



**DEVELOPMENT DESIGN
DRAWINGS & ASSOCIATED LIST
WATERJET PROPULSOR
DRAWINGS - Part 3**

Submitted to:

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In fulfillment of the requirements for:

**Contract No. N66001-02-D-0039
*Development of Port Related Transportation Technologies
to Advance Military Responsiveness to National Needs***

**Task Order No. 0014
*Development of an Advanced Waterjet Propulsor Concept
for High-Speed Sealift Applications, Phase II***

CDRL Data Item No. A007

Security Classification: Unclassified

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Approved for public release: distribution is unlimited

September 16, 2003

TECHNICAL DRAWING PACKAGE

**PROGRAM ELEMENT NO. 2.22
TASK ORDER NO. 14**

**CONCEPTUAL DESIGN DRAWING PACKAGE OF AN INTEGRATED HULL AND ADVANCED
PROPULSION SYSTEM FOR HIGH-SPEED SEALIFT APPLICATIONS**

System:

Hull and Waterjet Assembly Designed for the 50-knot Coastal Commercial Mission

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CCDoTT Fiscal 2002 Subcontract: S07-265302BLA
Contract No.: N66001-02-D-0039-0014

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This material is based upon work supported by the Space and Naval Warfare Systems Center, San Diego, under Contract N66001-02-D-0039 with the Center for the Commercial Deployment of Transportation Technologies (CCDoTT) at California State University, Long Beach.

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Space and Naval Warfare Systems Center, San Diego or the Center for the Commercial Deployment of Transportation Technologies (CCDoTT) at California State University, Long Beach.

FOREWORD

CDI Marine Systems Development Division (SDD) (formerly Band, Lavis & Associates (BLA)) conducted the work described in this working paper for the Center for the Commercial Deployment of Transportation Technologies (CCDoTT) at California State University, Long Beach. The principal points of contact at CDI Marine SDD were Mr. Alan Becnel and Mr. John Purnell. The principal point of contact at CCDoTT was Mr. Stan Wheatley.

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1.0 SCOPE

The need to deliver time-critical cargo, both commercial and military, has driven future commercial and sealift ships to higher speeds than those currently available using today's technology. The need for high speed of 45 to 50 knots and beyond will require the use of slender hullforms and efficient propulsion systems in order to reduce the ship's drag force and, therefore, the required installed power. Waterjets are the best choice for a propulsion system in these speed ranges due to the lack of appendage drag with a flush-mounted waterjet, recovery of part of the ship's frictional drag by ingesting the boundary layer into the waterjet, and the negative thrust deductions which have been measured on waterjet-propelled ships. These factors lead to higher propulsive efficiencies for waterjet-propelled ships at speeds above 25 knots.

Presently available large commercial waterjets, above 10,000 horsepower, are of the mixed-flow type where the flange diameter is on the order of 70 to 85 percent larger than the inlet diameter. The large flange diameter presents a very difficult integration with the slender hull required for high speed. Simply stated, there isn't enough beam available on the most optimum hullform, so the beam has to be increased to accommodate the mixed-flow waterjet. This results in increased drag and, therefore, higher installed power. It is clear that a more power dense waterjet system is needed for high-speed ships. The axial-flow waterjet is the solution to this problem.

The conflicting high-speed requirements of slender hulls and large amounts of installed power with multiple waterjets has led to the need for this development program on axial-flow waterjets. The coastal commercial ship mission, as identified in the High-Speed Sealift Technology Development Plan, was chosen as the baseline mission for conducting this analysis. The coastal commercial ship mission requires a 50-knot speed, a range of 1500 nautical miles, and a payload of 1500 metric tons at a full performance wave height of 2.4 meters. This particular mission was one recommended by MARAD for the NSWCCD High-Speed Sealift Innovation Cell. The overall program consisted of a design trade-off study to determine the best hullform and propulsion machinery arrangement for the coastal commercial mission¹, development of a conceptual integrated hull and advanced axial-flow waterjet for this mission using advanced computational fluid dynamics analysis², development of detailed model-scale designs for both a water tunnel model³ and a self-propulsion model⁴ and detailed test plans for both the water tunnel⁵ and self-propulsion evaluations⁶. This report covers the conceptual design drawings of the 600-foot coastal commercial ship with 90-inch diameter waterjets.

