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A Regional Deterrence Ship Design

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13. ABSTRACT *(Maximum 200 words)*

A systems engineering approach to the development of a warship optimized for the deterrence of regional conflicts in littoral waters is presented, followed by a description of the preliminary design of the ship shown by analysis to be most effective. The requirement for the project reported was to develop a ship which would be effective in deterring regional wars among third world nations; in hampering the military effectiveness of the aggressor should deterrence fail and in protecting or evacuating limited numbers of civilians. The study reports on an analysis of likely threat weapons, on the means used to choose defensive combat system capabilities to defeat such weapons and on the selection of capabilities necessary for successful operation in littoral waters. Major emphasis is placed on measures intended to significantly improve the ship's survivability relative to existing combatants. The design description includes data and numerous drawings.

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A Regional Deterrence Ship, RDS 2010

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 Prof. C. N. Calvano. (The officer students who comprised the design team were: LCDR Dwight Alexander, LCDR Dean Cottle, LT Kent Ketell and LT Jeff Riedel, all USN.)

ABSTRACT

A tentative operational requirement was given to the development team, calling for analysis and design of a ship which would be highly effective, through presence-projection, at operating in littoral waters to deter regional conflicts between third world nations and at hampering the military operations of the aggressor nation in the event the deterrent effort failed. The ship was also required to have significant capability to support the evacuation of friendly personnel; to be fully capable to be operationally integrated into a battle group; to support limited amphibious operations (conducted from other ships) and to have robust self-defense (but not area defense) capabilities. Because the ship would be operating in a high-tension area, it is likely to be fired upon from a peacetime footing and, therefore, was required to have significant vulnerability reduction features.

The report documents the identification of threat weapon characteristics and the analysis of four possible threat attack scenarios. For each scenario, the team required that the RDS 2010 be capable of achieving a kill probability in excess of .99 against all assumed threat weapon combinations. The report describes the analyses conducted and the combat systems suite selected to be incorporated in the ship.

Minimization of the likelihood and numbers of crew casualties was a high priority design guideline and the report discusses the various design alternatives considered to reduce the ship's vulnerability to threat weapons. A double hull was incorporated, providing significant reserve buoyancy, a measure of additional standoff distance against warhead detonations and providing the necessary volume for incorporation of yet-to-be-defined measures for defeating warhead effects. Considerable care was given to the arrangements of combat capabilities in *enclaves* to reduce the likelihood of loss of multiple capabilities from a single hit.

A complete description of the ship resulting after the first iteration of preliminary design is provided and considerable detail in the description of the ship is provided in appendices.

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I. INTRODUCTION

This paper is the final report for the Total Ship Systems Engineering (TSSE) student design project for the TSSE class of 1993. This report represents the compilation of all work performed over a two quarter period from October 1992 through March 1993. The various assignments and design products created have been integrated into this one design report to provide a detailed and comprehensive record of the work completed.

The design of the Regional Deterrence Ship (RDS) 2010 (formerly known as the Force Projection Ship (FPS) 2010) included all facets of a real design, though some detail had to be omitted in the interest of time and resource constraints. Overall, the project included the following major design phases:

(1) Requirements Setting
(2) Threat Environment and Analysis
(3) Combat System Definition
(4) Hull, Mechanical, and Electrical Feasibility Tradeoff Studies
(5) Preliminary Design and Cost Analysis
(6) Design Evaluation

The chapters of this report will include salient results of these design phases and other relevant material.

Figure 1-1 illustrates the timeline of the major evolutions which occured during the two quarter design effort. Appendix A contains the design history which chronicles the major design decisions associated with the various design phases.

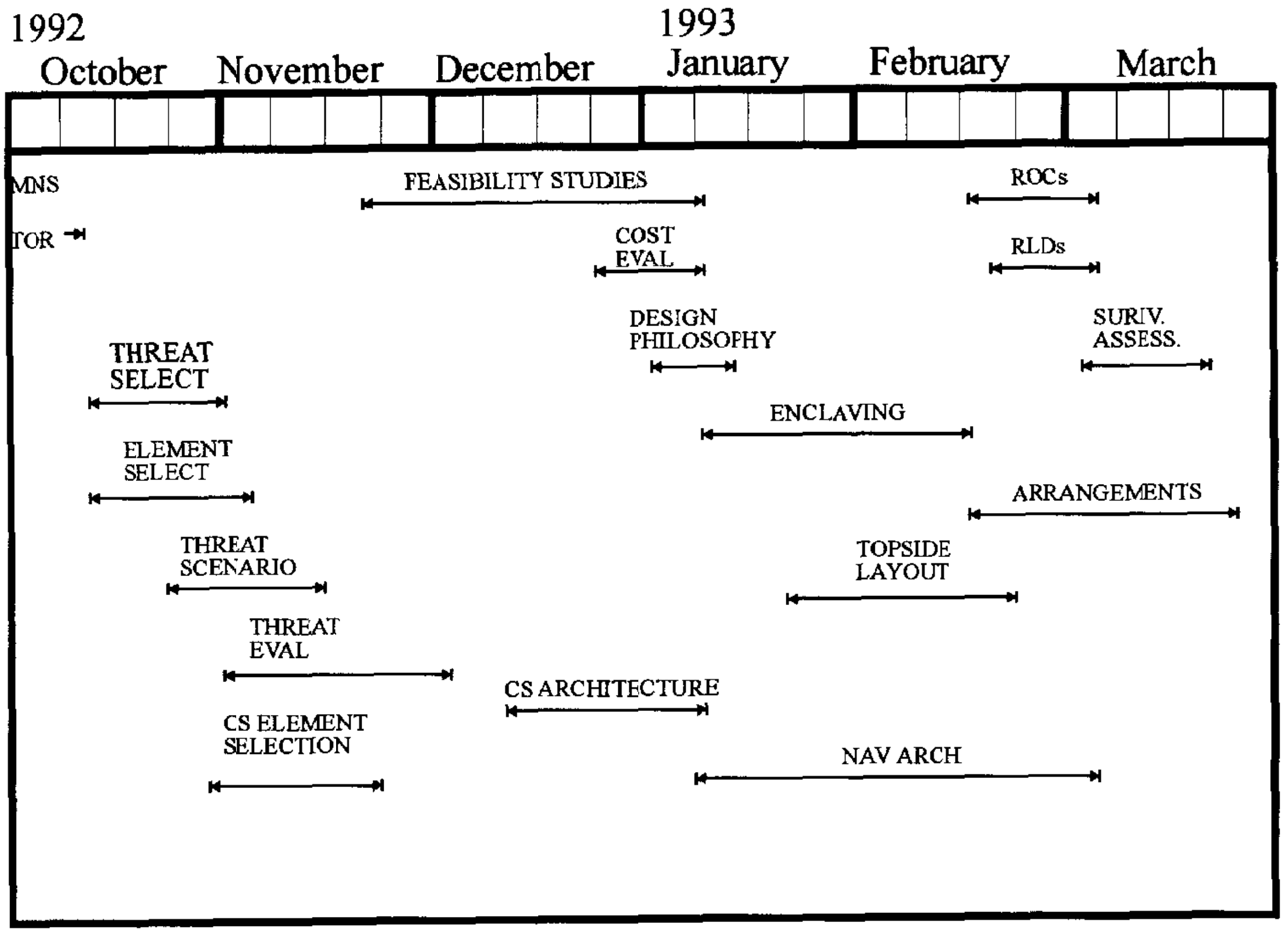

Figure 1-1. Design Timeline.

II. REQUIREMENTS SETTING PHASE

The requirements setting phase of the ship design process begins with the articulation of a need that is not being met by the current ship inventory. For this class, the professors acted as the "operators", representing the OPNAV structure. They articulated the geopolitical view of the world in the year 2010, with specific emphasis on the Naval roles and missions in this world view. Based on these roles and missions, they then postulated a Force Projection Ship (FPS) to meet a specific niche in the required U.S. defense posture. They defined in general terms the roles and capabilities of this envisioned ship, intending it to be the CNO top level guidance to kick off the design study.

The report provided by the professors is included in the pages which directly follow. The student design team was tasked to produce a requirements document for submittal to the CNO. This requirements document would then be given back to NAVSEA (the design team) to initiate feasibility studies for the FPS-2010.

A. CNO TENTATIVE REQUIREMENT STATEMENT

1. World View-2010 time frame

In terms of global reach, the world will be unipolar, with only the U.S. possessing meaningful global reach capabilities. The fundamental U.S. - FSU (Former Soviet Union) relationship will be one of cooperation--rather than competition--on most issues. This relationship, however, is becoming less important because the FSU is becoming fragmented to such an extent that, except for nuclear weapons capability, it possesses virtually no attributes normally associated with superpower status.

In regional terms, the 2010 world will be multipolar and the fundamental relationship among regional powers, on most issues of importance, will also tend to be more cooperative than competitive. The world will seem "kinder and gentler" in most respects, although potentially destabilizing developments will continue to bubble just below the surface in several of the world's traditionally troublesome regions. Any one, or a combination, of these could erupt and result in international crisis conflict in the near future.

a. The U.S. Navy will continue to require the ability to:

(1) operate in a forward-deployed mode, far from U.S. shores, for lengthy periods of time;

(2) project power ashore via tactical air power and cruise missiles;

(3) conduct opposed amphibious assaults;

(4) protect U.S. interests and U.S. nationals worldwide.

b. In this changed world, however, blue-water Naval engagements with a powerful adversary Navy will not be a threat. U.S. Navy operations are likely to have the following characteristics:

(1) take place mostly in littoral waters off the shores of nations which are now frequently referred to as "third-world";

(2) be of a peacekeeping or tension-reducing nature; Navy ships will find themselves introduced into volatile areas for the purpose of "cooling" down adversary nations within a region (transition from "peacetime" conditions to active engagement may occur without warning);

(3) be intended to remove U.S. nationals from trouble spots, or show U.S. resolve to protect its nationals as well as its other interests in the area;

(4) be part of a collective security organization (e.g. UN) sanction-enforcement effort and take the form of trade interdiction or embargo;

(5) consist of strike operations intended to "decapitate" an aggressor nation's war fighting capabilities, or opposed landings of limited size forces (up to Marine brigade size), or covert insertion of special forces;

(6) be challenged by nations with modern equipment (probably purchased from "first world" powers) in limited numbers; but operated in a skilled and determined way.

2. FPS Role in 2010

The study team sees the role of the envisioned FPS-2010 as follows:

a. lengthy deployment, world wide;

b. operations in all oceans (but not in polar regions);

c. either independent or Battle Group operations;

d. AAW (self defense but not area defense) against attacks launched by third world nations;

e. ASW against nuclear and non-nuclear submarines in shallow water;

f. ASUW against third world surface naval forces;

g. presence projection;

h. keeping ports and choke-points open to peaceful sea borne commerce;

i. support of special operations;

j. destruction of high-value, land-based Military targets;

k. support of amphibious assaults;

l. operations in mined areas;

m. interdiction of contraband-carrying ships.

3. Political Considerations

It is clearly in the best interests of the United States to be able to intervene early in potential regional violence in order to avert it or, at least, affect the outcome. However, such actions will not be acceptable if they carry a high price tag--in dollars, in international political impact or in American lives. Therefore, a surface ship to fill these roles must be designed to minimize:

a. the probability (and numbers) of crew member losses;

b. the probability of loss of the ship;

c. the share of the shrinking defense budget that the ships represent;

d. the probability of causing damage to non-combatants or neutrals.

4. Other

It is anticipated that 8 to 10 of these ships would be built.

Summary:

The design team's requirements document is included next. This is the result of a few iterations of submittals and revisions between NAVSEA (student design team) and CNO (professors). One major change that occurred during this process was a change in the name of the ship from *Force Projection Ship* (FPS) to *Regional Deterrence Ship* (RDS).

B. REQUIREMENTS DOCUMENT FOR REGIONAL DETERRENCE SHIP (RDS) 2010

1. General Description of Operational Requirement.

The Chief of Naval Operations (CNO) and Joint Chiefs of Staff (JCS) guidance for the Navy in the decade beginning in 2010 describes a change in emphasis and requirements for Naval combatants designed to be deployed in that time frame. The world will be unipolar with only the United States possessing meaningful global reach capabilities. The intense Cold War adversarial relationship with the republics of the former Soviet Union will have changed to one of cooperation on most issues. The republics of the former Soviet Union will possess virtually no attributes normally associated with superpower status, with the exception of their remaining nuclear weapons arsenal and capability.

The regional view of the world will be multipolar with the fundamental relationships between regional powers being more cooperative than competitive on most germane issues. However, potentially destabilizing developments will continue to simmer amongst nations in some traditionally troubled regions. As nations emerge from under unifying but repressive regimes, traditional ethnic strife will come to the forefront. These regional friction points could involve U.S. citizens and erupt into international incidents resulting in a crisis that draws in the United States.

To operate effectively in the world environment of 2010, a balanced Navy force structure is required which includes a Regional Deterrence Ship (RDS). The RDS 2010 is needed to meet the challenge of a reduced blue water threat while enhancing the capabilities required for operating in the coastal waters of third-world nations. The RDS 2010 will effectively show an American presence in any part of the world as a peacekeeping and tension reducing tool and show American resolve to protect U.S. citizens in a volatile region. Additionally, the RDS 2010 will be capable of operating as part of a collective security force with the ability to project power ashore while minimizing its own vulnerability and susceptibility.

2. Threat

The U.S. Navy faces a threat in 2010 primarily from modern and capable weapon systems possessed and skillfully operated by third-world nations in limited regional engagements. These weapon systems are purchased from first-world powers such as the U.S., its allies, China and member states and former allies of the former Soviet Union. The capability, skill, and determined manner in which these weapons may be deployed, though contained to a limited region, must be appreciated. The RDS 2010 must be capable of successfully defending itself while penetrating this weapons environment to complete its tasks. Specifically, these threats include:

a. air and surface launched anti-ship missiles with all categories of sophisticated homing techniques;
b. surface and submarine launched torpedoes in shallow water engagements;
c. waters mined with all varieties of mines;
d. small and medium caliber gunfire from coastal patrol craft;
e. biological and chemical agents;
f. attempted boarding by determined and professional forces.

Third-world nations have possessed and used many of the above listed weapons and techniques with increasing frequency over the past twenty-five years.

3. Shortcomings of Existing Systems.

To support the Navy's mission against the threats enumerated in Sections II.B.1 and II.B.2, the present inventory of U.S. Navy ships and ship acquisition schedule is too costly considering the drastically reduced defense budget. Present ships in the inventory are either over designed to meet conventional aspects of the above threat, and thus too expensive to send into such an unconventional environment, or lack the fundamental capabilities to engage or survive encounters with the specific threat categories listed in Section II.B.2. Specifically, no ship in the current inventory will effectively:

(a) conduct shallow water ASW;

(b) support the variety of aircraft associated with joint/coalition style force structures;

(c) transfer ("hand-off") AAW self-defense information between own-ship systems; or

(d) remain in a high readiness condition for a prolonged period without crew performance degradation.

Additionally, since pre-attack threat recognition is nearly impossible and defensive reaction time is exceedingly short during hostile encounters in congested coastal waters, the probability of a hit is high. The present ship candidates available to meet the mission needs have inadequate self-defense and survivability features.

4. Range of Capabilities Desired.

The RDS 2010 shall provide the following capabilities:

a. sustain a six month forward deployment with a two week replenishment interval;

b. completely integrated shipboard combat system;

c. AAW self defense against limited intensity/duration attacks;

d. ASUW against third world surface naval forces;

e. ASW in deep and shallow water while employed independently;

f. support amphibious assaults;

g. attack high value land based military targets (both coastal and interior);

h. receive real time targeting information from diverse sources;

i. interdict contraband carrying ships;

j. operate in mine infested waters;

k. rapidly configurable C^3 system for interoperability with joint/coalition forces;

l. operate at highest readiness condition for two weeks at a time;

m. operate in chemical, biological, and radiological environments;

n. operate in all oceans, less polar, in at least sea state five;

o. transit all major commercial shipping canals and waterways;

p. maximum speed of 25 knots for 85 hours;

q. endurance: 4000 nautical miles at 16 knots, followed by 20 days on station at 8 knots with a 400 nautical mile withdrawal distance at 6 knots;

r. projected lifetime of 40 years;

s. low signatures to avoid being detected, targeted or hit (enhance deception effectiveness.;

t. have special features to enhance the ability to fight hurt;

u. shock qualification required;

v. semiautomatic intelligent damage control system with remote sensors;

w. support short duration, covert operations;

x. incorporate an appropriate SSES;

y. support flight operations of non-assigned joint forces helicopters;

z. carry a surgeon and have operating room facilities.

5. General Affordability Limits.

The acquisition cost of RDS 2010 will not exceed 500 million dollars.

6. Platforms/Quantities.

Approximately 10 ships will be built.

7. Integrated Logistics Support (ILS).

Two key factors drive the required maintenance support for this class of ship: (1) forward based maintenance assets are not anticipated, and (2) lengthy, independent operations remote from other naval assets are anticipated. Therefore, incorporated into the ship design will be the following ILS features:

a. Built-In-Test-And-Evaluation (BITE) capability in all weapons, sensors, communications, and supporting vital equipment; Automated Test and Evaluation (ATE) capability to troubleshoot and fault isolate to replaceable components all removable and repairable circuit card assemblies; adequate manning and facilities to support micro-miniature component repair;

b. phased maintenance concept with a 15 year overhaul cycle for major system upgrades;

c. modular design of weapons, sensors and communications systems to facilitate system upgrades;

d. arrangement of machinery and equipment, including shipping/unshipping paths, to ease the change-out of equipment components and minimize adjacent system interference ripout (this facilitates at sea replacement and repair and lowers regular maintenance availability costs);

e. commonality of components for all ship systems, unless a significant loss of system performance would result;

f. automated component monitoring system in the engineering spaces to aid in phased maintenance planning and to minimize engineering watchstanders;

g. manning not to exceed 175.

8 Related Efforts.

TASM capability will continue to be available. To support the maintenance needs of this class, a forward deployable tender capability will be maintained.

Summary:

This requirements document kicks off the actual ship design process. These requirements are translated into desired operational capabilities which form the backbone of the ship design. The ability of the ship to perform these operational capabilities is a major judge of ship performance to design guidelines. The Required Operational Capabilities are included in the next section.

C. REQUIRED OPERATIONAL CAPABILITIES

Based upon the Range Of Capabilities Desired (Section II.B.4), the following primary and secondary Required Operational Capabilities (ROCs) and design requirements are delineated:

1. Primary ROCs

a. AAW self defense against limited intensity/duration attacks

b. ASUW against third world surface naval forces

c. ASW in deep and shallow water while employed independently

d. rapidly configurable C^3 system for interoperability with joint/coalition forces

e. receive real time targeting information from diverse sources

f. operate in chemical, biological, and radiological environments

g. operate in all oceans, less polar, in at least sea state five

h. attack high value land based military targets (both coastal and interior)

2. Secondary ROCs

a. support amphibious assaults

b. interdiction of contraband carrying ships

c. support short-duration covert operations

d. incorporate an appropriate SSES

3. Primary Design Requirements

a. operate in mine infested waters

b. sustain a six month forward deployment with a two week replenishment interval

c. completely integrated shipboard combat system

d. operate at highest readiness condition for two weeks at a time

e. operate in chemical, biological, and radiological environments

f. operate in all oceans, less polar, in at least sea state five

g. transit all major commercial shipping canals and waterways

h. maximum speed of 25 knots for 85 hours

i. endurance: 4000 nautical miles at 16 knots, followed by 20 days on station at 8 knots with a 400 nautical mile withdrawal distance at 6 knots

j. have special features to enhance the ability to fight hurt

k. semiautomatic intelligent damage control system with remote sensors

l. carry a surgeon and have operating room facilities

4. Secondary Design Requirements

a. projected lifetime of 40 years

b. low signatures to enhance deception effectiveness

c. shock qualification required

d. support flight operations of non-assigned joint forces helicopters

Table 2-1 shows the primary required operational capabilities applicable to this ship as taken from standard Navy ROC definitions.

TABLE 2-1. PRIMARY REQUIRED OPERATIONAL CAPABILITIES.

ANTI-AIR WARFARE (AAW). The destruction or neutralization of enemy air platforms and airborne weapons, whether launched from air, surface, subsurface, or land platforms.

- AAW 6 Detect, identify, and track air targets.
  - AAW 6.2 Recognize by sight friendly and enemy aircraft which may be encountered in expected operating areas.
  - AAW 6.3 Maintain accurate air plot.
  - AAW 6.4 Measure aircraft altitude with radar.
  - AAW 6.5 Detect, identify and track air targets with radar.
  - AAW 6.6 Acquire and track air targets with gunfire and missile control systems.
  - AAW 6.9 Conduct radar approaches for embarked aircraft.
  - AAW 6.* Detect and track air targets with an infrared sensor.
- AAW 9 Engage airborne threats using surface-to-air armament.
  - AAW 9.1 Engage high speed, med/long range airborne threats with med/long range missiles.
  - AAW 9.3 Engage low altitude threats with missiles and gunfire.
  - AAW 9.4 Engage low/medium/high altitude airborne threats with gunfire.
  - AAW 9.7 Engage airborne threats using portable missile systems.

ANTI-SURFACE SHIP WARFARE (ASUW). The destruction or neutralization of enemy surface combatants and merchant ships.

- ASU 1 Engage surface threats with anti-surface armaments.
  - ASU 1.1 Engage surface ships with long range cruise missiles.
  - ASU 1.2 Engage surface ships with medium range cruise missiles.
  - ASU 1.4 Engage surface ships with major caliber gunfire.
  - ASU 1.6 Engage surface ships with minor caliber gunfire.
  - ASU 1.9 Engage surface ships with small arms gunfire.
- ASU 4 Detect, identify, localize, and track surface ship targets.
  - ASU 4.1 Detect, localize and track surface contacts with radar.
  - ASU 4.2 Detect, identify, and track surface contacts visually.
  - ASU 4.5 Detect, identify, and track surface contacts with infrared equipment.
  - ASU 4.6 Detect, identify, and track surface contacts by ESM.
  - ASU 4.7 Identify surface contacts.
- ASU 6 Disengage, evade, and avoid surface attack.
  - ASU 6.1 Employ countermeasures.
  - ASU 6.2 Employ evasion techniques.
  - ASU 6.3 Employ EMCON procedures.

ANTI-SUBMARINE WARFARE (ASW). The destruction or neutralization of enemy submarines.

