Draft

Global Class Vessel with Seismic Capabilities

Science Mission Requirements

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Preface – Global Class Research Vessel with Seismic Capabilities Science Mission Requirements

The Academic Fleet Renewal effort aims for the timely replacement of the academic research fleet as a vital facet to oceanographic research in the United States. Comprehensive Science Mission Requirements (SMR) were developed for Ocean Class and Regional Class vessels 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. This same process has been applied to the Global Class Research Vessel with seismic capabilities. In this case the SMR is tailored to the vessel being evaluated for acquisition and modification; though it is expected these same SMRs would be applicable to ships with similar capabilities and therefore extend to possibilities beyond the replacement vessel.

Just as with the construction of new ships, a fundamental component in the process of refitting or converting a vessel is the formulation of the Science Mission Requirement: the SMR. The SMR states with as much specificity as possible what capabilities 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?” This SMR is intended to provide a science capability framework for the steps between community input, vessel acquisition, and final modification. 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 final planning and modification process.

Development of the SMRs for a Global Class Research Vessel with seismic capabilities began with the “Technical Option” papers prepared in advance of the *R/V Maurice Ewing* Midlife Workshop in order to facilitate workshop discussions. These papers drew on the Ocean Class SMR, the experience of the *Ewing*, and other community workshops. The intent of these papers was to present specific options that would address the science needs of the globally ranging general purpose vessel with the niche role of providing multichannel seismic (MCS) and refraction source capabilities for the UNOLS fleet. A *Ewing* Midlife Workshop conducted on October 22-23, 2002 and attended by 50+ scientists, marine technicians, marine engineers, and marine operators, discussed the optimal manner to meet future science needs. The workshop report details these deliberations and includes the recommendation that if the goal is to tow multiple long streamers and improve source repeatability using linear gun arrays and improve general purpose/OBS capabilities, then the *Ewing* cannot satisfy these needs. The workshop recommendation was to explore the possibility of securing a used industry vessel.

The intent here is to utilize the final form of the Ocean and Regional Class SMR to specifically address the SMR of an acquired and converted replacement vessel, in part by transposing much of the *Ewing* related information. As this SMR will demonstrate, the replacement vessel would revolutionize US academia’s capability to collect seismic data (both MCS and OBS) and would add a substantially new general purpose capability to the fleet.

The precursors to this SMR have served as a guiding document for the concept design and preliminary design for a replacement vessel. The SMR should help guide the final design of a converted Global Class Research Vessel with seismic capabilities.

Global Class Research Vessel with Seismic Capabilities Requirements

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Executive Summary

The FOFC provides a context into which any UNOLS vessel must be considered. The modern Global Class is a group within this structure of vessels, consisting of vessels with extended geographic range and includes the "Seismic" vessel. Recent updates of the SMR for Ocean and Regional Class vessels have refined the process of supporting new vessel design and construction. Though very similar, this effort is unique in the fact that the proposed vessel is an existing vessel, which would be bought and converted using some equipment currently on the *Ewing*. This difference will be apparent in a few of the requirements as this is not a full design process. Instead, the primary requirement is a maximum capability commensurate with ship size to support science, educational, and engineering operations in all oceans, with vastly improved seismic capabilities, improved over-the-side equipment handling, station keeping, and acoustic system performance, while providing a stable laboratory environment for precision measurements. All modifications should serve to maintain, or enhance, the vessel's reliability, cost effectiveness, and flexibility.

This vessel will support scientific (non-crew) parties as large as 40. Attention to the details of maintaining the high standard for habitability of crew and technician berthing should promote crew retention and the resulting expertise for supporting the scientific missions. The vessel conversion will include the addition of 5 staterooms and the relocation of 4 staterooms while retaining a total capacity of 60 in a surge mode. Benefits will be derived from operating under the vessel capacity for most of the scientific missions. In addition, extra common areas will be added. The vessel should support expeditions up to 50 days and a total range up to 14,400 nautical miles (26,667 km) at optimal transit speeds. The ship should be able to sustain 12 knots through sea state 4 with fine speed control.

The vessel should be able to support 3D MCS cruises with four streamers 8 km long. The vessel should ensure repeatability of the sound source by the ability to tow 4 linear gun arrays. In addition to these specific seismic requirements, the vessel must maintain the ability to handle 100 OBS' without interference with seismic operations.

The vessel should be fitted with a 1° x 1° multibeam deep water, 12 kHz sonar, and a 3°x 3° swath chirp subbottom profiler, in addition to a suite of other acoustic sensors, profilers, and single beam sonars. The vessel must have effective dynamic positioning relative to a fixed position in a 35 knot wind, sea state 5 and 2 knot current.