1.1 Identification

This conceptual design package describes a full-scale, 600-foot coastal commercial ship with four 90-inch diameter waterjet pumps that meets the requirements of the coastal commercial mission identified by the High-Speed Sealift Technology Development Plan. This document describes Version 1, Release 1 of the conceptual design.

1.2 System Overview

The purpose of this conceptual design is to demonstrate the feasibility of using advanced axial-flow waterjets to meet the 50-knot requirement of the coastal commercial mission and other similar high-speed sealift missions. The coastal commercial ship mission requires a 50-knot speed, a range of 1500 nautical miles, and a payload of 1500 metric tons at a full performance wave height of 2.4 meters. This particular mission was one recommended by MARAD for the NSWCCD High-Speed Sealift Innovation Cell. CDI Marine Systems Development Division developed the high-speed sealift waterjet conceptual design for the Center for Commercial Deployment of Transportation Technologies.

1.3 Document Overview

This document shall be used to demonstrate the feasibility of the 600-foot waterjet-propelled coastal commercial ship. The drawings shall be interpreted in accordance with ASME Y14.100. Distribution of the document is limited to the restrictions on the title page of this document.

2.0 REFERENCED DOCUMENTS

1. CDI Marine System Development Division Report, WP 748-2, "System Trade-Off Analysis to Select the Most Promising Waterjet propulsion System", September 2003.
2. CDI Marine System Development Division Report, WP 748-8, "Development of an Integrated Hull and Advanced Propulsion System for High-Speed Sealift Applications", September 2003 (Waterjet Propulsor Design).
3. CDI Marine System Development Division Report, WP 748-5, "Detail Design Drawing Package for Water Tunnel Evaluation of a Scale Model Axial-Flow Pump Designed for High-Speed Sealift Applications", September 2003.
4. CDI Marine System Development Division Report, WP 748-6, "Detail Design Drawing Package for Model Self-Propulsion Evaluation of a Axial-Flow Propulsor Designed for High-Speed Sealift Applications", September 2003.
5. CDI Marine System Development Division Report, WP 748-3, "Test Plan for Water Tunnel Evaluation of a Scale Model Axial-Flow Waterjet Pump Designed for High-Speed Sealift Applications", September 2003.
6. CDI Marine System Development Division Report, WP 748-4, "Test Plan for Model Self-Propulsion Evaluation of a Axial-Flow Propulsor Designed for High-Speed Sealift Applications", September 2003.

3.0 SYSTEM WIDE DESIGN DECISIONS

The system requirements and expected performance are specified in Reference 1.

4.0 SYSTEM DESIGN

The system design and supporting analysis are found in Reference 2. The system is composed of a 600-foot monohull with each of four 90-inch diameter waterjet units driven by a LM6000 gas turbine through a 2-stage epicyclic gearbox and Renk thrust bearing. The waterjet unit consists of an inlet, 5-bladed rotor, 8-bladed stator, shaft and shaft bearings. The gas turbines turn the rotor, which creates a low pressure on the forward side of the blade, and this low pressure causes the flow to be ingested into the inlet. As the flow passes through the rotor, the total pressure of the flow is increased to a level sufficient to produce a velocity equal to the required jet velocity. The average jet velocity times the flow rate times the fluid density is the gross thrust produced by the waterjet unit. The net thrust, which acts to propel the model, is the gross thrust minus the ingested momentum in the inlet flow. The ingested inlet momentum is the average velocity at a point on the ship one diameter forward of the inlet ramp tangency point times the ingested flow rate times the fluid density.

4.1 System Components

The conceptual drawings for an integrated hull and advanced propulsion system for a high-speed sealift application are shown in the following figures.

Figure 1 shows the conceptual design for a 600-foot high-speed sealift ship.

Figure 2 shows the section views of the waterjets at the transom and the engine modules in the machinery space.

Figure 3 shows the deck lines for the main, 2nd, and 3rd decks of the HSS ship concept.

