Antarctic Research Vessel (ARV)

Enhanced Aviation Deck Capabilities Assessment

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Revision History

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1. Executive Summary

The objective of this report is to provide summary documentation of the studies, analyses, and design changes made to the ARV following the ARV Preliminary Design Review (PDR) to focus on improving integration of the ARV with both crewed and uncrewed aircraft.

As the ARV preliminary design developed, the opportunity to provide enhanced aviation capabilities was identified as a desired area of study by the NSF as a means to improve the vessel's overall capability.

The provision of the Aviation Deck and Forward Hangar provide the ARV with the capability of launching and recovering small uncrewed aerial vehicles (UAVs; remotely and autonomously operated) for science surveys, ice surveys, and other reconnaissance. The enhancements studied and incorporated in the ARV design baseline discussed in this report include features to improve the existing UAV capabilities of the vessel, as well as provide the additional capability to land and deploy crewed helicopters from the vessel.

The following modifications, described herein, have been included in the current design baseline:

- Foremast relocated below 04 deck level
- Added area/volume reservation for required helideck firefighting systems
- Added area/volume reservation for additional safety gear
- Revised lab van location for better access in and out of the Forward Hangar
- Deck strengthening for helicopter landing and stowage
- Appropriate margin consumption to include the above features plus helicopter lashed on deck in the weight and stability baseline for DR5

The following improvements were not incorporated into current design products, but will be necessary for the ARV to complete integration of a helideck capability:

- Helideck markings
- Deck rails that fold down as netting in way of the helideck
- Tie-down fittings for securing helicopter to the helideck

The following items related to the addition of a helideck will be covered in a future design phase:

- Addition of acoustic insulation in nearby compartments
- Helideck lighting
- Flight navigation and visual aids
- Communication systems

1.1. List of Acronyms

ABS	American Bureau of Shipping
ARV	Antarctic Research Vessel
CONMOD	Contract Modification
DD&B	Detail Design and Build
DR	Design Review
ft	Feet or foot
HELIDK	ABS Notation
IMO	International Maritime Organization
KG	Vertical Distance between Keel and Center of Gravity
lbs	Pounds
LT	Long Tons
MVR	Marine Vessel Rules
NSF	National Science Foundation
OCL	Off Centerline
P/S	Port and Starboard
PDR	Preliminary Design Review
P-SPEC	Performance Specification
SNAME	Society Naval Architects and Marine Engineers
SOLAS	Safety of Life at Sea
UAV	Uncrewed Aerial Vehicle
VCG	Vertical Center of Gravity

1.2. Nomenclature

The General Arrangement, Reference (1), identifies the 04 Level weather deck forward of the Forward Hangar as the Aviation Deck. The helideck referred to in this document is a purpose-built helicopter landing area on the Aviation Deck designed for routine helicopter operations.

2. Assumptions

Throughout this assessment the following assumptions were made regarding crewed helicopter integration:

- No helicopter refueling facilities to be provided, no fuel drums/cans will be carried for manual refueling.
- Crewed helicopter will not be stored in the Forward Hangar – to be carried on deck only.
- No dedicated maintenance facility for the aircraft to be provided.
- Due to the extreme operating environment of ARV, it is assumed any helicopter landed would need the ability to be secured to the deck, in the event of sudden inclement weather.
    - To mitigate stability impacts, the weight and KG impact of helicopter on deck will be debited from CONMOD margin for this increased requirement.

- Fixed firefighting system for the helideck and outfitting will be debited from CONMOD margin.
- Structural weight development for flight deck reinforcement will be debited from DD&B margin.

