Key Performance Parameters (KPP)	Original SMR Language = SMR language in the Ad-Hoc Subcommittee Report – August 2019 SMR Change References: • Ref 1: 2021 NSF Capability Matrix – March 2020 • Ref 2: NSF Director's CD Phase Approval Memo and attachments – May 2021 • Ref 3: NSF Memo re: UNOLS ADA Guidelines – January 2022 • Ref 4: NSF Revision 3 of the ARV PEP Appendix 01 – May 2022	Changes to SMR
Other SMRs Prioritized by the Office of Polar Programs in Reference 2		No Change
		Minor Edits to SMR Language
		Requirements Change - Significant

Table 1: ARV Key Performance Parameters (KPP)

Parameter	*Requirement*	*Threshold Value*
Icebreaking	The capability to independently break ice	≥4.5 feet @ ≥3 knots
	Meet requirements for Polar Code notation	Polar Code PC3
Endurance	Maximum endurance without replenishment	≥ 90 days underway
Science & Technical Personnel	Provisions for berthing, messing, sanitation, and scientific workspaces	Crew and ≥ 55 science and technical personnel

Table 2: ARV Science mission requirements

D.2	**Science Mission Requirements**	**Threshold Requirement PEP Appendix 01 – Rev 03**	**Objective Requirement PEP Appendix 01 – Rev 03**	**NSF Approved Changes to SMR**
D.2.1	**Size and general requirements**			
	Size:	**Minimum size and capability as that of the *Nathaniel B. Palmer* with the added capabilities as defined by the KPPs and other key threshold SMR requirements.** Maximum draft constrained by the need to service ports/stations such as Palmer Station with a 28-foot maximum draft nominally required; Design for a Maximum Air Draft of 44m above waterline with ARV in arrival condition (10% fuel, 10% freshwater, and 10% consumables). Maximum length to allow berthing at Palmer Pier with winds speeds up to 35 knots without a Dolphin added to the pier.	Size and Capability sufficient to achieve all Mission Requirements.	*NBP no longer threshold for some areas (KPP) [Ref 2]* *Reduced maximum draft based on Palmer Pier evaluation report. Added Air Draft language based on CDR recommendation using Tasman Bridge in Hobart as the limiting factor. [Ref 4]*
	General Requirements:	Capacity to transport, deliver and pump ≥60,000 gallons of various grades of diesel to Antarctic research stations. Ability to **operate** in water temperatures 28°F to 90°F, air temperatures of minus 40°F to 100°F, and wind speeds of 100 knots. Conform to IMO Polar Code regulations for a PC3 vessel.	Greater Temperature Range for operations desired.	*Minor Edits* *[Ref. 4]*
D.2.2	**Accommodations and habitability**			
D.2.2.1	**Berthing and support facilities (KPP)**	**Berthing and support for ≥55 science and technical personnel.**		*≥ 55 made threshold, made KPP [Ref 2]*
D.2.2.2	Habitability: Overall	Accommodations and personnel spaces shall be designed to maximize comfort and reduce fatigue and to meet and/or exceed industry standards for acceptable noise and vibrations levels.		*Minor Edits – Separated into sub-categories.* *[Ref. 4]*
D.2.2.2	Habitability: ADA	Include one ADA compliant stateroom		
D.2.2.2	Habitability: Standards	All areas on the vessel, including lab and living areas, must meet American Bureau of Shipping HAB+ (WB) notation for habitability standards.	Include UNOLS ADA Guidelines to the extent possible as described in NSF memo dated January 12, 2022	*Add ADA guidelines. [Ref 3 & 4]*
D.2.2.2	Habitability: Gym	Common areas (non-working spaces) should include a gym: - The gym should be adequately sized for a variety of exercise methods, some of which require open spaces for movement - Fitness equipment should be ample and located in one or more dedicated spaces noise isolated from staterooms		
D.2.2.2	Habitability: Sauna	Common areas (non-working spaces) should include a Sauna.		
D.2.2.2	Habitability: Lounge	Common areas (non-working spaces) should include a large comfortable lounge (as in the NBP). Include provisions for isolation of lounge spaces from ship, equipment, and icebreaking noise		

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.2.2	Habitability: Conference Rooms & Learning Centers	Common areas (non-working spaces) should include Conference Rooms to be designed to consider noise and conduct remote conferences (video and audio)	Include at least one dedicated, small learning center (6-8 person capacity) to support linked programs with universities and allow conference meetings to occur concurrently. Also, provide ability to subdivide a larger conference room into temporary smaller learning centers.	*Made smaller separate learning centers an objective* *[Ref 4]*
D.2.2.2	Habitability: Mess Deck	Include galley and mess area capable of serving 4 meals per day isolated from noise.	Mess deck should be equipped with large windows for easy outside viewing and allow for natural lighting.	*Added Natural Lighting consistent with P-Spec* *[Ref. 4]*
D.2.2.2	Habitability: Polar Clothing Storage	Include space to store and change into polar clothing		
D.2.2.2	Habitability: Quiet Berthing Area	Isolate living spaces from noise; Hotel area to be 24/7 quiet zone		
D.2.2.2	Habitability: HVAC Temperature	Maintain temperatures in normally occupied spaces (A/C spaces) of at least 70°F in the heating season and 75°F or lower in the cooling season. Other spaces can have relaxed requirements based on the use of the space. Use SNAME Technical and Research Bulletin No. 4-16 for guidance. Environmental conditions range from a minimum air temperature of -40°F or less and seawater temperature of 28°F in winter and a maximum dry bulb air temperature of 100°F (82°F wet bulb) and seawater temperature of 90°F.	Maintain temperatures in normally occupied spaces (A/C spaces) of at least 70°F in the heating season and 75°F in environmental conditions outside of "threshold" range.	
D.2.2.2	Habitability: HVAC Humidity and Air changes	Laboratories require a non-condensing environment and shall have a relative humidity of 50% relative or lower. Other A/C spaces shall have a relative humidity of 55% or lower HVAC - rate of air changes: Use SNAME T&R Bulletin No. 4-16 for guidance		
D.2.2.2	Habitability: Airborne noise	Airborne noise in ship compartments and at deck stations shall be specified such that the weighted sound pressure levels meet or exceed the requirements of the ABS HAB+ (WB) notation. • Labs & Normally Occupied Spaces ≤ 60 dB • Working Decks ≤ 75 dB • Staterooms shall be sound insulated to limit noise between cabins as much as possible for privacy • Airborne noise specifications should be developed using an experienced shipboard noise consultant. Airborne noise levels during normal operations at sustained speed or during over-the-side operations using dynamic positioning shall conform to standards in USCG NVIC No. 12--82 and IMO Resolution A.468(XII), "Code on Noise Levels on Board Ships."	Meet or exceed the requirements of the ABS HAB++ (WB) notation	*Moved Airborne Noise requirement for UW Radiated Noise SMR to this SMR.* *[Ref 4]*
D.2.2.2	Habitability: Vibration	The ship and all ship components shall be free from excessive vibration. - Vibration in normally occupied spaces shall be limited to a maximum allowable velocity of 160 mils/sec (4 mm/sec) in maximum repetitive amplitude terms for a frequency range of 1 to 100 Hz in accordance with revisions to ISO 6954 recommended by SNAME T&R Bulletin 2-29A. - The vibration of the masts and other structures supporting vibration-sensitive equipment shall be limited to that level acceptable to the manufacturers of mast-mounted equipment, or ±0.1g over the frequency range of 1 to 100 Hz, whichever is less. - The vibratory response of the propulsion system over its entire power range and speed range through 115 percent of maximum shaft RPM shall be limited according to manufacturer's recommendations and so as not to harm installed machinery.		