Figure 4 shows the deck lines for the 4th and 5th decks and the inner bottom with the propulsion machinery layout on the 4th deck for the HSS ship concept.

Figure 5 shows the machinery room details.

Figure 6 shows views of the steering/reversing unit in the forward mode of operation.

Figure 7 shows views of the steering/reversing unit in the reverse mode of operation.

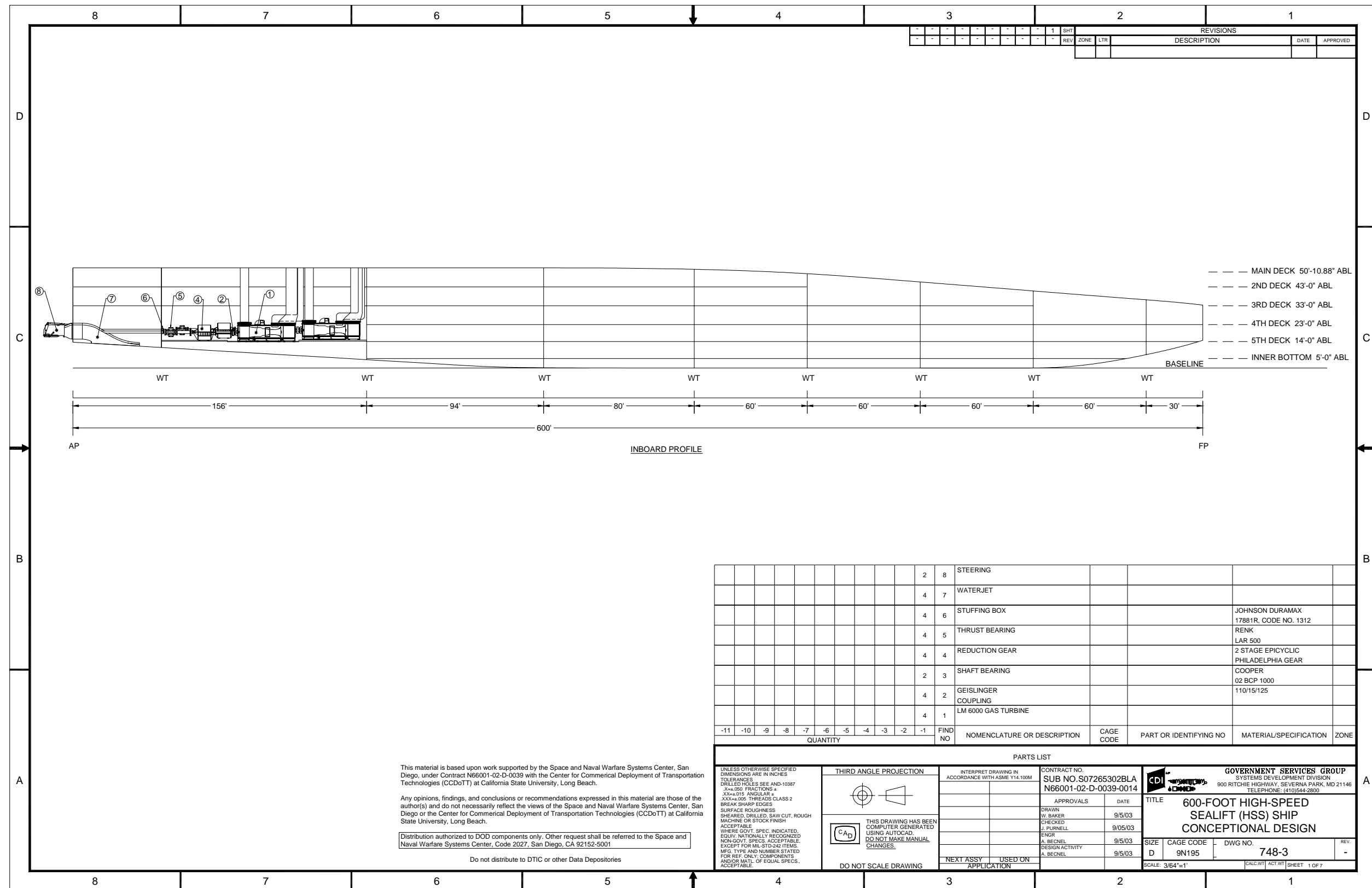


Figure 1. 600-Foot High-Speed Sealift (HSS) Conceptual Design

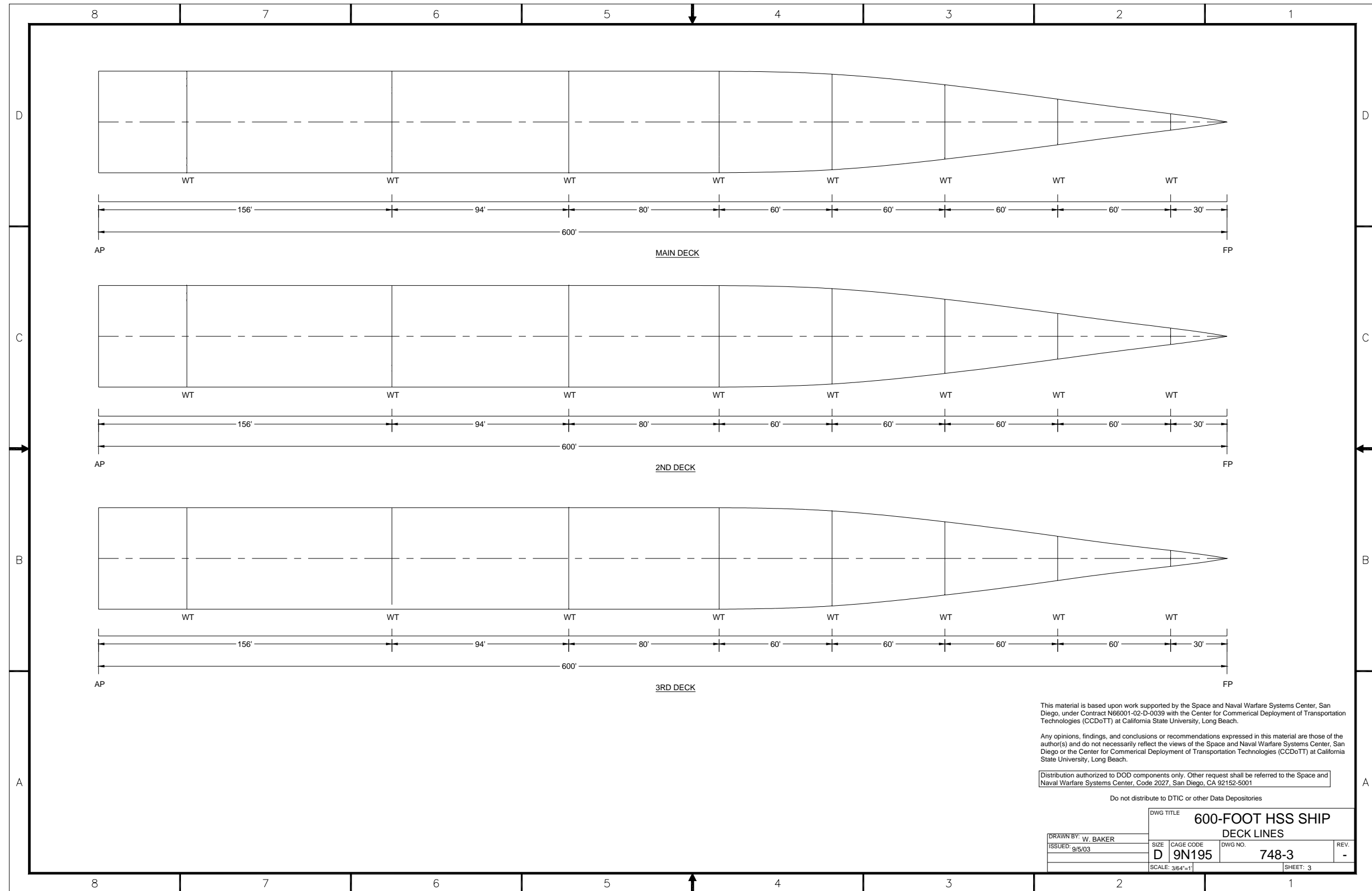