3. Helicopters Considered

Two helicopters have been confirmed to operate near McMurdo Station. The following helicopters were used to evaluate the required features to be added to ARV:

- Airbus Eurocopter H125 (formerly AS350 AStar)
  - Rotor Diameter 35.07 ft
  - Max Takeoff Weight 6,173 lbs.
  - # of Passengers 7

- Bell 407
  - Rotor Diameter 35.01 ft
  - Max Takeoff Weight 6,000 lbs.
  - # of Passengers 7

4. Clear Deck Area Requirements

The Aviation Deck to support UAV and helicopter operations is located forward of the primary house structure, sized to accommodate flight helicopter and UAV deployment and landing. The Aviation Deck is approximately 78 feet long and 77 feet wide at its widest point immediately forward of the house. The Aviation Deck is approximately 46 feet wide at the center of the helideck. These dimensions greatly exceed the Performance Specification threshold Aviation deck size of 24 feet by 30 feet.

ABS Marine Vessel Rules (MVR) Part 3, Chapter 2, Section 11.9, Reference (2), describes the dimensions and clearances required to land a helicopter on the ARV Aviation Deck. Figure 1 illustrates these requirements. Most dimensions are based on the helicopter rotor diameter (D). The Obstacle Free Sector is the approach and depart area that cannot have any protrusions above the deck. This area extends past the deck edge of the ship. The Limited Obstacle Sector is composed of two parts. The first sector extends from the edge of the helideck to 0.62 times the blade diameter. This zone can have deck protrusions up to 9.8 inches (25 cm). The second Limited Obstacle Sector extends from the first sector out to 0.83 times the blade diameter. The allowable deck protrusion height starts at 0.05 times the rotor diameter and increases at a 1:2 slope.