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.2.2	Habitability: Lighting	Lighting levels shall generally exceed by 30% the values given in IESNA RP-12-97, Marine Lighting, Table 3. - Laboratories shall have 100 foot-candles of light - Staging Bays and Working Decks shall have 70 foot-candles of light - In the laboratories, individual lights or groups of lights shall have independent switches to allow them to be controlled separately to provide varying light levels. - Navigation spaces shall be equipped with red illumination and normal lighting.	Labs shall have natural lighting to the extent possible, with the ability to black out portholes. The climate control labs and aquaria do not require natural light.	*Added Natural Lighting consistent with P-Spec* *[Ref. 4]*
D.2.2.2	Habitability: Human Engineering	Human engineering principles should be applied in the design of workspaces, including the use of natural lighting where possible. Headroom shall be maximized where possible with the following defined minimums from the deck to the underside of the finished overhead: • Main Deck Spaces = 7.5 ft • Common Area Spaces = 7.0 ft • Accommodation Spaces = 6.75 ft Headroom space and room for the installation of tall equipment shall be maximized while balancing the need for cable trays, adequately sized ventilation ducts, lighting, etc.	The distance from the deck to the underside of the finished overhead as follows: • Main Deck Spaces = 8.0 ft • Common Area Spaces = 7.5 ft • Accommodation Spaces = 7.0 ft Apply Human Engineering to all workspaces requiring Human-Machine Interface (HMI).	*Minor edit to reflect original SMR and be specific about certain spaces consistent with P-Spec.* *[Ref. 4]*
D.2.3	**Operational characteristics**			
D.2.3.1	*Icebreaking:*	*The capability to independently break ice of ≥4.5 feet @ ≥3 knots*	*Meet the threshold icebreaking criteria and maneuvering characteristics with up to one foot of snow cover.* *● Ice flexural strength = 500 kPa* *● Average speed in thin (0.5 m or less) ice = 5 to 6 knots* *● Level ice astern = 1.4 m (4.5 ft), same as ahead* *Maneuvering characteristics:* *● The vessel shall be able to turn 180 degrees within a diameter of 5 ship lengths (length on waterline) in 3.5-foot-thick level ice with 12 inches of snow cover, operating either ahead or astern* *● Breaking Out of a Track: In 4.5 feet of continuous level ice with 12 inches of snow cover, the vessel moving ahead shall be able to break out of an existing track and turn 90 degrees within 300 seconds from initiation of maneuver* *● Backing Out of a Track: In 4.5 feet of continuous level ice with 12 inches of snow cover the vessel shall back out of an existing track while maintaining directional ship control and turn 90 degrees within 300 seconds from initiation of maneuver* *● Star Turn in Level Ice: The vessel shall be able to turn 180 degrees within a 400-foot-wide reach in 4.5 feet of continuous level ice with 12 inches of snow cover*	*NSF made icebreaking performance a KPP and made the original Objective SMR the threshold.* *[Ref 1 & 2]* *Added the details of the additional ice maneuvering criteria in the Objective SMR, but some may be necessary to meet the threshold.* *[Ref 4]*
D.2.3.1	*Icebreaking: Polar Code Notation*	*Obtain an ABS Polar Code: PC 3 notation*		*KPP [Ref 1 & 2]* *Made meeting Polar Code PC3 a separate requirement but still part of the icebreaking KPP* *[Ref 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.3.2	*Endurance:*	Endurance of ≥90 days underway without replenishment. The criteria for meeting this requirement will be based on a Design Reference Mission (DRM) approved by NSF. Capacity to transport, deliver and pump ≥60,000 gallons of various grades of diesel to Antarctic research stations. This requirement shall not increase the total fuel capacity required to meet endurance requirement but achieved within the fuel capacity volume determined for endurance.		*NSF made Endurance a KPP and made Objective SMR the Threshold [Ref 1 & 2] requirement for transporting 60K fuel as part of endurance required fuel is a threshold requirement. Added DRM criteria. [Ref 4]*
D.2.3.2	Range:	17,000nm without replenishment at the defined cruise speed of ≥11 knots	17,000nm without replenishment at the defined cruise speed of ≥12 knots	*Added Speed [Ref 4]*
D.2.3.2	Operational Tempo:	Average annual operational tempo of 250-300 days/year		
D.2.3.3	Speed:	Cruise speed of > 11 knots in calm ice-free waters at ≤ 80% of installed propulsion motor maximum continuous rating (MCR)	Cruise speed of ≥ 12 knots in calm ice-free waters at ≤ 80% of installed propulsion motor maximum continuous rating (MCR) Maximum continuous speed of ≥ 14 knots in calm ice-free waters.	*Reverted to original SMR threshold and objective requirements of 11 & 12 knots in calm ice-free waters for cruise speed, but MCR requirement. Added Maximum speed consistent with P-Spec.* *[Ref 1 & Ref 4]*
D.2.3.4	Sea Keeping:	≥ SS4 - fully operable ≥ SS5 - operable for most routine operations ≥ SS6 - shipboard personnel can safely work Targets for maximum motions in SS5 are as follows subject to further study: • Limit maximum vertical accelerations to less than 0.15 g (rms) • Limit maximum lateral accelerations to less than 0.05 g (rms) at lab deck level. • Limit maximum roll to less than 3 degrees (rms) Limit maximum pitch to less than 2 degrees (rms) Sea-keeping capabilities and environmental controls should allow year-round work in heavy seas of the Antarctic and Southern Ocean as well as within sea ice. Vessel motions should be minimized through hull design, weight control and the use of passive or active anti-roll devices such that personnel can safely work in the SS6 or greater. The design should promote the safety of equipment operation and instrument deployments.		*Added original SMR language back to SMR Table.* *[Ref 4]*
D.2.3.5	Station Keeping and Dynamic Positioning:	Meet ABS DPS-1 performance requirements and the following science mission requirements at best heading: • ± 5 meters in 35 knot wind, SS4 & 2 knot current • ± 20 meters in 35 knot wind, SS5 & 2 knot current	Obtain ABS DPS-1 notation • DP system design and operation should minimize noise, vibration, and adverse effects on the operation of acoustic systems as much as possible • These issues should be evaluated early in the design process. • The DP system should have outputs for interfacing with science systems.	*Made meeting DPS-1 requirements the threshold SMR & getting the ABS Notation objective, added back original SMR language. This is consistent with the P-Spec (VP5)* *[Ref 4]*
D.2.3.6	Track Line Following:	As close as possible to objective when meeting requirements for station keeping & DP	Maintain a track line while conducting underway surveys for spatial sampling and geophysical surveys • within ± 5 meters of intended track • and with a heading deviation (crab angle) of less than 45 degrees • with 30 knots of wind, • up to sea state 5 • and 2 knots “beam” current. • This target may be required for ship speeds as low as 2 knots. • Straight track segments shall be maintained without large and/or frequent heading changes.	*Added remaining original SMR language to Objective SMR.* *[Ref 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.3.7	Ship & Winch Control:	Ship control and control of major deck machinery should be designed and specified with an integrated approach that: • Maximizes visibility, communications, safety, and efficiency of operations • Provides good visibility with clear sightlines to aft working deck and starboard side working deck deployment areas from the ship control and winch control stations. An aft winch control station (Deck Operations Station) overlooking the working decks shall be provided. Where needed visibility can be augmented with video cameras, especially for areas blocked from view	Include an aft control station located in the Bridge to provide a clear view of the aft decks. This station is intended to be primarily used during science operations on the aft weather decks and when backing into ice. Communications and video monitoring requirements are critical in the design of an aft control station. Include a connection in Deck Operations Station for a DP system portable control pack or additional ship controls.	*Edits to match original SMR and to add the Aft Deck Operations Station in the threshold column and the Bridge Aft Control Station into the Objective SMR column. This is to clarify the intent of the original SMR and to align with the PSPEC.* *[Ref 4]*
D.2.3.8	U/W Radiated Noise	"Sonar self-noise" should meet or exceed manufacturer's requirements. Significant efforts should be directed towards making the ship as acoustically quiet as practical without negatively impacting icebreaking capabilities. • Underwater radiated noise and airborne noise specifications should be developed using an experienced shipboard noise consultant. • Special consideration should be given to machinery noise isolation, including heating and ventilation. • Propeller(s) are to be designed for minimal cavitation, and hull form should attempt to minimize bubble sweep down • Sonar self-noise should meet or exceed manufacturer's requirements. Underwater radiated noise criteria that are less stringent than ICES 2009, such as those used for the RV *Sikuliaq*, RV *Armstrong,* and RV *Ride*, should be considered as a target.	The use of a drop keel or retractable centerboard could be considered to improve acoustic system performance. Lower noise levels around drive frequencies to the extent possible in the URN noise curve. Significant and detailed technical compromises are necessary to achieve a reasonable balance between the performance of ships' acoustic systems and the power and strength necessary to be an efficient icebreaker.	*Edited to better match original SMR and moved drop keel to objective requirement.* *[Ref 4]*
D.2.3.9	Helicopter Support	Requirement removed by NSF		*Requirement removed by NSF* *[Ref 1]*
D.2.3.10	Off Vessel Support for Field Work and Logistics:	Capable of support for field work off vessel on the ice, in boats, on islands and other land-based field camps and stations. It must also be capable of supporting transport of personnel, supplies and equipment to stations and field camps. Capacity to transport, deliver and pump ≥60,000 gallons of various grades of diesel to Antarctic research stations within the total fuel capacity required to meet endurance requirement. Requirements that support these activities are contained in SMR elements for Cranes (including accommodation ladder for rapid deployment to and from the ice), Vans, Storage, Work Boats, and inherent in many others such as endurance, icebreaking, dynamic positioning, seakeeping, etc. In developing the operational profile and design specifications the support for these activities off the ship should be carefully considered. The requirements for Work Boats and the ability to rapidly and efficiently deploy and recover these work boats is key to meeting this SMR.		*Added additional language from original SMR.* *Put the requirement to carry 60K of fuel and transfer to stations in this requirement.* *[Ref 4]*
