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Technical Report

The Surface Warfare Test Ship

by

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The current Self Defense Test Ship is over 45 years old, approaching the end of its useful life. A conversion of a de-commissioned SPRUANCE (DD 963) class ship is the basis for the replacement Surface Warfare Test Ship. The study proceeds from mission needs and operational requirements through a functional analysis and study of threat weapons to be employed against the SWTS. After summarizing the characteristics of a SPRUANCE Class ship, the study reports an analysis of four alternative conversion schemes. The alternatives are described, with the rationale for choosing that considered best. The chosen alternative is then described and analyzed in several important areas of concern including combat systems functionality, signature characteristics, engineering plant and habitability for test personnel. The fitness of the proposed design for several special evolutions is also described, and alternatives for further enhancing performance are presented.

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The Surface Warfare Test Ship

This report documents a systems engineering and design capstone project undertaken by students in the Total Ship Systems Engineering program at the Naval Postgraduate School. The project was performed under the direction of Professors C. N. Calvano and R. C. Harney. The officer students who comprised the design team were: LT David Wickersham, USN, team leader; LTjg Ioannis Farsaris, Helenic Navy, LT Philip Malone, USN, LCDR David Ruley, USN, LT Nathan York, USN

ABSTRACT

A systems engineering approach to the design of a ship conversion to satisfy the requirements for a Surface Warfare Test Ship (SWTS) to be employed by the Port Hueneme Division of the Naval Surface Warfare Center is presented. The ship described would meet test needs for future weapons and sensor systems and provide limited test capability for future hull, mechanical and electrical systems.

The current Self Defense Test Ship is over 45 years old, approaching the end of its useful life. A conversion of a decommissioned SPRUANCE (DD 963) class ship is the basis for the replacement Surface Warfare Test Ship. The study proceeds from mission needs and operational requirements through a functional analysis and study of threat weapons to be employed against the SWTS. After summarizing the characteristics of a SPRUANCE Class ship, the study reports an analysis of four alternative conversion schemes. The alternatives are described, with the rationale for choosing that considered best. The chosen alternative is then described and analyzed in several important areas of concern including combat systems functionality, signature characteristics, engineering plant and habitability for test personnel. The fitness of the proposed design for several special evolutions is also described, and alternatives for further enhancing performance are presented.

Faculty Evaluation

(This section of the report prepared by the TSSE faculty, Professors Calvano and Harney)

The first four TSSE student capstone designs were performed to meet requirements established by the faculty – requirements which were essentially “made up”, though realistic and of potential Navy interest. This design, like its three most recent predecessors, was undertaken at the suggestion of a “real Navy customer”. Previous designs done for interested parties outside the Naval Postgraduate School included an Arsenal Ship for the Assistant Secretary of the Navy (Research, Development, and Acquisition), an all short take-off, vertical landing (STOVL) aircraft carrier using conventional propulsion for the CVX program office [1], and a Maritime Pre-Positioning Force 2010 fleet for the Center for Naval Analyses and the U. S. Marine Corps [2]. This year the Ship Self-Defense Branch of the Port Hueneme Division of the Naval Surface Warfare Center (NSWCPHD) asked us to look at the design of a replacement for the current Self-Defense Test Ship (SDTS – the ex-Decatur). The replacement ship, if the program is approved, is expected to be based on a DD963 class ship, converted for the purpose.

The fact that the SDTS-replacement would be a ship conversion from an existing class of ship, rather than an entirely new ship design, was a point of concern for the faculty. We were apprehensive that a conversion project would not be as educationally challenging as a new ship design. We thought there might be less need for combat systems analysis, there would certainly be less need for use of the ASSET code in platform design and therefore less emphasis on naval architecture, and there might be fewer opportunities for innovation. The unquestionable need for a replacement SDTS coupled with the genuine interest in helping during the design process on NSWCPHD’s part, overcame our initial hesitation.

As it turned out, our fears were unjustified. Real concerns for safety and survivability drove combat systems analysis and topside design to as high a level of detail as achieved in previous projects. ASSET was still used to evaluate the stability of the modified design. The fact that historical costs were available for SPRUANCE class ships (the class selected for conversion) made possible far better cost estimates than had typically been achieved in the past. In addition, creativity was not stifled in the least. The students researched past and ongoing programs of potential relevance and included many of them in their trade spaces. Innovative ideas they adopted included moving the helicopter landing deck to the bow of the ship, incorporating an enclosed accommodation ladder, adding a boat ramp for barge handling, and significantly reducing the radar cross section of the superstructure, masts, and sensors.

Moving the helicopter landing deck forward of the VLS launchers improves the safety of EOD personnel disarming the weapons after a test (the test weapons of interest are mounted aft) and frees up considerable space for future test projects, without decreasing safety of flight operations. The enclosed accommodation ladder with "French Doors" in the hull removes a source of significant radar cross section, and makes for considerably safer at-sea debarkation and embarkation of research personnel. The boat ramp incorporated into the stern permits the test ship to carry, deploy, and recover its own test barge. This will result in considerable cost savings over the anticipated lifetime of the ship as an additional tug need not be rented to provide barge transport. Simple incorporation of screens, solid panels, and flexible radar absorbing material, alters the rectangular shape of superstructure objects and hides high cross section clutter, at minimal increases in cost and weight.

This year's team even went so far as to develop initial concepts of damage control in a highly automated ship during both manned and remote control modes of ship operation. In short the TSSE design satisfied or exceeded all of the requirements of the Mission Need Statement and the Operational Requirements Document.

On 9 December 1999 the TSSE team briefed their project before the NPS students and faculty as well as a select audience of individuals from Navsea and other self-defense stakeholders as well as the hierarchy at Port Hueneme. It was exceptionally well received. The TSSE faculty concur with this overall evaluation. Representing the work of only five students working part time for less than 6 months, the attached final report is an outstanding piece of work. In our opinion it is something of which not only the TSSE students and faculty, the Naval Postgraduate School, and NSWC Port Hueneme Division, but also the United States Navy can be proud.

[1] A Short Take-Off/Vertical Landing (STOVL) Aircraft Carrier (S-CVX), NPS Report NPS-ME-98-003, May 1998.

[2] The Maritime Preposition Force Ship 2010, NPS Report NPS-ME-99-002, April 1999.

SURFACE WARFARE TEST SHIP

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Chapter 1: *Introduction.*

The changing nature of warfare has forced United States Navy ships to operate closer to land. This littoral warfare exposes ships to a wider variety of threats while compressing the reaction time against these threats. In response to these increased dangers, the Navy is upgrading ship self defense weapon systems. The effectiveness of these improved weapon systems must be verified through realistic testing against real world threats at sea. Fleet downsizing has increased the demands upon the remaining ships. To reduce the time demands upon these ships, a dedicated test platform was developed: the Self Defense Test Ship (SDTS).

SDTS is homeported in Port Hueneme, CA, and is operated by Port Hueneme Division, Naval Surface Warfare Center (PHD NSWC). Since becoming operational in October 1994, it has successfully tested systems such as Rolling Airframe Missile (RAM) Block I, Close In Weapon System (CIWS) Block IA and IB, and NATO Seasparrow Missile System (NSSMS) RIM-7P and RIM-7R. The savings of commissioned warship time and manpower has been substantial. Additionally, the Test and Evaluation Teams have benefited from possessing a dedicated test platform with a schedule determined by test requirements rather than ship operational tempo.

The current SDTS, ex-USS DECATUR (Ex-DDG 31), is more than 45 years old. Recent hull surveys reveal significant deterioration that requires extensive and expensive repair. The SDTS cannot transport its own towed targets, incurring added tug expenses. The propulsion system of the SDTS cannot provide the maximum target speeds desired in some tests. This limited power precludes testing in moderate sea states. Furthermore, the ship cannot currently deploy for more than a few days without returning to port, and it cannot deploy to alternate test sites (such as Barking Sands in Hawaii). The new generation of weapon systems to be tested, such as Ship Self Defense System (SSDS) Mk 2 and Cooperative Engagement Capability (CEC), demand more deck space and enclosed volume than the ex-DECATUR can provide. A replacement for ex-DECATUR that does not suffer from these limitations is urgently needed.

To study the alternatives for the SDTS' replacement, PHD NSWC has teamed with the Total Ship Systems Engineering curriculum at the Naval Postgraduate School. Using a systems engineering approach, the SDTS has been analyzed, the needs have been defined, measurable requirements have been set, and an Analysis of Alternatives (AOA) has been conducted. The conclusions of the AOA are the basis for a conceptual design for the SDTS replacement: the Surface Warfare Test Ship (SWTS). SWTS will have the power, space, and volume to test all of the ship self defense systems presently under development and be the centerpiece of testing at Port Hueneme well into the 21st Century.

Chapter 2: *Current Capabilities*

The use of a dedicated Test and Evaluation (T&E) platform for weapons development has a long history in the Navy. In the recent past, the USS NORTON SOUND and ex-USS STODDARD have been used for this purpose. The present dedicated T&E platform is the ex-DECATUR. In 1987 an Iraqi attack on USS STARK with Exocet anti-ship cruise missiles resulted in the loss of 37 lives. This incident inspired the ex-DECATUR's conversion and employment as a Self Defense Test Ship (SDTS). SDTS is dedicated exclusively to testing ship self defense weapon systems. It has been instrumental in the development of the Infrared Sensor System (IRSS), Radiant Mist Infrared Sensor and Tracking System (IRST), Thermal Imaging Sensor System (TISS), and the SPQ-9B Fire Control Radar.

Prior to the SDTS, commissioned warships tested most weapon systems. These tests were taxing on the ship and on the weapons engineers. The ship scheduled the installation, testing, and removal of prototype systems, which distracted from training and maintenance. The test engineers dealt with the host ship's spectrum of priorities. The use of a dedicated T&E platform freed both the engineers and the active Fleet ships from these difficulties.

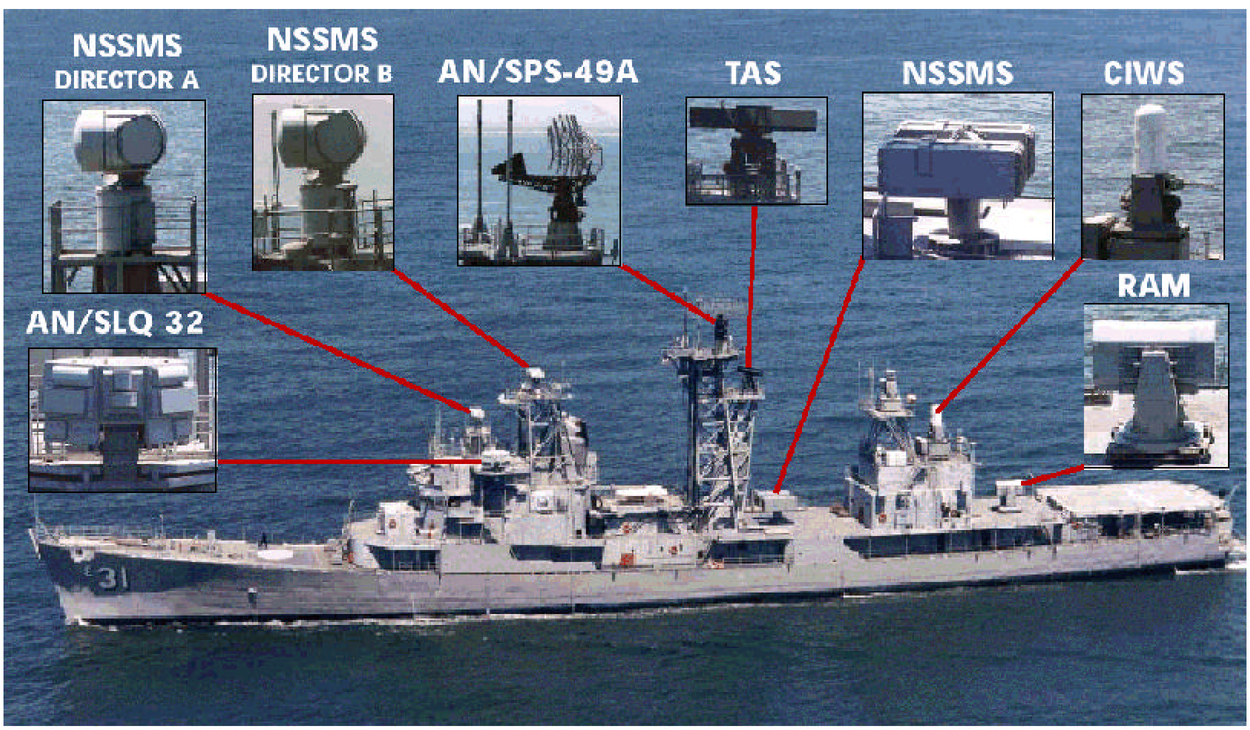

Figure 2- 1: SDTS Current Combat Systems Suite.

The second, and more important, capability of a dedicated T&E platform is the realistic threat profiles which can be used. For safety reasons, Target Missiles may not have a Closest Point of Approach (CPA) less than 2.5 nautical miles from manned vessels or commissioned ships[i]. By using a remotely controlled, uncommissioned ship, like SDTS, this restriction is avoided. Missiles can be flown as close to the ship as a test may require. To minimize the risk of damage to the SDTS, a decoy barge is towed astern. The decoy barge is described in Section 0

SDTS is now a mature program with well-established procedures and facilities. The current SDTS configuration is shown in Figure 2- 1. The replacement test ship must mesh with the existing program. It also must expand upon the capabilities of the current test ship. To minimize costs to the existing program, the SDTS's replacement must employ the same procedures and equipment to the maximum extent possible.

2.1 Ex-DECATUR

The ex-USS DECATUR, originally commissioned in 1956, was propelled, powered, and serviced by a 1200-pound steam engineering plant. It has a length of 418 feet, beam of 44 feet, and a draft of 20 feet. Ex-DECATUR displaced 4000 tons[1] (Note: Endnotes are provided at the end of each chapter). She was decommissioned in 1983.

After 9 years in mothballs, ex-DECATUR was converted for use as the SDTS. This conversion was completed in 1994. The expected service life was 10 to 15 years. It has a civilian contract crew of twenty-five to operate and maintain the ship. To reach the minimum watchstanding and maintenance manning requirements, steam systems were eliminated from the ship. Two diesel outboard drive units provide propulsion, and a diesel powered bow thruster provides fine maneuvering control. The maximum speed of SDTS is eight to ten knots. Three 550 KW diesel generators provide electric power for the ship. Hotel services are electrically supplied. Because ex-DECATUR did not have a flight deck, one was fabricated and installed on the fantail (Figure 2-2) to accommodate personnel and cargo transfer. SDTS has no organic helicopter hangar or maintenance facilities. It also has no lighting for nighttime flight operations. Sensors added during the conversion include the SPS-49A radar, Target Acquisition

[1] Jane's Fighting Ships 1986-1987. Ed. Moore, John, CAPT RN. Jane's Publishing Inc. New York,1986.

System (TAS), and Mk 15 Close in Weapon System (CIWS). The complete arrangement is shown in Figure 2- 1. Sensors and weapons organic to specific tests have been added as required. Two remote control systems enable SDTS to conduct unmanned operations: the Ship Remote Control System (SRCS) and the Combat System Remote Control System (CSRCS).

SDTS is homeported at Port Hueneme and operated by PHD NSWC. It is shown at sea on the Pacific Missile Test Range in Figure 2- 2. SDTS berths 64 people for up to 30 days and averages 72 days underway annually. Since SDTS became operational, it has conducted 19 unmanned, at sea, live fire tests and 54 manned firings. In the near future SDTS will test the High Frequency Surface Wave Radar (HFSWR), Evolved Sea Sparrow Missile System (ESSM), and additional SPQ-9B testing.

Figure 2- 2: SDTS at Sea.

The small size, high Operational Tempo, and age of SDTS have accelerated the ship's problems. Most of the deckspace is occupied. The planned installation of the LPD-17 Ship Self Defense Systems (SSDS) requires additional space for testing. The limited speed of SDTS (8-10 knots) requires excessive transit time (one calendar day for a one way trip to the OPAREA). The limited power also prevents SDTS from conducting tests in moderate sea states. This causes tests to be aborted at government expense due to deteriorated weather conditions after SDTS has already put to sea. Damage from a HARPOON impact in May 1999 is still being repaired. Most importantly, recent hull surveys have revealed serious corrosion: 30-40% of the length of the hull has lost more than half its original hull thickness (Appendix B, page 7). This requires major repair in the near future. Finally, the fuel tank system was improperly reactivated, resulting in algae in the tanks and tank seepage. This has led to degraded fuel quality and fuel leakage into ship's storerooms. The inherent problems with the SDTS are compelling reasons for the design of a replacement.

2.2 Decoy Barge

The most realistic test that a self defense system undergoes is the at sea, live fire evaluation. During such tests, one or more target missiles are fired at the SDTS. The target missile must present a realistic profile in order to produce a valid test of the self defense system. The missiles chosen to fly these missions are described in Section 3.4.1. They are actual anti-ship cruise missiles with telemetry components in place of the warheads. Unfortunately they are still capable of significant damage from kinetic energy as well as unexpended fuel.

Figure 2- 3: SDTS Towing a Decoy Barge.

To prevent damage to SDTS and maintain realistic threat profiles, a decoy barge is towed just astern of the ship. The target missiles either use active guidance or a beacon homing device. During tests with the actively guided target missiles, the passive decoy barge is equipped with radar reflecting trihedrals (Figure 2- 4). These trihedrals produce a Radar Cross Section (RCS) that is larger and more attractive than the SDTS, thereby seducing inbound missiles that might acquire the ship. Passively guided m issiles fly similar profiles. The active decoy barge, shown in Figure 2- 5, carries a beacon for the target missile to acquire. The decoy barge is towed between fifty and one hundred yards astern of SDTS as shown in Figure 2- 3. While tracking or homing on the decoy barge close astern of the ship, the target missiles present a realistic threat to the ship and are engaged by the self defense systems. Damage to the SDTS is averted as the target missile flies over the decoy barge or is successfully engaged by the self defense systems.