The hull design is a commonly used platform for oilfield service vessels including pipe carriers, supply vessels, dive support vessels and seismic research vessels (many of these in the North Sea) and as such is maximized for sea-kindliness and for ability to work in sea states 5 and higher. In sea state 4 the vessel should be fully operational, including 3D MCS, for all but the most demanding deployments and recoveries.

The stern working area will retain its specific design for handling MCS equipment in a safe and efficient manner. A capability should be developed for deployment of towed vehicles, moorings from the stern with the launch and recovery of these devices facilitated by a hydraulic boom. The open main deck will be situated on the starboard side with 1660 sq ft of open work area. In addition, a contiguous work area along one side should provide a minimum of 95 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.

An extended bridge and /or control booth should have maximum visibility of deck work areas and the alongside during science operations, 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.

Additional deck areas should be provided with the means for flexible and effective installation of vans, workboats, temporary equipment and incubators. Space should be available to carry five standardized 8 ft by 20 ft portable deck vans that may be laboratory, storage, or other specialized use. Two of these vans should be on the main deck. 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 200 and 300 LT.

The design of weight handling appliances to safely and effectively tow, deploy, and recover seismic equipment is well established on this vessel, and the amount of seismic equipment to be handled will be reduced in the conversion. The entire suite of over the side handling equipment including winches, wires, cranes, frames, booms and other appliances should be considered as a system, though some components may be cross-decked from the *Ewing*. 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 equipment. The winches should provide fine control and have maximum speeds of at least 100 m/min. The ship should be capable of towing paravanes for multiple streamers and other large scientific packages continuously for extended periods of time. A suite of 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 4800 sq ft including: Main instrument room/computer room, which houses permanent equipment such as the seismic acquisition and multibeam sonar systems; two main deck and two upper deck (dry) lab areas designed to be flexible; separate wet lab/hydro lab located contiguous to sampling areas that includes a high bay area; two climate controlled chambers and a seismic gun shop with an attached science work shop. Flexibility and support for different types of science operations within limited space are important criteria. 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 space for science. 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 uninterruptible power available wherever needed. Seawater systems should be designed to provide uncontaminated seawater to selected science work areas, including the wet lab and the forward main deck dry lab, 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 scientific data and 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 communication throughout the ship and with shore stations, other ships, aircraft, and data sources.

The ship should be as acoustically quiet as practicable as it was designed to strict specifications for the seismic trade. In addition, the propellers have been upgraded to further reduce noise from cavitation. The stem should be slightly modified to attempt to minimize bubble sweep down and a pod based upon, and sized almost identically, to the very successful pod on the French Vessel *Beautemps-Beaupre*, shall be employed to further isolate underwater arrays from bubble interference.

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

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 modified vessel could be effectively and safely operated in support of science by a well-trained crew. The global conditions, available ports and shore side services should be considered during the design modification process.

Summary of Global Class Vessel with Seismic Capabilities Science Mission Requirements

Parameter	**Capability or Characteristic**
Accommodations and habitability	
Accommodations	40 non-crew personnel
Habitability	Attention to details that ensure continued and expanded effective work and living spaces.
Operational characteristics	
Endurance	50 days (15 transit and 35 mission days)
Range	Up to 14400 nautical miles at optimal transit speeds.
Speed	12 knots sustainable through sea state 4
Sea keeping	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	Designed for towing and effective ship control
Ice strengthening	ABS Ice Class C
Over-the-side and weight handling	
Winches, wires, frames, and cranes	Handling equipment for deployment of seismic gear including paravanes and gun arrays. New generation frames, existing cranes plus cross decked and new articulating crane with multiple configurations, cross decked winches located for optimal flexibility, and other weight handling equipment that are all 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 suite of cranes that can reach all working deck areas with the capability of offloading vans and equipment weighing up to 20,000 lbs to a pier or vehicle in port is desirable.
Towing	The ship has a bollard pull, corrected to 5 knots of 86.2 Tonn
Science working spaces	
Working deck	Stern working area – 2,000 sq ft minimum open and near the center of pitch. Contiguous waist work area along starboard side that provides a minimum of 95 ft clear deck area
Laboratories	Total lab space should be approximately 4,862 sq ft including: Main instrument room/computer lab (2,345 sq ft); Two main deck dry labs (568,458 sq ft) on main deck; Two dry labs (476,402 sq ft) on upper deck; Separate wet lab/hydro lab (613 sq ft) located contiguous to sampling areas with 17’ high bay space for multiple purposes; A seismic gun shop with science workshop (400 sq ft); A separate science office off the instrument room and electronics repair shop/work space for resident technicians; Two climate controlled work space or chamber (100 sq ft each)