Figure 3. 600-Foot High-Speed Sealift (HSS) Deck Lines

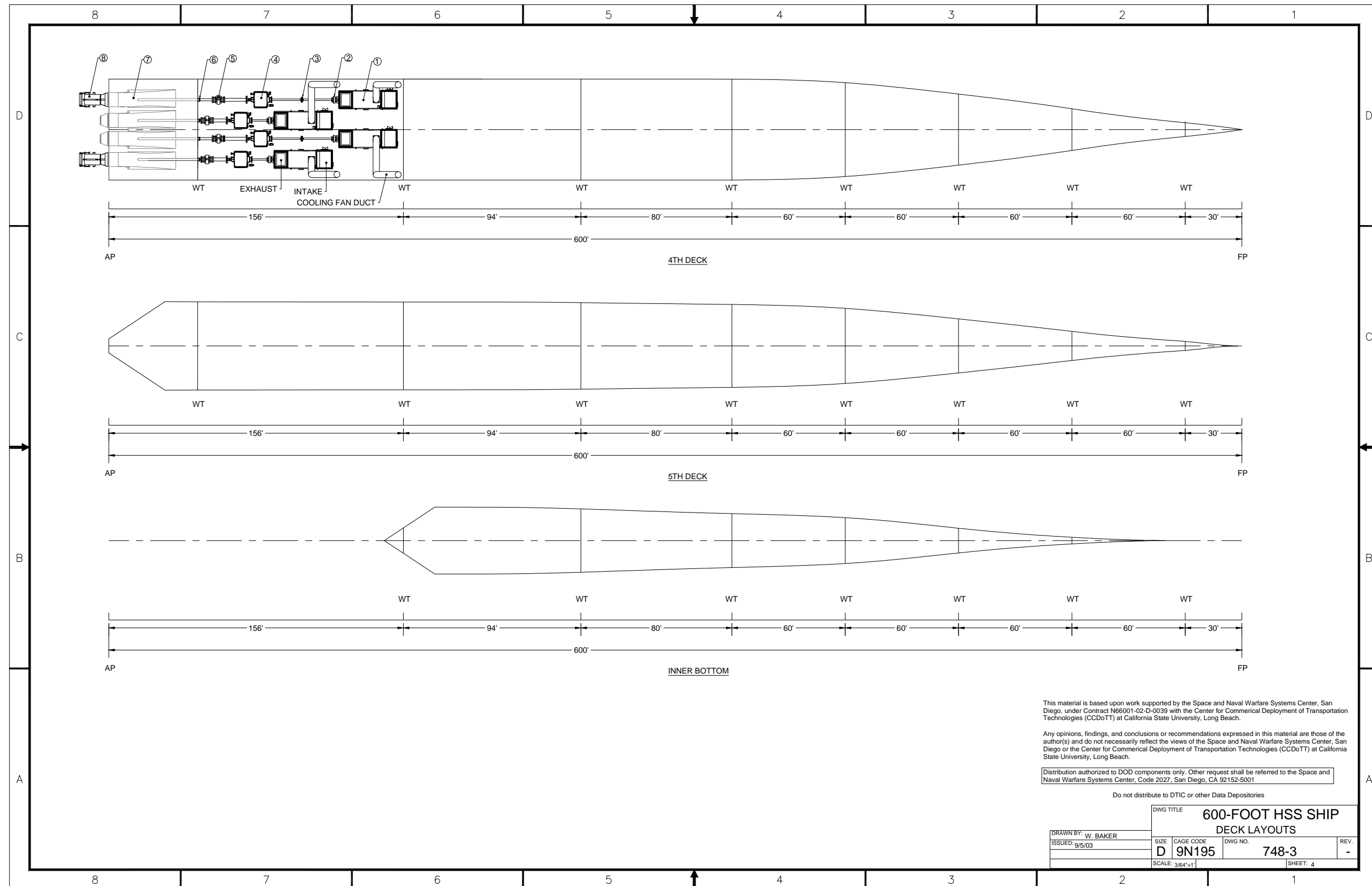


Figure 4. 600-Foot High-Speed Sealift (HSS) Layouts

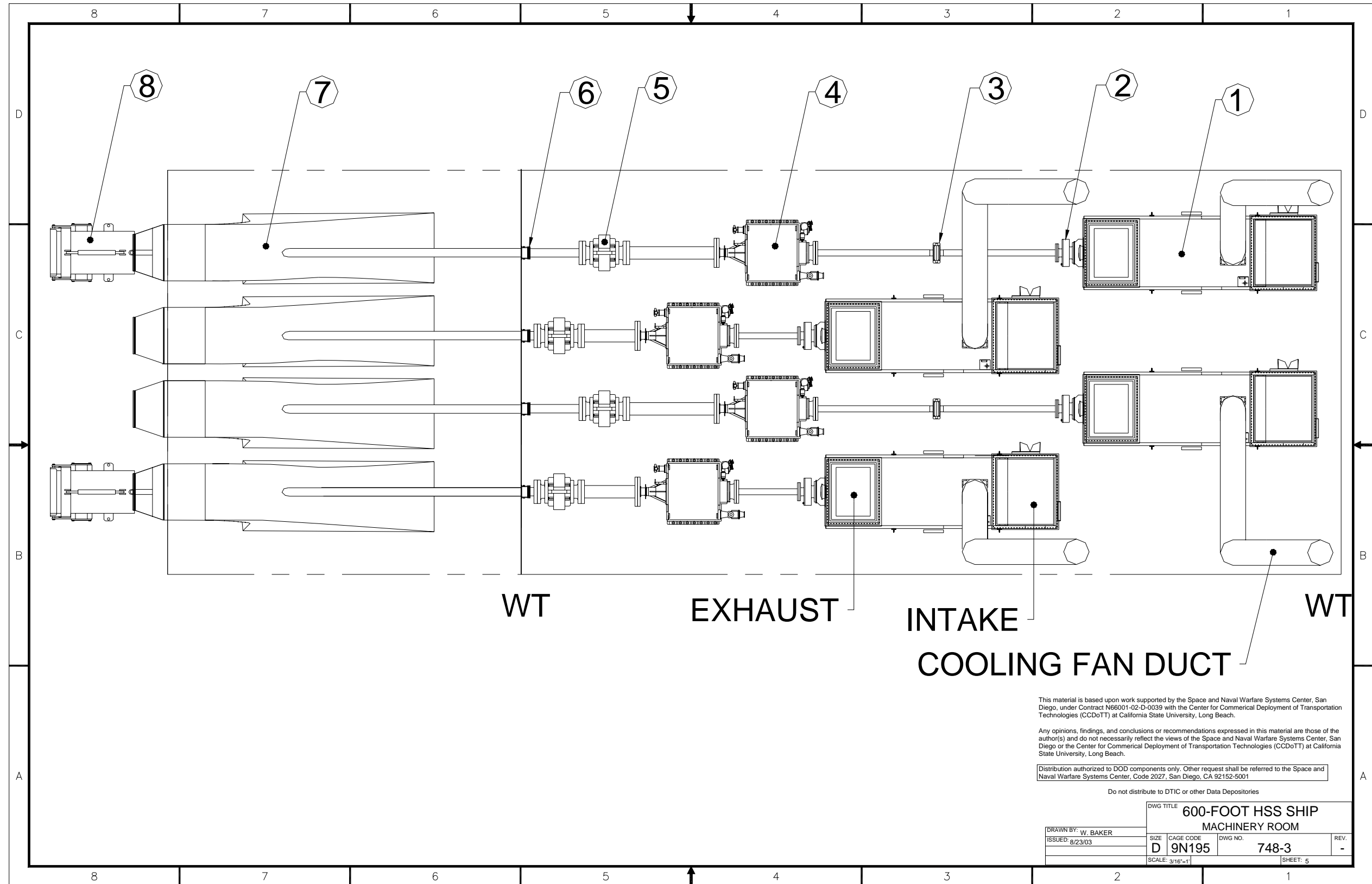