Figure 1: Helideck Obstacle Limitation Sector Requirements

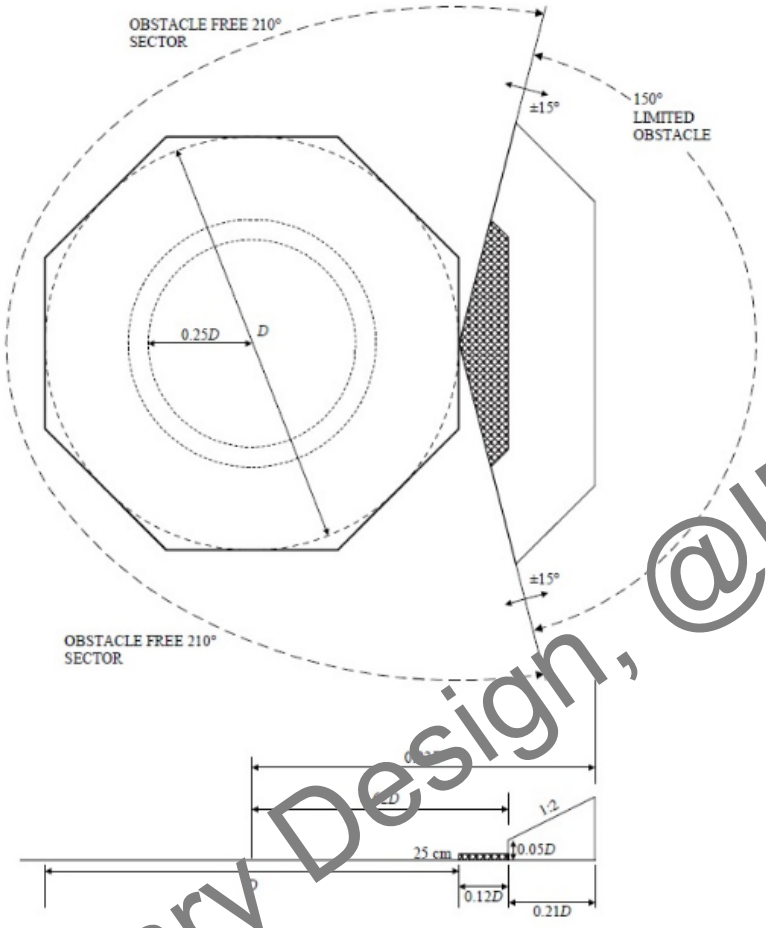
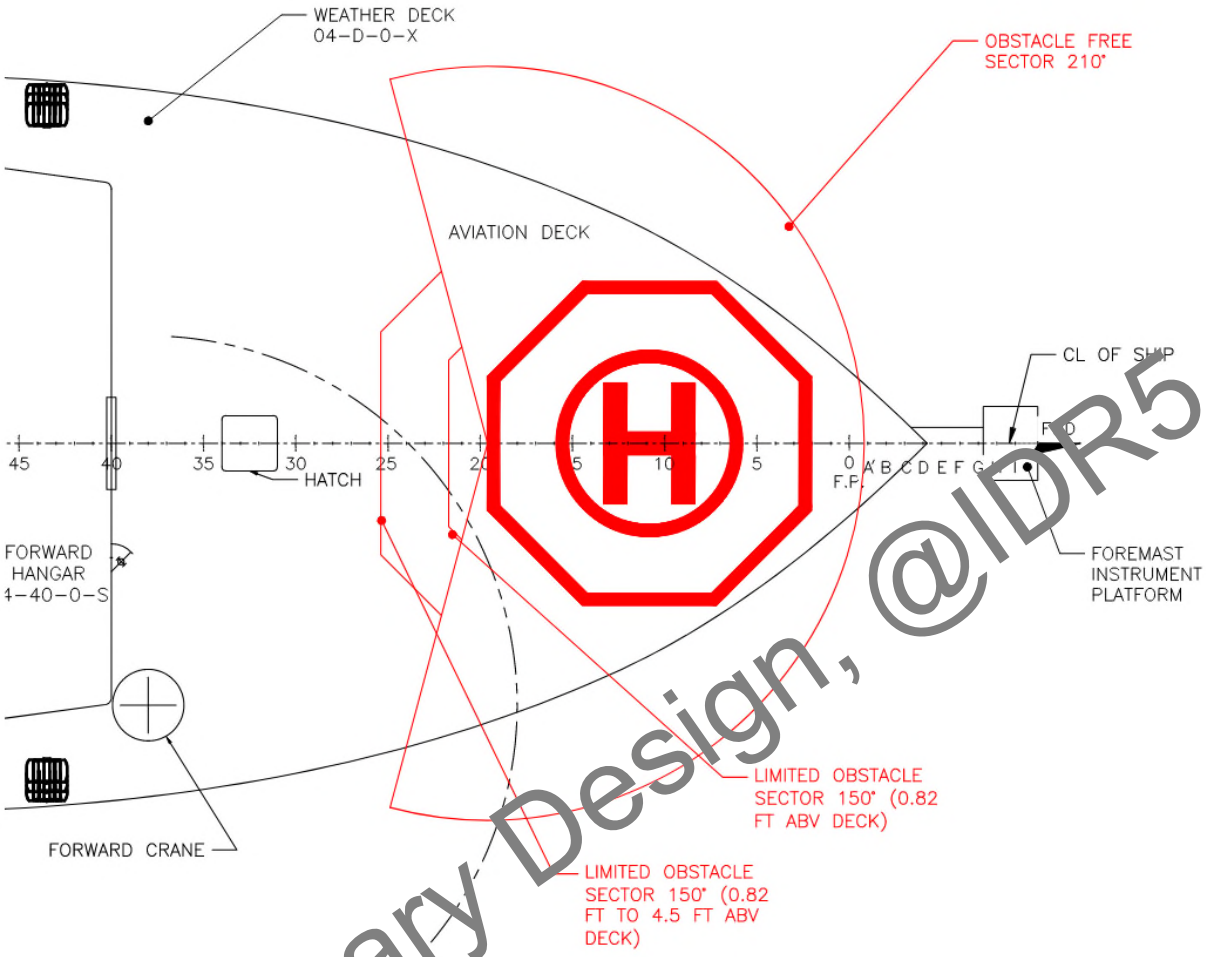


Figure 2 shows a 35.1-foot diameter helipad, as a redline markup, on the 04 Level of the General Arrangement, Reference (1). The addition of the clear space for a helipad should have a minimum impact on operations and useability of the forward weather deck, with the exception that, when helicopter operations are expected, the Limited Obstacle Sectors and the Obstacle Free Sector must be cleared of anything occupying the space, such as temporary science instrumentation or other mission-required equipment. Incorporating clear area around the helideck and creation of obstacle free zones also improves the ability of the vessel to support UAV operations.