Vans	Carry five standardized 8 ft by 20 ft portable deck vans two of which can be located on the main deck
Storage	Ample storage space dedicated to science items, 9,000 ft^3 of below deck protected storage space
Science load	Variable science load should be 300 LT
Workboats	At least one 16-ft or larger inflatable boat located for ease of launching and recovery
Masts	Multiple small, unobstructed bridge top masts for multiple sensor and communication installations
On deck incubations	Piping for incubations on upper aft deck
Marine mammal observations	Enclosed observation platform equipped with watch stander monitors and 360° visibility
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	
MCS	Ability to handle and tow 4 streamers 8 km long for 50 m CDP Ability to handle four linear gun arrays Two each 2000 psi compressors 2725 CFM each
Sonars	Deep water multibeam 1°x 1° in the 12 kHz range. A 3°x 3° swath chirp subbottom profile A suite of other acoustic sensors, and single beam sonars
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	Ensure that the modification of this vessel takes into account the ability to maintain and operate within domestic and international regulations in a reliable, secure and cost effective manner Vessel to be US Flagged and classed by DNV or ABS
Operability	
Life cycle costs	
Regulatory issues	

Global Class Research Vessel with Seismic Capabilities
Mission Statement and Overall Characteristics

The "seismic ship" is a vessel specifically identified 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 with an emphasis on seismic research, the Global Class Seismic vessel will be a general purpose ocean going vessel. The special equipment and configurations necessary for seismic operations will influence other areas, though this vessel's non-seismic capabilities, with few exceptions, approach or equal other Global Class ships. As a replacement for the current UNOLS Global Class Seismic vessel, this vessel will substantially expand the existing capabilities in general purpose areas and offer a revolutionary advance in multichannel seismic (MCS) abilities provided by the older and smaller *R/V Ewing.*

This ship is to serve as a general-purpose research vessel while also filling the niche role of providing MCS and refraction source capability. 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 MCS capabilities including 3D MCS and linear gun arrays, improved over-the-side equipment handling, expanded available multidisciplinary laboratories, station keeping, and acoustic system performance while providing a stable laboratory environment for precision measurements. This vessel will provide for larger scientific parties and greater flexibility in use of laboratory/deck spaces than are now available aboard the *Ewing*.

To accomplish these goals there are several features that have received high priority in selecting a vessel suitable for replacing the *Ewing*. Principal among these are the seismic systems, which are complex and require special considerations. This vessel 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 in dictating necessary modifications. 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 modifications. Attention to habitability issues during modifications such as public spaces, 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, particularly seismic vessels, as well as innovative new approaches will be used.

The model of converting an industry seismic vessel for UNOLS is a proven one. Modifications should be considered carefully as inevitable tradeoffs are necessary even on top of a successful operational vessel that has the potential to serve so many needs.

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 conversion. 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 this vessel. Sample mission profiles that have been identified as relevant to this vessel are included in Appendix I to provide examples of how this vessel might be used. As all desires cannot be fully realized on one vessel, it has been necessary to refine priorities in preparation for this document. These science mission requirements are organized with the following elements.

Science Mission Requirements - Details

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
- MCS
- Acoustic systems
- Project science system installation and power
- Discharges

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

Mission Scenarios

Size and Cost Constraints (FOFC fleet renewal parameters)

The FOFC Academic Fleet Renewal Plan states that the *Ewing* can be operated until about 2018, "but may require replacement earlier in that decade for technological and scientific reasons." The *Ewing* was due for a substantial refit following the UNOLS model of ensuring platform viability and safe reliable operations with a midlife refit. The overwhelming consensus within the community was that even after a substantial midlife refit, the *Ewing* could not meet present and future science mission requirements of the Global Class Seismic ship. These needs can, however, be served by a converted industry 3D seismic vessel.

The size of vessels built in the early 1990s is the ideal size for such a conversion. Not only will a newer ship extend the operational life projected for a seismic vessel (e.g., until 2018 for the *Ewing*), but newer ships are larger than vessels built at the time of the *Ewing*. Even more recent vessels have grown to be enormous, devoted almost solely to 3D seismics that these vessels can only be viable in a very lucrative business. Therefore the target vessel is the same length as the *Ewing* (~235 ft), but its beam is an additional 10 ft (~55 ft compared to 45 ft on the *Ewing*), giving the vessel 1.5 times the volume on the *Ewing*. In addition to the larger area, the target vessel has an increased propulsion plant with nearly four times the bollard pull (86.2 metric tones, corrected to 5 knots) of the *Ewing*, allowing significantly greater towing capacity.