Figure 5. 600-Foot High-Speed Sealift (HSS) Machinery Room

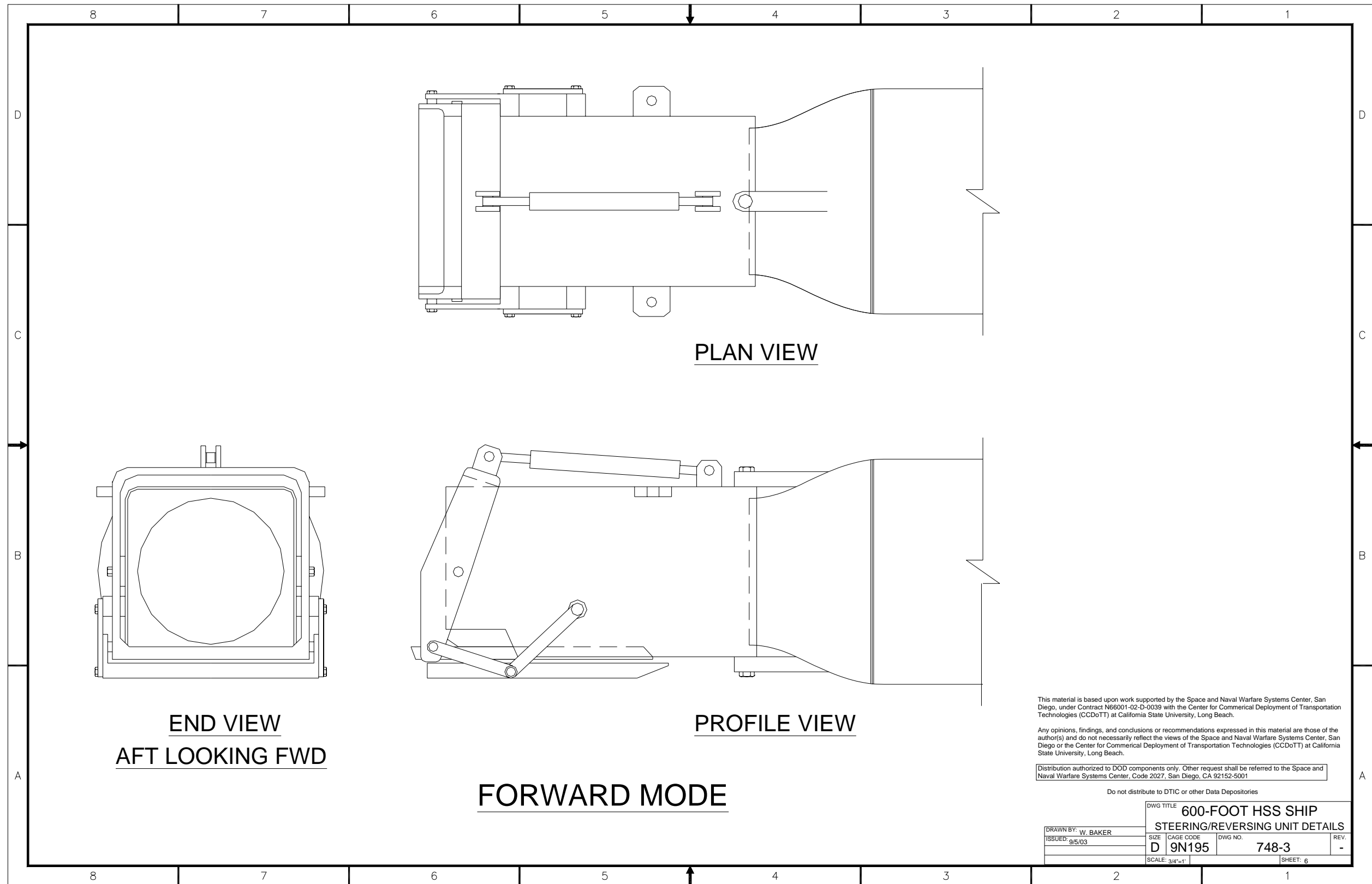


Figure 6. 600-Foot High-Speed Sealift (HSS) Steering/Reversing Unit Details – Forward Mode