- ASW 5 Provide for air operations in support of airborne anti-submarine operations.
  - ASW 5.1 Launch rotary wing aircraft involved in anti-submarine operations.
  - ASW 5.2 Recover rotary wing aircraft involved in anti-submarine operations.
  - ASW 5.4 Provide required conventional ordnance to support anti-submarine operations.
  - ASW 5.6 Conduct operations during all EMCON conditions.
  - ASW 5.7 Load/unload ordnance compatible with required aircraft turnaround times.
- ASW 7 Engage submarines with anti-submarine armament.
  - ASW 7.2 Attack with ASROC.
  - ASW 7.4 Attack with mortar/depth charges.
- ASW 8 Disengage, evade, avoid and deceive submarines.
  - ASW 8.1 Employ torpedo countermeasures and evasion techniques.
  - ASW 8.2 Employ acoustic countermeasures against submarines.

MOBILITY (MOB). The ability of Naval forces to move and maintain themselves in all situations over, under, or upon the surface.

- MOB 1 Steam to design capability and in the most fuel efficient manner
  - MOB 1.1 Steam at full power.
  - MOB 1.2 Steam with split plant operations.
  - MOB 1.7 Transit at high speed.
- MOB 3 Prevent and control damage.
  - MOB 3.1 Control fire, flooding, electrical, structural, propulsion, and hull/airframe casualties.
  - MOB 3.2 Counter and control CBR contaminants/agents.
  - MOB 3.3 Maintain security against unfriendly acts.
  - MOB 3.5 Provide damage control security/surveillance.
- MOB 7 Perform seamanship, airmanship, and navigation tasks.
  - MOB 7.1 Navigate under all conditions of geographic location, weather, and visibility.
  - MOB 7.2 Conduct precision anchoring.
  - MOB 7.3 Get underway, moor, anchor, and sortie with duty section in a safe manner.
  - MOB 7.4 Abandon/scuttle ship rapidly.
  - MOB 7.7 Provide life boat/raft capacity in accordance with unit's allowance.
  - MOB 7.15 Operate in chemically contaminated environment.

- MOB 10 Replenish at sea.
  - MOB 10.1 Receive vertical replenishment.
  - MOB 10.2 Receive fuel while underway (alongside method).
  - MOB 10.3 Receive munitions and provisions while underway.
  - MOB 10.6 Receive fuel while underway (astern method).
- MOB 12 Maintain the health and well-being of the crew.
  - MOB 12.1 Ensure all phases of food service operations are conducted consistent with approved sanitary procedures and standards.
  - MOB 12.2 Ensure the operation of the potable water system in a manner consistent with approved sanitary procedures and standards.
  - MOB 12.3 Maintain the environment to ensure the protection of personnel from overexposure to hazardous levels of radiation, temperature, noise, vibration, and toxic substances per current instructions.
  - MOB 12.5 Monitor to ensure that habitability is consistent with approved habitability procedures and standards.
  - MOB 12.6 Ensure operation and maintenance of all phases of shipboard environmental protection systems do not create a health hazard and are consistent with other naval directives pertaining to the prevention of pollution of the environment.

STRIKE WARFARE (STW). Support the destruction or neutralization of enemy targets ashore through the use of conventional weapons.

- STW 3 Support/conduct multiple cruise missile strikes either independently or in support of other strike forces.
  - STW 3.2 Support/conduct conventionally armed cruise missile strikes.

COMMAND, CONTROL AND COMMUNICATIONS (CCC). Providing communications and related facilities for coordination and control of external organizations or forces and control of unit's own facilities.

- CCC 3 Provide own unit's command and control functions.
  - CCC 3.1 Maintain a CIC capable of collecting, processing, displaying, evaluating, and disseminating tactical information.
  - CCC 3.3 Provide all necessary personnel services, programs, and facilities to safeguard classified material and information.
  - CCC 3.4 Carry out emergency destruction of classified matter and equipment rapidly and efficiently.
  - CCC 3.5 Employ Identification Friend or Foe/Selective Identification Feature (IFF/SIF) secure IFF mode 4.
  - CCC 3.6 Coordinate and control the operation of remotely piloted vehicles.
  - CCC 3.8 Establish voice communications with U.S. Marine Corps (USMC) evacuation and command nets and Naval Support Activity (NSA) net.
- CCC 4 Maintain Navy Tactical Data System (NTDS) or data link capability.
  - CCC 4.3 Transmit/receive and support Link 11.
  - CCC 4.5 Receive and process data link information from Satellite Communication (SATCOM).
  - CCC 4.6 Receive and process data link information from High Frequency (HF) systems.
  - CCC 4.7 Receive Link 14 information.
  - CCC 4.10 Transmit/receive and correlate targeting information with Link 4A.
- CCC 6 Provide Communications for own unit.
  - CCC 6.2 Provide visual communications.
  - CCC 6.3 Provide multi-channel cryptographically covered teletype send and receive circuits.
  - CCC 6.4 Provide uncovered Radio-Teletype/Continuous Wave communications.
  - CCC 6.5 Provide full duplex cryptographically covered HF teletype circuits.
  - CCC 6.10 Provide voice/teletype/computer data cryptographically covered satellite communication circuits.
  - CCC 6.11 Establish and provide fixed combat communications and relay support for NSW operations.
  - CCC 6.12 Provide internal communications systems.
  - CCC 6.16 Provide tactical, secure, anti-jam Ultra-High Frequency (UHF) voice communications.
  - CCC 6.18 Provide tactical, secure, anti-jam HF voice communications.
  - CCC 6.19 Provide tactical, secure voice or data communications.
  - CCC 6.20 Provide internal Ship Signal Exploitation System (SSES) communications system.

III. INITIAL DESIGN DECISIONS

At this point in the design process, several elements must essentially come together simultaneously. First, based upon the capabilities that this ship must possess and the political factors addressed in the requirements section, a prioritized listing of factors must be developed to aid the design team in the tradeoff and decision making process. This collection of priorities is known as the design philosophy.

While developing the design philosophy, initial thought is occurring on the types of technology and elements that we believe need to be placed on the ship to meet the aggregate of capabilities desired. This process includes drawing from the design team's experience base, researching design innovations in the literature, and examining existing equipment that may be suitable for inclusion on this ship. Some of the design innovations considered/desired are included in section two of this chapter.

This process culminates in the development of an element selection list, which is included in the third section of this chapter. The items on the element selection list are then examined, weighted, and judged to determine the elements that we believe will be most suitable for this ship design. It is not until after further stages of design effort that all of the elements can be deemed feasible.

A. DESIGN PHILOSOPHY

This design philosophy provides a prioritized listing of factors used in guiding design tradeoff decisions during all phases of the RDS-2010 design process. The factors selected and their relative weighting were governed by the *Requirements Document for RDS-2010* (Section II.B).

This design philosophy is intended for use exclusively by members of the RDS-2010 design team in determining tradeoffs and selections of design alternatives. Other uses or applications of this document are beyond the scope of its intent.

Specifically, the **Range of Capabilities Desired** and **General Affordability Limits** (Sections II.B.4 and II.B.5), lead to the following list of prioritized factors:

1. Cost, Acquisition
2. Combat System, Defensive
3. Vulnerability
4. Manning Reduction
5. Combat Capability, Offensive
6. R, M & A
7. Appearance
8. Signature/Detectability Reduction
9. Standardization
10. Upgradability
11. Sustainability
12. Environmental Impact
13. Future Growth
14. Habitability

Discussion:

(1) *Cost, Acquisition* - this factor ranked number one due to the severe budgetary constraints this ship must be designed and built under. Failure to account adequately for cost savings as a prime objective will most probably kill this project during the DOD and congressional approval levels of review. Cost is listed explicitly instead of some indirect parameters such as length, beam, draft, or displacement since cost control is the factor actually desired. Some may regard placing of the cost factor ahead of a military capability such as defensive systems as untenable, but it merely recognizes the reality of the current environment.

(2) *Combat System, Defensive* - also known as hard and soft kill capability, this feature addresses one portion of the susceptibility equation. The ability to defeat an incoming threat is of paramount importance for decreasing the vulnerability of this ship. This capability should be considered essentially equal with cost reduction in importance.

(3) *Minimizing Vulnerability* - once the ship is hit, minimizing this ship's vulnerability ranks high in importance due to the ship's mission requirements. Operating close ashore in unstable world regions greatly increases the likelihood of unexpected, close aboard attack.

(4) *Manning Reduction* - in concert with minimizing ship's vulnerability and reducing acquisition cost, adequate consideration will be placed on minimizing ship's manning consistent with mission needs, available technology and damage control requirements. Manning reduction is primarily achieved through automation of functions in all aspects of ship operations including ship control, engineering plant operations, and war fighting operations. Design decisions to automate functions to reduce manning requirements will reduce vulnerability if all aspects of the vulnerability equation are properly taken into account. The largest counter point to reduced ship's manning is the impact on damage control capability. Present design and practice makes damage control operations 100% manual (hence, manpower intensive). Failure of current ship designs to take advantage of the technological innovations which could supplant or enhance the requirement for a crew member involvement in damage control operations may prove to be as significant a driver on crew size as watch, quarter, and station bill requirements. The salient point remains that merely automating operating stations and maintenance functions will not necessarily alleviate the crew requirement if active measures are not taken to address the requirements driven by damage control teams and damage control concepts.

(5) *Offensive Combat Capability* - the RDS-2010 is not a major offensive strike platform, though any offensive capability which enhances the utility of the ship above and beyond the ship's tactical land strike mission requirements commensurate with the previous factors should receive consideration.

(6) *Reliability, Maintainability, and Availability (R, M & A)* - these design attributes are considered more important than the related areas of standardization, upgradability and sustainability, due to their impact on ship mission attainment and synergistic impact on manning reduction. Specifically, this ship's requirement to operate independently for sustained periods of time (no external maintenance support) make the reliability, maintainability, and availability of ship's equipment paramount.

(7) *Appearance* - the requirement of this ship to "show the flag" and perform the role of "presence projection" make design decisions affecting ship appearance a moderate attribute to be considered. Strong consideration should be made for design attributes which improve the "war fighting" appearance of the ship without excessive negative impact on the previous factors.

(8) *Signature/Detectibility Reduction* - ranked considerably lower than the other half of the susceptibility equation (defensive capability), these design features are not as important when taken in context with the ship's mission and probable operating theaters. Any design attributes which improve this factor without impacting previous factors should be considered, however.

(9) *Standardization of shipboard components* - since these features tend to drive up design and acquisition costs with little improvement in capability, this is not ranked high. This is a desirable attribute in cases where it can be obtained without disproportionate costs increases or in cases where it would dramatically improve aspects of R, M, & A.

(10) *Upgradability* - this factor which is the ease of implementing improvements to existing systems is driven by accessibility and the system architecture. It is desirable but not enhancing to the ship's mission.

(11) *Sustainability* - enhancement above baseline design requirements for ship's sustainability should only be considered if they do not negatively impact previous factors.

(12) *Environmental Impact* - enhancements beyond regulatory requirements are of lesser importance than other factors.

(13) *Future Growth* - design attributes that enhance the ease and capability for addition of new systems impacts original system architecture and architectural design margins. This capability is not considered important in view of the ship's small size and mission.

(14) *Habitability* - embellishment of ship's living spaces are inconsistent with mission requirements and stated design goals of decreased vulnerability and increased R, M, & A. Embellishments include features such as false bulkheads and overheads, wall and floor coverings chosen for cosmetic purposes and any other features which would enhance the spread of fire, toxicity of smoke, impede or obscure access to equipment, cabling, ventilation ducting, piping or other ship's systems. Aspects of habitability which would benefit crew morale should be considered and primarily include the allocation of adequate living space for each individual and the capability of the individual to control the environment of their living space.

B. CONCEPTIONS AND INNOVATIONS

During the early phases of any design process there are many ideas which are considered. The length of consideration may be limited to a few seconds or it may be extended through long discussions while determining what must be incorporated into the design. This section addresses some major ideas which the design team considered worthy of inclusion. The absence of a particular item from this section does not necessarily mean that it was overlooked or deemed unimportant. While some concepts were envisioned and dwelt on at great length, time and resources did not always permit the effort to proceed to as detailed level as would have occurred in industry.

1. TOTAL SHIP INNOVATIONS

Extensive use of computers throughout the ship will smooth the flow of data and information and automate many low level routine tasks. Personnel will serve in a supervisory role to monitor the "system". Multi-purpose interface consoles will be used to the maximum extent possible in *all* system interface capacities. These would include a software driven interface with touch sensitive screens. Essentially, any system function will be available from any interface terminal with appropriate access control. This allows for easy system upgrade without requiring changes in hardware consoles and associated interface cabling.

Ship maneuvering functions will be controlled automatically. Tracks will be entered at the navigation console and controlled through an auto pilot. The auto pilot will be linked to the combat system for proactive defensive maneuvers and collision avoidance. Roll stabilization can also be incorporated through the use of the rudder.

A survivability management system will be used to smartly reconfigure systems in anticipation of a weapon hit and provide proactive damage control to minimize the spread of secondary damage.

2. COMBAT SYSTEM INNOVATIONS

The ship's radar cross section is critical to the performance of the ship's defensive posture. The use of signature reduction technology in designing the ship's structure will significantly reduce detection ranges by redirecting incident energy away from the source. This enhances the effectiveness of decoys thus reducing susceptibility. As designers we can incorporate these ideas into our design by canting the ship's structure and providing storage compartments flush with the superstructure to remove topside clutter.

We envision a completely integrated combat system which includes all warfare areas. Each piece of equipment will be connected through a redundant, fiber optic multi-ring data bus. This will centralize information flow allowing any system to easily access the appropriate data on the bus. This will greatly improve the flexibility, survivability and upgradability of the system.

A Built-In Test and Evaluation module will be installed in every system to aid in minimizing system down time caused by failures and damage to system components. This would interface with another higher level system module, and by using System Readiness Logic provide up-to-date system status to operators. This would also provide a means to reconfigure the system for maximum combat readiness as required by tactical situations and doctrine planned into the software.

This ship has an expected life of 40 years. Historically, combat systems have been replaced every decade. Modular system design will be emphasized for ease of replacement, interface compatibility and for reduction in the cost associated with overhauls.

3. AFFORDABILITY FEATURES

Affordability was at the top of our design philosophy. Although production cost is only a small percentage of the overall acquisition cost, advanced production concepts will be used to achieve cost savings. This can be accomplished by reducing the cross boundary interface between production modules and minimizing the use of compound curvature requirements in steel work. Building zones need to be established early on so that the ship can also be built more efficiently.

In order to improve ship readiness for lengthy deployments we must improve the current maintenance philosophy. Designing this ship for a 15 year overhaul cycle and incorporating condition based maintenance should reduce system down time on patrol and improve operability. This statistically based replacement program will be accompanied by various new test methods in order to overcome some of the pitfalls experienced by the current generation of preventive maintenance. This process may incur a higher ship acquisition cost but will be significantly offset by a reduced life cycle cost. Standardization of components will also synergistically benefit the total ship through greater availability of parts and the requirement to stock fewer parts.

4. SURVIVABILITY FEATURES

Survivability features are integral to this design. The standard concepts considered to reduce the ship's susceptibility to a weapon's hit are threat warning, noise jamming and deception, signature reduction, threat suppression, use of expendables, and equipment to support the use of tactics. The standard concepts considered to reduce the ship's vulnerability are component redundancy or elimination, component location and/or shielding, passive damage suppression, and active damage control. Reduced manning also lowers the likelihood of casualties and reduces vulnerability. While manning reductions require additional acquisition investment for automation, there is a significant reduction in life-cycle cost associated with personnel. Designing with redundancy, the equipment capable of performing the same task, and enclaving together all equipment necessary for proper operation of that system will improve the damage tolerance of this design. This will be discussed in greater detail later.

A double hull design concept has great merit for the shell of this ship. The primary purpose of using a double hull is to reduce vulnerability. The significant addition of reserve buoyancy improves the ability to "FIGHT HURT". The inherent strength in the double hull design allows for reduced scantlings due to the higher section modulus, thereby reducing cost. The between skin distance will accommodate the latest in programmable welding technologies and provide for ease of inspection and maintenance.

5. PROPULSION PLANT VISION

From the results of several studies that have been done on modern propulsion systems, we determined that the Integrated Electric Drive was superior from the perspective of survivability, reduction in total weight of the propulsion system, and ease of arrangement. The flexibility associated with arrangements would also reduce the vulnerability of the propulsion system. Since shallow water operations pose a higher likelihood of propeller damage, a controllable reversible pitch propeller is not considered the best candidate. The integrated electric drive combines well with the fixed pitch propeller because each reversible propulsion motor has a full range of speed control.

Combined diesel electric and gas turbine propulsion has many advantages as well. Although the specific weight and volume of this system is higher than a conventional gas turbine system, the fuel efficiency at patrol speeds could justify consideration due to reduced fuel payload.

6. ELECTRIC PLANT VISION

Using today's technology ship service electric power can be generated from the variable frequency propulsion generators using solid state power converters. This power will be distributed throughout the ship using a ring bus, and each system will provide for its own specific voltage and frequency needs from the main power grid. Power management will be controlled automatically with smart load shed coordination with the combat system. System reconfiguration due to degraded capacity will be performed automatically to maximize available power consistent with the ship's tactical situation.

C. ELEMENT SELECTION OPTIONS

Table 3-1 lists the element selections that resulted from our study of design innovations and available equipment for inclusion on the ship. In some categories, there are multiple choices which must be winnowed out during the early phase of the design process. Other categories list only a single item, indicating our conclusion that this item is required for inclusion on the ship.

Using the Element Selection List, a lengthy search was conducted for data pertaining to the specific elements. This data, when available, was used for performing detailed comparisons of functional capabilities and physical parameters. Appendices B and C contain some of the relevant portions of that study. In Appendix B, page one, the *Payload Selection Matrix* is shown. This matrix includes all of the elements considered by mission warfare area. For the proposed ship there are several cases where two closely related alternatives exist for some of the elements under consideration. Option 1 and Option 2 are described in chart form for a quick comparison. In rows two and three the elements which were selected based on the various decision matrices are listed. The pertinent decision matrices which led to those conclusions are included in Appendix C.

Table 3-1. Element Selection List.

A. HULL

1. **Type**
   - *a. Single/mono*
   - *b. Double/mono*
2. **Collective Protection System**

B. MECHANICAL

1. **Plant type**
   - *a. Diesel engines*
   - *b. Gas turbines*
   - *c. Combined diesel and gas turbine*
   - *d. Combined diesel or gas turbine*
2. **Reduction gear**
   - *a. Mechanical (reversing, w/clutch)*
   - *b. Direct shaft coupled*
   - *c. Electric drive*
   - *d. Mechanical (non-reversing)*
3. **Propeller**
   - *a. Variable pitch*
   - *b. Controllable and reversible pitch*

C. ELECTRICAL

1. **Generator system**
   - *a. Diesel*
   - *b. Gas turbine*
   - *c. Propulsion derived*
2. **Distribution system**
3. **Power management system**
4. **Emergency power system**

D. COMBAT SYSTEMS

1. **Detection/sensors**
   - *a. Air: SPS-48/49/IFF, Low budget phased array*
   - *b. Surface search: SPS-67 family*
   - *c. IR search: SAR-8*
   - *d. ESM: SLQ-32(V)3*
   - *e. Sonar: High resolution hull and remote, SQS-53 (low budget)*
   - *f. LAMPS III*
   - *g. Acoustic intercept: WLR-9, SRS-1 (Combat DF)*
   - *h. Mk 23 (TAS)*
   - *i. KAS-1 (CWDD)*
2. **Command and decision**
   - *a. NTDS (Link 11)*
   - *b. WSA 423 C&C*
   - *c. ACDS*
3. **System information coordination**
4. **System readiness coordination**
5. **External communications: WQC, HF, UHF, VHF, SATCOM, JITDS, JOTS**
6. **Interior communications**
7. **Weapon control**
   - *a. Mk 92 FCS*
   - *b. Mk 91 FCS*
8. **Navigation**
   - *a. Furuno, LN-66, SPS-64*
   - *b. GPS, SATNAV*
   - *c. TACAN*
   - *d. WRN-5,*
9. **Engagement/weapons/countermeasure**
   - *a. Missile /Point defense: RAM, NSSM, SM-1/2, CIWS Mk 15, Goalkeeper, Stinger missile turret*
   - *b. Gun: 5" -54 cal Mk 45 gun, Mk 24 TDT, OTO 76mm gun, 25mm Chain gun, 7.62mm mini-gun*
   - *c. Torpedo: SVTT Mk 32, Mk 50*
   - *d. Depth charge system: RBU/ Hedgehog (upgrade)*
   - *e. Tomahawk VLS/ Harpoon*
   - *f. CM: Mk 38 decoy launcher, SRBOC, LAD Chaff, 3" rocket decoys*
   - *g. Anti-torpedo defense: Talisman, Nixie, NAE, ADC, CSA*
10. **Remote vehicle mine hunter/avoidance**

The second page of the *Payload Selection Matrix* (Appendix B) includes all of the elements considered by equipment categories. Page two of Appendix B contains all equipments/systems considered whereas page one only lists those associated with a specific warfare area. This step of the process addressed the elements, but not the quantity or arrangement of them. The intent is to determine the most cost effective (dollars, weight, area, etc.), yet capable equipment/system to meet the required capabilities as delineated in the CNO Tentative Requirement Statement. When two elements under consideration had a wide host of utility factors for comparison, it occasionally seemed appropriate to have a second alternative based on factors such as cost, weight, political mood, logistical commonality. The combat system elements have undergone a preliminary threat evaluation consisting of four diverse scenarios. This threat evaluation is presented in the next chapter as part of the Combat System Definition. The reasoning for the decisions which were agreed upon by the design team are described below, supported by Appendices B and C.

1. HULL

a. DOUBLE HULL vs. SINGLE HULL

Major issues: Passive protection, survivability, displacement, and cost

Minor issues: Ease of arrangement and producibility (ease of fabrication)

Proposed is the advanced double hull design (ADHD) concept which consists of two shells connected by longitudinal web girders and floors. Simply put, it will resemble the corrugated design used in designing high toughness, high strength cardboard boxes. Transverse frames and longitudinal stiffeners can be eliminated because of the inherent strength achieved by the cellular concept. Benefits include reduced vulnerability in the event of a hull impact, higher hull girder stiffness based on higher section modulus and greater producibility (easier to fabricate, insulate, outfit, and paint) with a projected cost savings of 8-12% now with further savings inevitable during maintenance periods. The between skin distance will be large enough to accommodate the latest programmable welding technology and to provide for ease of inspection, maintenance and preservation.

Disadvantages: 1% increase in displacement for the double hull design.

b. Collective Protection System

First option is to install a full collective protection system. Based on total ship impact (cost, weight, etc.), the system may be degraded to include two or three zones. This concept dovetails with the intent to enclave the ship into three to five enclaves. Ideally, each enclave will have collective protection, though if this becomes unreasonable from a size and weight (and thus cost) point of view, then selective collective protection sub-enclaves will be considered. Primary focus will be to maximize the mission readiness of the ship when collective protection zones are detailed.