The cost of acquiring, converting, modifying and outfitting a vessel of this sort is highly market dependent. A down turn in the oil industry and chronic over capacity have made this an ideal time for such a venture. The cost of the project should continually be compared to a refit of the *Ewing*. This process though not specifically enumerated within the FOFC plan is consistent with the goal of maintaining operating vessels' capability of successfully completing science mission requirements in a cost effective manner. The acquisition and conversion of this vessel even with a next generation seismic suite several times the magnitude of the *Ewing* outfitting will be substantially less than designing and constructing a new vessel with similar size, capabilities and endurance to that of the converted target vessel.

Accommodations & Habitability

Accommodations

A maximum capacity of up to 40 non-crew personnel in a surge mode should be accommodated. 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 maintenance of the vessel. As currently classed by DNV for unmanned engine the number of ship's crew is 12. The crew number when reflagged is assumed to be 20 in order to meet manning regulations, mission requirements and preventive maintenance. The concept of including modest temporary accommodations that can be used when needed (i.e., surge capacity) is important to the flexibility of this vessel to support a wider range of potential projects. Berthing vans are not practical because of vessel layout, but two staterooms presently outfitted for 3 persons will be designated 2 person rooms with a surge bunk in each. Several normally single rooms will remain outfitted with a second bunk for the maximum flexibility in housing a full complement.

The design of accommodations is somewhat unique as it has been adapted for a relatively beamy vessel. The rooming breakdown is for two exemplary capacities and is as follows: 1. science party of 36, 2. science complement of 30:

Science Complement 36 (including ship's technicians)
Crew: 12 single rooms (4 individual bath/shower, 2 of which also have day rooms; 4 shared bath/shower with another single room; 4 shared bath/shower with double room); 4 double rooms (shared bath/shower with single room). 8 of these staterooms are in two 4 stateroom clusters around a common area where the staterooms are just sleeping chambers with lockers. These clusters will each have 6 occupants assigned to four rooms.

Non-Crew: 2 single rooms (both individual bath/shower); 17 double rooms (3 rooms with individual bath/shower and day room, 8 rooms with individual head/shower, 6 rooms that share a bath/shower with another double room). Four of these double staterooms are in a 4 stateroom cluster around a common area where the staterooms are just sleeping chambers with lockers.

Surge (4 more): 2 of these non-crew double rooms with shared bath/shower are each able to accommodate another person. 2 of the 4 crew double rooms within the clusters that were slated for single occupancy can each take another person, making both of the crew four room clusters each have seven occupants.

Science Complement 30 (including technicians)

Crew: 16 single rooms (4 rooms with individual bath/shower - two of which also have day rooms, 12 rooms with shared bath/shower with another single room; 2 double rooms (individual bath/shower). Eight of these single staterooms are in 4-stateroom clusters around a common area where the staterooms are just sleeping chambers with lockers. These clusters will each have 4 occupants, all in single rooms, spread around the four rooms.

Non-Crew: 4 single rooms (individual bath/shower); 13 double rooms (3 rooms with individual bath/shower and day room, 7 rooms with individual head/shower, 6 rooms that share a bath/shower with another double room). 4 of these double staterooms are in 4-stateroom cluster around a common area where the staterooms are just sleeping chambers with lockers.

The maritime crew will 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. From the same motivation, the resident technicians have at least two dedicated single rooms and a high priority on further spread when the ship is not at maximum capacity.

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 new berthing, laboratories, vans, and other interior spaces should be engineered and designed to be effective in all potential operating areas. Air circulation rates should meet shore lab standards and SNAME standards for HVAC. Laboratories should 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. Design of internal environmental systems 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 to ensure the appropriate conditions are maintained.

At least some lab space should be clean for chemical analyses, which require separate ventilation and/or organic filters. A specialized van will be employed for the exacting chemical analyses.

The vessel conversion 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). The vessel currently satisfies IMO Res. A.468 (XII) as a general maximum noise level, with additional reduction of noise level in laboratories and related reduction areas. Special considerations were taken from design stage through the vessel building program in order to minimize hydroacoustic noise generated by the vessel. 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 conversion 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 modification designs.

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

The productivity of all personnel sailing on 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, etc. Providing equipment and space for exercise should be considered. Staterooms should include connections to the ship's network and entertainment systems, but they also need to be separated from the noise associated with off-hour activities.

Operational Characteristics

Endurance & Range

Total endurance should be fifty-five days, providing the ability to transit for 20 days at cruising speed and for 35 days of station work (see station keeping and towing). Some mission profiles, including 2D and 3D MCS, 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 35+ days is desired. The impacts on engines, water making capability, and other factors when on station or moving at slow speeds for extended periods of time must be considered and may necessitate the addition of a backup RO. Up to 14,400 nautical miles (35,800 km) total range at optimal cruising speed is desirable.

