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Prototype Demonstration of a Stern Embarkation Platform for the AOE 6 Class: A Navy/Industry Partnership

ABSTRACT The US Navy is striving to reduce total ownership costs of the Fleet. The operational and safety issues associated with several cases of loss or damage to AOE 6 class accommodation ladders, provided the opportunity to demonstrate the effectiveness of a Government-Industry partnership and the application of proven commercial technology in reducing manpower requirements and life cycle cost, while maintaining mission capabilities of an existing U.S. Navy replenishment ship.

Introduction

Accommodation ladders currently in use onboard U.S. Navy ships have been a constant personnel safety concern, a maintenance burden, and a financial drain. Often, ship personnel must work over the open ocean without safety nets when rigging and stowing accommodation ladders. In addition, rigging the AOE 6 class accommodation ladder requires the use of yellow gear and davits to handle most of the ladder components. A working party of 15 persons is assigned to accomplish the assembly or stowage process. A typical AOE 6 class accommodation ladder deployment can take more than four hours to complete. The AOE 6 class has been plagued with accommodation ladder problems since the start of the ship's detail design process. Additionally, the existing standard U.S. Navy accommodation ladder tailored for the AOE 6 Class (NAVSEA Dwg.AOE 10) was designed only for limited use when the ship is at anchor or when moored to a pier.

The Naval Surface Warfare Center Ship Systems Engineering Station (NSWCCD-SSES), Philadelphia has investigated and evaluated commercial, automated, access/egress systems that are integral with the ship's hull as part of the LPD 17 design development. M. Rosenblatt & Son, Inc. (MR&S), through their Alliance with an Italian cruise shipbuilder, arranged for the LPD 17 Hull System Design Team to visit the MV *Sun Princess* to witness the operation and inspect the side port embarkation system. A typical cruise ship embarkation system is fully automatic; capable of being deployed in minutes, and requires minimal personnel to operate the system. The cruise ship embarkation technology is adaptable to US Navy ships but had not been considered until the advent of low signature requirements for combatants.

This paper provides a summary of how Government and Industry collaborated in the successful application of Commercial Off the Shelf Technology (COTS) cruise ship embarkation systems to solve an operational and safety problem on the AOE class ships. The AOE 10 Stern Embarkation Platform and Accommodation Ladder (SEPAL) demonstration was accomplished by a core team (government and industry) consisting of NSWCCD-SSES, NAVSEA PMS 325D, NAVSEA PMS 512 (Affordability Through Commonality (ATC) Program Office), and MR&S. The core team was assisted by NAVSEA 05D, 05H, 053P1, 05P8, Planning Yard Division of Puget Sound Naval Shipyard, Supervisor Of Shipbuilding (SOS) Puget Sound, TODD Pacific Shipyard, Fincantieri Cantieri Navali Italiani, S.p.A., and Navalimpianti S.p.A.

Background

Selecting a suitable location for an accommodation ladder on the AOE 6 class was an ongoing process that dates back to an equipment arrangement study (NAVSEA AOE 6 class 1984) conducted in 1984. Several locations were considered, including the transom, aft of the Helicopter deck on the 01 level. This location was disregarded because of several disadvantages cited in the study. The decision was made to locate the accommodation ladder about mid-ships at frame 328 starboard and port, on the 01 level

During a port visit in December 1996, the USS *Supply* (AOE 6) lost an accommodation ladder off the coast of Turkey. A barge was tied to the ship and the accommodation ladder rested on the barge, similar to a pier side arrangement. The sea state increased and the resulting motion of the barge caused the accommodation ladder to break free from the ship and drop into the ocean. Although no crew members were injured during this incident, the ladder was not recovered. Similar problems have been experienced on other ships.

AOE class ships often cannot obtain port certificates because of the nature of their cargo, and often times must anchor in the open ocean miles away from a port. Typically, the AOE contacts a port service agent to bring out a barge, which is placed along side the ship to act as a staging platform and buffer for liberty parties and as a fender for large commercial water taxies.

During the AOE 6 class Lessons Learned Conference held on January 7, 1997, the USS *Supply* (AOE 6) and the USS *Arctic* (AOE 8) ships' representatives identified problems associated with the existing accommodation ladder and barges during anchorage periods. The First Lieutenant and ship's Boatswains recommended the installation of a fixed structure stern dock similar to the CVN 68 class to be considered during a scheduled yard availability period.

Concept Development

NSWCCD-SSES and the ATC Program Office (now NAVSEA PMS 512) suggested that PMS 325D use commercial cruise ship embarkation technology to improve the safety and operational efficiency of the accommodation ladder system. Additional anticipated benefits of this approach included reduced manpower requirements and lower life cycle costs.

A ship check of USS *Supply*, AOE 6, was conducted in April 1997 by representatives from NSWCCD-SSES 9780 and MR&S (ATC Hull 1997) to identify applicable operating requirements, design parameters, and to select a suitable location for an embarkation system. Interviews with ship's personnel, including the Boatswain and First Lieutenant, provided valuable insight as to the nature and severity of the accommodation ladder problems as well as potential solutions. All agreed that the transom area was the best location for an embarkation system, since at anchor, the ship heads into the wind creating a natural lee behind the stern. The wide beam and deep draft of the ship contribute to creating calm water behind the ship.