2. MECHANICAL

a. Plant Type (Including Transmission)

Several exhaustive studies have been conducted in order to determine the optimum power plant for destroyers and frigates [Ref. 1, 2, 3 and 4]. The term power plant here is used to include both propulsion and electrical plant. Factors addressed in these studies included:

(1) Propulsion and Electrical Plant Weight
(2) Propulsion and Electrical Plant Volume
(3) Power Plant Survivability
(4) Sustained Speed Margin
(5) Ship Top Speed
(6) Ship Detectability
(7) First Cost (Power plant)
(8) Life Cycle Cost (Power plant)
(9) Crew Size (Engineering)

(10) Energy Consumption

(11) Ship Displacement & Volume

(12) Ship Operability (Ease of Control)

(13) Complexity

(14) Standardization of Components

(15) Technical Risk

Evaluation criteria included many factors. The *initial cost factor* had highest priority. *Risk* and *standardization of components* had low priority in one of the studies. All of the other factors had medium priority. All of the studies showed that mechanical drive systems were inferior to the electric drive system options based primarily on weight and ease of arrangement. Some of the combined diesel and gas turbine systems had low energy consumption rates, though they were not rated well overall. A medium speed diesel may have an efficiency as high as 46% while a gas turbine has an efficiency of about 35%. On the other hand, a medium speed diesel may have a specific weight of 25 lb/HP, while the gas turbine specific weight is 3.5 lb/HP. These two factors give just a brief glimpse of why a very thorough study such as [1] is needed. Primarily, this study was used to determine which propulsion plant was optimum for this new ship class. The innovative and expensive podded propulsor seemed to be optimum in some cases, but considering that the low cost RDS 2010 must be capable of operating in mine infested shallow waters it does not seem a worthy candidate for this ship design. In order to obtain a balanced total ship design, a second propulsion plant candidate may have to be considered. The two options are addressed below.

(1) Option 1: Gas turbine integrated electric drive system

System consists of multiple propulsion gas turbines generators (PGTGs) supplying a propulsion power bus. Additional smaller gas turbine driven generators may be needed for efficient low speed cruising conditions. Ship's electric power needs will be derived from the propulsion bus via solid-state power converters. This system allows maximum flexibility in machinery plant layout to allow dispersion of components within the hull to decrease ship vulnerability.

(2) Option 2: Combined diesel electric and gas turbine electric drive

This combined diesel electric and gas turbine electric drive (CODLAG) system has the potential of increased plant efficiency at low cruising speeds based on a lower specific fuel consumption (lb/hp-hr), yet still provides the flexibility in machinery plant arrangement that is available with gas turbine electric drive. Additionally, this system may lead to smaller volume/fewer intakes and uptakes. The disadvantage of this system would be higher specific volume (ft^3/hp), specific weight (lb/hp) and initial ship cost ($).

b. Propeller - Variable Pitch vs. Controllable Reversible Pitch (CRP)

This decision is based on :

(1) the fact that the electric drive motors are reversible and have full-range speed control; and

(2) shallow water operations pose a higher likelihood of propeller damage, making a CRP propeller too high a risk (not robust enough).

3. ELECTRICAL

a. Generation Scheme

Electric power for either option will be derived from the propulsion power bus via solid-state ac-ac power converters.

b. Distribution system

The propulsion power bus will be a standard ring bus configuration for maximum flexibility and reliability. It is not perceived that propulsion power will be distributed to portions of the ship in which it is not required. The load power bus will also be a ring configuration. The electric loads will be supplied from solid-state power converters located in each enclave, with redundant capability to supply other enclaves (and vice versa).

c. Power management system

Power management will be controlled automatically with smart load shed coordination with the combat system. System reconfiguration due to degraded capacity and capability will be performed automatically to maximize available power consistent with ship's tactical situation. Deriving the ship's service electrical power from the propulsion generators allows the capability to momentarily divert all propulsion power from propulsion to ship's service to support critical combat systems operations during system reconfiguration.

d. Emergency power

There will be no dedicated emergency power system, though generator sizing and quantity will allow sufficient capacity for some generation capacity to remain in standby during full load conditions.

4. COMBAT SYSTEMS

a. Detection Systems/Sensors

(1) Air Search Radar

Several studies were performed comparing the SPS-48, SPS-49, Mk 92, and a Low Budget Phased Array (LBPA) radar systems. The LBPA is envisioned to be of the Aegis style, yet with reduced capability and cost. The system characteristics, weight and cost were compared and weighted so that cost and weight were of primary importance. Summaries of the analyses are included in Appendix C under the heading of *Primary Air Search Sensor Matrix* and *Secondary Air Search Sensor Matrix*.

(a) ***Option 1:*** Primary: SPS-49 Secondary: Mk-92

(b) ***Option 2:*** Primary: SPS-49 Secondary: SPS-48

(2) **Surface Search Radar**

The SPS-67 will be employed as the primary surface search radar with the primary navigation radar, the SPS-64, as the backup.

(3) **IR Search**

The SAR-8 will be used for infrared detection and tracking.

(4) **ESM**

The SLQ-32(V)3 will be used.

(5) **Sonar**

(a) The SQS-53 (low power/low budget) hull mounted sonar will be used. The Kingfisher mine hunting adjunct to the SQS-53 will be available before letting of the contract, so the technical risk in this area has diminished significantly. One concern, however, is that the SQS-53 sonar in general is too powerful in omni-directional and Sector Search modes for shallow water ASW missions, which is its primary purpose. However, a localization mode by beam steering could be used in shallow water with only minor degradation. A variant needs to be designed which will allow omni directional operation at low power.

(b) The Light Airborne Multi-Purpose helicopter (LAMPS III) will be the primary off hull sonar system for submarine detection and targeting with the Unmanned Undersea Vehicle, UUV, as the primary off hull mine hunting sonar system. The UUV is under risk of being dropped form the RDS 2010 class because of its high cost and low mission utility for the expected threats.

(6) **Acoustic Intercept Receiver**

The WLR-9 will not be used for detecting incoming torpedoes, since this function is inherent to the surface ship torpedo defense system (SSTD).

(7) **Chemical Detection System**

The KAS-1 chemical warning directional detector will be used.

b. Command and Decision

An integrated Command and Decision system will need to be designed around the specific elements of the combat system.

c. System Information Coordination

An integrated System Information Coordination system will need to be designed around the specific elements of the combat system.

d. System Readiness Coordination

An integrated System Readiness Coordination system will need to be designed around the specific elements of the combat system.

e. External Communications

The communications suite will consist of the following types of equipment to perform the functions currently done by underwater telephone, HF, UHF, VHF, and SATCOM transmitters and receivers. Additionally the suite of COPERNICUS architecture will include JTIDS, JOTS and SSES capabilities. It is conceived that these elements will be housed in panels, enclaved throughout the ship and that a radio room as we know it today will not exist. Data links for ship-ship and ship-shore data transfer will also be required.

f. Interior Communications

The interior communications system will consist of a fiber optic digital multiplexing system for voice and data distribution and traditional sound powered phone circuits for robust, damage control voice communications.

g. Weapon Control System

An integrated Weapon Control System will need to be designed around the specific elements of the combat system.

b. Command and Decision

An integrated Command and Decision system will need to be designed around the specific elements of the combat system.

c. System Information Coordination

An integrated System Information Coordination system will need to be designed around the specific elements of the combat system.

d. System Readiness Coordination

An integrated System Readiness Coordination system will need to be designed around the specific elements of the combat system.

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The communications suite will consist of the following types of equipment to perform the functions currently done by underwater telephone, HF, UHF, VHF, and SATCOM transmitters and receivers. Additionally the suite of COPERNICUS architecture will include JTIDS, JOTS and SSES capabilities. It is conceived that these elements will be housed in panels, enclaved throughout the ship and that a radio room as we know it today will not exist. Data links for ship-ship and ship-shore data transfer will also be required.

f. Interior Communications

The interior communications system will consist of a fiber optic digital multiplexing system for voice and data distribution and traditional sound powered phone circuits for robust, damage control voice communications.

g. Weapon Control System

An integrated Weapon Control System will need to be designed around the specific elements of the combat system.

h. Navigation System

The navigation system will consist of SPS-64 as the primary radar system, and the Furuno as the backup radar system. TACAN will be required as helicopter support. A study of this mission area was performed and is included in Appendix C as the *Navigation Radar Matrix*. Although the SPS-64 did not rate as well as the LN-66 or the Furuno overall, it was chosen as the primary navigation radar since it can send data to the fire control system and serves as the backup to the SPS-67 in the ASUW mission area. The Furuno and the LN-66 radar are essentially commercial grade, low cost navigation radars with no capability to be interfaced with the ship's combat system. They are useful in providing a low-cost navigation backup capability, however.

i. Engagement/Weapons

(1) Long Range Intercept Missile

The SM-1/2 family of missiles will be used for long range intercept of air and surface targets. The *Missile Selection Matrix* in Appendix C shows how the candidate's ratings compared.

(2) Short Range Intercept Missile

The RAM (RIM-116) series of missiles will be used for short range intercept of airborne targets.

(3) Anti-ship Missile

The Harpoon missile will be used, including the upgraded IR version of Harpoon, the Sea Launched Attack Missile (SLAM) version.

(4) Point Defense system

The Phalanx (MK-15) CIWS will be used for ultra-short range airborne target intercept. The CIWS *Selection Matrix* in Appendix C shows how the candidate's ratings compared.

(5) Naval Gunfire Support

(a) *Option 1*: The 5"-54 Mk-54 medium caliber gun provides a higher weight round and slightly improved range over option 2, but has a lower firing rate and double the weight. Use of the autonomous Naval strike round (ANSR) has the potential of increasing range to 50 nm, however at a significant cost increase per round.

(b) *Option 2*: The 76 mm Oto Melara medium caliber gun provides higher firing and training rates, but the round weight is one-fifth the weight of a 5" round. The *Medium Caliber Gun Selection Matrix* in Appendix C shows how the candidate's ratings compared.

(6) Small Caliber Gun

(a) The 25 mm Chain gun will be used.

(b) The 7.62 mm minigun will be used.

(7) Land Strike Missile

The Tomahawk Land Attack Missile (TLAM) will be used. With the system installed, it will be possible to use the Tomahawk Anti-Ship Missile (TASM).

(8) Anti-Torpedo Defense

The new Surface Ship Torpedo Defense (SSTD) system will be used.

(9) Torpedo

The Mk 50 Barracuda torpedo will be launched from the SVTT Mk 32 torpedo tube by the Mk 116 Fire Control System or a new fully integrated fire control system. In addition, the LAMPS helo has the capability to launch torpedoes.

(10) Depth Charge/Mortar System

The Soviet RBU-6000 and the antique US Hedgehog mortar systems are very heavy (30,000 lb loaded launcher) and would impose a significant impact on the RDS 2010. The need for this type of system still exists based on the fact that a

Mk 50 torpedo acquisition of an enemy submarine in shallow water has a lower than desired probability. A new light weight launcher is necessary since the Hedgehog is limited in range to 270 yards and a submarine's location could likely be determined at a longer range. Ideally, the LAMPS or UUV will assist in locating the submarine and the integrated fire control system would launch mortars aimed at a specific coordinate and set to explode at a designated depth. It is recommended that OPNAV assign a study group to determine the usefulness of deploying this type of weapon against submarines in shallow water.

j. Countermeasures

(1) ECM

(a) Based on the perceived threat, all of the countermeasures which were considered will be used and launched using the Mk 36 Super Rapid-Blooming Chaff (SRBOC) Launcher. These included Launched Active Decoy (LAD), SRBOC, and TORCH. These expendables will provide protection against missiles with active and passive radar and infrared homing systems. Most of the new countermeasures currently being developed will be launchable with this launcher.

(b) The SLQ-32(V3) provides ECM capabilities.

(2) Sonar Acoustic

The outdated Talisman and Nixie were compared and found to be similar except Nixie weighs 50% less. Additionally, the new Surface Ship Torpedo Defense (SSTD) will be operable by the year 2000. This system contains both active and passive defense measures and will be used on the RDS 2010 instead of the towed noisemakers and launched submarine style noisemakers (ADC, CSA and NAE).

IV. FEASIBILITY STUDIES - COMBAT SYSTEM DEFINITION

The next phase of the design process is defining the combat system. This is the first part of performing the feasibility studies. Since the combat system represents a major payload of the ship, the determination of the specific elements chosen for the combat system is required to proceed on with the Hull, Mechanical, and Electrical Feasibility Studies. The size, weight, location, power and other auxiliary service requirements of the payload, when combined with the performance requirements of the ship, will in many respects define the ship's HM&E characteristics.

Final selection of the combat system elements which comprise the combat systems suite of the RDS-2010 is an iterative process of selecting candidate combat system elements and then evaluating their ability to defeat threat weapons in plausible threat scenarios. Based upon the results of the threat scenario evaluation, adjustments can be made to the combat system elements. In addition, the minimum number of engagement elements are determined from the threat scenario evaluation.

In this chapter, the threats are first defined. Plausible threat scenarios are then presented to evaluate the ability of the candidate combat system elements chosen in the last chapter. Based upon this evaluation and the ability of the combat system elements to defeat the proposed threats, the minimum number of combat system elements can be chosen in the context of defeating the threat in the specified scenarios. This determination of number of combat system elements does not include the consideration of redundancy for reliability or survivability reasons.

A. THREATS

A survey was completed of the current threat weapon inventory using Naval Postgraduate School library resources. Based upon this survey, a number of threat weapons were developed that were felt to be similarly challenging as the actual threats.

This procedure, however, allowed the design team to keep this portion of the design process unclassified. Table 4-1 lists the threats that will be used to determine the combat system performance for the RDS-2010.

TABLE 4-1. RDS-2010 THREAT WEAPONS.

AIR/SURFACE/SUBSURFACE THREATS

Type	RPS 2010 Designated Enemy Name	RADAR Cross-Section (m^2)	Speed (mach)	Range (nm)	Warhead Yield (kg)	Guidance	Profile Trajectory
Missiles	THRASHER (A-S)	0.013	2.5	40	10	Passive Radar	Homes on Radar
	TAKEOVER (A-S)	0.7	3.4	300	1000	Active or Passive Radar	High Alt. w/50° terminal dive to target
	SEAGULL (S-S)	0.22	0.7	15	110	IR	15 meter sea skimmer
	SUNSTROKE (S-S)	0.1	2.5	65	450	Active Radar	10 meter sea skimmer w/1° dive
Subsurface	Small Mines	R=1 ft.				Various	
	Mk48		55 kts	35 kyds			
	Spearfish		70 kts	18 kyds			

B. THREAT SCENARIOS AND EVALUATION

In this section, the threats are combined with likely engagement actions to form plausible engagement scenarios. The scenarios consist of specified threat weapons launched at the ship. The number, range, and bearing of the threats were picked to match likely encounters in the suspected operational area in which this ship will be patrolling.

Due to time and resource constraints, only four AAW scenarios were evaluated. In actuality, additional scenarios would have to be developed and evaluated in the other warfare categories (ASUW, ASW, and mine warfare).

One of the most challenging defensive capabilities of the RDS-2010 ship is the defeat of the Anti-Shipping Missile (ASM) threat. Conflicts within recent memory have proven the effectiveness and lethality of the ASM threat, including the susceptibility of warships to damage. The solution to Anti-Shipping Missile Defense (ASMD) demands a mix of defensive concepts, including such hard kill weapons as missiles, guns and high-energy directed energy weapons be deployed in addition to other defensive systems such as ECM, ECCM, and decoys. Note that the success of these types of ASMD systems requires an overt and explicit effort in applying the techniques of vulnerability reduction to the ship to reduce its susceptibility to damage by ASM debris at the mission or firepower kill levels. Also, success of the ASMD system chosen for the ship requires the adoption of tactical plans and procedures tailored to the changing ASM threat.

The ASMD elements chosen for the RDS-2010 include:

- Missiles - SM-1/2 and RAM
- Guns - Mk15 Phalanx and Mk 45 5"/54
- ECM - SLQ-32 (V3)
- CHAFF

This section presents the results of the study of four diverse Anti-Air Warfare (AAW), defensive threat scenarios (specifically, ASMD) and is to be used in conjunction with the previous chapter's section on element Selection Options. Specifically, this section is used to determine and validate choices for the minimum number of missiles, types of missiles, guns, and close-in protection systems required to separately defeat the four surmised threat scenarios. Modifications to these quantities may and probably will occur as the design progresses. The threat ASMs used in these scenarios were defined in the previous section of this chapter.

Only AAW threat scenarios are presented. This does not imply that the ASW, ASUW, or mine-countermeasures are not important or not in need of study. Resource and time constraints, however, preclude similar studies in these defensive areas. The basic methodology present in this report would also be used to study these other defensive warfare areas, however.

1. Background Development

Performance of ASMD analysis, the ability to defeat an attacking ASM, is normally expressed in terms of the ability to protect the defending ship from damage. The acceptable level of ship damage is not well defined yet, though for the RDS-2010, this is considered a severe constraint. Emphasis is placed on defeat of the ASM threat vice accepting resulting damage from a "leaker".

In general, the capability to defeat a target is expressed as:

$$P_k = P_S = P_{S/D} \cdot P_D + P_{S/ND}(1 - P_D) \qquad (4\text{-}1)$$

where:

P_k = probability of target kill (or defeat),

P_S = probability of ship survival at the kill level of interest,

$P_{S/D}$ = probability of ship survival given that the ASMD system causes damage to the target,

$P_{S/ND}$ = probability that the ship will survive given that the ASMD system does not damage the target (i.e., the inherent survivability of the ship), and

P_D = probability that the target is damaged.

Clearly, (4-1) implies an assessment of the RDS-2010 ship survivability is inherent in quantifying a weapon's system capability to defeat the ASM threat. This is not included in this report, though a goal of "zero hits" for the RDS-2010 is desired in response to the *Requirements for Regional Deterrence Ship (RDS) 2010* (Section II.B).

The ASM defensive range can be roughly divided into three zones as depicted in Figure 4-1. The long range defensive system for the RDS-2010 is the SM-1/2 and associated Fire Control System (FCS). In the long range intercept game plan, the ability of the ASM to penetrate to the vicinity of the ship after intercept by the long range system is indicative of a lack of a kill. Indeed, standard practice criterion for long range system target defeat is not only ship protection, but damage to the ASM such that ship protection is guaranteed to the point where no further weapons must be addressed to the target in question. This kind of damage requirement is used to conserve expensive and volume consuming long range weapons by allowing the FCS or kill assessment system to identify a target kill and address the next weapon to the next most threatening target.

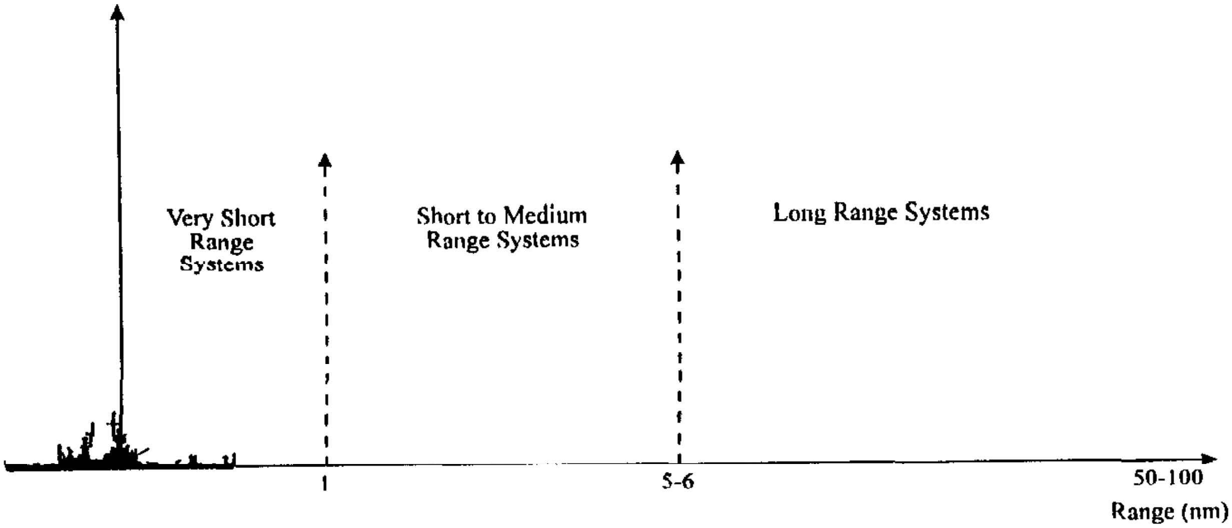

Figure 4-1. ASM Defensive Range

For short and medium range systems (SM-1/2 and RAM), the observable kill[¤] criterion does not apply. Evaluation of systems tests versus flying targets indicate that five to fifteen seconds are required in many cases to allow positive identification of a target kill, even under the classic catastrophic kill level. This means that for medium to short range systems, this time delay in kill identification may defeat the purpose of requiring observable kills. The defensive missile time-of flight (TOF), when coupled with the target speed, results in a very short second encounter requirement. Clearly, a shoot-shoot-look

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[¤] An observable kill is any damage to the ASM. Note that the characteristics of target reaction which is *observable* to the FCS or weapons assessment system is a function of the system performance criteria. For this reason, a more conservative evaluation of the required target damage observable to the kill assessment system is the *catastrophic kill* level (described as the classic nearly instantaneous breakup of the target).

engagement scenario is required in this situation. The required level of target damage produced for medium-to-short range encounters is considered to be at the catastrophic kill level.

For very short range ASMD (often known as "last-ditch" effort), the RDS-2010 employs the MK15 Phalanx system. In this scenario, even catastrophic target damage may not always protect the ship. Issues such as target speed, mass, and ship-to-target geometry at ranges under one nautical mile often couple to result in some level of ship damage from the debris of the destroyed ASM. Indeed, for very short range systems, the assessment of likelihood of own ship survival takes on a new meaning. The system must damage the incoming ASM such that either (1) it misses the defending ship by such a distance that upon water impact the air and water shocks produced by detonation of the warhead result in low probability of ship damage; or (2) target breakup occurs at such a range that the resultant particles either can not reach the ship or do not have a significant capability to produce ship damage upon impact.

The focus of this section of the report is the determination of *hit* and *kill* probabilities of incoming threats with the weapons systems employed on RDS-2010. The probability of hit, P_H, implies the likelihood that the kill mechanism or damage producing agent(s) employed by the defensive system interact with the target at some level of intensity. The actual methods to determine P_H by determining this level of intensity is beyond the scope of this discussion. Realize, however, that determination of P_H is comprised of inputs from such varied areas as target detection, tracking, fire control characteristics, pointing accuracy, weapon characteristics (ballistics, aerodynamics, etc.), reliability, maintainability, fuse characteristics, ECM environment, weather, target performance, and warhead characteristics. Fortunately, seldom do all these factors have to be considered simultaneously.