Figure 2: ARV Helideck Obstacle Sectors



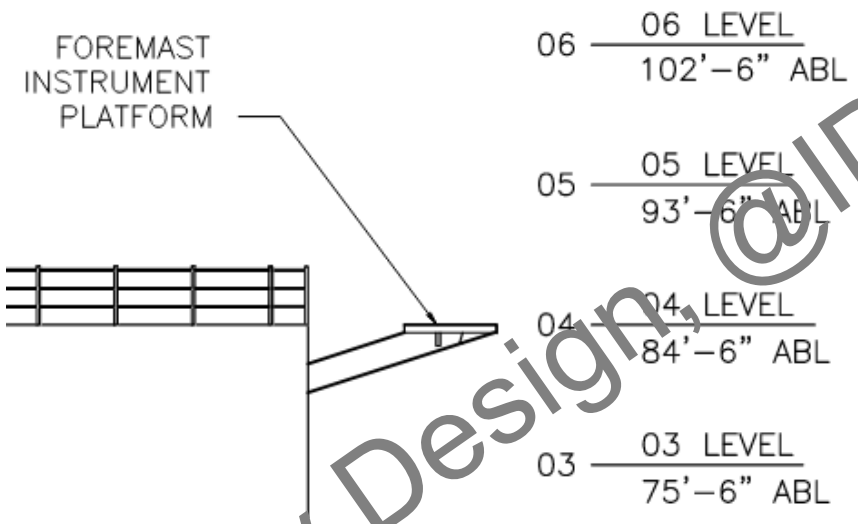
The Obstacle Free Sector will require the railing at the deck edge be capable of being lowered to a horizontal position during helicopter operations, similar to the configuration shown in Figure 3. The railing then acts in place of netting.

Figure 3: Example of Folding Railings

5. Air Flow Around Stem and Relocation of Foremast

The foremast needs to be located so that the structure, sensors, and lights do not protrude above the height of the helideck to support the clear area proposed in Section 4. One purpose of the foremast is to support air sampling experiments. To determine the suitability of the foremast, the SNAME paper "Stack Design Technology for Naval and Merchant Ships", Reference (3), was used to determine the air wake and boundary layer across the bow. With the limiting requirement that air sampling will only be done with wind headings up to a maximum of 45 degrees to either side of the bow, the calculations confirm that the air sampling mast is suitable to be placed past the bow and below the Aviation Deck.

Figure 4: Foremast Location



6. Structural Changes

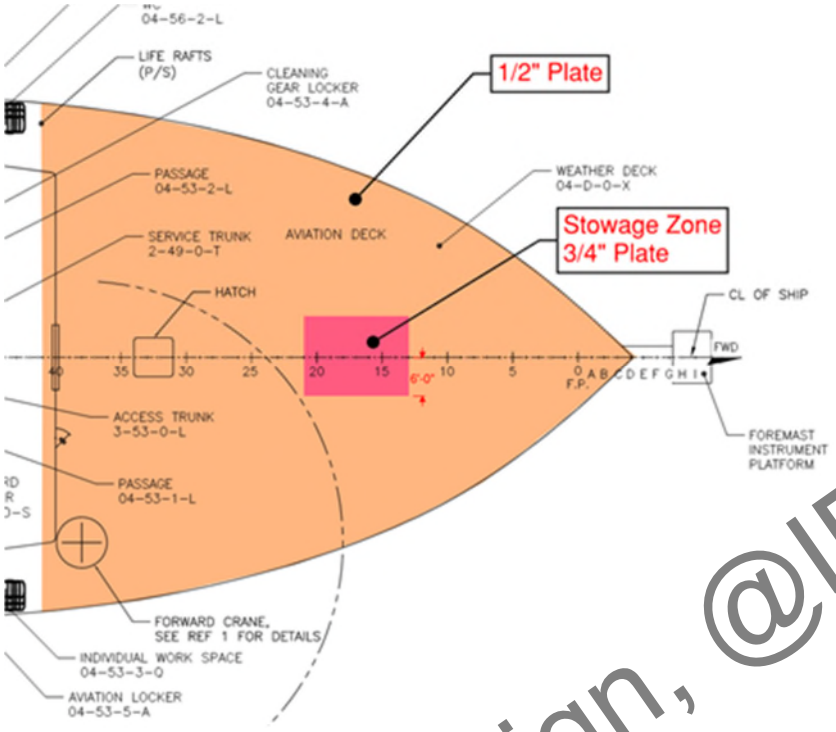
The structure of the 04 Level deck has been strengthened for the landing and stowage of the Bell 407, and Airbus H125 helicopters. The Bell 407 has an estimated takeoff weight of 6,000 lbs., while the Airbus H125 has a takeoff weight of 6,173 lbs. Both helicopters utilize skids for landing gear, which causes high concentrated point loads on the deck compared to wheeled landing gear. Official vendor data for the skid landing patch size was not available, so a patch size was assumed based on engineering judgement and industry standards.

