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ARV Science Advisory Sub-Committee of the OPP Advisory Committee

Report on DR #1, May 23, 2022

Members:

Bruce Applegate, UCSD Scripps Institution of Oceanography
Alice Doyle, UNOLS
Amy Leventer, Colgate University (Chair)
Carlos Moffat, University of Delaware
Clare Reimers, Oregon State University
Deborah Steinberg, Virginia Institute of Marine Science
Patricia Quinn (NOAA/PMEL, member and OPP/AC liaison)

Tim McGovern, National Science Foundation - OPP liaison
Jonathan Michael Prince, National Science Foundation – OPP liaison

INTRODUCTION

This document highlights recommendations and questions regarding several main aspects of design for the new Antarctic Research Vessel: general arrangements (SECTION 1), habitability and green ships (SECTION 2), and cyberinfrastructure and satellite communications (SECTION 3). In developing our comments, we relied on our own past shipboard experiences and those of our colleagues, with an eye toward future science demands. We note that this larger and more capable icebreaker, with longer endurance and modern science support systems, is likely to be highly subscribed, and that missions to previously inaccessible and more distant parts of the Antarctic margin will attract proposals from many disciplinary and interdisciplinary teams, as we explore new territory. In addition, we note the possibility that at times, the US Antarctic Program may be a one-ship operation. For these two reasons, we anticipate that labs and decks often will be fully utilized, and that they will need to be designed to be multi-purpose. Consequently, our comments focus on flexible lab spaces that can be adapted as new technologies develop, though we recognize that many traditional modes of data and sample collection will continue to be an important part of oceanographic field work. We address maximizing the use of space, including interior labs, exterior deck space, and van space on decks and in the hold, to accommodate the larger science complement. We advise continued attention to workflow patterns between labs and deck spaces. We appreciate the attention to hull design and the focus on the tradeoffs between more capable ice breaking and a quiet ship that can acquire high quality data from hull-mounted sonar and other acoustic systems. We advise a re-assessment of the level of battery-supported no emissions operations to support specific kinds of science. We also address cyberinfrastructure and satellite communications, which will continue to evolve such that planning for the future is critically important. We conclude with a set of smaller scale questions and comments that we hope draw attention to details that will make for an outstanding new Antarctic research vessel (SECTION 4), and a list of items that we recognize require more attention and discussion for future resolution.

A few of the recommended Science Mission Requirements (SMRs) from the 2019 subcommittee report, including the moonpool, and helicopter-based science capabilities, are not included in the ARV design under review because of tradeoffs with respect to vessel complexity and size. While colleagues have expressed their concerns, we advocate designing other solutions to the operations envisioned for these vessel facilities. Loss of the moonpool means that geotechnical drilling through a centered moonpool will not be possible. However, the large back and starboard decks, space for specialized science vans, and winch and A-frame capabilities on the new ARV will be beneficial as we continue to develop other over-the-side or seabed-based drilling platforms that could access continental shelf drilling sites. A more capable workboat, and an ARV with enhanced AUV and UAV platforms may accommodate some, but not all, of the ocean-cryosphere science missions. Lastly, some operations will simply need to be planned from other vessels, for example from partnering nations.

	Ocean AGOR (Armstrong)	Sikuliaq	Global AGOR (Thompson)	Nathaniel B. Palmer	ARV
Length (LOA)	238 ft	261 ft	274 ft	309 ft	345 ft
Sci/Tech Berthing	22	26	36	45	55
Total Lab Space	1,732 sq ft	2,200 sq ft	3,554 sq ft	3,805 sq ft	4,497 sq ft
Working Deck Space	2,557 sq ft	4,000 sq ft	3,620 sq ft	4,054 sq ft	7,197 sq ft
Endurance	40 days	45 days	60 days	75 days	90 days

SECTION 1: General Arrangements
Evaluation of the current design of lab spaces focused on the most common scientific activities to be conducted in each of the labs, and any special requirements for those activities. This included consideration of the normally installed equipment, furnishings, instruments and displays, the kinds of equipment and instruments that will be brought into each lab, and workflow patterns among labs, the CTD room, and the main deck. For each lab listed below, general text is followed by *questions*.