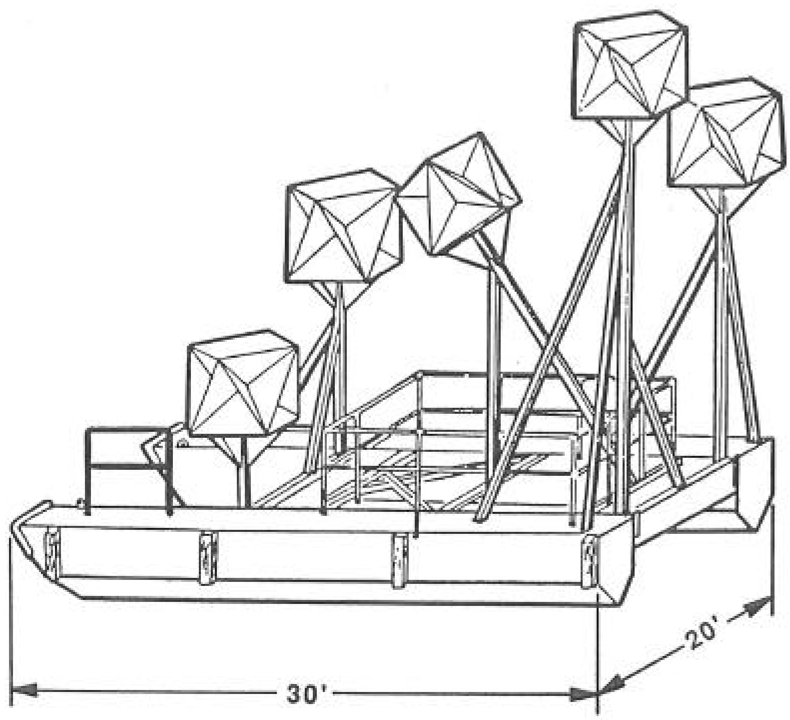

Figure 2- 4: Passive Decoy Barge for Actively Guided Missiles.

The test barges are mounted on pontoons and are 30 feet long, 20 feet wide, with a draft of 2 feet. The displacement is 10,000 pounds. The RCS of the barge is customized for each test event by setting the number and size of the reflectors. The barge is towed onto the range by a commercial range tug and taken under tow by SDTS at San Nicolas Island, as explained in the next section.

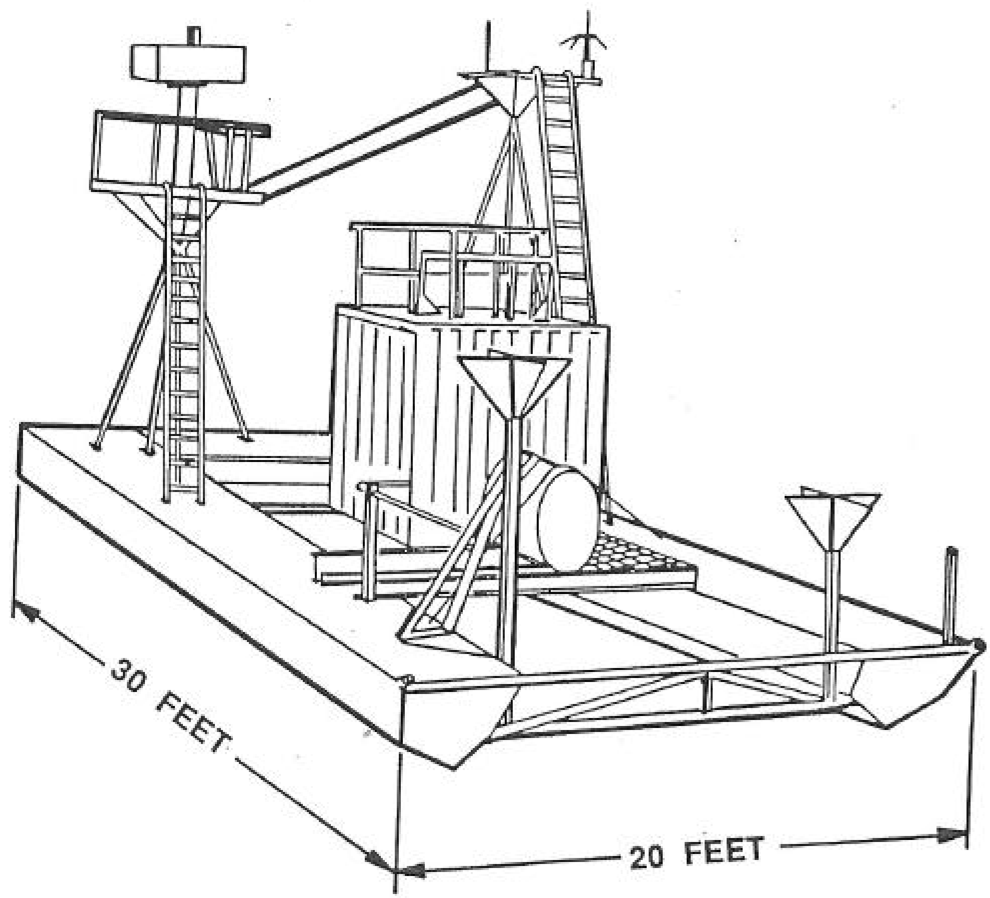

Figure 2- 5:Active Decoy Barge for Passively Guided Missiles.

2.3 Test Procedure

The test procedure used for a live fire event is well established. It is an integration of operators on board SDTS with operators at Point Mugu and Port Hueneme (Figure 2- 6).

Prior to getting underway, the self defense ordnance that will be used during this test is loaded into the ship's magazines. SDTS is fueled inport. The decoy barge is left in port to be towed by a range tug the day of the test.

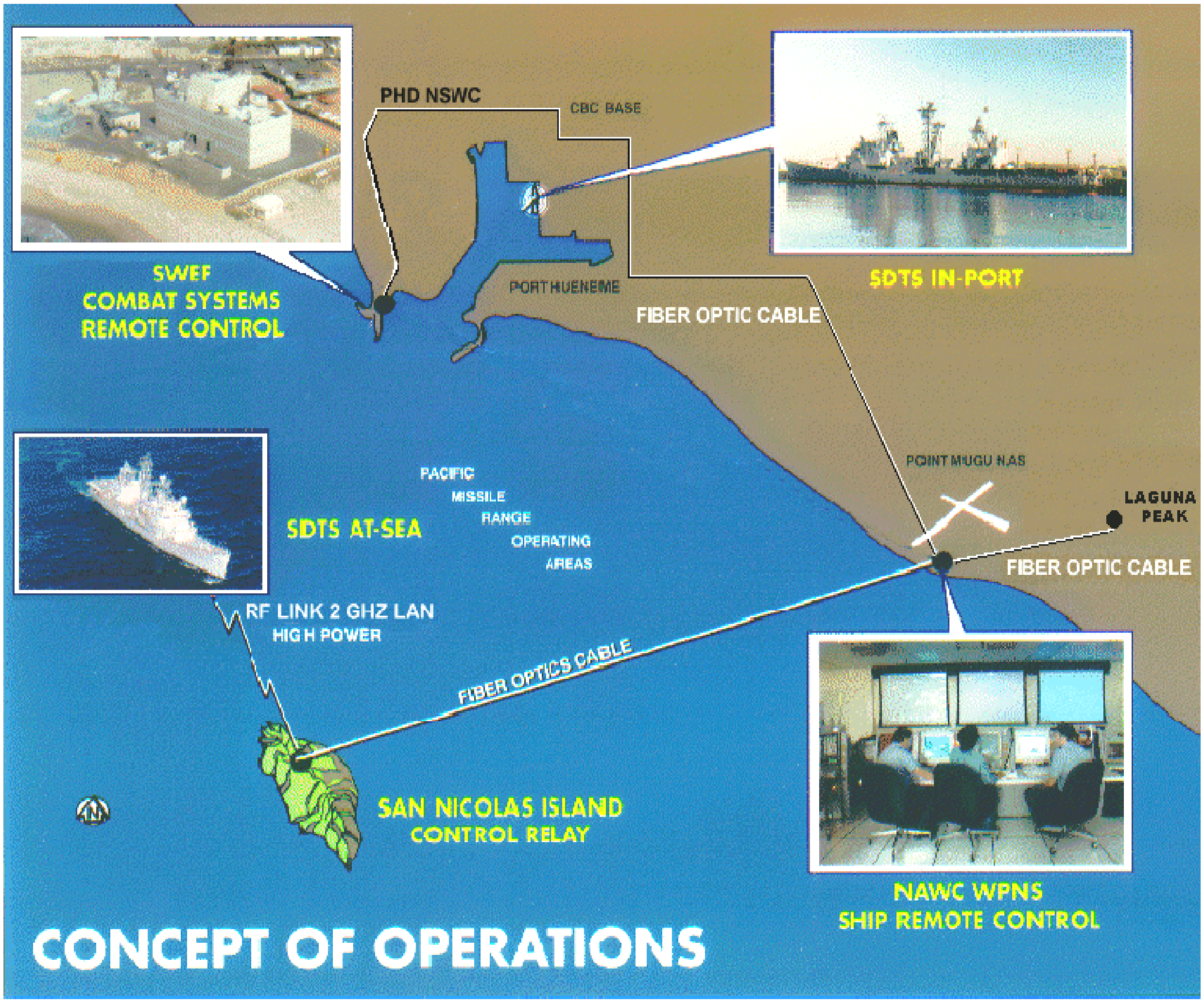

Figure 2- 6: Operation on the Pacific Missile Test Range.

SDTS has a maximum speed of 10 knots in calm seas. It must transit approximately sixty nautical miles from Port Hueneme to San Nicolas Island (SNI) in the Pacific Missile Test Range (PMTR). The ship gets underway one calendar day before the test event with the full test complement onboard. This complement includes the ships crew, all test event personnel, and engineers for other onboard systems. The total complement averages 60 people with a maximum of 100 people. During the transit, and after traffic lanes have been cleared, the ammunition is uploaded into the weapons. SDTS anchors overnight in Dutch Harbor, SNI.

Several hours before the test event, SDTS rendezvous with the crew boat and the tug towing the decoy barge. At this rendezvous, the decoy barge is taken in tow, the non-essential crew and test team personnel are transferred to the crew boat via small boats, and the anchor is weighed.

SDTS gets underway with a skeleton crew: five ship control personnel and ten to twenty test project engineers and technicians. The Master, Government OIC, First Mate, and two engineers transit the ship into the test area, 25-30 miles from SNI. The test project engineers and technicians prepare and check the weapon systems and sensors. During the transit, SDTS is placed under remote control. The Ships Remote Control System (SRCS) controls the navigation of the ship. SRCS is managed by Naval Air Warfare Center (NAWC) at Point Mugu NAS. The Combat System Remote Control System (CSRCS) monitors and controls the weapons and sensors. CSRCS is controlled by the Surface Warfare Engineering Facility (SWEF) at Port Hueneme. Remote control system checks are conducted to ensure successful connectivity and control. As each system is placed under remote control, beginning about 5 hours before the test, the remaining personnel are evacuated by helicopter to SNI, five to eight people at a time. The helicopters are contracted civilian Jet Rangers and Long Rangers. About 2 hours before the test, the ship arrives in the OPAREA and conducts dry runs. Once the ship is under complete remote control (about 45 minutes before the test), the last personnel are removed by helicopter to SNI.

The Pacific Missile Test Range is controlled at NAWC Point Mugu. PMTR uses radar at Point Mugu and on San Nicolas Island for range surveillance. Upon the approval of range control, the test event commences. The target missiles are fired from SNI or from aircraft operating from Point Mugu. The SDTS engages the missiles, and SWEF monitors the performance of weapons with video and data feeds.

At the conclusion of the test, the weapons systems are safed electronically via the CSRCS. Explosive Ordnance Disposal (EOD) personnel are inserted by helicopter on the forecastle, not the flight deck which is in the CIWS arc of fire, to mechanically safe the weapons. Once the weapons are safed, ship’s control personnel are delivered to the flightdeck to take local control of SDTS and return to SNI. At SNI, the SDTS anchors, all personnel return, and the decoy barge is transferred to the waiting tug. The weapons are downloaded to the magazines during the return to Port Hueneme.

Chapter 3: *Requirements Definition*

The ex-DECATUR fills a vital role in the weapons development process. However, it is at the end of its service life and a replacement is urgently needed. The replacement must provide all of the capabilities of the ex-DECATUR, but with more space, at higher speeds, and greater dependability.

The specific shortcomings of ex-DECATUR are:

- UNDERPOWERED- Even mild sea states can cause tests to be canceled at government expense.
- DEGRADED HULL- Significant hull corrosion will make SDTS unseaworthy in the near future.
- INSUFFICIENT VOLUME- The ship lacks space for additional systems and sensors.
- INSUFFICIENT BERTHING- Maximum capacity is 60 personnel. Berthing for 150 is frequently needed.

A Mission Needs Statement (MNS) was developed by PHD NSWC (Appendix C) detailing the deficiencies of ex-DECATUR and listing new needs for the successor ship. The faculty modified the MNS to make the design more academically challenging. The design team translated these needs into design requirements (Figure 3- 1). The design team utilized a systems engineering approach to accomplish this task. The first step was to clearly define what was required in the replacement. This began with describing the system desired by the customer, in this case PHD NSWC. These needs evolved into a complete set of design parameters in the Requirements Definition Process. This comprehensive list of "actions" serves as the foundation for the Operational Requirements Document (ORD). The ORD defines measurable parameters for each function. Any design that meets the requirements of the ORD can successfully perform as the SDTS replacement. Beginning with a comprehensive knowledge of the existing system, the shortcomings were analyzed and the procedures understood. The tasks that the replacement test ship must perform are captured in the Functional Flow Diagrams (FFD) (Appendix D). The conflicting tasks were resolved and inter-relationships identified. Different methods for meeting the requirements are studied in an Analysis of Alternatives (Section 6). One of these alternatives, actually a hybrid of the alternatives, is fleshed out in the conceptual design.

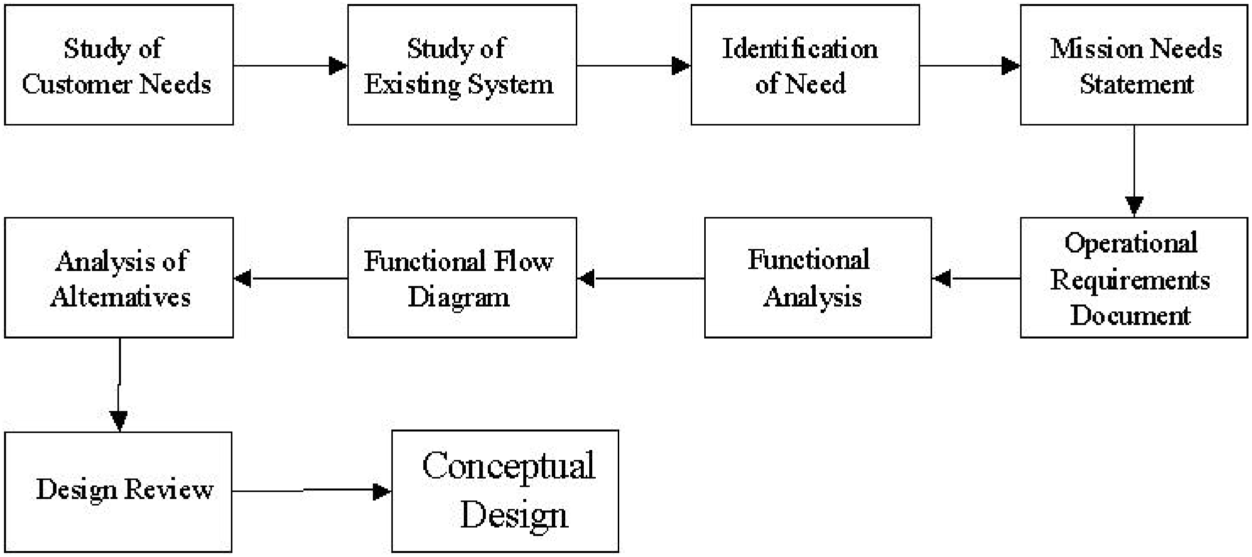

Figure 3- 1: Feasibility Study Flowchart.

The existing system, the hardware and procedures, has been reviewed in Section 2, and the shortcomings illustrated. PHD NSWC has defined specific requirements. Based on a study of existing commissioned hulls conducted by PHD (Appendix B), the SDTS replacement will be a converted SPRUANCE class destroyer. The decision to convert a DD 963 is based upon the existing hardware, large volume, and significant propulsive power. The proposed hull is USS O'BRIEN (DD 975) based upon an anticipated decommissioning date of 2001. The Analysis of Alternatives will use O'BRIEN as the unmodified hull.

3.1. Mission Needs Statement

In accordance with DoDInst 5000, PHD drafted a Mission Needs Statement. The Mission Needs Statement (MNS) is the starting point for the system design. It documents the un-met need of the Navy. In this case, the SDTS needs to be replaced. The MNS identifies the shortcomings of SDTS. It defines what capabilities are required to solve the deficiency. The Mission Needs Statement does not suggest a solution, but it does explain what the solution must be capable of performing.

The capabilities required by the Mission Needs Statement are highlighted here. The entire MNS is included as Appendix C.

- Sustained speed of 15 knots.
- Improved personnel transfer via helicopter and small boat.

