ARV Science Advisory Sub-Committee of the OPP Advisory Committee

Report on DR #3, November 14, 2022

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INTRODUCTION

This document expands on previous reviews, based on 77 new documents and another two, very-full days of presentations from the design team, on October 19th and 20th. One very welcome aspect of this third set of presentations was the back-and-forth conversation that was facilitated by the direct response to 'customer comments' during the second day of DR #3. It was abundantly clear that our input is carefully considered as changes are made to ship design, and in several cases we've been asked to comment very specifically on certain design elements, such as constraints on the location of specific containers, and ship's networking. It's also very helpful for us to understand the rationale for other aspects of ship design, such as the need for specific bulkheads, and the location of berthing around the perimeter of the ship leaving several interior locations on berthing decks as "unassigned' or loosely designated. As design of the ship evolves, we are focusing more closely on details, which are easiest to track in table format (Table 1). Larger aspects of design comments as well as general comments applicable to many ship spaces, are described below. We realize that many of these comments are "in the weeds." This level of scrutiny reflects the progress made in addressing larger issues raised during DR #1 and DR #2.

SECTION 1. General Arrangements (GA); (GA PX - the most recent version)
Specific Science Spaces

We appreciate the thoughtful re-arrangement of spaces; most importantly, dry spaces now are located forward and wetter spaces are located aft. Connectivity between labs is improved, though we suggest adding more doors, specifically a connection between the Wet Lab and Baltic Room, and another between the Main Lab and Science Operations Center. In terms of overall size (Table 2), most labs meet the requirements from the 2022 Habitability Study.

However, several labs and other spaces appear to be larger than needed, and it may be that some of those spaces could be made smaller, with the extra space re-allocated in a proportional manner. For example, the Electronics Lab, Electronic Tech Shop, Server Room, and IT office all may be larger than necessary; specific comments can be found in Table 1. On the port side, perhaps increase the sizes of the Hydro Lab and Bio/Chem Analytical Lab, and on the starboard side, perhaps increase the size of the Main Lab and Science Ops Center. The rationale for increasing the size of specific lab spaces is described below.

Hydro Lab

We recommend that the Science Seawater wall on the new ARV be larger than what the NBP has now. Although there will be Uncontaminated seawater taps in the science labs for the PIs, it is likely that

there will be additional “routine” measurements that are done in the Hydro Lab. We anticipate a greater number of “standard” underway seawater sensors, and that PIs will bring additional sensors and instrumentation that will be added to the seawater wall on a cruise-basis. For these reasons, we suggest increasing the size of the Hydro Lab.

Microscope Room
This lab will have space for 3 microscope stations plus their associated computers, and a higher workbench for benchtop fluorometer and/or cytometer. Both instruments are best used under low light conditions. One microscope space should have an anti-vibration table. This room will need compressed air connections, water and a sink. It also needs a secure cabinet to stow spare microscope parts and supplies, and drawers under the counter in between microscope spaces.

We suggest the room might be moved slightly farther aft; perhaps it could be moved to the space currently allocated to the LN2 space. We note that during DR #3 meeting, there was some discussion of moving the LN2 system farther aft, closer to the stack area, because it can be quite noisy.

Server Room
The size of the server room seems too big. Can the servers fit in the space outboard of the IT office? If yes, then the HVAC room could be moved aft, which then creates a whole additional lab where the Server HVAC is shown now.

Baltic Room
The ARV Team requested input on the proposed 6 x 6 double doors; Bruce Appelgate indicates the double door set-up on the R/V Sally Ride works well. The LARS system can articulate down to the water and has a docking head that can be swung out of the way.

Science Stores
The forward Science Stores is intended to provide storage for ship-provided instrumentation, equipment and consumables. This space currently is listed at 1098.6 sq. ft. (13, 183 cu. ft.), as compared to the space currently on the NBP (375 sq. ft. on main deck + 170 sq. ft. on lower deck + four 20 ft. containers). Additional space for ship provided materials will be available in the hold, perhaps in a storage container. Cruise participants will also bring extra science supplies and equipment, which can be stored in the hold. Storage of chemicals brought by science groups will need consideration, especially if they are hazardous or flammable. This is addressed below in a more general discussion of hazardous materials. Finally, we emphasize the need to get a pallet jack through the passage and in the door to the science stores.

Hazardous materials
Hazardous materials storage includes a variety of needs, each with its own storage demands. Perhaps most instructive is to use the example based on hazardous materials currently on the NB Palmer as a tool to sort out needs for the new ARV.

On the NBP, this includes:

- **Hazlocker** – ASC contractor chemicals – MT and ET solvents (for example, boat glue, electrowash, WD40, etc…), small amounts of extra commonly used science chemicals (EtOH, Acetone, formaldehyde) in case PIs don’t bring adequate amounts.
- **10 ft ISO Container** to hold current science cruise chemicals – on the helo deck. The advantage of using the container is that it can be brought on when needed. But if so- need to have a good place to bolt it down.
- **Hazardous waste storage** – currently much waste is stored in 55 gallon drums for large volumes. This is acceptable for standard, but not all, waste streams. Hazardous wastes can get significant on Bio cruises with multiple PIs, and of course, much larger volumes are associated with Hazmat runs, with materials from multiple cruises and the stations.
- **Lab space** hazardous chemicals lockers used for Small Grounded Flammables and Corrosives Lockers in lab spaces on the ship, designed for use with small, working quantities of chemicals.
- **Other**: Examples from previous projects

- A science project brought 480L of EtOH; the Captain would not allow this to be stored in the skin of the ship and thus had to be stored in a van on deck. We need to anticipate situations like this when we will need a van on deck for hazardous materials.
- Some Biology cruises have brought 4 pallet cages worth of packaged chemicals; where can these be stored?