Main Deck

Computer/Mapping/Electronics Lab
This lab space will serve as "mission control" for the science team, used for day-to-day cruise planning, work with shipboard data. Space to be allocated to a large bank of monitors, dedicated workspaces/work surfaces for charts, laptops, workstations for UAV and drone data downloads and processing, marine geophysics (sub-bottom and multibeam data, towed seismics), and work with ROV and satellite imagery. This space at times may need to accommodate the full complement of 55 science personnel, though space may more often be shared between shifts. As mission control, there needs to be a clear line of communications between this lab, the bridge, the dry (or main) lab, and the UAV deck and back deck, as well as spaces such as the marine mammal observatory.

Current deck plan:
The space allocated in the “Electronics Lab” is only 700 ft2, which is even smaller than the NBP “forward dry lab”, 1150 ft2. Could the “Science office”, just aft of the “Electronics Lab”, be relocated or combined to provide more space for mission control? Could some portion of the Science Office be allocated to the Salinometer and/or microscope rooms, neither of which have been allocated space on these plans (see below).

Main Lab (Labeled "Dry Lab" in the AR1 Main Deck Plan)
This lab will serve as a general workspace for science equipment and for processing of water, plankton, and sediment samples that cannot be accommodated in other laboratories. Common activities include instrument programming, charging battery packs, sensor calibrations, filtration and processing of water samples, sorting plankton or setting up incubation experiments, microscopy (that does not require darkness), and description and sub-sampling of sediments. Key considerations here include adequate access to bench space, multiple sinks, multiple hoods, clean water and the uncontaminated seawater line, and easy access to refrigeration and freezer space. Water work may include carrying up to 20 liter carboys from Baltic Room and back deck into the main lab. Sediment cores will range from 1-6 meters in length and will be carried from the main deck into the main lab, and later stored in a cold room. All aspects of working with cores can be messy (muddy) and so require proximity to sinks with sediment traps, and easily cleaned floors.

Current deck plan:
Main Lab will serve the same function as the NBP aft dry lab, which will function as described above. Our primary concerns include ease of getting samples and equipment back and forth between the main lab and the back deck, and depending on the layout, between the main lab and the Baltic Room. We are not sure whether we need double doors as access to cold rooms – and suggest that the extra space be used to increase the lab size, since this will serve as an all-purpose lab.

Bottom Mapping Transceiver Room / acoustics
Racks with equipment, unfriendly to humans, need for security, humidity and temperatures control

Current deck plan:
Is this large enough to house the electronic equipment? Will this space also house the gravimeter? Ease of access to hull mounted transducers? The transceiver room needs to be within cable run distance to transducers. How easy will it be to service hull mounted systems? The suite of sonar and acoustic systems is good (the SB29 is a "game changer"), but the plan might benefit from some flexibility to add higher frequency ADCPs as well. Scientists need the ability to easily integrate mission specific transducers/transponders, either as part of a drop keel, or using a transducer tube similar to the SIO approach. We assume all the acoustics can fit in the box/drop keel? Or there will be exchangeable bases? USBL?

Biology Lab
Filtration and processing work with water, plankton, and sediment samples that include work with preservatives and/or poisons, so a hood is mandatory, as is sink space, access to clean water and uncontaminated sea water. Floor drains are required.

Current deck plan:
This could be a space where use of poisons (i.e., a "dead lab") is isolated from other activities such as live plankton incubations ("live lab"). Or should the Aquaria lab be the "live lab" and include spaces for live sample processing?

Hydrology Lab
This lab serves as the site of the "water wall" for underway surface seawater characterization and is a location for analytical work that requires relatively good climate control. Common activities include nutrient analysis, collection of samples for [CO2] work, and a variety of flow-through instrumentation, such as a

thermosalinograph, the CO_2 system, FlowCam / CytoBot plankton image analysis, and flow cytometry. Critical features here include multiple sinks and bench space for instrumentation, access to clean water and of course, uncontaminated sea water. Clean power outlets protected from seawater exposure should be distributed throughout the space. Samples coming from Baltic room and back deck are expected.