- Observable signatures reduced to maximize probability of target homing on towed decoy barge.
- Size and configuration to accomplish simultaneous installation and testing of multiple weapon systems.
- Support future testing of:
- Battle Group Interoperability/ BGI System Integration Tests.
- Vertical Launch Enhanced Seasparrow Missile
- LPD 17 Systems (SSDS Mk II)
- DD 21 Related Projects

3.2. Operational Requirements Document

The Operational Requirements Document (ORD) is a strong tool for the design team. The ORD is derived from the MNS. It defines acceptable Measures of Performance (MOP). This comprehensive list of MOP's sets a measurable quantity for every function that the ship must perform. Any design that fulfills every aspect of the ORD will satisfy the mission of the replacement test ship. The ORD for the replacement ship is presented in Appendix E.

Acceptable Measures of Performance have two levels: Threshold and Objective. Threshold parameters are the minimum acceptable performance. Objective parameters are the best-desired performance. SWTS must meet the threshold requirements. Performance in excess of the objective parameters is not required and seldom beneficial.

Several of the requirements defined in the Operational Requirements Document had significant impact on the overall design of the replacement ship. Foremost among these, the replacement ship shall: (the requirement line numbers from the ORD are listed in parenthesis):

- Be capable of testing many systems currently under production for surface ship installation. (4.a.10)
- Support simultaneous installation of SSDS Mk2, LPD 17 version, plus SPS-49A, and the most limiting system from above (4.a.11).
- Have a Radar Cross Section less than DECATUR (threshold), objective is 10% of DECATUR RCS. (4.a.17)
- Be converted from steam services to electric services. (4.a.26)
- Be capable of transferring personnel by boat and helicopter. (4.a.13 and 14)
- Provide berthing for 150 personnel for 12 days, including berthing for 12 females. (4.a.18)
- Have 15 knot top speed and an endurance of 12 days (4.a.2)
- Use one engineroom as an HM&E test platform.(4.a.27)

3.3. Functional Analysis

The ORD describes what the replacement ship must be capable of performing. These capabilities are top level requirements. The functional analysis describes each function that the ship must perform in order to support the top-level requirements. For example, if the ship must be capable of 15 knots (top level requirement), the ship must also be capable of taking on fuel, lighting off the engines, and getting underway. The product of the Functional Analysis is a sequence of Functional Flow Diagrams (FFD). These diagrams are included as Appendix D.

The FFD shows relationships of functions. Precursor functions are shown before subsequent functions. Identifying the functions that the replacement ship must perform defines the requirements of the ship. Particularly in the case of a conversion, the functions must be well defined. The existing functions can easily be identified and retained; however, the added functions must be integrated into the ship. The FFD's uncovered several additional functions that the design team needed to add to the ship in order to fulfil the ORD. The functions are

- Control ship access.
- Monitor for fire and flooding electronically.
- Provide internal ship Local Area Network.
- Deploy and recover the Decoy Barge.
- Install the Ship's Remote Control System and Combat Systems Remote Control System.
- Transfer Personnel Underway via Helicopter and Boat
- Reduce Radar Cross Section.
- Berth Civilian Crew.
- Eliminate Steam Services.

These functions define "what" must be done. "How" the functions are completed is determined within the Analysis of Alternatives, and the various ways to accomplish the functions makes each alternative unique. The Operational Requirements Document is the primary guidance for the ships design. Four alternatives are presented in Section 6 that meet the requirements set forward in the ORD. Therefore, each is an acceptable alternative from a performance perspective. Section 6.8 details the conclusions of the AoA. This design review determines the alternative that is the basis for the Conceptual Design.

The replacement ship is designated the Surface Warfare Test Ship (SWTS).

3.4. Threat Analysis

SWTS faces a specific threat: Anti Ship Cruise Missiles (ASCM). It is not expected to encounter torpedoes, mines, or gunfire. Any requirement to test defensive systems against these other threats would likely impose requirements on the SWTS in excess of those contained in the ORD. Presently, PHD NSWC uses seven varieties of ASCM. The SWTS must be optimized to face any of these threats. A study of the target missiles enables calculations for the required Fields of View for sensors. Two of the target missiles have active homers. To maximize the relative signal of the decoy barge to the SWTS, the Radar Cross Section of SWTS must be minimized at the frequencies of these emitters.

3.4.1. Target Missile Profiles

PHD NSWC uses seven types of ASCM as targets. Because the ASCM is the target of the Self Defense weapon system that is being tested, it is called the "Target Missile". The seven targets are listed in Table 3- 1[ii,iii]

Target	Harpoon AGM-84	Vandal MQM-8G	Vandal ER	Vandal EER	Exocet MM-40	HARM AGM-88	SETT-8
Midcourse Flight Profile	Low	High Or Low	High Or Low	Low	Very Low	Medium	CLASSIFIED
Terminal Flight Profile	Sea Skim or Pop-Up	High Dive or Skim	High Dive or Skim	High G maneuver	Very Low	Medium	
Guidance	Active Ku Band	Passive	Passive	Passive	Active I Band	Passive	
Speed	0.85 M	2.5 M	2.5 M	2.5 M	0.9 M	0.9 M	
Dia. [inch]	13.5	30	30	30	13.7	10	
Area [sq in]	143	706	706	706	147	79	
Weight [lbs]	1145	4409	4409	4409	1884	798	

Table 3- 1: SDTS Order of Battle.

These missiles cover the range of current ASCM threats and are representative of current threats faced by the United States Navy. The targets will not change in the near future. The missiles vary in size, signature, speed, and flight profile. The flight profiles vary from sea skim, sea skim with terminal popup, and high dive. The Vandal EER has a high G terminal "jink" designed to confuse self-defense systems. The targets can be air-launched or launched from San Nicholas Island. The missiles are fired in salvos as determined by the test requirements. Most salvos are one or two missiles.

The active seeker frequencies are between 8 and 18 GHz. These are the frequencies of interest for Radar Cross Section performance evaluation.

Chapter 4: *Design Philosophy*

The Design Philosophy is a decision-making strategy. It provides a prioritization of design goals for the entire design team to use. The decision to convert the USS O'BRIEN limited the scope of the design by defining the hull, superstructure, and engineering plant.

The O'BRIEN has ample room to install any of the systems required by the ORD. The benefit of spaciousness is offset by the increased Radar Cross Section (RCS). The damage to SDTS caused by the Harpoon hit in May 1999 placed a high priority on signature reduction.

The mission of O'BRIEN will change from warship to test platform. As a test platform, the threat will be directed to arrive from aft of the beam. The locations of the weapons and sensors can be designed to have unobstructed Fields Of View (FOV) from the aft aspect.

The SWTS must provide a large degree of flexibility to the test engineers. This includes defining maintenance and meeting areas for the test personnel.

Safe operation of the ship is a vital requirement. This encompasses normal evolutions as well as evaluating and improving the method for boat and helicopter personnel transfers.

The SWTS will have different berthing standards than a warship. The comfort of the civilian crew and test personnel as well as the need to provide an on board environment conducive to creative problem solving requires a change in the current berthing arrangements.

Minimizing the maintenance requirements and manning lessens the operating costs. The largest impact of this is the removal of steam from the ship and installation of electric services. The costs will also be leveraged (described in Section 16.1) by providing a test platform for other types of testing such as a HM&E test engineroom and new underway replenishment equipment.

Because the systems that will be tested will change over time, providing room for future growth is important. This growth will take the form of additional weapons and sensors. One can readily anticipate that future self defense systems will be more complex with more components than current systems.

If a system, such as SONAR, will not be used by SWTS, but the space is not needed for another purpose, the system will be laid up in place to conserve cost.

This design philosophy is the basis for design trade off decisions to maximize the SWTS's performance as a whole platform. The complete list of priorities is given as Table 4-1.

Design Philosophy

1. Radar Cross Section Reduction
2. Large Field of Views
3. Test Flexibility
4. Safety
5. System and Sensor Flexibility
6. Ability to test widest range of systems
7. Accessibility to systems and sensors for maintenance/installation/removal
8. Room for Future Growth
9. Minimum Manning
10. HM&E Testing
11. Comfort of Crew and Riders
12. Redundancy
13. Survivability
14. Minimum Modifications
15. Low cost
16. Battle Group Interoperability
17. Recommisionable

Table 4-1: Prioritized Design Objectives.

Chapter 5: *Projected Capabilities*

The SWTS will replace SDTS, but the remaining infrastructure of PHD and PMTR will not change. SWTS must integrate easily into these existing programs. The SWTS must function with the decoy barge, helicopters, and boats currently used on the range. The first system that will be tested is the Ship Self-Defense System (SSDS). Many of the SSDS sensors will remain on board the SWTS after SSDS is completed.

5.1. SPRUANCE Class Destroyer

The proposed hull for the SWTS conversion is USS O'BRIEN (DD 975). O'BRIEN is scheduled to decommission in 2001. Like all SPRUANCE hulls, O'BRIEN was designed as an anti-submarine warfare ship, and the strike capability was added later. It is not equipped for anti-air warfare. O'BRIEN has an aluminum superstructure, and the Bridge and Combat Information Center (CIC) are spacious. It has been modified to carry two SH-60B helicopters in its hangar with twin Recovery, Assist, Secure, and Traverse (RAST) tracks. The specifics of the O'BRIEN's hull are listed in Table 5- 1 and the topside arrangement is shown as **Error! Reference source not found.**.

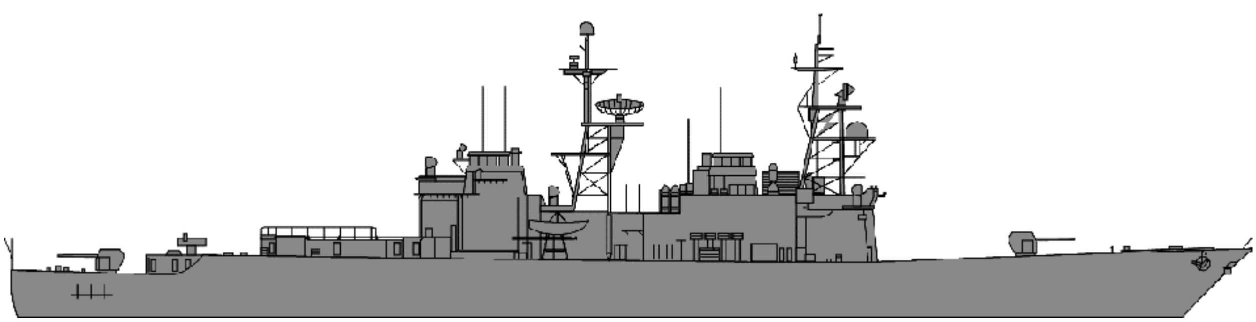

Figure 5- 1: SPRUANCE Class Destroyer with VLS Profile.

Length	563 feet
Beam	55 feet
Displacement	8,200 tons
Draft	30' 6; forward, 20' 6"aft
Armament	two 5-inch 54 caliber LWG two Mk 15 20 mm CIWS two triple-tube torpedo launchers Mk 29 NATO Seasparrow Missile System Harpoon Cruise Missile System Mk 41 Vertical Launch System
Aircraft	2 SH-60B Helicopters
Propulsion	4 General Electric LM 2500 gas turbines total of 80,000 shaft horsepower
Speed	30+ knots
Complement	22 Officers 22 Chief Petty Officers 320 Enlisted
Date Launched	17 July 1976
Date Commissioned	3 December 1977

Table 5- 1: USS O'BRIEN Characteristics.

5.2. Payload

The O'BRIEN is a SPRUANCE Class Destroyer with the Vertical Launch System (VLS). The configuration of the O'BRIEN is shown as Figure 5- 2. The O'BRIEN has two Mk 45 five inch 54 caliber Light Weight Guns. The forward 5" gun is Mount 51; the aft is Mount 52. The two CIWS mounts are named similarly: Mount 21 is installed on the 04 level forward, starboard side; Mount 22 is installed on the 04 level aft, port side. The Harpoon missiles are mounted on the 03 level midships on the "Harpoon Deck." The Mk 91 NATO Seasparrow Missile System (SWY-1) is Mod 0, so there is only one Mk 95 director installed. The Mk 29 NATO Seasparrow Missile Launcher is on the "Missile Deck," the 01 level aft of the flight deck. O'BRIEN has a 61 cell Mk 41 VLS launcher on the forecastle.

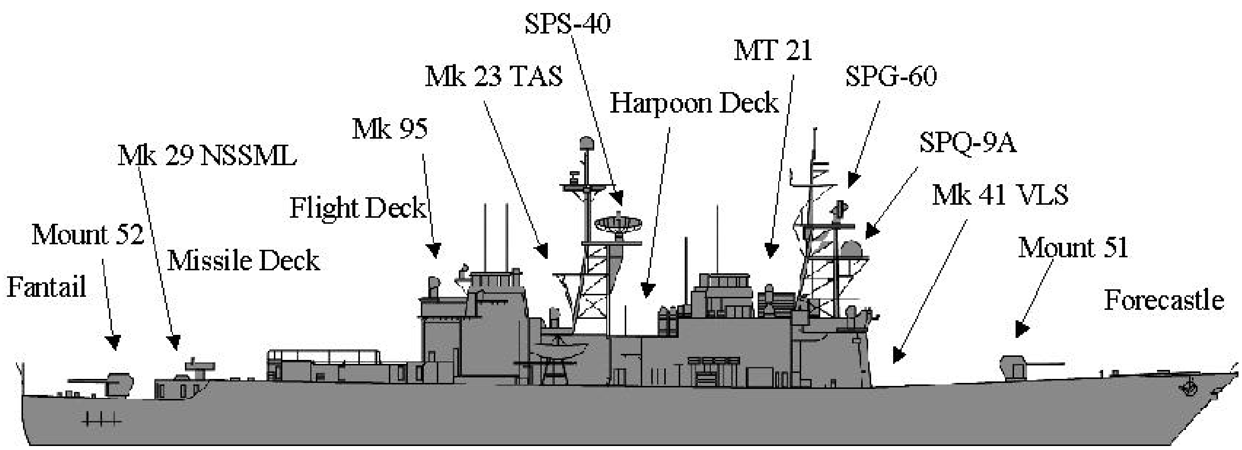

Figure 5- 2: USS O'BRIEN Weapons and Sensors.

The O'BRIEN possesses significantly more deck space and internal volume than the DECATUR possesses. All of the systems presently installed on DECATUR will easily fit on O'BRIEN. The major internal arrangements challenge is the Ship Self-Defense System (SSDS) as configured for LPD-17 (SSDS Mk 2 Mod 2). Table 5- 2 lists the requirements of this system. PHD NSWC has additionally requested that an SPS-49A radar and CIWS Block 1B be installed. A camera mounted on a CIWS pedestal monitors inbound targets and records the engagement of those targets. This "CIWS Camera Mount" must be located near the CIWS and boresighted to the CIWS mount to minimize parallax errors.

A second Mk 91 NSSMS director must be added to meet the SSDS Mk 2 Mod 2 requirements. Although SSDS does not require a five-inch gun, one will be retained for possible future testing.

LPD 17 Configuration	USS O'BRIEN (DD 975) Configuration
Detect	
SPQ-9B SPS-48E SPS-49 ** SPS-73	SPQ-9A SPS-40 Mk 23 TAS CIWS BLK 1A SPS-55
ESM	
SLQ-32A(V)2	SLQ-32A(V)2
Controls	
ACDS RNSSMS	SWY-3 NTDS RNSSMS
Engage	
RNSSMS RAM BLK 1 CIWS BLK 1B ** 5"/54 Mk 45 LWG**	RNSSMS RAM BLK 0 CIWS BLK 1A 5"/54 Mk 45 LWG

** Systems not part of SSDS, but requested by PHD NSWC.

Table 5- 2: SSDS Mk 2 Mod 2 Configuration and USS O'BRIEN's Combat Systems Suite.

5.3. Berthing

The SPRUANCE is designed for a crew of 22 Officers, 22 CPOs, and 320 enlisted. The entire SPRUANCE class has been modified for integrated (co-ed) crews. The Officer's berthing has thirteen staterooms and a CO's inport and at sea cabins. CPO berthing is split for nineteen males and three females. The crew berths in six spaces with between twenty-four and seventy-two bunks in standard Navy three rack tiers. Each berthing space has a dedicated shower room and head. Only the CO's cabins and the XO's stateroom have a private head and shower.

5.4. Hull, Mechanical and Electrical

The O'BRIEN's engineering plant consists of two engine rooms and three auxiliary machinery rooms. Each Engine Room has two Gas Turbine Engines for propulsion and one Gas Turbine Generator (GTG) for electric power. A third GTG is located on the starboard side of the second platform below the missile deck. Hotel services are provided by steam. The O'BRIEN is a sturdy, well-powered ship.

Chapter 6: *Analysis of Alternatives*

The conversion of a DD 963 class destroyer into the SWTS requires the modification of a warship to a remote-operated ship as guided by the design philosophy. To meet the thresholds and objectives that have been set by the ORD, the design team proposed four different alternatives. All of the alternatives have the same baseline, consisting of the hull, superstructure, and engineering plant of the DD 963, weapons and sensors of the SSDS, the remote control systems and berthing/messing arrangements. These aspects, common to all alternatives, are presented in Section 5.1.

In the following analysis, only the differences between the four alternatives are discussed along with the advantages and disadvantages of each. The internal volume of the O'BRIEN easily accommodates the required payload, therefore, internal arrangements are relegated to the detailed design phase (Section 7.2). The conclusions of the Analysis of Alternatives are the basis for the conceptual design.

5.1. Aspects Common to all Alternatives

The baseline vessel for the design is a DD 963 class destroyer. USS O'BRIEN (DD 975) is assumed to be the proposed hull. In addition to the combat systems payload, aspects common to all the alternatives include the HM&E configuration and the habitability arrangements.

