DIRECTORATE FOR GEOSCIENCES

OFFICE OF POLAR PROGRAMS

Designing Cyberinfrastructure for the Antarctic Research Vessel (ARV)

CI4MF 2024 18 January 2024

NSF ARV Team

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Tim McGovern, ARV Program Manager

Caitlin Jarecki, ARV Assistant Program Manager (USN PEO Ships)

Mike Prince, ARV Project Manager

Tim Howard, OPP/AIL Information Technology Support Manager

National Science Foundation
WHERE DISCOVERIES BEGIN

Preliminary Design Rendering

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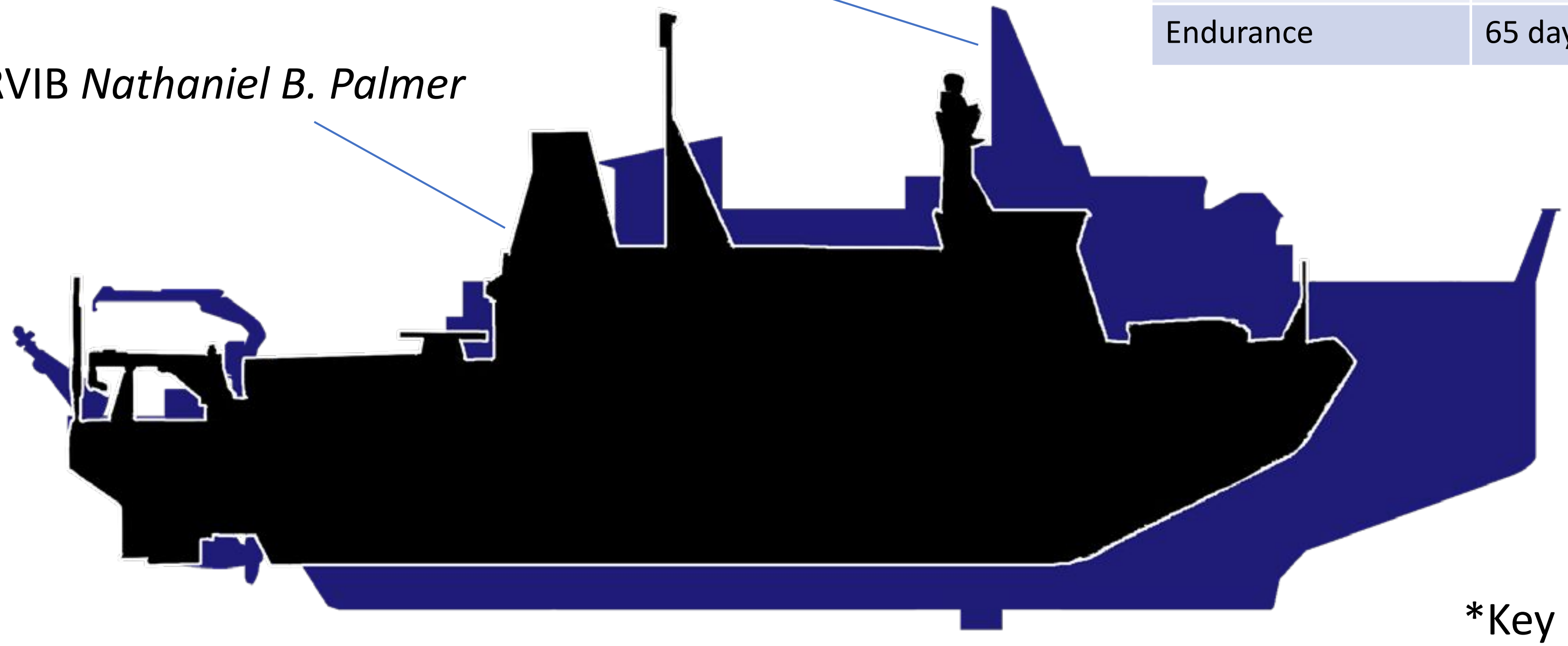
Overview – Replacement for NBP

	Nathaniel B. Palmer	Antarctic Research Vessel	
Length	309 ft	365 ft	**Bigger**
Sci/Tech Berthing	45	**55***	**More scientists**
Total Lab Space	3,805 sq ft	4,497 sq ft	**More lab space**
Working Deck Space	4,054 sq ft	7,197 sq ft	**More deck space**
Endurance	65 days	**90 days***	**Longer endurance**

AND greater icebreaking capability ≥4.5 ft @ 3 kts (Polar Class 3)*



*Key Performance Parameter (KPP)
Current Design & Hull Form meets all KPPs

ARV Placemat with Specifications

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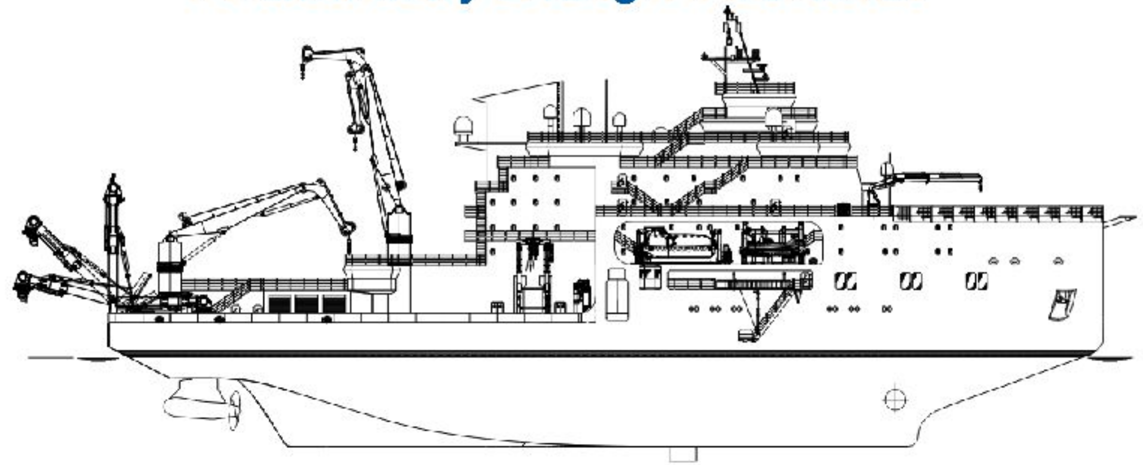
Antarctic Research Vessel (ARV) Preliminary Design Placemat



REFERENCE MISSION	
Duration	90 days

DIMENSIONS	
Length, Overall	365.0 ft
Length, BP	349.0 ft
Beam, Overall	80.0 ft
Beam, WL	79.3 ft
Design Draft	32.5 ft
Working Deck Freeboard	13.0 ft
Displacement (Design Draft)	13,430 LT
Light Ship Weight (including margins)	9,790 LT
Deadweight	3,640 LT

ACCOMMODATIONS	
Ship's Crew	29
Science Complement	55 (Including 2 ADA-accessible berths)

PROVISIONS	
Freeze	90 days
Chill	90 days
Dry	90 days

AVIATION	
UAV Launch/Recovery	150 lbs
UAV Hangar	1,472 ft²
Helicopter Landing	Bell 407 Airbus H125

MACHINERY SYSTEMS	
Azimuthing Podded Propulsors	2 x 9.5 MW
Bow Thrusters	1 x 1.9 MW
Ship Power Plant	22.3 eMW
Propeller	2 x 16.0 ft FPP

AUXILIARY SYSTEMS	
A/C Plants	Qty 3 @ 205t
Fire Suppression	NOVEC and Water Mist
Mission Fuel Capacity	60,000 gal
Ship Service Battery	2.7 MWh
Wastewater Holding	20 days

COMMUNICATIONS
HF Transmit and Receive
Ku, Ka, C, and UHF SATCOM
GMDSS
INMARSAT
UHF/VHF LOS Comms
UAS Comms
Fleet Broadband

NAVIGATION
AIS
ECDIS
S & X Band Radar
Ice Radar
DGPS

MISSION EQUIPMENT	
2 Main Deck Cranes	Maximum reach: 65ft 70,000 lbs @ 50ft
Portable Utility Crane	4,000 lbs @ 40ft
Forward Crane	4,000 lbs @ 40ft
Stern A-Frame Side A-Frame	80,000 lbs slewing
Meteorology Mast	1
Atmospheric Mast	1
CTD Hydroboom	Fast-acting, Reaches water level
Piston Core LARS	40m
Multibeam Sonar Suite	
Sonar Drop Keel	0 ft / 3 ft /10 ft
Container Quantity	20 TEU

PERFORMANCE	
Open Water	
Maximum	> 17 kt
Cruise	11 kt
Quiet	8 kt
Ice	
Continuous 3 kt	> 4.5 ft + 1 ft snow
Continuous 6 kt	> 1.6 ft
Turning out	> 4.5 ft
Range	> 17,000 nm
Towing	
4 kt	25,000 lbs
6 kt	10,000 lbs

CLASSIFICATION	
ABS ✠A1 Oceanographic	✠AMS
CCO-POLAR (-35°C,-45°C)	Ice Class PC3
✠ACCU	CRC
Unrestricted service	R2
EEDI-PH3	ENVIRO
HAB++(WB)	BWT+
ESS-LIBATTERY	HYBRID IEPS
ILM	UWILD
POT	

MISSION SPACES	
Containers	8 in Science Hold 12 on Weather Decks
Lab Area, Total	8,263 ft²
Aft Work Deck	7,724 ft²
Science Stores	42,571 ft³
Side Deck Length	170 ft.
Baltic Room Area	704 ft²
HAZMAT Storage	214 ft²
Science Observation Deck	1,163 ft²