Current deck plan:
In the future, we anticipate an increase in flow-through instrumentation, so a larger hydrology lab may be needed. Given frequent work with image analysis of plankton directly from the seawater line, we note the need for a gentler system that is proximal to the ship's seawater intake. Also, we must have sufficient ice-free clean water.

Aquarium Room and Wet Lab
These labs serve similar purposes - used for wet, messy activities such as receiving and sorting of samples from plankton net tows, fish trawls, dredges, extrusion of multicore sediments, and incubation of live animals. These labs need access/ hook ups to flowing seawater at multiple sites, floor drains, and lots of sink space with sediment traps. In addition, these labs may be the site of cleaning moored instruments upon recovery when conditions are unsafe on deck.

Current deck plan:
We have concerns about having to go through Baltic room to walk between the aquarium room and the wet lab; it would be nice to have them contiguous since work in these two labs is complimentary, for example, incubating live animals in the aquarium room and bringing samples into the wet lab to process. For mooring work, when instruments are recovered, ready access to the main deck is key. On many cruises, we expect the Baltic Room to be used frequently, requiring access to the Wet Lab through the main passageway. While some of this could be done out of the Back Deck staging bay, access to water and sinks would be helpful. We recommend maximum flexibility in design such that each of these two labs could be used for all the activities described above.

Baltic Room
The Baltic Room is very heavily used for CTD operations. Space is needed for scientists to maneuver easily around the rosette, and to carry heavy carboys, and smaller racks of sample bottles out to other labs. The floor shouldn't have lots of tripping hazards. Ample floor drains are needed; if the room takes a big wave it needs to drain quickly.

Current deck plan:
While we understand that the Baltic Room was positioned to maximize stability during deployment of the CTD/Rosette, we have concerns about access to most of the labs, which are mainly forward of the CTD room, except for the Aquaria. Given the arrangement pictured, transport of samples/equipment between the back deck and the labs is via the main passageway or through the Baltic room. Our concerns include the need for closer and easier access in both directions. The question is how to minimize this problem through rearrangement of lab spaces.

Back Deck Staging Bay (Labeled "AUV Staging Bay" in the AR1 Main Deck Plan)
Staging of a variety of over-the-side gear, including but not restricted to AUVs and mooring gear. This could also include a place to secure a trace metals rosette. Note that although some instruments can be staged here, without sinks/water access, it doesn't replace a wet lab providing ready access to the main deck.

Current deck plan:
Will the staging bay have open access or a garage-door style access? Might it be enlarged and the adjacent shop sizes reduced? The door should be very large, and the bay needs to have a mechanism to easily get large/heavy equipment into / out of the room. The bay should be heated. Is the staging bay accessible through from the labs when the ship is in transit and/or when decks are secured? Could a door be added to the Gas Bottles Store for access to the Marine Tech Shop & Staging Bay?

Microscope Room
Physical stability is important for proper visualization (and so scientists don't get seasick). This lab is best located mid ship and aft for stability. Room will often need to be completely darkened for proper viewing of samples, so interior location is best. This room can also be used for fluorometry which requires low light. Space for 3 microscopes, plus their associated computers, and fluorometer, so 3 microscope desks and a space for at least one fluorometer or other instrument.

Current deck plan:
Not included on deck plans, could be on the main deck, but an alternate location, on 01 deck is acceptable. Perhaps this room could be located in the current position of the "Science Seawater" space.

Salinometer room
Climate controlled room for autosal, room for 1 person

Current deck plan:
Not included on deck plans

Other Decks

<u>0-1 Deck</u>
Lounge/Conference Room
Space for the entire science team for cruise planning, data presentations.
We suggest combining the Library and Conference room and having a separate lounge so that there is a "work" space and a space for relaxing.

