class vessels. The FOFC parameters were defined as:

Endurance: 40 days
Range: 20,000 km (10,800 n. mi.)
Length: 55-70 m (180'- 228')
Science berths: 20-25

Cost: $50 million (This is interpreted to mean the total cost for design, construction, and outfitting in 2001 dollars).

These parameters are defined further by the science mission requirements described in this document. It is envisioned that all or most of these vessels will fall in the middle of the size range defined, that endurance will be 40 days, and that science berths will be at least 20 with surge capacity to 25 or more. The specified range has the potential for driving the size of the vessel beyond what is economical and may be an area where compromise will be needed.

Draft is a design element that should be considered carefully as the size of the vessel evolves. A shallower draft, less than the 19-foot draft of the THOMPSON Class vessels is desirable for operations in shallow waters and to allow shallow depth mounting of ADCP transducers. On the other hand, a deeper draft could increase sea-keeping capabilities (which is a high priority for these vessels) and allow for increased endurance. The OCEANUS Class vessels that these vessels will replace have a draft between 18 and 19 feet, which contributes to their sea-keeping ability. Access to normal ports of call should be considered so that the operation of this vessel is not too severely restricted because of a draft that precludes all but a few ports.

Cost will be a significant factor influencing the design, construction, and outfitting of these vessels. The budget and funding mechanisms available to the sponsoring agency for these vessels will determine the total budget for design, construction, and outfitting. The FOFC plan sets this number at approximately 50 million dollars per vessel in 2001 dollars. The actual amount available for detailed design and construction will be less than 50 million depending on how much is required for project management, outfitting and preliminary design costs. Long term operating costs should be considered carefully in the design process so that decisions are not made that would drive up the yearly operating and maintenance costs. These vessels should be nearly as capable as Global Class vessels, but should use a smaller portion of the funds available for ocean science support.

Accommodations & habitability

Accommodations

Twenty to 25 non-crew personnel in one or two-person staterooms with every attempt to keep the number at the upper end of the range is highly desired. The number of crew and therefore the total complement will be determined by the Coast Guard Letter of Inspection, the support requirements for the scientific mission, and proper maintenance of the vessel. The concept of including temporary accommodations that can be used when needed (i.e., surge capacity) is important to the flexibility of these vessels to support a wider range of potential projects.

The design of accommodations needs to be for optimum habitability for the normal science party size, but with the ability to expand to larger science party sizes when needed. Supporting infrastructure would be designed around the largest possible complement. Shower and toilet facilities should support no more than four people per unit when there is a normal size of science party. Staterooms should be designed to optimize the available space. Providing basic storage, washbasins, and limited workspace should be attempted in the design. Additional storage and larger workstations could be provided in common space elsewhere. Provisions should be made to accommodate gender imbalance.

The maritime crew and resident technicians should be berthed in single person staterooms to the maximum extent possible in order to promote crew retention and the resulting expertise for supporting the scientific mission.

The non-crew personnel (i.e., the Science Party) would consist of the personnel from the various scientific programs, the assigned marine technicians, technical support personnel for certain types of instrumentation (e.g. JASON II group, OBS groups, coring groups, etc.), foreign observers, education and outreach personnel, and anyone else not part of the maritime crew.

Habitability

Heating, ventilation, and air conditioning (HVAC) appropriate to berthing, laboratories, vans, and other interior spaces being served should be engineered and designed to be effective in all potential operating areas. Laboratories shall maintain temperatures of 70-75° F, 50% relative humidity, and 9 to 11 air changes per hour in all intended operating areas, taking into account the full range of external sea water and air temperatures. Maintaining internal environmental conditions should consider the anticipated number of door openings (in a given period of time), and/or the normal door positions (open or closed) for each compartment's intended purpose.

Air circulation rates should meet shore lab standards and SNAME standards for HVAC.

At least some lab space should be clean for chemical analysis. This analytical lab space requires separate ventilation and/or organic filters, and, if possible, located in a separate lab space or specialized van.

The design should support maintaining acceptable noise levels throughout the ship and utilize specifications and standards applicable to vessels (USCG NVIC 12–82, IMO Resolution A.468 (XII) and OSHA regulation: 29CFR1910.95). These noise standards should be met as closely as possible at normal cruising speeds or in Dynamic Position (DP) mode, with ventilation systems operating at maximum levels, acoustic systems operating at maximum power, and with deck machinery operating. Noise reduction engineering should be integrated with design efforts at the earliest stages in order to incorporate noise level considerations in decisions about layout and arrangement of spaces.

Vibration should be minimized using ABS and/or SNAME standards, and provisions should be made for mounting sensitive instrumentation in a manner to compensate for vibration and ship motion. Ship's motion is an important design criterion that will affect habitability and is addressed in the sea-keeping section.

Lighting levels should meet shore laboratory or office standards (OSHA). Lighting levels should be controllable for individual areas within labs to accommodate requirements for microscope work or other low light requirements. The ability to maximize the amount of natural lighting through the use of a sufficient number of port lights in lab spaces, staterooms, and common spaces should be included in the design.

HVAC performance, noise, vibration, and lighting standards should be defined for all occupied spaces on the vessel.

The productivity of all personnel sailing in these vessels can be enhanced by providing comfortable, aesthetically pleasing spaces, and by including, to the extent possible, areas for off-hour activities other than staterooms and workspaces such as a library, lounge, or conference room with tables, good lighting, video capability, and etc. Providing equipment and space for exercise should be considered. Staterooms should include connections to the ship's network and entertainment systems, but they need also to be separated from the noise associated with off-hour activities.

Operational characteristics

Endurance & range

Total endurance should be forty days, providing the ability to transit for 20 days at cruising speed and for 20 days of station work (see station keeping and towing). Some mission profiles will require continuous underway survey or towing operations at speeds from 4 knots up to the normal cruising speed. The ability to conduct this type of cruise for up to 30+ days is desired. The design process should consider the impacts on engines, water making capability, and other factors when on station or moving at slow speeds for extended periods of time.

Up to 10,800 nautical miles (20,000 km) total range at optimal cruising speed is desirable. A minimum of 8,000 nautical miles at optimal cruising speed is required. Range should be maximized without sacrificing sea-keeping ability and without driving the size and cost of the vessel beyond available funds.

Speed

14 - 15 knots maximum speed at sea trial in calm seas and 12 knots sustainable through sea state 4 (1.25 – 2.5 m wave heights) is desirable. An optimum cruising speed of at least 12 knots is desired, but should not come at the cost of decreased sea-keeping ability, excessive fuel consumption, or excessive noise.
Speed control in sea state 4 or less (< 2.5 meters wave height) should be

0.1 knot in the 0-6 knot range and
0.2 knot in the 6-14 knot range.

Sea-keeping

Sea-keeping is the ability to carry out the mission of the vessel while maintaining crew comfort and safety, and maintaining equipment operability. It is an important design criterion to maximize the sea-kindliness of these vessels and maximize their ability to work in sea states five (2.5 – 4 m wave heights) and higher within the constraints of their overall size. It is desirable for these vessels to operate 75% of the time in the winter in the Pacific Northwest and in the North Atlantic. Bilge keels, anti-roll tanks or other methods to reduce the motions of these vessels should be used to enhance sea-keeping.

In sea state four (1.25 – 2.5 m wave heights) the vessel should be fully operational for all but the most demanding deployments and recoveries.