Suggestions for the proposed ARV, much in line with the existing plan for the NBP:

- **Hazlocker** - 60 sq ft (600 cu ft) on aft deck, with only access from the deck, we suggest this be enlarged. As described above this space is intended for contractor chemicals – MT and ET solvents (for example, boat glue, electrowash, WD40, etc…), and small amounts of extra commonly used science chemicals (EtOH, Acetone, formaldehyde) in case PIs don't bring adequate amounts.
- **10 ft ISO Container** - As in the past, many cruises will require substantial volumes of chemicals. This container could be stored on the back deck or the UAV deck, with adequate tie-downs, or in the hold. Note that for cruises with UAV demands on the UAV deck, it is less likely that this space could accommodate a 10 ft ISO Container for chemicals, and there may be some chemicals that the Captain will not allow to be stored in the hold, so a container on the back deck may be the site for hazardous chemical storage.
- **Hazardous waste storag**e - In addition to hazardous chemicals, processing of samples will result in hazardous waste that needs to be stored on the ship. This may include large volumes of "tainted water" and Intermediate Bulk Containers ("IBCs"). Where will these be stored?
- **Lab space** - As on the NBP, we suggest that Hazardous chemicals lockers be included in labs that have hoods, for scientists to store working quantities. This includes the Wet Lab, Main Lab, Hydro lab, Bio / Chem Analytical Lab, Baltic Room (Flammables locker), and Atmospheric Lab.
- **Other** - As noted in the specific examples above, based on previous cruises on the NBP, we can expect to have some cruises with extra storage needs for chemicals they bring, and also in terms of the volume of waste produced.

Met Lab and Marine Mammal Observation (MMO) space

The Met Lab will support space for instrumentation mounted outside on the deck including radars, lidars, and met sensors. Racks and bench space are needed for computers and electronics, including data loggers. Through holes must be present for cables from instrumentation mounted on deck or on the foremast. Science Space arrangements currently include: workbench countertop; secure lockable cabinets and modular cabinets; 1 rack for compressed gas cylinders; 1 compressed air drop; 2 Science LANS (Local Area Network) space housing electronics and computers for remote sensing instruments outside on deck.

During DR #3, we were asked if the Met Lab and MMO spaces could be integrated into a single space. Yes, that is possible, with the caveat that the elements listed above, are included in this single integrated space.

Engineering office on main deck, ladder to engine room

While there is space on the main deck for the Engineering office, with a ladder to the Engine Room, we suggest that the Engineering office might be better directly associated with the Engine Room, so that the Engineers can keep a close eye on the functioning of the Engines. It may be that space is extremely limited in the Engine room, but if possible, we suggest moving the Engineering office down a deck.

Incubators

Currently the deck incubators are located on the 0-1 deck in a less than optimal spot, with too much shading. These need clear sky access. During DR3 there was discussion of widening the boat deck so that the incubators could be placed just inboard of a workboat, instead of tucked into a corner on the 01-deck. This space will need seawater plumbing, and a bolt down pattern for securing the incubators. Carrying heavy and bulky supplies, instruments, and samples between the main deck and the 0-1 deck can be facilitated by the lift, which is located approximately mid-ship. The NBP has space for 5 incubators; we suggest the same on the new ARV. For our next report we can provide dimensions for the incubators.

We note that for maximum future flexibility, we suggest considering additional locations for seawater plumbing, even if that's not where incubators are "normally" placed on polar missions. On more temperate missions, additional locations might be used for incubators, for example, the UAV deck. For this reason, we suggest plumbing for seawater on the UAV deck, and the inclusion of a bolt down pattern for securing incubators.

Science seawater systems
The ship will have 2 separate systems, one with a gentle intake to reduce pulsation, shear and heat transport from the pump, to maximize the reliability of the physical oceanographic data, and minimize disturbance to the organisms. Flow rates through the sensors must be kept constant. The 2nd system, intended for the incubators, will supply a higher rate flow, necessary to keep temperatures as close to in-situ temperatures. This higher flow rate is driven by the long distance flow to the incubators, and the need to maintain recirculation. As noted above in discussion of the UAV deck below, we ask that the ship design includes planning for the possibility of an alternate location for incubators and considers all locations that could need science seawater and / or higher flow incubator water.

UAV Deck and Hangar, use with helicopter, additional uses
One question that has come up is whether the science community is interested in an expanded UAV deck that could accommodate a single helicopter. We presented the following scenario:
If we had a cooperative and coordinated two-ship cruise, for example, a ship with helicopter capabilities (hangar space for two helicopters and helicopter deck) that is accompanied by the new ARV which could do the heavy duty icebreaking, paving the path for the helicopter-ship, would it be scientifically valuable, in that situation, to have space to land a helicopter on the ARV, to transfer personnel and equipment? While ideally members of the community continue to advocate for two helicopter capacity in the hangar on the proposed ARV, we suggest that if we are planning on having a deck for a large UAV to be launched and recovered, then we should make the deck large enough for an AS350 to land on, even if only to support medevac or other rescue operations from the ARV. Additional consideration of supporting two helicopters on the new ARV may arise from the National Academies' ad hoc committee that will "provide guidance to the National Science Foundation's Office of Polar Programs on future directions for Southern Ocean and Antarctic nearshore and coastal research." (https://www.nationalacademies.org/our-work/future-directions-for-southern-ocean-and-antarctic-nearshore-and-coastal-research)

In terms of more detailed planning for the UAV Deck and Hangar:

- It would be useful if this deck could support other operations if UAV use is limited.
- For this reason, a bolt pattern is needed, to facilitate future flexibility.
- If this space is used for Lab Vans and/or Containers, we need to be sure the deck is strengthened and has sufficient tie-downs. For cruises without UAVs on board, this space could house atmospheric sampling vans. This would require a bolt pattern on the UAV deck and the deck itself must be able to support containers weighing up to 20,000 lbs.
- Hangar needs Science LAN; the network connectivity must also be available for Lab Vans, such as Atmospheric Sampling Vans.
- As noted earlier, this space may be used for Incubators but it will need science seawater (see incubator comments above). We suggest planning for future flexibility by having more than one location where incubators could be placed.
- Lithium batteries for drones will be stored in the UAV hangar. What kind of fire suppression is appropriate?
- Space nearby the UAV hangar to store fuel mixtures.

