SECTION 1
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REQUIREMENTS AND CAPABILITIES

The requirements (and capabilities) for a research vessel usually are set out in two general categories: Platform Requirements and Scientific Requirements. The former category includes size, speed, accommodations, habitability, construction, propulsion, endurance, electronics, regulatory factors, and so on. Science requirements often overlap with platform requirements but go on to include mission definitions, laboratories, work decks, deck equipment, instrumentation, etc. Often not explicitly stated but of driving importance is cost, both construction and operating cost. This discussion will be concerned chiefly with science mission requirements and will address platform requirements only where they are affected by science requirements.

Whereas the science mission requirements for larger seagoing research vessels generally are similar, the requirements for small vessels can differ considerably due to varying coastal environments and specific priorities of the operating lab (training, disciplines and scope of operations).

In planning for a new (or conversion) research vessel, the usual sequence of events is as follows:

- Mission Definition
- Mission Requirements
- Concept Design
- Preliminary Design
- Final (Contract) Design

The "Mission Definition" and "Mission Requirements" should be prepared by the prospective operator in conjunction with user scientists. The design phases should be undertaken by a qualified naval architect with oversight by a committee of intended users.

Mission Definition

The Mission Definition or Profile is a brief statement setting out the principal use (or uses) of the proposed vessel, intended area of operations (and environment), scientific disciplines, operating capabilities and scientific accommodations.

An example of a Mission Profile is that prepared by the Woods Hole Oceanographic Institution for a small SWATH coastal research vessel.

- *Operational capability during all seasons off the Northeast Coast, making short cruises of up to ten days and distances no further than Bermuda* (650 *miles).*
- *Coastal science studies in bays and gulfs including multi-anchor moored stations. Open sea operations in all science disciplines including net tows, deep sampling, ROVs, diving support, seismics, coring and buoy work.*
- *Equipment and instrument testing during development stage needing platform capability (size and stability) simulating larger ships where equipment ultimately will be used*
- *Student training and practicum.*
- *Rapid response to oceanographic and atmospheric " events " possibly involving heavy weather transits at reasonable speed*
- *High flexibility in science outfitting -all winches, cranes, .frames, etc. to be totally portable through the use of deck boltdowns.*
- *Seakeeping of paramount importance and performance on-stations (including dynamic positioning) -stopped or slow speed- being more important than cruising. Lab and berthing accommodations to support J* 2 *science personnel.*
- *Total science payload (may reach* 20 *Ltons) highly variable and may include winches, vans, ROVs, cranes, and itinerant deck I~ such as buoy moorings.*

The Mission Definition is the starting point in the development of the vessel requirements. It is a brief but important statement. If the subsequent design development proves too costly or incongruous to the intended vessel, design review should include the mission profiles and be amended accordingly. The next step in the design process is Mission Requirements.

Mission Requirements

Following the mission definition, the Mission Requirements become the guidelines for directing the design (or conversion) of a research vessel. The science requirements define vessel and shipboard needs for operational capabilities, working environment, science accommodations, and outfitting. From the requirements can be deduced the size, speed, endurance, and overall capability .Additional aspects -habitability , safety , and cost are important factors and can have a significant impact on ship design, but these are either mandatory or statutory and usually are defined elsewhere

The UNOLS Fleet Improvement Committee has established a standard format for presenting science mission requirements. It includes the following categories:

- *General*
- *Size*
- *Endurance*
- *Accommodations*
- *Speed*
- *Seakeeping*
- *Station Keeping*
- *Ice Strengthening*
- *Deck Working Area*
- *Cranes*
- *Winches*
- *Overside Handling*
- *Towing*
- *Laboratories*
- *Special*
- *Science Facilities*
- *Vans*
- *Workboats*
- *Science Storage*
- *Acoustical Systems*
- *Navigation! Positioning*
- *Internal Communications*
- *Exterior Communications*
- *Ship Control*
- *Instrumentation*

In order to suit any particular application, these categories may be expanded or reduced. This is especially true in the case of smaller vessels where many of the categories may not be applicable, and special needs may dictate others.

Each of these categories is discussed briefly in the following sections:

General -This is a restatement of the Mission Profile along with any other design requirements. For smaller day, or short cruise, vessels, the educational use is often important and should be emphasized here or in a separate category.