The 04 deck was designed for two separate load cases:

1. The loads associated with landing the helicopters on the deck. The requirements for this load cases are defined in the ABS MVR, Section 3-2-11/11, Reference (2).
2. The loads associated with stowing the helicopter. ABS MVR, Reference (2), provides general direction for calculation of stowed helicopters loads, but does not explicitly define the wind speed, wind pressure, sea state, and ship motion accelerations to be used. In correspondence with ABS, ABS suggested the ARV design team propose a methodology using first-principals, which they will then review. As such, the following conditions were used:
    a. Wind pressures associated with a 100 knot wind, as defined in the P-SPEC for stability limits.
    b. Wave slap was excluded, due to the height of the 04 Level relative to the waterline.
    c. Due to the impact ship motion accelerations have on the weight and structure of the deck, two different conditions were examined.
        i. Standard Stowage: Ship Motion Accelerations associated with Sea State 4. These loads were applied to the helicopter while positioned anywhere on the flight deck.
        ii. Storm Stowage: Ship Motion Accelerations associated with Sea State 8. The P-SPEC as currently written states: “The ARV shall provide the capability to secure and store the Helicopter on deck in up to maximum Sea State 9 (Survival).” The tools available at this stage of design only allow for ship motion acceleration predictions up to Sea State 8. It is suggested that before incorporating Sea State 9 accelerations into the structural design, further discussion with ABS occurs. These loads were only applied while the helicopter is located on the dedicated reinforced stowage area, located between Frame 13 and 21, and 6 ft OCL (P/S).

For the landing loads associated with Load Case 1 and the standard stowage loads, it was found that the entirety of the 04 Level forward of FR 41 needed to increase in size from ¼” plating to ½” plating, as shown in Figure 5. For the stowage loads associated with storm conditions (Sea State 8), it was found that within the dedicated stowage area, the plating will need to be increased in thickness from ½” to ¾”. These changes have been incorporated in the DR5 design baseline and the weight and moment impact debited from DD&B weight and KG margins.

Figure 5: Aviation Deck Plate Thickness



For relocation of the helicopter after landing to the dedicated stowage zone, ground handling wheels similar to those shown in Figure 6 will need to be used. When not in use, the ground handling wheels will be stored within the Forward Hangar or Aviation Locker.

Figure 6: Helicopter Ground Handling Wheels

For full details on the structural methodology, as well as the structural arrangement, see Reference (4) and Reference (5), respectively. The proposed structural methodology will require ABS review to confirm suitability during the next phase. Additionally, official vendor data on

the helicopters will be required before finalizing the structural analysis. Lastly, there are expected to be structural impacts to the stanchions and bulkheads below the flight deck, which will be quantified in a later design phase.

7. Area/Volume Reservations for Fixed Firefighting

SOLAS Chapter II-2 Part G, Regulation 18 Section 5, Reference (6) and ABS MVR Part 4 Chapter 7 Section 2 paragraph 5.3.2, Reference (2), require the following fire-fighting appliances for helidecks.