Current deck plan:
This is a lot of space for an infrequent activity. Could the main lab be used instead for cruise planning and science team meetings? We note that the plans include the 0-1 deck lounge/conference room, the 0-2 deck science library, and the 0-3 deck conference room. We would like to re-visit the intended use of these spaces to be used for meetings, quiet workspace, telepresence/video connections, and lounge space.

<u>0-2 Deck</u>
Atmospheric Lab
Housing of electronics for instrumentation on the foremast. We've discussed whether it is preferable that the foremast be able to be laid down on the bow to install instrumentation (sonic anemometers, gas phase inlets, etc.) - user friendly. The rationale for this is that it can take hours to install flux instrumentation that would go on the foremast. The NOAA global class ships have this arrangement. On the other hand, the SIKULIAQ forward mast has provisions for getting access to mount instruments

without dropping the mast down, but that may or may not be viable depending on what needs to be mounted. The advantage of a fixed mast is that it is more stable and durable for icebreaking operations. Since the Atmosphere Lab will house electronics for instrumentation on the foremast, that will require throughputs through the bulkhead.

Current deck plan:
We note the need for an unobstructed location.
***Remaining item for future discussion and resolution: We will seek out details regarding the size and weight of anticipated instruments that will need to be mounted on the mast on a project basis, to address the suitability of plans.*

Science Library
*We are not sure what would be housed here since most materials are available online, could function as a quiet workspace, comfortable seating? Combining **Lounge & Library w/ Telepresence/video requirements?***
Keeping habitability in mind - should these be separate?

<u>0-3 Deck</u>
Conference Room - *not sure of intended use, berthing on 0-3 deck is mixed crew and science. Would this also function as the primary muster space?*

<u>0-4 Deck</u>
UAV Hanger and deck space
10 ft. of bench space for computer and ground station. Space for 2 - 3 people. Storage space for equipment.
UAV Deck - 825SF - *is this sufficient? Welcome addition to the ARV.*

The following input was provided by Chris Zappa, chair of the SCOAR committee:
In consultation with colleagues, they note that from their experience of flying UAVs from the RV Falkor and RV Araon (and that of the UAV pilots they have consulted), they noted that the current designed space is adequate as long as the spaces are roughly square, but stressed that the target for the design should be:
Dedicated Deck space of 40 ft x 40 ft. = 1600 sq ft.
Dedicated Hangar space of 30 ft x 30 ft. = 900 sq ft.

These dimensions were found to be the optimal dedicated space requirements for the types of systems they fly. This amount of space would likely be useful for a broad base of users. This allows for multiple UAVs (at least 3), ground control stations, and enough hangar work area for maintenance before, during and after flying. They suggest that these are dedicated spaces for the UAVs and not multi-purpose whenever the UAVs are onboard.

<u>0-7 Deck</u>
Marine Mammal Observation Space
Space for 2-3 people, elevated location on ship with unobstructed view in all directions (360 degrees). Must have communications with the bridge and main lab (rapid seismic shutdown). Space must be heated.

Meteorology Lab
Instrumentation for aerosol and gas phase species that require the shortest inlet possible to minimize sampling losses. 40 ft. of bench space for instrumentation with the ability to swap about benches for instrument racks the PIs will bring. Space for 5 - 6 people. Bench or rack space for electronics for instruments on the deck (see below). Hole in the ceiling with a sampling mast extending ~ 3m above ceiling height. Throughput holes from the ceiling into the lab for additional gas phase inlets. Instruments requiring an unobstructed view of the sky (lidars, radars) mounted on the deck starboard of the Met Lab.

Vans
We have many questions concerning container space and access on the ARV, as described below. Currently the ship will be designed to carry 20 container vans, but it's not clear where they will be located, and depending on location, how easy they can be accessed.
Three vans can be mated with a passageway to main deck laboratories but their range of purposes is unclear.

How many containers are workable/accessible on the back deck? Are there more than the three slots indicated on the deck diagram? Are these three in a garage? Will they all have access to power? Water?