In sea state five these vessels should be able to:

- Maintain underway science operations at 9 knots
- Maintain on station operations 80 % of the time, including:
  - CTD operations 90% of the time
  - Mooring deployments 75% of the time
  - Coring operations 50% of the time
  - ROV or other sensitive deployment operations 50% of the time
- Limit maximum vertical accelerations to less than 0.15 g (rms)
- Limit maximum lateral accelerations to less than 0.05 g (rms) at lab deck level
- Limit maximum roll to less than 3 degrees (rms)
- Limit maximum pitch to less than 2 degrees (rms)

At sea state six (4 – 6 m wave heights) these vessels should maintain 7 knots and be capable of station operations 50% of the time.

At sea state seven and greater (> 6 m wave heights), these vessels should be able to operate safely while hove to.

These motion criteria specifications should be verified as adequate and achievable during the earliest concept design phase. Otherwise, other motion criteria that result in ship motions that allow personnel and equipment to work effectively can be utilized during the concept design phase as long as the intent of the above sea keeping specifications is not sacrificed. Tables showing sea state and the practical effects of ship motion are included as appendices V and VI.

Station keeping

Station keeping is the ability to maintain a position and heading relative to a station or track line that allows the mission of the vessel to be completed. These vessels should be able to maintain station and work in sea states up through 5 (2.5 – 4 m wave heights) at best heading.

Dynamic positioning, using the best possible and multiple navigation inputs, should be possible, in both relative and absolute references in the following conditions:

- 35 - knot wind
- Sea state 5
- 2 - knot current

The maximum excursion allowed should be ± 5 meters (equal to navigation accuracy) from a fixed location for operations such as bore hole re-entry through sea state 4 at best heading and up to ± 20 meters at best heading through sea state 5.

DP system design and operation should minimize noise, vibration, and adverse effects on the operation of acoustic systems as much as possible, and these issues should be evaluated early in the design process.

Track line following

The vessel should maintain a track line while conducting underway surveys for spatial sampling and geophysical surveys within ± 5 meters of intended track and with a heading deviation (crab angle) of less than 45 degrees with 30 knots of wind, up to sea state 5 (2.5 – 4 m wave heights) and 2 knots "beam" current. This target may be required for ship speeds as low as 2 knots. Straight track segments shall be maintained without large and/or frequent heading changes.

Ship control

The chief requirement for ship control is maximum visibility of deck work areas and alongside during science operations and especially during deployment and retrieval of equipment. This should be accomplished with a direct view to the maximum extent possible and enhanced with closed circuit television systems. Portable hand-held control units or alternate control stations could also be used at various locations that enhance visibility and communications with the working deck during over the side equipment handling. The functions, communications, and layout of the ship control station should be carefully designed to enhance the interaction of ship and science operations. For example, ship course, speed, attitude, and positioning should be integrated with scientific information systems. Voice communication systems between the bridge, labs, working decks, and machinery spaces should be designed to effectively enhance ship control during science operations. Also, an integrated bridge management and collision avoidance system should be provided to help ensure safe and efficient science operations in traffic congested coastal waters. Autopilot and DP systems should be integrated with sophisticated control settings that allow appropriate response levels for the type of work being conducted. These systems should also be designed to enhance manual control of the vessel whenever needed.

Ice strengthening

It is desirable that two vessels (one in Atlantic & one in Pacific) in this class have the capability to operate in the presence of 6/10 coverage of first year ice and should be designed to meet the criteria for the appropriate ice classification.

Over-the-side and weight handling

Over-the-side handling

The design of weight handling appliances to safely and effectively deploy, recover, and sometimes tow a wide variety of scientific equipment should be considered at the earliest stages of the design cycle so that they are integrated in the earliest layout of spaces. The entire suite of over the side handling equipment including winches, wires, cranes, frames, booms, and other appliances should be considered as an integrated system and perhaps engineered and designed by a single contractor/manufacturer. Designs for over the side appliances and equipment should include innovative thinking and consider ideas that will reduce the amount of human intervention necessary for launch and recovery of equipment, both on wires and un-tethered, and that will control packages from the water to the deck. Heave compensation and other techniques designed to minimize stress on cables and equipment should be included in designs of these systems. These systems should be developed to enhance personnel safety, reduce manning level requirements, increase operability in heavier weather, and protect science and ship's equipment.

The Stern Frame should be designed for a dynamic safe working load of 30,000 lb through its full range of motion, and it must structurally engineered to handle 1.5 times the breaking strength of cables up to one inch, such as the tether for large ROV systems (up to 120,000 lbs breaking strength). The stern A-frame should have a 15-ft minimum horizontal and 25-ft vertical clearance from the attachment point for the block to the deck. At least a 12-ft inboard and outboard reach is required.

Side weight handling appliances or frames should be designed to handle the loads for piston coring (e.g. 9/16 inch 3 x 19 wire) and have a safe working load of at least 20,000 lbs. Multiple locations and/or multiple devices should be provided that will facilitate deploying coring equipment, equipment from either side, and from the bow area. Portable weight handling appliances should be located to work with winch and crane locations, but be able to be relocated as necessary. The design of frames and other weight handling equipment should allow removal to flush deck foundations.

The capability to carry additional over the side weight handling appliances along working decks from bow to stern should be included in the design.

Control stations(s) need to give the operator protection, provide operations monitoring, and be located to provide maximum visibility of over the side work.

The need for any human-rated systems should be identified early in the design process.

Winches and wire

These vessels should be designed to operate with a new generation of oceanographic winch systems that are an integral part of the equipment handling and deployment system. The winches should provide fine control (0.1 m/min under full load); maximum winch speeds should be at least 100 meters/min; and constant tensioning and other parameters, such as speed of wire, should be easily programmable while at the same time responsive manual control must be retained and immediately available at any time. Manual intervention of winch control should be available instantly for emergency stop and over-ride of automatic controls. Wire monitoring systems with inputs to laboratory panels and shipboard recording systems should be included. Wire monitoring systems should be integrated with wire maintenance, management, and safe working load programs. Local and remote winch controls should be available. Remote control stations should be co-located with ship control stations and should be located for optimum operator visibility with reliable communications to laboratories and ship control stations. Winch control and power system design should be integrated with other components of over-the-side handling systems to maximize safety and protection of equipment in heavy weather operation and to maximize service life of installed wires. Adequate provisions for connecting slip rings and ship's power and data network to the E-M and F-O cables should be included in the design.

Two hydrographic-type winches capable of handling up to 10,000 meters of wire rope, electromechanical or fiber-optic cables having diameters from 1/4" to 1/2" should normally be installed. Winches should be readily adaptable to new wire designs with sizes within a range appropriate to the overall size of the winch.

A heavy winch complex capable of handling 12,000 meters of 9/16" wire/synthetic wire rope and/or 10,000 meters of 0.68" electromechanical cable (up to 10 KVA power transmission) or fiber optics cable should be permanently installed. This complex is envisioned as one winch with multiple storage drums that could be interchanged in port or are installed such that wire could be led from either drum to the traction winch. Overall space and weight limitations would dictate whether or not more than one storage drum could be installed simultaneously or may make it necessary to carry somewhat shorter lengths of wire or cable.

Winches handling fiber-optic cable should be traction winches that allow storage of the cable under lower tension unless new technologies in wire construction allow otherwise. This includes winches for both 0.68" and smaller cables.

Additional special-purpose winches (e.g., clean sampling, pumping, multi-conductor) may be installed temporarily at various locations along working decks. Winch sizes and power requirements should be considered during the design phase in order to establish reasonable limits for the vessel size.

Permanently installed winches should be out of the weather where feasible to reduce maintenance and increase service life. The trawl/tow winch should be below the main deck, but smaller winches may be located in semi-protected areas of the 01 deck to allow for better fairlead.