Fold-down mast
The mast will serve as an aerosol and gas phase inlet to the instruments in the Atmospheric lab. Folding it down will compromise those measurements. Comparisons between ship-based measurements and those on a UAV will be of interest so the mast should be in place as much as possible when the UAV is sampling.

Vans
Previously we described the need to locate spaces on the ship for a variety of vans to be housed, including space on the back deck, in the hold, and perhaps on the UAV deck, as needed. We have updated Table 3 and now highlight the special demands in terms of where each can and cannot be placed (for example, in hold, not in hold; no immediate access to ship's interior [rad van]; best place for trace metal van? What about seismic compressor vans that might need special cooling? Core logging van with cesium source that must point outward?). In terms of requirements for power, water, heating/cooling and venting, at this time we suggest all places where vans might be located, should be wired/plumbed to allow for connections to these services. While some containers ultimately may not need each service, we suggest building for flexibility into the future.

Currently, the plans include 8 vans to be stacked - 4 across and 2 high - in the hold, with catwalk-style access to the upper level of vans. We are concerned with how easily and safely vans can be loaded through the hatch and moved into place in the hold. Three containers can be accommodated in the "lab van bay." The intention here is to allow access to these vans even if decks are closed due to weather. We are concerned with how well a garage door style opening will fare in rough seas. Does this bay need to include an overhead structure? We also question how the vans will be placed in the bay, and then taken out. We are not sure how to load 3 vans into this space -- side-by-side oriented athwartships, loaded through a 20-foot wide roll-up door facing aft? We ask for additional consideration of where vans will be located, how they will be secured, and how they will be moved into place safely and efficiently.

Several more containers can be placed on the back deck without taking up all the available deck space. There was some discussion if some of the back deck vans could be stacked 2 high, but ultimately this was reconsidered and decided against. Instead, the group discussed whether a boat could be placed on top of one of the port vans. Finally, on cruises with limited or now UAV operations, 2 more vans can be placed on the UAV deck, as long as it is strengthened to accommodate the weight of the vans and has a bolt down pattern for securing the vans.

Workboats
We suggest that the 01 deck – where the boats are – should have a bolt down pattern. We continue to emphasize the need for rapid and easy deployment and recovery, and ease of loading personnel and instruments. Finally, we appreciate the presentations on the different kinds of workboats being considered; one request is that the workboats be nimble and can maneuver into tight spaces as well as a zodiac.

Working from the sea ice
Given the greater access to areas of heavier sea ice concentrations, we anticipate scientific work from the sea ice. Options to deploy personnel and gear via a gangway as well as from the crane, through person baskets, will be required depending on the type of ice work. As mentioned, the crane will need to be person-rated.

SECTION 2: General Arrangements (GA PX), general comments

Additional considerations pertaining to more than one lab and/or to deck spaces:

Networking needs
- All science labs, science support spaces (such as the Marine Mammal Observations Space and Aquarium Room, Back deck staging bay, UAV hangar), staterooms and dayrooms, the back deck, and all spaces where containers and incubators may be housed, require network access. More simply, all spaces except W/C and showers, should be wired for network access. We make this suggestion with an eye toward the future, since adding wiring "after the fact" is much more difficult. We also suggest strong wireless network access, though we recognize that this will be difficult to achieve everywhere on a ship.

Power

- We call out the need for 50hz power in the Main lab, Analytical Lab, Hydro Lab, and Electronics Lab
- All science labs must have both regular “ship” power and clean power associated with an Uninterruptible Power Source (UPS)

Sinks

- The Pspec mentions that each sink must be able to drain 3 ways – bucket, graywater and overboard. It must be relatively easy to switch between these modes. Also, sediment traps are needed in sinks in the Main Lab, Wet Lab and Aquarium Room, so that they don’t clog and then flood.

Lab spaces

- All lab spaces should all have 2-ft OC deck bolt pattern, and unistrut on all bulkheads that lines up with unistrut secured to the overhead.
- Prefer movable benches that can be reconfigured using deck bolts, reserving permanently-installed benches for places where there are bulkheads, sinks or fume hoods that preclude them from moving.

Hazardous chemicals storage (corrosives and flammables) and hoods

- Storage must be available for working quantities in any lab with a hood. This includes the following labs: Main Lab, Bio / Chem Analytical Lab, Wet Lab, Hydro Lab, Baltic Room (Flammable Storage Cabinet), Atmospheric Lab. We have additional comments regarding hazardous chemicals storage in section 2.

Cargo Hold – Currently the cargo hold is accessed by a single hatch.

- Hatch must be heated.
- Containers will be loaded through the hatch, stacked, and then moved into place in the hold.
- Moving 2 containers stacked will be difficult and highlights the importance of having a safe and easy way to slide the containers into place. The current system on the NBP is unsafe and difficult to get right, so it is a very slow process.
- All containers in the hold need to be accessible, so a walkway will be needed.
- Hold will need a bolt down pattern for securing items.

Deck heating

- The main deck will have below deck electrical heating. As noted above, it will be important for the hatch to also have heating.
- Other decks will have electric mats that sit on top of the decks. Will this interfere with our ability to bolt down stuff? Will there be issues with items being too heavy for the electric mats?
- Will the deck heating (below decks and/or electric mats?) have zonal control?

Batteries

- We support the use of batteries for peak shaving (when you rely on battery power to reduce power consumption for a short period of time, to avoid a spike in consumption) and spinning reserve (when you take a generator offline and use the batteries for reserve power). We also suggest planning for future flexibility since we are designing for 50 years into the future and need to anticipate how to adapt to evolving technology. While we initially sought out specifics from the community regarding science use demands (ship’s speed and for how long), this is probably not the optimal way to plan. Instead, we suggest building in the ability to add batteries and their connections in the future.