Size -Although size ultimately is determined by the requirements, the prospective operator may consider it important to state a limiting size either in length, draft, or tonnage, or all three. Regulatory aspects often are a factor in a size limitation.

Endurance -This is based upon scope of intended cruising and nature of operations. The endurance formula should include a percentage of cruising and on-station work. The cruising range can be stated here.

Accommodations Here are stated the intended number of scientific personnel and provision for berthing arrangements. The current trend is for two person staterooms with a common WC between two staterooms. Crew size usually is an outgrowth of the design and or regulatory factors, but may be stated here as a limiting number.

Speed -Speed can be a scientific requirement when the duration (and cost) of a cruise becomes an important factor. There are current instances where higher speeds (greater than 20 knots) have been a major design requirement. An optimum speed can be calculated using cruise costs (fuel, etc.) vs. "time" consumed. It comes, however, at an additional "price". The design often results in a narrow beam, uncomfortable vessel not otherwise suited to work or cruising in a seaway. In heavy seas such hulls cannot make the intended speed and the greater cost and engine size is wasted. Furthermore, experience has shown that most research vessels carry greater loads with deeper drafts than the naval architect designed for with the result that the design speed cannot be achieved

Careful attention should be given to all factors when a high cruising speed is considered.

Seakeeping -There is almost full agreement by seagoing scientists that seakeeping, both underway and on-station is one of the most important of requirements. Seakeeping is often misnamed "stability". The latter is a safety tenn and not necessarily a measure of a stable environment for which seakeeping is a preferred term. A stiff vessel, i.e. one which rolls rapidly with high accelerations, can have high stability but afford poor seakeeping.

Seakeeping is important to ensure that work can be carried out safely, effectively, and continuously, both on deck and in the lab. This is especially true in smaller vessels on short cruises where excessive motion can render the entire cruise unproductive.

A reasonable seakeeping goal for a research vessel of 80-100 ft. is to maintain headway and/or science operations in sea state 4 (4-8 ft. seas) and limited work in higher sea states. (See Appendix B) In new construction, seakeeping should be a principal consideration of the naval architect. Improvements in conversions can be achieved by ballasting, larger rolling chocks (bilge keels) and other roll suppression systems such as anti-roll tanks, active fins, and paravanes (flopper-stoppers).

Station-keeping -Although related to seakeeping, station-keeping includes the added element of ship control at the best, or desired, heading on station or along a given track line. This is a function of the maneuverability of the vessel including propulsors and control systems. On smaller vessels this traditionally has been accomplished manually using the screws and bow thruster (if available) by the mate on watch. Success usually depends upon the skill of the operator, twin screws, and the effectiveness of the bow thruster.

A typical station keeping requirement is to maintain station at best heading in 25 knot wind, sea state 4, and one-knot current.

A bow-thruster is desirable but not without controversy. The two chief uses, mooring and station keeping can dictate different installations and power. For the former, a simple tunnel thruster with 50-100 hp itinerant operations usually is adequate. For station keeping, twice the power with continuous operation and an azimuthing thruster may be needed. Experience has shown that on a small vessel a bow thruster is noisy, is located close to the sleeping quarters, and generally is not used. In order to be effective, a bow thruster should be readily available. When better station heading is needed (e.g. bow thruster), starting it from the conn should be available so it is not neccessary to wake up the engineer to start another generator to place the bow thruster on line.

Dynamic positioning, becoming more common on larger vessels, is now getting attention by small vessel operators. Here the added requirement for excursions no greater than 50 meters and plus/minus 5 degree heading, requires automatic propulsion control systems with input from GPS or acoustical beacons. Experience has shown that dynamic positioning without a stern thruster or azmuthing propellers is unsuccessful, and that the quick response of smaller hulls is difficult to control. Until more experience is gained using dynamic positioning on smaller vessels, a requirement for its use should be viewed with caution. A stem thruster, however, might be well considered even to the exclusion of a bow thruster. Norwegian vessels frequently have stern-thrusters only and report good results especially in acoustics where a bow thruster may be a chronic problem for echo sounding.

Ice Strengthening -This is a matter of regional consideration and inclusion as a requirement should stem from the mission definition. If ice strengthening is considered necessary, the various ice classes defined by the American Bureau of Shipping should be consulted. If work in ice (and cold weather) is a requirement, then additional requirements for protecting personnel and work on deck should be considered.