Wire fairleads, sheave size, and wire train details need to be integrated with the general arrangement as early in the design process as possible in order to increase the possibility of limiting wire bends and overly complicated wire train. Sheave sizes, number, and locations should be designed to maximize wire life and safe working load. It should be possible to fairlead wires from permanent winches over the side or over the stern.

Details of winch location should include provisions for easily changing wire drums, spooling on new cable, and changing from one storage drum to another, and for major overhaul of winches so that these operations can take place with minimum time and effort in port. Some operations, such as re-reeving wires through fairlead blocks or switching the wire being used through a frame or with a traction winch, should be factored into designs so that the operations can be performed at sea safely and efficiently.

Cranes

A suite of modern cranes should be provided to handle heavier and larger equipment than can be handled by previous vessels of this size and should be integrated with the entire over-the-side handling system. A crane that can reach all working deck areas and that is capable of offloading vans and equipment weighing up to 20,000 lbs to a pier or vehicle in port is desirable. This will generally mean being able to reach approximately 20 feet beyond one side of the ship (usually starboard) with the design weight. At least one crane should be able to deploy buoys and other heavy equipment weighing up to 10,000 lbs up to 12 feet over the starboard side at sea in sea state 4.

One or two smaller cranes, articulated for work with weights up to 4,000 lbs at deck level and at the sea surface, with installation locations forward, amidships, and aft should be provided. They would also be usable with re-locatable crutches as an over-the-side, cable fairlead for vertical work and light towing. If the design includes the need to store and launch boats or to deploy equipment from the foredeck, then design for cranes or weight handling should accommodate those needs. Cranes may need to have servo controls, motion compensation or damping as part of the integrated over the side handling systems discussed earlier in that section. The ship should be capable of installing and carrying portable cranes for specialized purposes.

The need for any human-rated crane should be identified early in the design cycle for that vessel.

Towing

The ship should be capable of towing large scientific packages up to 10,000 lbs tension at 6 knots, and 25,000 lbs at 4 knots. Winch control should allow for fine control (± 0.1 meters/min) at full load and all speeds. Winches should be capable of sustaining towing operations continuously for days at a time.

Towing operations include mid- to low-load operations with mid-water equipment such as towed undulating profilers, single and multiple net systems, and biological mapping systems. Other systems may involve larger loads and spike loads such as deep towed mapping systems, bottom trawls, camera sleds, and dredges.

Science working areas

Working deck area

A spacious stern working area with 1,500 sq ft minimum aft of deckhouses, open and as clear as possible from one side to the other, is required. In addition, a contiguous waist work area along one side (starboard preferred) that provides a minimum of an 80 ft length of clear deck along the rail should be available. This area will to allow for 20 meter piston coring and other operations. A minimum width of eight feet is needed for the coring operations and the overall width of the waist deck should be wide enough to accommodate all planned operations. The total amount of clear working area available on the main deck aft should be maximized and equal to at least 2,000 sq ft. Among the possible van locations, the ability to install one ISO standard van with room for passage along the starboard side should be considered.

Deck loading should meet the current ABS rules (i.e. designed for a 12 foot head or 767 lbs/sq ft) and provide a minimum aggregate total of 60 tons on the main working deck. Point loading for some specific large items (such as vans and winches) should be evaluated in the deck design since these may generate loads of 1,500 lbs/sq ft or higher.

All working areas should provide 1”-8NC (SAE National Coarse Thread) threaded inserts on two-foot centers with a tolerance of ± 1/16” on center. The bolt down pattern should be referenced to an identifiable and relevant location on the deck to facilitate design of equipment foundations. The inserts should be installed and tied to the deck structure to provide maximum holding strength (rated strength should be tested and certified). Tie down points should be provided for any clear deck space that might be used for the installation of equipment including the foredeck, 0-1 deck, bridge, and flying bridge and should extend as close to the sides and stern as possible.

Stern deck area should be as clear as possible and highly flexible to accommodate large and heavy temporary equipment. Bulwarks should be removable and all deck-mounted gear (winches, cranes, a-frames, etc.) should be removable to a flush deck to provide flexible re-configuration.

The design should provide a dry working deck with provisions for allowing safe access for deployment and recovery of free-floating equipment to and from the water. Traditionally low freeboard and stern ramps have been provided as means to accomplish this goal. The use of stern ramps has been limited and should be included in new designs only if required by specific planned operations. Low freeboard facilitates launch and recovery operations, but results in wetter decks and less reserve buoyancy. The use of innovative design features to facilitate safe and effective equipment launch and recovery while maintaining dry and safe weather decks should be carefully considered. Removable bulwarks with hinged freeing ports to provide dry deck conditions in beam or quartering seas have proved effective. The use of a moon pool can be considered. The use of wood or synthetic decking material to protect equipment, promote draining of water, and to provide for safer footing should be considered.

A clear foredeck area should be capable of accommodating small, specialized towers, booms, and other sampling equipment as much as possible. Providing tie down sockets, power, water, and data connections will facilitate flexible use of this space.

Additional deck areas should be provided with the means for flexible and effective installation of incubators, vans, workboats, and temporary equipment. (See relevant SMRs below for details)

All working decks should be equipped with easily accessible power, fresh and seawater, air, data ports, and voice communication systems. Adequate flow of ambient temperature seawater for incubators should be available on decks supporting the installation of incubators.

All working decks need to be covered by direct visibility and/or television monitors from the bridge. Gear deployment areas should maximize direct clear visibility.

Laboratories

Lab - Number, type, and size

The majority of the lab space should be located in one or two large lab(s) that can be reconfigured, partitioned, and adapted to various uses to allow for maximum flexibility. This flexibility is an important design criterion.

To the maximum extent possible, labs should all be located on the same deck adjacent to each other and adjacent to the main working deck areas. Labs should be located so that none serve as general passageways. Doors and hatches should be designed to facilitate installing large equipment, loading scientific equipment, and bringing equipment to and from the deck areas. Doorsills should be temporarily removable.

The total lab space should be approximately 2,000 sq ft (dimensions below are approximate guidelines).

A main (dry) lab area (1,000 sq ft) should be designed to be flexible for frequent subdivision providing smaller specialized labs.

A separate wet lab/hydro lab (400 sq ft) is to be located contiguous to CTD/rosette launching and sampling areas.

An electronics/computer lab (300 sq ft) should be provided as a separate lab or as a defined area in the main lab. This space should be dry and separated as much as possible from sources of electronic noise. It may include a central watch standing space that should accommodate visiting science equipment as well as normally installed equipment. Provisions for remote displays in other labs should be part of lab designs.

A separate electronics repair shop/work space for resident technicians that includes provision for repair bench space for visiting technicians is required. Storage space for resident technician spares and tools should be defined in the design so that it is not taken from useable laboratory space. A small separate room or partitioned space for IT (server, telephone, and network) equipment is desirable.

A high bay/hanger space for multiple purposes adjacent to the aft main deck should be included. This space should support protected set up and repair of equipment, sample sorting, and other related functions.

A climate controlled workspace or chamber (approx. 100 sq ft) is required. This can be accommodated by providing a separate walk-in space, or it can be provided with a laboratory van. If provided as a permanent space this area should be useable for other purposes when not needed as a climate controlled space. This space should be capable of controlling temperature to ± 0.5°C and as low as –2°C. Lighting levels should be controllable and programmable.

Design of HVAC systems should be integrated with designed partitioning of laboratory spaces so that temperature control can be achieved. Lighting control should also take into account partitioning plans.