Speed

14 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 inability to optimize sonar installation, excessive fuel consumption, or excessive noise.
Speed control in sea state 4 or less (< 2.5 m 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 along with equipment operability. The hull on the target vessel is a proven North Sea design that has been selected for many seismic research vessels. Commercial seismic operations involve over-the-side and towing operations that are strong indicators of sea-keeping during other operations.

In sea state 4 (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 5 this vessels should be able to:

- Maintain underway science operations at 9 knots
- Maintain 3D MCS operations
- 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

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

At sea state 7 and greater (> 6 m wave heights), these vessels should be able to operate safely while hove to.

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. The vessel should be able to maintain station and work in sea states up through 5 (2.5 – 4 m wave heights) with best heading.

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

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

and in absolute references in the following conditions:
- 20 - 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, fuel usage, and adverse effects on the operation of acoustic systems as much as possible, including the turbulence caused by thrusters not in use. Automatic bow thruster tunnel thrusters have been investigated and are not practical. The additional forward retractable azimuthing thruster should retract leaving as near to a clean faired surface as possible.

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° with 30 knots of wind, up to sea state 5 (2.5 – 4 m wave heights) and 2 knots "beam" current. These track line conditions may also be required for ship speeds as low as 2 knots. Straight track segments should 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 over-the-side. This should be accomplished with a direct view to the maximum extent possible and enhanced with closed circuit television systems. To this end, the starboard portion of the bridge will be extended aft allowing clear view of the entire open working deck. Portable hand-held control units or alternate control stations could also be used at various locations to enhance visibility and communications with the working deck during over-the-side equipment handling. The functions, communications, and layout of the ship's control station should be carefully integrated 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 utilized to help ensure safe and efficient science operations in traffic congested 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

The vessel is ice strengthened to class C-0. It is understood that MCS operations are not compatible with any ice cover and that this class does not give the capability to operate in the presence of 6/10 coverage of first year ice.

Over-the-Side and Weight Handling

Over-the-Side Handling

The design of weight handling appliances to safely and effectively deploy, recover, and tow a wide variety of scientific equipment should be considered so that they are integrated in the layout of spaces as much as possible. The entire suite of over-the-side handling equipment including winches, wires, cranes, frames, booms, MCS equipment (paravane winches, paravane booms, streamer winches, sound source array umbilical winches and tail buoy booms) and other appliances should be considered. Designs for over-the-side appliances and equipment should include innovative thinking and consider ideas that will control packages from the water to the deck with the minimal amount of human intervention necessary for launch and recovery of equipment, both on wires and untethered. These systems should be developed - or in the case of MCS, follow proven techniques to enhance personnel safety, reduce manning level requirements, increase operability in heavier weather, and protect science and ship's equipment.

A side A-frame is the major equipment for heavy lifts or leads over the side. This frame should be designed for a dynamic safe working load of 30,000 lbs through its full range of motion, and it must be structurally engineered to handle 1.5 times the breaking strength of cables up to one inch, such as the tether used for large ROV systems (up to 120,000 lbs breaking strength). The side A-frame should have a 15-ft minimum horizontal and 25-ft vertical clearance from the attachment point of the block to the deck. At least a 12-ft inboard and outboard reach is required. Multiple locations and/or multiple devices should be provided that facilitate deploying coring equipment, equipment from either side, and from the bow area. Portable weight handling appliances should be located within working range of winch and crane locations but should also be able to be relocated as necessary. The design of frames and other weight handling equipment should allow removal to flush deck foundations.

The Stern over-the-side handling structure should be designed for a dynamic safe working load of 30,000 lbs through its full range of motion, and it must be structurally engineered to handle 1.5 times the breaking strength of cables such as the 0.680 and 9/16. The stern over-the-side structure is thought to be a fixed boom capable of an outboard reach of 15 feet and an inboard reach of 20 ft. This boom will operate through a clear opening that has a 12-ft minimum horizontal and 25 ft vertical clearance from the attachment point of the block to the deck. The boom will fully retract leaving the stern cut out clear.

The capability to carry additional over the side weight handling appliances along the open main deck should be included in the design.

The control station gives the operator protection, provides operation monitoring, and is located to provide maximum visibility of over-the-side work.

There is no need for any human-rated.

Oceanographic Winches and Wire

Winches are an integral part of the equipment handling and deployment system. The vessel will begin operations with the current generation of oceanographic winch systems cross decked from the *Ewing*. The winches should provide fine control (0.1 m/min under full load) with maximum winch speeds of at least 100 m/min. 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 override 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 are necessary.

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 replaced when new wire designs with sizes within a range appropriate are introduced.

A heavy winch capable of handling 12,000 meters of 9/16" wire/synthetic wire rope and another heavy traction winch capable of handling 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 the two cross decked *Ewing* winches until a single winch with multiple storage drums, capable of leading wire from either drum, is standardized.