Deck Working Area -The layout of the science work deck is extremely important in the design of any research vessel. In a small vessel, the tradeoffs between deckhouse and open deck area must be carefully considered. As a general rule, one-third of the main deck area should be given over to science work. This usually is the stern area although several successful R/V's have had the work area in the waist or forward area. However, in view of lesser vertical accelerations in the after area, and towing requirements, a stern work deck is preferable. Important requirements for the work deck include"

- .It should be as uncluttered as possible; hatches should be flush; equipment such as capstans, bitts, cranes, frames, winches, etc should be portable.
- .Deck should be flat or have minimum camber.
- There should be bulwarks with cleats and tiedowns at frequent intervals. Pipe railings should be avoided. Several (if not all) bulwark sections should be removable.
- .One inch threaded boltdown sockets should be installed on a 2-ft. grid pattern for the installation of portable equipment.
- The stern quarters should be as square as possible in order to provide maximum railing and workspace.
- All workdeck(s) should have multiple access for power, fresh & sea water, air, and hydraulics, and cableways for data & communication lines.

Cranes -A crane (or cranes) is an essential item of R/V shipboard outfit. It should be specified to match the vessel size and anticipated uses. A typical installation is a main crane located at the forward end of the work deck or on the 01 deck overlooking the work deck and able to reach most of the work deck. It should be able to handle weights up to, say, 5,000 lbs over the side and 1,000 lbs. fully extended over the stem.

Cranes can be either telescoping or articulated with the choice usually at the operator's preference. A telescoping crane usually has a greater capacity and reach for its weight, but an *r* ~ articulated crane is more versatile and eliminates the danger of pendulous weights when working at sea. A telescoping crane when properly braced can be used for fairleading overside wires and towing equipment. Such work will shorten the life of an articulated crane and/or damage it.

In addition to the main crane, a smaller auxiliary crane is useful -usually as a portable articulated type able to be placed at several locations on the work deck or even forward.

Winches -Oceanographic winches are the primary tools of a research vessel. The kind and sizes of winches along with the installed wires and cables determine the ships basic capability for work at sea. Science requirements should state the type, number, and size of winches to be installed. Common terminology used in describing oceanographic winches and wire includes:

- **Hydrographic Winch** -A winch carrying mechanical wire, usually 3/16" or 1/4", used chiefly for sampling in the vertical water column with Nansen or Nisken bottles. Also for small net tows or bottom sampling grabs-
- **CTD Winch** -A winch usually similar or identical to the Hydro Winch but equipped with conducting cable usually 1/4" or 5/16" (0.322) used for electrical or electronic instruments connected to deck units via the conducting cable and slip rings. These include crus, rosettes, small sampling nets, thermal probes, etc. CTD winches and Hydro winches often are interchangeable.
- **Trawl Winch** -A heavier winch used for trawling, dredging, or coring and equipped with mechanical wire usually 3/8" to *1/2* (or 9/16" on larger vessels). As the use of electronic instrumentation becomes more prevalent, many operators elect to carry conducting cable on the Trawl winch for use with large controllable

nets (MOCNESS) and towed vehicles. Larger vessels are now outfitted with dual storage drums so that either wire can be used on the same winch. On some vessels the heavier winch by tradition is termed Coring Winch.

The foregoing comprises the basic suite of winches common to most research vessels. This, of course, can be varied widely according to the mission profile and special needs of the users. A key element in any small research vessel is flexibility where portable winches can be brought on and off depending on cruise needs. Important here are the deck boltdowns and power sources.

Two common types of winches are Traction Winches and Drum Winches. The former have tandem driving wheels and the wire or cable is led to separate storage drums. A drum winch both pulls and stores the wire on the same drum. Traction winches usually have better control and the cable is not stored under heavy tension. They are, however larger and more expensive than drum winches and are seldom applied to small vessels. Drum winches are more common on small R/V's. When selecting the appropriate winch for a small R/V .The following factors should be considered:

- **Winch Size** -The common hydro/CTD winch found on large R/V's usually has a capacity for 10,000 meters of 5/16" cable and 75 to 100 hp. The trawl winch is rated for 10,000 meters of 9/16 wire rope or 8,000 meters of 0.68" electromechanical cable. These sizes usually are excessive for a small R/V unless there is a compelling requirement for deep sea capability .A more typical winch arrangement for a coastal research vessel of 75-90 ft. might be two similar hydro/CTD winches carrying 2,000 meters of 3/16- *1/4"* wire rope on one winch and 2,000 meters of l/4-5/16" conducting cable on the other; and a trawl winch with 1,500 meters of 3/8-1/2" wire rope or conducting cable. Flexibility can be achieved by having interchangeable drums.
- **Electric V5. hydraulic power** -Either can be suitable depending on the vessel's power system. Hydraulic power is the more common in smaller vessels. The power source can be an electro-hydraulic power unit or power takeoffs (PTO) from an engine, or both.
- **Level Winding** -For winches spooling more than 500 meters of wire, a level winding device is essential. The most common is a diamond thread; others are available-
- **Wire Monitoring** -This includes metering devices to measure and display the wire out, line speed, and tension. Wire out metering is mandatory in all winches. Others are desirable but not essential on a small R/V .
- **Winch Controls** -On small vessels, the winches usually are controlled from deck stations at or near the winch. There is an increasing requirement that the winch also be controlled from the lab. This capability should be included in all new vessels.

Additional, and important information is contained in the publication ***Handbook of Oceanographic Winch, Wire and Cable Technology,*** 2nd Edition, NSF/ONR, 1989.

Overside Handling -Various frames, davits and other handling gear are required to launch and retrieve overside instrumentation, and are an essential adjunct to the winch arrangement. The most common installations are the overstern A-frame and A- or J-frames for side lowerings. The size and capacity of the frames should match the wires and cables in use. The frames should be ram operated and special attention should be given to adequate inboard and outboard reaches, and to the horizontal and vertical clearances.

It is important that the ultimate strength of overside handling equipment be greater that the breaking strength of the wires or cables in use.

Towing -Net tows and dredging are traditional requirements for a small coastal R/V. More recent requirements that should be planned for include Multiple Opening and Closing nets (MOCNESS), side scan acoustic imagers, and towed vehicles. These and other new equipment require special handling arrangements, deck space, and fine winch speed and ship speed controls.

Laboratories -Along with the work deck and winches, shipboard scientific laboratories are the objects that set research vessels apart from others. Planning for a lab should include the following elements:

- Good Location with suitable access to the work deck and other labs. The Main Lab preferably should be on the Main Deck with direct access to the work deck and to the Wet Lab.
- Size should be determined by the mission profile taking into consideration the number of scientific personnel, anticipated cruise duration, and work use. A typical 90-ft general purpose R/V would have a 400 sq.ft. main lab and a 150 sq. ft. wet lab. Use of the lab as a fore & aft passageway should be avoided; experience has shown that when a lab is used as a passageway, 25% of the available space may be lost.

- Environment including Air Conditioning, Ventilation, lighting, noise levels, and vibration suppression should be carefully planned.
- Flexibility should be planned for including moving benches, cabinetry , sinks and instrumentation on and off from cruise to cruise-
- Cabinetry should be of the highest quality .Experience shows that cheap metal cabinetry deteriorates quickly.
- Electrical Outlets both ships service and clean power should be abundantly located.
- Sink Drains should not go to the ship's sanitary system but should go to a separate neutralizing tank and/or directly overboard.
- Cleanliness should be ensured through the use of suitable materials.

Special Science Facilities -Equipment or installations to support specialized projects as recommended by and agreed upon prospective users should be made part of the Mission Requirements Phase. Examples of these are:

- Science workshop.
- Centerwell .
- Scuba support facility .
- Aquaria
- ROV and AUV support
- Incubators
- Photo Lab.
- Meteorological tower .
- Stern Ramp.
- Coring facility

Vans -Vans can be viewed as a specialized science facility (i.e. "clean lab", scuba support, etc) or can be treated as regular shipboard outfit used as a lab annex, storage, or extra science berthing. They are widely used on larger R/V's and have limited adaptability to smaller vessels, if weight and space are available. If vans are intended for use, they should be explicitly stated as a mission requirement and not become an afterthought. The traditional van is an 8x20 ft. container van converted for shipboard use: insulation, interior sheathing, power outlets, HVAC, cabinetry, etc. They must have at least two exits and must meet other safety standards.

Berthing vans are now required to be approved by Coast Guard. As a general rule, berthing vans should not be carried on the Main Deck.