D.2.4	**Over-the-side and weight handling**			

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.4.1	Over the side handling:	An integrated approach to design and specification of weight handling and over-the-side equipment based on required science performance requirements is required. Whenever possible, control of winches with handling devices should be coordinated and automated. Plan for the use of temporarily installed systems for some requirements such as large ROV systems, longer length coring, drilling, etc. Design should support flexibility and safe/efficient operation. Create arrangements that will protect winches from the weather, allow for use to multiple locations such as over the stern and the side. The use of an over-the-side handling system single source vendor or system integrator should be considered.	Account for current advances in technology and tension member (wire/cable) developments including the use of synthetic cables. Consider innovative designs for deployment of systems in ice and very cold conditions. For example, some recent research icebreaker designs include a "side pool" system that creates a protected ice-free area alongside the ship's starboard side CTD launching area.	*Edited to reflect original SMR language.* *[Ref 4]*
D.2.4.2	Winches & Wire: General	These vessels should be designed to operate with a new generation of oceanographic winch systems that are an integral part of the equipment handling and deployment system. The winches should: • provide fine control (0.1 m/min under full load); • maximum winch speeds should be at least 100 meters/min; • constant tensioning and other parameters, such as speed of wire, should be easily programmable • 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 of automatic controls. • Wire monitoring systems with inputs to laboratory panels and shipboard recording systems should be included. • Wire monitoring systems should be integrated with wire maintenance, management, and safe working load programs. • Local and remote winch controls should be available. • Remote control stations should be: ○ should be located for optimum operator visibility ○ with reliable communications to laboratories and ship control stations. • Winch control and power system design should be integrated with other components of over-the-side handling systems to maximize safety and protection of equipment in heavy weather operation and to maximize service life of installed wires. • Adequate provisions for connecting slip rings and ship's power and data network to the E-M and F-O cables should be included in the design. • See Frames and Handling Device design criteria for integrated hands-free operations	• Remote control stations should be co-located with ship control stations • Electric drives and motors should be used whenever possible.	*Reverted to Ad-Hoc report complete description of requirements and broke the SMR into sub-sections. Moved some requirements to Objective SMR.* *[Ref 4]*
	Winches & Wire: Hydro Winches	Two hydrographic-type winches capable of handling up to 10,000 meters of wire rope, electromechanical or fiber-optic cables having diameters from 1/4" to 1/2" should normally be installed. Winches should be readily adaptable to new wire designs with sizes within a range appropriate to the overall size of the winch.		*Used Original SMR language.* *[Ref 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
	Winches & Wire: Heavy Winches	A heavy winch complex should be permanently installed capable of: • handling 12,000 meters of 9/16" wire/synthetic wire rope • and/or 10,000 meters of 0.68" electromechanical cable (up to 10 KVA power transmission) • or 0.681 fiber optics cable, or modern equivalent in active use. • At least one winch should be capable of supporting operations over the stern and starboard side. This complex is envisioned as one or two winches with the possibility of multiple storage drums that could be interchanged in port. Alternately this could be a traction winch with two or more storage drums that can be used interchangeably. Winches should be adaptable to new wire/cable designs including synthetics within a range appropriate to the overall size of the winch.		*Used Original SMR language without moonpool reference.* *[Ref 4]*
	Winches & Wire: Other Design Criteria	Winches handling fiber-optic cable should normally be traction winches that allow storage of the cable under lower tension unless new technologies in wire construction allow otherwise. This includes winches for both 0.681" and smaller cables. Wire fairleads, sheave size, and wire train details need to be integrated with the general arrangement as early in the design process as possible in order to increase the possibility of limiting wire bends and overly complicated wire train. Sheave sizes, number, and locations should be designed to maximize wire life and safe working load. Requirements in 46 CFR 189.35 - "Weight Handling Gear" and in the UNOLS Research Vessel Safety Standards should be adhered to. It should be possible to fairlead wires from permanent winches over the side or over the stern. Details of winch location should include provisions for easily changing wire drums, spooling on new cable, and changing from one storage drum to another, and for major overhaul of winches so that these operations can take place with minimum time and effort in port. Some operations, such as re-reeving wires through fairlead blocks or switching the wire being used through a frame or with a traction winch, should be factored into designs so that the operations can be performed at sea safely and efficiently. Permanently installed winches should be out of the weather where feasible to reduce maintenance and increase service life.	The trawl/tow winch should be below the main deck, but smaller winches may be located in semi-protected areas of upper decks to allow for better fairlead.	*Used Original SMR language. Moved some language to objective SMR.* *[Ref 4]*
	Winches & Wire: Temporary Winches	Additional special-purpose winches (e.g., clean sampling, pumping, multi-conductor) may be installed temporarily at various locations along working decks. Winch sizes and power requirements should be considered during the design phase in order to establish reasonable limits based on the vessel size.		*Used Original SMR language.* *[Ref 4]*

D.2	**Science Mission Requirements**	**Threshold Requirement** **PEP Appendix 01 – Rev 03**	**Objective Requirement** **PEP Appendix 01 – Rev 03**	**NSF Approved Changes to SMR**
D.2.4.3	Cranes	A suite of modern cranes should be provided to handle the required cargo loads, scientific equipment deployments in the cold weather conditions of the intended operating area and should be integrated with the entire over-the-side handling system. • One or two cranes that provide the capability to reach all working deck areas and that are capable of offloading vans and equipment weighing up to 20,000 lbs. to a pier or vehicle in port is desirable. This will generally mean being able to reach approximately 20 feet beyond one side of the ship (usually starboard) with the design weight. At least one crane should be able to deploy buoys and other heavy equipment weighing up to 10,000 lbs. up to 12 feet over the starboard side at sea in sea state 4 or 5 if possible. At least one crane should be articulating in order to keep the load close to the crane head. • At a minimum one crane should be certified for lifting personnel. This will allow for placement of personnel via basket over the side of the vessel, onto the sea ice, small craft, or ice shelf. • One or two smaller cranes, articulated for work with weights up to 4,000 lbs. at deck level and at the sea surface, with installation locations forward, amidships, and aft should be provided. They would also be usable with relocatable crutches (or other means) as an over- the-side, cable fairlead for vertical work and light towing. • If the design includes the need to store and launch boats or to deploy equipment from the foredeck, then design for cranes or weight handling should accommodate those needs. • Cranes may need to have servo controls, motion compensation or damping as part of the integrated over the side handling systems. • The highest rated crane needs to have the capacity and reach to service a Geotechnical drilling rig. The ship should be capable of installing and carrying portable cranes for specialized purposes utilizing the deck bolt down system and/or container fittings with foundations and capabilities within the limits of the existing structural deck requirements.		*Used Original SMR language with some minor edits.* *[Ref 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.4.3	Frames & Handling Devices	A Stern A-Frame and handling devices on the Starboard and possibly Port side should be included to properly handle intended instrument deployments with wires and cables fairlead from installed and temporary winches. Design specifications and safe working loads should be based on the breaking strength of the intended wires and cables in accordance with 46 CFR 189.35 and the UNOLS Research Vessel Safety Standards. • Stern A-Frame dimensions and range of motion should accommodate intended instrument and equipment deployments. As a minimum the stern 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 for large ROV systems (up to 120,000 lbs. breaking strength). The stern frame should have a 15-ft minimum horizontal and 25-ft vertical clearance from the attachment point for the block to the deck. At least a 12-ft inboard and outboard reach is required. • Additional Starboard side handling devices should be designed for safe and efficient deployment of nets, towed devices, coring devices, small ROVs, etc. At least one Starboard side device should be capable of supporting wires or cables fairlead from the heavy winch complex. • A launch and recover system coupled to one or both hydro-winches to function as a CTD Handling System over the starboard side near mid-ship or from a Baltic room should be designed to allow safe and efficient hands-free deployment of a large GO-SHIP CTD system in ice or in open waters of sea state five or greater. • Cranes or handling systems for rescue boats and work boats should meet regulatory requirements and be designed and located for efficient, rapid, and safe deployment of the boats in sea state four or greater. • The ability to load cargo, equipment, and personnel safely from the vessel decks should be included in the arrangements for boat handling systems. • Small boats and Rescue boats should be capable of being launched with at least one crew member on board.	Consideration should be given to an A-Frame design that incorporates a forward maintenance position to facilitate changing blocks and wire leads as well as an outboard position parallel to the sea surface or near to it for deployments in ice similar to the A-Frame on Sikuliaq.	*Used Original SMR language without moonpool reference.* *[Ref 4]*