The winch handling fiber-optic cable is a traction winch that allows storage of the cable under lower tension. This winch handles 0.68" cable.

Additional special-purpose winches (e.g., clean sampling, pumping, multi-conductor) may be installed temporarily at various locations along working decks.

Wire fairleads, sheave size, and wire train details need to be integrated to minimize 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.

Permanently installed winches should be housed out of the weather, when feasible, to reduce maintenance and increase service life. Details of winch location should include provisions for easily changing wire drums, spooling on new cable, 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.

Cranes

A suite of cranes should be provided to handle heavier and larger equipment than can be handled on the *Ewing* and should, as much as possible, 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 currently installed. This will generally mean being able to reach approximately 15 feet beyond one side of the ship (usually starboard) with the design weight. For docks with added distance between the vessel and trailer trucks, vans will have to be lightened to approximately 15,000 lbs. This 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 of the two smaller articulating cranes will be located on the starboard side upper deck just aft of the open deck cut out. This crane can transport equipment from the upper deck to the main deck and support over the side operations. In addition this crane can position a second articulating crane either on the main deck or aft on the upper deck. On the main deck this second articulating crane is for work with weights up to 4,000 lbs at deck level and at the sea surface, with installation locations forward, amidships, and aft provided. The ship should be capable of installing and carrying portable cranes for specialized purposes and clearing the main deck of all vessel cranes. The second position for the main deck articulating crane is aft on the upper deck allowing over-the-side support of stern operations.

All working decks must be provided with crane support.
There is no anticipated need for any human-rated.

Towing

The ship is now capable of towing 8, 8 km streamers with 100 m spacing and 8 linear gun arrays. The maximum duty after conversion will be 4, 8 km streamers with 200 m spacing and 4 linear gun arrays 50 m from center for alternate sourcing, all at five knots. With a bollard pull of 81 tonnes corrected to 5 knots, this ship will pull any large scientific package. Towing other than for MCS can be from either the side A-frame or the stern boom.

Winch control should allow for fine control (± 0.1 meters/min) at full load and at all speeds. Winches should be capable of sustaining towing operations continuously for extended periods.

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.

<u>Science working areas</u>

Working Deck Area

A spacious mid station working area with 1,700 sq ft minimum, open and as clear as possible, is required. In addition, a contiguous waist work area along the starboard side that provides a minimum of 95 ft length of clear deck along the rail should be available. This area will to allow for 40 m 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. When not actively conducting MCS or refraction work, the linear gun arrays can be stowed, opening a large area contingent to the main deck that is covered but with a deck height of 11.25 ft. Among the van locations, there is the ability to install two ISO standard vans with room for passage around the main deck.

Deck loading should meet the current ABS rules (i.e., designed for a 12 ft 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.

Main 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 reconfiguration.

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. The ship's hull sides are straight around the open deck, which is advantageous to instrument recovery and deployment. A low freeboard and existing stern ramp may provide a second means to accomplish this goal. The use of stern ramps has been limited and will be retained primarily for its MCS special purpose role. 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 will not be considered.

A clear upper deck, formally the helicopter deck 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.

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 in direct visibility of and/or covered by televised cameras connected to monitors on the bridge. Gear deployment areas should have maximum direct clear visibility from the bridge.

Laboratories

Lab - Number, Type, and Size

The majority of the lab space should be located in four large lab groups, three of which can be reconfigured, partitioned, and adapted to various uses to allow for maximum flexibility. The fourth lab shall be the instrument room, which contains most of the permanent equipment such as the MCS and sonar systems as well as processing space and watchstanding stations. This lab will serve the same purpose as the main lab on the *Ewing.*

To the maximum extent possible, multiuse labs should all be located on the same deck adjacent to each other and adjacent to the main working deck areas. Two lab clusters border the open main deck: one forward with a wet and dry lab and the other to port with another dry lab, MCS source array lab, and general science workshop. The remaining lab cluster is directly above the port labs and consists of two dry labs. 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.

Total lab space should be approximately 4,862 sq ft including (dimensions below are approximate guidelines).

Main instrument room/computer lab (2,345 sq ft). This space is dry and separated as much as possible from sources of electronic noise. It includes a central watch standing space that should accommodate visiting science equipment as well as normally installed equipment. Provisions for remote displays in this and other labs should be part of lab designs.

Two main deck dry labs (568,458 sq ft) on main deck.

Two dry labs (476,402 sq ft) on upper deck.

Separate wet lab/hydro lab (613 sq ft). This space is located contiguous to sampling areas with 17 ft high bay space for multiple purposes. This space should support protected set up and repair of equipment, sample sorting, and other related functions.