Refrigerator/freezer space (100 sq ft) should be built in to the lab space with provisions for temporary additional space. Two units with similar configuration, and refrigeration equipment capable of maintaining temperatures between –15°C and 10°C (these temperature requirements should be verified during design) would allow for flexible use by science projects needing freezer and/or refrigerator space. A –80°C freezer should be available.

Lab - Layout and construction

Flexibility and support for different types of science operations within limited space are the important design criteria for these vessels. Benches and cabinetry should be flexible and reconfigurable (e.g. SIO erecter set and/or Unistrut™). Bench and shelving heights should be variable to allow for installation and use of various types of equipment. Bench tops should be constructed of materials that will allow equipment to be tied down or secured easily and that can be cleaned and replaced as necessary. The ability to easily install or remove cabinets and drawers as needed should be included. Provisions for large, flat chart/map tables including a light table should be incorporated in the lab design.

Refer to the section on habitability for guidance on the importance of lighting, air circulation, etc.

Labs should be fabricated using materials that are uncontaminated and easily cleaned. Furnishings, HVAC, doors, hatches, cable runs, and fittings must be planned to facilitate maintaining maximum lab cleanliness. Spaces and materials that may trap chemical spills should be avoided.

Static dissipative deck coatings to reduce static damage to electronics should be required in “ET” shop and computer/electronics spaces, and recommended in other lab spaces. Deck coatings should protect the ship’s structure, be easily cleanable, easily repairable, and resistant to damage from chemical spills. Deck materials or padding should provide safe footing and minimize fatigue to working personnel that need to stand for long periods.

The distance from the deck to the underside of the finished overhead should be 7.5 to 8 feet. Headroom space and room for the installation of tall equipment should be maximized while balancing the need for cable trays, adequately sized ventilation ducts, lighting, etc.

Through the design process, minimize the incursion of “ship stuff” (e.g., air handlers, gear lockers, and food freezers) into the lab space.

Labs should have bolt downs (1/2”-13NC on two foot centers) in the deck in addition to Unistrut™ on the bulkheads and in the overhead. Deck bolt downs on one-foot centers should be considered for some areas.

Locations for two fume hoods in the main lab and one in the wet lab should be included in the laboratory layouts. Exhaust ducting, electrical connections, and sink connections should be permanently installed in place to allow for easy installation and removal of fume hoods. Fume hood locations should accommodate hoods at least four feet wide.

Sinks should allow for flexible installation, removal, and additional sinks when needed. At least two locations in the wet lab and four locations in the main lab (some of which are located with the fume hoods discussed above) should be provided with stubbed out plumbing at convenient locations. More locations can be provided if possible. Drains should be designed to work at all times, taking into account operating conditions that create various trim and list conditions, rolling, etc. Drains should be capable of being diverted over the port side, into holding tanks, or to the normal waste system, and should allow for continuous discharge of running water. Sinks should be large enough to accommodate five gallon buckets and the cleaning of other equipment.

Work with radioactive materials should be restricted to radiation lab vans that remain isolated from the interior of the vessel.

Lab - Electrical

Each lab area is to have a separate electrical circuit on a clean bus with continuous delivery capability of at least 40-volt amperes per square foot of lab deck area (the amount of power needed will be verified at the time of design). Un-interruptible power should be available throughout all laboratory spaces, bridge/chart room, and science staterooms. The use of modular UPS design can be considered. Separate circuits should be available for tools and other equipment that will not interfere with clean power circuits. Use current IEEE 45 or equivalent standards for shipboard power and wiring and current IEEE standard for UPS and clean power specifications.

Electrical service for the labs should include:

- 110 VAC, single phase 75-100 amps service for each lab;
- 208/230 VAC, 3-phase, 50 amps, “readily available” (i.e., in the panel, or 1-2 outlets); and
- 480VAC, 3-phase available “on demand” (for example, run into the lab from auxiliary outlets on deck).

There should be dedicated science wire-ways with dedicated transits to all science and instrumentation locations, including locations at the bow, at the seawater intake locations, and at winches. Science wire ways should be separated from power and other signal cables. There should also be non-energized wiring installed and dedicated to supporting project science systems (appropriate gauge and number of conductors determined during design phase). Provisions for easy installation and removal of temporary wiring should be made.

Lab - Water and air

Uncontaminated seawater should be supplied to most laboratories, vans, and several key deck areas. This water must be collected as close as possible to the bow and piping must be made from materials acceptable to the majority of science users. Provisions for keeping piping clear and clean should be included in the design. Provisions for changing pumps, valves, and piping when necessary should be included in the design. Provisions for connecting multiple users in addition to semi-permanent equipment should be provided. A backup or alternate system should be considered. Provision of space and connections as close to the intake as possible are desired.

Clean hot and cold water should be provided to sinks and equipment in labs and on deck. Good feed water to instrumentation to make 18 mega-ohm water (e.g., Millipore Milli-Q) is required. Ship's water made with commercial reverse osmosis equipment is not adequate without further treatment. Space or equipment for adequate clean water (18 mega-ohm) supply should be provided.

A separate, higher volume seawater source with temperature control or high enough flow to maintain ambient surface seawater temperature for incubations should be provided. Sea chest location and maintenance should be designed for proper operation on a continuous basis. This system should be separate from fire fighting, ballast, and ship service saltwater systems, or designed as part of a flexible and redundant seawater supply system that allows operation of ship's service systems without interfering with science operations.

The ship's service compressed air supply (@100 psi) should be available in the labs and have the ability to add filters as needed. Clean dry air needs are to be handled by bottled air or user supplied filter systems. Volume of air and whether or not a continuous supply will be required should be considered during the design stages in order to ensure that installed compressors are properly rated. The need to support high volume or specialized air requirements such as seismic work, driving air powered pumps, or SCUBA tank recharging should be clearly specified and carefully considered early in the design process. Provisions for removable fixtures in the lab spaces designed to secure compressed gas tanks need to be included.

Design of seawater systems should be integrated with instrumentation requirements and should be conducted with review and input by expert user groups. In particular, current advice on acceptable materials and specifications for providing bubble-free uncontaminated seawater under all steaming and sea conditions should be sought.

Vans

The vessel should be capable of carrying two (2) standardized 8 ft by 20 ft portable deck vans that may be laboratory, berthing, storage, or other specialized use. Also it is desirable that it include the capability to carry up to two (2) additional portable, possibly non-standard size, vans (500 sq ft total) on superstructure and working decks (total of four vans).

- Hookup provision for fresh water, uncontaminated seawater, compressed air, drains, Peck and Hale fittings, communications, data, and shipboard monitoring systems. Connections and other provisions for vans should be designed around UNOLS standard vans.
- Electrical connections for 20 amps 480 VAC 3-phase, 40 amps 230 VAC 3-phase, and 40 – 50 amps 208 VAC single phase should be provided. 110 VAC single phase may also need to be provided, but usually can be provided by panels in the van from step down transformers. (Verify requirements at time of design.)
- Van should have direct access to ship interior, but located in wave-sheltered spaces. Safe access to and from vans is a primary design consideration.
- Radiation vans should be capable of installation so that they can be isolated from the interior of the vessel while still allowing safe access for personnel.
- Supporting connections at several locations around ship is desirable.
- Ship should be capable of offloading vans using own cranes.