D.2.4.4	Towing/Trawls/Ice-clearing stern:	The vessel should be capable of towing large scientific packages up to 10,000 lbs. tension at 6 knots, and 25,000 lbs. at 4 knots. • Winch control should allow for fine control (± 0.1 meters/min) at full load and all speeds. • Winches should be capable of sustaining towing operations continuously for days at a time. • Towing operations include mid- to low-load operations with mid-water equipment such as towed undulating profilers, single and multiple net systems, and biological mapping systems. • Other systems may involve larger loads and spike loads such as deep towed mapping systems, bottom trawls, benthic grabs, camera sleds, and dredges. • The vessel should be capable of towing multi-channel seismic streamers and air guns. • Icebreaking design should consider the capability of creating sufficient ice-free area astern to allow the towing of nets and other equipment astern while icebreaking.		*Used Original SMR language.* *[Ref 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.4.5	ROV/AUV Support:	The vessel must be able to host and deploy/recover Remotely Operated Vehicles (ROV) and Autonomous Underwater Vehicles (AUV) with a wide variety of capabilities. • Provisions for operation in ice-covered seas need to be made, such as the possibility of deployment over the side after ice clearing, with a capable handling system. • Adequate deck space for up to four ROV support vans and dedicated launch and recovery systems along with sufficient deck and tie down hardware strength to accommodate the loads created with ROV/AUV systems will be required for the largest currently available systems such as JASON. • A hanger bay with climate control for staging ROV/AUV operations is required.		*Used Original SMR language edited to remove redundant language.* *[Ref 4]*
D.2.4.6	UAS Support:	The vessel should be capable of launching and recovering small, un-crewed aircraft for multiple science surveys, ice survey and reconnaissance (remotely or autonomously operated). The vessel design should meet the basic UAS shipboard requirements, including: • communication (air band radios) • sufficient "real-estate" to install system antennas (omni and directional) • sufficient physical clearance for take-off and landing • sufficient internet bandwidth to access remote sensing and aviation forecast products needed for flight planning. • rapid response via small boat may be necessary to retrieve a UAS that malfunctions or lands in the water.	A dedicated launch and recovery deck with an adjacent hanger/workshop should be considered.	*Prioritized NSF SMR.* *[Ref 2]* *Used Original SMR language edited to remove non-design related language.* *[Ref 4]*
		Intentionally Blank		

D.2	**Science Mission Requirements**	**Threshold Requirement** **PEP Appendix 01 – Rev 03**	**Objective Requirement** **PEP Appendix 01 – Rev 03**	**NSF Approved Changes to SMR**
D.2.5	**Science working spaces**			
D.2.5.1	Working deck area:	Working deck(s) area of ≥ 5,500 ft2 Design criteria includes: • Deck loading should meet the current ABS rules • An aggregate total deck load of 100 Tons is required to maintain the capability of the existing vessel. • Point loading for some specific large items should be evaluated in the deck design. • 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 the design of equipment foundations and 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. • Bulwarks should be removable and all deck-mounted equipment should be removable to a flush deck as much as possible to provide flexible re-configuration. • Hinged freeing ports or other means should be provided to maintain dry deck conditions in beam or quartering seas. A clear foredeck area and other additional deck areas should be capable of flexible and effective installation of: • small, specialized towers, booms, incubators, vans, workboats, UAS, and other temporary sampling 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 on decks supporting the installation of incubators. • Covered by direct visibility and/or television monitors from the bridge with maximized direct clear visibility for deployment areas. • The main exterior working deck should be equipped to keep key working areas ice free.	• Maximize open working deck areas at all levels at the main deck and above consistent with meeting other requirements to facilitate installation of additional vans, incubators and other equipment that require deck space or an open view of the sky. • 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. • Stern deck area should be as clear as possible and highly flexible to accommodate large and heavy temporary equipment. • The total aggregate load on the main working deck should be maximized within the constraints of deck size, variable science load and stability.	*Made the original SMR Objective requirement for total deck area the Threshold requirement and identified this as a prioritized NSF SMR.* *[Ref 2]* *Used Original SMR language edited to remove non-design related language and added deck size objective intentions.* *[Ref 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.5.2	Laboratories:	Scientific laboratory space of ≥ 5,700 ft^2 to accommodate up to 55 scientists. Lab spaces (with approximate square footage) should include the following: • Aft Dry Lab (~1100) • Forward Dry Lab (~1100) • Wet Lab (~900) • Hydro Lab (~750) • Baltic Room/Staging Area (~700) • Electronics Lab/Computer Lab (~700) • Environmentally Controlled Lab (~100) [Autosal] • Built-in refrigerators/freezers. ○ At least 2 rooms must be included. ○ Cooled independently. ○ Seawater drops in each room. ○ Humidity controls in each room. ○ High quality fixtures, corrosion resistant. ○ Deck bolts and drains. ○ Temp range 15°F to 50°F with variance of +/- 2°F (-10°C to 10°C with variance of +/- 1°C). • Bio Lab (~400) • Aquarium Room, with flowing seawater (~400) • Marine Technician Shop (~150) • Electronic Technician Shop • Electronic Equipment Room, with separation of computing facilities with climate control and limited vibration (~100) • Microscope Room (~100) • Changing/Mud Room (~100) • Hazardous material storage lockers on main deck • Gravitometer – appropriate space and location to meet operational and any security requirements.	Scientific laboratory space ≥ 6,500 ft^2 Use Containerized Lab Vans for functions that are not needed on every cruise to the maximum extent possible. The design should also accommodate these functions as much as possible as separate spaces, within other lab spaces or with space for dedicated lab vans: • Gimbaled platform • Electrophoresis equipment • Trace Metal Clean lab • Core Processing Facilities	*Used Original SMR Language with some items moved to Objective SMR. Used original threshold and objective total lab space requirements.* *[Ref 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.5.2.1	Layout & construction - General	Flexibility and support for different types of science operations within limited space are the important design criteria for these vessels. Construction and Material Requirements: • Benches and cabinetry should be flexible and reconfigurable (e.g. SIO erector set and/or Unistrut™). • Bench and shelving heights should be variable to allow for installation and use of various types of equipment. • The ability to easily install or remove cabinets and drawers as needed between cruises should be included. • Provisions for large, flat chart/map tables including a light table should be incorporated. • High quality benches and cupboards installed in all lab areas. • Countertops should be chemical resistant where needed. • 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. • Countertops could have brass inserts for eyebolts in a grid pattern, every 2 feet. • Overhead cupboards should be high quality and have LED adjustable task lighting available. • 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. • The distance from the deck to the underside of the finished overhead should be 7.5 to 8 feet. Headroom space and room for the installation of tall equipment should be maximized while balancing the need for cable trays, adequately sized ventilation ducts, lighting, etc. • Through the design process, minimize the incursion of "ship stuff" (e.g., air handlers, gear lockers, electrical panels and transformers not related to the labs, sounding tubes, valve controls, food freezers and etc.) into the lab space. • Labs should have Unistrut™ on the bulkheads and in the overhead. Consider Fiberglass Unistrut™ • Bulkhead pass throughs to adjacent labs and spaces in all labs with approved watertight and fire boundary ratings. Allow for growth in the number of cables. • Doors must be wide enough for cargo. • Laboratory spaces shall be located on Main Deck, adjacent to each other and the working deck area as much as possible.	Other design criteria to consider and include as much as possible include: • Clean sites for genomics and trace organic and metals analysis and sample preparation. • Installed gas bottle racks in all labs, removable, 5 bottles each. • Oldham MX43 gas detector or equivalent installed in all labs. • Specific laboratory HVAC requirements to be carefully designed and installed. To include independent temperature control for each space, filtered to provide high quality air with the intakes located away from contaminating sources, minimum 8 - 10 air changes per hour. • Small flammables cabinet. Located near exterior door where CTDs are done. • Small anteroom for clothes changing wet/cold gear strongly preferred. • Capability of storing instruments and sampling gear, washing nets, and processing benthic samples in a warm environment during winter operations.	*Used Original SMR Language with some items moved to Objective SMR.* *Broke this SMR into sub-sections.* *[Ref 4]*
D.2.5.2.1	Layout & construction - Lighting	Lighting Requirements: • Include natural lighting in most labs, with the ability to black out portholes. • Light levels in labs should meet UNOLS standards, 100-foot candles. • Lights must be controllable in the aquarium room to darken space.		*Used Original SMR Language.* *Broke this SMR into sub-sections.* *[Ref 4]*