For the analysis conducted in this section, many gross simplifications are employed to allow solution of the problem with available data and techniques. The purpose of this phase of the design process is to delineate the basic analysis technique which is used for a "first-order" evaluation of the RDS-2010 combat system effectiveness against proposed scenarios. The remainder of the section is organized with a general procedural and calculation summary used for the analysis, followed by specific analysis of four threat scenarios. These scenarios were chosen to be representative of a diverse range of ASM threat situations that could likely be encountered based on the guideline contained in the *Requirements for Regional Deterrence Ship (RDS) 2010* (Section II.B). Finally, a summary of the results is presented with recommended weapon types and load out with supporting combat systems elements.

a. Assumptions

Of general note, the inbound target is assumed to be non-maneuvering, with exception of the terminal flight phase prior to impact. Also, a target hit is considered a kill.

(1) Radar Horizon

For the scenarios considered a conservative assumption is made that the radar horizon is 15 nautical miles at the surface. The radar horizon equation is given by:

$$rh = 1.667\left(\sqrt{H_{\text{target}}} + \sqrt{H_{\text{radar}}}\right) \qquad (4\text{-}2)$$

where: rh = radar horizon in nm,
H_{target} = height of target above surface in feet, and
H_{radar} = height of own radar above surface in feet.

Assuming a target height of zero feet and a 15 nautical mile radar horizon, (4-2) is solved for an own ship radar height of 81 feet. This is the minimum height for the surface search radar.

(2) Operational Arcs.

The ship's weapon and sensor systems are assumed to have a 360° clear arc of fire and detection capability[□].

(3) Combat System Readiness

It is assumed that the combat system is in a full readiness condition.

b. General Scenario Rules

To ascertain whether a particular threat can be engaged, the following ground rules are used:

(1) A minimum ten second time delay is assumed from time of detection to time of engagement. This time delay accounts for the lag in:

(a) processing and passing information from the search radar to the Fire Control System (FCS);

(b) the illuminator locating the target and passing information to the FCS; and

(c) the operator intervention occurring prior to the Weapon Control System (WCS) automatically launching the long range engagement weapon. If the operator fails to intervene within the allotted ten seconds, the ship can still command destruct the weapon.

(2) A delay of four seconds is used from the time-of-kill assessment to the time of weapon re-engagement.

c. Analysis.

The following assumptions, equations, and values were used to calculate the probabilities of kill, the probabilities of hits, and the expected number of hits.[□]

[□] It is understood that the 360° clear arc of fire and detection, and the 15 nm radar horizon are assumptions that will require modification once the ship's superstructure has been defined.

[□] The methodologies employed in this portion of the report are taken from a MIT Professional Summer Course entitled *Surface Ship Combat System Design Integration,* presented August 5-9 1991 at the Draper Laboratories in Cambridge, Mass.

(1) General

(a) Assume three basic self-defense systems are integral to the ship:

(i) missiles,

(ii) guns, and

(iii) jammers/decoys.

(b) Assume an incoming missile will ***not*** hit the ship if and only if at least one of the defensive systems is successful (i.e., the threat weapon will function as designed and will hit the ship unless explicitly defeated by own ship defensive systems).

(c) For the probability formulations, the following events are defined:

- ▶ Let A be the event that the defensive missile is successful.
- ▶ Let B be the event that a gun system is successful.
- ▶ Let C be the event that the incoming missile is decoyed/jammed.

(d) The cumulative probability that at ***least*** one system is successful against each incoming missile is described in general by the cumulative probability formula given by:

$$P(CUM) = 1 - \prod_{i=1}^{n} \left(1 - P_k(i)\right) \qquad (4\text{-}3a)$$

where: P(CUM) = cumulative probability of a kill by *n* kill mechanisms, and

$P_k(i)$ = probability that the $i^{\underline{th}}$ kill mechanism succeeded.

For the specific cases presented in this report with three kill-systems, the cumulative kill probability is given by:

$$P_{kill,threat\,i} = 1 - [1 - P(A)][1 - P(B)][1 - P(C)] \qquad (4\text{-}3b)$$

where: $P_{kill,threat\,i}$ = cumulative probability of defeating the $i^{\underline{th}}$ threat,

P(A) = probability that a defensive missile is successful,

$P(B)$ = probability that a gun is successful, and

$P(C)$ = probability that a jammer/decoy is successful.

(e) The probability that the ship will take a hit is given by:

$$P(\text{hit}) = 1 - \prod_{i=1}^{n} P_{\text{kill, threat } i} \quad (4\text{-}4)$$

(f) The expected number of hits is given by:

$$HT_{exp} = P(\text{hit}) \cdot m \quad (4\text{-}5)$$

where: m = the number of incoming threat missiles.

(2) Defensive Missile System Model

To determine the overall kill probability of the defensive missile system:

(a) assume one incoming missile;

(b) assume the defensive missile system has n chances (shots) at the incoming missile; and

(c) assume each shot has a kill probability of p.

In this case, a kill is assumed if intercept occurs. The overall kill probability of the defensive missile is given by:

$$P_{kill}(A) = 1 - (1 - p)^{n}. \quad (4\text{-}6)$$

(3) Defensive Gun System Model

To determine the overall kill probability of the defensive gun systems (Mk45 5"/54 and Mk15 Phalanx), the following general formulation is employed:

$$E_L = P_{kill}(A) = a\left\{1 - \prod_{i=1}^{N}\left[1 - P_L(i)\right]\right\}$$

where:

E_L = engagement effectiveness, (4-7)

a = System availability,

N = number of rounds or bursts fired, and

$P_L(i)$ = single-round or burst effectiveness of the i^{th} round or burst.

In this report, the engagement effectiveness is assumed to be the same as the kill probability, though it really only implies that the fire control solution was adequate to place the round where it was needed, not that it actually got there. Additionally, system availability, *a*, is assumed 100% when needed.

(a) Overall kill probability of the defensive gun system is range dependent.

(b) Number of rounds fired is a function of:

1) firing rate (*FR*);
2) burst duration (T_{burst});
3) size of magazine (number of rounds available);
4) maximum pre-programmed burst duration.

Overall kill probability of the Mk 15 Phalanx Close In Weapons System (CIWS) is dependent on the specific target. Variables such as attack profile, speed, and Radar Cross Section (RCS) impact the kill probability. No easy analytic solution exists that reasonably approximates the kill probability for a general case. Based on physical flight parameters and profiles, the RDS-2010 ASM threats listed in Table 4-1 are assigned the kill probabilities listed in Table 4-2.

TABLE 4-2. ASM THREAT PHALANX PKILL.

ASM Designation	*Phalanx P_{kill}*
TRASHER	0.3
TAKEOVER	0.85
SEAGULL	0.7
SUNSTROKE	0.5

These probabilities assume the target is engaged the entire effective range of Phalanx (0.81 to 0.05 nm).

The 5"/54 Mk 45 Naval Gun Mount with Mk 86 Gun Fire Control System (GFCS) firing an IR fused round has a single shot kill probability against a missile that is approximated by:

$$P_{kss} = 0.5\exp\left\{\frac{-R^4}{5}\right\}$$

where: (4-8a)

$P_{kss} =$ single-shot kill probability, and

$R =$ target range in nm.

A plot of (4-8a) is shown in Figure 4-2, which shows there is little reason to engage the 5"/54 gun on a missile target in excess of 2.5 nm range.

The engagement kill probability for the 5"/54 gun system would be given by:

$$P_{kill}(B) = 1 - \prod_{i=1}^{n}\left(1 - P_{kss}(n)\right)$$

where

$P_{kill}(B) =$ overall gun engagement kill probability (4-8b)

$P_{kss} =$ single shot kill probability

$n =$ number of rounds shot during engagement

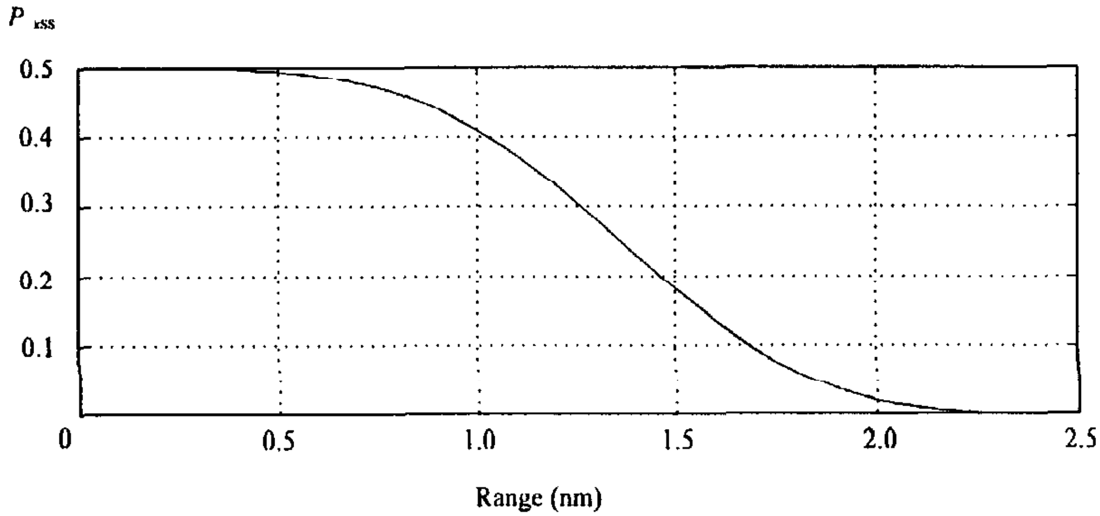

Figure 4-2. PkSS of 5"/54 Mk 45 Gun System with IR fused round.

(4) Jammer/Decoy System

The overall kill probability of the jammer/decoy systems onboard, P(*C*), is a function of several variables, including:

(a) equipment technical capabilities (hardware and software);

(b) tactical employment of both jammer and decoy systems; and

(c) environmental factors such as atmospheric conditions including wind currents, air density, particulate content, humidity, etc.

For the purpose of this analysis the probability of the jammer/ decoy systems obtaining a kill of the incoming threat missile is:

$$P(C) = 0.4 \quad . \tag{4-9}$$

The actual analysis to derive the number given by (4-9) is quite involved and beyond the scope of this report.

The scenarios are presented in a time line format, starting with time, $t = 0$ as the threat launch time, and positive values of time being the time of flight (TOF). The time line is run until all threats have theoretically impacted the ship. This method allows analysis or weapon system capabilities in terms of reaction times and capability of engaging all threats until time of impact. In reality, this gives a worst case scenario, since running the problem to impact assumes no defensive system defeated the inbound threat. Sizing the number of weapons/launchers/guns and FCS supporting hardware on this figure would lead to an overly conservative design.

A more realistic evaluation is accomplished using the cumulative kill probabilities as TOF increases. This gives a kill probability for each threat for each defensive event undertaken in time. Using this technique, assessment can be made of reasonable kill probability as the threat event progresses; e.g., a 99.9% kill probability will be achieved with six defensive missiles launched. These time-event cumulative probabilities are included on the timelines. This methodology will lead to a more realistic weapon loadout requirement.

2. SCENARIO I: Simultaneous launched high-altitude and sea skimming missiles

This scenario involves simultaneous launch of two threat missiles:

- *Takeover* (high altitude, terminal dive) missile launched at a range of 135 nautical miles on a relative bearing of 060°. This missile is designated *Threat A*.
- *Sunstroke* (10 meter sea skimmer) missile launched at a range of 40 nautical miles on a relative bearing of 120°. This missile is designated *Threat B*.

The launching platforms are two different air contacts which displayed no hostile intent prior to missile launch. Figure 4-3 depicts the scenario graphically along with missile flight profiles.

Using the formulations presented in the analysis section and the timeline Table 4-3, the following results are given:

a. *Threat A* encounter:

(1) Missile engagement (9 missiles - 6 SM-1/2, 3 RAM) -

by using (4-6) with n = 9 missiles and p = 0.7 (a typical value for defensive missile system against incoming missile threat):

$$\begin{aligned} P_{kill}(A) &= 1-(1-0.7)^9 \\ &= 0.999980 \end{aligned} \qquad (4\text{-}10)$$

(2) Mk 15 Phalanx CIWS engagement -

one 6.5 second burst that covers the entire effective range of the Phalanx yields , using Table 4-2, a kill probability of:

$$P_{kill} = 0.85 \quad .$$

(3) Mk 45 5"/54 Medium Caliber gun encounter - not used.

(4) Jamming and Decoy $P_{kill}(C)$ is given as 0.4 by (4-8).

The overall kill probability of *Threat A* is found by using (4-3) and the values found in (1) through (4) above:

$$P_{kill,Threat\,A} = 1 - [1 - 0.999980][1 - 0.85][1 - 0.4] \quad (4\text{-}11)$$
$$= .9999982 \quad .$$

Note the running cumulative probabilities in the right hand column of the *Threat A* encounter time line. The final value of 0.999997 does not include the Jamming and Decoy kill probability.

b. ***Threat B* encounter:**

(1) Missile engagement (6 missiles - 2 SM-1/2, 4 RAM) - using (4-6) with n = 6 missiles and p = 0.7:

$$P_{kill}(A) = 1-(1-0.7)^6 \quad (4\text{-}12)$$
$$= 0.99927$$

(2) Mk 15 Phalanx CIWS engagement -

one 6.5 second burst that covers the entire effective range of the Phalanx yields , using Table 4-2, a kill probability of:

$$P_{kill} = 0.5 \quad .$$

(3) Mk 45 5"/54 Medium Caliber gun encounter - not used.

(4) Jamming and Decoy $P_{kill}(C)$ is given as 0.4 by (4-8).

The overall kill probability of *Threat B* is found by using (4-3) and the values found in (1) through (4) above:

$$P_{kill,Threat\,B} = 1 - [1 - 0.99927][1 - 0.5][1 - 0.4] \quad (4\text{-}13)$$
$$= 0.999978 \quad .$$

Note the running cumulative probabilities in the right hand column of the *Threat B* encounter time line. The final value of 0.99964 does not include the Jamming and Decoy kill probability.

The probability that the ship will take a hit during this scenario is found using (4-4):

$$\begin{aligned} P(\mathrm{hit}) &= 1-[P_{\mathrm{kill,Threat\,A}}][P_{\mathrm{kill,Threat\,B}}] \\ &= 1-(0.9999982)(0.999978). \\ &= 23.8\mathrm{x}10^{-6} \end{aligned} \tag{4-14}$$

The expected number of hits is found using (4-5):

$$\begin{aligned} HT_{exp} &= \mathrm{P}(hit)\cdot m \\ &= (23.8 \times 10^{-6})\cdot 2 \\ &= 47.6 \times 10^{-6} \quad . \end{aligned} \tag{4-15}$$

c. Summary

To achieve a 99.9% kill probability of each threat indicates that the minimum combat system required is:

(1) 6 SM-2(ER)

(2) 2 SM-l(ER)

(3) 2 independent illuminators

(4) 4 RAM

(5) 1 CIWS mount

(6) ECM system

Additional requirements include a long range air search radar, a surface search radar, a missile FCS, and an integrated combat system.

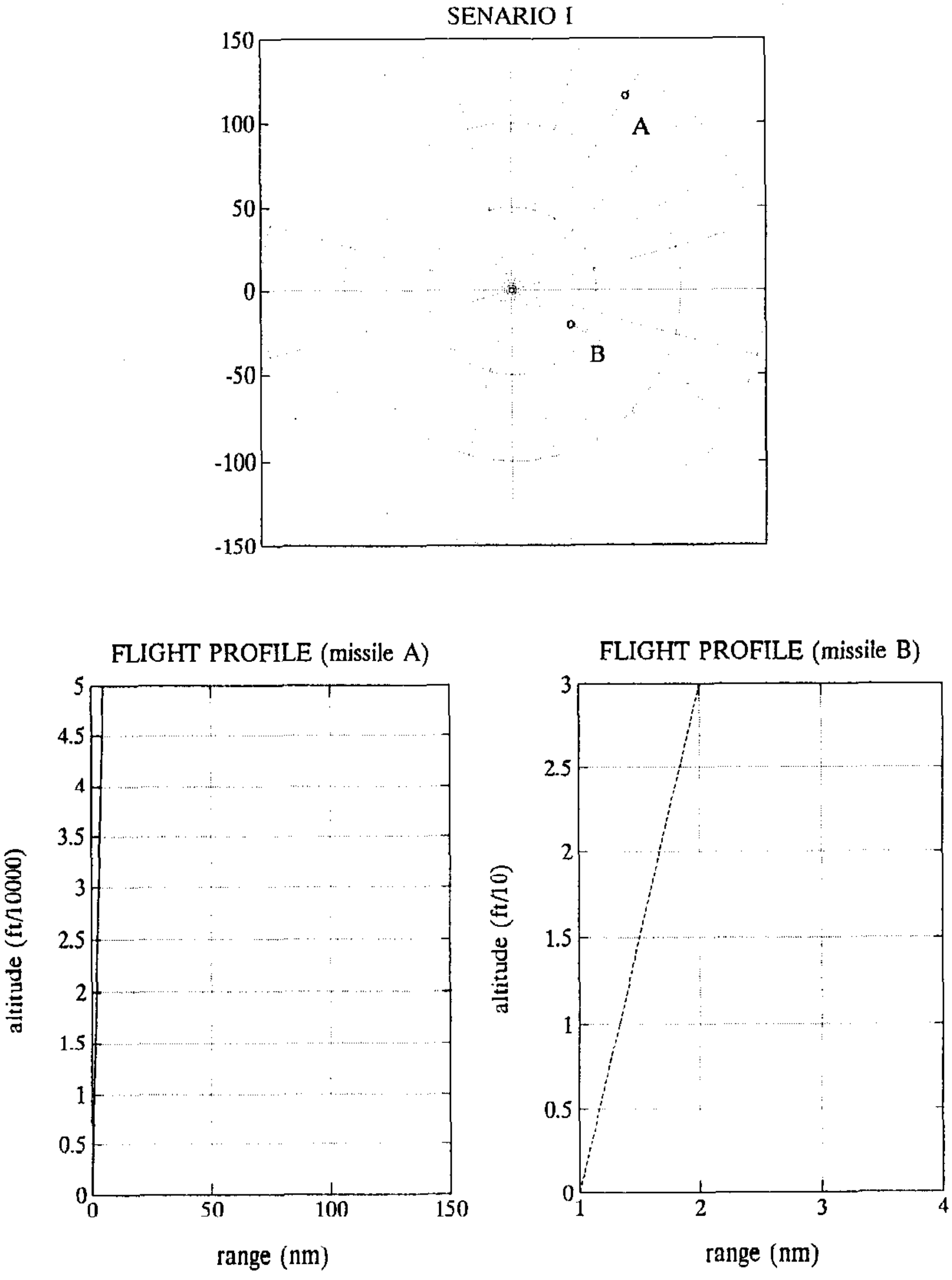

Figure 4-3. Scenario I.

TABLE 4-3. SCENARIO I.

Threat A, 'Takeover', v = 3.4 Ma, High Alt. Diver						
Time (sec)	Range (nm)	ASMD Weapon				Cumulative Kill Prob.
		SM-1/2	RAM	CIWS	5"/54	
0	135	Detect				
10	129.3	Lnch SM-2				0.7
14	127.1	Lnch SM-2				0.91
60	101.0					
70	95.3					
74	93.1					
76	91.9					
79	90.2					
83	88.0					
85	86.8					
87.1	85.6					
88.4	84.9					
89.5	84.3					
91.4	83.2					
93.9	81.8					
94.4	81.5					
95.2	81.1					
96	80.6					
91	83.4					
92	82.9					
93	82.3					
96	80.6					
141	55.1	Assess				
143	54.0	Assess				
147	51.7	Lnch SM-2				0.973
150	50.0	Lnch SM-2				0.9919
199	22.2	Assess				
200	21.7	Assess				
204	19.4	Lnch SM-2				0.997570
208	17.1	Lnch SM-2				0.9992710
214	13.7		Lnch			0.9997813
217	12.0		Lnch			0.999934
224	8.1	Assess				
225	7.5	Assess				
229	5.2		Assess			
230	4.7		Assess			
232	3.5			Eng 6.5 s		0.999990
233	3.0		Lnch			0.999997
236	1.3		Assess			
238.2	0.0	Impact				

Threat B, 'Sunstroke', v = 2.5 Ma, 10 meter skimmer						
Time (sec)	Range (nm)	ASMD Weapon				Cumulative Kill Prob.
		SM-1/2	RAM	CIWS	5"/54	
0	40					
10	35.8					
14	34.2					
60	15.0	Detect				
70	10.8	Lnch SM-1				0.7
74	9.2	Lnch SM-1				0.91
76	8.3		Lnch			0.97300
79	7.1		Lnch			0.99190
83	5.4	Assess				
85	4.6	Assess				
87.1	3.7		Assess			
88.4	3.2		Assess			
89.5	2.7			Eng 6.5s		0.99595
91.4	1.9		Lnch			0.99879
93.9	0.9		Assess			
94.4	0.7		Lnch			0.99964
95.2	0.3		Assess			
96	0.0	Impact				

3. SCENARIO II: Simultaneous launched sea skimming missiles

This scenario involves simultaneous launch of three threat missiles:

- *Sunstroke* (10 meter sea skimmer) missile launched at a range of 65 nautical miles on a relative bearing of 090°. This missile is designated *Threat A*.
- *Seagull* (15 meter sea skimmer) missile launched at a range of 15 nautical miles on a relative bearing of 210°. This missile is designated *Threat B.*
- *Sunstroke* (10 meter sea skimmer) missile launched at a range of 50 nautical miles on a relative bearing of 330°. This missile is designated *Threat C.*

The launching platforms are three different surface contacts which displayed no hostile intent prior to missile launch. Figure 4-4 depicts the scenario graphically along with missile flight profiles. Using the formulations presented in the analysis section and the timeline Table 4-5, the following results are given:

a. *Threat A* encounter:

(1) Missile engagement (6 missiles - 2 SM-1/2, 4 RAM) -

using (4-6) with n = 6 missiles and p = 0.7 (a typical value for defensive missile system against incoming missile threat):

$$\begin{aligned} P_{kill}(A) &= 1-(1-0.7)^6 \\ &= 0.99927 \end{aligned} \tag{4 16}$$

(2) Mk 15 Phalanx CIWS engagement -

one 4.0 second burst that covers the entire effective range of the Phalanx yields , using Table 4-2, a kill probability of:

$$P_{kill} = 0.5 \quad .$$

(3) Mk 45 5"/54 Medium Caliber gun encounter -

three rounds at ranges indicated on the time line giving a kill probability using (4-8) of:

$$P_{kill} = 0.52 \quad .$$

(4) Jamming and Decoy $P_{kill}(C)$ is given as 0.4 by (4-8).