Eight containers fit in the hold, stacked two high. How will we access the hold while at sea? Will these vans in the hold serve as storage and/or lab space? How will the upper vans be accessed? What is the ease of moving cargo around the hold?

The list below highlights the number of vans needed for a variety of science missions.

List of containerized science:

- Trace metal clean van (**1**) on back deck and trace metal clean rosette.
- Radioisotope van (**1-2**) (These vans are needed to keep the rest of the ship entirely radiocarbon free. Research groups may need to work with two different radioisotopes, (14C and 3H). These van are usually located on the back deck.
- Refrigerated Van - for experiments that require the samples to be kept cold while processing. Usually on the back deck, but it may be that this work can be cone in one of the interior cold rooms near the main lab.
- Sediment coring vans (**4**) **-** MST track van (with cesium source), core splitting van, archival supply van, CT-scanning van (shielded van), best if all on back deck though archival supply van could be in hold if easily accessible and supplies can be moved easily.
- ROV work, for example Jason, typically shipped with **5** vans and the team brings **4** vans on board - rigging van, tool van, and 2x control vans. The rigging van can go anywhere on board that has access. The tool van is on the main deck close to Jason, and the 2x control vans are on the main deck on some ships, on the 01 or 02 on some ships. Jason can be operated with a single control van if space dictates.
- AUV Work - for example AUV Sentry or other AUVs. It is expected at least **2** van slots are required.
- Seismic work will require compressor vans. Most compressor containers are 100 scfm each, need **2-3** compressor vans (depending on the array size ranges and rep rates) plus a backup. We had several questions about *how well compressor vans function in the Antarctic environment and how they will be cooled, which were answered by Lee Ellett at SIO. He noted that compressor vans can work in cold weather with a few modifications. They already have powered pre-heaters but in really cold conditions an antifreeze injector is needed for the air outlet. We also wondered about the number of compressor techs/engineers that are needed on board to care for those*

vans? Ellett noted that SIO has been running with a single compressor mechanic and four technicians for acquisition, compressor, and sound source support. It is a little lean but workable for up to three compressors.
Finally, What are the tradeoffs between containerized compressors versus on-board, built-in compressors?
Towed seismic work also requires **1** van for seismic gun servicing, and **1** container for the streamer. Total **6** vans on the back deck.

SECTION 2: Habitability and Green Ship

Habitability:
We are excited to see that the science complement of 55 people is one of the SMRs. Our comments focus on health and safety, and a reminder of this larger complement of scientists and science staff, and the likelihood of longer missions, potentially reaching the 90 day endurance. For these reasons, extra attention to comfortable living conditions is important.

1. How might the potential for health problems related to easily transmittable illnesses, (like COVID), be minimized? Additional considerations for HVAC and ventilation of spaces, the ability to isolate and ease of assisting people in isolation? Hospital access and size? It looks small for the number of personnel and needs to have easy access for getting injured folks in and out. Note that the 02 level Hospital placement locates it between two science cabins.

2. Have single-occupancy staterooms been considered? Strongly recommend single-person staterooms for marine technicians as well as for the crew -- for similar reasons regarding the ability for them to get adequate rest. They are considered under the COI as "scientists", but their role in many ways involves duties and responsibilities more akin to mariners.

3. Quiet on board -- in staterooms as well as work areas. Hearing loss is a significant concern for career mariners and techs. Quiet living/working spaces are more productive and welcoming. The design team made a comment about being concerned that staterooms would be "too quiet" because you might be able to hear noises from outside rooms --and cited 50dB. But that's not too quiet IMHO -- the bulkheads need to have noise reduction built-in. Totally worth it.

4. Lighting: well-engineered lighting (brightness/spectrum) is super important for similar productivity and comfort reasons.

5. Interior color palette and furnishings that are welcoming and pleasant. Consider involving an interior design professional.

6. WiFi connectivity in state rooms. (See ***Cyberinfrastructure***)

7. Space for refrigerator in mess for leftovers and late night or other snacking.

8. Place generously-sized workout space / gym in a decent place (natural light, not terribly noisy); they are often in such horrible spots.