Additional information gathered during the meeting with ship's personnel included the following: water taxis that interface with the AOE are approximately 100 feet in length with a 40 ton displacement, the gunwales on water taxis range approximately 3.5-4.5 feet above the waterline, the stern of the AOE provides a suitable approach and landing area for all size craft, the main deck on the port side provides a good location for access and egress, the main deck is protected from the weather by the flight deck above, and the large viewing ports provide good visibility for security. Other suggestions included locating an upper platform on the main deck inboard of the port quarter rope chock in the stern bulwark, an athwartship ladder leading down to a robust embarkation platform, vertical stowage of the embarkation platform against the transom during ocean transit, and vertical adjustment of the platform through a range of approximately 5 feet to account for variations in ship's draft. The stern embarkation system would primarily be used for personnel and light stores transfer when the ship is at anchor.

Based on the design requirements and constraints resulting from the ship check, MR&S and NAVSSES developed a concept design based on cruise ship embarkation technology (Figure 1). The AOE 6 class Stern Embarkation System concept offered a vertically adjustable stern mounted embarkation platform and accommodation ladder. The fully automatic platform would be capable of being adjusted to up to five feet of draft variation of the AOE 6 class. The platform would hinge down to facilitate passenger embarkation and would stow in the vertical position against the transom. The system was intended to be a fully automatic system that deploys in a matter of minutes and requires as few as four personnel to operate the system.

Prototype Acquisition Process

The AOE Class Program Manager, PMS 325D, reviewed and evaluated the concept design and SEPAL proposal. Based on the potential benefits of the advanced personnel transfer system, PMS 325D funded the prototype demonstration of the SEPAL concept for the AOE class ships.

PERFORMANCE BASED SPECIFICATIONS

In the spirit of Acquisition Reform, the Team used a modified commercial "turn-key" approach to the process of developing, constructing, and installing the prototype

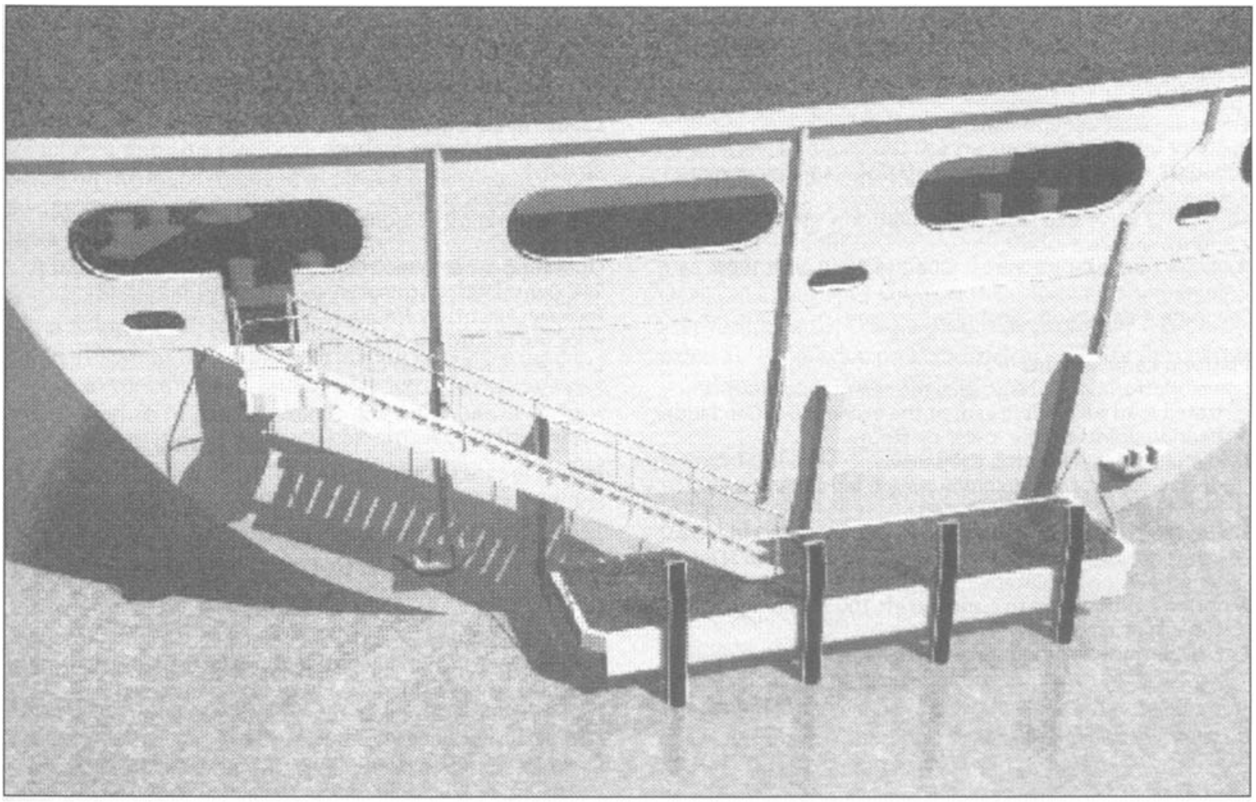

FIGURE 1. 3D Concept Design

embarkation system. The first step involved the development of a performance-based specification (Performance Spec 1997) that captured the desired attributes of the commercial technology with appropriate modifications to meet Navy-specific requirements. Considerable effort was made to maximize the use of readily available commercial components and commercially accepted standards promulgated by regulatory bodies and classification societies (ABS, IEEE, and ISO).