Holding tanks

- The holding tanks have a capacity for 20 days without discharge. Is this adequate? Will it limit operations?

Starboard passageway main deck

- During the DR3 meeting, we discussed whether some of the starboard passageway space could be absorbed by the Main Lab and Science Ops Center. In this arrangement, the lift would open both to the port passageway and to the Main Lab. On reconsideration, we suggest a preference for maintaining the starboard passageway, rather than gaining the extra lab space.

W/Cs and Changing Room

- Thank you for adding more W/Cs to the main deck, with 2 additional W/Cs accessed from the Changing Room. We suggest removing the framing around the toilets, since these are single-person W/Cs.
- For the Changing Room, we suggest adding at least one more access door, and to organize the interior "galley style" for better functionality (people go in one door and out the other, so better flow through).

SECTION 3: Handling Equipment - Cranes, A-frames, Winches, Jumbo Piston Coring

Here we outline concerns about reach and placement of the cranes and the ease with which large items can be placed in the hold (one or two picks?), the placement of the starboard and stern A-frames and the overall ease, safety and speed with which workboats can be deployed and recovered (rapid response to whale sightings and recovery of instruments like gliders for example), and the challenges of handling a Jumbo Piston core..

Cranes

- Location on the back deck – is there sufficient back deck space with the crane located in the middle?
- Can the cranes reach everywhere on the back deck – and 01 deck – where the boats are? The back deck main crane must be able to reach outboard of the ship all the way around, even both aft corners.
- Cargo Ops – one of the cranes must be able to reach from the dock to the cargo hold hatch.
- The starboard crane could be moved aft to make better use of its radius, and to make it more functional.
- Forward crane – we were asked how far beyond the ship must the crane reach to deploy equipment. This will be dependent on ship wake modeling.
- In response to a request from the marine geophysics community to provide the ability to conduct 3-D seismic surveys, we reached out for additional details. Under open water conditions this could be facilitated by cranes or booms that hold the outer streamers to either side of the ship, however, while working in ice all streamers would be towed directly behind the ship. Specific details were forwarded to the design team (Ross Hein contact).

Starboard A-frame

- Details of the integration of the starboard A-frame remain to be addressed, with questions of whether it is integrated into the house or along the rail. If the A-frame is integrated into the house, it will infringe on space in the lab(s) where the integration is located, and also on the deck. Also, the starboard A-frame is not centered off of either the Aquarium or Wet Lab – one leg is centered opposite the Aquarium and the other at the aft end of the Wet Lab. Lining the A-frame up to the Wet Lab would allow for easier transfer of the rosette for storage in Wet Lab.
- This A-frame will be needed to conduct Jumbo Piston Coring operations, a factor leading to why such a sturdy A-frame is needed, and hence, why it will take up some space on deck and/or in a lab.
- Specific use case – when a TMC (Trace Metal Clean) rosette is used in addition to the standard CTD, the rosette is deployed off the starboard A-frame using a science supplied portable winch and synthetic wire. We want to be sure that the winch can be secured and the wire led to this starboard A-frame. Can other portable winches (i.e., science provided or from the winch pool) be led to this A-frame? Where would these winches be mounted?

- Will the A-frame location affect these deployments?
  - Plankton nets, MOC1

Stern A-frame

- As the ship increased in length, we note that the stern A-frame will need to slide farther aft than in drawing, to extend its aft reach.

JPC handling

- Pipe will be handled in a truss to ease handling and to minimize bending from the weight of the core. We were asked "how much is too much bend?" and while we defer to coring specialists for this answer, we acknowledge that some bending will occur, based on our experience with 25 meter JPCs taken on the NBP. Use of the truss could certainly decrease bending, depending on the details and process of core recovery. Will the truss be used to help bring the core to horizontal, or simply used for core placement once the core is horizontal? The truss also provides a place for a sleeve to keep the core warm, a factor critical in keeping the liner from freezing to the inside of the core barrel. Will this be accomplished with a giant hot air blower? We understand that the core will be extruded from the stern forward into the Baltic room, which will be helpful in keeping some personnel protected from the weather. More details regarding the extrusion process will need to be discussed and made consistent with the design.

SECTION 4: Berthing and Public Social Spaces

We appreciate the positive response to our interest in including more single staterooms with dayrooms for science. One is already allocated to the Chief Scientist on the 0-3 deck. Additional single berth staterooms are included in GA PX, on both the 0-2 and 0-3 decks, and that two of these may also include dayrooms. These single staterooms with dayrooms are intended for a Co-Chief Scientist and Marine Projects Coordinator; all three of the single staterooms with dayrooms should be comfortably sized. Additional single berth staterooms may be allocated to Marine Techs.

- Science Berthing:

0-3 deck: 2 2-berth staterooms + 11 1-berth staterooms
0-2 deck: 18 2-berth staterooms + 2 1-berth staterooms (I am pretty sure there are 19 doubles on this deck but I can't find the 19th?)

- While it may be more efficient for 2 person staterooms to share T/S facilities, we suggest that each 2 person stateroom have their own T/S. Two single person staterooms could share a T/S but each should have its own sink and vanity.
- The aft location of the hospital on the 0-2 deck provides a degree of isolation and privacy. In addition, access is good, in terms of being able to move a patient on a stretcher into the hospital. We wonder if there is a specific requirement for a hospital of a certain size given the number of persons on the ship.
- Other spaces to keep in mind for inclusion on the 0-2 and 0-3 decks include linen lockers, cleaning supplies space, and a space to store personal luggage that is easily accessible, either on the same deck as the rooms or on a deck serviced by the lift.

Public social spaces

We focused on a re-evaluation of public social spaces with many recommendations for changes. Perhaps the biggest change is the suggestion that the Gym / Sauna be relocated to the 0-2 deck, using the space that is designated as the Laundry on the PX General Arrangements, just forward of the Hospital. This space has the advantage of being slightly more private than the 0-1 deck, yet still has some natural lighting. Here, the addition of windows would be helpful for lighting since this space is behind the starboard side frame handling device.