Science (and ship's) storage

Although storage space for multiple legs may not be required for this class of vessel as often as on Global Class vessels, the provision of dedicated storage/workshop space for science and ship use will enhance the effective utilization of lab space and allow for some expeditionary cruises. Approximately 5,000 cubic feet of storage space that could also be used as shop or workspace when needed would be desirable. Storage space on this class vessel would be used for shipboard technician's tools and shared use equipment in addition to project related equipment. Some open space for large items and some space with shelving would be desirable. Access to the storage space should be safe and effective from the labs and working deck. The ability to load and remove large, heavy items and to properly secure them in the storage area should be provided.

Adequate provisions should be made for ships stores and spares and may need to be included as a separate defined area in the same storage area. Providing adequate and specified storage for both the science project's and ship's needs will help to ensure maintainability, operability, and prevent encroachment into science areas by required ship needs.

Provide accessible safe storage for chemical reagents and hazardous (non-radioactive) materials. The use of lockers or storage containers outside the lab space should be considered. Accommodating required separations of certain materials needs to be provided. Provisions for storing gasoline safely should be identified in the design. Radioactive materials would be stored and used only in radiation vans. Only working quantities of other hazardous materials would be stored in the labs. Provisions for safe storage of gas cylinders should be considered. (See lab water and air section above.)

Science load

A variable science load of 200 LT is desired and should be at least 100 LT. This load would include science related equipment, supplies, and instrumentation not normally installed on the vessel. Examples are mooring equipment, ROV systems, temporary winches, rock and mud samples, lab equipment, temporary cranes or frames, vans, and extra workboats. Items that would NOT be included are regularly installed winches (permanent and removable), Stern A-Frames, other normally installed handling equipment, rescue boats, and ship's workboats.

To prevent losing this variable science load to the inevitable growth in light ship displacement, a service life allowance of approximately 5% additional load capacity should be included in the design. The ship's ballast system should have the capacity and capability to compensate for a changing science load during a cruise.

Workboats

At least one (1) 16-ft or larger inflatable (foam collar or semi-rigid) boat should be located for ease of launching and recovery. Include the capability to carry and deploy a scientific workboat 25-30 ft LOA outfitted specially for supplemental operations at sea.

Required rescue boats may be capable of serving as a science workboat with careful planning. Otherwise, workboats will be required in addition to any IMO/USCG required rescue boats.

Masts

The main mast and a second lightweight and removable mast will both have yardarms capable of supporting up to five scientific packages weighing between 30 and 100 lbs. Radar, radio, and other RF frequency generators will not be installed on these yardarms, but meteorological packages could be. Meteorological packages should be mounted in locations where the air mass is disturbed as little as possible by the ship's structure. Use modeling to determine the best configuration. Provisions for mounting the lightweight mast in the least disturbed air possible should be included in the design.

The main mast should be designed such that ship's crew/technicians can easily/safely/comfortably work aloft on the mast to change sensors and instruments. Any secondary mast should be similarly designed or be easily lowered to service instruments. Connections and wiring will be installed to allow easy connection between sensors and instruments located on the masts and the vessel's fiber-optic data transfer network.

A crow's nest may be considered to support science operations such as marine mammal work, bird surveys, and others.

Clearance under bridges should be considered on a regional basis for determining the maximum allowable height (air draft) of the vessel. The use of innovative designs should be considered if bridge clearance is a limiting factor.

On deck incubations and optical equipment/instruments

Design of deck layout and science infrastructure should include consideration for carrying out a certain amount of deck incubation or optical experiments without interfering with other deck operations. This deck area must receive as much unobstructed sunlight as possible. At the same time, the weight of wet incubators may need to be considered for decks that are high above the baseline. Specifying deck area to be used for these experiments early in the design process will help to ensure that other design decisions do not have a negative impact on providing this capability and will ensure that the required services are provided. Other important design considerations are that a continuous flow of near surface seawater at ambient temperatures (< 1 degree C above ambient) is available with adequate flow (e.g., minimum 50 gals/min) using a dedicated system (i.e. not fire pump or flushing pump) in order to maintain the proper temperature for the experiments.

The advice and input of expert scientific user groups should be sought as part of the design process to ensure current requirements are met.

Marine mammal & bird observations

Design of the pilothouse area and/or flying bridge should include provisions for obstruction free (at least a combined180 degrees forward of the beam) observations by two to three scientific personnel. These bird and mammal observers may be on watch continuously during daylight hours and observation locations should include chairs, access to navigation/data network, and a protected location for portable computers and/or logbooks. Mounting locations for big eyes or similar devices may be required for some observers. Observer locations should be free from radiation hazards generated by RADARS and other communication equipment.

Science and shipboard systems

Navigation

Best available navigation (real-time kinematics, differential, P-code, and 3-axis GPS) capability shall be provided with appropriate interfaces to data systems and ship control processors for geo-referencing of all data, dynamic positioning, and automatic computer steering and speed control. Back-ups and redundant systems should be provided to ensure continuous coverage.

Best available electronic charting (e.g., ECDIS) and bridge management system shall be provided.

GPS aided attitude heading reference system (AHRS) and/or other available systems for determining ship heading, speed, pitch, roll, yaw, etc. as accurately as possible should be installed and integrated into ship and science systems.

Bridge navigation, management, and safety systems will meet all regulatory requirements and facilitate effective science operations with minimal manning. Systems should be designed so that any changes to bridge navigational display and control systems will not have any effect on science data collection processes. Communication of waypoint information between science and bridge system should be an integral part of the system. Specification, purchase, and installation of systems should take place as close to delivery as possible to ensure the most up-to-date systems.

Provisions for temporary installation of short or ultra short baseline acoustic systems and other navigations systems when necessary should be included so that they can be integrated with existing systems.

Data network and on board computing

A modern and expandable data network should be integrated into the design for all spaces on the research vessel including labs, deck areas, instrument mounting spaces, bridge, machinery spaces, common areas, and staterooms. Wireless networks should be available in laboratories. Connecting cables/wiring should be installed to all areas and include provisions for growth.

Specifications for actual cables/wiring should be made as close to installation as possible in order to assure the most up-to-date equipment. Routers, connectors, and associated equipment necessary to operate the network should be specified, purchased, and installed as close to delivery as possible for the same reason. The design and specifications for the data network, general computing capability, and on board post processing capability should be completed by a knowledgeable user and operator group based on best available equipment and technology at the time that it is compatible with equipment commonly used by ship users.

High performance computing systems that are reliable and redundant will be needed for data logging, processing, plotting, and display, especially for multibeam swath mapping cruises. These systems will be used by shipboard technicians as well as by the scientific party. Final selection of computers, disks, tapes, plotters, and screens should be delayed as long as practical, to keep current with technological advances and to insure compatibility with the vessel's operating institution.

Standards for shipboard wiring (IEEE 45 or current guidelines) address keeping signal and power wiring separate and should be adhered to. During the design phase routes for wires to be installed should be planned and layouts should include permanent non-energized wires as well as provisions for temporary wiring. Such plans should add flexibility and accommodate growth in equipment and temporary project equipment.

Real time data collection, recording, and display

A well designed "system" for real time collection of data from permanently installed sensors and equipment as well as provision for temporarily installed sensors and equipment that allows for archiving, display, distribution, and application of this data for a variety of scientific and ship board purposes should be designed and specified by a group of knowledgeable science users and operators. This "system" should be integrated with the data network and other onboard systems with access to data and displays available in staterooms and all working spaces. While planning for this system should begin at early stages to ensure that it is integrated into the ship's infrastructure, the actual specification of hardware and operating system should be made as close to delivery of the vessel as possible to ensure an up to date system. Final location of intakes for underway seawater sampling should be determined following final hull design to minimize thermal contamination, bubbles, intake blockage, and to maximize water flow.