ASC ANTARCTIC SUPPORT CONTRACT

leidos

GIBBS & COX A Leidos Company

November 7, 2023

General Arrangement – Profile

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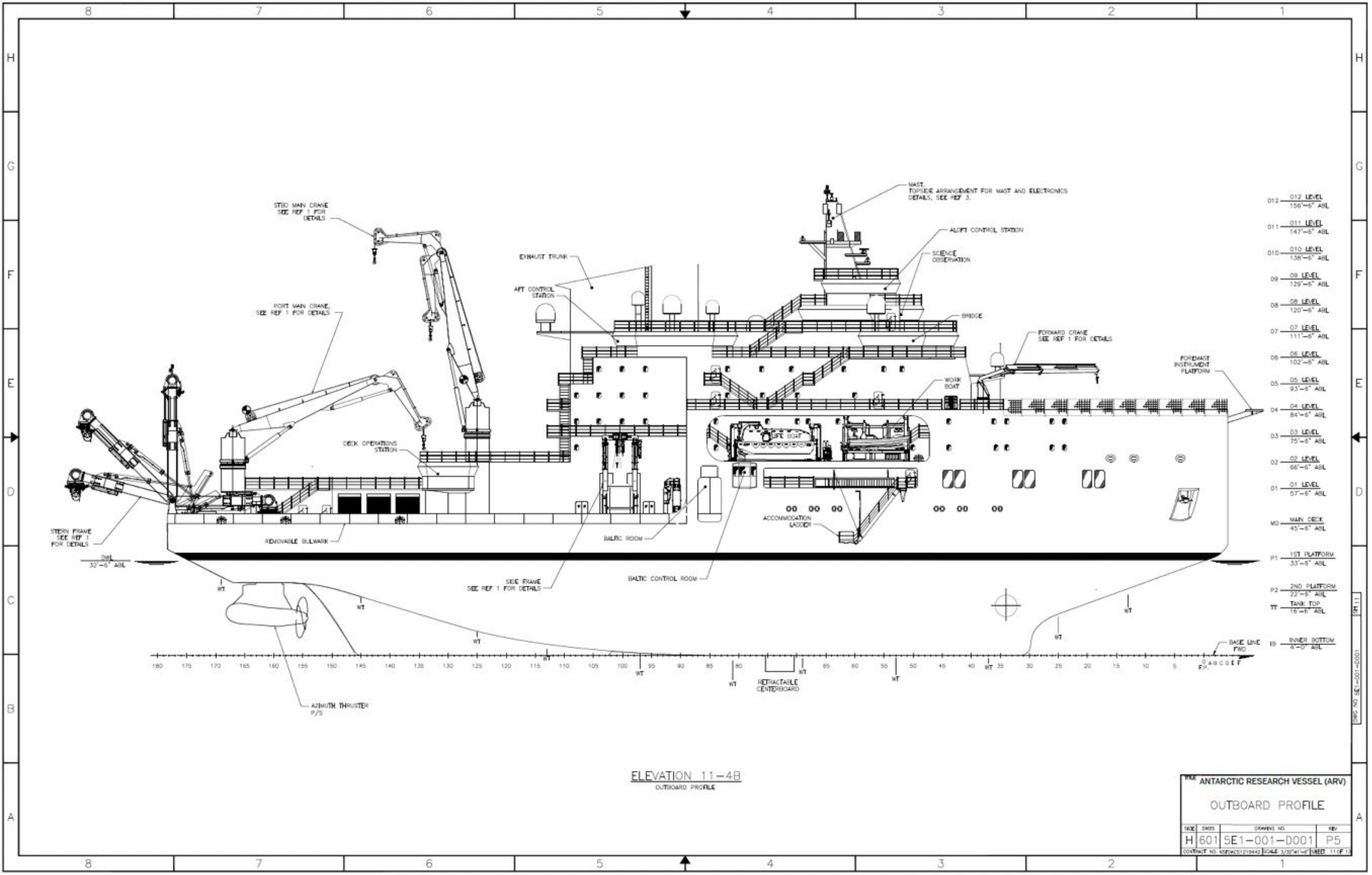
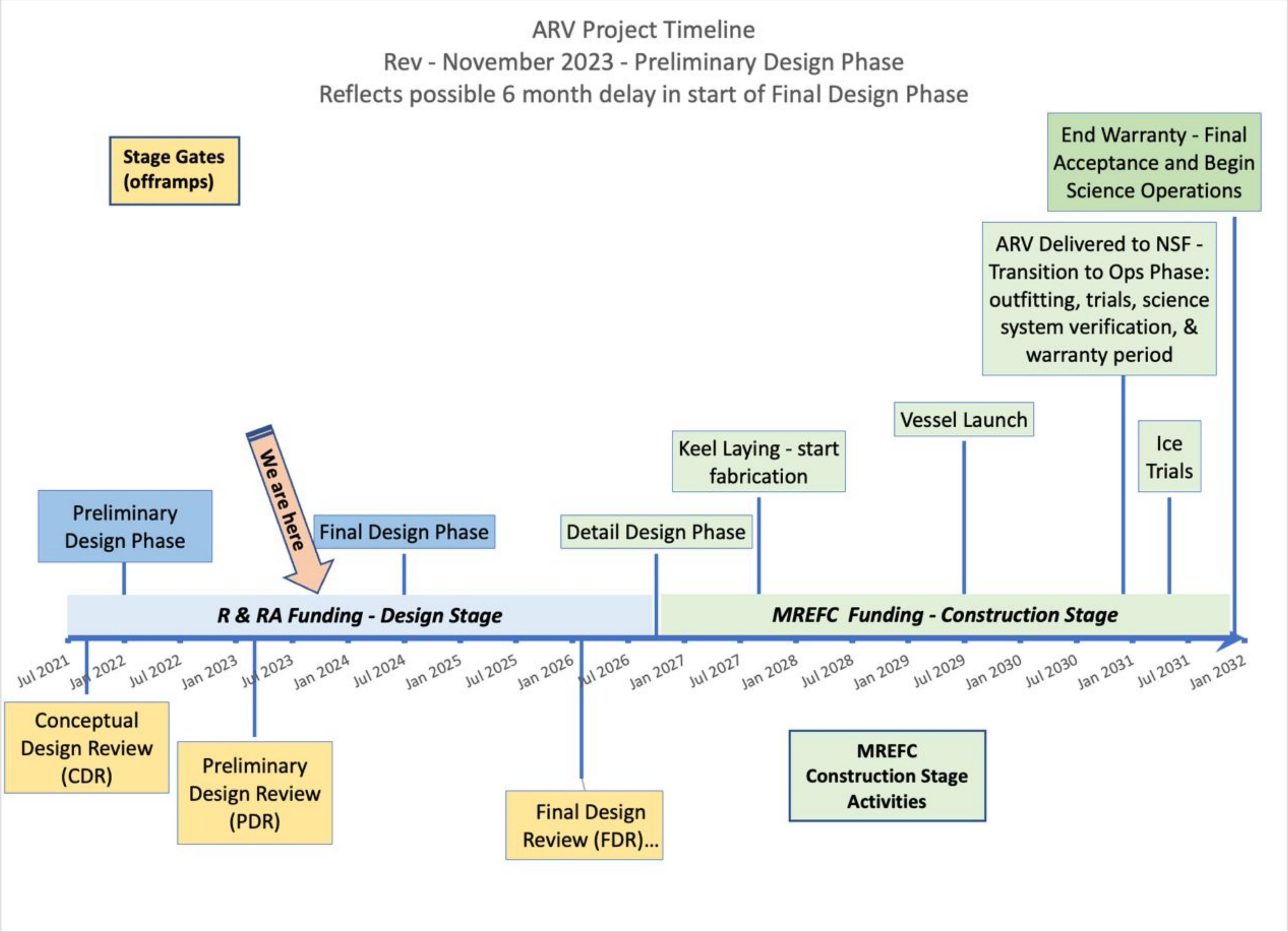


Drawings & Reports go to:
https://future.usap.gov/arv-doc-library/

ARV Schedule



Next Steps:

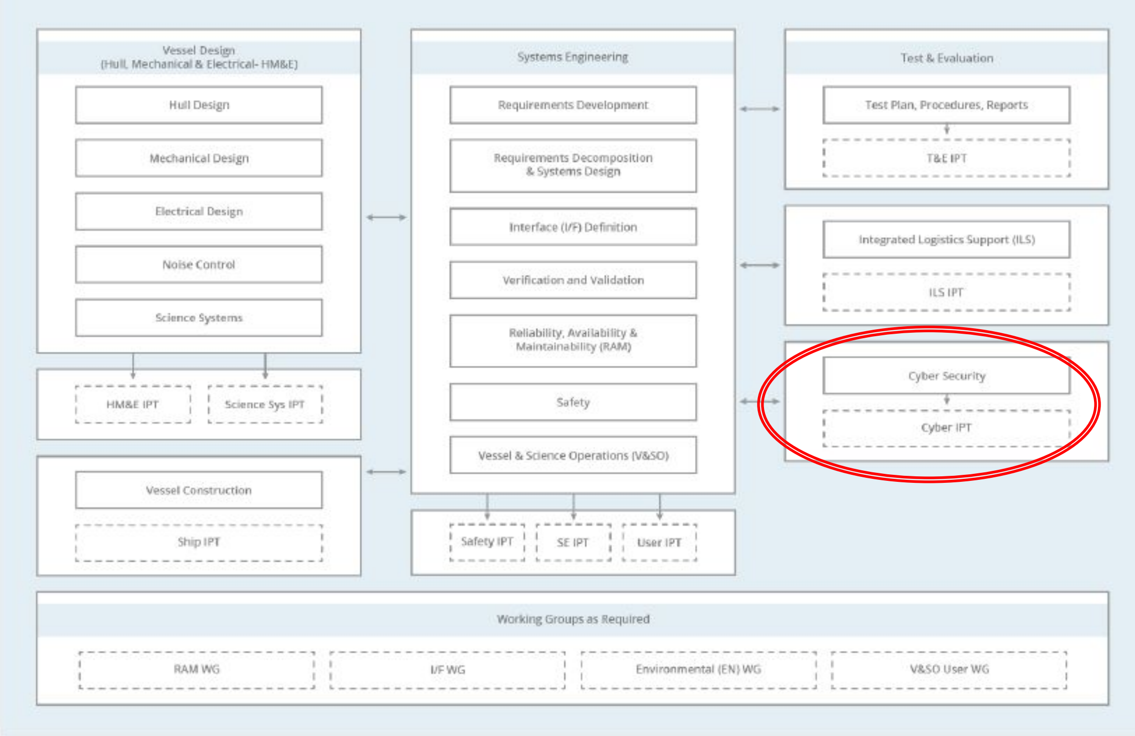
- RFP and Selection of the Vessel Integrator to complete the project. (CY 24)
- Final Design Phase (CY 24-26)
- Final Design Review (CY 26)
- Appropriation and Approvals to start Construction Stage (CY 26)