We suggest that two Laundry Spaces are allocated, with one on the 0-3 deck primarily for Crew, who may have greater restrictions on times available to do laundry, and a second Laundry on the 0-2 deck. The

“Crew Laundry” could be located in the Unassigned Forward area of the 0-3 deck, while the “General Laundry” could be located in the “Auditorium” space, in the forward part of the 0-2 deck. Both these spaces are interior, and surrounded by berthing spaces, so good soundproofing and quiet closing doors will be critical. Laundry spaces will need adequate venting so that the dryers work. Also, both these spaces are pretty large, so it might be possible to split each of the two interior spaces, forward on the 0-2 and 0-3 decks, into a Laundry and a small Library space for quiet work.

As noted above, we suggest that the space on the 0-1 deck that currently appears as Gym / Sauna in the PX GA, to be utilized as public space as a Library space for quiet work. Consequently, on the 0-1 deck we will have three major public spaces: a Lounge, a Conference Room and a Library. The Lounge is intended for noisy social activities, like movies and cards, with a big screen and comfortable couches / armchairs. The Conference room, intended for group work, might be set up with 2 large conference style tables with seating, a portable monitor and conferencing phone/”owl”, while the Library space might house reference books and charts, and have a combination of smaller workspaces and comfortable seating. We suggest that the Lounge and Conference Room can be combined, by opening a divider, to create a single large meeting space for the occasional times it is needed.

CONCLUSIONS

We thank the design team for their response to our comments and questions, clearly visible in the changes to vessel design from DR #1 to this third iteration; for example, the re-arrangement of lab spaces on the main deck with dry spaces now located forward and wetter spaces located aft. In this report we also suggest reconsideration of the location of public social spaces, for example, with the gym re-located to the 0-2 deck, and a library space located on the 0-1 deck, proximal to the Conference Room and Lounge. Additional larger scale comments regard the storage of hazardous materials, and our continued questions regarding the placement of science containers. Finally, we recognize that this report focuses closely on details of design. Careful consideration of each lab space, all deck spaces, and over-the-side handling equipment is critical in the development of the new polar research vessel.

	TABLE 1: General Arrangements and Space Arrangements		
Space + use (new name vs. name in SMR documents**)**	**Location + Connectivity**	**Space Arrangements (P1)**	**Special Considerations**
		normal text (P1 arrangements) *italics text (recommendations for SASC)*	
MAIN DECK			
Science Operations Center (Forward Dry lab)**.** day-to-day cruise planning, work with shipboard data; banks of monitors, dedicated workspaces/work surfaces for charts, laptops, workstations for UAV and drone data downloads and processing, marine geophysics, work with ROV data and satellite imagery.	Dry lab, forward location, easy connectivity to main passage, clear line of communications to bridge, labs and other science support spaces.	General purpose tables (fixed laminate countertops with securing rails) for about 12 people in 3 rows; 12 Science lans; double row monitor wall most forward; 2 large chart tables.	
Main Lab (Aft Dry Lab)**.** Multi-purpose lab, with flexible benches and layout configurations, for science equipment and for processing of water, plankton, and sediment samples; filtration + processing of water samples, sorting plankton, setting up incubation experiments, microscopy (that does not require darkness), description / sub-sampling of sediments.	Wetter lab, more aft location, ease of moving samples and equipment back and forth between main lab, back deck, + Baltic Room. Easy access to refrigeration + freezer space; water work may include carrying 20 liter carboys from Baltic Room and back deck into main lab; sediment cores 1-6 meters long will be carried from deck into main lab + later stored in a cold room, in max 1 m lengths.	SS countertops, as indicated in the space arrangements, *are very hard to tie down to; instead we suggest workbench countertops to accommodate the need for tie-downs*; 4 double ss sinks + 3 single ss sinks; fridge, -20 and -80 freezers; 2 large hoods; compressed gas bottle rack; 4 compressed air drops; 9 science lans; *Milli-Q water + uncontaminated seawater; working with cores is messy (muddy) - requires sinks w/ sediment traps, and easily cleaned floors and floor drains. Use of nesting tables for increased flexibility of use of space and efficiency of use. Where will the floors drain to? Icemaker? 220V power? Other power?*	
Electronics Lab instrument programming, charging battery packs, sensor calibrations; large format printers; *outreach and telepresence center*	forward location, near Science Operations Center, ET Shop	workbench countertop with space for 14 - *too many chairs?*; 4 lockable cabinets + 4 modular cabinets; rack for compressed gas cylinders; 24 Science lans; 4 bookcases; double-doors; *Telepresence (comms with colleagues, NSF, + outreach efforts that effectively present excitement of scientists at work) might involve 4-6 people on board - accommodated by a temporary partition in aft part of lab.*	Prefer movable benches that can be reconfigured using deck bolts, reserving permanently-installed benches in places where there are bulkheads, sinks or fume hoods that preclude them from moving. In this case, the forward benches might be good to be permanent, because they are below the monitor framework. Where do printers go? Large format plotter? I like having unistrut on all the bulkheads in the labs, lining up with unistrut on the overhead.
Baltic Room CTD operations	Mid-ship location with other "wet" labs proximal to Baltic Room; *access should be provided through Baltic room to/from adjacent labs*	workbench; rack for compressed gas cylinders; 1 ss double sink; 1 science lan; flammable storage cabinet; *Floor with minimal tripping hazards; Ample floor drains to facilitate rapid water drainage; Door that has sufficient opening for an extra-large 36 place rosette.*	Upper deck catwalk storage?
Wet Lab wet, messy activities - sorting of samples from plankton net tows, fish trawls, dredges, extrusion of multicore sediments, incubation of live animals; site of cleaning moored instruments upon recovery when conditions unsafe on deck.	Wet Lab and Aquarium Room contiguous + near Baltic Room + Back Deck	1 single ss sink + 2 ss double sinks; 2 secure lockable cabinets + 2 modular cabinets;1 rack for compressed gas cylinders; large ss countertops; ice maker; refrigerator; 1 small hood; 6 Science lan; 1 compressed air drop; 3 stubbed out plumbing; *freezer (-20 or -80?); Temperature controlled incubator; access/ hook ups to flowing seawater and freshwater at multiple sites, floor drains, sink space with sediment traps*	Splitting hairs here but is the incubator both Temp and Light controlled? Put icemaker here or in Main Lab?
Aquarium Room wet + messy - aquaria for live organisms	same as above	workbench countertop; rack for compressed gas cylinders; 2 science lan; 1 compressed air drop; 7 salt water valve tank attachment points; *Room for aquarium tanks of various sizes- Aquarium Tanks ideally portable, Xactic tanks; floor drains, sinks with sediment traps; lights must be controllable to darken space*	
Hydro Lab site of “water wall” for underway surface seawater characterization; collection of samples for [pCO2] work; nutrient analysis; flow-through instrumentation - thermosalinograph, pCO2 system, fluorometer, transmissometer, nitrate analyzer, FlowCam/CytoBot plankton image analysis, flow cytometry. Outlets to add science supplied instrumentation and/or to collect discrete water samples. Pressure regulated so that as instruments are added/removed the pressure to the online instrumentation doesn't change. Other operations could include Nutrient Analysis, other analyitical instrumentation.	Samples coming from Baltic room and back deck, access to Chemistry lab	workbench countertops; 2 single and 2 double ss sinks; 1 large + 1 small fume hood; ice maker; -80 chest freezer; 3 racks for compressed cylinders; 4 compressed air drops; 4 science lans; secure lockable cabinets and modular cabinets; *access to clean water and uncontaminated sea water, Clean power outlets protected from seawater exposure distributed throughout. Analytical work requires relatively good climate control. Anticipate increase in flow-through instrumentation, so larger Hydro Lab may be needed. Image analysis w/plankton directly from seawater line, need for gentle system proximal to intake.* *Historically this has also had the nutrient analysis and other analytical work.*	