Internal communications

Internal communication system providing high quality voice communications throughout all science spaces, working, and berthing areas should be provided. Point to point and all-call capabilities are required such as 21mc and 1mc systems. A sound powered phone emergency system should be included.

All staterooms should have phones for internal communications. A primary and backup (spare) telephone switch capable of providing one voice line to every space on the ship and access to off-ship services such as INMARSAT or equivalent equipment should be provided. Voice telephone wiring to all spaces on the vessel should be installed. Consideration should be given to including installed equipment to support pagers, mobile phone/radio (UHF) communications, or other versatile methods for contacting key (or all) personnel.

Alarm and information panels should be installed in key workspaces, common areas, and all staterooms. The alarm system and information panels should connect to vans seamlessly.

The ability to install closed circuit television monitoring and recording of working areas should be provided to improve operations and safety.

The ability to install monitors (flat screen) for all ship control, environmental parameters, science and over the side equipment performance should be available in all, or most, science spaces and common areas.

Infrastructure for internal communications and data networks should adhere to IEEE 45 standards (or current guidelines) for keeping signal and power wiring separate and other safe reliable design considerations.

External communications

Reliable voice channels for continuous communications to shore stations (including home laboratories), other ships, boats, and aircraft should be provided. This includes satellite, cellular, VHF, HF, and UHF (best available and required by regulations).

Voice and data communications should be provided through the best available systems (currently cellular (near shore) and satellite based systems). Plans should include high-speed data (best current capability) communication links to shore labs and other ships on a continuous basis; data transmission systems should be connected to internal networks and phone systems to provide accountable calling, network (internet), and email access. Transmission of video, photographs, and large data sets, as well as access to data sources and web sites ashore on a continuous basis, should be available.

Facsimile communications or other methods to transmit graphics and hard-copy text at high speeds on demand are also required.

A programmable VHF and UHF radio-direction finder capable of supporting frequencies utilized by transmitters on drifters, AUVs, buoys, and other science systems should be available. Current and up to date requirements should be verified as close to delivery as possible.

Locations for satellite, cellular, and other line of sight antennas should be clear and as high as possible. The design should minimize interference between systems, provide for installation of additional systems, and ease of maintenance as much as possible. Provisions for some permanently installed wiring from temporary antenna mounting locations or from permanently installed antennae to the laboratories to facilitate user-installed antennae or receiving equipment should be included.

Design should include capabilities for acoustic communication with submersibles, data buoys, and underwater sensors based on currently utilized technology as well as the ability to tie underwater data transmission and voice signals with other communications systems. Provisions should be included for changing or installing underwater acoustic transducers as needed.

Plans need to provide locations for installing temporary antennae including antenna to receive direct satellite readouts of environmental remote sensing data. External communications systems should be completely integrated with internal voice and data systems to the maximum extent possible.

Underway data sampling and data collection

The infrastructure and space for continuous underway sampling and data collection for as many ocean and atmospheric parameters as possible should be included in all design phases and construction details. This would include, but not be limited to surface (or near surface) seawater temperature, salinity, fluorescence, chemical, and biological measurements. Provisions for adequate continuous flow of seawater in all underway conditions to all permanently installed and temporary sensors should be included. System design including proper location for equipment, pump materials and design, de-bubblers, screening, intakes, and plumbing materials that ensure accurate measurements should be made based on current advice from science experts.

Provisions for sampling clean, uncontaminated, and ambient temperature seawater while underway at all speeds should be included in the design.

Acoustic systems

Acoustic capabilities and quiet operation are important design criteria for this class of vessel. Each ship should be as acoustically quiet as is feasible considering the choice of all shipboard systems, their location, and installation. Special consideration should be given to machinery noise isolation, including heating and ventilation. Propeller(s) are to be designed for minimal cavitation, and hull form should attempt to minimize bubble sweep down. Consideration of specialized mounting arrangements for transducers to enhance system performance should be part of the design process utilizing past experience and expertise of equipment manufacturers and expert users. Design criteria for noise reduction should take into account reducing radiated noise into the water and ship that may affect biological research objectives, acoustic system performance, and habitability. Other design considerations should be directed at maximizing the performance of installed acoustic systems. Guidance, advice, and operational criteria from appropriate experts should be used during the design and construction process to accomplish these high priority goals and to identify the future scientific requirements.

Installed systems should be based on the currently best available systems and should include the following types of systems:

- 12 kHz single beam deep-sea echo sounder that meets the International Hydrographic Office (IHO) standards for accuracy.
- Sub-bottom profiler operating in the 2 to 8 kHz frequency range with an array suitable for use with a 10 kW transmitter, or best available system at acquisition time. System should include frequency and amplitude modulated transceiver with capability to operate at fixed frequency with variable ping length. Allocate transducer space for a parametric sub-bottom profiler.
- A multi-beam swath mapping sonar system capable of one degree or better resolution at full ocean depth for bathymetric mapping (meet IHO standards), and for guiding seafloor sampling/photography and deep tow geophysical profiling studies. The system should be capable of obtaining reasonable data at depths as shallow as 50 meters.
- Acoustic Doppler Current Profiling system with transducer wells for more than one frequency (i.e. 38, 75 or 150 kHz); hull mounted with a combined capability of 1000 meter depth and fine scale shallow water performance.
- Systems for acoustic navigation, tracking and communications with submersibles and other underwater systems.

Transducer wells, void spaces, or dagger boards should include the following provisions:

- Locations fore and aft to optimize transducer operation.
- The ability to change and service transducers easily while the vessel is at sea.
- Several transducer-mounting locations that can be adapted to a wide variety of transducers within a reasonable size range. Use of centerboard or other innovative methods to place transducers in location for optimum performance.
- Design for expanding transducer numbers, changing requirements, and equipment to ensure the ability to change and add acoustics systems over the life of the vessel.

Provisions should be made in the structure of the hull and/or deck for mounting temporary transducer/transponder poles on one or both sides of the vessel.

Project science system installation

Provisions are required for installing equipment that is brought on board occasionally such as SeaSoar, MOCNESS, MR1, Deep Tow, towed sonars, portable seismic reflection systems, gravimeters, and specialized ADCPs. Taught and slack tether ROVs, AUVs, remotely piloted aircraft, and other systems should also be readily accommodated. The types of equipment will need to be defined during concept and preliminary design cycles, and as much flexibility as possible should be designed. Generally providing power sources, deck space, mounting locations, and data connections will accommodate most needs, however, in some cases it may be necessary to provide fuel, hydraulic power or other services.

The electrical system capacity and design should take into account provisions for the cruise variable connection of systems with large electrical motors or power demands. Provision for multiple simultaneous connections should be possible for 480V 3-phase, 208 – 230V 3-phase and single phase, and 110V single phase with up to 50 amps service for vans, laboratories, and on deck. Final design specifications should take into consideration common electrical requirements for currently used and planned equipment, and excess capacity should be designed in to the maximum extent possible.

Discharges and waste

All liquid discharges from sinks, deck drains, sewage treatment systems, cooling systems, ballast pumps, fire fighting pumps, and other shipboard or science systems should be on the port side, with tanks capable of holding normal discharges for a minimum of 24 hours. Design should allow for zero discharges on the starboard side, including deck drains, when required during normal operations.

A well thought out waste management plan should be developed during the design phases so that these vessels can prevent, control, or minimize all discharge of garbage and other wastes at sea. The use of all appropriate and best available systems and methods such as compactors, incinerators, vacuum toilets, low flow showers, oily water separators, efficient marine sanitary devices, recycling, adequate holding tanks, and others should be used to prevent, reduce, and control waste discharges. The location of garbage storage areas should be well defined. The vessel should be designed and equipped so that it can effectively adhere to all local, state, federal, and international (MARPOL) pollution regulations, to prevent contamination of science experiments, protect the environment, and to ensure the health and safety of embarked personnel.