The interview with the representatives from the USS *Supply* (AOE 6) provided insight to the operating requirements for the platform, associated components, and system arrangements. The operating assumptions for the performance specification included the following categories: environment, structure, mechanical, electrical, sea state, personnel safety, life cycle, maintenance and factor of safety. Table 1 is a summary of the SEPAL performance requirements. It was envisioned that the platform would "ride" on a guide rail structure welded to the transom plating. An upper platform was to be fixed to the transom at the main deck level, and an accommodation ladder would attach (hinge) to this platform and rest on the embarkation platform. A local push button control station would be provided at the upper platform and an OOD Station was to be installed nearby. The control station would allow the operator to control all functions of the embarkation platform and accommodation ladder. Hydraulic power equipment and electrical control panels were to be located below deck in the steering gear room. In emergencies, in the powered back-up mode, the platform and ladder could be operated remotely from the Steering Gear Room. In the deployed position, the embarkation platform could be vertically adjusted to account for draft variations in the parent ship. The SEPAL system could be operated by one crewmember while three other members prepared the platform (ready the fenders and erect the portable stanchions and lifelines). The system was designed to be fully deployed for boat operations in less than fifteen minutes.

CONTRACT TECHNICAL DOCUMENTATION:

The performance requirements were incorporated in the body of the performance-based specification. The specification provided details of how the equipment was intended to function. Accompanying the Performance Specification is the Technical Documentation Schedule and the Documentation Requirements Specification. These documents provided instructions and project scheduling information to the vendor for design, engi-

TABLE 1

SEPAL Performance Requirements

Environmental Requirements
30 lb/ft2 wind load
500 lb/ft2 wave slap load, upper platform and lower platform, deployed
1000 lb/ft2 wave slap load, lower platform, stowed
7.5 lb/ft2 snow/ice load
Ambient temperature, range -20oC to 29oC with 100% humidity
Sea State 4 operation capability

Platform Requirements
Lower platform, 110 lb/ft2, plus the simultaneous concentrated load of 165 lb/tread, of the accommodation ladder bearing points on the lower platform
Upper platform, 110lb/ft2, the simultaneous load of the dead weight of the accommodation ladder and a ladder distributed load of 165lb/tread
Deckedge protection, 3 course high, 150 lb horizontal load on stanchion head Fender impact load, craft 100 ft in length/40 ton displacement @ 3 knots
Mooring fittings sized to handle craft 100 ft in length/40 ton displacement
Lower platform incrementally adjustable, 5 ft travel

Ladder Requirements
165 lb tread load
30 lb/ft2
30 inch ladder width
Deployed range of ladder inclination not to exceed 52o

Operating Mode Requirements
Self Contained, Automated
Primary: Electro-hydraulic
Back up: Electro-mechanical
Emergency1: Mechanical
Emergency2: Manual
Normal Powered Cycle: 7. 0 minutes stowed/deployed/stowed position

Miscellaneous Requirements
Lighting: Fiber Optic lighting provided on accommodation ladder
Design ABS and USCG compliant
Platform System to meet to ASTM 1166 Human Engineering Factors

Testing Requirements
System was functionally tested in the factory to demonstrate vertical, stowage and deployment cycles.
Post Installation Test was accomplished to ensure system meets performance characteristics.
Operational Test is scheduled to mechanically inspect the system during a period of 1 year for the date of installation.

neering, fabrication, and testing of the stern embarkation platform and accommodation ladder prior to installing the system on an AOE 6 class ship.

The Performance Specification and the Technical Documentation package were an integral part of the Sole Source Purchase Contract for the prototype Stern Embarkation Platform and Accommodation Ladder (SEPAL) system to be installed on the AOE 10. In December 1997, a fixed price (design, build, and deliver) contract was awarded to the Merchant Shipbuilding Division of Fincantieri Cantieri Navali Italiani, S.p.A. and their preferred supplier, Navalimpianti, S.p.A. for the prototype AOE 6 class SEPAL System. Fincantieri, located in Trieste, Italy is one of the leading cruise ship builders in Europe. Navalimpianti, located in Monfalcone, Italy is the preferred supplier of embarkation systems to all European cruise ship builders. Fincantieri and Navalimpianti worked together to design, engineer, fabricate and test the embarkation platform, associated components and system controls.

DESIGN BUILD PROCESS:

NSWCCD-SSES Code 9780, in the role of Project Manager, provided technical oversight and coordinated the efforts of various activities assisting in the design and installation of the prototype SEPAL. During the various stages of development, the stern embarkation concept evolved from simple sketches to detailed 2D and 3D CAD drawings showing the arrangement and details of all components, as well as defining the interfaces with the ship. NAVSEA provided guidance and input throughout the design process. In particular, SEA 05P8 assisted in the development of the performance specification; SEA 05P1 reviewed FEM analysis and structural drawings, which included the platform guide frames, embarkation platform and foundations that support rotating components; and SEA 05H established loading criteria for the platform and supporting structure in the stowed and deployed positions.

One of the primary differences between a commercial design and a military design for embarkation systems is operational limitations; cruise ship embarkation systems are operated during calm seas (sea states 0-1) while military use requires the transfer of crew and/or troops in sea states up to and including sea state 3. The SEPAL was designed to operate in all weather conditions including extreme temperature and sea state 4 conditions. However, the operation of the SEPAL is limited to sea state 3 for operational and personnel safety concerns.