A seismic gun shop with science workshop (400 sq ft).

Resident Technician work space. A separate science office, off the instrument room and electronics repair shop/work space, for resident technicians should be provided. 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 climate controlled work space or chamber (100 sq ft). This will be accommodated by providing two separate walk-in spaces and can be supplemented by a laboratory van. 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.

A chilled water HVAC system 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.

A refrigerator/freezer space (100 sq ft). This space should be built with provisions for other uses when not required. Refrigeration equipment capable of maintaining temperatures between –15°C and 10°C (temperature requirements should be verified before final design) would allow for flexible use by science projects needing freezer and/or refrigerator space. A –80°C freezer can be added when required.

Lab - Layout and Construction

Flexibility and support for different types of science operations within limited space are the important design criteria for the vessel. 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 considered. 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 the "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 who need to stand for long periods of time.

The distance from the deck to the underside of the finished overhead will exceed 7.5 to 8 ft. 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, the incursion of "ship stuff" (e.g., air handlers, gear lockers, and food freezers) into the lab space should be minimized.

Labs should have full sized Unistrut™ on 2 ft centers flush with the deck in addition to Unistrut™ on the bulkheads and in the overhead. Deck bolt downs on one-ft centers should be considered for some areas.

Locations for two fume hoods in the main lab aft port 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.

Sink spaces should allow for flexible installation and removal of sinks with additional sinks available when needed. At least two locations in the wet lab, two locations in the forward main deck lab, two locations in the aft port main deck lab, and one location in each of the upper deck labs (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. Current IEEE 45 or equivalent standards for shipboard power and wiring and current IEEE standard for UPS and clean power specifications should be used.

Electrical service for the labs should include:

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

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 to be 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 several 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 also should be included in the design. Provisions for connecting multiple users in addition to semi-permanent equipment should be provided. Provision of space and connections as close to the intake as possible are desired. A work station will be available directly above the collection pipe, allowing water collection immediately for applications where longer passage through insulated pipes is undesirable. 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, thus the vessel's Milli-Q will have its own, secondary RO. 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 is separate from fire fighting, ballast, and ship service saltwater systems; thus allowing 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. There is no immediate perceived need to support specialized air requirements such as driving air powered pumps, or SCUBA tank recharging. 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 five (5) standardized 8 ft by 20 ft portable deck vans for laboratory, storage, or other specialized uses.

- 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 access to ship interior and be 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

Storage space for multiple legs is required for this class of Global vessel. 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 9,000 cubic ft of dedicated storage space is available. Storage space on this class vessel would be used for 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 is included as a separate defined area with separate storage areas. 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 are 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 300 LT is desired. 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 MCS equipment, regularly installed winches (permanent and removable), Side A-Frame, 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 as this is especially important for MCS operations where there is such a different effect on vessel stability between having the gear on board and having the gear deployed.

Workboats

At least one 22-ft or larger work boat designed for in water streamer repair and able to serve other needs is necessary. This boat should be located for ease of launching and recovery. The main deck offers the capability to carry and deploy another scientific workboat 25-30 ft LOA outfitted specially for supplemental operations at sea.

Workboats will be in addition to the IMO/USCG required rescue boat.

Masts

The large area of unobstructed Bridge top deck allows for many options for mounting science and navigation equipment. The lack of a large obstructing mast allows other equipment locations to be designed such that ship's crew/technicians can easily/safely/comfortably work to change sensors and instruments. Any secondary masts 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 midships platform, 56 ft above the water, will serve as primary mammal observation platform. This platform will neither serve Radar, radio, other RF frequency generators, nor extremely vibration sensitive equipment, but can serve as an accessible platform for other scientific packages.

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. The remaining part of the Helicopter deck has been specified as the area to be used for these experiments. 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

Suitable viewing platform along with acoustic and other necessary systems should be provided to carry out detailed marine mammal studies. In conjunction with the midships platform other observation stations should be available. Redesign of an existing midships platform area will include provisions for 360° obstruction free observations by four to eight scientific personnel. This platform is 56 ft above the water line and allows line of sight viewing over the Bridge and Helicopter deck. The field of viewing to the sides is directly up to the hull. The field of viewing straight fore and aft is within 160 ft of the bow and stern (which is on par with the Bridge view ahead and much better than the Bridge view to the stern). Mammal observers may be on watch continuously during daylight hours and the observation location will include a protected booth with chairs, worktables, and access to the navigation/data network. Dual mounting locations for big eyes or similar devices will be installed on either side of the mammal observation booth. 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 vertical reference system (POS MV) 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, nor will all bridge navigation displays be effected by the science data collection systems. Communication of waypoint information between science and bridge system should be an integral part of the system.