D.2.5.2.1	Layout & construction - Decks	Lab Deck Requirements: • 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 that need to stand for long periods. • Labs should have bolt downs (1/2"-13NC on two-foot centers) in the. Deck bolt downs on one-foot centers should be considered for some areas.		*Used Original SMR Language.* *Broke this SMR into sub-sections.* *[Ref 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.5.2.1	Layout & construction – Fume Hoods, Sinks, Water & Air	Fume Hood Requirements: • Locations for two chemical rated fume hoods with explosion proof motors in the main lab and one in the wet lab should be included. • 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. • Snorkel system with removable snorkels must be present in all labs. 1-4 snorkels per lab. • Fume hoods and snorkels must not recirculate into ship and shall exhaust safely to atmosphere away from personnel. Sink Requirements • Sinks should allow for flexible installation, removal, and additional sinks when needed. • At least two locations in the wet lab and four locations in the main lab (some located with the fume hoods) should be provided with stubbed out plumbing at convenient locations. • More locations can be provided if possible. • At least one large sink with a sediment trap that is easily accessible for cleaning should be included. • 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. • Fresh water, hot and cold must be available in: ○ All labs except computer or labs with only electronic equipment. ○ 1-3 sinks per lab. ○ Salt water from the uncontaminated seawater system must be available in each lab with a sink. ○ Seawater must be available in copious quantity in an aquarium room. • There must be filtered emergency eyewashes on all sinks, emergency showers in each lab. There should be drains under all showers. Emergency showers at least 20 GPM. Eye washes at least 0.4 GPM. All lab spaces should have at least one eyewash station.	Other design criteria to consider and include as much as possible include: • Ships compressed air drop available on ceilings in each lab. • Ships compressed air must be sufficiently clean to support a liquid nitrogen plant 30-40 psi. • Microscope Room [should be] quiet, low vibration, [with] space reservation for antivibration table, compressed air connections, water and sink, no window required. • Clean Lab [will have] high flow HEPA hood and laminar flow hood. Laminar flow at the door. Trace metal clean (no metals inside of this lab). • Ice makers required in 1 or 2 labs.	*Used Original SMR Language with some items moved to Objective SMR.* *Broke this SMR into sub-sections.* *[Ref 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.5.2.2	Lab Electrical - General	Each lab area is to have a separate electrical circuit on a clean bus and continuous 'household' quality power. • The electrical system capacity and design should consider 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 50 to 200 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 included to the maximum extent possible. • Clean uninterruptible power should be available throughout all laboratory spaces, bridge/chart room, and other spaces as necessary to protect equipment, data, and operations. ○ The use of modular UPS design can be considered. • Separate circuits should be available for tools and other equipment that will not interfere with clean power circuits. • Use current IEEE 45 or equivalent standards for shipboard power and wiring and current IEEE standard for UPS and clean power specifications. Scientific wire ways must be considered throughout the ship connecting relevant scientific workspaces. • These wire ways must be accessible for frequent change out of cabling to support various scientific missions. • Double-tiered wire trays, with one tray above hidden ceilings for long term cable placement and one tray below the ceiling for rapid cable routing are required. • Science wireway routing will be defined between various laboratories and include other working areas including the pilot house, main and forward mast, staging bay and aft working deck. • Science wire ways should be separated from power and other signal cables. • Transitions through watertight bulkheads and decks will be appropriately protected with approved pass-through systems. • Where applicable, conduit piping to connect scientific workspaces on different ship levels shall be used. The quality of the electrical power supplied to science & ship control systems is very important. Electrical power quality specifications should be implemented and met (e.g., a specified maximum percent total harmonic distortion at a common reference point, along with voltage, stability, phase, and power quality rating specifications).	The design should include a specific electrical power plan for each laboratory or other designated science space, including locations designed to support science vans, climate-controlled chambers, and so forth. The electrical power specifications in the science design should also be specific in terms of power quality. Consideration should be given to the feasibility of using software-defined power systems.	*Used Original SMR Language with most items in the Threshold SMR.* *Separated circuits and receptacle requirements into a sub-section.* *[Ref 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.5.2.2	Lab Electrical – Circuit and Receptacle Requirements.	Electrical service for the labs should include: • 110/120 VAC, single phase 75-100 amps service for each lab • 120VAC Ship Power - Ship power system servicing all lab and computer spaces with at least 8 x 20 Amp circuits per lab in addition to the UPS service. • Lab Receptacles - Two 120-volt, single-phase receptacle strips, each fed by a 20-amp circuit breaker, shall be provided for every 6 linear feet of bulkhead and shall be installed at a height of approximately 42 inches above the finished deck. Each strip shall have six standard NEMA 5-20R receptacles. • 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). • Weather Deck Power Service - 2x 100 Amp 3-Phase 208V, 4x 60 Amp 3-Phase 208V, and 2x 100A 440V 3-Phase power for powering deck containers and portable equipment. Some systems may need as much as 200A of 440V 3-phase AC power. • Container Hold Power Service - 2x 100 Amp 3-Phase 208V, 4x 60 Amp 3-Phase 208V, and 2x 100A 440V 3-Phase power for powering container hold containers and portable equipment. • 120VAC 30 Amp Power Service - Each Lab, Computer Space, Science Workshop, • Staging Area and Aquarium Space shall have at least one 30 Amp 120V 60Hz circuit provided in addition to normal 20 Amp service. • For van hook-ups - Electrical connections for 20 amps 440 VAC 3-phase, 40 amps 230 VAC 3-phase, and 40 – 50 amps 208 VAC single phase should be provided. 30 amps 110 VAC single phase may also need to be provided, but usually can be provided by panels in the van from step down transformers. There may occasionally be a possible need to supply electrical power to cargo vans being carried in route to science stations.	• Foreign Equipment Power Capability - 2x 20 Amp per lab and computer space at 220V 50Hz or the ability to provide conversion for foreign equipment power requirements when needed.	*Used Original SMR language from Ad-Hoc report, divided lab electrical into two sections, move most requirements to threshold SMR. Most of this is mirrored in the P-Spec.* *[Ref 4]*
D.2.5.3	Vans:	Total supportable vans in all spaces should be ≥ 20 Space is needed for carrying at least seven (7) “UNOLS Standard” lab vans or equivalent on the main aft deck plus the aft areas of decks above the main deck. Space is also needed in an area forward of the pilot house - sited to provide the best feasible degree of protection from heavy seas - for up to two additional “UNOLS Standard” lab vans. Capacity to carry at least eight (8) standard containers (including, for example, laboratory, berthing, or frequently accessed storage vans) in an accessible and human habitable working area below decks. Additional spaces should be provided for standard 20-foot intermodal containers being carried in transit to/from Antarctic research sites, containing equipment for other marine expedition legs, or to carry stored wastes, emergency supplies, or other items. Spaces intended for such vans do not require the full range of hook-ups for laboratory vans, but at a minimum must have 120/240-volt power available. All container tie-down locations intended to support laboratory vans should be supplied 20 amps 440 VAC 3-phase, 40 amps 230 VAC 3-phase, and 40 – 50 amps 208 VAC single phase should be provided. 30 amps 110 VAC single phase may also need to be provided, but usually can be provided by panels in the van from step down transformers; non-freezing fresh water and seawater lines; non-freezing grey water line; compressed air, and data and communications hook-ups, including for the ship’s emergency notification system. Work with radioactive materials should be restricted to radiation lab vans that remain isolated from the interior of the vessel.	Total supportable vans in all spaces should be ≥ 24 Design should consider that some vans might include specialized lab space (such as for working with radioisotopes, under contamination free and trace metal free conditions and/or other environmentally controlled conditions), or operator-supplied support vans for specialized ROVs, coring, or drilling equipment.	*8 vans below deck made threshold. Prioritized NSF SMR.* *[Ref 2]* *Used Original SMR Language with some items moved to Objective SMR.* *[Ref 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.5.4	Storage:	Storage spaces will include: • Storage for resident technician deck and rigging equipment and spares • Storage for resident technician shop equipment and spares • Storage for resident computer technician equipment, supplies, and spares • Reagent and hazardous materials storage, separate from crew hazardous materials. • Storage for spares for ship's science gear • Storage for specialized outdoor/weather clothing • Storage for spares and boxes for scientist-provided science gear • Climate-controlled storage (at least two, with temperatures individually selected from at least -20°C to +10°C), able to accommodate 10-foot-long cores, sited to permit an access path for the cores from the aft working deck. • Storage for compressed gas cylinders from the science teams • Storage for chemical and other scientific wastes • Storage for bulk cargo items to be delivered to Antarctic sites Storage spaces should be provided in all classes represented by those presently on the Nathaniel B. Palmer, with at least that ship's present capacities except: 1. Increased capacity for hazardous items storage, including in the laboratories, and for chemical wastes. 2. Significantly increased storage is needed for scientific cargo. This would include support for the storage needs of multiple cruise legs. The basic scientific cargo storage space should be at least twice that of the Academic Research Fleet global-class research vessels.	• Climate-controlled storage should be outfitted for optional use as climate-controlled laboratories if possible. • Significantly increased storage is needed for scientific cargo. This would include support for the storage needs of multiple cruise legs. The basic scientific cargo storage space should be ≥3 times that of the Academic Research Fleet global-class research vessels	*Added in the rest of the original SMR language, edited for clarity and with some items moved to the Objective SMR.* *[Ref 4]*
D.2.5.5	Science Load:	Sufficient variable science load should be included in weight, draft, stability calculations taking into account the required variable scientific equipment and systems, science storage, vans, additional work boats and deck load.		