Workboats -In most cases, a science workboat will be required, if not as part of the permanent outfit, then as requirement for selected cruises (SCUBA support, beach landings) and therefore should be considered in the mission requirements. Stowage location and launching & recovery are the major elements although motor & gas stowage and communications should be included. The rigid hull inflatable (RIB) is the most popular boat in use today although the straight inflatable often may be more appropriate for smaller vessels.

Science Storage -Adequate stowage of scientific equipment and samples is one of the greatest deficiencies in small R/V designs. Storage space in small vessels takes away from other much needed space and usually receives a low priority. It should, however, be included as a mission requirement. The amount of storage space depends on the size of the vessel and average cruise duration. As a general rule the need can be equated to 10% of the laboratory space. A requirement by users for refrigerated storage can be expected.

Acoustical Systems -The provision for science echo sounding and any other acoustical systems should be included in the Mission Requirements. All small R/V's should carry a survey grade echo sounder. A dual channel 12/50 kHz instrument with a paper recorder is frequently used. To this can be added additional systems recommended by prospective users. These include:

- **Precision Depth Recorders** which may require additional transducer(s) and lab space. Ordinarily on small vessels these should be carried only as part of a cruise project.
- **Sub-Bottom Profller** usually a 3.5 kHz system. Experience has shown that such *0! Q* systems are not very successful on smaller vessels. If required, a towed transducer is recommended.

- **Acoustic Doppler Current Profiler (ADCP)** again has not proven successful when installed in shallow draft, light displacement vessels. Some small vessels have used a portable ADCP extended downward over the side while stopped or towed slowly.
- **Shallow Water Multi-Beam System** is a current requirement for small survey vessels. It is, however, expensive and requires elaborate transducer mounts and specially trained operators and data processors.
- **Side Scan Sonar** has proven highly successful as a towed system on small vessels.

- **Color Fish Finders** are popular in the pilot house and are finding increasing use during science work.

Acoustical systems are greatly affected by ship generated noise and bubble sweepdown along the hull. As such, machinery types and mounts, the placement of transducers, and bow shape can be an important factor, and the naval architect should be accordingly cautioned.

Planning should include one or more spare transducer openings in the hull to accommodate new and special project instrumentation.

Navigation/ Positioning -The primary requirement here is for accurate navigation data as an input to the various data systems and to ship control processors. To do this a dedicated GPS is required to be integral with the science navigation system. The advent of the three dimension GPS attitude ("e.g. Ashtech") system can provide stabilized platform reference for multi-beam and ADCP systems. Other advances in electronic navigation may pose requirements in this area. Also, acoustic navigation systems for precise positioning and AUV/ROV tracking may be recommended.

Internal Communications An adequate internal communication system should be provided for commensurate with the size of the vessel. This includes:

- High quality voice communication s throughout all science spaces and working areas.
- Data transmission, monitoring, and recording system available throughout science spaces.
- Closed circuit television monitoring of outside working areas including subsurface performance of equipment.
- Monitoring of all ship control, navigation, environmental parameters, science and equipment performance.

Exterior Communications -A suitable communication system is required for communications with shore stations (including home lab) and other vessels. Depending on the size of vessel and operating areas, this can be accomplished by UHF, VHF, and satellite communications as well as cellular phones. Provision also should be available for facsimile communications and hard copy text. The need for high-speed communication links to shore stations and other vessels should be examined.

Ship Control -A chief requirement is maximum visibility of deck work areas and adjacent sea surface during science operations both from the pilot house and from science control stations (winches, cranes, ROV's, etc).

The functions, communications, and layout of the ship control station(s) should be designed to enhance the interaction of ship and science operations. For example, course, speed, and positioning will often be integrated with scientific operations which require control to be exercised from a laboratory or deck station.

Instrumentation -The science outfit which a small R/V should te prepared to carry and handle should be examined to ensure that there are provisions to install, operate, maintain, and stow the equipment. This applies both to instrumentation carried on board permanently or portable instruments used as needed for a cruise. These include, but are not limited to, the following:

Permanently Installed

- Echo sounders
- CTD System
- Water sampling bottles
- Rosette system
- Expendable bathythermograph
- Surface thermosalinograph
- Fume hood(s)
- Salinometer
- *R/O* distilled water maker Autoclave
- Water deionizer
- Meteorological system

Portable

- XBT probes
- Gravity corers
- Piston corers
- Bottom dredges
- Sampling nets
- Pingers

A description of equipment to be carried on a research vessel is important in arriving at a suitable design. There is a long history of naval architects not being aware of the full extent of equipment ultimately brought on board, with the result that the vessel is more heavy, deeper, slower, and more cluttered than planned for.