9. Electrical outlets. Every stateroom should have at least 8 for device charging, personal computers etc.

Green Ship:
We appreciate all efforts toward Green Ship operations and recognize some of our own limitations in assessing the details described in the Engineering Report: Green Ship Alternatives Study Report. We focused on two aspects of the report, first hull design, which impacts icebreaking capabilities, seakeeping, fuel use, sonar and acoustic fidelity, and towing abilities. Second, we ask that the conditions for battery operations be reconsidered, so that a more robust determination of battery bank needs toward quiet ship operations can be done. We provide some guidance here.

1. **Hull Design** (elements to keep at the top of a list):

- o consideration of impact of hull design on sea-keeping performance in rough waters
- o acoustically quiet for highest quality marine geophysical data from hull-mounted systems
- o ease of clearing ice from under the hull (again for hull-mounted systems)
- o some hull-mounted instrumentation (e.g., EK-60) requires *in situ* calibration requiring positioning/moving a calibration sphere below transducer.
- o maintenance of ice-free path behind ship for safe towing of instruments – “ice clearing stern”)
- o low friction hull coating – many good reasons, lower fuel usage may become increasingly critical as fuel prices rise, also more environmentally friendly. Are any other complementary methods being considered?

2. **Battery operations conditions**:

Currently, the ship design includes a “battery bank” to run the ship for periods of low emissions – which could be for times that scientists are collecting samples/data that require no emissions and/or very quiet operations (10 minutes with 24 MW load) and/or for zero-emissions operation while in port (16 hours with 2 MW load). The difference in the number, and ultimately space requirement, for the batteries, is really large, for these two scenarios. Can this design driver be looked at again?

It is difficult to imagine atmospheric measurements that would benefit from an hour at a time of emission-free conditions. That requirement is usually met by moving the ship so that, when possible, the relative wind is on the bow. An emission-free period of 6-24 hours with a vessel speed of 2-3 kts would accommodate the atmospheric chemistry community.

We are uncertain of the need for zero-emissions while in port; what is the goal of having zero-emissions while in port for 16 hours? Environmental reasons and / or scientific?

*** We will continue to seek out more information about the kinds of science that would benefit from this (e.g., quiet operations during work with marine mammals), the amount of time per battery operation conditions, ship's speed for activity, and how often (i.e., daily? weekly?). These details will help evaluate parameters driving battery bank needs.*

SECTION 3: Cyberinfrastructure and Satellite Communications
As described in detail below, our primary concern is that we continue to look forward to needs and advances in these two elements of ship design, to anticipate space and resource needs in the decades ahead.

Cyberinfrastructure
Should be engineered into the ship at this early stage to ensure that adequate space and resources are reserved. CI requirements will evolve a lot over the life of the ship, so plan for future growth and flexibility. How will both operational technology (OT) and information technology (IT) be accommodated? Involve seagoing experts on CI and cybersecurity to design networking approach to assign correct resources.

- Network connectivity to staterooms (WiFi)
- Fiber to staterooms (for remote viewing of data/cameras)

Server room – is this big enough?
Shipboard networking is evolving towards enterprise solutions similar to land-based research facilities. This room needs to be scoped to house cyber infrastructure (computing clusters, VDI controllers, networking hardware) with space to permit full-size racks that are fully accessible. Work benches and supply storage should be adequate for IT technicians to work inside to maintain and troubleshoot hardware. AC needs to be adequate to maintain cool room temperatures. The door needs to be big enough to accommodate full-size racks. Recommend the designers reach out to folks at (for example) OSU, UAF, SIO and STARC who have designed or are designing similar installations in the ARF and on HEALY for recommendations. See specific comments below regarding cyber infrastructure.