Stability

A worst case stability condition is the basis for the preliminary stability analysis. The analysis calculates the effect on the stability of the DD 963 hull with the addition of the SWTS payload. This includes the SPS-49 and SPS-48 radars, CIWS camera mount, reduced RCS panels (superstructure and masts), RAM launcher, and the removal of the VLS weapons. The results are a 0.18-ft increase in KG and a slight decrease in the righting arm at large angles of heel. The analysis concludes that the DD 963 hull has ample stability for the SWTS conversion.

Hull, Mechanical, and Electrical Design (HM&E)

The SWTS utilizes the existing DD 963 Hull, Mechanical and Electrical systems to the maximum extent possible. Major changes to the HM&E configuration i nclude; dedication of one engine room as a HM&E test bed, single shaft operation, and the conversion of all steam auxiliaries to electric.

Habitability

The SWTS will improve upon the existing DD 963 habitability configuration. The ship will support 150 personnel (including 12 females) for 14 days underway. The berthing compartments will be outfitted to provide more personal space for the civilian crew. Galley facilities will be modified to efficiently meet the needs of a smaller crew with few long underway periods.

5.2. Alternative A: Minimum Change Version

The Minimum Change version incorporates all the components of the SSDS MK2 (see Section 5.2) plus the SPS-49A. **Error! Reference source not found.** details the topside layout. The existing masts and superstructure are used to mount all the sensors and weapons with the exception of the CIWS camera mount. A camera platform is installed on the port side of the flight deck to mount the camera. This position places t he camera near the CIWS (Mount 22) to minimize parallax error. Mount 22, located on the 04 level aft, has a field of view on the port side and aft only. In this alternative, the capability of engaging targets is limited to the port side only. The magazine on the 04 level aft will be maintained for the CIWS ammunition and the NSSM magazine on the missile deck will store the rest of the ship's ammunition. The starboard boat deck houses one rescue boat; the port boat deck is not used.

Major Modifications: The Radar Cross Section must be reduced to match the magnitude of ex-Decatur in order to make Alternative A competitive. Because Alternative A is limited to port side engagements, the RCS of concern is the port aspect. Major reduction in RCS is achieved by removing the clutter from the hull and the superstructure. This clutter consists of firefighting equipment, underway-replenishment equipment, the port boat and davit, and life raft stowage racks. This equipment is permanently removed or stowed in cove red areas. For further reduction of the RCS, the top pole masts are removed as well as the yardarms above the SPS-48E platform.

Various sensors are added to increase the engagement effectiveness and the testing capability of the SWTS. The Mk 23 TAS, SPG-60 and SPS-40 radars are removed. The SPS-49A radar is added on the forward mast on the former SPG-60 platform. The SPQ-9A is removed and replaced by a SPQ-9B, mounted at the Mk 23 TAS platform (aft side of the aft mast). SPQ-9B's field of view must be unobstructed in the aft and port aspects because it is the primary designation sensor for RAM. The second additional Mk 95 NSSMS director is mounted on the port side of the forward mast. The existing Mk 95 director remains on the 04 level on starboard side. The SPS-48E is mounted on the aft mast on the former SPS-40 platform. The mast above the SPS-48 is removed.

Mount 51 is retained while Mount 52 is removed. The VLS and aft CIWS remain in their current positions, while the RAM launcher is added to the aft port corner of the fantail. The Mk 29 NSSMS Launcher is removed. The removal of NSSMS and Mount 52 provides space for future testing of weapons that can be placed on the missile deck or fantail.

Advantages: The primary goal of this version is to minimize the conversion costs. The minimum change version incorporates all the requirements set by the customer (PHD) while minimizing structural changes. The extended SSDS (including SPS-49) will allow a continuous test and evaluation platform under live-fire conditions that will give vital information for future modifications for the SSDS Mk-2.

The existing weapons system placement is maintained to the maximum extent in order to reduce the cost and time for the conversion of the SWTS. Despite the CIWS camera platform on the forward port corner, the flight deck remains operational and free of clutter with no need for further certification for flight operations. The free space on the fantail and missile deck provides ample space for future growth or the addition of new components to the SSDS.

Disadvantages: The main disadvantage of this version is it is capable of port side engagement only. The reduced fields of view for weapons and sensors do not allow the full use of the capabilities that the SSDS components currently provide.

The large RCS of Alternative A will require the RCS of the decoy barge to be augmented during tests of active-homing threat missiles.

5.3. Alternative B: Improved Version

The Improved Version includes all the weapons and sensors of the minimum change option with minor modifications to the superstructure and to the external arrangement of the combat systems and sensors. It is shown as Figure 6- 1. A lower RCS is achieved through the extensive use of Radar Absorbing Material (RAM), reduction of the top part of the masts, and other modifications to the superstructure. A distinctive modification in this version is the barge ramp. Another new feature is the Enclosed Accommodation Ladder, an improved means of transferring personnel at sea. The flight deck remains operable and the use of the hangar remains the same as in the minimum change option. The improved arrangement of sensors and weapons enables Alternative B to conduct engagements on both the port and starboard sides.

Major Modifications: A significant effort is made to reduce the RCS of Alternative B. Bulkheads on the superstructure are covered with RAM material. On the boat deck, a bulkhead covered with RAM material is added at the deckedge to shield the boat and midships area. RAM panels are added on the masts. Doors in the panels allow access into the mast enclosure, and interior access ladders provide maintenance access to the mast. The panels are of low density so the stability of the ship is only slightly effected as explained in Section 9.8.4.

Mount 51 is maintained to test future gun modifications. The RCS of the gun is substantially large, so a covering will be constructed and placed whenever Mount 51 is not included in tests. This case is constructed of lightweight material and with slopped sides covered with RAM material to minimize RCS.

The same stealth construction technique is implemented on the base supporting the CIWS and the CIWS camera. The CIWS (Mount 22) and the CIWS camera are moved to the starboard side of the missile deck. This allows both systems an unobstructed field of view aft of the beam.

New base mountings are used for the platforms of the Mk-95 directors, which are located over the aft intakes. This mounting will set the directors one over the other to save space and increase the field of view. The RAM launcher is moved to the starboard side main deck at the stern. This is the current installation location for RAM launchers in the fleet.

The barge ramp is located at the stern just aft the former location of MT 52. A detailed description of the Barge Ramp is given in Section11.3.1. The width of the stern is satisfactory to accommodate both the ramp and the RAM launcher. With this ramp, the need for target tow services is eliminated. This will save a minimum of $18,000 per test.

The second innovation in this version is the Enclosed Accommodation Ladder (EAL). On SDTS and Alternative A, accommodation ladders are used to transfer personnel at sea. The EAL provides safer transfer during the tests with no contribution to the RCS of the ship. The EAL is a cofferdam with two watertight doors in the side of the hull. The door heights allow personnel to transfer from the ship to a tug or a smaller boat in a variety of sea states. A detailed description of the AEL is given in Section 11.2.1.

Advantages: The ability to engage targets on port and starboard sides aft of the beam is the largest improvement over Alternative A. There is also significant RCS reduction. The installation of the barge ramp and the AEL increase the life-cycle savings and operability of the SWTS. The cost is minimized in a version with a reduced RCS. The full use of the hangar and the flight deck is an advantage for flight operations. There is still space for future installation of one more large system on the fantail.

Disadvantages: Although the RCS is reduced to a level lower than that of ex-Decatur, it remains high for the standards of the ORD. The location of CIWS at the missile deck introduces two disadvantages. First, the low height reduces the acquisition range for sea skimming targets. Second, because the CIWS radar dome is higher than the flight deck, the helicopter angle of approach is more restricted. Lastly, the height of the RAM launcher obstructs a small portion of the CIWS camera's field of view at 180 Relative.

Page Reserved for Figure: Alternative B, Improved Version.

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Figure 6- 1: Alternative B, Improved Version.

5.4. Alternative C: Optimized Version

General Description: The Optimized version introduces radical changes to the topside layout. These changes significantly reduce the RCS, increase the fields of view of all the weapons and sensors, make flight operations safer, and increase the space available for future growth. The topside arrangement drawing is shown as Figure 6- 2. The flight deck is moved forward in place of Mount 51. A new structure, the Aft Weapons Platform, is built on the former flight deck to support SSDS weapons. Mount 52 is retained for testing future gun modifications. More liberal use of RAM material and superstructure shaping reduces the RCS to almost half of the O'BRIEN's original RCS. The barge ramp and the EAL are also incorporated in this version. Alternative C possesses significant operational improvements over the previous alternatives.

Major Modifications: Moving the flight deck forward is the most significant modification from the previous alternatives. The ex-DECATUR's flight deck platform is transferred to SWTS and mounted forward of the VLS launcher on the site of Mount 51, which is removed. Using the ex-DECATUR's flight deck minimizes the installation cost of the move and provides a proven platform. When the SWTS is aligned for remote operation, the last personnel extraction and first insertion is conducted with the weapon systems armed. The flight deck's forward location means the helicopter never has to enter the arcs of fire. This increases the safety of the flight operations. In the event that a target missile hits SWTS during test operations, there is less chance that the forward flight deck will be damaged since it is forward and away from high RCS objects and active emitter components. The main disadvantage of the forward flight deck is the loss of hangar for helicopter stowage, but the use of hangar was infrequent and not identified as a requirement. Another disadvantage is that in heavy seas landing would be more difficult because the forward location will have more motion. The landing envelopes are listed in the Classified NATOPS manual using the forward Vertical Replenishment Station tables.

To reduce RCS, sloped lightweight RAM panels (similar to those used on masts) are installed along the superstructure below the missile deck and former flight deck. RAM material is added on the aft face and door of the hangar. RAM panels are added to the bridge wings to eliminate dihedrals.

All of the sensors remain in the same locations, but the weapons are moved to higher positions. All the weapons, with the exception of the VLS launcher, are located aft. On the flight deck, the aft weapons platform is constructed to support the RAM, CIWS, and CIWS camera. RAM is installed on the aft starboard corner of the flight deck. CIWS is placed on the first step, above and forward of RAM. This position provides CIWS with an unobstructed field of view. The CIWS camera is installed on the second step, above and forward of CIWS. It also has on unobstructed field of view. With this configuration the camera is higher than the CIWS gun which is an arrangement that is preferred by PHD. The stair step structure allows the missile deck to remain free for future installations. The location of MT 52 does not interfere with barge ramp operations as described in Section 11.3.1.

Advantages: The extended fields of view and the reduced RCS are the main advantages of Alternative C. The forward flight deck allows nearly 270 degrees of coverage by the aft mounted SSDS weapons and sensors. The stair step structure provides co-location of CIWS and camera mount and protected maintenance enclosures for both of them. The higher location of the RAM launcher protects it from heavy seas and towing operations.

The space for future installations is maximized with the complete missile deck available as well as areas on the 04 level aft, former flight deck, and port side of the fantail. The port side of the former flight deck is open for craning equipment on and off the ship with full access to the hangar for stowage.

The safety advantages of the new flight deck location have been described. The flight deck location, barge ramp, and the EAL increase the safety of personnel through the range of operations.

Disadvantages: The conversion costs increase in this version mainly due to the extensive relocation of the weapons and flight deck. New procedures for landing must be established to ensure safe operations.

The total RCS is still higher than 50% of the original ship, due to retention of wall-sided superstructure. This falls short of the ORD objective target of 10%. Mount 52, though covered when not operable, increases RCS and occupies a significant space that could be used by future installations.

Page Reserved for Figure: Alternative C, Optimized Version.

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Figure 6- 2: Alternative C, Optimized Version.

5.5. Alternative D: Ideal Version

General Description: As the name suggests, the Ideal Version incorporates major measures for stealth construction by reshaping the entire superstructure. It is the only version that reduces not only the RCS but also the IR signature. These modifications are viewed in Figure 6- 3. The masts are removed and the new AEM/S used in USS RADFORD and LPD-17 are placed forward and aft respectively. The location of weapons is the same (including the covering case for the aft 5"/54 gun) and the arc of fire remains close to 270^o. The aft weapons platform for the CIWS and the camera is constructed as in Alternative C. RAM material is extensively used on the superstructure and the hull. The barge ramp is incorporated. The EAL and the forward flight deck increase the safety of test operations as in the Alternative C.

Major Modifications: The latest stealth-design masts the US Navy has introduced into LPD-17 and to USS RADFORD are incorporated. The forward mast is identical to the one placed on USS RADFORD and encloses the SPS-49, SPS-73, the FURUNO navigational radar, and the communications antennas. The aft mast is similar to the one to be used in LPD-17 and encloses the SPS-48 and SPQ-9B. The Mk-95 directors are located aft over the hangar. The first director is immediately aft of the aft engineroom stack (as in the previous version) and the other on a new structure located to port of the aft stack and positioned higher to achieve a field of view of almost 270^o.

For RCS reduction, new sloped side panels covered with RAM material are installed on all vertical bulkheads. To facilitate this, the outer portions of the helicopter hangar are removed, the bridge wings are minimized, and the forward windbreaks are removed. On the superstructure, where RAM covered panels were used in the previous versions on vertical bulkheads, extensions are added to support slopped sides that bring the sides of the superstructure to the deck edge producing the desired reduced cross section. To further reduce RCS, every trihedral and dihedral is eliminated either by adding RAM covered panels or by removing objects or protrusions.

This is the only version that incorporates a reduction in the IR signature. This is accomplished by installing new advanced stacks that are currently in development. The advanced stacks are also designed to reduce the RCS. The exhaust plenum of the Number 3 Gas Turbine Generator on the missile deck is similarly redesigned for this version.

Advantages: The advantages for this version come from the innovations used for the first time all in one version. They give the best emplacement for the SSDS components while keeping near 270^{o} coverage.

The reduced IR signature that is achieved in this version allows the expansion of SSDS tests to include IR-guided ASCMs, as well as the testing of improved low-IR emission stack designs in the future. The superstructure includes many newly designed attributes that make SWTS an attractive platform for agencies that want to test innovative counter-measures technologies.

This version has the lowest RCS of all, but it still falls short for the objective proposed by the ORD. The substantial size of the SPRUANCE class makes any further reduction on the RCS extremely expensive because it will involve the reconstruction of the whole superstructure and hull.

The advantages from the barge ramp, the forward flight deck, and the space available for future installations combine to increase the flexibility of operations and improve safety for the test personnel.

Disadvantages: The cost of conversion for this version is significantly larger than the other three versions due to the substantial modifications of the superstructure and the fitting of new masts which must be customized for SWTS. The RCS reducing components also increase the total weight of the platform.

Page Reserved for Figure: Alternative D, Ideal Version.

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Figure 6- 3: Alternative D, Ideal Version.

5.6. Radar Cross Section Comparison

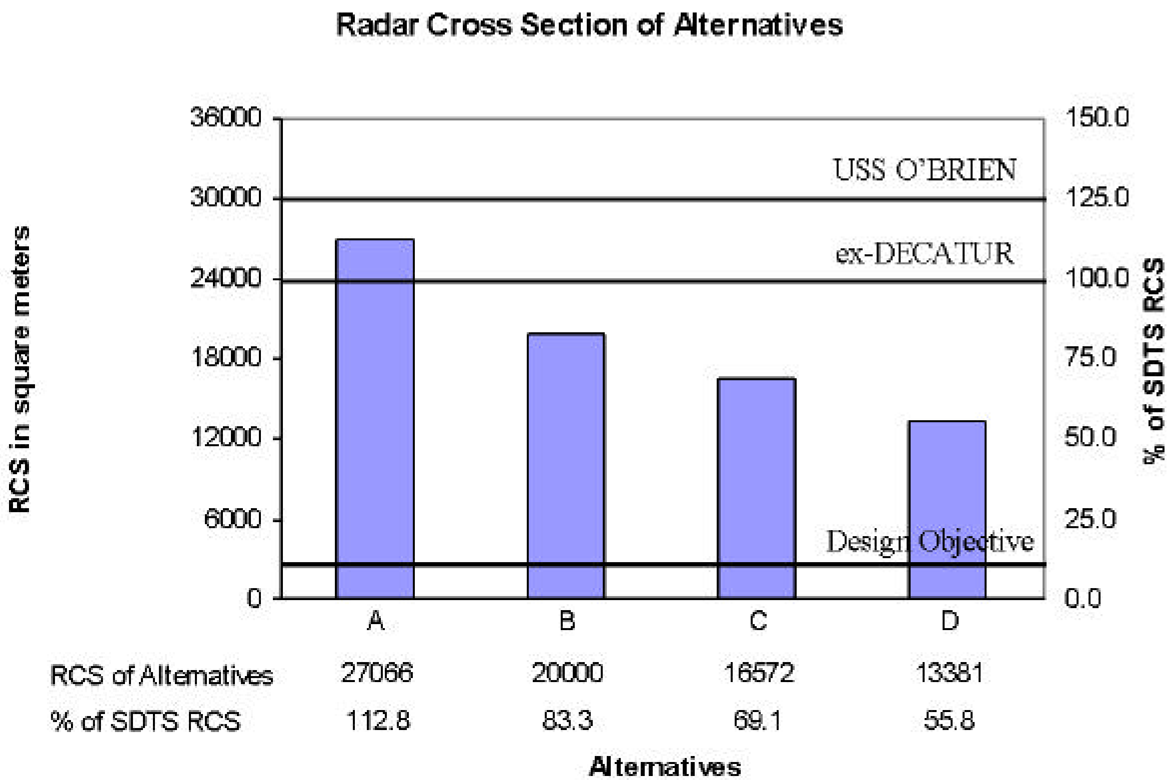
The current test threat missiles have active seekers. The geometry of each test is set so the target missile will acquire the test barge and not the SWTS; however, if the RCS of SWTS is significantly larger than the test barge, it may present a more attractive target to the seeker. While the target missiles do not carry warheads, they are still capable of significant damage to the ship. This damage would cost significant money and time to repair. A small RCS is a high design priority. The RCS of each alternative must be computed and compared to determine the most desirable alternative.