Provisions for temporary installation of short or ultra short baseline acoustic systems (e.g., HiPAP) 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 are 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 ensure compatibility with the vessel's operating institution.

Standards for shipboard wiring (IEEE 45 or current guidelines) address of keeping signal and power wiring separate should be followed. During the conversion 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 allow 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 an early stage 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.

Multichannel Seismics/ Refraction Source

This global class vessel will have substantial general purpose abilities; while at the same time will fill the niche role within UNOLS of providing MCS and refraction source capability. The vessel must be capable of efficiently performing both 2D and 3D (multiple streamer) surveys. The streamer will be solid state offering immunity to common sources of streamer noise, increased strength and resistance to damage, and consistent buoyancy without ballasting. The seismic group interval is 12.5m with 8 seismic channels per 100m of streamer. The recording system will include substantial real time quality control, processing and archive quality storage media.

2D MCS will be performed with a streamer as long as 10 km. 3D MCS will utilize four streamers of at least 6 km each. The spreading for the 3D MCS can be as much as 200 meters between streamers resulting in 50 meter CDP spacing. The more conventional 25 meter CDP spacing is also achievable by narrowing the streamer spacing to 100m.

3D surveys can be further expedited by towing dual sound sources. The sound sources will be linear, therein greatly increasing the source signature and repeatability. The high pressure air is supplied by redundant air compressors and will be regulated by a digital control valve.

The conversion of this industry 8 streamer 3D seismic vessel will not be at the expense of any of the systems or spaces that have been refined to safely and efficiently perform 3D MCS. The paravane (wing like equipment used to achieve streamer and source spread) equipment as well as the streamer and sound source array equipment will remain and be utilized as designed

Acoustic Systems

Acoustic capabilities and quiet operation are important design criteria for this vessel, both for its original seismic mission and its proposed more general oceanographic mission. Special considerations were taken from design stage and throughout the building program in order to minimize hydroacoustic noise generated by this vessel. A propulsion plant upgrade was coupled with a propeller change to improve the vessels hydroacoustic noise signature. Modeling for hydroacoustic (low frequency) noise was performed prior to this conversion on this class of seismic ship for light pulling (24 tons) at 5 knots, heavy pulling (66 tons) at 5 knots and maximum speed (15.4 knots) prior to modifications. Considerations of specialized mounting arrangements for transducers to enhance system performance should be part of the design process utilizing past experience (French vessel Beatemps-Beaupre) and expertise of equipment manufacturers and expert users. The resulting design is for an underhull mounted pod below the bubble stream. 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:

- A multi-beam swath mapping sonar system capable of one degree by one degree 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 m.
- 12 kHz single beam deep-sea echo sounder that meets the International Hydrographic Office (IHO) standards for accuracy.
- A modern chirp subbottom profiler that is demonstrated to produce a 3 degree by 3 degree beam across a 30 degree swath.
- Cross deck existing ODEC Bathy-2000P chirp subbottom profiler and array of sixteen TR-109 transducers
- 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 m depth and fine scale shallow water performance.
- Systems for acoustic navigation, tracking and communications with submersibles and other underwater systems.

The pod should include the following provisions:

- The ability to change and service transducers easily with divers.
- Several transducer-mounting locations that can be adapted to a wide variety of transducers within a reasonable size range.
- 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.

Science Project 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 suitable for this vessel will need to be defined during the conversion design, 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 conversion so that this 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 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 can be added as necessary. Provisions for low-level radioactive waste storage will be incorporated in the radiation vans.

Exhaust and air system discharges should be separated from sensor locations as much as possible.

Construction, Operation & Maintenance

Maintainability

Maintaining the ability to maintain, repair, and overhaul these vessels, and the installed machinery and systems efficiently and effectively 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 after conversion 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. Adequate backups and spares should be maintained. Equipment monitoring systems and planned maintenance systems will help ensure that equipment remains in the best possible condition.

Operability

The vessels conversion should ensure that the vessel can be effectively and safely operated in support of science by a well trained crew complement. The global conditions, available ports, and shore side services at remote ports should be considered during the conversion design process. The impact of 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.

Security

The vessel conversion plan must include security measures to ensure the safety of the science party, the vessel, and its crew both at sea and in port. New technologies should be thoroughly explored to protect the vessel and make it a less vulnerable target without endangering the crew.

Life Cycle Costs

A thorough evaluation of conversion, annual operating, and long-term maintenance costs must be conducted during the conversion design cycle in order to determine the impact of design features on the total life cycle costs.

Regulatory Issues

The impact of USCG and international regulations on the conversion and reflagging of this vessel must be carefully considered.

Appendix I. 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

Appendix II. Ship Motion Criteria

Source of Descriptions: 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	