CI & CS Project Guidance

- NSF Research Infrastructure Guide - https://www.nsf.gov/pubs/2021/nsf21107/nsf21107.pdf
  - Section 6.3 – Cyber Security Requirements
- ARV Performance Specification & Science Mission Requirements
- ARV Project Execution Plan
  - Section 7 and Appendix 13 – Systems Engineering Plan includes Cyber IPT
  - Section 12 – Cyber Infrastructure and Cyber Security

Table 1. IPT & WG Functions

IPT/ WG Name	Responsibility	Members	Meeting Frequency
Systems Engineering IPT [SE IPT]	Coordinates SE activities: Requirements decomposition, allocation, traceability and compliance; technical budgets; KPPs, trade studies, interface management.	Led by SE. SME's from each IPT as required NSF Representative	Monthly Final Design through Construction Stage.
Cybersecurity IPT [CYBER IPT]	Coordination and review of the activities related to the development and implementation of Hardware (HW) and Software (SW) and network enclaves to satisfy Cybersecurity requirements.	Led by Cyber Lead, SMEs invited as required. NSF Representatives	Monthly Final Design through Construction Stage.



ARV Project Team – Cyber = Key Component

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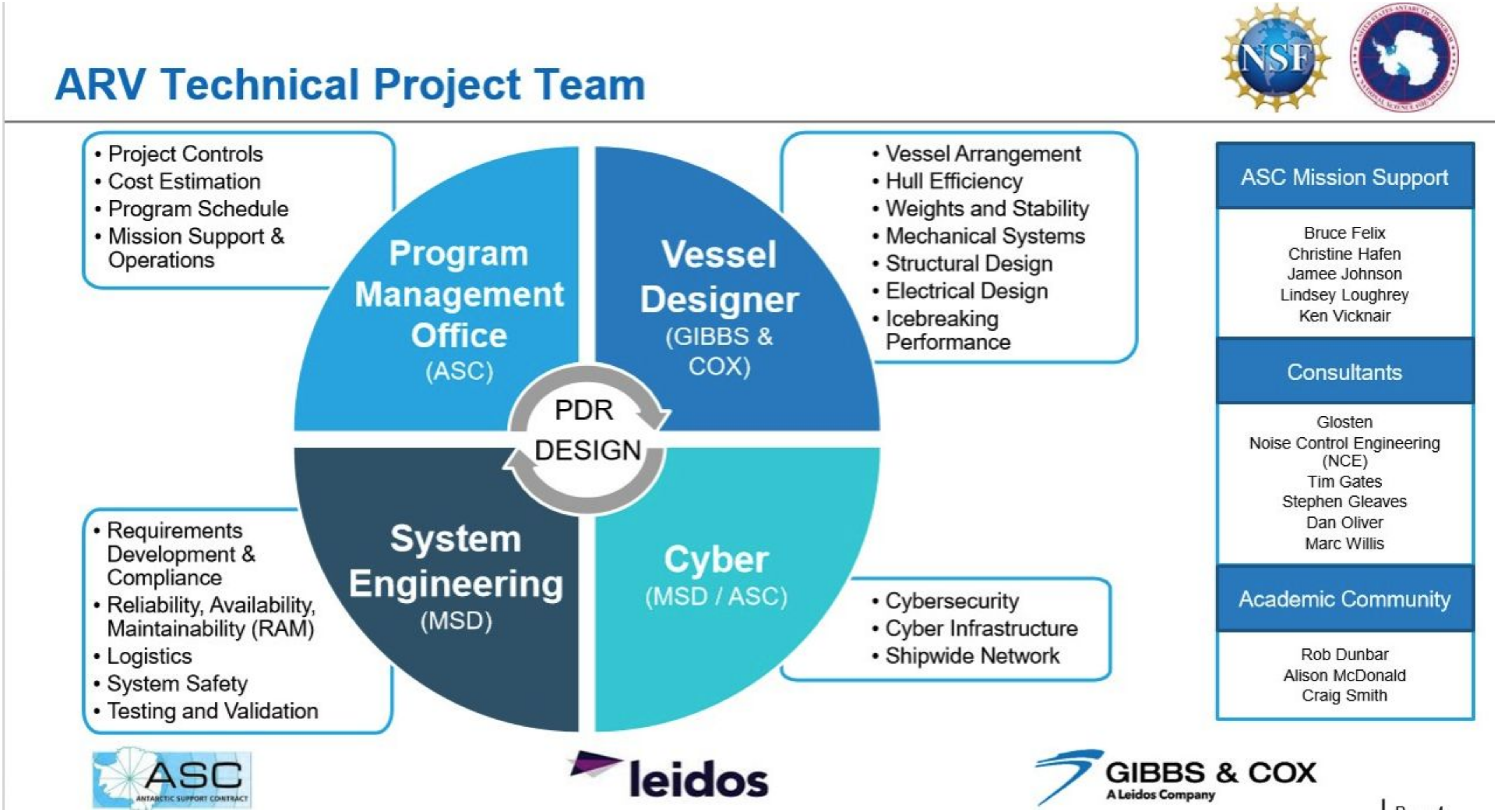
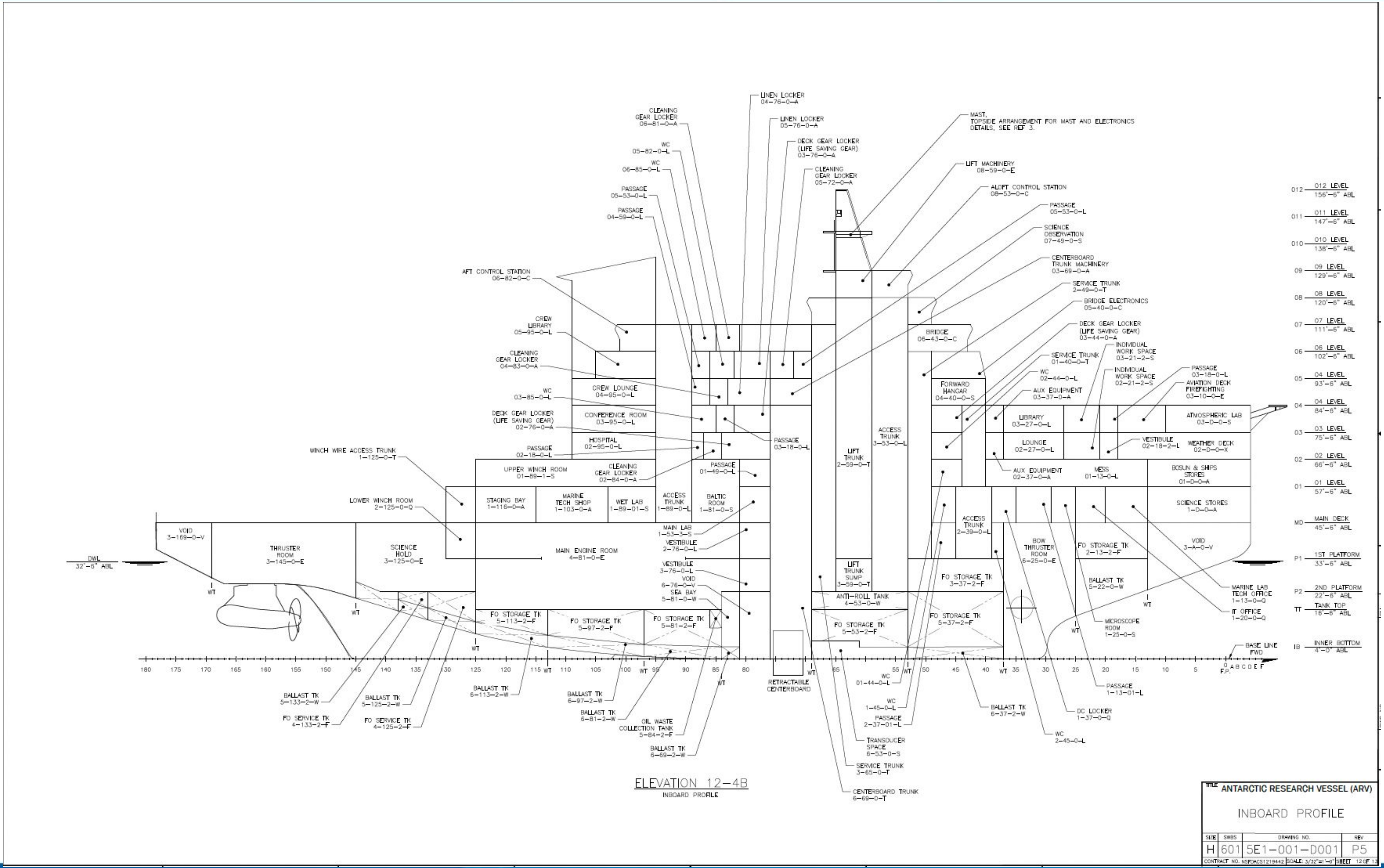
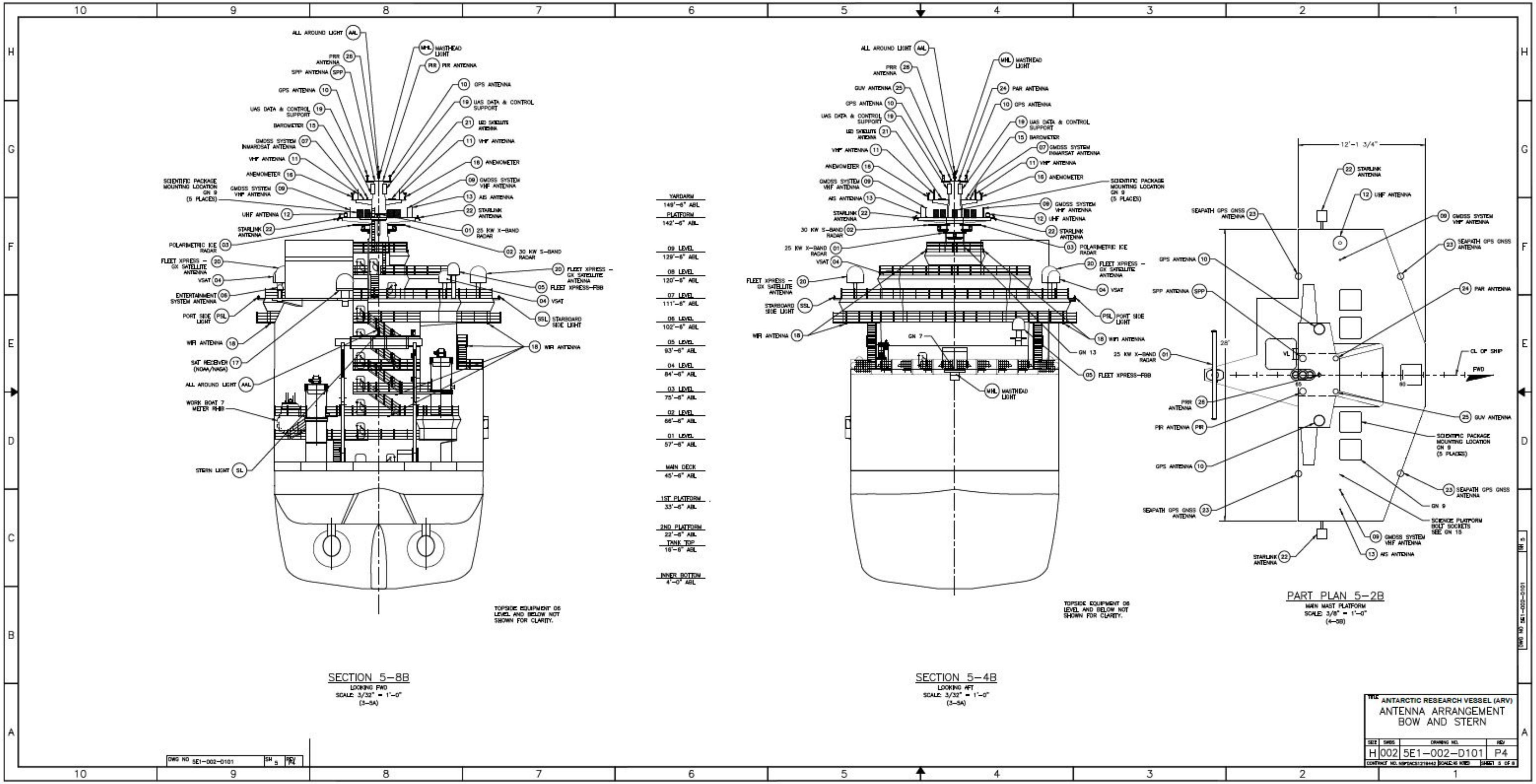