- Two hose reels fitted with foam-making branch pipe and non-collapsible hose sufficient to reach any part of the helideck.
- At least two dry powder extinguishers for a total capacity of not less than 100 lbs.
- CO_2 extinguishers with a total capacity of not less than 40 lbs, with one of these extinguishers being equipped to enable it to reach the engine area of any helicopter using the helideck.
- Fixed foam system with at least two fixed foam monitors or deck integrated foam nozzles.

To support the foam fire-fighting requirements ARV will need to be outfitted with a fire-fighting foam system that provides a discharge rate of 1,370 liters/minute for 5 minutes. Rev P4 General Arrangement, Reference (1), provides area/volume for this additional equipment in the Aviation Deck Firefighting Space, Forward Hangar, and Aviation Locker.

8. Weight & Stability

The additional fixed firefighting system and firefighting outfitting to support the helideck are estimated to be approximately 2 LT. Assuming a Bell 407 helicopter sitting on the helideck, the helicopter and firefighting equipment will increase the displacement of the ARV by 4.3 LT and the VCG of the ship will increase 0.25 inches in the Full Load Condition. This change will be debited from COMMOD margin for the DR5 Design Weight Estimate to maintain the weight and stability performance baseline of the ARV with the increased requirement to include a helicopter on deck. The change in Light Ship displacement and center of gravity for the increased thickness of the Aviation Deck will be debited from DD&B margins and captured in the Rev P4 update to the Design Weight Estimate, Reference (7).

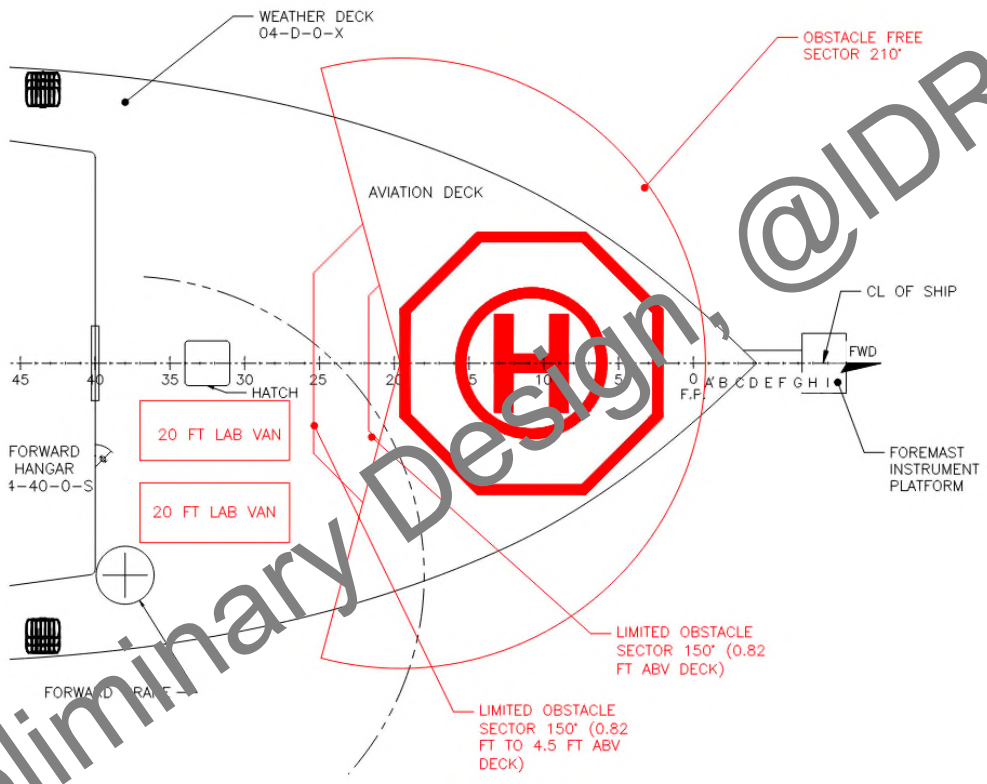
The Intact and Damage Stability Report, Reference (8), will be updated to incorporate the DR5 Design Weight Estimate.