D.2.5.6	Workboats:	The research vessel should be equipped with two 20-to-30-ft rigid hull inflatable boats (RHIBs) or the equivalent. • To transfer of scientists and their gear from ship-to-shore and ship-to-ice to make measurements, install instruments, and collect samples. • To conduct supplemental research activities that are made away from the vessel. • Boats should be optimized for work in brash ice and rocky shore landings. In addition, include a scientific workboat (~30 ft LOA) specifically fitted out for supplemental operations at sea • including data/sample collecting, instrumentation, and wide-angle seismic measurements. • The workboat should have 12-hour endurance • and include both manned and automated operation • and clean construction. • The scientific workboat shall be launched via its own davit system. Include a landing craft style workboat (25-30 ft LOA) or alternative to ensure the ability to land personnel and supplies ashore in support of field work. The RHIBs and Workboat locations on the research vessel should facilitate safe, easy and efficient launching and recovery. • Preference is to be able to launch craft with personnel aboard, rather than transferring people to the boat.	There are alternatives to the RHIB that are under development, which may be more suitable for operation in the rough and cold seas surrounding Antarctica. These alternatives should be given equivalent consideration.	*Added in all the wording from the original SMR and some additional edits consistent with the P-Spec.* *Added Landing Craft to Threshold requirement to be consistent with PSPEC and due to the importance of being able to put science and equipment ashore.* *[Ref 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.5.7	Masts: Fore and Main Mast	The ship shall have a permanently mounted foremast that is equipped with an instrument platform for permanently mounted atmospheric and meteorological sensors. The instrument platform shall also be capable of temporarily mounting additional sensors with preinstalled cableways for routing power and data cables. Access to the instrument platform shall be built into the foremast to allow at sea servicing and installation of sensors. The foremast shall be wired by 2 x 20 Amp circuits in a waterproof junction box and include an accessible wireway linking the foremast with interior scientific wireways. Provisions for the installation of ice lights if required should be included in the design of the foremast. The main mast shall be provided with yardarms capable of supporting five scientific packages each weighing 100 pounds and measuring 2 feet wide by 2 feet long by 3 feet high. This mast should have a clear view of the sky and able to support multiple GPS antennas, meteorological and optical instrumentation. This mast shall have a top working platform of at least 3'x10' in size for servicing instruments, be wired by 4x20 Amp circuits in a waterproof junction box and include an accessible wireway linking the midships mast with interior scientific wireways. Mast and Flying Bridge design and layout must consider the mounting and location of Satellite communications systems that allow for unobstructed view of communications satellites and continuous connectivity at any heading.	The foremast should have at least 3 inlet ports for air sampling that will accommodate Teflon tubing that can run from the foremast through a conduit to the foredeck and into the compartment below the foredeck. The ability to close off the inlet tubes to prevent water seepage when not in use is important. The ability to blow compressed air into the ports or tubing to expel liquid water during sampling is also required. The foredeck should include space for an air-sampling van with clean science power (110V and 220V) available to the van. • Similarly, the below deck compartment should have the same power supplies available. • Both locations should have access to the science Ethernet. • The foredeck van should also be able to incorporate additional inlet tubes and sampling ports that feed directly into the van. • Care should be taken that sewage line vents are not located near the van or foremast.	*Used original SMR language, moved some items to objective SMR.* *Separated SMR language related to other sensor requirements not directly related to mast design requirements.* *[Ref 4]*
D.2.5.7	Masts: Other Sensor requirements	The foredeck should also include a standard deck bolt pattern that easily allows the installation of a temporary (secondary) mast, davit, or crane. The davit or crane would facilitate the mission specific bow deployments of a temperature/conductivity (or other sensor) chain to sample the undisturbed upper ocean. There should be the capability to install temporarily larger and heavier atmospheric instruments (e.g., aerosol filter samplers, lidars, and upward looking radiometers, vertically pointing cloud radars) on the deck atop the bridge or other suitable place where there is an unobstructed view of the sky. There should be the ability to secure these instruments to the deck plates or the rails, with unobstructed views of the sky, adequate power, and the ability to connect to the interior scientific wireways.	Because the vessel will often be operating in sea ice, scientists will need to be able to map sea ice and sea ice drift in the regions in which the vessel is operating. This can be facilitated by having the ship's X-band radar data made available in near real time to the science team. Provision should be made to do so.	*Separated some of the Original Mast SMR not directly related to mast design requirements.* *[Ref 4]*
D.2.5.8	Geotechnical Coring & Drilling:	The vessel must be able to core sedimentary sections in ice-covered seas. The vessel must be equipped to acquire long stratigraphic sections (40 m via a piston core or other long core system). The vessel should be able to support drilling operations as allowed by sea ice movement and available ice-clearing assistance. Drilling in Antarctic waters typically requires at least one additional ship to reposition icebergs that threaten the drilling ship when engaged in operations. Be capable of accommodating temporarily installed geotechnical drilling to 300-400 m below sea floor, at water depths of up to 1250 m in ice covered areas. Improvement in sediment coring capabilities is linked to adequate laboratory and storage space for initial core analysis and cold storage.	The vessel must be equipped to acquire long stratigraphic sections 50 m via a piston core or other long core system).	*Used Original SMR language, rearranged slightly to separate coring from drilling requirements.* *Moved 50M piston core to objective requirement.* *[Ref 4]*
D.2.5.9	Moon Pool:	Requirement removed by NSF		*Requirement removed by NSF.* *[Ref. 1 & 2]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.5.10	Deck Incubations:	Deck incubator positions (unshaded by structure) with a means for securing to the vessel shall be provided. Seawater delivery to each incubator with a flow capacity of 50 gallons/min is required. Incubator seawater should be within 1°C of ambient seawater temperature. Fittings for water supply and outflow drainage will be required on the deck and as close to incubator locations as possible. Drain lines should be as large as possible to ensure proper flow through the incubators along with measures to prevent freezing. The total number of incubators to be serviced at one time should be determined considering available deck space and input from science users and will determine total pump capacity required. It should be possible that at least two deck incubators can be used simultaneously side-by-side. Plumbing should include valves that can be fine-tuned to adjust flow rates.		*Used original SMR language, slightly rearranged.* *[Ref. 4]*
D.2.5.11	Mammals & Bird Observations:	Design of the pilothouse area and/or flying bridge should include provisions for making weather- protected, heated, and obstruction free (at least a combined 180 degrees forward of the beam) observations by two to three scientific personnel. Bird and mammal observers will be on watch continuously during daylight hours and observation locations should include secured, but removable chairs, access to the navigation/data network, and a protected location for portable computers and/or logbooks. Mounting locations for big eyes or similar devices may be required for some observers. Observer locations should be free from radiation hazards generated by radars and other communication equipment.	If an ice bridge is included in the design, it could be considered as an option for providing the mammal and bird observation capabilities.	*Added remainder of the original SMR and reworded the ice bridge consideration as an objective SMR.* *[Ref 4]*
D.2.6	**Science and shipboard systems**			
D.2.6.1	Navigation:	Best available navigation (real-time kinematics, differential, 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. • Backups and redundant systems should be provided to ensure continuous coverage. • Best available electronic charting (e.g., ECDIS) and bridge management system shall be provided. • GPS aided attitude heading reference system (AHRS) and/or other available systems for determining ship heading, speed, pitch, roll, yaw, etc. as accurately as possible should be installed and integrated into ship and science systems. • Bridge navigation, management, and safety systems will meet all regulatory requirements and facilitate effective science operations with minimal manning. • Systems should be designed so that any changes to bridge navigational display and control systems will not have any effect on science data collection processes. • Communication of waypoint information between science and bridge system should be an integral part of the system. • Specification, purchase, and installation of systems should take place as close to delivery as possible to ensure the most up-to-date systems. • Provisions for temporary installation of short or ultra-short baseline acoustic systems and other navigations systems, when necessary, should be included so that they can be integrated with existing systems.	ABS Requirements for Notation NIBS (Navigational Integrated Bridge System) should be considered as a design and construction requirement.	*Added remainder of original SMR and added NIBS as an objective requirement.