The overall kill probability of *Threat A* is found by using (4-3) and the values found in (1) through (4) above:

$$P_{kill,Threat\,A} = 1 - [1 - 0.99927][1 - 0.5][1 - 0.52][1 - 0.4] \tag{4-17}$$

$$= 0.99989 \quad .$$

Note the running cumulative probabilities in the right hand column of the *Threat A* encounter time line. The final value of 0.9998 does not include the Jamming and Decoy kill probability.

b. ***Threat B* encounter:**

(1) Missile engagement (12 missiles - 4 SM-1/2, 8 RAM) -

using (4-6) with $n = 12$ missiles and $p = 0.7$:

$$\begin{aligned} P_{kill}(A) &= 1-(1-0.7)^{12} \\ &= 0.9999995 \end{aligned} \tag{4-18}$$

(2) Mk 15 Phalanx CIWS engagement -

one 6.5 second burst that covers the entire effective range of the Phalanx yields , using Table 4-2, a kill probability of:

$$P_{kill} = 0.7 \quad .$$

(3) Mk 45 5"/54 Medium Caliber gun encounter -

38 rounds, with approximately one round fired every 3 seconds starting at a range of 13.8 nm as indicated on the time line. The kill probability using (4-8) is:

$$P_{kill} = 0.934 \quad .$$

(4) Jamming and Decoy $P_{kill}(C)$ is given as 0.4 by (4-8).

The overall kill probability of *Threat B* is found by using (4-3) and the values found in (1) through (4) above:

$$P_{kill,ThreatB} = 1 - [1 - 0.9999995][1 - 0.7][1 - 0.934][1 - 0.4] \qquad (4\text{-}19)$$
$$= 0.999999993 \quad .$$

Note the running cumulative probabilities in the right hand column of the *Threat B* encounter time line. The final value of 0.99999988 does not include the Jamming and Decoy kill probability.

c. *Threat* C encounter:

(1) Missile engagement (5 missiles - 1 SM-1/2, 4 RAM) - using (4-6) with $n = 5$ missiles and $p = 0.7$:

$$\begin{aligned} P_{kill}(A) &= 1-(1-0.7)^5 \\ &= 0.9976 \end{aligned} \qquad (4\text{-}20)$$

(2) Mk 15 Phalanx CIWS engagement -

one 6.5 second burst that covers the entire effective range of the Phalanx yields , using Table 4-2, a kill probability of:

$$P_{kill} = 0.5 \quad .$$

(3) Mk 45 5"/54 Medium Caliber gun encounter - not used.

(4) Jamming and Decoy $P_{kill}(C)$ is given as 0.4 by (4-8).

The overall kill probability of *Threat C* is found by using (4-3) and the values found in (1) through (4) above:

$$P_{kill,ThreatC} = 1 - [1 - 0.9976][1 - 0.5][1 - 0.4] \qquad (4\text{-}21)$$
$$= 0.99927 \quad .$$

Note the running cumulative probabilities in the right hand column of the *Threat C* encounter time line. The final value of 0.9988 does not include the Jamming and Decoy kill probability.

The probability that the ship will take a hit during this scenario is found using (4-4):

$$\begin{aligned} P(\text{hit}) &= 1-[P_{\text{kill,Threat A}}][P_{\text{kill,Threat B}}][P_{\text{kill,Threat C}}] \\ &= 1-(0.99989)(0.999999993)(0.99927) \\ &= 840\text{x}10^{-6} \end{aligned} \tag{4-22}$$

The expected number of hits is found using (4-5):

$$\begin{aligned} HT_{exp} &= \text{P}(hit)\cdot m \\ &= (840 \text{ x } 10^{-6})\cdot 3 \\ &= 2.52 \text{ x } 10^{-3} \ . \end{aligned} \tag{4-23}$$

d. Summary

To achieve a 99.9% kill probability of each threat indicates that the minimum combat system required is:

(1) 7 SM-1(ER)

(2) 2 independent illuminators

(3) 10 RAM

(4) 2 CIWS mount

(5) 1 5"/54 gun mount

(6) ECM system

Additional requirements include a long range air search radar, a surface search radar, a missile FCS, and an integrated combat system.

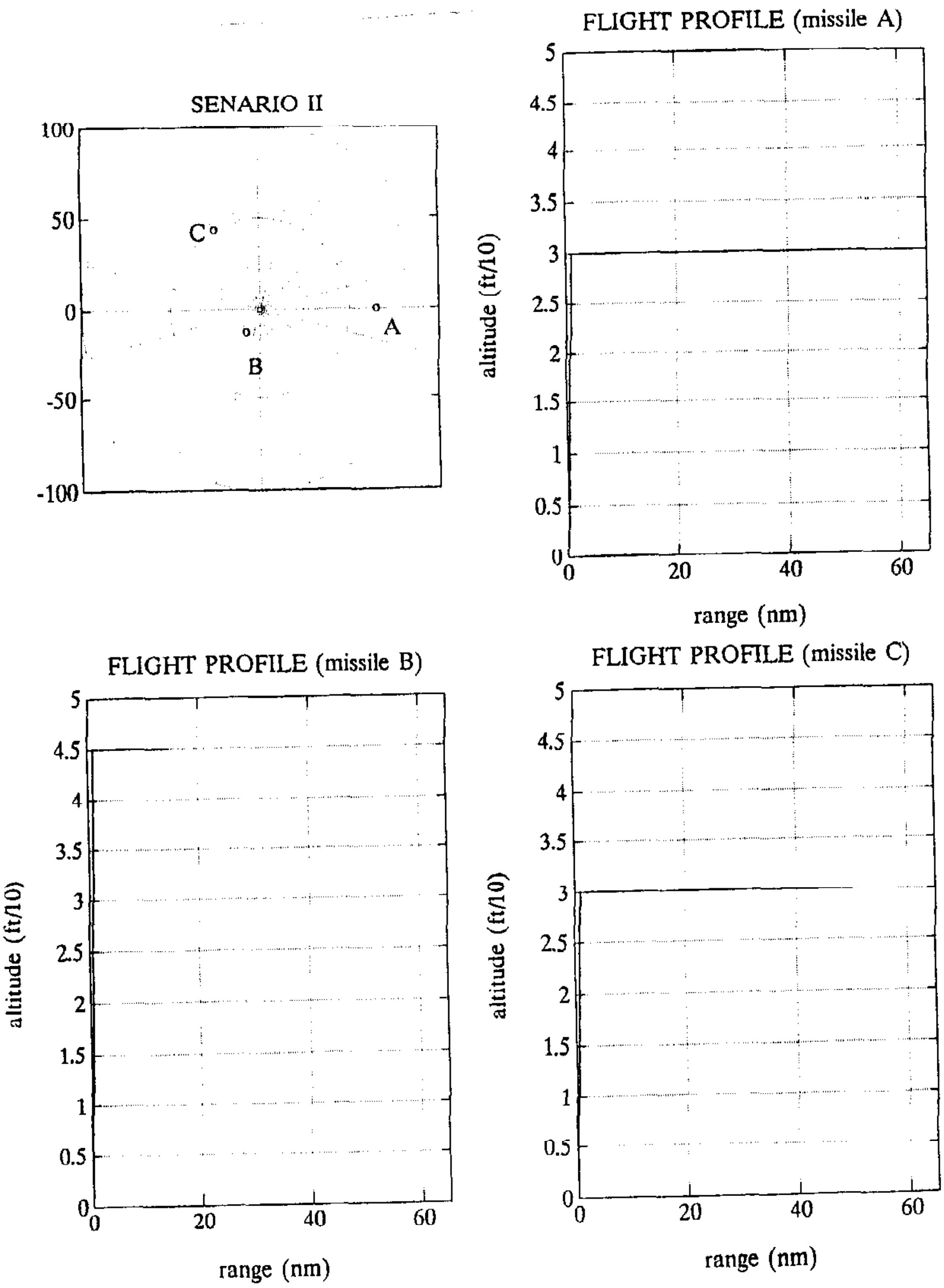

Figure 4-4. Scenario II.

TABLE 4-4. SCENARIO II.

Threat A 'Sunstroke', v=2.5 Ma, 10 meter skimmer						
Time	Range	ASMD Weapon				Cumulative
(sec)	(nm)	SM-1/2	RAM	CIWS	5"/54	Kill Probability
0	65					
10	60.8					
14	59.2					
35	50.4					
39	48.8					
43	47.1					
47	45.4					
53	42.9					
57	41.3					
65	37.9					
68	36.7					
78	32.5					
80	31.7					
83	30.4					
86	29.2					
88	28.3					
89	27.9					
91	27.1					
92	26.7					
95	25.4					
96	25.0					
97	24.6					
98	24.2					
100	23.3					
101	22.9					
104	21.7					
106	20.8					
106.7	20.5					
107	20.4					
108	20.0					
109	19.6					
109.3	19.5					
110	19.2					
122.6	13.9	Detect				
112	18.3					
113	17.9					
114	17.5					
115	17.1					
116	16.7					
117.8	15.9					
119.5	15.2					
120	15.0					
122.5	14.0					
122	14.2					
121.5	14.4					
124.5	13.1					
128.5	11.5					
131.6	10.2	Lnch SM-1	Lnch			0.91
134.6	8.9		Lnch			0.973
135.6	8.5	Lnch SM-1				0.9919
144.6	4.8	Assess				
145.6	4.3		Assess			
148.5	3.1	Assess	Assess		1 rnd	0.9979
151.6	1.8		Lnch	Eng 4.0s	1 rnd	0.9988
154.1	0.8		Assess			
154.6	0.6		Lnch		1 rnd	0.9998
156	0.0	Impact		▼		

Threat B 'Seagull', v= 0.7 Ma, 15 meter skimmer						
Time	Range	ASMD Weapon				Cumulative
(sec)	(nm)	SM-1/2	RAM	CIWS	5"/54	Kill Probability
0	15	Detect				
10	13.8	Lnch SM-1			10 rnds	0.7
14	13.4	Lnch SM-1				0.91
35	10.9	Assess				
39	10.5	Assess			▼	
43	10.0	Lnch SM-1			1 rnd	0.973
47	9.5	Lnch SM-1			1 rnd	0.9919
53	8.8	Assess			1 rnd	
57	8.4	Assess			3 rnds	
65	7.4		Lnch		▼	0.9976
68	7.1		Lnch		5 rnds	0.9993
78	5.9					
80	5.7		Assess		▼	
83	5.3		Assess		1 rnd	
86	5.0		Lnch		1 rnd	0.9998
88	4.7				1 rnd	
89	4.6		Lnch			0.99993
91	4.4				1 rnd	
92	4.3					
95	3.9		Assess		1 rnd	
96	3.8					
97	3.7					
98	3.6		Assess		1 rnd	
100	3.3				1 rnd	
101	3.2		Lnch			0.99998
104	2.9		Lnch		1 rnd	0.999994
106	2.6		Assess			
106.7	2.6				1 rnd	0.999994
107	2.5					
108	2.4					
109	2.3		Assess		1 rnd	0.999994
109.3	2.2					
110	2.2					
111	2.1				1 rnd	0.999994
112	1.9					
113	1.8					
114	1.7				1 rnd	0.999995
115	1.6					
116	1.5				1 rnd	0.999996
117.8	1.3					
119.5	1.1		Lnch		1 rnd	0.999997
120	1.0					
121.5	0.8		Assess		1 rnd	0.9999985
122	0.8			Eng 6.5s		0.9999996
122.5	0.7		Lnch		1 rnd	0.9999998
124.5	0.5		Assess		1 rnd	0.99999988
128.5	0.0	Impact		▼		

Threat C 'Sunstroke', v=2.5 Ma, 10 meter skimmer						
Time	Range	ASMD Weapon				Cumulative
(sec)	(nm)	SM-1/2	RAM	CIWS	5"/54	Kill Probability
0	50					
10	45.8					
14	44.2					
35	35.4					
39	33.8					
43	32.1					
47	30.4					
53	27.9					
57	26.3					
65	22.9					
68	21.7					
78	17.5					
80	16.7					
83	15.4	Detect				
86	14.2					
88	13.3					
89	12.9					
91	12.1					
93	11.3		Lnch			0.7
95	10.4					
96	10.0		Lnch			0.91
97	9.6					
98	9.2					
100	8.3					
101	7.9					
104	6.7					
106	5.8					
106.7	5.5					
107	5.4					
108	5.0		Assess			
109	4.6		Assess			
109.3	4.5					
110	4.2					
111	3.8					
112	3.3		Lnch			0.973
113	2.9	Lnch SM-1		Eng 6.5 s		0.9960
114	2.5					
115	2.1		Lnch			0.9988
116.4	1.5	Assess	Assess			
117.8	0.9		Assess			
119.5	0.2					
120	0.0	Impact		▼		

4. SCENARIO III: Two simultaneous launched mobile sea skimming missiles and a delay launched sea skimming missile

This scenario involves simultaneous launch of three threat missiles:

- *Seagull* (15 meter sea skimmer) missile launched at a range of 15 nautical miles on a relative bearing of 030° at time $t = 0s$. This missile is designated *Threat A*.
- *Seagull* (15 meter sea skimmer) missile launched at a range of 10 nautical miles on a relative bearing of 150° at time $t = 0s$. This missile is designated *Threat B*.
- *Sunstroke* (10 meter sea skimmer) missile launched at a range of 20 nautical miles on a relative bearing of 320° at time $t = 10s$. This missile is designated *Threat C*.

The *Seagull* launching platforms are two different surface contacts (fishing craft) which displayed no hostile intent prior to missile launch. These fishing craft were hidden amongst other fishing craft, making them impossible to distinguish. The *Sunstroke* missile is launched ten seconds after the two *Seagull* missiles from a surface contact which was being closely monitored. Figure 4-5 depicts the scenario graphically along with missile flight profiles.

Using the formulations presented in the analysis section and the timeline Table 4-6, the following results are given:

a. *Threat A* encounter:

(1) Missile engagement (12 missiles - 4 SM-1, 8 RAM) - using (4-6) with $n = 12$ missiles and $p = 0.7$:

$$\begin{aligned} P_{kill}(A) &= 1-(1-0.7)^{12} \\ &= 0.99999946 \end{aligned} \tag{4-24}$$

(2) Mk 15 Phalanx CIWS engagement -

one 6.5 second burst that covers the entire effective range of the Phalanx yields, using Table 4-2, a kill probability of:

$$P_{kill} = 0.7 \quad .$$

(3) Mk 45 5"/54 Medium Caliber gun encounter - not used.

(4) Jamming and Decoy $P_{kill}(C)$ is given as 0.4 by (4-8).

The overall kill probability of *Threat A* is found by using (4-3) and the values found in (1) through (4) above:

$$\begin{aligned} P_{kill,Threat\,A} &= 1 - [1 - 0.99999946][1 - 0.7][1 - 0.4] \\ &= 0.99999990 \quad . \end{aligned} \tag{4-25}$$

Note the running cumulative probabilities in the right hand column of the *Threat A* encounter time line. The final value of 0.999999841 does not include the Jamming and Decoy kill probability.

b. ***Threat B* encounter:**

(1) Missile engagement (10 missiles - 2 SM-1, 8 RAM) -

using (4-6) with $n = 10$ missiles and $p = 0.7$:

$$\begin{aligned} P_{kill}(A) &= 1-(1-0.7)^{10} \\ &= 0.999994 \end{aligned} \tag{4-26}$$

(2) Mk 15 Phalanx CIWS engagement -

one 6.5 second burst that covers the entire effective range of the Phalanx yields, using Table 4-2, a kill probability of:

$$P_{kill} = 0.7 \quad .$$

(3) Mk 45 5"/54 Medium Caliber gun encounter -

7 rounds, with approximately one round fired every 3 seconds starting at a range of 2.5 nm as indicated on the time line. The kill probability using (4-8) is:

$$P_{kill} = 0.8749 \quad .$$

(4) Jamming and Decoy $P_{kill}(C)$ is given as 0.4 by (4-8).

The overall kill probability of *Threat B* is found by using (4-3) and the values found in (1) through (4) above:

$$P_{kill,ThreatB} = 1 - [1 - 0.999994][1 - 0.7][1 - 0.8749[1 - 0.4] \qquad (4\text{-}27)$$
$$= 0.9999999 \quad .$$

Note the running cumulative probabilities in the right hand column of the *Threat B* encounter time line. The final value of 0.9999998 does not include the Jamming and Decoy kill probability.

c. ***Threat C* encounter:**

(1) Missile engagement (4 RAM) -

using (4-6) with $n = 4$ missiles and $p = 0.7$:

$$\begin{aligned} P_{kill}(A) &= 1-(1-0.7)^4 \\ &= 0.9919 \end{aligned} \qquad (4\text{-}28)$$

(2) Mk 15 Phalanx CIWS engagement -

one 6.5 second burst that covers the entire effective range of the Phalanx yields , using Table 4-2, a kill probability of:

$$P_{kill} = 0.5 \quad .$$

(3) Mk 45 5"/54 Medium Caliber gun encounter - not used.

(4) Jamming and Decoy $P_{kill}(C)$ is given as 0.4 by (4-8).

The overall kill probability of *Threat C* is found by using (4-3) and the values found in (1) through (4) above:

$$P_{kill,ThreatC} = 1 - [1 - 0.9919][1 - 0.5][1 - 0.4] \qquad (4\text{-}29)$$
$$= 0.9976 \quad .$$

Note the running cumulative probabilities in the right hand column of the *Threat B* encounter time line. The final value of 0.99595 does not include the Jamming and Decoy kill probability.

The probability that the ship will take during this scenario is found using (4-4):

$$\begin{aligned} P(\text{hit}) &= 1-[P_{\text{kill,Threat A}}][P_{\text{kill,Threat B}}][P_{\text{kill,Threat C}}] \\ &= 1-(0.99999990)(0.9999999)(0.9976) \qquad (4\text{-}30) \\ &= 2.4\text{x}10^{-3} \end{aligned}$$

The expected number of hits is found using (4-5):

$$\begin{aligned} HT_{exp} &= \mathrm{P}(hit)\cdot m \qquad (4\text{-}31) \\ &= (2.4 \text{ x } 10^{-3})\cdot 3 \\ &= 7.2 \text{ x } 10^{-3} \end{aligned}$$

d. Summary

A 99.9% kill probability of each threat is not possible due to *Threat C* kill probability of only 99.76%. To achieve 99.9% kill probability on *Threat A* and *Threat B*, and a 99.76 kill probability on *Threat C* indicates that the minimum combat system required is:

(1) 6 SM-1(ER)

(2) 2 independent illuminators

(3) 11 RAM

(4) 1 CIWS mount

(5) ECM system

Additional requirements include a long range air search radar, a surface search radar, a missile FCS, and an integrated combat system.

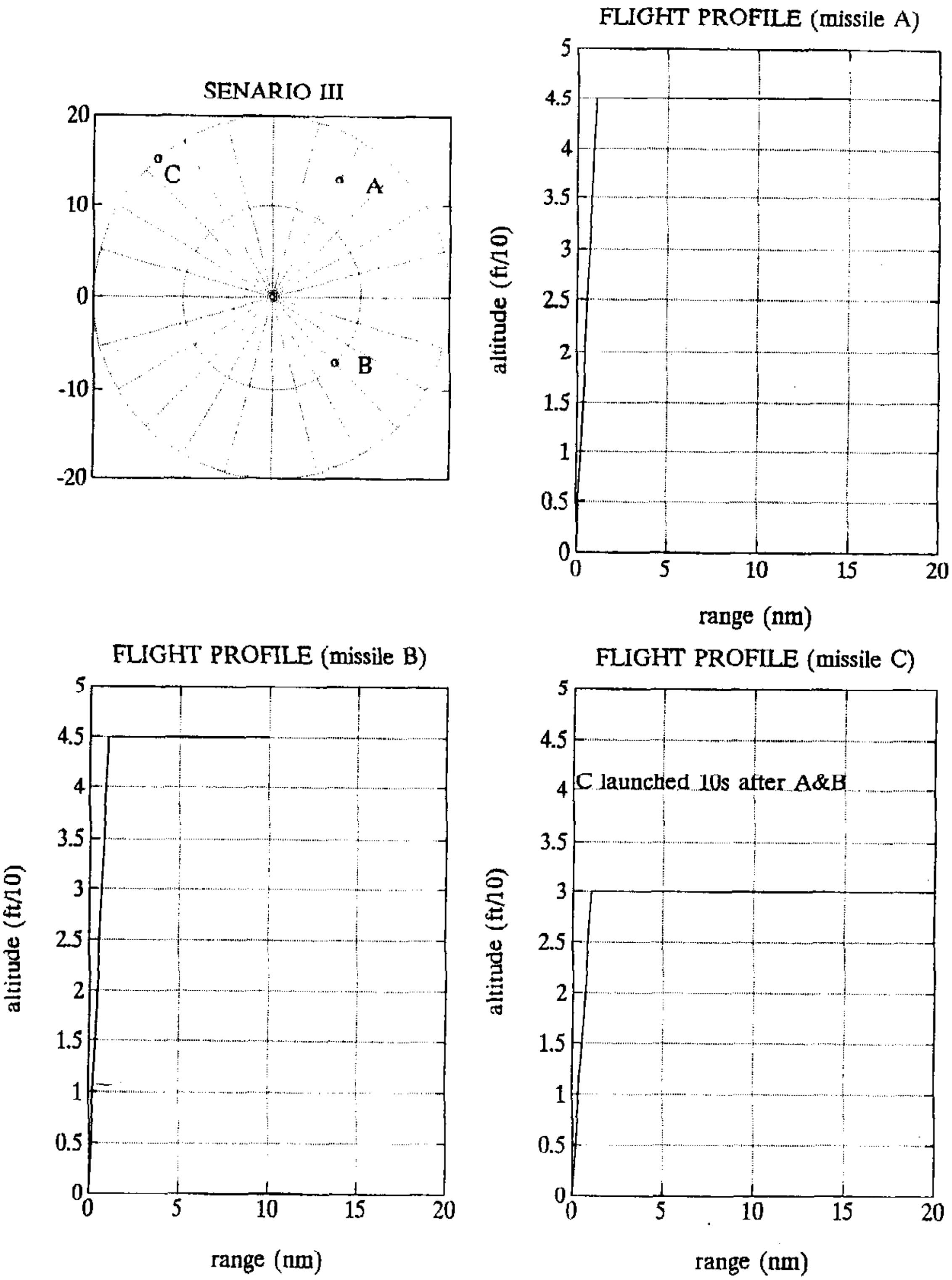

Figure 4-5. Scenario III.

TABLE 4-5. SCENARIO III.