Biochem / Analytical Lab (Bio Lab) Sensitive biogeochemical analytical work that requires clean space, excellent venting, climate control. Filtration and processing work with water, plankton, and sediment samples that include work with preservatives and/or poisons.	easy access to Hydro lab and Baltic room? *Note size now 758 sq ft. - this lab could be made even bigger*	workbench countertop; secure lockable cabinets and modular cabinets; 3 racks for compressed gas cylinders; ice maker; -20 freezer; 2 doulbe ss sinks; 2 small fume hoods; 10 Science lan; compressed air drop; *positive pressure and good temperature control*; *access to clean water and uncontaminated sea water; Floor drains required; Note that "hazardous" chemicals will be used in this lab space - need hazardous chemical storage for working quantities.* *Refrigerator; note specificity of hoods - laminar flow hood and chemical hood mandatory; glove box*	Given expansion of scope of work to be completed in this lab, we suggest increasing the size; seems like space could come from ET lab and/or ET shop?
Cold Rooms 2 rooms for flexibility of temperature control (freezer + refrigeration); storage of samples + analytical work requiring temperature control (porewaters, sea ice cores)	easy access to main lab	each: *temp control -30 C to +10 C (-20 F to +50 F)* [ARV Pspec]; 1 double ss sink; phenolic countertop; adjustable ss shelving, *red and white lighting.*	
Autosal Room space for salinometer, climate control	near hydrolab, easy access to Baltic room	*Temp control of 1-2 C, w/ range from 21-23 C (http: //www.soest.hawaii.edu/HOT_WOCE/sal-hist-report/2.1.2.html); Ambient temp measured w/ digital thermometer near salinity sample boxes away from Autosal to prevent thermometer from being affected by heat of Autosal and allows thermometer to measure temp of area in which samples have equilibrated.*	No specific information in Science space arrangements
Microscope Room transmitted and epi-fluorescence microscopy, binocular micrososcopy, fluorometer and/or cytometer	mid ship location for stability - could be farther aft, perhaps switch with LN2 space, though LN2 system may work best with less ship movement? P2 sized at 191.9 sq ft	Space for 3 microscopes, plus associated computers, and higher workbench countertop space for fluorometer or cytometer (both need low light); One space reserved for anti-vibration table. *Compressed air connections, water and sink. Secure cabinet to stow spare microscope parts and supplies; Drawers under counter in between microscope spaces*	
Gravimeter	Newest gravimeters do not require special security so don't need "special" space	special requirements for mounting instrumentation since this needs to be on a gimbled platform	Space to mount a gimbaled platform in an area that does not see heavy traffic
Bottom Mapping Transceiver Room / Acoustics	Space located within cable run distance to transducers.	Easy access to service hull mounted systems. Suite of sonar and acoustic systems good. Scientists need 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 is essential.	
Science Stores includes (1) mostly instrumentation and supplies that the ship supplies and (2) PI provided supplies. Ship supplied Science Supplies in a temperature controlled and permanent place, PI provided extra supplies stored in hold	forward location for easy access to lab equipment and general lab supplies - all dry	Room for pallet jack so heavier items easily moved; all adjustable stainless steel shelving and shelving with cabinet doors; *double doors for easy movement of heavy, awkward, big items; flush hatches/doors so a pallet jack and move over the threshold*	
Marine Tech (MT) Shop	Aft location, closest to back deck	workshop bench, locker, vise, lathe, bandsaw, arbour press, drill machine, grinding machine, welding machine and station	
Marine Lab Tech (MLT) Space *(Science Office)*	Forward location, close to Science stores	*Workbench for testing/repair, bookshelf; lockable storage for instrumentation/ equipment/ consumables; desk/computer station w/ lan jack; 2 chairs*	
ET Shop	Forward location	rack for compressed gas cylinders, 2 tool cabinets, 2 workbenches, bookcase, cabinets (10), chair(s)? *Workbench for electronic repairs, computer station, stores for small electronic spares (fuses, cables, wire, etc.) - something like lockable Lista Cabinets*	
Electronic Equipment Room location of servers and server HVAC	Forward location; adjacent to ET Shop and proximal to Operations Center	Server racks must be accessible from front and back; not oriented adjacent to bulkheads as currently drawn. Sufficient space in the computer racks for future growth or science supplied instrumentation. Small countertop (composition?) and chair. *Important that this space is isolated from the other lab areas and temperature controlled as the servers will generate a lot of heat.*	
IT Office	Close to Electronic Equipment Room	*2-3? computer stations, easy access to sat comms. terminal(s)*	
Engineering Office	Main deck with ladder to engine room - suggest re-locating to lower deck for direct view of Engine Room		
Hazardous Materials Storage	Aft deck	May have a locker and a van, need to consider venting requirements	Addressed in detail in the ARV SASC review document, with several types of storage needed
USW Instrument Room (Bow thruster room)			Does it need its own room?
Transducer Room			is this the same as the transceiver room?
Gas Bottle Storage Room SMR call outs 5 gas bottle racks but still need gas bottle storage space for easy bottle exchange on longer cruises	many labs have gas bottle racks	located in Main Lab, Electronics Lab, Baltic Room, ET Shop, Wet Lab, Aquarium Room, Hydro Lab (3), Atmospheric Lab, Met Lab	
OTHER DECKS			