* *[Ref 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.6.2	Data Network:	High-speed data processing facilities capable of handling large data sets for rapid processing, display, evaluation, and archiving are needed. System hardware should be designed to accommodate the highest data rates available at delivery of the vessel. • data sets might include LiDAR elevation surveys from glaciologists, seismic imaging and multibeam swath map output. • System should include receiving real-time updates of the ship's navigation data and disposition of the X-band radar data for analysis by the science party. A split IT network with dedicated USAP servers and other equipment separate from any crew IT network is necessary. • Four (4) network drops per stateroom are required (2 - person owned computers, 1 - smart tv, 1 - IP phone). • At least One (1) network drop per common area, lab and other areas to be designated for WIFI (WAP). • Two (2) drops per station in all computer / dry lab areas. • Four (4) network drops in IT / ET workshop. • CCTV must be available in every lab. • A central command station for all operations must be available, this includes a radio and CCTV at hand, and room for several monitors. • GPS strings must be available in every lab. • All labs should have WIFI access and LAN drops, at least every 4 bench feet. • There must be a lab dedicated to servers, etc. that has adequate space for racks and other DAS equipment. A data presence system shall be capable of local (ship-based) data processing and further visualization of real-time data with the potential for a shore-side component. It is recommended that user input be sought by the NSF to identify key data-intensive instruments needed by a wide user group and to have these and the support systems they require set-up on the vessels.		*Added some of the additional original SMR language, re-arranged for clarity and without some of the discussion.* *[Ref 4]*
D.2.6.3	Real Time Data:	A well-designed "system" is required for real-time collection of data from permanently installed sensors and equipment as well as from temporarily installed sensors and equipment that allows for archiving, display, distribution, and application of the data for a variety of scientific and ship- board purposes. • This system 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. • It should include real-time updates of the ship's navigation data and disposition of the X- band radar data for analysis by the science party. • While planning for this system should begin at early stages to ensure that it is integrated into the ship's infrastructure, the actual specification of hardware and operating system should be made as close to the delivery of the vessel as possible to ensure an up-to-date system.		*Added all the original SMR Language.* *[Ref. 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.6.4	Internal Communications:	Internal communications including phones, PA, entertainment systems, ship alarms, some bridge comms, via LAN, voice and CCTV connections throughout laboratories and living spaces should be designed and provided with an integrated approach and should include: • Internal communication system providing high quality voice communications throughout all science spaces, working, berthing areas should be provided, and be available to all inhabited vans. • 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. • 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. • There should be CCTV outlets in all science spaces and staterooms, with channels available in those locations to monitor science operations and environmental conditions. • 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, common areas, and staterooms. 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. While planning for this system should begin at early stages to ensure that it is integrated into the ship's infrastructure, the actual specification of hardware and operating system should be made as close to the delivery of the vessel as possible to ensure an up-to-date system. Fiber-optic cabling for data and VOIP communications should be installed throughout vessel.		*Used all original SMR language edited for clarity.* *[Ref. 4]*
D.2.6.5	External Communications:	Primary high-speed Internet access will be provided by a Very Small Aperture Satellite (VSAT) system. A location for installing a 2-to-3-meter VSAT or similar actively stabilized antenna will be provided in the design with a full-sky view. Above 70 degrees Latitude Internet connectivity will be provided by ganged (load equalized) systems via Low Earth Orbit (LEO) satellite systems such as Iridium Pilot, or one of several emerging LEO offerings that may provide more bandwidth than Iridium over the poles. Ship-based weather satellite receivers (e.g., Terascan ™ and Dartcom) provide real- time visual and infrared imagery from NOAA HRPT and DMSP satellites with no delay. The ARV design should have a suitable mounting location for a 1.5m dynamic antenna to support direct satellite reception. The technical specifications for external communications should be re-evaluated at final design time to consider recent technical developments. The actual specification of hardware and operating system should be made as close to the delivery of the vessel as possible to ensure an up-to-date system.	A flat panel phased array antenna should be considered. The operating area and schedule of the ship will probably require it to be outside of VSAT footprints often and therefore a location for an Inmarsat ™ antenna such as a Fleet Broad Band ™ will also be required. Goal should be a radio uptime requirement of 99% uptime for satellite radios, either by dual radome or some other means. A split IT network with dedicated USAP servers and other equipment separate from any crew IT network is recommended. Due to limited top deck space, it is likely that satellite antennas will need to be shared between the ship and USAP IT networks. Newer technologies implemented in the higher latitudes should be considered as the design develops.	*Used all original SMR Language.* *[Ref. 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.6.6	Science Seawater System:	Flow-through scientific seawater system capable of delivering ≥40 liters/minute to all laboratory spaces. The underway system should be designed with the following criteria: • The underway seawater sampling system should consist of an intake near the bow and the surface to provide uncontaminated seawater, resistant to ice-clogging, while the ship is underway and/or stationary. • Careful attention to system design for operations in ice is necessary to minimize and mitigate ice-clogging drawing on lessons learned from other ice capable research vessels. • A secondary intake location for use if the primary intake is compromised by heavy seas or ice clogging. • 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. • Minimize the time lag between intake and sampling location (sensor suite and/or lab sinks) with an objective of less than 2 minutes desired. • Include an alarming system for seawater if it over pressurizes or shuts off. • Anti-icing: develop requirements to deal with de-icing that does not affect seawater requirements. • Piping material should be corrosion resistant and as chemically neutral as possible within the limits of regulatory requirements. • If more than one intake is installed ensure that the intake being used is flagged in the data stream. • This system will support a suite of standard sensors (temperature, conductivity, depth, and fluorescence), but also be flexible enough to include multiple ports for additional sensors. • Provide underway seawater taps at 4 or more sinks in lab-accessible spaces • Allow users to configure to either continuous or discrete sampling of underway. • Additional access points should be provided in sinks in other labs (chem. labs, trace metal labs, wet lab) • Ability to access underway seawater from labs in vans on deck). • Design for installation of additional sensors (user-supplied or ship supplied) mounted near the ship's 'standard' CTD-fluorometer package. • Although these additional sensors could be standalone with their own datalogging, the underway system should be designed to allow the voltage output to be recorded and merged with the ship's underway data feed. • The underway sampling system should include an infrared sensor installed at the bow for measuring sea surface skin temperature. • Maintenance of the underway sampling system is critical for obtaining high-quality data. The system should be designed to conduct periodic (approximately daily) back-flushes with freshwater or a dilute bleach rinse, to prevent accumulation of growth/biofilms in the underway plumbing. • The system should have the ability to access coarse strainers for conducting daily rinses. This can be done by bifurcating the inflow so that one side can be taken out of line for cleaning.	Flow-through scientific seawater system capable of delivering 100 liters/minute to all laboratory spaces. Add a third intake point for improved mitigation of fouling in various ice conditions. Consider adding a low flow seawater intake or collection system that could be used to capture and hold delicate biological organisms without damage.	*Edited and added in most of the original SMR Language. Retained the Original SMR threshold and objective flow requirements consistent with the P-Spec.* *Added an objective requirement for collecting delicate biological organisms through a seawater intake similar in purpose to the "Wet Room" on the NUYINA.* *[Ref. 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.6.7	Acoustic Systems: General	The hull design and structure for transducer installation should support the installation and operation of the following systems: General Requirements: • At sea transducer maintenance capability wherever possible. • Hull design or features designed to minimize bubble sweep down • Noise and vibration treatments to minimize SONAR self-noise	A drop-down keel should also be considered carefully to: • minimize effects from bubble sweep down • provide capability for the installation of mission specific equipment without need of a dry dock	*Except as noted below, this SMR is not changed other than breaking it into separate systems.*
D.2.6.7	Acoustic Systems: Multi-Beam Mapping	Deep Ocean and Shallow Water multibeam bathymetric mapping systems.		