Threat A 'Sunstroke', v=2.5 Ma, 10 meter skimmer						
Time	Range	ASMD Weapon				Cumulative
(sec)	(nm)	SM-1/2	RAM	CIWS	5"/54	Kill Probability
0	65					
10	60.8					
14	59.2					
35	50.4					
39	48.8					
43	47.1					
47	45.4					
53	42.9					
57	41.3					
65	37.9					
68	36.7					
78	32.5					
80	31.7					
83	30.4					
86	29.2					
88	28.3					
89	27.9					
91	27.1					
92	26.7					
95	25.4					
96	25.0					
97	24.6					
98	24.2					
100	23.3					
101	22.9					
104	21.7					
106	20.8					
106.7	20.5					
107	20.4					
108	20.0					
109	19.6					
109.3	19.5					
110	19.2					
122.6	13.9	Detect				
112	18.3					
113	17.9					
114	17.5					
115	17.1					
116	16.7					
117.8	15.9					
119.5	15.2					
120	15.0					
122.5	14.0					
122	14.2					
121.5	14.4					
124.5	13.1					
128.5	11.5					
131.6	10.2	Lnch SM-1	Lnch			0.91
134.6	8.9		Lnch			0.973
135.6	8.5	Lnch SM-1				0.9919
144.6	4.8	Assess				
145.6	4.3		Assess			
148.6	3.1	Assess	Assess		1 rnd	0.9919
151.6	1.8		Lnch	Eng 4.0s	1 rnd	0.9988
154.1	0.8		Assess			
154.6	0.6		Lnch		1 rnd	0.9998
156	0.0	Impact		▼		

Threat B 'Seagull', v=0.7 Ma, 15 meter skimmer						
Time	Range	ASMD Weapon				Cumulative
(sec)	(nm)	SM-1/2	RAM	CIWS	5"/54	Kill Probability
0	15	Detect				
10	13.8	Lnch SM-1			10 rnds	0.7
14	13.4	Lnch SM-1				0.91
35	10.9	Assess				
39	10.5	Assess			▼	
43	10.0	Lnch SM-1			1 rnd	0.973
47	9.5	Lnch SM-1			1 rnd	0.9919
53	8.8	Assess			1 rnd	
57	8.4	Assess			3 rnds	
65	7.4		Lnch		▼	0.9976
68	7.1		Lnch		5 rnds	0.9993
78	5.9					
80	5.7		Assess		▼	
83	5.3		Assess		1 rnd	
86	5.0		Lnch		1 rnd	0.9998
88	4.7				1 rnd	
89	4.6		Lnch			0.99993
91	4.4				1 rnd	
92	4.3					
95	3.9		Assess		1 rnd	
96	3.8					
97	3.7					
98	3.6		Assess		1 rnd	
100	3.5				1 rnd	
101	3.2		Lnch			0.99998
104	2.9		Lnch		1 rnd	0.999994
106	2.6		Assess			
106.7	2.6				1 rnd	0.999994
107	2.5					
108	2.4					
109	2.3		Assess		1 rnd	0.999994
109.3	2.2					
110	2.2					
111	2.1				1 rnd	0.999994
112	1.9					
113	1.8					
114	1.7				1 rnd	0.999995
115	1.6					
116	1.5				1 rnd	0.999996
117.8	1.3					
119.5	1.1		Lnch		1 rnd	0.999997
120	1.0					
121.5	0.8		Assess		1 rnd	0.9999985
122	0.8			Eng 6.5s		0.9999996
122.5	0.7		Lnch		1 rnd	0.9999998
124.5	0.5		Assess		1 rnd	0.99999988
128.5	0.0	Impact		▼		

Threat C 'Sunstroke', v=2.5 Ma, 10 meter skimmer						
Time	Range	ASMD Weapon				Cumulative
(sec)	(nm)	SM-1/2	RAM	CIWS	5"/54	Kill Probability
0	50					
10	45.8					
14	44.2					
35	35.4					
39	33.8					
43	32.1					
47	30.4					
53	27.9					
57	26.3					
65	22.9					
68	21.7					
78	17.5					
80	16.7					
83	15.4	Detect				
86	14.2					
88	13.3					
89	12.9					
91	12.1					
93	11.3		Lnch			0.7
95	10.4					
96	10.0		Lnch			0.91
97	9.6					
98	9.2					
100	8.3					
101	7.9					
104	6.7					
106	5.8					
106.7	5.5					
107	5.4					
108	5.0		Assess			
109	4.6		Assess			
109.3	4.5					
110	4.2					
111	3.8					
112	3.3		Lnch			0.973
113	2.9	Lnch SM-1		Eng 6.5 s		0.9960
114	2.5					
115	2.1		Lnch			0.9988
116.4	1.5	Assess	Assess			
117.8	0.9		Assess			
119.5	0.2					
120	0.0	Impact		▼		

5. SCENARIO IV: Simultaneous launch of shoulder missiles

This scenario involves simultaneous launch of two shoulder fired threat missiles:

- *Stinger* (shoulder mounted, IR home) missile launched at a range of 1.5 nautical miles on a relative bearing of 300°. This missile is designated *Threat A*.
- *Stinger* (shoulder mounted, IR home) missile launched at a range of 2.0 nautical miles on a relative bearing of 130°. This missile is designated *Threat B*.

The *Stinger* launches occur simultaneously from two different pleasure craft which displayed no hostile intent prior to missile launch. Figure 4-6 depicts the scenario graphically along with missile flight profiles.

Using the formulations presented in the analysis section and the timeline Table 4-6, the following results are given:

a. *Threat A* encounter:

(1) Missile engagement - none

(2) Mk 15 Phalanx CIWS engagement -

one 3.5 second burst that covers the entire effective range of the Phalanx. A kill probability for the *Stinger* is estimated to be about 0.3 due to the small size of the missile and short reaction time:

$$P_{kill} = 0.3 \quad .$$

(3) Mk 45 5"/54 Medium Caliber gun encounter - not used.

(4) Jamming and Decoy $P_{kill}(C)$ is considered ineffective for this scenario.

The overall kill probability of *Threat A* is found by using (4-3) and the values found in (1) through (4) above:

$$P_{kill,Threat\,A} = 1 - [1 - 0.3] \qquad (4\text{-}11)$$
$$= 0.3 \quad .$$

b. *Threat B* encounter:

(1) Missile engagement - not used.

(2) Mk 15 Phalanx CIWS engagement -

one 5.0 second burst that covers the entire effective range of the Phalanx. A kill probability for the *Stinger* is estimated to be about 0.4 due to the small size of the missile, but there is slightly longer reaction time as compared to Paragraph IV.B.5.a above: $P_{kill} = 0.4$.

(3) Mk 45 5"/54 Medium Caliber gun encounter - not used.

(4) Jamming and Decoy $P_{kill}(C)$ is considered ineffective for this scenario.

The overall kill probability of *Threat B* is found by using (4-3) and the values found in (1) through (4) above:

$$\begin{aligned} P_{kill,threat\ a} &= 1 - [1 - 0.4] \\ &= 0.4 \quad . \end{aligned} \tag{4-13}$$

The probability that the ship will take a hit during this scenario is found using (4-4):

$$\begin{aligned} \mathrm{P(hit)} &= 1 - [\mathrm{P_{kill,Threat\ A}}][\mathrm{P_{kill,Threat\ B}}] \\ &= 1 - (0.3)(0.4) \\ &= 0.88 \end{aligned} \tag{4-14}$$

The expected number of hits is found using (4-5):

$$\begin{aligned} HT_{exp} &= \mathrm{P}(hit)\cdot m \\ &= (0.88)\cdot 2 \\ &= 1.76 \quad . \end{aligned} \tag{4-15}$$

c. Summary

The minimum combat system required is:

(1) 2 CIWS mount

Additional requirements include a surface search radar and an integrated combat system.

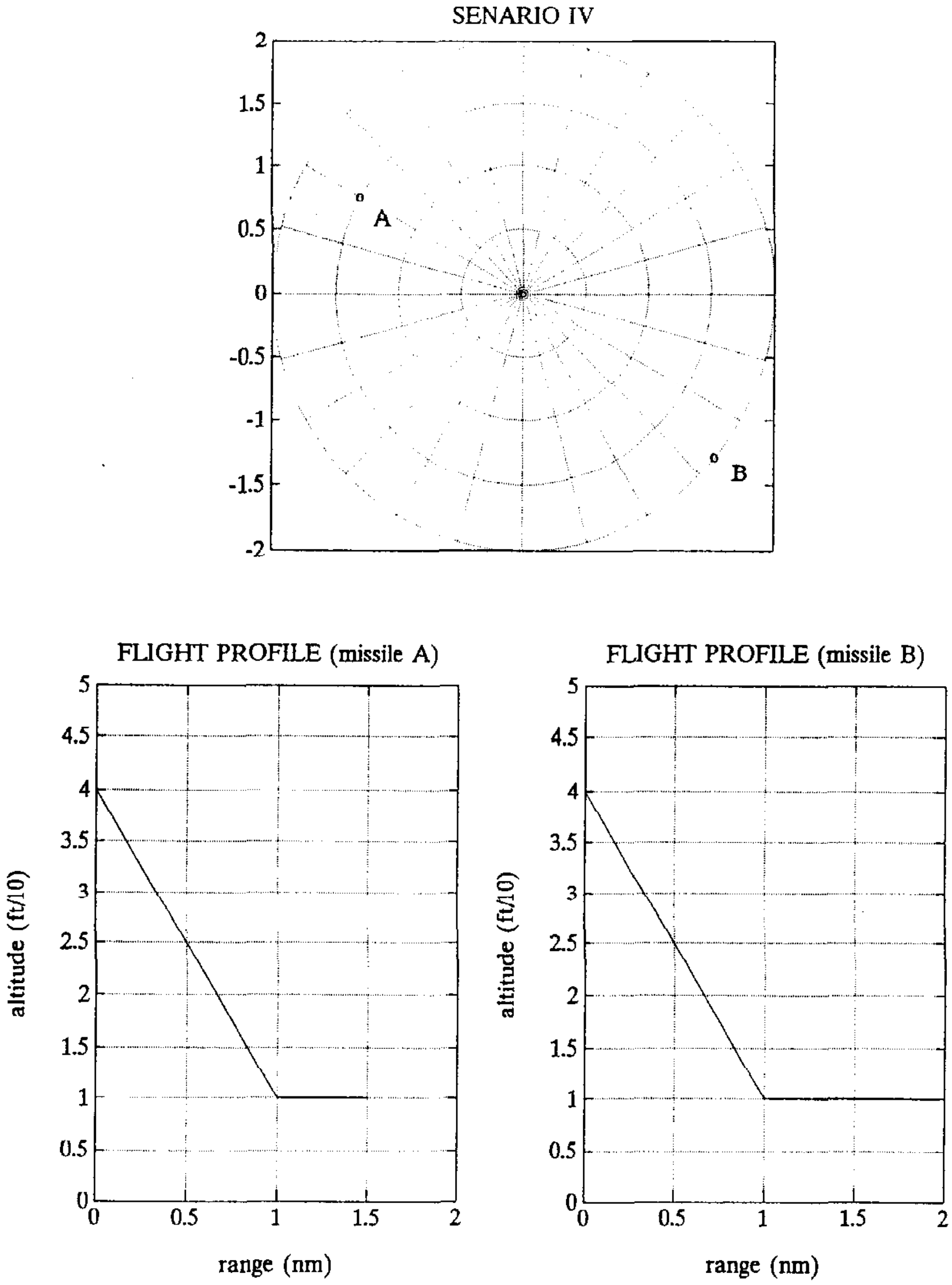

Figure 4-6. Scenario IV.

Table 4-6. Scenario IV.

Threat A, 'Stinger', v = 2.0 Ma, Heat seeker						
Time	Range	ASMD Weapon				Cumulative
(sec)	(nm)	SM-1/2	RAM	CIWS	5"/54	Kill Prob.
0	1.5					
1	1.2			Eng 3.5s		0.3
2	0.8					
3	0.5					
4	0.2					
4.5	0.0	**Impact**				

Threat B, 'Stinger', v = 2.0 Ma, Heat seeker						
Time	Range	ASMD Weapon				Cumulative
(sec)	(nm)	SM-1/2	RAM	CIWS	5"/54	Kill Prob.
0	2					
1	1.7			Eng 5.0 s		0.4
2	1.3					
3	1.0					
4	0.7					
5	0.3					
6	0.0	**Impact**				

6. SUMMARY:

Based on the four outlined scenarios, the following minimum number of systems and items will be incorporated into the initial design of the RDS-2010:

a. A combat system consisting of the following engagement elements will be used:

- 24 cell VLS (VLS loadout as required by mission)
- 2 RALS (Ram Alternate Launcher System)
- 2 MK 15 PHALANX
- 1 5"/54 MK 45 GUN MOUNT w/ FCS
- 2 SPG-XX ILLUMINATORS
- 1 SLQ-32(V3) w/ 2 DECOY LAUNCHERS
- 1 LONG RANGE AIR SEARCH RADAR
- 1 SURFACE SEARCH RADAR

b. The ship must be able to sustain a hit from a STINGER size missile and maintain mission capabilities.

c. Although the scenarios, as presented, would imply no requirement for the SAR-8 IR sensing system, the weakest defensive capability lies in the short range, hand-launched missile system (STINGER types). Research needs to be accomplished in the area of quick-reaction detection of a missile launch and autonomous defeat of the weapon. This is envisioned as some type of automatic flare system coupled to a sensor like the SAR-8. Immediately on detection of missile launch, a flare-type decoy would be deployed to draw the missile away from the ship. This flare will have to be propelled along a predetermined flight path to allow the missile to lock-in on it and then be drawn away from the ship. Another area in which research is required is active IR emissions for disabling the missile seeker, by overload or deception.

C. COMBAT SYSTEM DESCRIPTION AND ARCHITECTURE

1. Design Statement

The RDS-2010 Combat System and supporting elements are designed to meet the requirements delineated in Section II.B. Specifically, the combat system must:

a. provide AAW self-defense against limited intensity/direction threats;

b. provide ASUW against third-world surface naval forces;

c. provide ASW in deep and shallow water while employed independently;

d. support amphibious assaults;

e. attack high value land based military targets;

f. receive real time targeting information from diverse sources; and

g. operate in mine infested waters.

These requirements and the evaluation of threat scenarios (Section IV.B) confirmed and refined the combat system element selection (Section III.C.4).

2. Top Level Design Goals

Based on the above requirements, the top level combat system design goals are:

a. self-defense;

b. discriminate targets to minimize unwanted damage;

c. fight hurt--minimize damage by effective assessment and rapid restoration;

d. continuous high readiness for extended periods;

e. self-sufficient-capable of independent or small group operations;

f. improved anti-terrorist security;

g. improved counter targeting through decoys and deception devices;

h. built in automatic reconfigurability of ship's systems based on evolving threat scenario/condition;

i. built in fault identification with rapid repair capability; and

j. combat system automation with preset options for layered self-defense.

3. Combat System Description and Capability

Figure 4-7 depicts the functional arrangement of the RDS-2010 combat system, including major data flow connectivity. General design attributes include:

a. Primary connectivity between elements is provided by a multi-channel, multi-redundant fiber optic ring bus. Envisioned is a minimum of five functionally redundant data buses geographically separated within the ship to decrease vulnerability. Each system has multiple channel capacity and each channel has the capability to carry multiplexed data. Determination of data types and flow that allow use of multiplexing vice dedicated channels must be determined during detailed combat system design. As a minimum, each ship enclave contains one *bus manager* to ensure surviving enclaves have data bus capability. The application of the Fiber Optic Data Multiplexing System (FODMS) and Fiber Optic Interior Voice Communications System (FOIVCS) improves capability and enhances survivability while reducing ship acquisition cost, primarily via the associated weight and volume savings.

b. Two manned Command and Decision (C&D) elements (i.e., Combat Information Center - CIC) are provided, one acting as the ship's primary CIC (CIC #1) and the other an alternate CIC (CIC #2). Functional redundancy is provided between these two C&D elements, though actual hardware, layout, and number of operator stations is scaled down in CIC #2. The two CICs are located in separate enclaves. The C&D element utilized the available sensors and external information data stream to provide the necessary information to create a complete tactical picture. The computer processing power required by all modules of the C&D element is distributed amongst the modules providing redundant capacity and eliminating processing bottlenecks. There will be no "central computer" in the traditional sense. The tactical picture created must be complete and coherent enough to provide necessary reaction time for ship defense. The major modules of the C&D element are:

(1) *Detect and Track.* This module determines contact detection and develops track files on contact data received from various ship's sensors. The module exports the track files to the correlate module and ring bus for use by the other C&D correlate module.

(2) *Correlate.* This module develops correlation of data from various detection elements on and off the ship and Detect & Track module to develop a central track file. This provides precise localization and identification of all contacts. The central track file is exported to the C&D control element and ring bus for use by the other C&D element's C&D module.

(3) *Command and Decision Module.* This performs assessment of detection tracks as friendly, neutral, or enemy. It makes engagement decisions and sets the engagement priorities. Additionally, it coordinates own ship operations with the operations of other ships or aircraft in the task force. The decision to engage or not is made in this module. Capable of fully automated ship self-defense operation, the level of automation employed is determined by the responsible person in charge.

(4) *Multipurpose Consoles.* These represent generic, programmable operator interface consoles that provide the man/machine interface with all modules of the C&D element. These consoles are militarized versions of modern, commercial workstations. Additionally, there is a large screen multifunctional display for large area geographic display of tactical situations.

(5) *Weapons Control Module.* The actual weapons selection and engagement coordination is performed by this module. It also maintains an inventory of available ordnance and carries out engagement planning needed for each weapons release. The module coordinates the use of individual weapon elements to prevent interference between own ship weapons and damage to friendly forces. Finally, the module provides the kill assessment for each individual engagement.

c. The *power interface module* provides the interface management function between the ship's engineering plant electric plant control module and the combat system with regards to load shed command and coordination. On loss of electrical generation capacity due to casualty, the electric plant control module sends a load shed command to the combat system, essentially conveying available generating capacity and bus configuration. The interface module communicates with the C&D element to determine combat system needs commensurate with tactical situation. With a balance between power requirements (demand) versus generating capacity, the power system interface module transmits shut down[¤] commands to appropriate combat system elements and also communicates electric plant reconfiguration requests to the electric plant control module.

d. *Readiness assessment, fault detection and localization.* The survivability management and readiness assessment (SM/RA) module works in conjunction with the various combat system element's built-in test and evaluation (BITE) capabilities to provide an integrated system readiness assessment. All the combat system elements must have this BITE capability. The survivability management sub-module uses the system status (readiness assessment) and tactical situation (C&D element) to direct combat system reconfiguration to employ alternate functionality during casualty situations. An additional BITE feature is the requirement that all combat system elements provide automated troubleshooting capability. This enhances fault localization and subsequent repair to place equipment fully operational in as short a time as practical. The readiness assessment sub-module provides the commanding officer and tactical action officer with a real-time comprehensive assessment of the ship's ability to continue fighting. Additionally, it enables the combat system officer of the watch and engineering officer of the watch to better coordinate efforts to maintain/recover mission readiness prioritized to current mission

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[¤] a shut down command will cause a device specific action ranging from total device shutdown to placing the device in a power savings (standby) mode needs. The readiness data includes current status of mission capabilities, times to failure and times to recovery. Readiness data is obtained from all systems including auxiliaries that supply the individual combat systems.

e. *Survivability and reconfigurability.* System survivability is enhanced by a number of design features, including:

(1) dual C&D element functionality which is geographically separated in CIC #1 and CIC #2;

(2) alternate sensor capability in all spectrums except IR detection;

(3) multiple, redundant connectivity between combat system elements;

(4) graceful degradation of overall system capability upon partial power loss through smart load shed management.

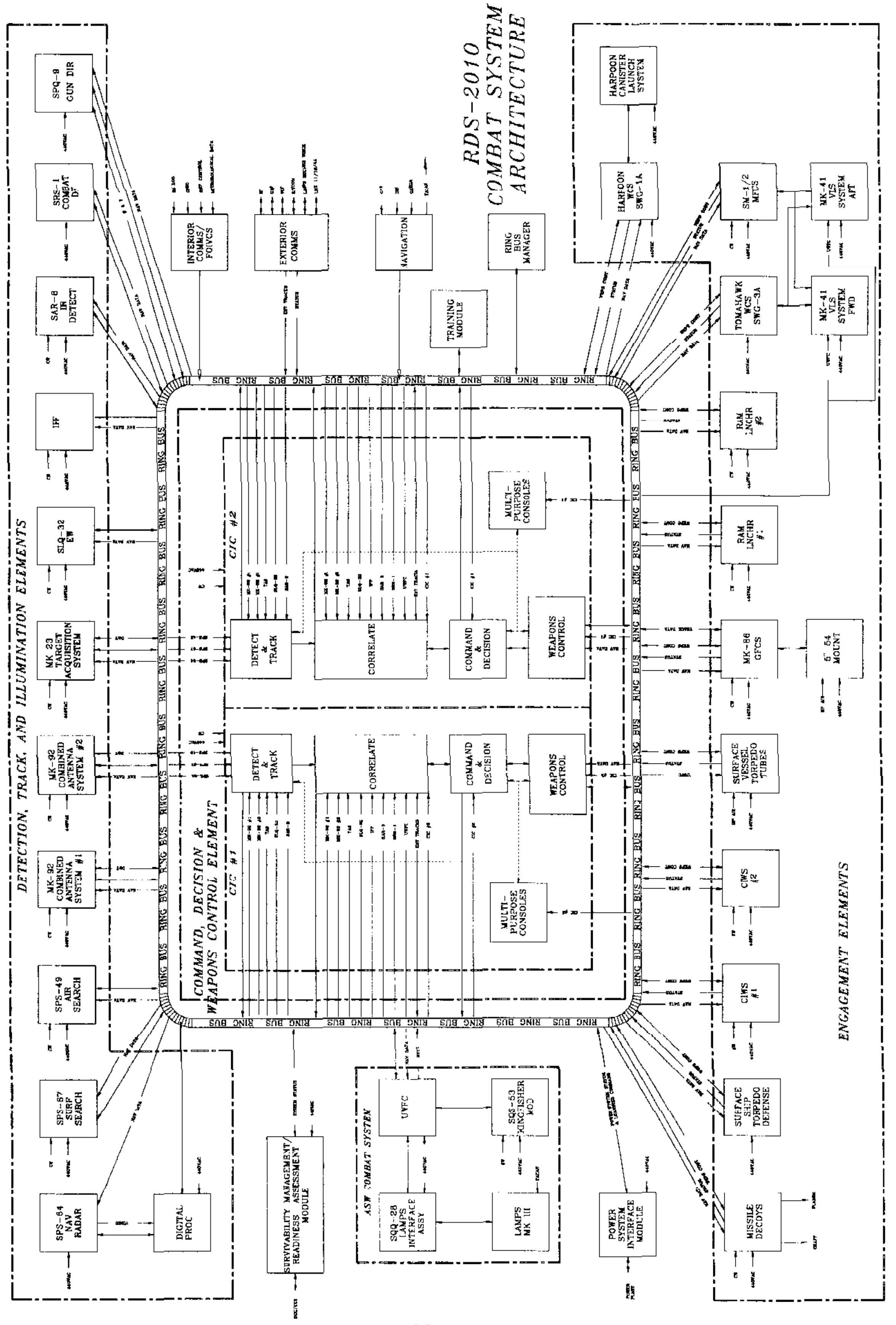
With the available redundant/alternate functional capabilities, system reconfiguration is practical to optimize combat system employment during casualty conditions. This feature is addressed in Section IV.C.3.d above.

f. *Embedded training.* The integrated combat system includes an embedded training module to allow realistic threat scenario engagement exercises. These training scenarios will exercise the C&D element and watchstanders. Essentially, this entails the capability to run pre-programmed engagement scenarios by injection of track and other necessary data directly onto the data bus.

g. *Embedded support service management.* Primary support services for the combat system are electrical, chilled water, sea water, ambient space cooling and dehumidification, and high pressure air. With the enclaving scheme, each enclave has fully self-contained capability with the exception of electrical power generation. Electrical power generation is limited to the three enclaves containing the two engine rooms and one auxiliary machinery space aft. Status of these systems is maintained by Damage Control Central (DCC)/Central Control Station (CCS) and the engineering plant status module.