CI – Complex and Extensive CI Requirements



- Ship Operations Systems
  - Power Management
  - Propulsion Control
  - Navigation
  - Communications
  - Life Support
- Science Systems
  - Communications
  - Data management
  - Data Use, Display, Archive
  - Acoustic Systems
  - Met Sensors
  - Seawater Sensors
  - Ice and Weather
  - Remote Access & Outreach
- Guest Network
  - Personal Use & Comms

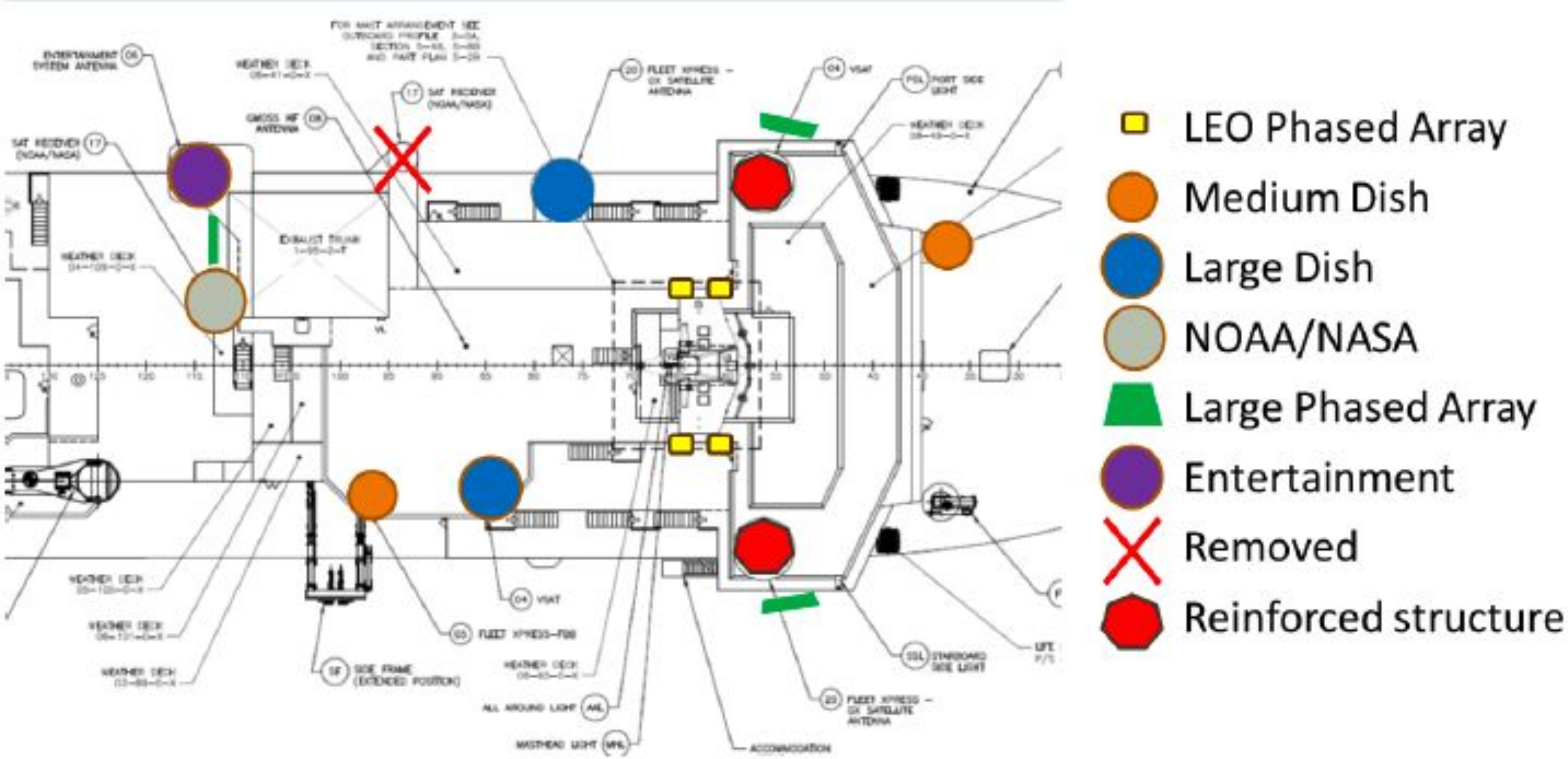
CI – Topside Arrangement – Comms & Sensors



CI – SATCOM Arrangements

Planning for the Future

Figure 13: Recommended SATCOM SWaP-C Configuration



G&C recommends developing a design budget process using a Space, Weight, and Power and Cooling, commonly referred to as “SWaP-C,” design based around the latest technology models" that could be used for ship design and construction.