During detail design and fabrication, NSWCCD-SSES evaluated the platform structure using CSA/NASTRAN FEA modeling. The analysis was an overall spot check to review and verify stress loading on key platform pin structures and the platform vertical guide structure. Based on the loads imposed at elevated sea states, each member was found to have a material yield stress safety factor of at least 3.

Although the AOE 6 class ships were built at National Steel & Shipbuilding Company (NASSCO), Puget Sound Naval Shipyard (PSNSY) is the Class Planning Yard, acting as a clearing house for information related to modifications to specific AOE hulls. Relevant information was transferred to NSWCCD-SSES and was forwarded to Navalimpianti during detail design. Additionally, PSNSY contributed to the overall SEPAL installation package. They developed the mechanical interface installation drawings. These interface drawings include structural, mechanical, and electrical details and were used by installation personnel at Todd Pacific Shipyard.

FUNCTIONAL TESTING:

The Stern Embarkation Platform and Accommodation Ladder System was ready for factory testing in Italy by mid-July 1998, seven months after award of the contract. The platform testing was conducted at Navalimpianti's fabrication facility in Monfalcone, Italy, (Figure 2.). Navalimpianti constructed a special test fixture patterned after the AOE 6 class transom in their facility in Monfalcone, Italy, to carry out the required functional testing. The System met the testing requirements as outlined in the performance specification and was accepted by the Navy for shipment to the U.S. In August 1998, the structure, hydraulic power unit, and associated control panels were packaged and shipped from Italy to Todd Pacific Shipyard, Seattle, Washington. The prototype was designated for installation on USS *Bridge* (AOE 10) during the DSRA beginning January 1999.

Installation Process

Prior to installation, NSCWCD-SSES organized a SEPAL planning conference. The planning conference was held at the SOS Puget Sound Office at Todd Pacific Shipyard. Attendees included representatives from NSCWCD-SSES, PSNSY, NAVSEA, SOS Puget Sound, Todd Pacific Shipyard, Navalimpianti, and MR&S, Inc. Attendees reviewed Navalimpianti's technical documentation package which included SEPAL component and installation drawings, PSNSY interface installation drawings, and the SEPAL Test Procedure.

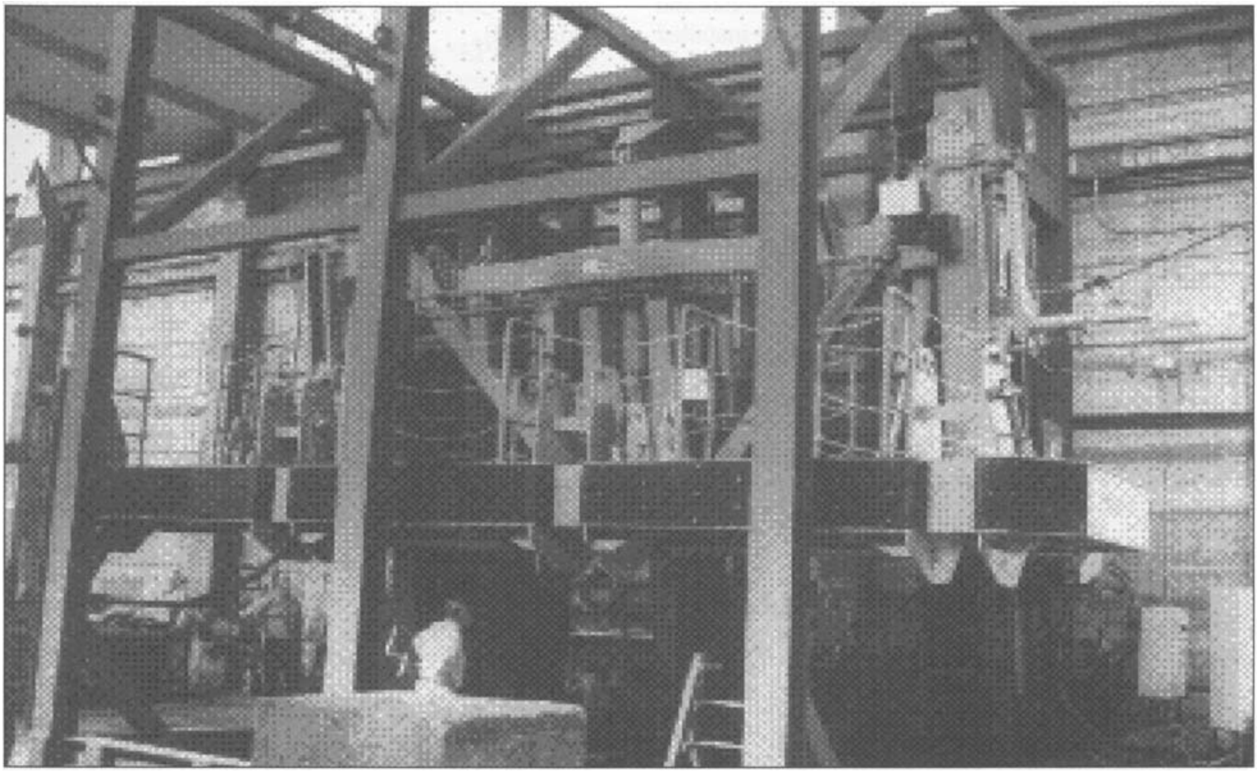

FIGURE 2. SEPAL Test Fixture

The SEPAL arrived at Todd Pacific Shipyard in early September 1998 and was stored in the steelyard, covered from the elements with a tarp. The hydraulic and electrical equipment was stored in a government warehouse. NSWCCD-SSES and the Navalimpianti Technical Representative arrived on January 12, 1999 to assist Todd Pacific Shipyard during the installation process.