Sample Requirements

The UNOLS Fleet Improvement Committee has compiled a set of scienctific mission requirements for various types and sizes of research vessels. In Appendix A, following, the requirements for a small general purpose research ship are reproduced.

Priorities

In any statement of requirements an ordering of priorities is important for the guidance of follow on activities leading to the design phases. In the case of research vessels, the UNOLS Fleet Improvement Committee made a comprehensive survey of the relative importance of mission requirements. The views of many practicing investigators from all disciplines were solicited. The following is the majority viewpoint.

Priorities for Research Vessel Requirements

- Seakeeping
  - Stationkeeping
- Work Environment
  - Lab Spaces and Arrangements
  - Deck Working Area: overside handling, winches & wire
  - Flexibility
- Endurance
  - Cruising Range
  - Days at Sea
- Science Complement
- Operating Economy
- Acoustical Characteristics
- Speed
  - Ship Control
- Payload
  - Science Storage
  - Weight Handling

Most respondents agreed that seakeeping, particularly on station, and work environment were the two top priorities. But the remaining requirements were ranked so closely together that they become of equal importance. The stated requirements then become threshold levels, and any characteristic that falls below the threshold becomes a high priority. For example, speed which is ranked relatively low, above, would become a high priority if a proposed vessel showed a design speed below the required, or threshold, level.

This emphasizes the importance of assigning genuine, realistic requirements. The acceptance of a design characteristic less than the original requirement signifies either that the original requirement was flawed, or that the vessel will not measure up to its intended service.

Concept Design

The concept design stage is the first step in translating the stated requirements into the actual design process. It is a technical and engineering effort done by a qualified naval architect to develop the hull form, machinery, and general arrangements that integrate the various scientific requirements, combining laboratory arrangements, deck handling, outfit, storage and ship control into a single shipboard system. Here the requirements of the regulatory agencies (USCG & ABS) are defined. From the concept design, the prospective operator and users can evaluate whether the vessel thus described is what was really intended.

The scope of a concept design includes:

- Technical description of the design.
- Discussion of the vessel design and its responsiveness to the requirements.
- Summary of vessel specifications
- General arrangement plans.
- Inboard and outboard profile plans.
- Scientific arrangement.
- Machinery arrangement.
- Operating characteristics, including costs.
- Estimated construction cost.
- Artists concept drawing.

The concept design provides the opportunity *for* feedback into the requirements and the testing of the comments and suggestions that ought to be forthcoming at, this stage of the design. It is doubtful whether the next stage of the design process, the preliminary design, will closely resemble the concept design, but the concept design will have served its purpose if it has tested the requirements and permits the next stage to start with any reasonable degree of confidence.

Summary

The foregoing descriptions of the Mission Definition, Science Mission Requirements, and Concept Design are the key elements in the initial planning phases of a research vessel design for new construction or conversion. Because of the greater diversity of missions and sizes of small coastal research vessels, much of this information may not be applicable or may require modification, and additional material may need to be inserted. The main thrust of what is presented, however, has been developed by numerous experienced seagoing investigators and has produced many successful designs.

Attachments

Appendix A

Scientific Mission Requirements for Small General-Purpose Oceanographic Research Ship", UNOLS 1988

Appendix B

Sea State Table

Appendix A

July 1988

Research Scientific Mission Requirements
for
Small General-Purpose Oceanographic Ship

General: This monohull ship will serve as a general-purpose research vessel with_limited endurance and maximum flexibility of operations. It is fully capable of continuous 24-hour operations. The primary design requirement is to combine multi-disciplinary capability with small size and cost effectiveness. Vessels of this size often serve educational programs in addition to their research work. For this vessel, endurance and cruising speed are secondary to broad operational capabilities and seakeeping qualities.

Size: LOA = less than 150 ft.; BEAM = not less than 30 ft.; DISPLACEMENT =_500 to 650 tons; GROSS TONNAGE = <300 tons; DRAFI' = 7 to lOft.

Endurance: 21 days. Endurance formula should include 50% cruising and 50% on-station. RANGE = 5,000 nautical miles.

Accommodations: 12 to 16 scientific personnel in two-person cabins, under research cruise I conditions. Expandable to 24 with a van. Up to 40 personnel on day trip basis. Crew size < 10.