CI – Acoustic Systems

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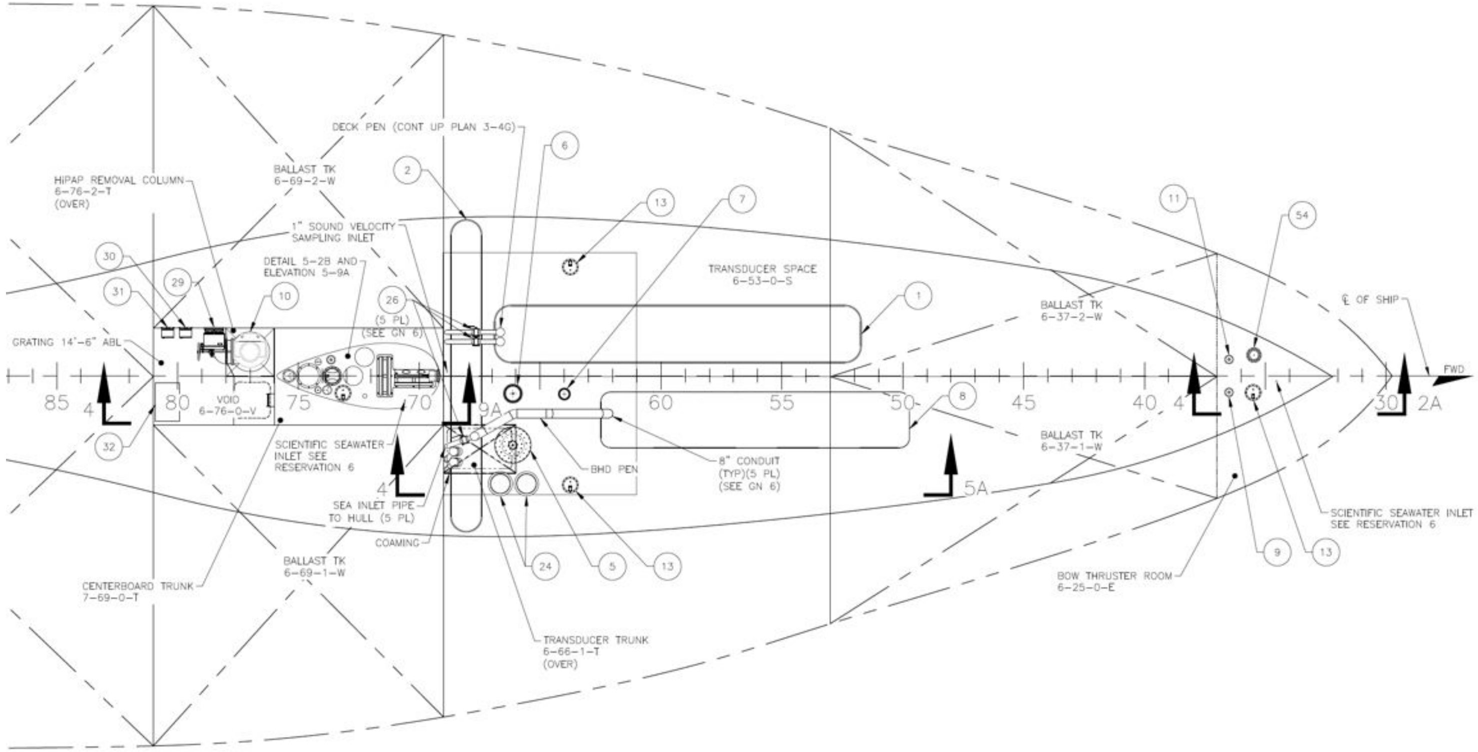
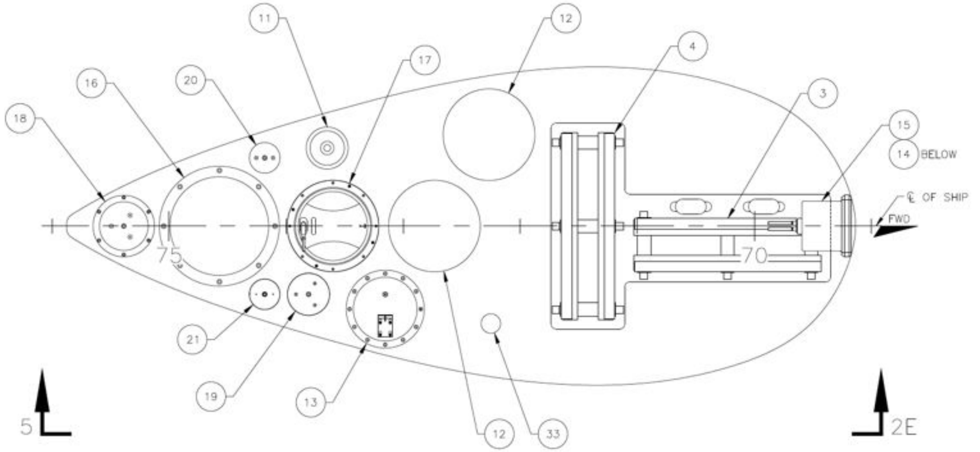
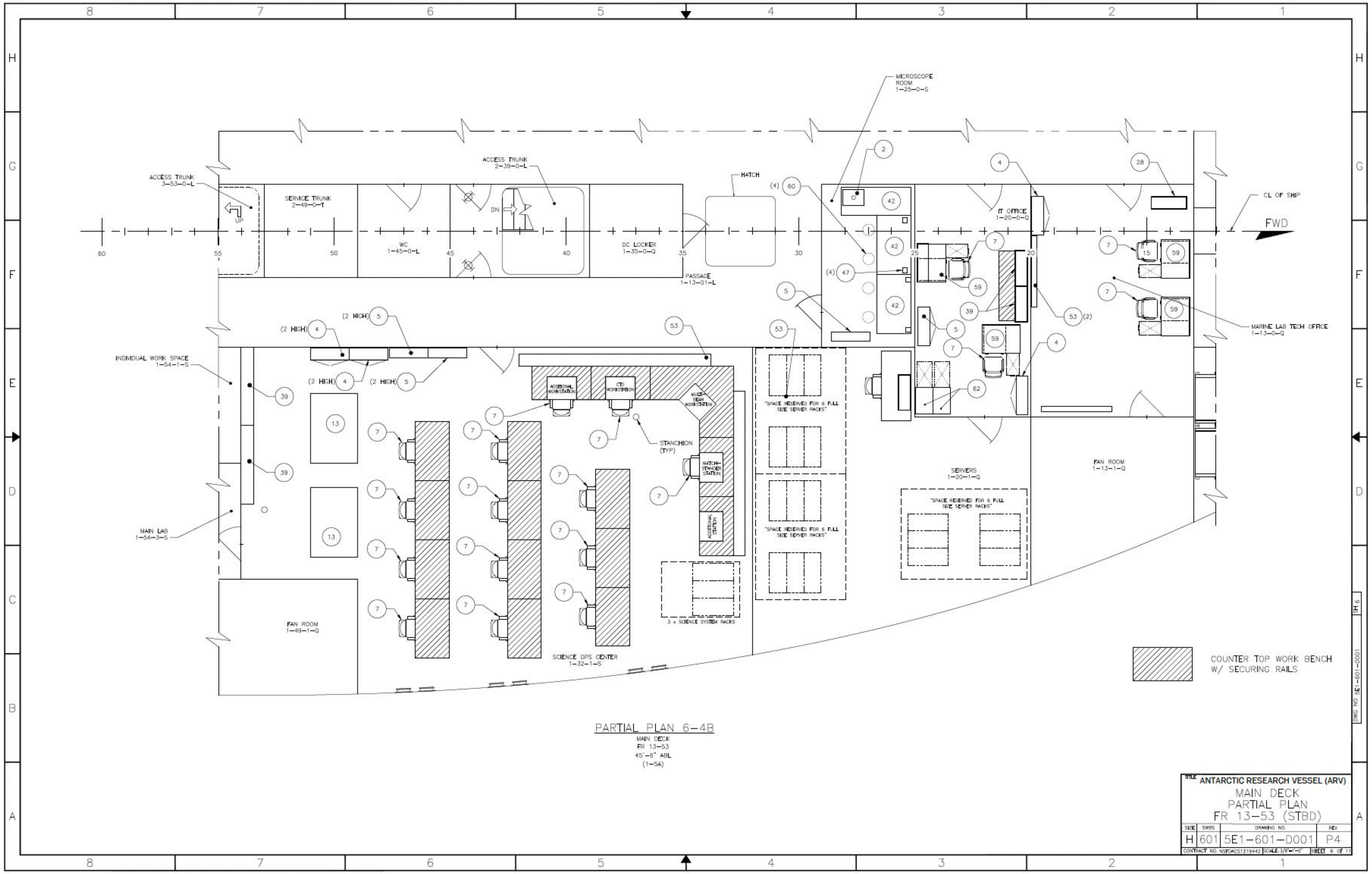


ITEM NO.	QTY PROVIDED	DESCRIPTION
1	1	TRANSDUCER: DEEP WATER, MULTI-BEAM, 1'
2	1	TRANSDUCER: DEEP WATER, MULTI-BEAM, 1'
3	1	TRANSDUCER: SHALLOW WATER, MULTI-BEAM, 1', TX
4	1	TRANSDUCER: SHALLOW WATER, MULTI-BEAM, 1', RX
5	1	ACOUSTIC DOPPLER CURRENT PROFILER 38 KHZ
6	1	ACOUSTIC DOPPLER CURRENT PROFILER 75 KHZ
7	1	ACOUSTIC DOPPLER CURRENT PROFILER 300 KHZ
8	1	SUB-BOTTOM PROFILER, 3'
9	1	ACOUSTIC RELEASE TRANSPONDER 12 KHZ
10	1	USBL
11	2	SPEED LOG
12	2	19" CENTERBOARD SPARE
13	5	HYDROPHONE
14	1	FORWARD LOOKING CAMERA
15	1	FORWARD LOOKING SONAR
16	1	MBESS TRANSDUCER 18 KHZ
17	1	MBESS TRANSDUCER 38 KHZ
18	1	MBESS TRANSDUCER 70 KHZ
19	1	MBESS TRANSDUCER 120 KHZ
20	1	MBESS TRANSDUCER 200 KHZ
21	1	MBESS TRANSDUCER 333 KHZ