As the installation process progressed, additional modifications or changes were required. An in-depth critique of the drawings was accomplished to allow for a few, but necessary, design improvements in equipment, arrangement, safety, and improved operating capability. The critique also facilitated the incorporation of Port Engineer Requests (PER) and Advanced Drawing Change Notices (ADCN).

As part of the installation process, local ship's structure had to be reinforced. The ship's structure effected by the SEPAL installation included the transom shell plating, main deck bulwark, After Steering Gear Room, and Fuel Oil Tank 4-685-0-F. One of the most significant modifications was increasing the size of the transom welds on stiffeners L-3 and L-4 port and starboard, since they backup the platform guide rail foundations. When the weld modifications were complete, the platform guide rail foundations were assembled into a large fixture in the steel shop. The fixture was then fitted to the ship in the plane of the transom (Figure 3). Horizontal back-up structure was installed between the transom stiffeners to reinforce the chocks on the guide rail foundations and internal structure. Bracket type chocks were installed inside the Steering Gear Room behind the external lifting cylinder foundation. Another important structural modification was added, a longitudinal reinforcing bracket in the fuel oil tank connecting the transom stiffener L-4, to transverse frame 725.

Concurrently, foundations for the hydraulic system and electrical power panels were installed in the Steering Gear Room. Once the foundations were set, equipment was installed and piping and cables were connected. The next step was to lift the embarkation platform into the guide rail foundations. With the embarkation platform in the open position, the structure was secured to the transom with chain falls. With the platform in-place, work progressed on installing external platform foundations. The platform-lifting cylinder was attached to its foundation and external hydraulic piping was connected to the other cylinders.

Prior to energizing the hydraulic power pack, the system was checked for leaks and the oil filtered. Using a temporary hydraulic power source, the platform was cycled through its different modes and checked for proper operation. The upper platform and the accommodation ladder cradle were subsequently attached to the ship. The accommodation ladder was then connected to the upper platform. When the electrical cable installation was completed, a system check was performed and proximity switches were adjusted. With the installation complete the entire system was cycled through its different modes to further insure proper operation (Figure 4).