o Almost everything is going networked or able to be put on a network these days. A structured wiring plan needs to account for future impact where many 8K video feeds are able to be propagated throughout the ship
o Any modern ship will have hundreds to thousands of devices plugged in
o Wiring materials and labor is cheap and easy to do ONLY during construction. A ship's wiring plan should take into account 20 years or more of use and plan accordingly. A holistic plan for how to serve ship operations and science needs should be developed. Coax, single-mode fiber, multi-mode fiber and some Cat (EG Cat7) cable should all be run between network distribution points to make patching systems from one point on the ship to another fairly trivial
o For maximum reliability with minimum bandwidth concerns, networking should generally be designed for high-performance and high-availability. Furthermore, component failures should be designed to gracefully degrade network rather than offline network as much as possible
o Should have network distribution points on every deck, for ease of wiring in unforeseen equipment down the line. For cybersecurity reasons, recommend they live in a dedicated closet -- much like a wiring closet in a building
o Plan for PoE++ or UPoE so that the network can power many small devices with clean cabling backed by UPS power without the need for power jacks near such equipment (EG cameras, video repeaters, small computers, WiFi)
o Plan for WiFi as part of the wiring plan. Anything less than 100% WiFi coverage to the vessel -- from a fuel tank to the bridge -- does not account for the ship's future needs. Engineers carrying tablets will need to check fuel
o For networks supporting science, keep the number of hops between switches to a minimum to avoid latencies that could affect timing accuracy of equipment using the ship's network
o Design for a central UPS room that can feed all ship's network distribution points power from a datacenter-grade UPS
o Plan for equipment lifecycle. Devices must be installed with adequate space in rack to make them easily replaceable for emergency reasons as well as best practice of replacing such equipment every 5-7 years

- o Planning for a lifecycle maintenance on network equipment ensures that the ship avoids performance bottlenecks as faster network technology comes to market
- o Dedicate at least one space on the ship to be a datacenter. Retrofitting a science lab will result in a compromised layout
- o Plan for datacenter size racks, which are taller, deeper and wider than those typically seen on ships, but are designed for dense cabling.

Satellite communications

Should be engineered into the ship at this early stage to ensure that adequate space and resources are reserved. Satellite antennas should be given "pride of place" at top of main mast with full sky view. Alternatively, if an antenna is placed where its sky view is partially blocked by other ship structures, there needs to be redundant antennas that can be arbitrated to maintain continuous connections. Provisions need to be planned for evolving to use Low Earth Orbit (LEO) and Mid Earth Orbit (MEO) constellations as they become available. Receiver hardware needs to be easily accessible and maintainable by IT technicians. Recommend the designers consult with HiSeasNet personnel for recommendations.

- ○ Plan for a primary and secondary Internet system that use different frequency bands, minimally, to remain online under a diverse set of conditions. Each system should also have a low-throughput out-of-band way to reach it to obtain on-land expert support for these systems when needed.
- ○ For conops (continuous operations), plan for a minimum of three satellite dishes per system and up to eight. This accounts for infrastructure that uses Low Earth Orbit and Medium Earth Orbit satellite systems which will need to track multiple satellites at once.
- ○ For conops, plan for two places on the ship (EG two datacenters) as modern satcoms gear supports dual Below Decks Equipment (BDE) setups for more reliability

SECTION 4: General Arrangements: general questions and comments, and a final note concerning topics that will require additional investigation and discussion before resolving.

This section consists of smaller scale questions brought up by members of the subcommittee, and our colleagues who contributed their knowledge based on prior experience on polar research vessels. This section of miscellaneous but important observations, focuses on essential details that could be overlooked, yet when addressed, will result in a much improved ARV design.

<u>Main Deck Labs</u>

Fume hoods – Fume hoods with chemical storage for working quantities are needed to accommodate a variety of chemicals including acids (HCl, nitric, HF), preservatives (formaldehyde and glutaraldehyde), poisons (e.g., mercuric chloride).
In anticipation of maximum flexibility, distribution of hoods in every lab can be advantageous.

High quality DI water: It could be useful to have 2 machines in 2 different laboratories. This gives a backup and also more supply.

Sinks in labs often seems to be limiting

Ice maker - accessible in the main lab (or somewhere in labs). This must be in addition to any food ice makers and of ample size. Two, one smaller and one larger, could be useful, give more volume and also a back-up.