The RCS is affected by modifications to the superstructure including addition, removal and rearrangement of weapons and sensors, and modifications to the hull. Many of these modifications are done specifically to reduce the RCS; others are designed to have a small impact on the RCS. All of the test threat missiles use X band emitters, so all of the impacts are considered for this narrow band of frequencies.

The RCS is quantified by determining the RCS of the ex-Decatur and USS O'BRIEN by estimating the contributions of the hull, superstructure, sensors, masts, and weapons. These are demonstrated in Section 8. The contribution of each modification to USS O'BRIEN is calculated and summed in a table for each alternative. These tables are listed in Appendix H.

The results of the calculations are shown in Figure 6- 4. The ORD defines the RCS threshold as 100% of ex-Decatur. The objective is to reduce the RCS to 10% of ex-Decatur. Alternative A fails to meet the RCS threshold. Alternatives B, C, and D all meet the threshold but fall short of the objective.

Figure 6- 4: RCS of the Alternative Versions.



5.7. Field of View Comparison

An initial field of view (FOV) study determines problem areas for each of the alternatives. An unobstructed field of view is defined as a clear field of view from 090°R to 270°R, ability to elevate from horizontal to 75°, and depress to an angle to reach sensor/weapon minimum range. In the case of the camera mount, minimum range is identified as the target barge. The systems included in this study are RAM, CIWS, CIWS Camera Mount, NATO Sea Sparrow Director (NSSM) (Mk-95) #1, NSSM Director (Mk-95) #2, SPS-48E, SPS-49A and SPQ-9B. A summary of results is located in Table 6- 1.

Conflicts were identified in alternatives A and B. The problem areas in alternative A occur with the CIWS mount and the NSSM director #1. The position of CIWS is on the port side of the O-4 level aft. The aft engine room stacks block the starboard view. The position of the NSSM director #1 is on a platform on the port side of the forward mast. The mast itself blocks its starboard view. Alternative B's conflict occurs at the camera mount. The camera is located on a platform raised 5 feet up from the O-1 level on the missile launcher deck. The RAM launcher obscures a few degrees of the entire view. What makes those few degrees critical is that a portion of the target barge is obscured which may inhibit the view of a critical moment of the test. Both alternatives C and D have a clear field of view for all systems.

Sensor	FOV	Alt. A	Alt. B	Alt. C	Alt. D
RAM	Depress to Min Range	Y	Y	Y	Y
	Elevate 75	Y	Y	Y	Y
	090R to 270R	Y	Y	Y	Y
CIWS	Depress to Min Range	Y	Y	Y	Y
	Elevate 75	Y	Y	Y	Y
	090R to 270R	**NO**	Y	Y	Y
Camera	Depress to Min Range	Y	**NO**	Y	Y
	Elevate 75	Y	Y	Y	Y
	090R to 270R	Y	**NO**	Y	Y
Mk 91 #1	Depress to Min Range	Y	Y	Y	Y
	Elevate 75	Y	Y	Y	Y
	090R to 270R	**NO**	Y	Y	Y
Mk 91 #2	Depress to Min Range	Y	Y	Y	Y
	Elevate 75	Y	Y	Y	Y
	090R to 270R	Y	Y	Y	Y
SPS 48	Depress to Min Range	Y	Y	Y	Y
	Elevate 75	Y	Y	Y	Y
	090R to 270R	Y	Y	Y	Y
SPS 49	Depress to Min Range	Y	Y	Y	Y
	Elevate 75	Y	Y	Y	Y
	090R to 270R	Y	Y	Y	Y
SPQ 9	Depress to Min Range	Y	Y	Y	Y
	Elevate 75	Y	Y	Y	Y
	090R to 270R	Y	Y	Y	Y

Table 6- 1: Field of View Comparison.

5.8. **Conclusion of Analysis of Alternatives**

The Radar Cross Section, Fields of View, and method of personnel transfer are the most significant differences among the alternatives. Alternatives C and D have the same FOV and personnel transfer methods. The RCS of Alternative D is approximately 25% lower than Alternative C's RCS due to extensive structural modifications to the superstructure and mast structures. These modifications would be expensive. Alternative C possesses the same FOV and safe personnel transfer method with a RCS that is in the middle of the acceptable RCS band. This performance is at a significantly lower cost than Alternative D. Alternative C is therefore selected as the basis for the detail design. Section 16 presents four optional modifications to the baseline Alternative C that can reduce radar cross section, or reduce cost by reverting to standard personnel transfer and barge towing practices.

Chapter 7: *Combat Systems Design.*

The SWTS is designed to provide a robust platform to test new weapons and sensors. The first system to be tested will be the SSDS Mk 2. This system includes SPQ-9B, SPS-48E, SPS-73, SLQ-32A V(2), RAM Block 1, RNSSMS, and ACDS. In addition to SSDS, the initial combat systems payload includes an SPS-49A, CIWS Block 1B and 5"/54 Mk 45 at PHD NSWC request.

Several systems are removed or laid up to reduce maintenance requirements and provide space for new systems. The SQR-19 (Towed Array Sonar) and SLQ-25 (NIXIE) are removed so the barge ramp can be installed. The Mk 32 Mod 14 Torpedo mounts are removed to allow space for the Enclosed Accommodation Ladder and to reduce maintenance. The SPS-55 is removed to eliminate RCS contributions to the mast. The forward 5"/54 Mk 45 LWG is removed to provide space for the new flight deck. The Mk 29 NSSM launcher, forward CIWS mount and SPG-60 fire control director are removed to provide space for future systems. Forty-eight of the 64 Mk 41 VLS cells are laid up to reduce maintenance. The entire Sonar system is not required and is laid up.

5.9. Payload External Arrangements

The external arrangements are critical to providing the greatest coverage for all weapons and sensors. Figure 7-1 shows the profile of the entire SWTS. Geometric sections of the ship will be described individually.

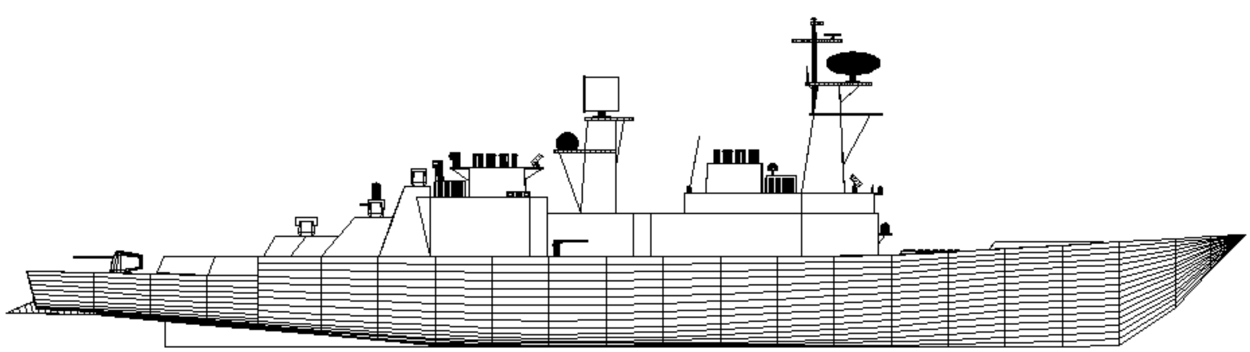


Figure 7- 1: Surface Warfare Test Ship Profile.

1.9.1. Sensors

The AN/SPS-49A is a long-range 2-D air search radar. It is designed for primary detection and tracking out to 250 nm.

Parameters:

- Requires 86 kVA of 440 Hz power and 10.1 kVA of 115 volt power.
- UHF band (300 to 1000 MHz)
- Antenna dimensions: 288 x 171 in (including pedestal)
- Antenna weight: 3165 lbs (above deck), 14,000 lbs (below deck)

The SPS-49A is located on the second platform of the forward mast (Figure 7-2) at frame 150. It is 104 ft above the waterline.

The AN/SPS-73 is the primary navigation radar. This radar replaces the SPS-55, and is integrated into SSDS Mk 2. The SPS-73 is located on the third platform of the forward mast at frame 159. It is 124 ft above the waterline.

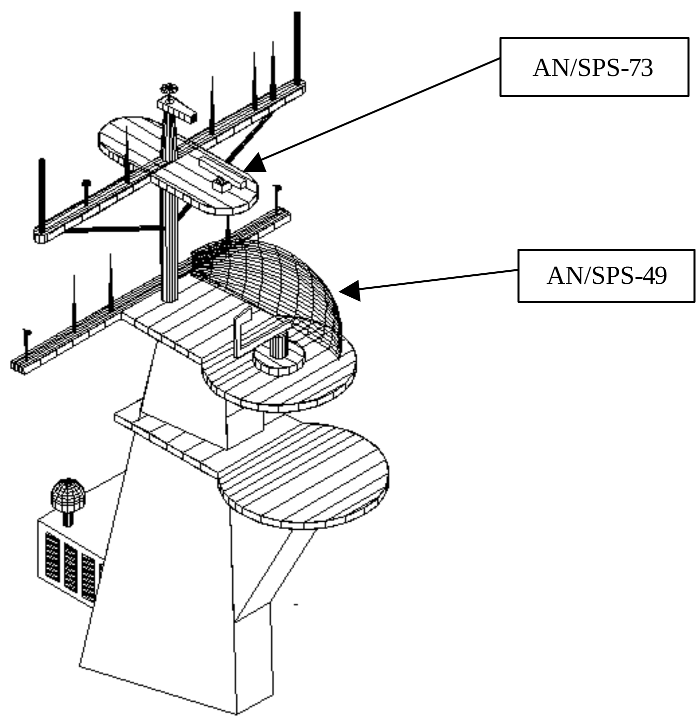


Figure 7- 2: Foremast.

The AN/SPS-48E is a long-range 3-D air search radar designed to provide plan position and height information on air targets out to 220 nm. It uses a combination of mechanical scanning and electronic beam steering to determine the targets position.

Parameters:

- Requires 112 kVA 440 Hz power
- E/F band (2 to 3 GHz)
- Antenna Dimensions: 194 x 228 in (including pedestal)
- Antenna weight: 5684 lbs (above deck), 24,018 (below deck)

The aft mast (Figure 7-3) is modified to support the SPS-48E. All the mast structure above the second platform is removed to make space for the radar. The SPS-48E is located on the second platform of the aft mast at frame 268, 88 ft above the waterline.

The SPQ-9B is a track-while-scan surface search and low altitude air search radar. Its primary use is target acquisition for SSDS Mk-2 and has a range of 20 nm and maximum ceiling of 2000 ft.

Parameters:

- X band
- Antenna Dimensions: 54.5 x 70.825 in (radome 120 x 96 in)
- Antenna weight: 1185 lbs (including radome)

The SPQ-9A was originally installed on the first platform of the forward mast of the O'BRIEN. The upgraded antenna is relocated to the first platform of the aft mast at frame 282. It is 73 ft above the waterline.

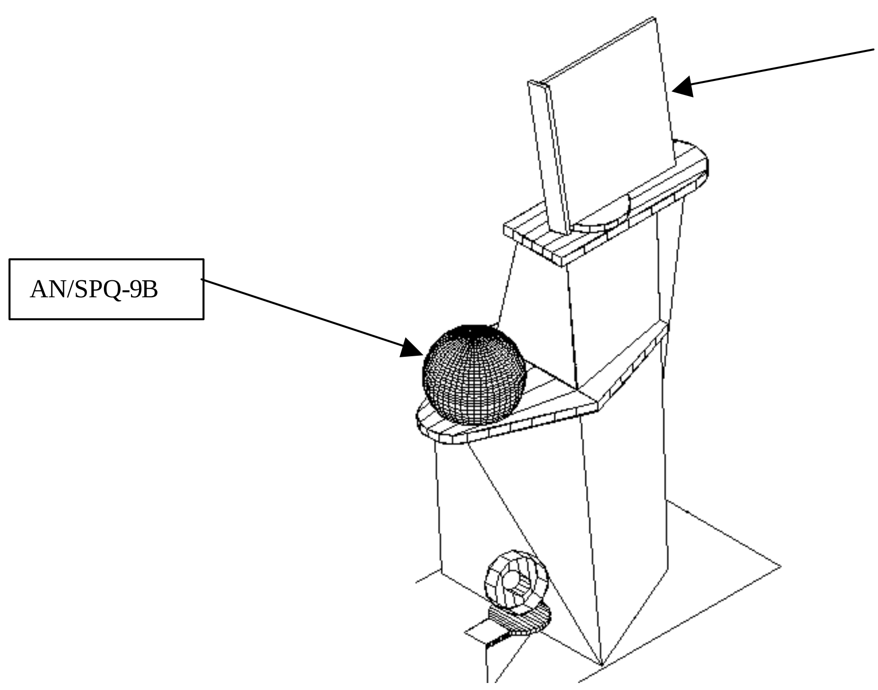


Figure 7- 3: Aft Mast.

A camera system mounted on a CIWS base is a SWTS unique item. This camera system has the same footprint as a CIWS mount; however, instead of a gun it accommodates several Infrared and visual cameras. This camera mount is boresighted to the CIWS Blk 1B so that it can follow incoming targets and record test data. The camera is mounted on a specially designed platform/enclosure on the flight deck. The camera mount will be removed from the SDTS and installed on the SWTS. The camera is located at frame 349 and is 62 ft above the waterline.

The platform that houses the CIWS and camera mount is a two-tiered version of a CIWS maintenance enclosure (Figure 7-4). The design uses sloped paneling to minimize the RCS contributions. The enclosure houses the two bases, providing an enclosed area to conduct maintenance. The platforms are on the starboard side of the former flight deck. The first tier is 23 ft above the deck and the second tier is 8 ft above the deck. Access to the enclosure is provided by a door in the forward portion of the platform, which opens to the starboard helicopter hangar.

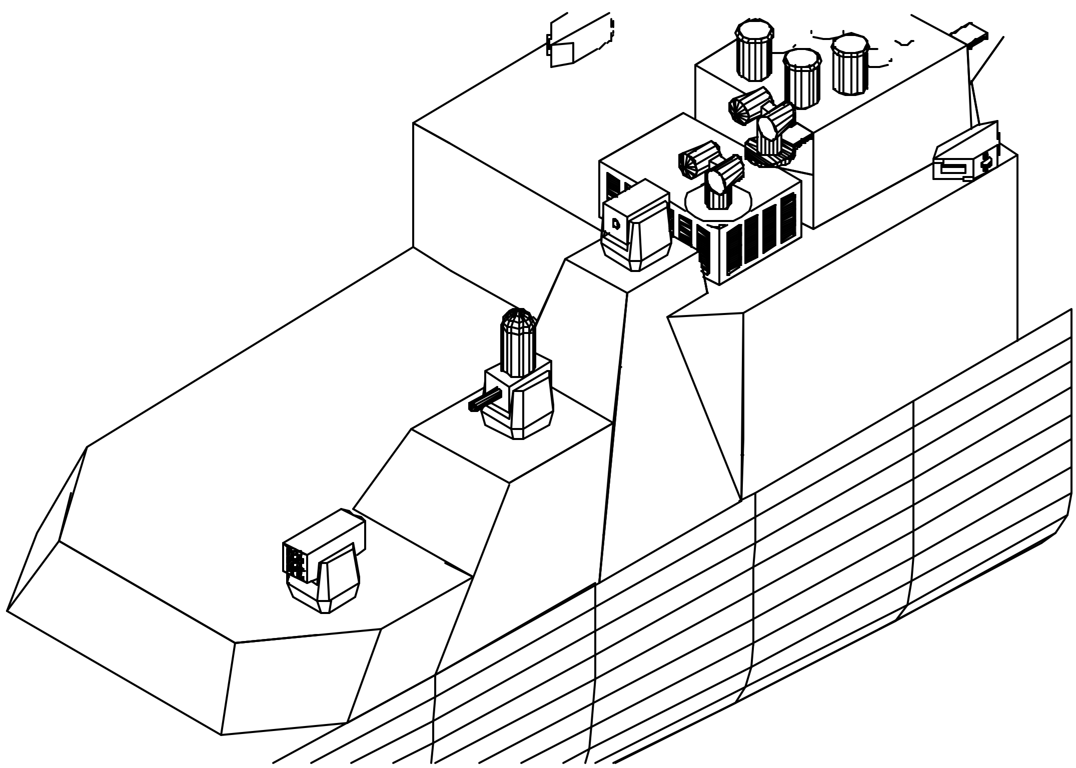


Figure 7- 4: Aft Weapons Platform on the Former Flight Deck.

The SLQ-32A (V)2 is the electronics warfare suite for SSDS. This system replaces the existing SLQ-32 (V)2 already installed on the USS O'BRIEN. The SLQ-32A is a new version that takes advantage of advances in architectural and processing technology. The antennas are located at frame 317 (port) and frame 302 (starboard), on the 04 level, 51 ft above the waterline.

1.9.2. Weapon Systems

The Rolling Airframe Missile (RAM) Block 1 is a lightweight, quick-reaction anti-ship missile system for close in defense. The system consists of the RIM-166A missile, the Mk 49 launcher, and a control panel. The missile is fire-and-forget and has two tracking modes: RF and IR. To assign a launcher, SSDS will pull track data from its sensors (SPS-48E and SPQ-9B) and provide the RAM system with a launch bearing. Once the track data is input to the system, the missile is fired and engages the target.

Parameters:

- Launcher dimensions: 9.8ft long x 4.9ft high x 3 ft wide
- System weight: 6LT (above deck), 2060 lbs (below deck)
- Arc of fire: 360° (limited by ship structure)
- Elevation: -25° to +80°
- Range: 5.17 nm

The Mk 49 launcher will be transferred from the SDTS and installed on the starboard edge of the aft flight deck, astern of the CIWS platform. Its location is at frame 400 and is 40 ft above the waterline.