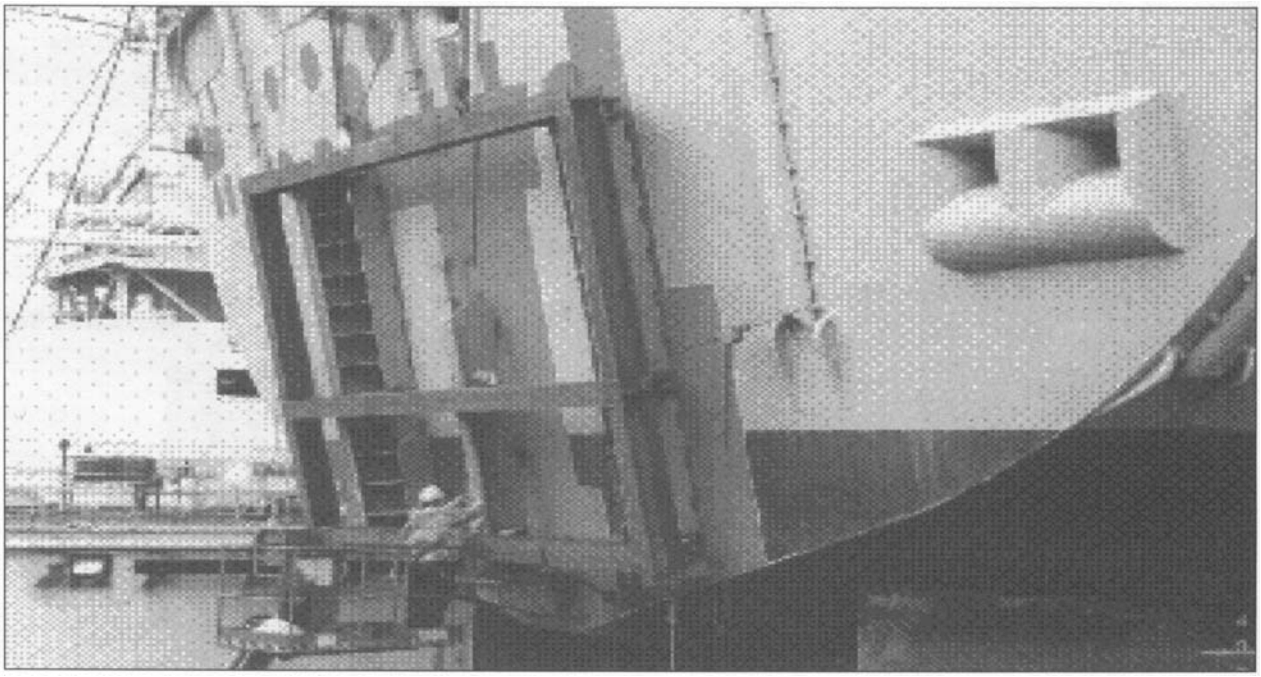

FIGURE 3. SEPAL Installation

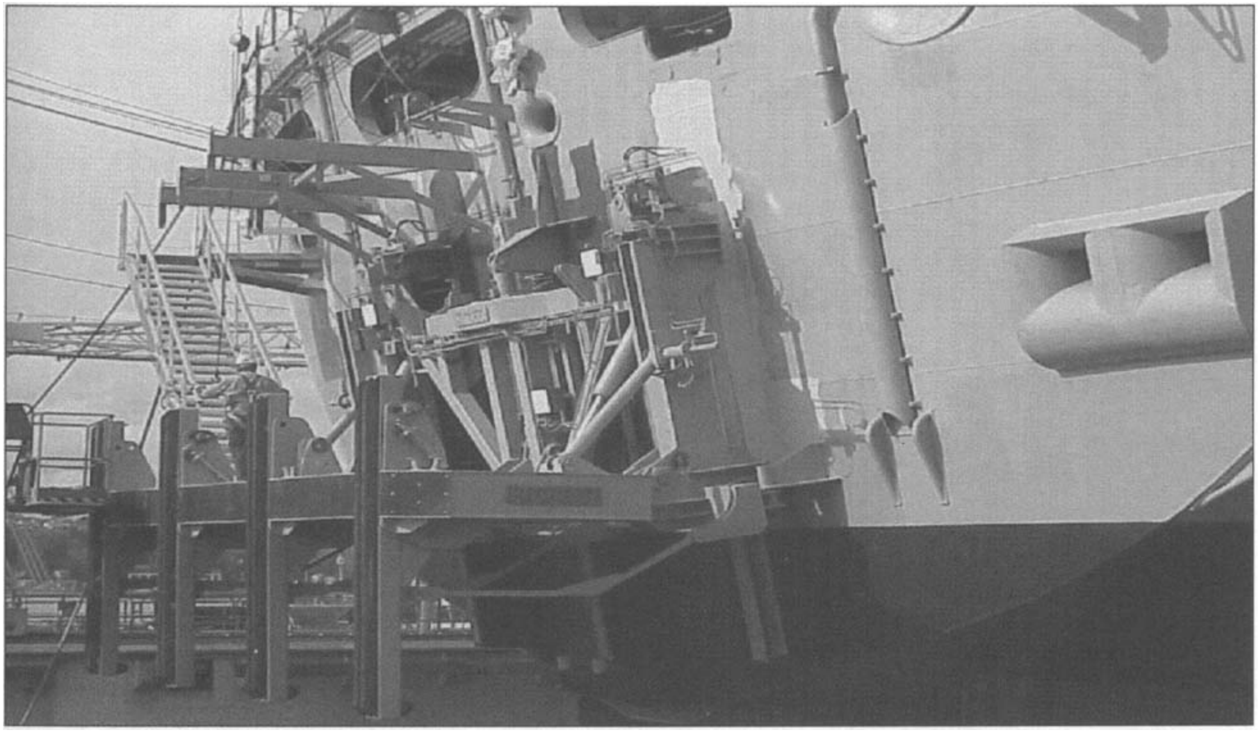

FIGURE 4. SEPAL Platform Assembly

Acceptance Testing & Evaluation

Final acceptance testing of the prototype SEPAL began immediately after installation was complete. Portable stanchions were pull tested in the rigging shop. Static load weight testing was performed on the platforms, and ladder treads (Figure 5). Dynamic testing was performed on the ladder wire rope and winch motor. Platform cycle testing consisted of operating the equipment through deployment, stowage, and vertical cycling. Performance tests were conducted on the hydraulic and electrical systems. Emergency operation tests and boat mooring tests were also performed after satisfactory completion of normal operational testing. Figure 6 shows the boat-mooring test in progress.

Prior to the end of the DSRA, the Navalimpianti technical representative held training sessions for the crew. Several crewmembers were trained on the system components, operation, maintenance requirements, and troubleshooting. Since the SEPAL is a prototype system, repair parts were included with the procurement of the platform. During the SEPAL installation a technical manual was developed by the contractor in NAVSEA format and copies provided to the ship.

The SEPAL installation is an alternative to using the traditional USN accommodation ladder as a personnel transfer system. To insure the SEPAL installation meets the USS *Bridge* (AOE 10) operational requirements, the SEPAL is being evaluated under at-sea conditions and use for a period of one-year beginning August 1999 The evaluation will assist in the development of the SEPAL maintenance plan, ILS support plan, and personnel training. Specific checkpoints will be conducted monthly via collecting data from visual inspections and recording specific measurements. No equipment is to be dismantled during the evaluation period, relying principally on visual checks of the system. The evaluation period will serve to validate the anticipated benefits of the SEPAL installation. If the evaluation is favorable, a ShipALT for the installation of a SEPAL system on the remainder of the AOE Class will be considered.

Summary

The installation of the SEPAL Prototype on the AOE 6 class ship is an example of the ability of government and industry to collaborate and develop cost-effective and timely solutions to shipboard operational and safety problems. The prototype SEPAL installation has already demonstrated significant reductions in manpower requirements. Anticipated improvements in operational effectiveness, and reduced life cycle costs associated with automated personnel transfer systems will be evaluated during ship deployments for a period of twelve months. Figure 7 shows the SEPAL outfitted and ready for transfer operations.