Speed: 12-13 knots cruising~ sustain 10 knots through sea state 4. Maximum speed = 14 knots. Speed control plus/minus .1 knot in speed range from i 0 to 6 knots. Design trade-offs should favor seakeeping over speed.

Seakeeping: Maintain science operations at these speeds and sea states:

- 9 knots in sea state 4
- 7 knots in sea state 5
- 4 knots in sea state 6

Station-keeping: Maintain station and over-the-side vertical operdtions in sea state 4, without dynamic positioning. Bow thruster.

Ice Strengthening: ABS Class C (ability to transit loose pack ice) may be desirable for one or more vessels of this class, but distinct from a dedicated, ice-strengthened, high-latitude research vessel.

Deck Working Area: Approximately 1500 sq. ft. with contiguous work area along starboard waist =_8 ft. x 20 ft. minimum for CTD and rosette sampler handling. Deck loading at 15001bs./sq.ft."

Heavy duty hold-downs on 2-ft. cente~. Able to accommodate at least one (preferably two) 8 ft. by 20 ft. van yet retaining clear access to stem and waist work areas. Removable bulwarks with hinged freeing ports to provide dry deck conditions in beam or quartering seas.

All working decks with multiple access for power, fresh and salt water, air and cableways for data and voice communications lines. Low freeboard at fantail (3to 5 ft.). No stem ramp.

Cranes: -One articulated crane to handle large and heavy (up to 8,000 lbs.) gear_over both sides, on station and underway, with lateral motion damping, and an outboard reach of 14 ft. on one side. This crane also capable of reaching all working deck arras for-loading and off-loading of equipment (including empty van). Man-rated for launch and recovery of small submersibles. A second, smaller crane with re-location sites forward, midships and aft; articulated for work at deck level and at the sea surface, with weights up to I4,000 Ibs., also usable as over-the-side, cable fairlead for vertical work and light towing

Winches: Two modem winches with state-of-the-art controls providing fine control (0.5 m/min); constant tensioning or with tension accumulator. Wire monitoring systems on both winches, with readouts on laboratory panels and shipboard recording systems, as well as on the bridge. Local and remote control boards. Winches to be re-locatable (in port) to allow reconfiguration of deck layout. Capable of transferring winch drums at sea.

Hydrowinch with interchangeable drums capable of handling up to 30,000 ft. of wire rope, synthetic line or electromechanical cables having diameters from 1/4" to 3/8" or 11 mm standard (e.g. Markey DESSS-5 or equivalent). Slip rings with six conductors.

Trawling winch capable of handling 20,000 ft. of *1/2"* trawling or coring wire or 20,000 ft. of 0.68" electromechanical cable (up to 10 KV A power transmission) or fiber optics cable. Can be operated with interchangeable drums. Slip rings with six conductors. A traction winch. is a possible alternative.

All weather winch control station(s) located for optimum operator visibility of work area and overside gear, with fail-safe communications to deck level, laboratories, and bridge A-frame controls included.

Overside Handling: Various frames, davits and other handling gear to accommodate wire, cable and free-launched arrays. Matched to work with winch and crane locations, and with moveable capstans, but able to be relocated as necessary.

Stem A-frame to have 15-ft. throat (horizontal width at deck level and up to 15 ft. off deck) and 20-ft. vertical clearance, 12-ft. inboard and outboard reaches. Man-rated for launch and recovery of small submersibles. Safe working load of 20,000 lbs. Controls to be located at A-frame and at winch control station.

Towing: Capable of towing midwater and benthic gear at speeds up to 4 knots with line tensions of 20,000 lbs.

Laboratories : Minimum of 1,000 sq. ft. of laboratory space allocated: 75% main lab (including separate electronics lab capability), and re configuration into smaller specialized labs. Wet lab to be located contiguous to sampling areas; main lab with temperature and humidity precisely controlled.

Labs to be located so that none serve as general passageways. Access between labs to be convenient. Dry lab and electronics lab areas with door sills to keep water out. Main lab access to be large enough to accommodate transfer of large equipment items.

Labs to be fabricated using uncontaminated and "clean" materials and constructed so they can be easily maintained in an uncontaminated condition.

Furnishings, HVAC, doors, hatches, cab1e runs, plumbing, and fittings to be planned for maximum lab cleanliness.