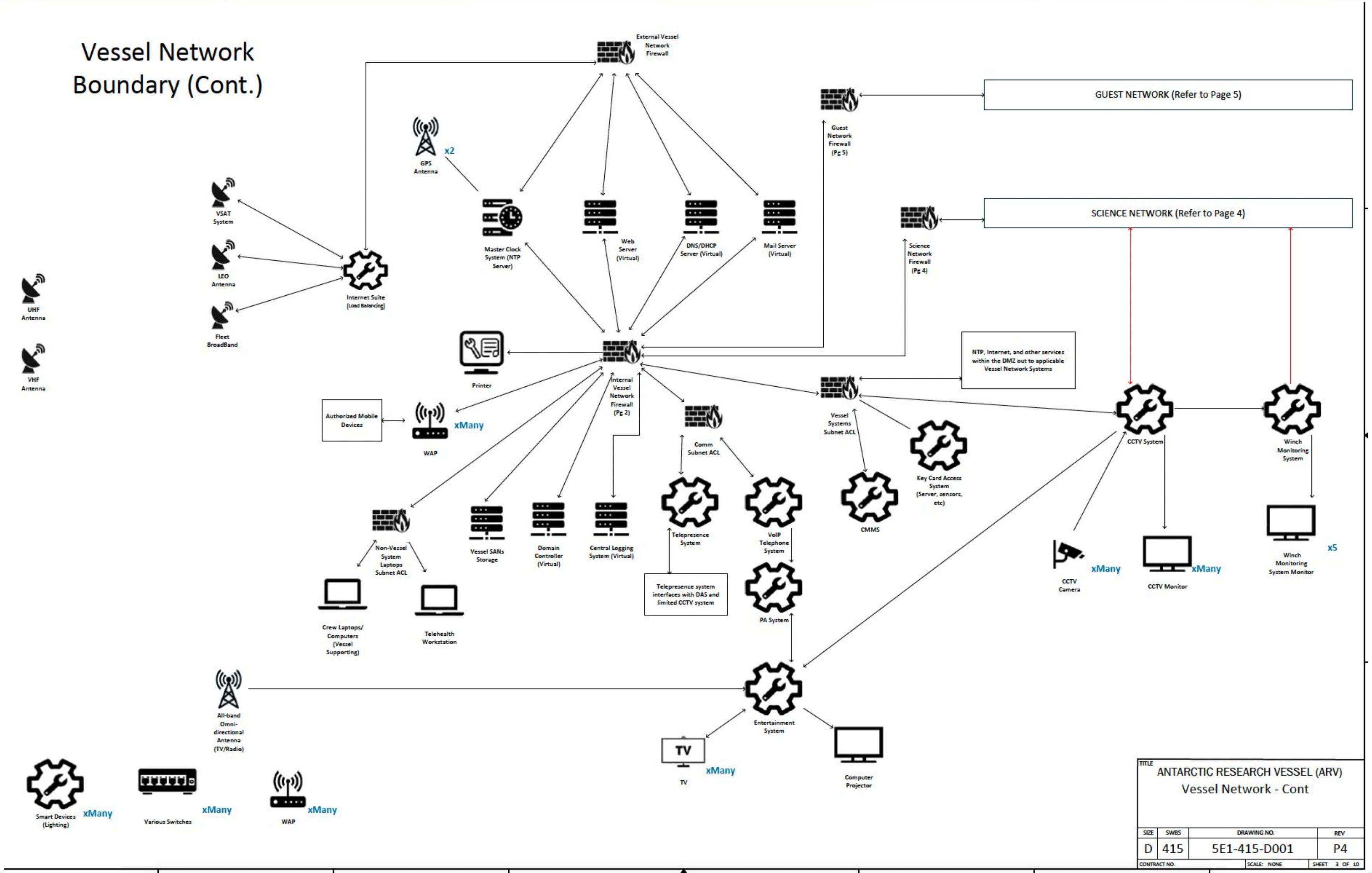


DETAIL 5-2B
CENTERBOARD ARRANGEMENT

CI – Lab Spaces – Server Room



CI – Network Diagrams – Three Networks



CI – Network Diagrams – Vessel Network

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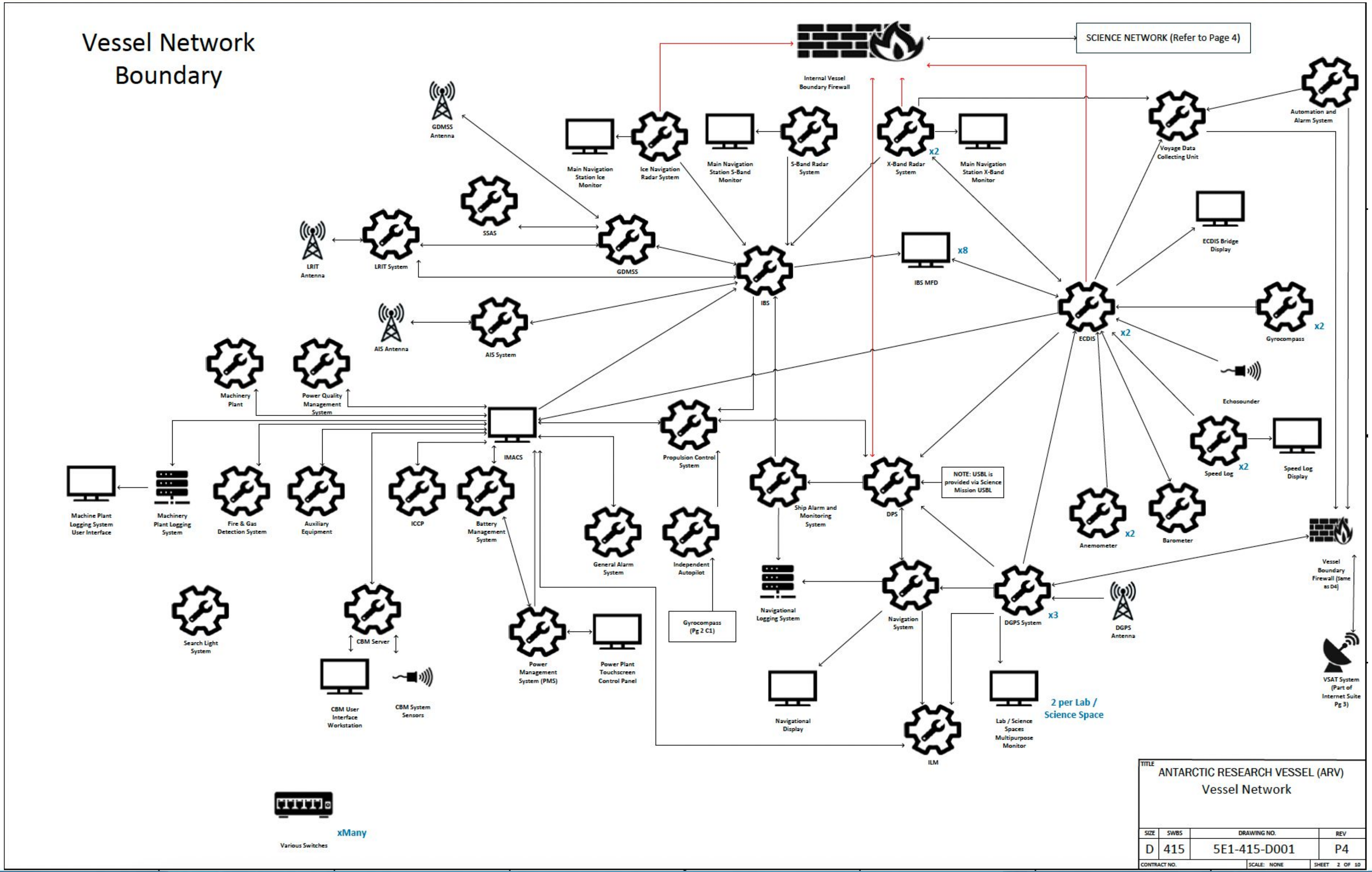