Atmospheric Lab Measurement of aerosol and gas phase species including distrcete filter samples and real-time continuous sampling. Sample air will be drawn from an inlet line on the foremast. Racks and benches for aerosol and gas phase instrumentation.	0-2 deck forward; intake location access from foremast	workbench and ss countertop; secure lockable cabinet, modular cabinet; rack for compressed gas cylinders; 1 compressed air dop; 1 Science lan (*1? more needed*); *space could house ion chromatographs which need a source of deionized water and a sink; instrumentation requires gas cylinders and compressed air; Hood and hazardous materials storage for working quantities of solvents and acids; Sampling handling will require a glove box. Internet access and desk space for laptops and data processing.*	consideration of how inlet line will be "protected" if foremast is "foldable" - this will impact continuity of measurements
Meteorologic Lab Support space for instrumentation mounted outside on the deck including radars, lidars, and met sensors. Racks and bench space for computers and electronics. Through holes for cables from instrumentation mounted on deck or on the foremast.	0-7 deck; Met Lab and MMO Platform can be integrated into a single multi-use space with the science space arrangements of each in this space	workbench countertop; secure lockable cabinets and modular cabinets; 1 rack for compressed gas cylinders; 1 compressed air drop; 2 Science lans; *space housing electronics and computers for remote sensing instruments outside on deck.*	Met Lab and MMO Platform can be integrated into a single multi-use space with the science space arrangements of each in this space
Marine Mammal Observation Platform required during seismic surveys, also stand-alone marine mammal / bird surveys	0-7 deck; 360 degree observation as high as possible	countertop with base shelves, 4 Science lans, 6 Big Eye Binocs	Met Lab and MMO Platform can be integrated into a single multi-use space with the science space arrangements of each in this space
MPC Office	01-deck; centrally located	*Large Computer station/desk;4 chairs or a nice loveseat; filing cabinet; bookshelves; area to mount charts; safe; printer; lan jack; coffee station*	
DECK SPACES + associated "GARAGE" SPACES			
AUV Staging Bay Staging of over-the-side gear, including but not restricted to AUVs ; also mooring gear, trace metals rosette.	Staging bay accessibility from MT shop when ship is in transit and/or decks secured	*Large, garage-door style access; bay currently designed with lift machinery in overhead to easily get large/heavy equipment into / out of the space; heated - helpful for recharging batteries; easy access to freshwater for rinsing instruments.*	
UAV Hangar and Deck	Forward, clear flight launch and recovery path	*Garage-door style access, heated space for recharging battery banks; lockable tool cabinet; removable workbenches and cabinets; deckbolt pattern to enable securing items to the floor. Nearby storage for fuel mixtures. Science lan. Bolt pattern for tie downs.*	UAV deck must be reinforced so that it can support a van or two for atmospheric measurements
Aft Winch Control Room for crew handling over-the-side operations, will crew be able to control ship from here? also for science handling and observation of over-the-side operations	back deck with excellent visibility both starboard and aft	*adequate space for 4-5 scientists to observe over-the-side operations; space for temporary science instrumentation that may need cable connection to instruments on deck*	good VHF comms, clear view of all of the backdeck
LEISURE/SOCIAL/MEETING SPACES			
Deck/Level 03:			
Crew Laundry and Little Lounge (Unassigned) - divide this space in two	needs excellent soundproofing; quiet closing doors; exhaust for laundry	laundry machines in crew laundry; comfortable seating and table in lounge?	
Deck/Level 02:			
Laundry and Little Library (Auditorium) - divide this space in two	needs excellent soundproofing; quiet closing doors; exhaust for laundry	laundry machines in crew laundry; comfortable seating and table in lounge?	
Gym / Sauna (Laundry Room)	slightly more private than the 0-1 deck, yet still has some natural lighting; addition of windows would be helpful for lighting, since this space is behind the starboard side frame handling device.	Gym equipment	note new location, windows requested; space large enough for both Gym and Sauna?
Deck/Level 01:			
Lounge - intended for noisy social activigties, like movies and cards		big screen and comfortable couches / armchairs	retractable divider between Lounge and Conference Room so that when needed, can be combined into a single larger space
Conference Room - group work		2 large conference style tables with comfortable seating; a portable monitor and conferencing phone/" owl	retractable divider between Lounge and Conference Room so that when needed, can be combined into a single larger space
Library (Gym / Sauna / Spa) - quiet individual work		smaller workspaces and comfortable seating	