An on-deck hazardous storage capability for chemicals plus a holding capability for class C waste should be provided. Provisions for low-level radioactive waste storage will be incorporated in the radiation vans.

Discharges of engine exhaust, tank and sewage system vents, exhaust from fume hoods, and ventilation systems should be designed so they do not re-enter the ship's interior or ventilation systems, and so they can all be directed away from the ship at the same time with proper placement of the relative wind (i.e. all on the port side aft). Exhaust and air system discharges should be separated from sensor locations as much as possible.

Construction, operation & maintenance

Maintainability

Starting with the earliest elements of the design cycle, the ability to maintain, repair, and overhaul these vessels, and the installed machinery and systems efficiently and effectively with a small crew should be a high priority. This ability is a science mission requirement in the sense that increased reliability and fewer resources and man-hours devoted to maintenance and repair means more time and personnel support for science. Ship layout should include adequate space for ship repair and maintenance functions such as workshops with proper tools, spare parts storage, and accommodations for an adequate number of crew. Design specifications should include provisions for reliable equipment (including adequate backups and spares) that are protected from the elements to the maximum extent possible. Equipment monitoring systems and planned maintenance systems combined with configurations that provide for reasonable access by repair and maintenance personnel will help ensure that equipment remains in the best possible condition. Specifications for equipment should require all equipment vendors to provide parts lists, manuals, and maintenance procedures in electronic form for integration with a Computerized Maintenance Management System (CMMS). This will all reduce the overall cost and effort for maintaining a reliable research vessel.

Operability

Design should ensure that the vessel could be effectively and safely operated in support of science by a well trained, but relatively small crew complement. The regional conditions, available ports, and shore side services should be considered during the design process. The impact of draft, sail area, layout, and other features of the design on the ability to operate the vessel during normal science operations should be evaluated by experienced operators, technicians, scientists, and crewmembers.

Life cycle costs

A thorough evaluation of construction costs, outfitting costs, annual operating costs, and long-term maintenance costs should be conducted during the design cycle in order to determine the impact of design features on the total life cycle costs. Economy of operation has been a big benefit of the smaller classes of research vessels, and this aspect should be retained as much as possible in the new Ocean Class designs.

Regulatory issues

The impact of USCG and international regulations on the design and outfitting of these vessels should be carefully considered.

The following mission scenarios are designed to show the types of work the Ocean Class vessels may carry out. In some cases these scenarios illustrate how scientists currently adapt to existing vessels and point out areas that might suggest design features to accommodate science project equipment. They do not represent all possible scenarios and are intended to serve as examples. Distances are in nautical miles (nm).

Type of work:	2D and 3D high resolution chirp sonar (deep towed) profiling		
Number in science party:	13		
Time of year:	Year round		
Area of operations:	Mid-Atlantic U.S. (New Jersey shelf)		
Dist. from nearest port:	100 nm	Transit speed:	12 knots.
Dist. Survey/towing:	3,000 nm	Towing/survey spd:	4.5 - 5.5 knots.
Days on station	Days towing/survey	Days transit	Total days
2	30	2	34
Major or special equipment:	We will bring our own tow-body and towing winch. We will also install our own WAAS/DGPS navigation equipment and install a boom over the side (stbd) to track the fish.		

Type of work:	Piston coring – up to 15 meter long in up to 4km water depth.		
Number in science party:	12		
Time of year:	Spring - Fall		
Area of operations:	Eel River/Santa Barbara/Monterey		
Dist. from nearest port:	100 nm	Transit speed:	9 + knots.
Dist. Survey/towing:	-	Towing/survey spd:	-
Days on station	Days towing/survey	Days transit	Total days
20	-	0 – 4	20 – 24
Major or special equipment:	Heavy gear handling and rigging for piston coring		

Type of work:	Launching & servicing gear on MARS (NEPTUNE) type observatories. Supporting observations		
Number in science party:	16		
Time of year:	Summer for most, some operations year round		
Area of operations:	Monterey Bay/ Juan de Fuca Plate		
Dist. from nearest port:	30 – 100 nm	Transit speed:	9 + knots
Dist. Survey/towing:	-	Towing/survey spd:	-
Days on station	Days towing/survey	Days transit	Total days
5 –6	7	0 – 1	12 – 14
Major or special equipment:	Dynamic positioning, heavy gear handling on deck, and lowering to bottom.		

Type of work:	Current meter moorings, ADCP & Triaxus/Sea Soar type survey, CTD transect, productivity experiments		
Number in science party:	24		
Time of year:	Spring or early summer, upwelling season or winter		
Area of operations:	Coastal shelf – off Point Arena, California		
Dist. from nearest port:	100 nm	Transit speed:	12 knots
Dist. Survey/towing:	1,500	Towing/survey spd:	8 knots
Days on station	Days towing/survey	Days transit	Total days
14	10	3	27
Major or special equipment:	Crane and anchor sled for mooring work, ADCP, CTD, towed undulating profiler, incubators		

Type of work:	Intensive biological and physical survey and drifter following on the continental shelf		
Number in science party:	22		
Time of year:	Spring and Summer		
Area of operations:	Northeast US coastal waters		
Dist. from nearest port:	200 nm	Transit speed:	14 knots
Dist. Survey/towing:		Towing/survey spd:	
Days on station	Days towing/survey	Days transit	Total days
7	2	1	10
Major or special equipment:	MOCNESS, light profilers, CTD/rosette, incubators, ship-to-shore data link for satellite data, ADCP.		

Type of work:	Deployment/turn-around of moorings		
Number in science party:	6		
Time of year:	All		
Area of operations:	South Atlantic		
Dist. from nearest port:	2000 nm	Transit speed:	10 knots
Dist. Survey/towing:		Towing/survey spd:	
Days on station	Days towing/survey	Days transit	Total days
4	1	20	25
Major or special equipment:	Anchors and hardware for 3 moorings		

Type of work:	Lagrangian Float Studies		
Number in science party:	11		
Time of year:	Any/All times		
Area of operations:	Open Ocean		
Dist. from nearest port:	>1000 nm	Transit speed:	12+ knots
Dist. Survey/towing:	3500 nm	Towing/survey spd:	10+ knots
Days on station	Days towing/survey	Days transit	Total days
	27	8	35
Major or special equipment:	4 Sound Source moorings, CTD casts with bottles, ADCP to 1000 m, RAFOS float deployments		

Type of work:	Open Ocean Biophysical/Chemical Interactions		
Number in science party:	12		
Time of year:	Summer		
Area of operations:	North Atlantic		
Dist. from nearest port:	300 nm	Transit speed:	12+ knots
Dist. Survey/towing:		Towing/survey spd:	6 knots
Days on station	Days towing/survey	Days transit	Total days
	26		28
Major or special equipment:	Pumping SeaSoar, RF/ARGOS-tracked surface drifters, incubations, radioactive tracers, ADCP		

Type of work:	Laying cable in support of observatories (e.g., NEPTUNE)		
Number in science party:	20		
Time of year:	Prefer all year, but bias to summer		
Area of operations:	NE Pac		
Dist. from nearest port:	500 nm	Transit speed:	12 knots
Dist. Survey/towing:	100 nm	Towing/survey spd:	5 knots
Days on station	Days towing/survey	Days transit	Total days
10	5	5	20
Major or special equipment:	Cable laying equipment, ROV		