CIWS Block 1B is the next generation of the Phalanx. The system is modified in several respects to integrate the system with SSDS and AEGIS. A surface engagement capability is added. A tunable, narrow-band filter is added to the search radar and a high-definition thermal imaging system is installed with an electro-optic video tracker.

Parameters:

- System weight: 12,000 lbs (above deck), 466 lbs (below deck)
- Arc of fire: 360° (limited by ship structure)
- Elevation: -25° to +80°
- Range: 6000 yds

The CIWS mounts 21 and 22 on the O'BRIEN are removed and the CIWS from the SDTS is transferred. The new mount is installed on the lower tier of the flight deck weapons platform at frame 368, 48 ft above the waterline.

The Mk 45 5"/54 is a single barrel automatic multi-purpose gun. On the SPRUANCE class, this mount is used for air and surface engagements as well as fire support for forces ashore. The USS O'BRIEN has two mounts; one on the forecastle and the other on the fantail. The forward mount was removed to make space for the flight deck and the aft gun mount was retained for future munitions testing and surface fire missions.

The SPRUANCE class has 64 Mk 41 VLS B/L III cells used for Tomahawks. In the future, the Evolved NATO Sea Sparrow Missile (ESSM) will be added to that inventory. The SWTS will be used to test self-defense weapons; so it will not require the capability to launch Standard Missile or Tomahawk. The SWTS does not require all 64 cells. Six of the 8 modules are laid up. The remaining 16 cells, System Module (A7) and Standard Module (A8) are converted to VLS B/L VII to fire ESSM. No changes are required for the ship services provided to VLS such as HVAC, electrical, water and air.

Evolved Seasparrow Missile (ESSM) is the next generation of self-defense missile system to be developed from the NATO Seasparrow Missile System. It uses a semi-active RF seeker with midcourse guidance. ESSM is designed to engage faster, lower, smaller and more maneuverable anti-ship cruise missiles. Improvements from the RIM-7M/P include higher speed (Mach 2.0), increased maneuverability (>30g), a new warhead, and a smaller radar cross section. One significant advantage is the extended range. ESSM triples the NSSM range to 24 nm, expanding the self-defense envelope of the ship. ESSM is packaged in quad-packs that are compatible with the Mk 41 VLS system.

The ESSM fire control system for SWTS is the Re-architectured NATO Seasparrow Missile System (RNSSMS). The RNSSMS is an upgrade to the standard NSSMS. It takes advantage of current technology by replacing the analog circuits with digital circuits and using fiber optics to connect each part of the system. The integration of ESSM with the RNSSMS is not completed and provisions will be required before ESSM can be tested from this platform.

1.9.3. Communications Suite

SWTS maintains three groups of antennas for the conduct of its test mission:

1) Voice and Data Communications: For normal underway operations and during periods of Battle Group Interoperability, SWTS mounts a reduced DD 963 comms suite that includes:
   a) 1 HF voice antenna

b) 4 VHF line-of-sight voice antennas
c) 2 UHF line-of-sight voice antennas
d) INMARSAT satellite voice antenna
e) UHF satellite voice and data antenna set
f) UHF satellite broadcast receiver antenna set
g) EHF satellite voice and data antenna (laid-up)

2) Data Links: Primarily employed to control SWTS during unmanned, remote operation at sea, the Ship Remote Control and Combat Systems Remote Control links are served by two antennas each for full azimuth coverage. This also includes the ship wide remote sensing system, TWARSES.
3) Navigation: Includes one SATNAV and two GPS satellite navigation receivers. The TACAN antenna for control of aircraft is also described.

Each antenna has the appropriate transceiver and antenna coupler retained. Most of these components are located in the Radio Transmitter Room on the 03 level.

Table 7-1 identifies the antenna groups with their designated locations aboard SWTS. The design endeavored to keep original DD 963 antennas in place to reduce conversion costs. Location changes are indicated in the table.

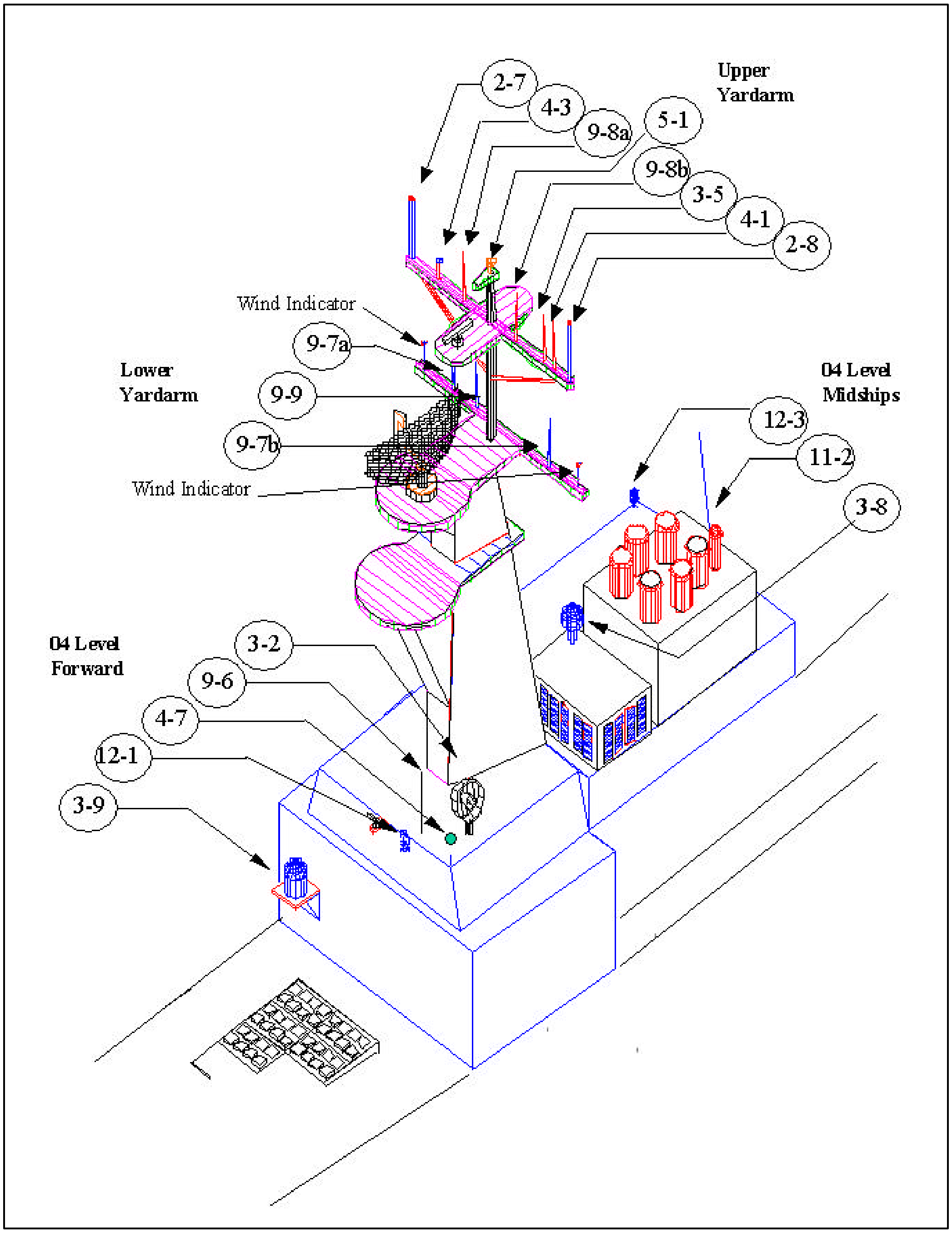
Figure 7-5 shows the antenna mounting arrangement for SWTS. Antenna numbers are cross-referenced to the table and maintain the original DD 963 antenna numbers except where indicated.

An EMI survey/analysis has not been conducted on this antenna arrangement, as discussed in Section 17.3.

ANT Note 1	NOMENCLATURE	DESIG	FREQ	DD-963 LOCATION	SWTS LOCATION
COMMUNICATIONS					
11-2	HF	NT-66047	2-30 MHz (T) 14-35MHz (R)	04 Level CL Fr 227	Same
2-7	UHF / VHF / IFF LINE-OF-SIGHT GROUP	AS-3020	225-400 MHz 30-76 MHz	Aft Mast Stbd Fr 271	Upper Yardarm Stbd Fr 168
2-8	UHF / VHF / IFF LINE-OF-SIGHT GROUP	AS-3020	225-400 MHz 30-76 MHz	Upper Yardarm Port Fr 168	Same
3-1	UHF SATCOM	AS-3018A WSC-1	240-318 MHz	Aft Corner Of Aft Stack	Fwd Corner Of Aft Stack
3-2	UHF SATCOM	AS-3018A WSC-1	240-318 MHz	04 Level Port Fr 151	Same
3-5	VHF	AS-2809	30-76 MHz	Upper Yardarm Port Fr 168	Same
9-6	VHF	NAW-300A	30-76 MHz	04 Level Port Fr 151	Same
3-8	INMARSAT	B16471-802	6 GHz (T) 1.5 GHz (R)	05 Level CL Fr 186	Same
12-1	UHF SATCOM BROADCAST RCVR	AS-2815 SSR-1	248-255 MHz	04 Level Port Fr 135	Same
12-3	UHF SATCOM BROADCAST RCVR	AS-2815 SSR-1	246-255 MHz	04 Level Stbd Fr 227	Same
3-9	EHF SATCOM (*In Lay-Up*)	AN/USC-38	44000 MHz(T) 20000MHz(R)	01 Level Stbd Fr 130	Same
DATA LINKS					
9-7a*	SHIP REMOTE CONTOL DATA-LINK	N/A	902-928 MHz	N/A	Lower Yardarm Stbd Fr 168
9-7b*	SHIP REMOTE CONTOL DATA-LINK	N/A	902-928 MHz	N/A	Lower Yardarm Port Fr 168
9-8a*	CS REMOTE CONTROL DATA-LINK	N/A		N/A	Upper Yardarm Stbd Fr 168
9-8b*	CS REMOTE CONTROL DATA-LINK	N/A		N/A	Upper Yardarm Port Fr 168
9-9*	TWARSES	N/A		N/A	Lower Yardarm Stbd Fr 168
NAVIGATION					
4-1	SATNAV	WRN-5	150 MHz 400 MHz	Upper Yardarm Port Fr 168	Same
4-3	GPS #1	AS-3819	1227 MHz 1575 MHz	Upper Yardarm Stbd Fr 168	Same
4-7*	GPS #2	NAV 6510	1227 MHz 1575 MHz	N/A	04 Level Stbd Fr 148
5-1	TACAN	URN-25	962-1024 (T) 1151-1213 (T) 1025-1150 (R) MHz	Aft Mast Top Fr 271	Fwd Mast Top Fr 168

Notes: 1) Antenna numbers are from DD 963 Table of Antennas, except for “*” numbers which are new antennas.

Table 7- 1: SWTS Communications Suite.



Upper Yardarm
2-7
4-3
9-8a
5-1
9-8b
3-5
4-1
2-8
Wind Indicator
9-7a
Lower Yardarm
9-9
9-7b
Wind Indicator
04 Level Midships
12-3
11-2
3-8
04 Level Forward
3-2
9-6
4-7
12-1
3-9

5.2. Systems Not Accommodated

All systems required by the Operational Requirements Document (ORD) have been successfully accommodated. Two systems identified as possible future payloads, the High Energy Laser (HEL) and the Multi-Function Radar (MFR), may provide challenges in terms of electrical power and space accommodation, however, hard data is not available at this time.

2.1.1. Fields of View

A detailed study of the fields of view and firing arcs for each system shows that all systems are clear from beam to beam. The AUTOCAD solid model of the SWTS is ray traced to produce Field of View diagrams. Figure 7- 6 is a sample Mercator coverage diagram showing the blockage of equipment and structures. Appendix I contains Field of View Diagrams for all weapons and sensors.

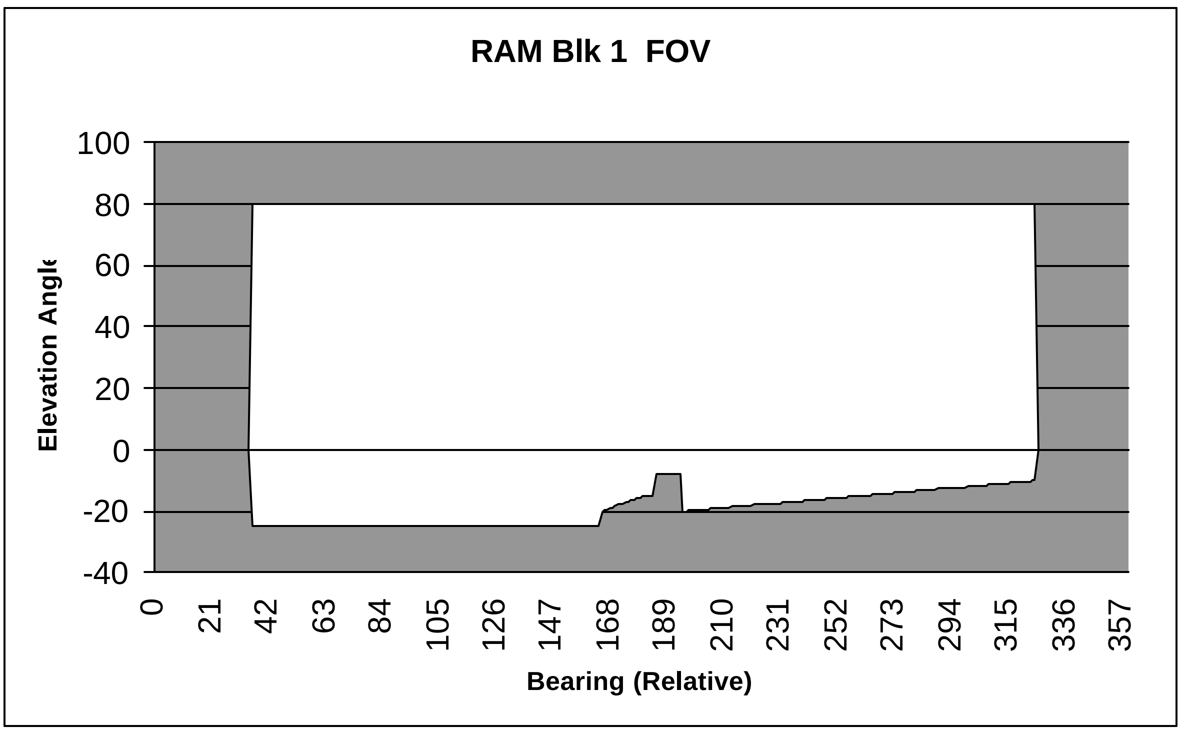


Figure 7- 6: Typical Field of View Diagram.

5.2. Internal Arrangements

A design philosophy for internal arrangement was set as follows:

a) Retain required-function spaces in an unmodified state to reduce conversion costs.
b) Spaces with a function no longer required with a large amount of equipment are laid-up and locked.
c) Spaces with a function no longer required with a small amount of equipment are stripped and identified as expansion spaces.
d) Similar function spaces are grouped together whenever possible.
e) Support equipment spaces are placed as near as possible to supported equipment.
f) Data Collection Rooms are placed throughout the ship to support testing of various systems and processes.
g) Personnel, stores, and equipment movement are minimized.
h) Laborsaving devices are retained where beneficial in supporting minimum manning.

5.3. Command and Control Spaces

The primary control space for ship operations, combat systems employment, and test coordination is the Combat Information Center (Section 5.8.5.1). Ship piloting, at-sea routine and helicopter control are conducted from the bridge (Section 5.8.5.2). Engineering and damage control are conducted from the Central Control Station (Section 9.2). Table 7-2 identifies SWTS command and control spaces:

Space	Compt Num.	Modifications (summary)	Former Function
CIC	02-139-0-C	Remove OJ consoles Lay-up TWCS, GFCS Add SSDS consoles Add Test Coord Area	Same
Bridge	03-140-0-C	Add TWARSES, SRCS Add Furuno radar display Lay-up OJ console Add 4 life rafts on wings	Same
Central Control Station	2-272-0-C	Add TWARSES Add SRCS	Same

Table 7- 2: Command and Control Spaces.

5.4. Combat System Sensor and Weapon Equipment Spaces

Large spaces no longer needed for the SWTS mission are converted to support the larger array of sensors to be fitted. The following table identifies SWTS sensor and weapon support spaces:

Space	Compt Num.	Modifications (summary)	Former Function
EW Cooling Equip Rm	04-292-2-Q	Add cooling equipment	TAS Fan Room
EW Local Control Equip Rm	04-292-1-Q	Add (V)3 capability	Same
Mk 91 NSSMS Director #2 Equip Rm	03-284-2-Q	Add equipment ESSM Mod	TAS Equip Room

Mk 91 NSSMS Director #1 Equip Rm	03-324-01-Q	ESSM Mod	Same
SPS-48E Radar Equip Rm #1	03-188-01-Q	Add equipment	Ship's classroom
SPS-48E Radar Equip Rm #2	03-212-0-Q	Add equipment	EW Workshop
Radar Room #1	03-154-02-Q	Remove SPG-60, SPS-55 equip Add SPQ-9B, Furuno equip	Same
CIWS and Camera Equip Rm	03-346-1-Q	New structure	N/A
Electronics Repair Shop	02-178-1-Q	N/A	Same
Message Processing Center	02-188-01-C	Remove unneeded radio equipment Add CSRCS Elect Rack Add Camera Control Elect Racks	Same
Radio Transmitter Rm	02-220-01-C	Remove unneeded radio equipment	Same
TACAN Equip Rm	02-220-4-Q	N/A	Same
SPS-49A Radar Equip Rm #1	02-247-0-Q	Remove SPS-40 equipment Add SPS-49A equipment	SPS-40 Radar Equip Room
SPS-49A Radar Equip Rm #2	02-260-0-Q	Remove stowage racks Add SPS-49A equipment	Aviation Storeroom
SPS-49A Cooling Equip Rm	02-267-2-Q	Add cooling equipment	Helo Det office
CIWS Magazine	02-281-2-M	N/A	Torpedo Magazine
Weapons Maintenance Rm	02-276-0-Q	N/A	Helo Repair Shop
RAM Maintenance Locker	02-346-1-Q	New structure	N/A
CIWS Maintenance Locker	02-366-1-Q	New structure	N/A
Data Processing Center	01-138-0-C	N/A	Same
Elect CW Equip Room	01-206-01-Q	N/A	Same
Main Magazine	01-398-0-M	N/A	NSSMS magazine
RAM Equipment Room	01-398-1-A w/ UNREP Sta	Remove UNREP station bulkhead Add RAM equipment	UNREP Gear Locker UNREP Station
Mk 41 VLS	1-94-0-Q	Lay-up 6 of 8 modules	Same
MK 41 Support Equip Rm	1-130-0-Q	N/A	Same
Gyro Room #1	2-128-0-Q	N/A	Same
IC/Gyro Room #1	3-128-0-Q	N/A	Same
IC/Gyro Room #2	3-382-0-Q	N/A	Same

Table 7- 3: Sensor/Weapon Support Spaces.