D.2.6.7	Acoustic Systems: ADCP	38 kHz and 75 kHz Acoustic Doppler Current Profilers (ADCP)	If space permits, a 150 kHz and/or 300 kHz (ADCP) systems for use in shallow water	
D.2.6.7	Acoustic Systems: Sub-Bottom Profiler	3.5 kHz Sub-Bottom Profiler, CHIRP or Parametric Narrow Beam Profiler.		
D.2.6.7	Acoustic Systems: 12 kHz systems	12 kHz Echosounder and 12 kHz Acoustic Release transponder		
D.2.6.7	Acoustic Systems: Bio-Acoustic systems	Bio-acoustic Sonars – 38, 120 and 200 kHz transducers as a minimum	Bio-acoustic Sonars –18 and 70 kHz in addition to the threshold requirement.	
D.2.6.7	Acoustic Systems: USBL	Ultra-short baseline (USBL) underwater systems positioning transponder (e.g., HiPAP)		
D.2.6.7	Acoustic Systems: Monitoring	Hydrophones and Hull-mounted Underwater Cameras (forward looking) for acoustic and bubble sweep down monitoring.		
D.2.6.7	Acoustic Systems: Forward looking SONAR	Forward looking SONAR for navigation		*Added FLS to be consistent with P-Spec.* *[Ref. 4]*
D.2.6.7	Acoustic Systems: Spare Transducer Wells	At least one spare transducer well for the installation of mission specific equipment. Transducer well should be sized to fit a ≥19” diameter transducer or the maximum size allowable by the surrounding structural members.	Two or more spare transducer wells for the installation of mission specific equipment. Transducer wells should be sized to fit a ≥19” diameter transducer or the maximum size allowable by the surrounding structural members.	*Added specific requirement for 1 to 2 spare transducer wells consistent with P-Spec.* *[Ref. 4]*
D.2.6.8	Seismic:	The vessel should have the power and infrastructure to deploy seismic gear, including towed multichannel streamers at speeds of 3.5-4.5 kts in moderate (3/10-4/10) sea ice cover. Use Containerized Compressors and systems that can be easily configured on board. Need to have a regular maintenance facility to ensure equipment remains functional. (Seismic Air Compressors (Borsig-LMF) 1,200 scfm at 2,000 psi, are adequate)	Built-in compressors and systems incorporated into the ship's systems. This objective requirement should only be implemented if it is determined that containerized seismic compressor systems cannot be reliably provided. If this determination cannot be made during preliminary design or final design phase, then a space, weight and power reservation for a suitable system should be incorporated into the design. A trade-off study should be conducted early in the design process.	*Containerized Air Compressor specified by NSF.* *[Ref. 1]* *Built-in compressor made an objective requirement to be evaluated for cost, maintainability, and reliability versus containerized unit. A trade-off study should be conducted.* *[Ref. 4]*
D.2.6.9	Project Systems & Power:	A very wide variety of scientist-supplied sampling and laboratory equipment must be accommodated, in a variety of locations on the ship, including, but not limited to, all laboratories, all science decks, and access points on the scientific seawater system, including near the intake. Design Considerations include: • The types of equipment will need to be defined during preliminary design cycle, 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 include 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.	The ability to provide direct power to select systems designed for foreign power requirements should be considered.	*Minor Edit - Added design considerations from the original SMR.* *[Ref 4]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.6.10	Discharges:	Compliance with new environmental regulations, such as emissions and discharges, is required. • The ARV will need to adhere to MARPOL and IMO Polar Code regulation with respect to discharges of wastewater and solid waste. • MARPOL regulations dictate that the waste must be held in holding tanks until the vessel is in ice-free waters. • Generally treated wastewater discharges can be made in areas having ice concentrations >0.1. • Untreated water discharges must be 12 nm. from land or ice and/or shore. • There can be no discharge of food wastes onto ice. Science related requirements: • All vessel underway discharge must be consolidated to one side of the vessel (normally port side) providing a "clean working side". • As a minimum, a holding period for treated wastewater to be 20 days. Onboard marine sanitation device (MSD) to be appropriately sized to be able to process grey or black water at the same or greater rate as USCG standard daily generation rates for crew and passengers. • A careful evaluation of daily wastewater generation and holding time requirements should be made as part of the design once crew complement and waste treatment and holding tank specifications are developed.	Increase holding time of treated wastewater to 60 days.	*Added other details from original SMR, no change to requirements. Clarified holding requirements and made 20 days holding a clear threshold requirement and 60 days an objective requirement for holding treated wastewater (gray and black).* *[Ref. 4]*
D.2.7	**Construction, Operation & Maintenance**			
D.2.7.1	Green Ship:	Meet IMO, USCG, Polar Code and Antarctic Treaty requirements. Environmental, sustainable ship design features should be incorporated in vessel design, but in use must not interfere substantively with critical mission performance criteria such as icebreaking capacity, endurance, and range.	These features might be included in the design and specifications: • Incorporation of recycled materials, non-polluting equipment and instrumentation and fuel efficient or alternative fuel technologies to make these vessels as environmentally friendly and cost effective as possible. • Based on best research ship practices at the time of design and construction, specific equipment and materials should be specified. • Green ship technologies might include use of reflective exterior paints and electrochromic glass to reduce HVAC loads, use of devices which provide improved oil-water separation, improved marine sanitation devices, design for use of environmentally safe oils, use of software-defined shipboard electrical power systems, and use of selective catalytic reduction (SCR) for emissions control. • A hybrid battery system should be considered as a potential addition to a diesel-electric configuration, with a goal of being able to provide zero emission periods for air sampling and quiet ship operations. Underway battery operation periods of approximately 1 to 4 hours at slow speeds (1 to 3 knots) or while holding station in calm weather is desired. A hybrid battery system also offers additional benefits in terms of peak power load shaving and instantly available power reserve in case of a generator failure. The capacity of the battery system should be maximized within the constraints of space, weight, and overall project cost.	*Added objective design features.* *[Ref. 4]*
D.2.7.2	ADA Compliance:	Implement ADA Guidelines as feasible to accommodate disabilities that meet USAP qualifications for participation, within the budget and size constraints for the vessel. Reference: ADA Guidelines for UNOLS Vessels_Final_Feb08.pdf. Implement specific guidelines detailed in NSF Memo (Ref 3 Jan 2022)		*Specific ADA Guidelines provided in NSF Memo January 2022 consistent with P-Spec.* *[Ref. 3]*

D.2	Science Mission Requirements	Threshold Requirement PEP Appendix 01 – Rev 03	Objective Requirement PEP Appendix 01 – Rev 03	NSF Approved Changes to SMR
D.2.7.3	Maintainability:	Starting with the earliest elements of the design cycle, the ability to maintain, repair, and overhaul these vessels, and the installed machinery and systems efficiently and effectively with a small crew should be a high priority. • Ship layout should include adequate space for ship repair and maintenance functions such as workshops with proper tools, spare parts storage, and accommodations for an adequate number of crew. • Design specifications should include provisions for reliable equipment (including adequate backups and spares) that are protected from the elements to the maximum extent possible. • Equipment monitoring systems and planned maintenance systems combined with configurations that provide for reasonable access by repair and maintenance personnel will help ensure that equipment remains in the best possible condition. • Specifications for equipment should require all equipment vendors to provide parts lists, manuals, and maintenance procedures in electronic form for integration with a Computerized Maintenance Management System (CMMS).		*Added specifics from original SMR.* *[Ref. 4]*
D.2.7.4	Operability:	Design should ensure that the vessel could be effectively and safely operated in support of science by a well-trained, but relatively small crew complement. • The remote Southern Ocean and Antarctic conditions, available ports, and shore side services should be considered during the design process. • The impact of draft, sail area, layout, and other features of the design on the ability to operate the vessel during normal science operations should be evaluated by experienced operators, technicians, scientists, and crewmembers.		
D.2.7.5	Life cycle costs:	A thorough evaluation of construction costs, outfitting costs, annual operating costs, and long- term maintenance costs should be conducted during the design cycle in order to determine the impact of design features on the total life cycle costs.		