Support service configuration is coordinated with required combat system capability as determined by the tactical situation during casualty situations. Maximum capability will be maintained consistent with available capacity remaining during casualties. With input to/from the survivability management system, certain automatic damage control actions can be accomplished before a weapons hit occurs. For instance, upon detection of appropriate heat and smoke levels following a detonation within a compartment, the pertinent fire sprinklers can be started to douse the fire and cool adjacent compartment's bulkheads and ventilation dampers can be automatically closed. Also, the electric plant can be shifted before fire removes distribution capability that is routed through the scene of the fire.

h. *Automated Communications Suite.* To provide manning reduction and increase external communication throughput, the external communications suite is automated. This automation allows incorporation of the external communications function as an integral part of the integrated combat systems suite. Features such as automated electronic message routing with dispersed remote terminals streamline message dissemination. Automated external connectivity allows integration of this ship in a task force/battle group scenario. Export of sensor data and import of weapons command functions extends the integrated fighting power of the task force/battle group. Import of real time data from outer sources provides a coherent, integrated picture of the battle space. With continuously updated information the ship could support or be supported by other ships, shooting targets its own sensors cannot detect.


RDS-2010 COMBAT SYSTEM ARCHITECTURE
DETECTION, TRACK, AND ILLUMINATION ELEMENTS
SPQ-9 GUN DIR
SRS-1 COMBAT DF
SAR-8 IR DETECT
IFF
SLQ-32 EW
MK 23 TARGET ACQUISITION SYSTEM
MK-92 COMBINED ANTENNA SYSTEM #2
MK-92 COMBINED ANTENNA SYSTEM #1
SPS-49 AIR SEARCH
SPS-67 SURF SEARCH
SPS-64 NAV RADAR
DIGITAL PROC
INTERIOR COMMS/ FOIVCS
EXTERIOR COMMS
NAVIGATION
RING BUS MANAGER
TRAINING MODULE
RING BUS
COMMAND, DECISION & WEAPONS CONTROL ELEMENT
CIC #1
CIC #2
DETECT & TRACK
CORRELATE
COMMAND & DECISION
WEAPONS CONTROL
MULTI-PURPOSE CONSOLES
ENGAGEMENT ELEMENTS
HARPOON CANISTER LAUNCH SYSTEM
HARPOON WCS SWG-1A
SM-1/2 MFCS
MK-41 VLS SYSTEM AFT
TOMAHAWK WCS SWG-3A
MK-41 VLS SYSTEM FWD
RAM LNCHR #2
RAM LNCHR #1
MK-86 GFCS
5" 54 MOUNT
SURFACE VESSEL TORPEDO TUBES
CIWS #2
CIWS #1
SURFACE SHIP TORPEDO DEFENSE
MISSILE DECOYS
ASW COMBAT SYSTEM
UVFC
SQS-53 KINGFISHER MOD
SQQ-28 LAMPS INTERFACE ASSY
LAMPS MK III
SURVIVABILITY MANAGEMENT/ READINESS ASSESSMENT MODULE
POWER SYSTEM INTERFACE MODULE

D. BATTLE ORGANIZATION AND BATTLE STATION LOCATIONS

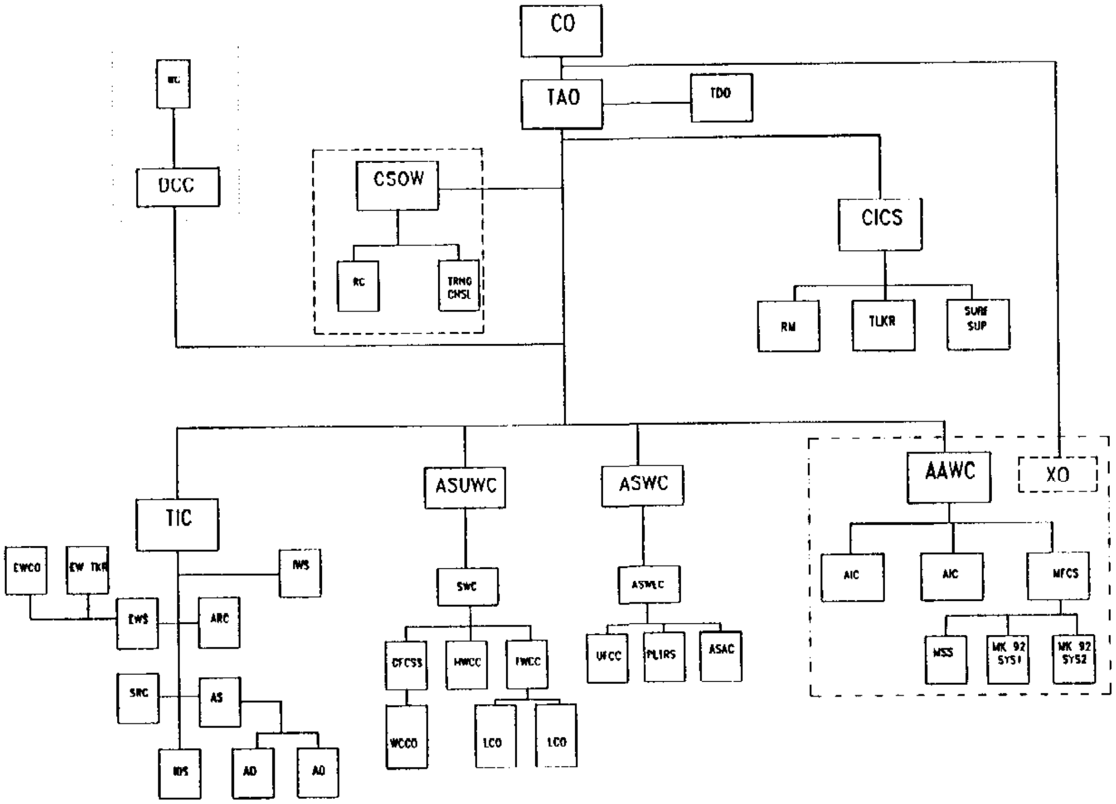
The manning requirements for the ship drive many design parameters, especially in the H, M & E areas. Manning is primarily driven by watchstation requirements during battle conditions, and driven to a lesser extent by normal ship operations. For this reason, the Battle Organization and Battle Station Locations, along with the envisioned manning plan for the RDS-2010 are included in this chapter.

The RDS 2010's Condition I and Condition III Battle Organizations are given in Figures 4-8 and 4-9, respectively. The connectivity of the watch organization is for supervisory functions only, and has nothing to do with the flow of information to each watch station. Since each watch station will be connected to the data multiplexed ring bus, all watch stations will have access to any desired information. The watch stations that require consoles will be established with either one of three different types;

1. a multi-purpose console capable of performing any watch station function,
2. an Aegis-type large screen multi-purpose Command and Display console,
3. or a watch station specific console used only for local equipment control

and specific functions.

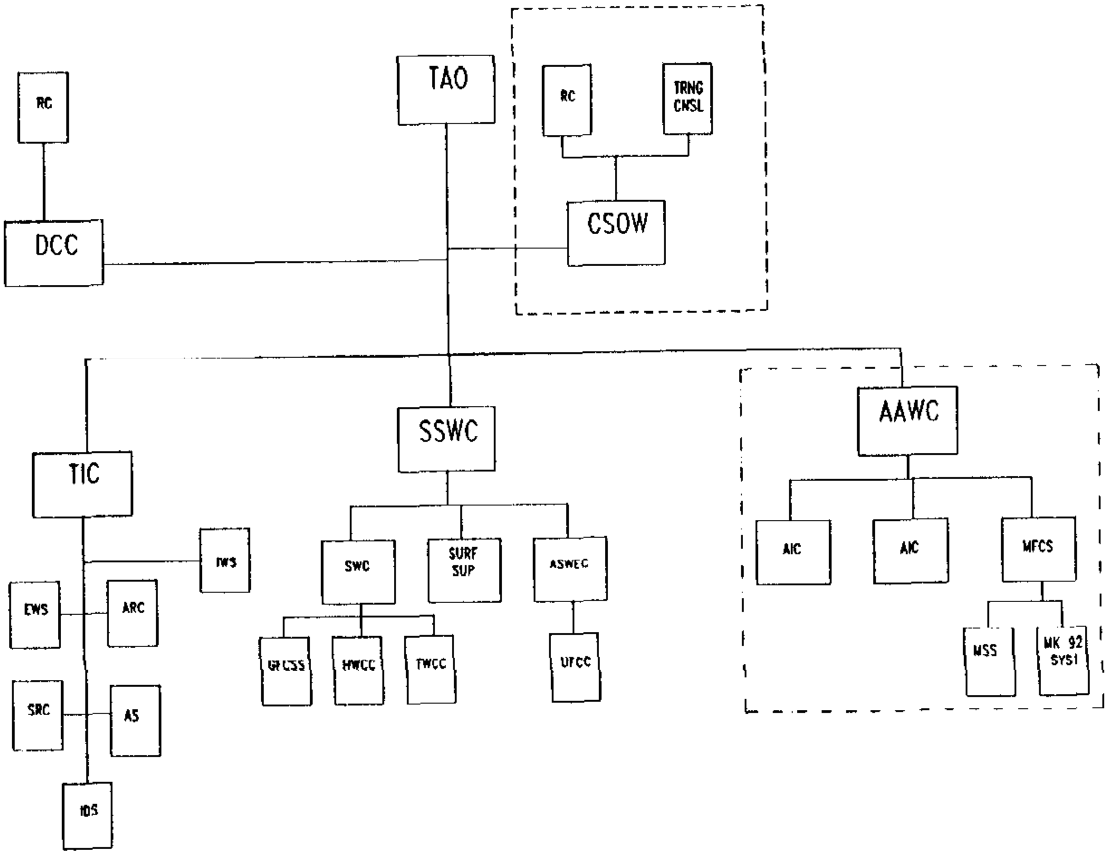
The desired capability of the combat system watch team during Condition III is that it can fight the ship in a short duration, limited capacity until the ship can man Condition I watch stations. The RDS 2010's manning will allow, with minor exceptions, all watch stations to be stood in a three section, 4 hours on/8 hours off, watch rotation. This will allow ample time for the off watch sections to conduct training , maintenance and housekeeping. The envisioned manning and departmental organization of the RDS 2010 is shown in Table 4-7 and Figure 4-10, respectively. It is understood that this is not a formal manning document, but an attempt by the team to determine the number of personnel required to man the ship. Additionally, it is useful for analyzing whether this number supports the reduced manning goal.



LEGEND

TAO	TACTICAL ACTION OFFICER	DCC	DAMAGE CONTROL COORDINATOR
CICS	CIC SUPERVISOR	TDO	TACTICAL DISPLAY OPERATOR
TIC	TACTICAL INFORMATION COORDINATOR	EWS	ELECTRONIC WARFARE SUPERVISOR
ARC	AIR RADAR COORDINATOR	IWS	INTELLIGENCE WATCH SUPERVISOR
SRC	SURFACE RADAR COORDINATOR	AS	ACOUSTIC SUPERVISOR
IDS	IDENTIFICATION SUPERVISOR	AO	ACOUSTIC OPERATOR
RC	READINESS CONSOLE	ASUWC	ANTI-SURFACE WARFARE COORDINATOR
SWC	SURFACE WEAPONS COORDINATOR	GFCSS	GUN FIRE CONTROL SYSTEM SUPERVISOR
TWCC	TOMAHAWK WEAPONS CONTROL CONSOLE	HWCC	HARPOON WEAPON CONTROL CONSOLE
SURF SUP	SURFACE NAV SUPERVISOR	ASWC	ANTI-SUBMARINE WARFARE COORDINATOR
ASWEC	ANTI-SUBMARINE WEAPONS COORDINATOR	UFCC	UNDERWATER FIRE CONTROL COORDINATOR
AAWC	ANTI-AIR WARFARE COORDINATOR	LCO	LOCAL CONTROL OPERATOR
ASAC	ANTI-SUBMARINE AIRCRAFT CONTROLLER	XO	EXECUTIVE OFFICE
WCCO	WEAPONS CONTROL CONSOLE OPERATOR	RM	RADIOMAN
EWCO	ELECTRONIC WARFARE CONSOLE OPERATOR	CSOW	COMBAT SYSTEM OFFICER OF THE WATCH
MK 92 SYS	MK 92 SYSTEM COORDINATOR	EW TKR	ELECTRONIC WARFARE TALKER
MSS	MISSILE SYSTEM SUPERVISOR	AIC	AIR INTERCEPT CONTROLLER
MFCS	MISSILE FIRE CONTROL SUPERVISOR		

Figure 4-8. Condition I Battle Organization.



LEGEND

TAO	TACTICAL ACTION OFFICER	DCC	DAMAGE CONTROL COORDINATOR
TIC	TACTICAL INFORMATION COORDINATOR	EWS	ELECTRONIC WARFARE SUPERVISOR
ARC	AIR RADAR COORDINATOR	IWS	INTELLIGENCE WATCH SUPERVISOR
SRC	SURFACE RADAR COORDINATOR	AS	ACOUSTIC SUPERVISOR
IDS	IDENTIFICATION SUPERVISOR	SWC	SURFACE WEAPONS COORDINATOR
RC	READINESS CONSOLE	AIC	AIR INTERCEPT CONTROLLER
SSWC	SURF-SUBSURFACE WEAPONS COORDINATOR	GFCSS	GUN FIRE CONTROL SYSTEM SUPERVISOR
TWCC	TOMAHAWK WEAPONS CONTROL CONSOLE	HWCC	HARPOON WEAPON CONTROL CONSOLE
SURF SUP	SURFACE NAV SUPERVISOR	MSS	MISSILE SYSTEM SUPERVISOR
ASWEC	ANTI-SUBMARINE WEAPONS COORDINATOR	UFCC	UNDERWATER FIRE CONTROL COORDINATOR
AAWC	ANTI-AIR WARFARE COORDINATOR	CSOW	COMBAT SYSTEM OFFICER OF THE WATCH
MK 92 SYS	MK 92 SYSTEM COORDINATOR	MFCS	MISSILE FIRE CONTROL SUPERVISOR

Figure 4-9. Condition III Battle Organization.

Table 4-7. MANNING FOR THE RDS 2010.

DEPARTMENT	OFFICERS	CPO'S	ENLISTED	TOTAL
SHIP SUPPORT	CO, XO, SUPPO (3)	HMC, MSC, SKC (3)	HM, YN (2), PN (2), PC SH (2), SK(6) DK, MS (9) (24)	30
SHIP CONTROL	OPS, CICO COMMO (3)	OSC, RMC, BMC, QMC (4)	RM (4),QM (2) SM (2), BM (13) OS (14) (35)	42
COMBAT SYSTEM	CSO, FCO, EMO, ORDO (4)	ETC, EWC, FCC (3), GMC, STC (7)	EW (4), ET (4) ST (5) FC (16), GM (8) IC (4) (41)	52
ENGINEERING	CHENG, MPA, DCA, A+E (4)	GSC (2), ENC, EMC, DCC (5)	GS (12), EM (6) HT (2), DC (5) EN (5) (30)	39
INTELL DET	(0)	CTC (1)	CT (4)	5
MED DET	SURGEON, P.A. NURSE (3)	(0)	HM (2) (2)	5
AIR DET	PILOTS (4)	ATC (1)	AIR CREW, AIR TECHS, METEROLOGIC (14)	19
FLAG/STAFF	(0)	(0)	(0)	(0)
AVAILABLE MANNING	21	21	150	192

NOTES:

1. The Suppy Officer, Suppo, will handle supply and administrative matters.
2. The entire ship's company will have their food prepared in the ship's galley.
3. The FC's will handle all maintenance, repair and operation of the fire control and data transfer systems.
4. The listed ratings include designated and non-designated personnel.

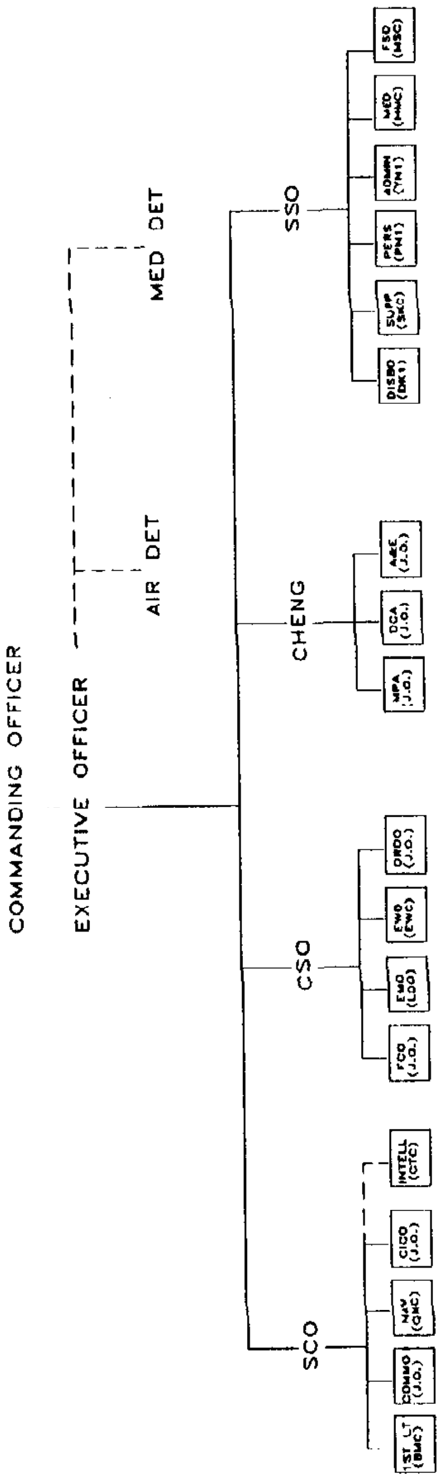


Figure 4-10. Departmental Organization.

V. HULL, MECHANICAL, AND ELECTRICAL FEASIBILITY STUDIES

Once the ship's major payload, *the combat system*, is determined in terms of specific elements and their quantities, then the element's size, weight, power and service requirements can be used as a starting point for determining the ship's hull, mechanical, and electrical characteristics required to support the payload. This next phase of the feasibility studies uses a computer based ship design tool, supplied by NAVSEA, known as the Advanced Surface Ship Evaluation Tool (ASSET). Within ASSET there exists a series of computational modules which address a specific domain of ship design, such as hull geometry, hull structure, resistance, propulsion, machinery, weight, space, hydrostatics, seakeeping, manning, or cost. Through a unique command language, the user directs the execution of the modules. In using the input support module, essentially all ship characteristics which are known *a priori* (i.e., such as the above mentioned payload characteristics and the defined ship performance characteristics) are entered into and stored in this ASSET program's data bank. The designer then, through various commands, directs the program to iteratively calculate the major ship's characteristics until the data converges on a solution. The modules of the ASSET program have been designed in such a way as to provide the capability of design synthesis and analysis. The converged solution, however, may or may not meet all the desired characteristics. It is at this point that the ship design team must begin tradeoff decisions in an attempt to gain a balanced ship with as many of the desired characteristics that are economically and technically feasible.

A. INITIAL CONVERGENCE

Table 5-1 summarizes the major ship's characteristics attained during the first convergence of the ship RDS 2010 using the Monohull Surface Combatant version of the ASSET program. Since the design has not been optimized, the complete and voluminous output reports of ASSET are not included with this report. The primary goal at this stage of the feasibility studies was to gain enough experience and confidence with the ASSET program to obtain a converged design. The next stage of feasibility studies will be to iterate, using ASSET, and attempt to optimize the design using the top level design goals and performance characteristics for guidance. This process will entail making design decisions, attempting to balance numerous competing design goals until a ship is obtained which reasonably meets the set design requirements and constraints. The ability to meet all design goals simultaneously is in no way guaranteed.

Portions of this feasibility study use alternative elements to those selected in earlier phases of the design. This was necessary because of the inability of this computer program to successfully accommodate electric drive with electric power generation. When the design team attempted to use the electric propulsion generators, each main machinery room was required to be 114 feet in length. This is another area requiring modification in future versions of the ASSET series of programs.

In general the size of the ship is too large for the present payload. Some of the excess volume and length is due to the use of the double hull which this ASSET program currently does not incorporate. It also appears that the ASSET program is heating and ventilating the volume in the double hull. A decision was made to use the portion of the double hull volume below the water line for tankage, so this also needs to be adjusted.