5.5. Test Support Spaces

Test support spaces directly contribute to the conduct and evaluation of any test performed by the SWTS. Primary control and coordination of tests is carried out in CIC. Data Collection Rooms (DCRs) are outfitted with work tables and chairs, ample electrical outlets, cable tubes to adjacent spaces, and atmospheric controls. These rooms will allow Navy and industry technicians to effectively acquire test data without interfering with equipment or personnel processes. The layout of the Special Projects Space is described in Section 5.8.5.1. The following table identifies SWTS test support spaces:

Space	Compt Num	Modifications (summary)	Former Function
Data Collection Rm #1	03-291-0-C	Add DCR mods	Bosun Office
Data Collection Rm #2	02-174-1-C	Add DCR mods	CIC Admin
Test Control and Coordination Area	02-139-0-C	Add Test Director position Add Test Coord Console	CIC

(within CIC)		Add Camera Control Console	
Special Projects Rm	02-139-2-C	See Section 7.3	Sonar Control
Data Collection Rm #3	01-178-1-Q	Add DCR mods	Elect Repair Shop
Conference Room	01-265-0-C	Add chairs Add display system Add computer work desks	Wardroom
Data Collection Rm #4	01-382-0-Q	Remove RAST equipment Add DCR mods	RAST Equipment Rm
Data Collection Rm #5	2-464-2-Q	Add DCR mods	Small Arms locker
Engineering Data Collection Rm	2-261-1-Q	Add DCR mods	Supply Office

Table 7- 4: Test Support Spaces.

5.6. Expansion Spaces

The voluminous hull and superstructure of the DD 963 design provides many expansion opportunities for future installations. The following spaces are no longer needed for the SWTS mission and are set aside for future use as equipment installation spaces, test support spaces, or ship support spaces to be determined at a future date:

Former Space Name	Compt Num	Description	Modifications (summary)
ECM Room	03-220-2-Q	10’x20’ room	Lay up and lock
ASMD Launcher Spt Rm	03-292-1-A	8’x8’ room	Strip
Decon Station	01-188-4-L	8’x6’ space	N/A
UNREP Gear Locker	01-232-2-A	8’x8’ storeroom	N/A
Fire Gear locker	01-228-4-A	3’x8’ storeroom	N/A
Port side Quarterdeck	Fr264 – Fr 290	26’x10’ weather deck area	N/A
NSSMS Launcher Control	01-393-2-C	20’x10’ room	Lay up and lock
Missile Deck Area	Fr 426 – Fr 464	38’x20’ weather deck area	N/A
Ship’s Store	1-174-1-A	17’x16’ room	Lay up and lock
CCC and CMC Offices	1-196-1-L	20’x12’ room	N/A
PO1 lounge	1-204-1-L	15’x8’ room	Strip
Port Torpedo Room	1-390-2-M	30’x15’ space	Strip
GTG3 Waste Heat Boiler Rm	1-426-0-Q	15’x10’ space	Lay up and lock
Special Clothing Strm	2-426-0-A	6’x24’ storeroom	N/A
Bosun Strm #3	1-434-0-A	15’x24’ storeroom	N/A
Launcher Equip Rm	1-440-2-A	6’x15’ space	Strip
Inert Gas Strm #1	1-449-1-A	8’x19’ storeroom	Strip
Hobby Shop	2-220-5-Q	8’x12’ space	Lay up and lock
Laundry	2-382-0-Q	32’x24’ space	Lay up and lock
Flam Liquid Strm #1	2-491-1-K	6’x6’ storeroom	Lay up and lock
Storeroom	2-464-01-A	6’x15’ storeroom	N/A
Physical Fitness Rm	2-436-0-G	28’x24’ space	N/A
Armory	2-479-2-Q	15’x6’ space	Lay up and lock
Storeroom	3-426-0-Q	28’x24’ storeroom	N/A
CBR Strm	6-464-4-A	10’x10’ storeroom	N/A
Landing Force Equip Strm	6-482-2-A	20’x10’ storeroom	N/A

Table 7- 5: Expansion Spaces.

5.7. Ship Support Spaces

General ship support-type spaces are retained where needed to support the SWTS mission. The following table identifies retained ship support spaces:

Space Name	Compt Num	Modifications (summary)	Former Function
Quarter Deck	01-236-01-L	N/A	Same
Rider Lounge	01-270-0-L	N/A	Wardroom lounge
Windlass Room	1-0-0-E	N/A	Same
Combat Systems Office	1-138-1-Q	N/A	Weapons Dept Office
Test Directors Office	1-138-2-Q	N/A	Ships Office
Ships Admin Office	1-154-1-Q	N/A	Dispersing Office
Deck Dept Office	1-162-1-Q	N/A	Operations Dept Office
Tech Library	1-159-0-Q	N/A	Same
Crew lounge	1-248-1-L 1-260-1-L	N/A	CPO Lounge CPO Mess
Medical treatment Room	1-382-0-L	N/A	Same
Sickbay	1-398-0-L	N/A	Same
Medical Strm	1-406-0-A	N/A	Same
Stewards Linen Locker	1-412-0-Q	Remove barber equipment	Barber shop
Laundry	1-390-1-M	Remove torpedo gear Add commercial washers/dryers Add folding tables Add ironing equipment	Stbd Torpedo Room
Enclosed Accommodation Ladder	1-382-3-Q 2-382-5-A 3-382-1-Q	See Section 11.2	Fan room Store room Filter Cleaning shop
Paint Mix and Issue	1-457-0-K	N/A	Same
Inert gas Storeroom	1-460-1-A	N/A	Same
Rider Office Complex	2-149-0-L	Remove racks and lockers Add 18 desks and lockers	Crew Berthing
Engineering Dept Office	2-260-0-Q	N/A	Same
Machine and welding Shop	2-387-01-Q	N/A	Same
Hull Workshop	2-414-0-Q	N/A	Same
Tool Issue	2-394-2-Q	N/A	Same
Electrical Work shop	2-404-2-Q	N/A	Same
Flam Liquids Strm #1	2-491-1-Q	N/A	Same
Line Locker	2-506-3-A	N/A	Same
Line Locker	2-506-2-Q	Remove bathy equipment Add mooring line reels	Bathy Equip Room
Supply Office	3-283-0-Q	N/A	Supply Support Center
Supply Storeroom #1	3-260-01-A	N/A	Same
Supply Storeroom #2	3-283-2-A	N/A	Same
Engineering Storeroom	3-382-2-A	N/A	Supply Dept storeroom
Mooring Line Storeroom	6-488-1-A	N/A	Same

Table 7- 6: Ship Support Spaces.

5.8. Spaces Placed in Lay-Up

Spaces not needed to support the SWTS mission are placed in lay-up and secured (locked). The following table identifies spaces placed in lay-up:

Space Name	Compt Number
Signal Shack	04-162-0-C
Landing Control Station	03-332-2-Q
RAST tracks	Former flight deck
Wardroom Pantry	01-260-0-L
Sonar Equipment Room #1	1-28-01-Q

MT 51 Loader Drum Room	1-58-01-M
Elevator Machinery Room	1-82-1-Q
Decon Station #1	1-434-2-L
Fwd Ammo Elevator	3-82-0-T
Torpedo Elevator	Fr 418
Aft Ammo Elevator	3-464-0-T
Sonar Equipment Room #2	2-28-01-Q
Fwd Ammo Pallet Staging	2-58-01-Q
Entertainment Equipment Rm	2-236-1-A
Main Engine Room #2	5-300-0-E
Trash Compactor Room	2-382-4-Q
Aft Ammo Pallet Staging	2-464-01-A
MT 52 Loader Drum Room	2-482-0-M
Sonar Equipment Room #3	3-28-01-Q
MT 51 Projectile Magazine	3-62-01-M
MT 51 Powder Magazine	3-76-1-M 3-76-2-M
Crew Berthing	3-146-0-L
Dry Cleaning Plant	3-394-1-Q
Small Arms Magazine	3-437-2-M
Aft Ammo Pallet Staging	3-464-01-Q
CPRSR Room	6-464-3-Q
Flam Liquids Strm #2	3-476-1-K
MT 52 Projectile Magazine	3-482-0-M
MT 52 Powder Magazine	3-494-0-M

Table 7- 7: Spaces Placed in Lay-Up.

5.1. CIC Layout

The SWTS Combat Information Center is the nerve center for sensor and weapon employment and test control. Figure 7-7 lays out of the new SWTS CIC. Initially, the primary system to be tested is the SSDS Mk2. The SSDS console in development, with positions for the TAO and two operators, is fitted in front of two rear-projection large screen displays (LSDs). Behind the SSDS console is the test control group consisting of the test director's position, a comms console for two test control/coordination personnel and the remote camera control console. Other changes to the original O'BRIEN CIC include:

a) Addition of CIWS Block 1B console.
b) Rearchitectured NSSMS consoles (from ex-DECATUR).
c) Removal of several operations consoles including the MT 51 gun console. MT 52 Console and Gun Control Console (GCC) are laid-up.
d) Lay-up of the Tomahawk Weapon Control System.
e) Lay-up of one of four OJ-type tracker consoles.
f) CIC Admin is converted to Data Collection Room #2 to support monitoring/testing of equipment and events in CIC.

Special Projects Room: This space will support high-level classified tests and data acquisition. To support this mission, a SCIF-type space is arranged with the necessary security features, including a vault. Optimally located adjacent to CIC, the former Sonar Control space is stripped of all console and sonar related equipment. Room for Special Project equipment is provided to port and a table for workstations is provided to starboard. A classified planning/briefing table is included. This space is an extended form of the Data Collection Rooms found through out the SWTS.

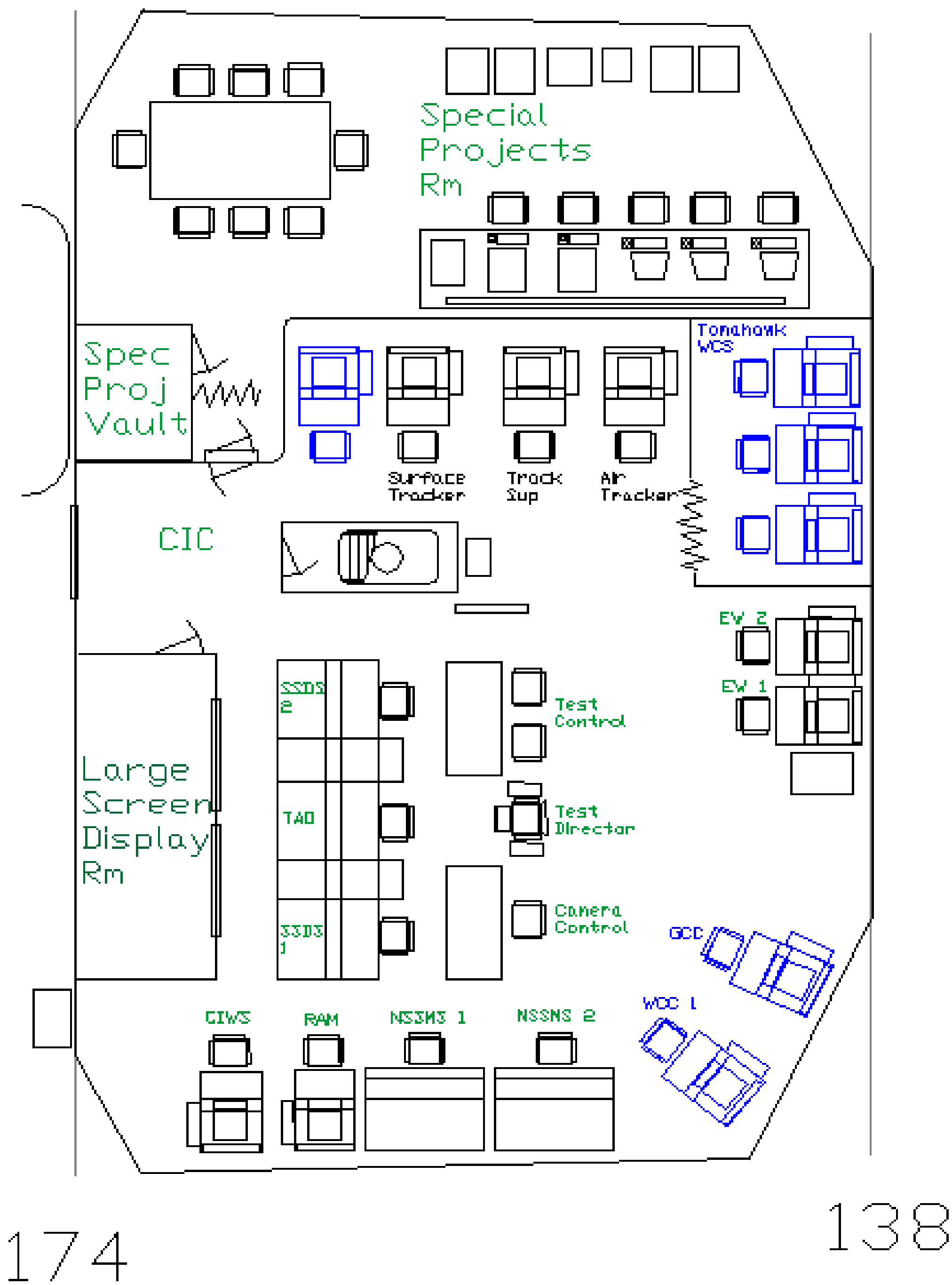


Figure 7- 7: Combat Information Center Layout.

5.2. Bridge Layout

The majority of the SWTS bridge layout and equipment is retained with the following additions:

a) The Ship Remote Control Console is added at the aft bulkhead.
b) The TWARSES Monitoring Panel is mounted on the aft bulkhead.
c) A Furuno radar display console is added next to the chart table.
d) The OJ-194 console is laid-up.
e) The bridge wing bulkheads are extended completely around the wings for RCS reduction.
f) Two 30-person life rafts are mounted on each bridge wing.
g) Additional VHF comms for flight operations control are added.
h) Lighting control panel for helicopter deck is mounted on the aft bulkhead.

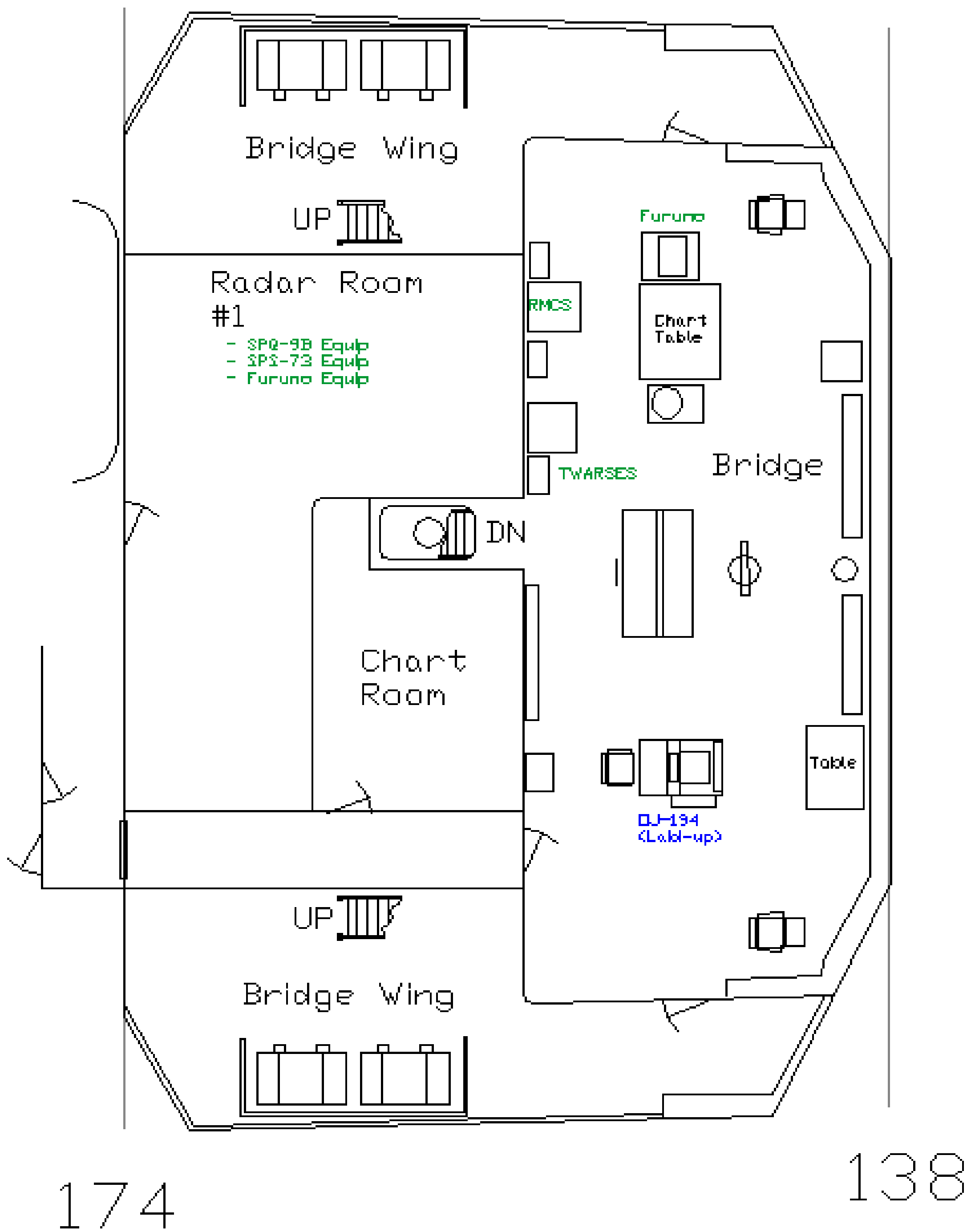


Figure 7- 8: Bridge Layout.