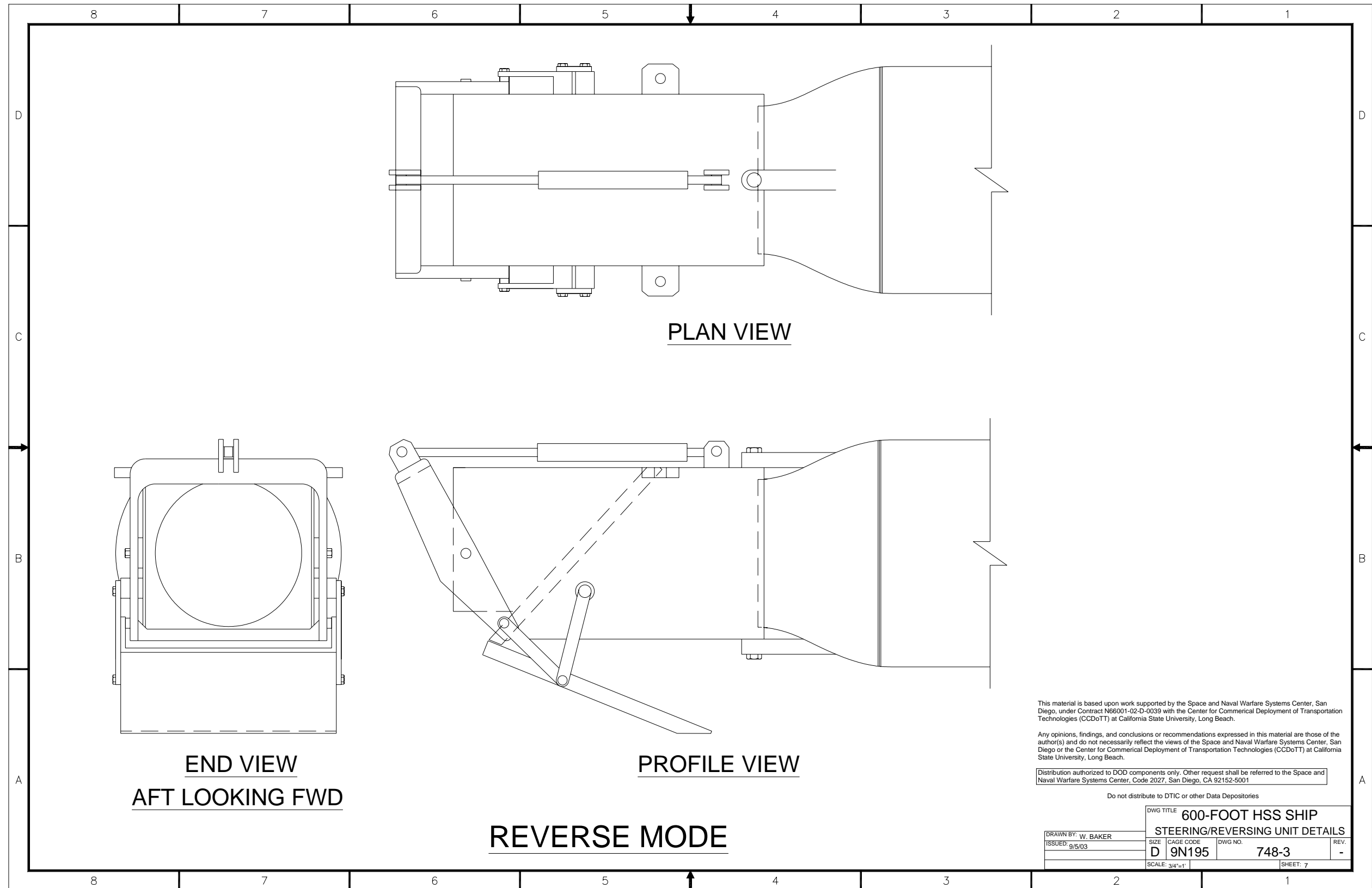


Figure 7. 600-Foot High-Speed Sealift (HSS) Steering/Reversing Unit Details – Reverse Mode