CI – Network Diagrams – Science Network

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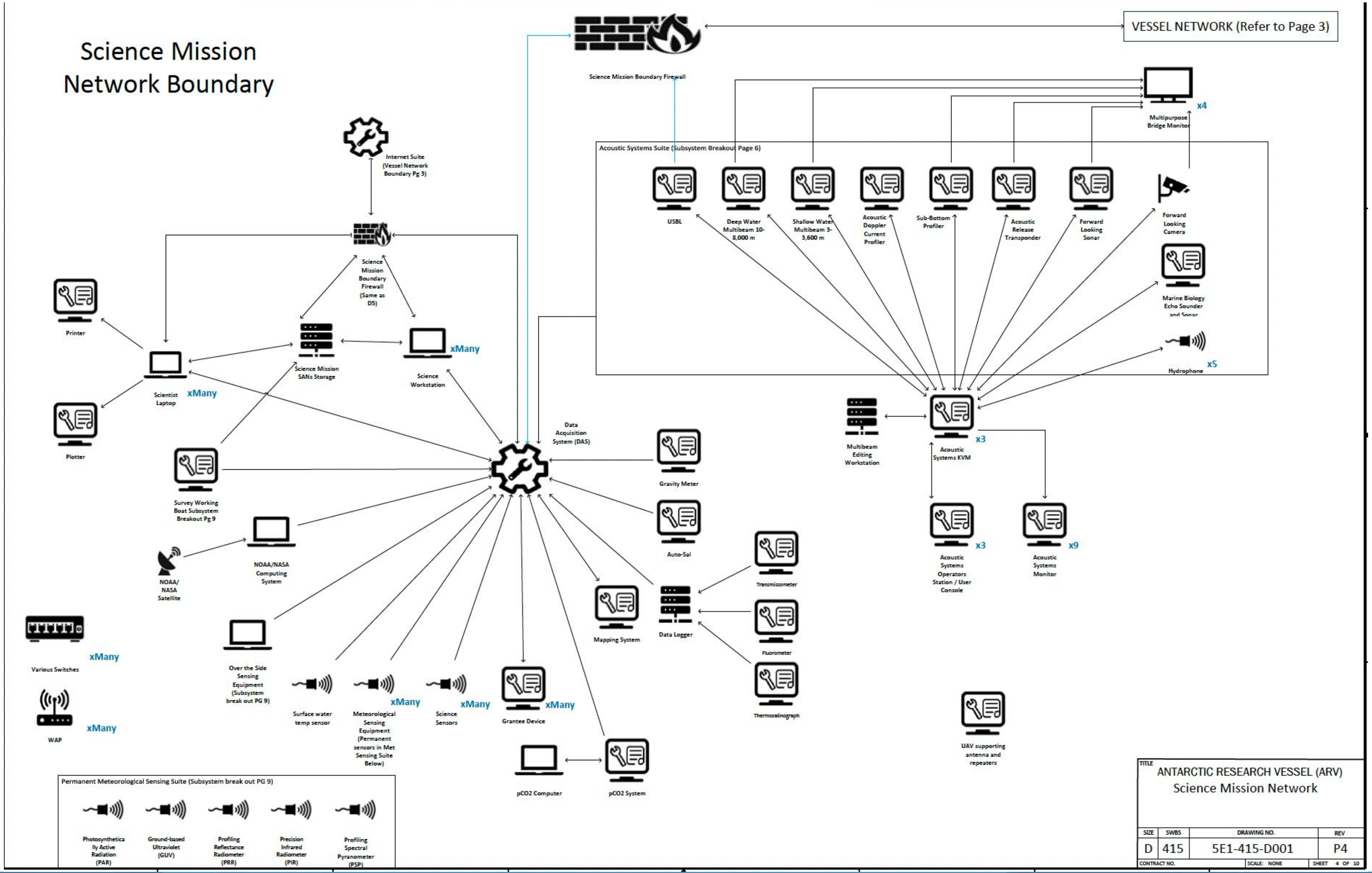
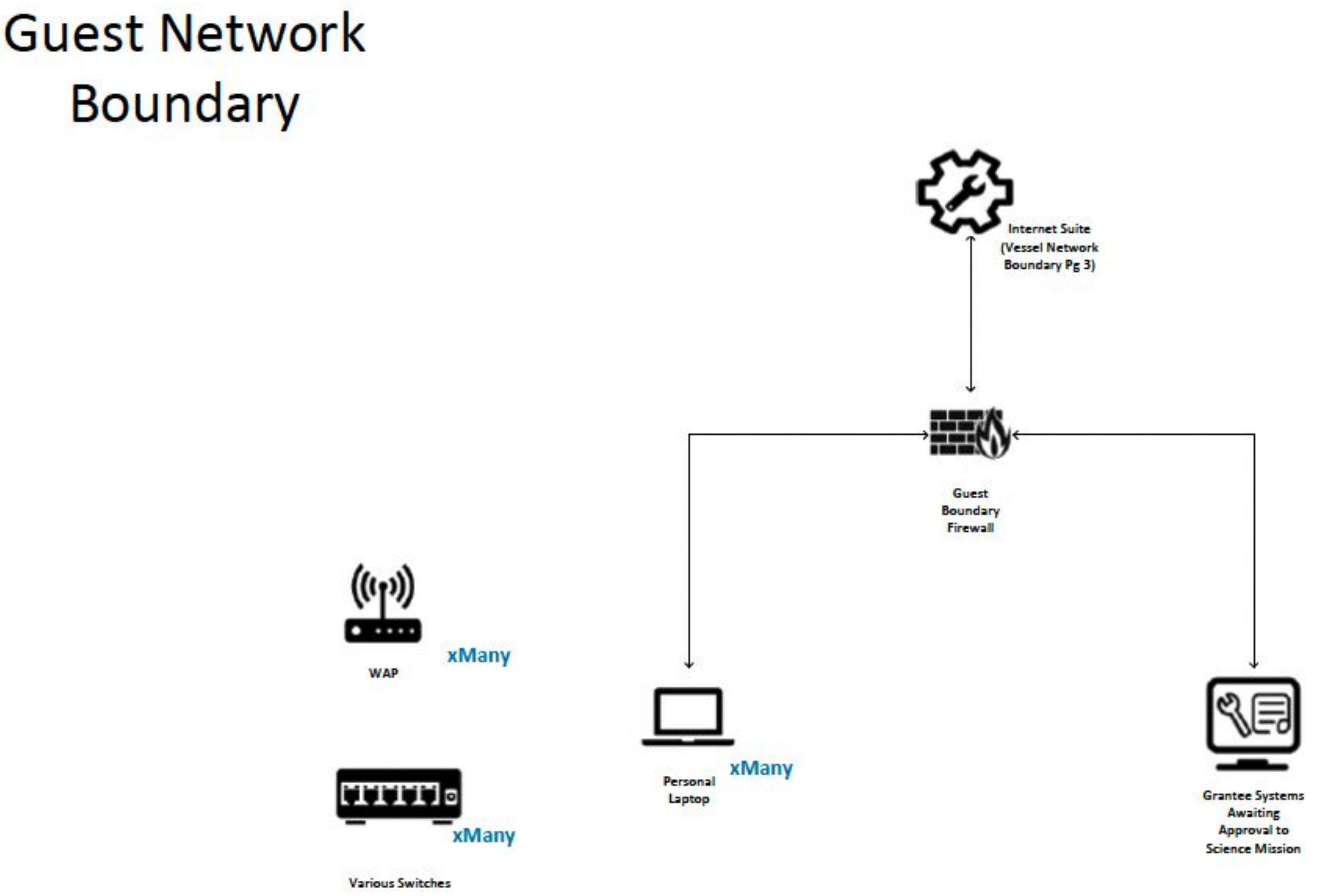


CI – Network Diagrams – Guest Network



The end result – fitting it all in…

Lessons Learned from other projects:

- Model the routing of cables and placement of equipment before starting installation.
    - 3D modeling down to very small (less than 1” diameter) cables
    - 3D modeling of all equipment foundations and locations
- Make sure all related equipment is identified and located in detailed construction drawings.
    - Finding a suitable location after construction has started is problematic and uses space allocated for some other use.
- Specify actual equipment (make/model) as late as possible in the construction process.
    - Design and model representative space, weight, power, cooling, connections and locations that will accommodate the eventual equipment selection. “SWaP-C” mentioned earlier.
    - Don’t underestimate size, weight, power requirements in early design efforts
- Visualize and diagram all connections, integration and utilization of all Cyberinfrastructure as part of creating the design documentation.

Science & Cyber Community Engagement

- ARF (UNOLS) Cyber Working Group (CIWG)
  - Weekly Meetings
- ARV (UNOLS) Facilities Groups
  - Multibeam Advisory Committee (MAC)
  - UHDAS – ADCP Data Acquisition
  - Shipboard Automated Meteorological and Oceanographic System (SAMOS)
  - Rolling Deck to Repository (R2R)
- Trusted CI – Cyber Security Support
- Compass CI – Cyber Infrastructure Support

Science Community Engagement

<u>Science Advisory Subcommittee (SASC)</u>
Reports:
<u>https://future.usap.gov/arv-community-input/</u>

- Dr. Amy Leventer, (Chair) Colgate University
- Ms. Alice Doyle, UNOLS
- Dr. Carlos Moffatt, Univ of Delaware
- Dr. Deborah Steinberg, VIMS
- Dr. Kristin O'Brien, UAF; GEO AC Rep

<u>Past Members</u>

- Dr. Patricia Quinn, NOAA/PMEL
- Dr. Clare Reimers, OSU
- Dr. Bruce Appelgate, UCSD/Scripps

* ***Seeking nominations for 3 new members***

Compass CI Review & Recommendations

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CI Recommendations for the Antarctic Research Vessel (ARV)
Author(s): Anirban Mandal, Ilya Baldin, Erik Scott, Ewa Deelman (CI Compass)
Date: September 15, 2023

1. Develop canonical science use cases to help exercise the CI system.
   Develop a small set of validating science use cases, both current and projected, representative of the scientific experiments performed by the broader NSF Office of Polar Programs (OPP) researcher community.
   a. Attach soft performance expectations and any other specific requirements (compute, network, storage) for each of the validating canonical science use cases.
2. Design "CI Cruise" to overlap with ship design reference mission to validate canonical science use cases.
   Develop a detailed plan for piggybacking design and evaluation of the shipboard CI capabilities with respect to the validating science use cases during the 90-day ship design reference missions. This can be referred to as "CI Cruise".
3. Develop and test on a small-scale twin of shipboard CI infrastructure.
   Develop a sandbox testing platform that is a small-scale twin of the planned CI for the research vessel on shore-side, and identify a small number of teams willing to test drive the science use cases in that small-scale twin
4. Develop vessel IT operational use cases.
   Develop canonical operational use cases to design, test and validate the general IT operations that are required during all cruises. These use cases should exercise all IT functions in the ship, e.g. external comms, internal comms, PA, entertainment systems, ship alarms, CCTV, email, guest WiFi network, DNS and other network functions, etc.