Type of work:	Moving ship tomography		
Number in science party:	15		
Time of year:	All year		
Area of operations:	North Pacific, North Atlantic		
Dist. from nearest port:	500 nm	Transit speed:	
Dist. Survey/towing:		Towing/survey spd:	
Days on station	Days towing/survey	Days transit	Total days
15		15	30
Major or special equipment:	Acoustic sources and power supplies, navigation		

Ocean Class Research Vessel
Science Mission Requirements Study Process and Participants

Federal agencies were urged by the Academic Fleet Review (Schmitt et al., 1999; conducted for the National Science Foundation and approved by the National Science Board in May 1999) to begin the process of long-range planning for the renewal of the fleet. As a result of this report, the Federal agencies, through the Federal Oceanographic Facilities Committee (FOFC), and with input from the academic community (via UNOLS), produced a plan entitled "Charting the Future for the National Academic Research Fleet" <http://www.geo-prose.com/projects/fleet_rpt_1.html>. Over the next 20 years, the Plan calls for a fleet that is more capable than at present, but fewer in number. In the Plan, four classes of ships (Global, Ocean, Regional and Local) were used to describe the future fleet. The "Ocean Class ships will fulfill a critical need in fleet modernization, by replacing the aging "Intermediate" ships with vessels of increased endurance, technological capability, and number of science berths. These will be ocean-going vessels, though not globally ranging."

An Ocean Class steering committee was appointed by the UNOLS Council in February 2002 to lead the process of developing science mission requirements for this new class of vessel, which is the first step towards design and construction. The steering committee members were:

Dave Hebert (Chair)
University of Rhode Island

Joe Coburn
Woods Hole Oceanographic Institution

James Cochran
Lamont-Doherty Earth Observatory

Tim Cowles
Oregon State University

Charles Flagg
Brookhaven National Laboratory

Dennis Hansell
University of Miami

Bob Knox
Scripps Institution of Oceanography

Starting with the parameters outlined in the FOFC fleet renewal plan and with previously published SMRs an online questionnaire was created and publicized widely in the UNOLS community. More than sixty researchers, ship operators and technicians provided input that was used in preparing the initial draft of a new SMR.

A workshop was held on July 23-24th in Salt Lake City, Utah to draft comprehensive science mission requirements for the Ocean Class. This workshop was funded through the UNOLS office grants and was attended by researchers, technicians, ship operators, funding agency program managers and naval architects.

As a result of the workshop a draft Ocean Class SMR report was prepared and has been available for community review and input on the UNOLS web page. A summary description based on the SMR as well as a table of major characteristics is provided (Appendix II). The detailed SMR is a more comprehensive document that attempts to provide enough detail to guide the design and build cycle from concept designs to outfitting of the finished vessel. This makes for a much longer document than previous versions of SMRs, but we hope this will serve to ensure that important details are considered starting at the earliest stages of design.

All interested members of the community were asked to review the complete SMR document and provide feedback to help produce the final report. The online version provides comment blocks for each section. Community input to the Ocean Class SMR Questionnaire is posted on the UNOLS website at <http://www.unols.org/fic/ocean/ocsmrinput.html>.

This document and further developments in the academic fleet renewal process are posted to the UNOLS Fleet Improvement Committee web page: http://www.unols.org/fic/

UNOLS and the Fleet Improvement Committee would like to thank all of the participants of the Ocean Class Workshop and those who participated by providing community input.

Ocean Class SMR Workshop Participants:

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John F. Bash	URI	Pete Kilroy	NAVSEA
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Ocean Class SMR Community Input Participants:

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Terrence Joyce	WHOI	Mark Wimbush	URI
Grace Klein-MacPhee	URI		

Beaufort Wind Scale & Sea State

#	Wind [knots]	Description	Sea State	Wave Ht [feet]	Effects at Sea
0	< 1	Calm	0	0	Sea like a mirror
1	1-3	Light air			Ripples with appearance of scales; no foam crests
2	4-6	Light breeze	1	< 0.3	Small wavelets: crests of glassy appearance, no breaking
3	7-10	Gentle Breeze	2	0.3-1.6	Large wavelets: crests begin to break, scattered whitecaps
4	11-16	Moderate breeze	3	1.6-4	Small waves, becoming longer; numerous whitecaps
5	17-21	Fresh breeze	4	4-8	Moderate waves, taking longer form; many whitecaps; some spray
6	22-27	Strong breeze	5	8-13	Larger waves forming; whitecaps everywhere; more spray
7	28-33	Near gale	6	13-20	Sea heaps up; white foam from breaking waves begins to be blown in streaks
8	34-40	Gale			Moderately high waves of greater length; edges of crests break into spindrift; foam is blown in well-marked streaks
9	41-47	Strong gale			High waves; sea being to roll; dense streaks of foam; spray may reduce visibility
10	48-55	Storm	7	30-30	Very high waves with overhanging crests; sea surface takes white appearance as foam is blown in very dense streaks; rolling is heavy and visibility reduced
11	56-63	Violent storm	8	30-46	Exceptionally high waves; sea covered with white foam patches; visibility seriously affected
12	> 63	Hurricane/typhoon	9	> 46	Air filled with foam; sea completely white with driving spray; visibility greatly reduced

Description of Ship Motion Criteria

Source: Marintek

DESCRIPTION	CRITERIA RMS-Value	COMMENTS	REFERENCE
VERTICAL ACC.:			
Exposure: 0.5 hour	0.10 g	10% motion sickness incidence ratio (MSI) (vomiting) among infrequent travelers general public	ISO 2631/3 1987 & 1982
1.0 hour	0.08 g		
2.0 hours	0.05 g		
8.0 hours	0.03 g		
Simple Light work possible	0.27 g	Most of the attention devoted to keeping balance	Connoly 1974
Light manual work might be carried out	0.20 g	Causes fatigue quickly. Not tolerable for longer periods	Mackay 1978
Heavy manual work might be carried out	0.15 g	Limits in fishing vessel	
Work of more demanding type	0.10 g	Long term tolerable for crew	Payne 1976
Passenger on a ferry	0.05 g	Limit for persons unused to ship motions	Goto 1983
Passenger on a cruise liner	0.02 g	Older people. Lower threshold for vomiting to take place	Lawther 1985
ROLL:			
Light manual work	4.0°	Personnel effectiveness	Comsrock 1980
Demanding work	3.0°	Personnel effectiveness	Hosada 1985
Passengers on a ferry	3.0°	Short routes. Safe footing	Karppinen 1986
Passenger on a cruise liner	2.0°	Older people. Safe footing	Karppinen 1986
PITCH:			
Navy Crew	3.0°	Limits to avoid damage to personnel	Comstock 1980
Light manual work	2.0°	Personnel effectiveness	Hosada 1985
Demanding work	1.5°	Personnel effectiveness	Hosada 1985
HORIZONTAL ACC.:			
Passenger on a ferry	0.025 g	1-2 Hz frequency. General public	ISO 263/1
Navy crew	0.050 g	Non-passenger and navy ship	
Standing passenger	0.070 g	99% will keep balance without need of holding	Hoberock 1976
Standing passenger	0.080 g	Elderly person will keep balance when holding	Hoberock 1976
Standing passenger	0.150 g	Average person will keep balance when holding	Hoberock 1976
Standing passenger	0.250 g	Average person max. load keeping balance when holding	Hoberock 1976
Seated person	0.150 g	Nervous person will start holding	
Seated person	0.450 g	Persons will fall out of seats	