9. Other Supplementary Features

9.1. Forward Lab Van Locations

The ARV Performance Specification, Reference (9), requires space for two laboratory vans on the Aviation Deck. These vans are 20 ft ISO containers. Figure 7 shows that there is sufficient space to place the two vans on the starboard side of the vessel aft of the helideck and its Limited Obstacle Sectors. Locating the vans to the starboard side also increases the usability of the Forward Hangar by allowing a straight line path from the landing spot into the Hangar.

Figure 7: Lab Vans on 04 Level



9.2. Area/Volume Reservations for Additional Safety Equipment

SOLAS Chapter II-2 Part G, Regulation 18 Section 5, Reference (6), and ABS MVR Part 4 Chapter 7 Section 2 paragraph 5.3.2(e) and (f), Reference (2), require the following equipment be provided near the access point to the helideck:

- Two sets of fire-fighter's outfits
- Adjustable Wrench
- Fire Resistant Blanket
- 24 inch bolt cutters
- Grab or salving hook
- Heavy duty hacksaw with 6 spare blades

- Ladder
- Lifeline of 3/16” diameter x 50 ft long
- Side-cutting pliers
- Set of assorted screwdrivers
- Harness knife complete with sheath

The General Arrangement, Reference (1), provides area and volume for this additional equipment in the Aviation Deck Firefighting Space, Forward Hangar, and Aviation Locker.

10. Summary of Design Modifications

The DR5 design baseline includes modifications to increase the efficiency of the Aviation Deck and allow the deck to be used for helicopter landing in case of emergencies. The following modifications, described herein, have been included in the current design baseline:

- Foremast relocated below 04 deck level
- Added area/volume reservation for required helideck firefighting systems
- Added area/volume reservation for additional safety gear
- Revised lab van location for better access in and out of the Forward Hangar
- Deck strengthening for helicopter landing and stowage
- Appropriate margin consumption to include the above features plus helicopter lashed on deck in the weight and stability baseline for DR5

Under-deck heating has previously been integrated into the ARV design for the Aviation Deck as shown on the Deck De-Icing Plan, Reference (10).

The following improvements were not incorporated into current design products, but will be necessary for the ARV to complete integration of a helideck capability:

- Helideck markings
- Deck rails that fold down as netting in way of the helideck
- Tiedown fittings for securing helicopter to the helideck

The following items related to the addition of a helideck will be covered in a future design phase:

- Addition of acoustic insulation in nearby compartments
- Helideck lighting
- Flight navigation and visual aids
- Communication systems

As stated in this report, analyses have been performed in accordance with ABS MVR, Reference (2), which largely mirror the ABS Guide for Class Notation Helicopter Decks and Facilities (HELIDK Notation) Reference (11). Following the recent addition of a Performance Specification requirement to design the Aviation Deck to suit the ABS HELIDK Guide, Reference (11), the ABS HELIDK Guide will be assessed for impact to the design presented in this report.

11. References

(1) ARV General Arrangement, Rev P4, Document No. 5E1-001-D001
(2) ABS Marine Vessel Rules, July 2021
(3) Stack Design Technology for Naval and Merchant Ships, Baham and McCallum, SNAME Transactions, Volume 85, 1977
(4) ARV Structural Design Report, Rev P3, Document No. 5E1-061-R001
(5) ARV Superstructure Drawing, Rev P2, Drawing No. 5E1-150-D001
(6) IMO International Convention for the Safety of Life at Sea (SOLAS)
(7) ARV Design Weight Estimate, Rev P4, Document No. 5E1-096-R001
(8) ARV Intact and Damage Stability Report, Rev P3, Document No. 5E1-079-R001
(9) ARV Performance Specification, Rev A Change 05, 23 June 2023.
(10) ARV Deck De-Icing Plan, Rev P2, Document No. 5E1-517-D101
(11) ABS Guide for Class Notation Helicopter Decks and Facilities, October 2015