Design Reference Mission (DRM) – CI Version

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Table 3: DRMC1 Thwaites/Pine Island Bay – Vessel Movement Daily Activities

Activity Start		Activity End		Activity Hours	Location	Operation	Cruise days	Activity Type
Date	Shift	Date	Shift					
14-Dec	AM	14-Dec	AM	12	Punta Arenas, Chile (PUQ)	Depart	1	Hotel only
14-Dec	PM	20-Dec	PM	156	PUQ to Amundsen Embayment	Transit open ocean (Approx 1,590 nm)	1 - 7	Open water transit
21-Dec	AM	22-Dec	PM	48	Amundsen Embayment	CTD work	8 - 9	On station
23-Dec	AM	24-Dec	AM	36		Trace metal tow-fish	9 - 11	Acoustically quiet transit
24-Dec	PM	24-Dec	PM	12		Sea glider deployment	11	On station
25-Dec	AM	26-Dec	PM	48		Transit - first and second year ice	11 - 13	Icebreaking
27-Dec	AM	27-Dec	PM	24		Transit - first and second year ice	13 - 14	Icebreaking
28-Dec	AM	30-Dec	AM	60		CTD work	15 - 17	On station
30-Dec	PM	30-Dec	PM	12		Sea glider deployments	17	On station
31-Dec	AM	31-Dec	AM	12		Transit - first and second year ice	18	Icebreaking
31-Dec	PM	31-Dec	PM	12		Mega-core/CTD	18	On station, DP
1-Jan	AM	1-Jan	AM	12		VMP transect	19	Acoustically quiet transit
1-Jan	PM	1-Jan	PM	12		Transit light ice	19	Ice transit

Compass CI Recommendation # 2 is to create a companion CI Cruise Scenario to evaluate the CI/CS requirements to support this Design Reference Mission.

Figure 1: Future Thwaites Glacier Cruise Track

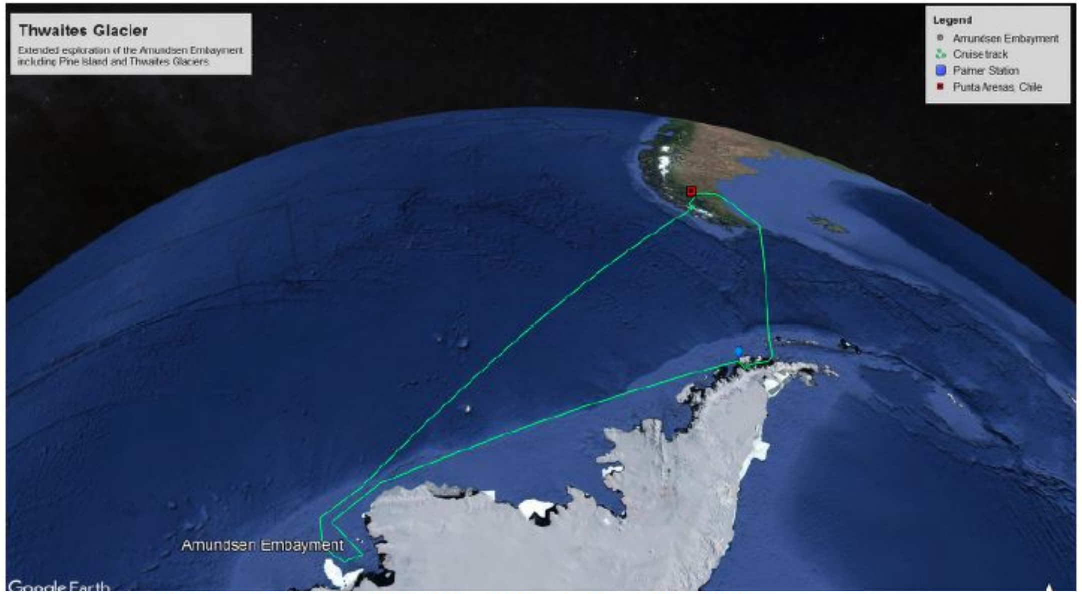

Table 2: DRMC1 Thwaites/Pine Island Bay – Vessel Movement Summary

Location	Fair Weather Duration (days)		
	Southern Ocean	Amundsen Embayment	Amundsen Sea
Open water transit	10	-	-
Acoustically quiet transit	-	16	-
Icebreaking	-	9	-
On station	-	37.5	-
On station, DP	-	10	-
Deployment	-	3	-
Hotel only	1	-	0.5
Ice Transit	-	2	1
Totals (90-day total mission duration)	**11**	**77.5**	**1.5**

Next Steps

- Final Design Phase
  - Continue to develop the Ship-wide Network Diagram moving from a Logical Diagram to a Physical Diagram
    - Depicting cable type
    - Determining exact placement of individual equipment
    - Developing rack diagram
  - Continue Development of Cyber Security Controls
    - Security Control Traceability Matrix (SCTM) – 5E1-402-P001
    - NIST SP 800-53 Rev 5
    - 356 controls shaping three networks' security stance
    - Sets subsequent phases up for cyber success
  - Continue reaching out to the Science and Cyber Community
    - Attendance at UNOLS CIWG Ship Ops and Tech Services meetings provide beneficial insight
    - Compass CI to review updated Network Diagrams and CI details
    - Trusted CI to review Cyber Security planning
    - NSF CI/CS program officers and USAP CI/CS expertise continued involvement in ARV project development.
- Construction Stage
  - Continue Design Development w/Ship Builder – Source specific vendors and equipment
  - Installation of CI and Testing

Community Outreach and Public Info

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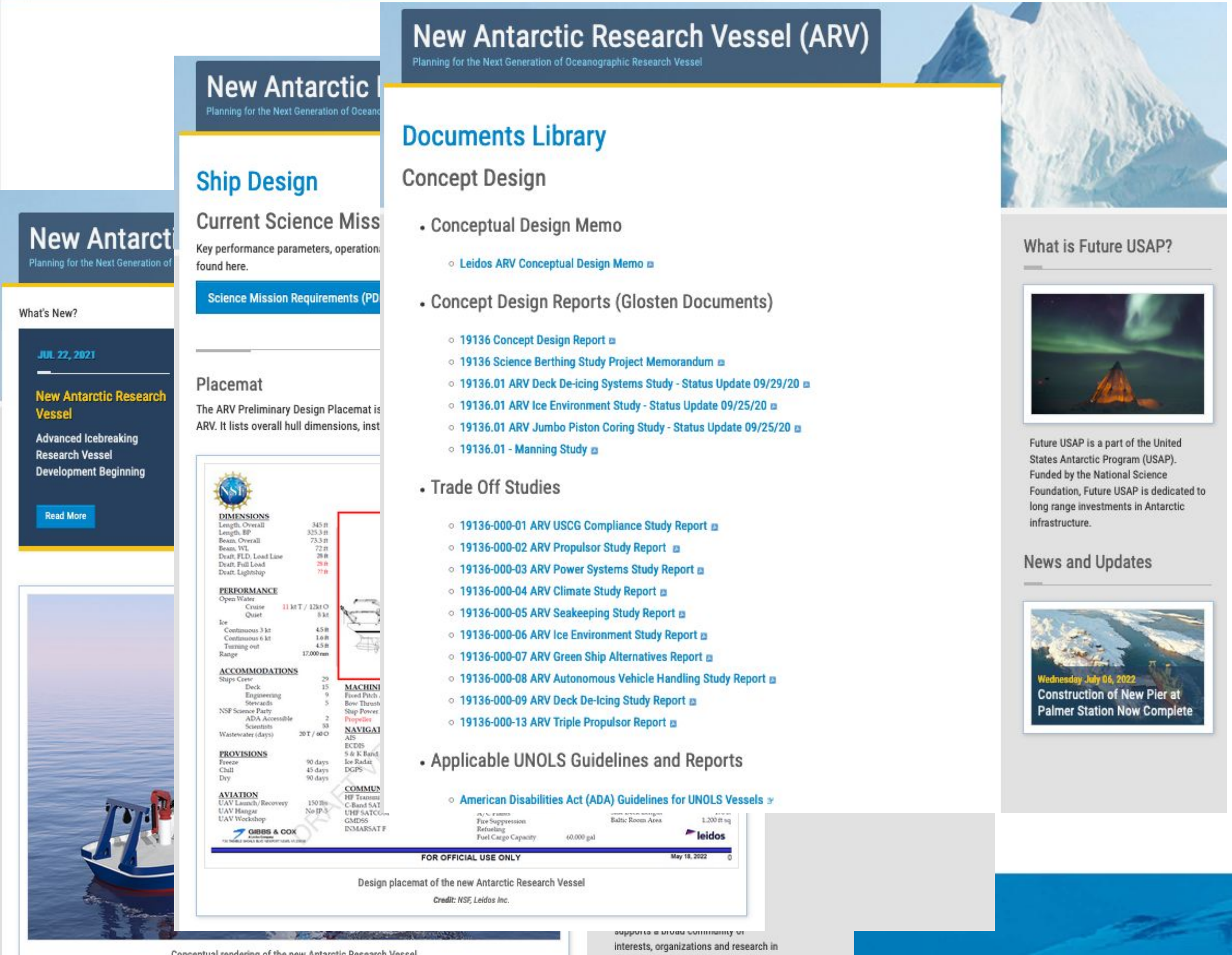

future.usap.gov/arv

Antarctic Research Vessel Summary

- ~20 years of sustained scientific demand
- Continued ability to support cutting edge NSF research for the next 40 years
- Enhanced capabilities over existing USAP research vessel
- Strong Teaming with Industry

Preliminary Design Rendering

Preliminary Design Rendering

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Questions