Hazmat Storage on the main deck: *Is this sufficient space; seems small? Or is this space designed for only working quantities? If it is to handle bulk quantities, perhaps it could be moved to another deck or van(?) to free up space on the main deck? Big Biology cruises can create a lot of hazardous waste, and if you have multiple cruises in a year, it gets pretty sizable. Currently, on the NBP, hazardous waste is packaged in the helo hangar and stored on the helo deck. This ship may at times be tasked with removal of hazardous materials from Palmer Station and USAP vessels for transport back to the U.S. and proper disposal.*

Main passage wide enough for a standard pallet jack

Flush hatches to ease flow of heavy stuff into/out of the labs

Science Seawater Tank – This may be intended to be a tank similar to the Nuyina "wet-well".
https://www.antarctica.gov.au/nuyina/science/wet-well/
We are uncertain of whether this is a valuable addition to the ARV.

Marine Tech Shop: *This shop should be accessible from indoors on the main deck.*

Change room: *Can this also have a bathroom so that both bathrooms on the main deck are accessible regardless of sea state? It doesn't seem that there are enough WCs/toilets on the Main Deck for a scientific/technical party of 55. Having the second toilet accessible at all times would be welcome.*

Back Deck and other exterior spaces

Deck incubators: *where will they be located? Need natural sunlight and minimal shadowing from the ship's structure. Possible location on 01 level weather deck? Will need ample amounts of seawater with pumps that will not easily clog.*

Starboard A-Frame: *Is there sufficient deck space under the A-frame?*

Cranes: *Can they reach everywhere on the main deck? On the 01 deck? On the foredeck? Lower deck storage?*

Winches:
Lighter weight operations (e.g., plankton tows) require a smaller wire rope (¼ in) or (e.g., microstructure profilers, underway CTD) the installation of small custom winch.
Small portable winch off starboard A-frame? Space?

Ease of servicing/changing wires/drums to be considered

Extreme flexibility in fairleading cables to different overboarding sheaves is important, and *merits close attention*

Towing capabilities: *investigate towing needs both from stern and starboard, and the use of the starboard crane with the addition of a long boom as an option; also investigate the Azipods and the ability to clear ice from the stern and a little off to the side.*

Work boat(s)?
Scientists often require loading gear (AUVs, electronics, sampling systems) prior to launching. This is often most convenient when the boat is accessible from the main deck. Rapid deployment for, e.g., tagging of whales is critical and also benefits from having the boats deploy from the main deck. *If launched from the 01 deck, how will material and people be safely loaded and deployed with the boat?*

Trash: *Biodigesters for food? How does that work? If there is no incinerator how can we deal with trash for 90 days?*

Refrigerated garbage storage on 01 deck: *seems to be in prime location, is an alternate location possible?*

Liquid Nitrogen Plant: The USAP currently uses a liquid nitrogen plant for large biology cruises that require a lot of liquid nitrogen. The current plant is in a 10ft container which needs power and compressed air with water separators. On the NBP this van sits in the helo hangar.

Bosun's Shop: *Is the 1st platform location convenient for this shop, or is a location on the main deck more useful?*

Finally, we call out several items that will require additional investigation and discussion before resolving:

Vans: We listed the variety and numbers of vans that we anticipate for multidisciplinary science but remain uncertain about how these will be arranged on the decks and in the hold, and how easily they can be accessed and used.

Foremast: We will seek out details regarding the size and weight of anticipated instruments that will need to be mounted on the mast on a project basis, to address the suitability of plans.

Battery Banks: We will continue to seek out more information about the kinds of science that would benefit from this, the amount of time per battery operation conditions, ship's speed for activity, and how often (i.e., daily? weekly?). These details will help evaluate parameters driving battery bank needs.

Conference/lounge/library spaces: We note that the plans include the 0-1 deck lounge/conference room, the 0-2 deck science library, and the 0-3 deck conference room. We would like to re-visit the intended use of these spaces to be used for meetings, quiet workspace, telepresence/video connections, and lounge space, and so optimize their size and locations.