5.9.Ship's Remote Control System

During unmanned operations, two remote control systems control and monitor SWTS. The Combat Systems Remote Control System (CSRCS) controls the combat system weapons and sensors. The Ship's Remote Control System (SRCS) controls all remaining aspects of the ship. As described in Section 2.3, NAWC at NAS Point Mugu controls SWTS while the ship is on the range. The specific functions that must be controlled and monitored are navigation, damage control, and engineering. Two major evolutions occur while the SWTS is unmanned: flight operations for personnel transfer and the test event. The SRCS must provide control during these operations. The system also provides a "Kill Switch" designed to shut down the GTGs in the event of an emergency. The ship will go dead in the water. Remote monitoring can still be performed via TWARSES and SRCS.

The Surface Targets Division at NAWC installs and maintains the SRCS. The system presently in use on the SDTS is the analog Integrated Target Control System (ITCS). A workstation on the bridge controls the functions of the ship and interfaces with the operators via an RF data link. Controller Area Networks (CANs) integrate and control the ship's systems. Although the ITCS has not been installed on any system as complex as the O'BRIEN, the system is modular and can be scaled for use on the SWTS. It will be digital to allow testing on any range.

The installed ITCS network is shown in Figure 7.9. CAN's are shown as square boxes, receivers and transceivers are shown as octagons, antennae are shown as triangles (apex down), and the central workstation is shown as a heavy box in the center of the diagram. The first line shows the location by space and console. The following lines show the parameter that is controlled or monitored. A control function is denoted by "+" while a monitored parameter is denoted by "-"

The central workstation is a standard Industrial PC that is installed on the bridge as shown in Figure 7-8. The workstation has two way communications with Point Mugu via a digital RF data link. Three link options exist for the SWTS application. The most likely arrangement is two 4-foot whip antennas operating at 902 MHz.

The CAN nodes are 11"x4"x4". CAN's are installed on the following equipment:

- A CAN on the GPS receiver provides ship's position information.

- A CAN on the Ship's Control Console on the bridge provides course and speed information. It also controls the throttle settings and the rudder position.
- A CAN on the Anemometer provides wind direction and speed information crucial for flight operations.
- A CAN on the Firemain Control Panel on the Damage Control Console in CCS provides data on the firemain pressure and firepump discharge pressures.
- A CAN on the Electric Plant Control Console in CCS monitors the GTG loading and will provide a "Kill Switch" to secure electric power to the ship.
- In CCS, the Propulsion and Auxiliary Machinery Information System Equipment (PAMISE) is one component of the Propulsion and Auxiliaries Control Console (see Section 9). On the PAMISE, the Central Information System Equipment (CISE) houses three Signal Conditioning Equipment components (S/CE). These three S/CE convert sensory data from throughout the engineering plant into analog data, monitor for alarm conditions, and provide meter signals[iv]. A CAN on each of the S/CE's taps these monitored signals and transmit the data to the ITCS workstation.
- A control element activates HALON and AFFF bilge sprinkling systems. Four HALON systems exist: MER1, MER2, AMR1, and AMR2. Six AFFF bilge sprinkling systems exist: MER1, MER2, AMR1, AMR2, 3GTG, and the JP-5 pump room. The systems are plunger activated. A total of ten control elements are required.

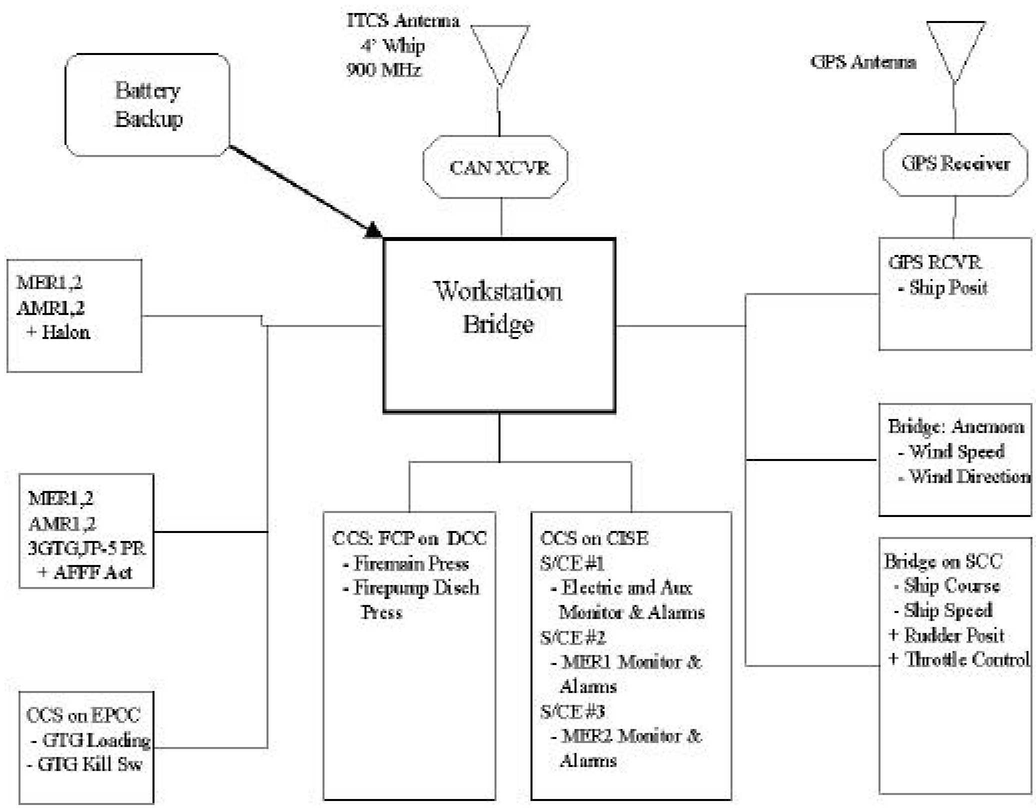


Figure 7- 9: Ships Remote Control System Internal Interfaces.

The CPU on the bridge records all of the data that SRCS receives in a digital "Session Log." Any of this data may be selected for transmission on the data link, but to maintain the speed of the SRCS datalink, most data is sent on request. Alarms and warning information are always sent as soon as SRCS receives the signal. Vital data such as ships position, course and speed, and rudder position are also continuously transmitted.

A battery backup for the remote control system is installed to provide four hours of uninterrupted power (ITCS UPS) for the workstation, GPS receiver, and ITCS Transceiver. Four hours provides ample time for emergency response personnel to arrive on the ship, conduct initial damage control, and restore the ship to manned operations. The Uninterrupted Power Supply in CCS provides power to the EPCC and PACC. These consoles can monitor and control the engineering spaces. TWARSES has a battery backup that continues to supply damage control information to the ITCS. The ITCS UPS enables the engineering plant, damage control, and ship's position information to the ship's controllers. This information will be crucial for the emergency response personnel.

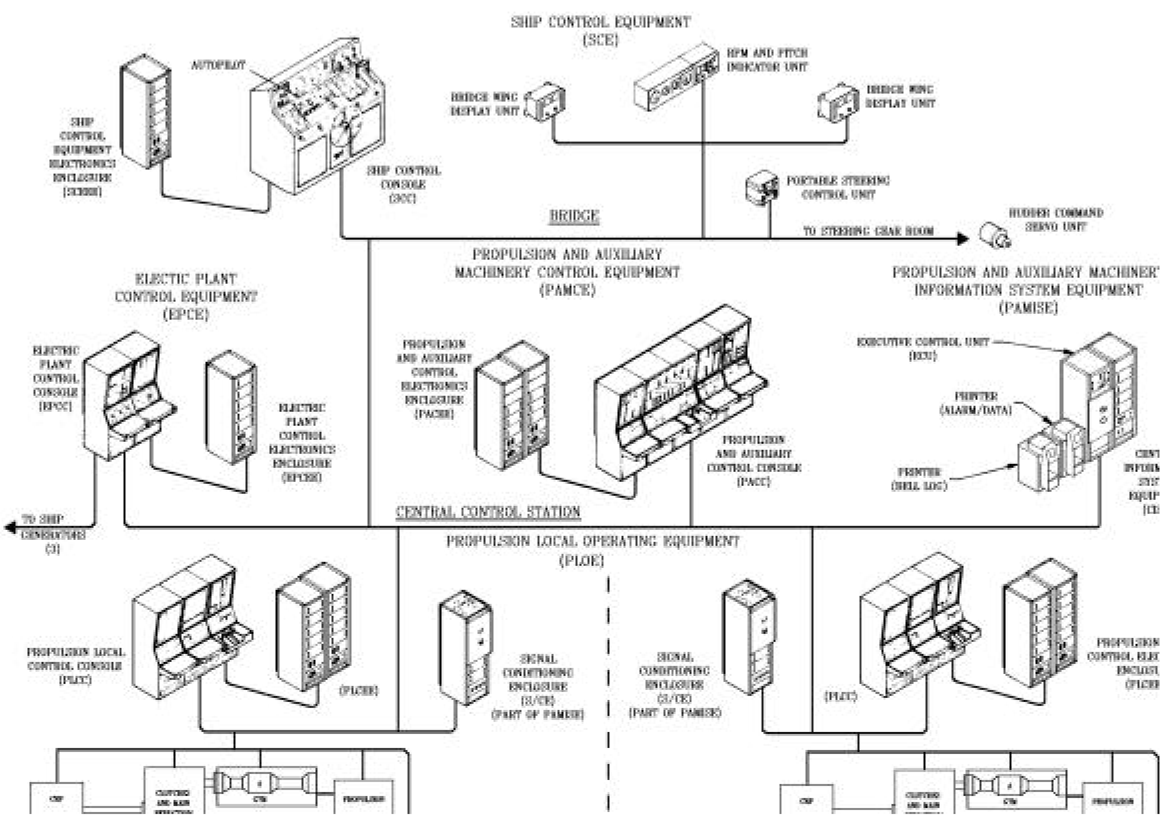


Figure 7- 10: Ship Control Equipment.

5.1. Combat Systems Remote Control System

SWTS remote live-fire testing is possible only using the Combat Systems Remote Control System (CSRCS). This digital data-link system allows control of sensors, weapons, and the Combat Direction System by personnel operating consoles from the safety of a shore-side facility.

The CSRCS electronics racks are located in the Message Processing Center, aft of CIC. The system is aligned for remote operation at a console located adjacent to the Test Control Station in CIC, in coordination with the Camera Control console operator.

Data-link connectivity is maintained by two dipole antennas located on the upper yardarm of the forward mast for 360-degree coverage. Transmission is received by the San Nicolas Island Control Relay and sent by fiber-optic cable through Pt Mugu to the SWTS remote CIC at Surface Weapons Engineering Facility (SWEF) (Figure 7- 11).

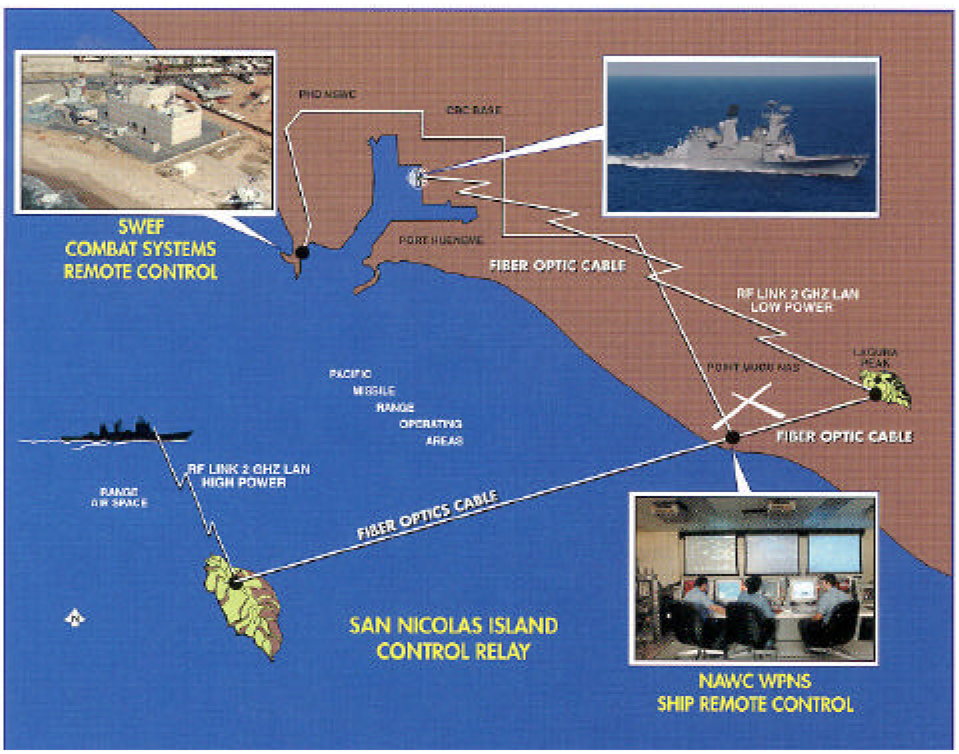


Figure 7- 11: Combat Systems Remote Control System.

5.2. Camera Plan

Cameras are an essential part of the data collection portion of any test. They are used to monitor control panels, weapon mounts and other systems and record test data. All the cameras are tied into a single network. The network is a part of the Combat Systems Remote Control System. Each shore operator is able to monitor the weapon to ensure it is aimed in the correct direction and operating properly.

9.2.1. Camera Locations

Cameras are located throughout the ship. One set is placed in the engineering plants during remote operation. These cameras augment the TWARSES for damage control and allow the shore team to monitor any unusual conditions that may arise in the engineering plant. An example of placements for these cameras is in CCS to monitor the ships control panels.

A second set of cameras monitors the combat systems. A camera is located at each local and remote combat system control panel. These cameras have a full view of the control panel so the shore operator is certain that his input is received and expected action takes place. The shore operator is able to quickly shift between views to verify that the local and remote panels agree.

The third set of cameras is located topside. Each weapon mount and weapon director has a camera aimed at it. These views allow the shore operators to verify that the weapon or director is aimed in the direction of the target.

The final set of cameras is used to collect external test data. Cameras are mounted topside to give a complete view of the aft portion of the ship and the target barge. These cameras provide the overall picture of the test from several different angles. One bank of cameras is trainable. They are referred to as the Camera mount. The Camera Mount is a CIWS Mount that has the gun and radar dome removed and a platform added that can accommodate multiple cameras. The platform movement is slaved to the motion of the CIWS. This gives a unique view of the test. The camera will be focused on the inbound missile and provide visual hit and subsequent target dynamics data to evaluate the test.

9.2.2. Camera Control

The Camera Control Console, located next to the Test Director's position in CIC, controls all combat systems-related cameras. Cameras are set up for remote operation and recording from this console. The actual camera electronics racks are located just aft of CIC in the Message Processing Center, adjacent to the Combat Systems Remote Control System.

5.3. Battle Group Interoperability

The SWTS retains the communications capability of a DD 963 class destroyer but with reduced redundancy (see Section 7.1.3). The communications suite gives the SWTS a Link 11 NTDS capability for operations in a Battle Group environment. UHF SATCOM voice, data and broadcast is retained while EHF SATCOM is placed in a laid-up status. Cooperative Engagement Capability (CEC) is not required for the mission of the SWTS; however, the space, weight and power required for basic CEC are available to support future installation.

5.10. Combat Systems Placed in Lay-up

Several of O'BRIEN's original combat systems have been placed in lay-up. These systems are available for activation if required by a test.

- Tomahawk Weapon Control System: TWCS has one Engagement Planner Console removed. The remaining EP console and two Launch Control Consoles are available for activation to test TWCS.
- SRBOC: This system could be activated as is or converted to NULKA for SSDS Mk 2 Mod 2 testing.
- SQS-53B: This system is intact except the Nixie and Towed Array are removed and the Sonar Consoles are removed. A local control console network would have to be provided.
- 5 inch Gun: The aft 5 inch gun remains with the Weapons Control Console and one Gun Control Console.
- Vertical Launch System: The remaining six modules with 45 cells and the crane are available for reactivation.

- RAST: The Recovery, Assist, Secure and Traverse system remains and could be used to transport classified systems (Directed Energy) to and from the hangar during tests to keep the system out of sight.

[ii] Friedman, Norman. World Naval Weapon Systems. The Naval Institute Press. Annapolis, MD. 1989.

[iii] Jane's Weapon Systems 1988-89. Jane's Information Group, Inc. Alexandria VA. 1988.

[iv] DD963 Propulsion Plant Manual.