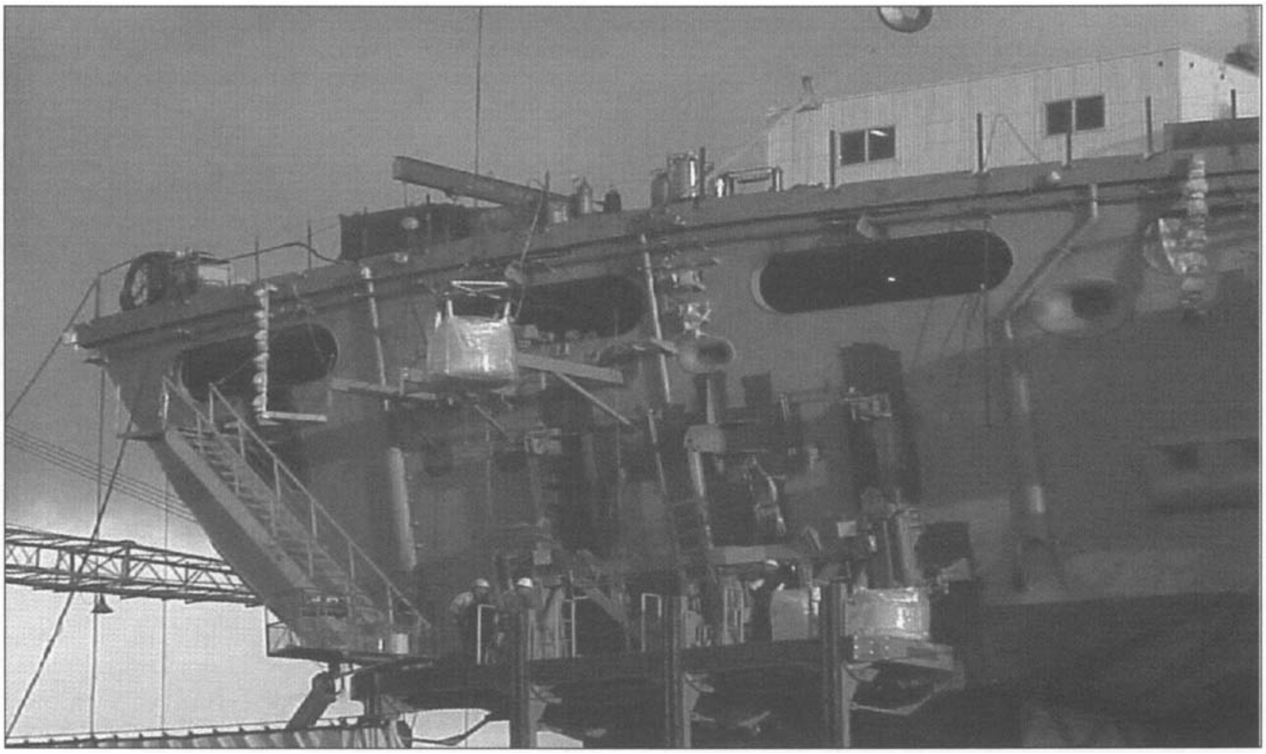

FIGURE 5. SEPAL Static Load Test

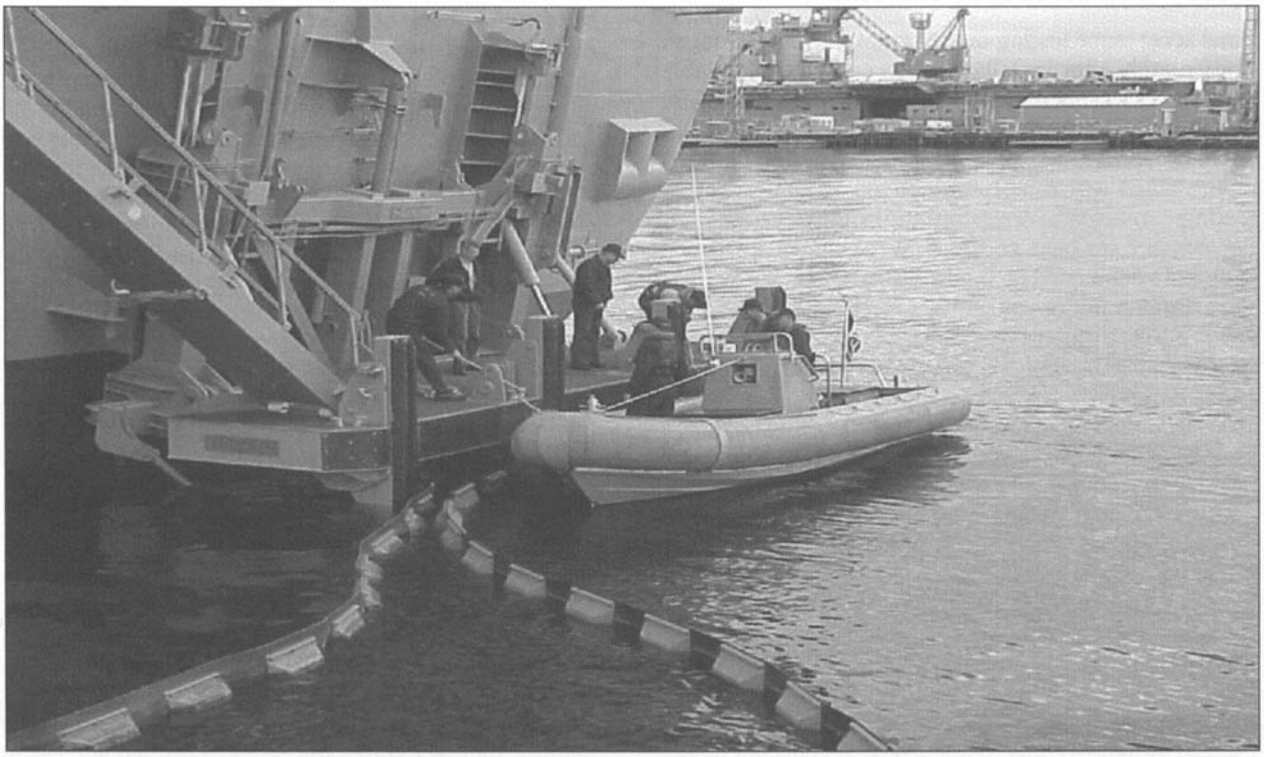

FIGURE 6. SEPAL Boat Mooring Test

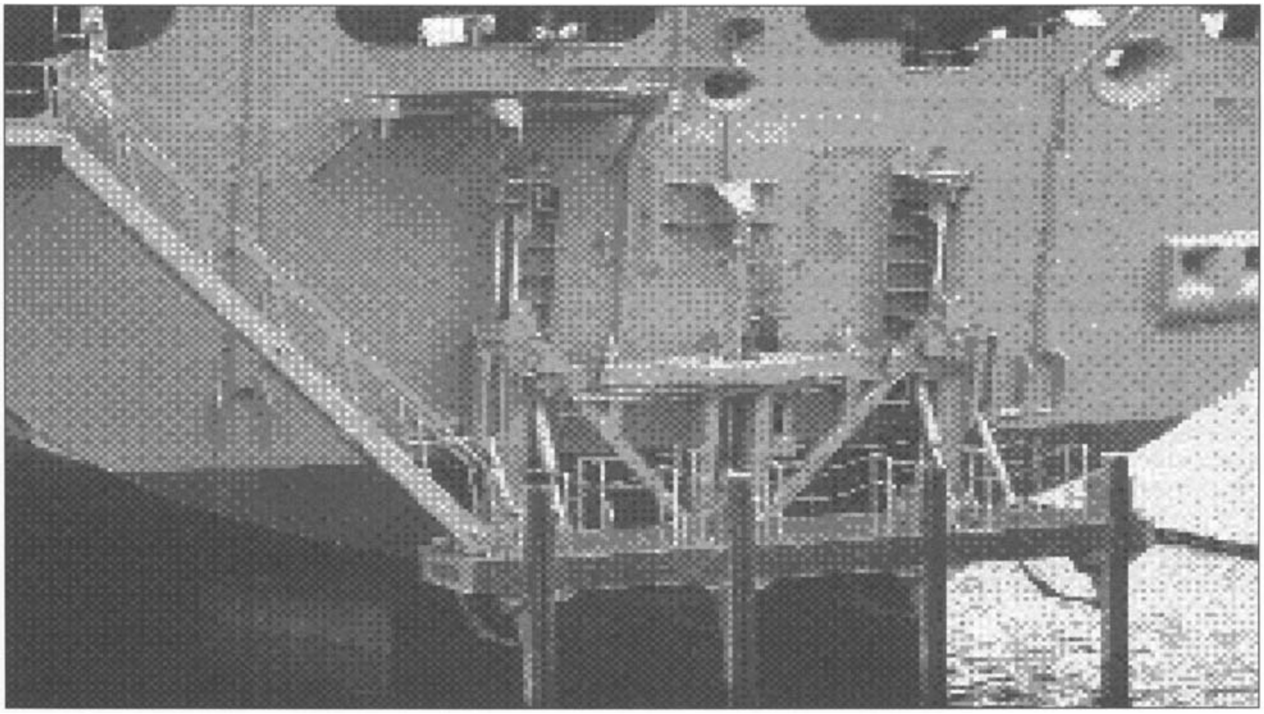

FIGURE 7. Completed SEPAL

Conclusion

Technology demonstrations such as the SEPAL Prototype Demonstration are a practical approach to the mitigation of risk associated with the insertion of promising commercial technologies into future US Navy ships. The SEPAL demonstration on the AOE 6 class can be considered as a proof-of-concept installation. The SEPAL installation on the AOE 10 is a success story of industry working with the government to solve a problem with the existing USN equipment.

The SEPAL demonstration was a back-fit to an existing ship with the specific goal of correcting an operational and safety problem. For future ship designs, the SEPAL concept should be considered early in the design phase to fully realize the potential benefits of the system. Variants of this technology are being studied for advanced multi-purpose approaches to personnel and cargo transfer functions for other classes of U.S. Navy ships. ✣

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The authors acknowledge Robert Wasalaski for his valuable insight to explore new technologies and make the sailor's job easier. The authors acknowledge and thank all of the associates from Navlimpianti who dedicated their support during the engineering development, fabrication, testing and installation of the SEPAL. Additionally, the authors acknowledge the effort, teamwork and cooperation all of those who were associated with the success of the project from: PSNSY, AOE 6 class Planning Yard Services, SUPSHIP Puget Sound, and Todd Pacific Shipyard.

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