	TABLE 2: Size of spaces		
Space + use (name sugg. vs. name in SMR documents**)**	**Size (all areas ft^2)**		
	2022 Habitability Study	***2019 SMR***	***P1 General Arrangements***
MAIN DECK			
Science Operations Center (Forward Dry lab).	1400	~1100	1131.8
Main Lab (Aft Dry Lab).	1400	~1100	1550.2
Computer/Electronics Lab nts	700	~700	792.7
Baltic Room	700	~700	703.6
Wet Lab	580 (more if possible)	~900	900
Aquarium Room	340	~400	420.2
Hydro Lab	530 (more if possible)	~750	737.1
Biochem / Analytical Lab (Bio Lab)	500	~400	758.3
Cold Rooms	2 @ 100 each, climate control/cold labs		144 each
Autosal Room		~100	100
Microscope Room		~100	191.9
Gravimeter			doesn't need separate space
Bottom Mapping Transceiver Room / Acoustics	195		180
Science Stores	4130 (forepeak main deck), Science Hold (16,000)		1098.6
Marine Tech (MT) Shop	250	~150	280
Carpenter Shop			360
Marine Lab Tech (MLT) Space (science space)	260		80
ET Shop	100	~100 (ET Shop/Electronic equipment room	234.1
Electronic Equipment Room	230		792.7
Changing Room/Mud Room		~100	520
Hazardous Materials Storage	650		60
USW Instrument Room (Bow thruster room)	100		?
Transducer Room	200		180
Gas Bottle Storage Room			?
Servers			771.4
Engineering Office			480.2
MPC Office			132.3
OTHER DECKS			
Atmospheric Lab	300		1661.3
Meteorologic Lab	340		331.6
Marine Mammal Observation Platform	550		1142.4
DECK SPACES			
AUV Staging Bay	450		480
UAV Hangar and Deck	450 (hangar)		494.1 (hangar) + 5562.8 (weatherdeck)
Aft Winch Control Room			146.3
Lab Van Bay			369.7
LEISURE/SOCIAL/MEETING SPACES - note many changes in designation of spaces; sizes based on GA P1 and may not be as up to date as GA PX			
Deck/Level 03:			
Crew Laundry and Little Lounge (Unassigned) - divide this space in two			600?
Deck/Level 02:			
Laundry and Little Library (Auditorium) - divide this space in two			600
Gym / Sauna (Laundry Room)			487.4
Deck/Level 01:			
Lounge - intended for noisy social activigties, like movies and cards			809.4
Conference Room - group work			649.6
Library (Gym / Sauna / Spa) - quiet individual work			441.3 + 181.9 + 51.6

	TABLE 3: Vans	
SPECIALIZED VANS: UNOLS shared equipment pool (http://marops.cms.udel.edu/uecvp/ and https://ceoas.oregonstate.edu/west-coast-van-pool), or part of the USAP equipment pool (https://www.usap.gov/usapgov/vesselscienceandoperations/). **Operational Requirements (power, water, heating/cooling, venting, network connection) all spaces where vans may be located should have this capability**	**Location + Connectivity; Limitations + Challenges**	**Space Arrangements**
Radioisotope Vans (1-2) depending on which isotopes are being used	**Main Deck** - **exterior location mandatory** to limit possibility of radioisotope contamination of interior of ship; consider pathways of use by scientists and limit possiblity of contamination of ship - **no direct entry without a contamination control zone at the access point.**	https://www.usap.gov/USAPgov/vesselScienceAndOperations/documents/Rad%20Van%2001.pdf; https://www.usap.gov/USAPgov/vesselScienceAndOperations/documents/Rad%20Van%2002.pdf; https://www.usap.gov/USAPgov/vesselScienceAndOperations/documents/Rad%20Van%2003.pdf; https://www.usap.gov/USAPgov/vesselScienceAndOperations/documents/Rad%20Van%2004.pdf
Trace Metals Van	**Main Deck** - place where people can suit up into clean suits connected to passageway to change, this **CAN open directly into ship**	https://www.usap.gov/USAPgov/vesselScienceAndOperations/documents/TMC%20Van%2007.pdf
Seismic Compressors Vans (2 - 3)	**Main deck** with accessible connection to air guns	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) 2 each 385 scfm at 2,000 psi). Probably need 2 - 3 compressor vans for a seismic cruise (depending on the array size ranges and rep rates) plus a backup; 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.
Seismic Gun Shack workshop for air gun maintenance	**Back deck** - could also use Aquarium Room if cruise conditions permitted	countertops, electric, heated
Seismic Streamer Van	**Back deck**	streamer and winch, does container need to be on deck, or can that be in hold, with winch and streamer mounted on deck?
Jumbo Piston Coring Vans (4) archival supplies, Multi-sensor core logger (MSCL), core splitting & processing, core shipping (refrigerated), a 5th container with CT scanner, but this could also be in MSCL container	**Archival supplies could be in hold, others on back deck**. Refrigerated shipping container instead of storage in cold room, or could have shipping container in port and transfer all cores; Core splitting and processing van and MSCL van on back deck	Archival supplies in hold, no special needs except routine access; Multi-sensor core logger and core splitting/processing need heat, power; Shipping van needs power; MST van must have track pointed outboard toward lightly accessed area, because of cesium source
AUV Vans (2)	**Back deck** with door opening to open back deck for deployment of AUV	specific to each AUV
ROV Vans (4) capability to support Jason, as an example	**Back deck**	https://ndsf.whoi.edu/; 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.
Liquid Nitrogen Plant	**10 ft van. Isolated location (not on the back deck)**	
Atmospheric sampling vans	**UAV Deck**	Need to reinforce the UAV deck to support vans. Need bolt pattern for tying them down.
Light Incubation Van		https://www.usap.gov/vesselScienceAndOperations/documents/Light%20Incubation%20Van%2014.pdf