Fume hood to be installed permanently in wet lab. Main lab to have provision for temporary installation of fume hood. Hood flues able to withstand acid fumes and situated so no fumes can be drawn back to occupied areas inside or on deck.

Cabinetry shall be of high-grade laboratory quality including flexibility through the use of unistruts and deck boltdowns on 1 ft. centers.

Heating, ventilation, and air conditioning (HV AC) capabilities as follows: labs shall maintain temperature of 70- 75° F in all weather conditions; 25% relative humidity; and 9-11 air changes per hour. Each lab area 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. Labs to be furnished with 110 v and 220 v AC. Maximum estimated laboratory power demand is 50 KV A. Uncontaminated sea water supply to wet and dry labs, and deck areas (including anywhere on the fantail). Compressed air supply to all labs and deck area; supply to be clean and oil free, with lOO Ibs. Service pressure at outlets.

Special Science Facilities: Science shop with workbench, vise, and basic hand and power tools.

Scientific freezer space = 36 cubic ft. @ -20° C, and 50 cubic ft. @ -5° C.

SCUBA support facilities- compressor, water entry platform and ladder, tank storage racks.

Space and capability for setting up an operating station for a small ROY; with deck space for cable payout and coiling, launch and recovery .ROY control center with video monitor, recording gear and communications in the main lab or on the bridge.

Undisturbed air-flow at bow *for* air-sea interaction studies

Van: Capable of handling and carrying at least one standard 8 ft. by 20 ft. portable deck van, which may be laboratory , berthing, storage or other specialized use. Hookup provision for power, HV AC, fresh water, uncontaminated sea water, compressed air, drains, communications, data and shipboard monitoring systems. Van should have close, if not direct access to ship's interior. Ship should be capable of loading and offloading empty van using its own crane at dockside.

Workboats: One 16 ft. rigid hull boat with inboard or outboard power, and at least one 12 !0 16 ft. inflatable boat with outboard power .

Science Storage: Readily accessible 1250 cubic ft. minimum for operator's science support gear and resident technician's stores. Accessible safe storage for chemical reagents and hazardous (non-radioactive) materials.

Acoustical Systems: Ship to be as acoustically quiet as possible in the choice of all shipboard systems and their location and installation. Ship to have conventional 12 kHz, and 3.5 kHz echo sounding systems and provision for additional systems as needed. Transducers to be mounted so as to provide clean transmission and reception from both lateral (tracking) and vertical signals. Three transducer wells with at sea access for servicing and installation.

Navigation/ Positioning: Differential Global Positional System (DGPS) and Loran C with appropriate interfaces to data systems in lab and ship control processors**.**

Short baseline acoustic navigation system,

Internal Communications : Internal communication system providing high quality voice communications throughout all science spaces and working areas.

Data transmission, monitoring, and recording system available throughout science space including van and key working areas.

Closed circuit television monitoring of all outside working areas including subsurface performance of equipment and its handling.

Monitors for all ship control, environmental parameters, science and overside equipment performance to be available in all, or most, science spaces.

Exterior Communications: Reliable voice channels for continuous communications to shore stations (including home laboratories), other ships, boats and aircraft. This includes satellite, VHF and UHF .

Facsimile communications to transmit high-speed graphics and hard-copy text on regular schedules.

High speed data communications links to shore labs and other ships on a continuous basis.

Capability to receive real-time satellite imagery.

Ship Control: Chief requirement is maximum visibility of deck work areas and adjacent sea surface, during science operations and especially during deployment and retrieval of equipment.

The functions, communications, and layout of the ship control station should be carefully designed to enhance the interaction of ship and science operations. For example, ship course, speed, attitude, and positioning will often be integrated with scientific operations requiring control to be exercised from a laboratory or deck working area.

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Appendix B

Sea State	*Description*	*Height*	
		Feet	*Meters*
0	Calm-glassy	0	0
1	Calm-rippled	0 to ½	0 to 0.1
2	Smooth-wavelets	½ to 1 ½	0.1 to 0.5
3	Slight	1 ½ to 4	0.5 to 1.25
4	Moderate	4 to 8	1.25 to 2.5
5	Rough	8 to 13	2.5 to 4
6	Very rough	13 to 20	4 to 6
7	High	20 to 30	6 to 9
8	Very high	30 to 45	9 to 14
9	Phenomenal	Over 45	Over 14