TABLE 5-1. ASSET SHIP'S DESIGN SUMMARY, INITIAL CONVERGENCE.

```
PRINTED REPORT NO.  1 - HULL GEOMETRY SUMMARY
HULL OFFSETS IND-     GENERATE                 MIN BEAM, FT                   60.00
HULL DIM IND-         B+T                      MAX BEAM, FT                  110.00
MARGIN LINE IND-      CALC                     HULL FLARE ANGLE, DEG            .00
HULL STA IND-         OPTIMUM                  FORWARD BULWARK, FT             4.00
HULL BC IND-          GIVEN


                  HULL PRINCIPAL DIMENSIONS (ON DWL)
#LBP, FT                       450.00   #PRISMATIC COEF              0.650
#LOA, FT                       467.82   #MAX SECTION COEF            0.950
#BEAM, FT                       63.78   #WATERPLANE COEF             0.787
#BEAM @ WEATHER DECK, FT        63.78   #LCB/LCP                     0.506
#DRAFT, FT                      15.01    HALF SIDING WIDTH, FT       1.00
#DEPTH STA 0, FT                52.95    BOT RAKE, FT                0.00
#DEPTH STA 3, FT                47.02    RAISED DECK HT, FT          0.00
#DEPTH STA 10, FT               38.50    RAISED DECK FWD LIM, STA
#DEPTH STA 20, FT               39.25    RAISED DECK AFT LIM, STA
#FREEBOARD @ STA 3, FT          36.01    BARE HULL DISPL, LTON    7600.69
#STABILITY BEAM, FT             63.78    AREA BEAM, FT              43.39


      BARE HULL DATA ON LWL                 STABILITY DATA ON LWL
#LGTH ON WL, FT                450.00      KB, FT                           8.17
#BEAM, FT                       63.78      BMT,  FT                        22.53
#DRAFT, FT                      15.00      KG,   FT                        24.30
#FREEBOARD @ STA 3, FT          36.02     #FREE SURF COR, FT                0.00
#PRISMATIC COEF                 0.650     #SERV LIFE KG ALW, FT             0.00
#MAX SECTION COEF               0.951      WATERPLANE COEF                 0.787
 GMT, FT                         6.39      WATERPLANE AREA, FT2         22594.41
 GML, FT                       972.40      WETTED SURFACE, FT2          29890.24
#GMT/B AVAIL                    0.100      GMT/B REQ                       0.100
 BARE HULL DISPL, LTON        7605.03
 APPENDAGE DISPL, LTON         239.35
 FULL LOAD WT, LTON           7844.38
```

B. FINALIZATION OF MAJOR SHIP CHARACTERISTICS AND COMBAT SYSTEMS ELEMENTS

The previous section addressed work accomplished during the first academic quarter, when the RDS 2010 was modeled computationally and the synthesis portion of ASSET used in order to ensure convergence. However, at that time the cost did not come within the limit of $350 million. The first order of business in the second academic quarter was to lower the cost. To make the design economically feasible and acceptable, many factors were adjusted to bring the cost within a workable range. Table 5-2 summarizes the major ship's characteristics attained during the final convergence of the ship RDS 2010 using the Monohull Surface Combatant version of the ASSET program.

TABLE 5-2. ASSET SUMMARY, FINAL RUN.

```
PRINTED REPORT NO.  1 - HULL GEOMETRY SUMMARY

MIN BEAM, FT                 40.00
MAX BEAM, FT                 55.00
HULL FLARE ANGLE, DEG         7.00
FORWARD BULWARK, FT           4.00

                   HULL PRINCIPAL DIMENSIONS (ON DWL)
                   ==================================
LBP, FT                      390.00     PRISMATIC COEF               0.650
LOA, FT                      409.31     MAX SECTION COEF             0.919
BEAM, FT                      55.00     WATERPLANE COEF              0.787
BEAM @ WEATHER DECK, FT       60.27     LCB/LCP                      0.515
DRAFT, FT                     15.01     HALF SIDING WIDTH, FT         1.00
DEPTH STA 0, FT               45.00     DEPTH STA 3, FT              41.46
DEPTH STA 10, FT              36.50     DEPTH STA 20, FT             37.40
FREEBOARD @ STA 3, FT         30.46     BARE HULL DISPL, LTON      5493.55
STABILITY BEAM, FT            55.00     AREA BEAM, FT                54.17

     BARE HULL DATA ON LWL                    STABILITY DATA ON LWL
     =====================                    =====================
LGTH ON WL, FT               389.99     KB, FT                        8.19
BEAM, FT                      55.00     BMT,  FT                     16.92
DRAFT, FT                     14.99     KG,  FT                      19.59
FREEBOARD @ STA 3, FT         30.48     PRISMATIC COEF               0.649
MAX SECTION COEF              0.921
WATERPLANE COEF               0.788     GMT, FT                       5.51
WATERPLANE AREA, FT2       16904.38     GML, FT                     763.36
WETTED SURFACE, FT2        22804.14     BARE HULL DISPL, LTON      5496.68
APPENDAGE DISPL, LTON        225.04     FULL LOAD WT, LTON         5721.71
```

The cost was significantly reduced through various adjustments of hull material, stiffener spacing, deckhouse structure, and principal dimensions. The hull and structural material was changed to a steel with a higher strength-to-weight ratio, HY-80, resulting in a significant savings weight (200 tons). This in turn reduced the powering requirement, shrinking the length and displacement further because of the decrease in fuel required for endurance. Although this provided a significant cost savings as predicted by the ASSET cost module, it is surmised that the cost reduction in the real world might not have been as grand because of the added labor and quality assurance procedures associated with welding HY-80 steel.

Stiffener spacing was adjusted from a maximum allowed spacing of 24 inches to 48 inches, permitting the Hull Structures module of ASSET to better optimize the sizing and placement of stiffeners considering the complex relationship between the stiffeners and the plating to which they are welded. The use of enclaved auxiliary systems and fiber optic cabling will minimize the amount of space needed in the overhead. The hull average deck height was lowered from 10.5 feet to 9.95 feet to minimize the internal volume of the ship and permit the addition of another deck. The prismatic coefficient was adjusted in order to attempt a positive reduction in the size of the hull, but there was no apparent cost or volume savings. Apparently, the initial value of $Cp = 0.65$ was near optimum. The maximum section coefficient was adjusted downward as far as possible within the constraints of the hydrostatic limitations. This brought about savings in fuel usage and a higher sustained speed as a result of lowered resistance.

At the time of initial convergence the deckhouse size indicator had been set at "max", causing the deckhouse to extend over 50% of the ship at a three deck height. This was changed to "min" so that only the volume and area required for equipment and personnel would be generated, reducing the deckhouse weight by about 400 tons. Additionally, the hull flare angle and the deckhouse side angle offset were changed from zero to seven degrees in order to reduce the effective radar cross-section and improve appearance. We removed the forward auxiliary machinery room after assessing the machinery requirements recommended by the initial convergence. Removal of this space which was nearly empty returned approximately 10,000 ft^3 of internal arrangeable volume.

The double hull posed some challenges because the ASSET program is unable to deal directly with this concept. In order to have a double hull volume which is not lighted, heated nor air conditioned, it was necessary to make data base adjustments in the endurance range and payload to account for the extra volume available for tankage. By not lighting, heating nor air conditioning the double hull void, a significant reduction in electrical power was realized. The double hull volume below the waterline is used for endurance fuel tankage, while the volume above the waterline is reserved for buoyancy and for increasing internal blast resistance against anti-ship missile explosions. The issue of whether to fill these spaces with an energy absorbing material or to leave them void must be resolved during subsequent design iterations.

The helicopter hangar area was reduced by half as the helicopter compliment was reduced from two to one for cost reasons. The associated helicopter payload items were also reduced as required to support only one helicopter. The reinforced helicopter deck remains capable of supporting the larger CH-53 Sea King which is used to tow a mine clearing sled and could be used for evacuation of U.S. citizens from political hot spots.

These changes allowed a decrease in bare hull displacement of approximately 2000 tons to the current design displacement which is slightly under 5500 tons. While revisiting the subject of heating, we determined that it would be more cost effective to use a waste heat boiler to carry some of the ship hotel heating requirements. With a smaller ship, the lighting, heating and ventilation requirements were also reduced, allowing a smaller ship service gas turbine generator set.

The use of integrated electric drive was abandoned during feasibility studies. Designing the RDS 2010 with this developing technology was unacceptable on the basis of the technical risk and cost involved, because the larger machinery rooms needed for the current generation of propulsion generators drove the ship length beyond 500 feet. Instead, the team chose four propulsion gas turbines (two per shaft), driving a standard mechanical reduction gear drive train, as the propulsion plant. Two of the three ship's service generators are powered from power take-off units attached to the reduction gears, one per shaft, to meet power requirements during cruising and battle conditions. The remaining ship's service generator is for standby use and is powered by a dedicated gas turbine. The four main gas turbines, which are currently the smallest available commercially, are larger than required for the ship's propulsion and electrical power needs. Use of even smaller propulsion turbines is preferable, since the mission speed requirements have been exceeded, but they are not presently available in production models. The option of going from the four small gas turbines to two larger gas turbines was not taken because of factors affecting machinery plant survivability and reliability. The fixed pitch propeller had to be replaced with a controllable pitch propeller to remain compatible with this propulsion train. This is a major disadvantage for shallow water operation because of the CRP complexity which makes it less robust than a fixed pitch propeller.

To minimize the technical risk involved in the development of the new mortar system, the first flight is designed to have both the new mortar system and the current version of the vertically launched ASROC.

C. COST REDUCTION SUMMARY

After many major and minor changes, we came to the point of diminishing returns on ship modifications for the sole purpose of cost reduction. The ship cost had been nearly halved from $850M, yet it did not come within the stringent $350M requirement. There comes a point in many phases of design at which one phase of design must end before the next phase can begin. This point had arrived since for educational purposed we needed to proceed to the next phase of preliminary design. It was at that time the following request for an adjustment to the cost ceiling was made.

D. REQUEST FOR ADJUSTMENT TO COST CEILING

During the first academic quarter, the RDS 2010 was modeled to be technically feasible, however, the follow-on ship cost did not come within the limit of $350 million. To make the design economically feasible and acceptable, many factors were adjusted to bring the cost within a workable range. Currently, the projected cost from the ASSET Cost Analysis Module is $809/476M for the first/follow-on ships respectively. The projected cost as determined using the Gibbs and Cox two digit cost estimating scheme was $290M. To meet the mission requirements and provide adequate self-defense, the cost ceiling per follow-on ship should be raised to $475M. This is strongly recommended in order to meet the mission requirements without degradation.

Certain features of the vessel could be modified in order to come closer to the present $350M cost limit. Two likely options are: 1) removal of the LAMPS III system, or 2) reversion to a single hull. The drawback to removal of the LAMPS III system is a major degradation of the ASW mission area. Additionally, a single hull ship would be considerably more vulnerable to missile hits and mine explosions. If capability must be removed to remain within cost constraints, the options are recommended in the given order because the likelihood of being targeted by a missile is higher than being stalked by a submarine at long range.

In the current political environment it is entirely possible that no new class of ship will ever be built. As shipyards and defense contractors recognize this fact they may consider a reduction in profits in order to keep the production lines operating. This may serve to ameliorate the problem. It is recommended that the cost ceiling be raised to $475 million dollars for follow-on ships.

E. RESULT OF COST CEILING ADJUSTMENT PROPOSAL

The above proposal was approved and the cost ceiling extended to $500 million.

VI. THE ENCLAVED SHIP

Ship's survivability is high on the list of design priorities. This is due to the emphasis in the "CNO Tentative Requirement Statement" (Section II.A.3) that this ship be highly survivable *and* minimize crew casualties. The design team considered a major design attribute to enhance the survivability was to enclave the ship. *Enclaving* is a concept for reducing ship vulnerability by dividing the equipment associated with the ship's mission capabilities into subsets which can be located in different autonomous or semiautonomous regions within the ship. This minimizes the loss of mission critical functions caused by a hostile weapon hit and maximizes the ability to fight hurt. Enclaving is the synergistic zoning of the combat system and H, M & E systems into regions which can function independently as required to provide a subset of the ship's mission capability. Without the positive side effects of this synergism, the prospect of *enclaving* could be too costly based on the installation of duplicate system elements. In addition to duplication of functionality, the concept of alternate functionality of equipment is used to enhance the enclaving concept. By this we mean, for instance, the ability to use a surface search radar as a less capable, but backup air search radar. When survivability and cost are approached from the perspective of numbers of ships available to fight, a more survivable ship is a more valuable asset to the nation.

There are two types of decision making involved in designing an enclaved combatant. Major conceptual decision making is usually done by higher authorities while the actual engineering tradeoff decision making is performed by the shipbuilder's detailed design team. Additionally, since the combat weapon system, H, M & E support systems, propulsion systems and other necessary ship's systems are a complex total ship system package, the need exists for an iterative design approach in which the effects of certain decisions are monitored for overall effect and modified by the total system integrator (ship design management team). The design challenge is to *enclave* while minimizing the addition of duplicate equipment. As the art of interface engineering evolves and standards are narrowed, the ability to *enclave* is enhanced.

The goal is to *enclave* functionality and arrange associated support systems to allow the loss of a single *enclave* without reducing the support services required by the other enclaves to maintain their combat system equipment operational. A worthy goal is to ensure that support systems not included in an *enclave* are available from the adjacent *enclave*. Each *enclave* is provided with self-sufficient damage control capability. Electrical power will be available from the ship's service ring bus and interior communications data will be available from the fiber optic data bus. Although the central damage control console will be located in the Central Control Station, each *enclave* will get its automatic and real time human generated damage control commands via one of the five fiber optic data buses. For the sake of damage control and mission war fighting capability, it is desirable that the personnel be berthed within each *enclave* near their general quarters or damage control station.

For the sake of producibility and reduction in cost, *zones* have been established that often coincide with the *enclave* boundaries. The boundaries extend vertically from the keel to the weather deck and horizontally for two to four subdivisions (i.e. compartments).

A. FACTORS AFFECTING EQUIPMENT COMBINATIONS

There are a number of factors which affect the actual location and the combinational synergism of equipment placement. These factors are the major determinants in the design teams decision making process when it came to locating specific equipment onboard the ship:

1. constraints of topside arrangement;
2. collocation of interdependent or series combat system equipment;
3. separation of functionally parallel combat systems equipment by at least one weapon damage perimeter;
4. *enclave* boundaries determined by existing zones (collective protection, fire, flooding, etc.);
5. balance *enclaving* with other factors of the ship design via the design philosophy;
6. minimize the crossing of boundaries for ease of producibility;
7. armored cable ways protect fiber optic and power cables; and
8. loss of a single enclave will not degrade other enclaves.

B. ENCLAVE ARRANGEMENT

Table 6-1 lists many of the major ship systems and equipment by enclave. Figure 6-1 illustrates the physical enclave boundaries overlaid on the ship.

TABLE 6-1. LOCATION OF MAJOR EQUIPMENT AND FUNCTIONS BY ENCLAVE..

ENCLAVE #5	ENCLAVE #4	ENCLAVE #3	ENCLAVE #2	ENCLAVE #1
AN/SLR-24 SSTD Mk 16 CIWS LAMPS III interface SQQ-28 Lamps Mk III elec Aviation Support HIFR Helo rearm and magazine. LC #7 LC #8 FP #5 Ammunition storage Hospital room Pyro storage JP5 Pump room Steering room	Aft Mast: Mk 92 #2 IFF TACAN SPS-67 surf search SPS-49 air search #2 SVTT Alt CIC Harpoon CLS Harpoon missile storage HWCC SWG-1A Harpoon Mk41 VLS Launcher (16 cell) VLS mag dewatering system #2 Mk 31 RAM PDMS RAM missile storage Mortar Launcher #2 IC SWBD AFT Radio Group #2 LC #6 FP #4 CW Plant #3 Collective Protection Fans #3 #3 HPAC AMR w/SSGTG SWBD 3SG SWBD 3SA SWBD 3SB	SSES LC #4 LC #5 FP #3 CIC Radio Group #1 CW Plant #2 Collective Protection Fans #2 #2 HPAC UUV SRS-1 Combat df Countermeasure launchers ER #2 w/ GT # 3 & 4 #2 VSCF Gen/ cycloconverter SWBD 2SG SWBD 2SA SWBD 2SB	Fwd Mast: Mk 92 #1 SAR-8 Furuno Mk-23 TAS SPQ-9 SPS-64 surf search/ nav Pilot house Nav Center #1 SVTT SLQ-32 Mk36 Mk 16 CIWS DCC/CCS Mortar Launcher #1 LC #3 FP #2 IC SWBD FWD CW Plant #1 Collective Protection Fans #1 Ammunition storage #1 EX-35 25mm w/stinger #2 EX-35 25mm w/stinger Countermeasure launchers ER #1 w/ GT # 1& 2 #1 VSCF Gen/ cycloconverter SWBD 1SG SWBD 1SA SWBD 1SB	Sonar Equip room Sonar SW pumps UWFCS Mk41 VLS Launcher (16 cell) VLS magazine de-watering system Combat Maintenance Central Mk-86/5" 54 Gun mount Ammunition storage #1 Mk 31 RAM PDMS RAM missile storage LC#1 LC#2 FP #1 SWG-3A Tomahawk SM-1/2 MFCS #1 HPAC

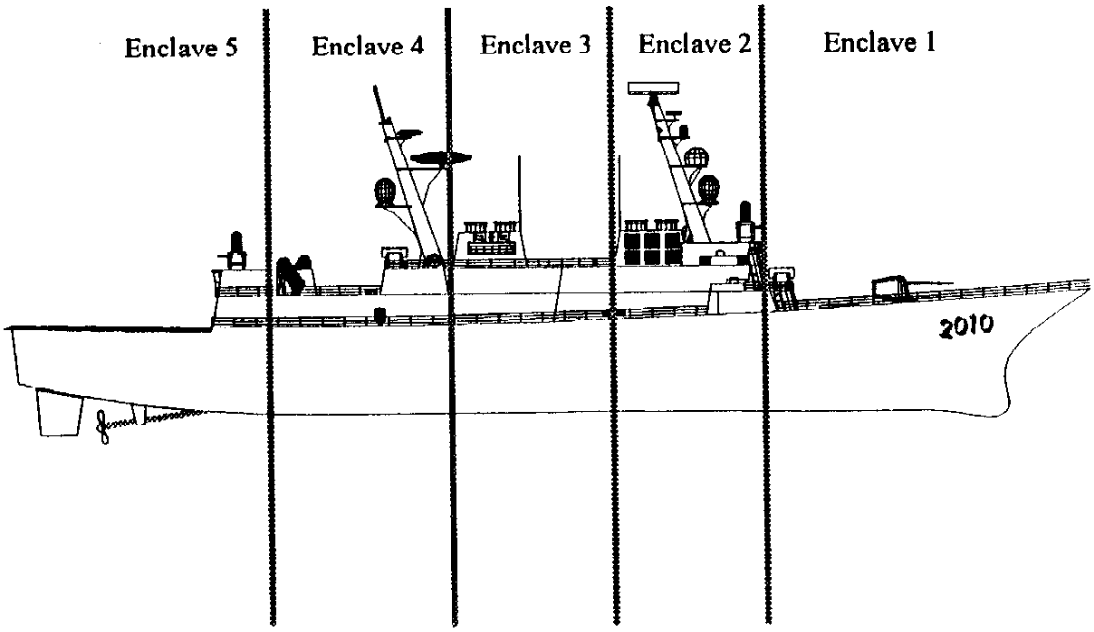


Figure 6-1. Enclave Boundaries.

VII. SHIP'S ELECTRICAL GENERATION AND DISTRIBUTION SYSTEM

The original vision of the ship's electrical generation and distribution system consisted of an integrated electrical drive plant with ship's service power derived from power converters. These power converters would change the unregulated (voltage and frequency) propulsion bus power to 60 Hz, 450 Vac standard shipboard power. This scheme had many merits in an enclaved ship due to the natural distributed ship's service power generation that results. As mentioned in Chapter 5, however, the integrated electric drive option had to be dismissed due to difficulties in manipulating the ASSET program.

We did maintain a form of propulsion derived ship's service power, however. The propulsion plant is a standard two gas turbine per shaft mechanical-reduction gear coupled system. There are power takeoff (PTO) units on each reduction gear coupled to high speed, high frequency generators. The output of these generators feed a solid-state power converter which conditions the power to regulated three-phase, 60 Hz, 450 Vac standard ship's service power. To achieve the required *n*-1 redundant capacity, a third ship's service gas turbine generator (SSGTG) is included in the plant design.

By using PTO fed generators, the need for dedicated prime movers for two of the three ship's service power sources is removed. This should decrease weight and increase available volume within the ship. In addition, high speed generators are smaller and lighter than equivalent power 60 Hz generators.

The distribution scheme chosen is a standard three power source ring bus configuration. Enclaving is enhanced by using a modified zonal distribution scheme off the ring bus with multiple load centers strategically placed throughout the ship. Figure 7-1 shows the ring bus structure. Figure 7-2 shows the geographic locations of the generators and load centers. Figure 7-3 indicates the interconnectivity of the power distribution system and major ship's loads.

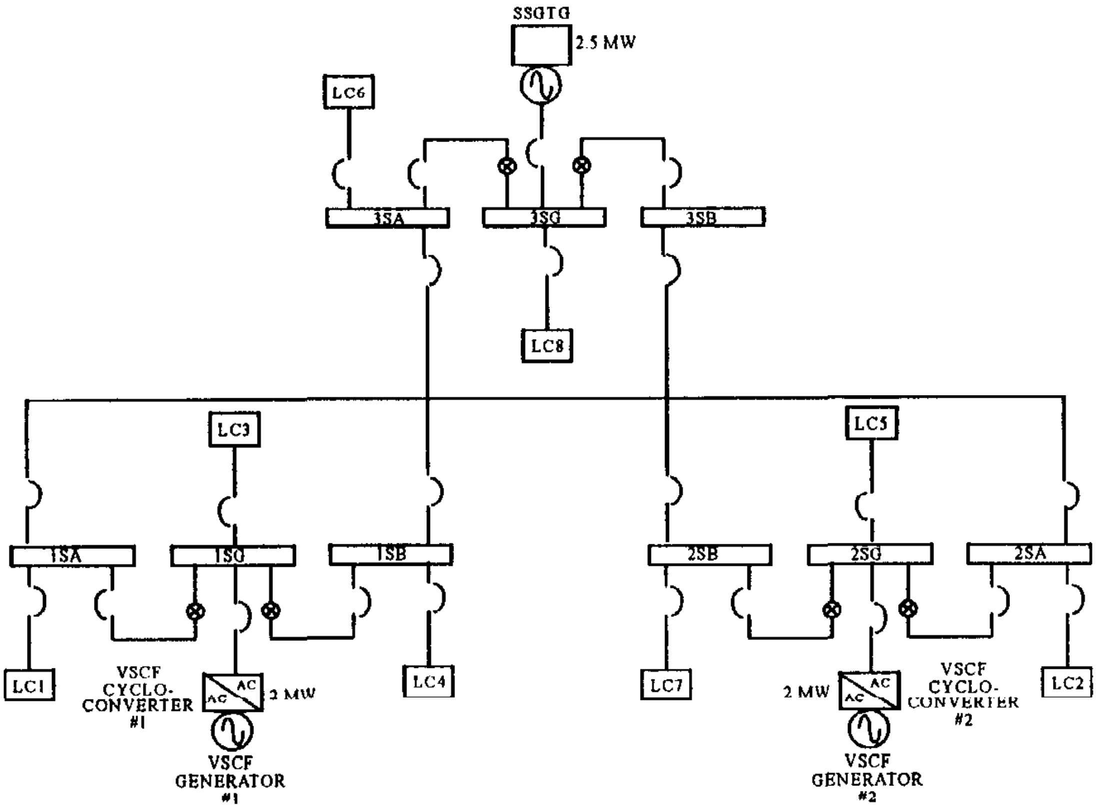


Figure 7-1. Bus Tie Diagram.

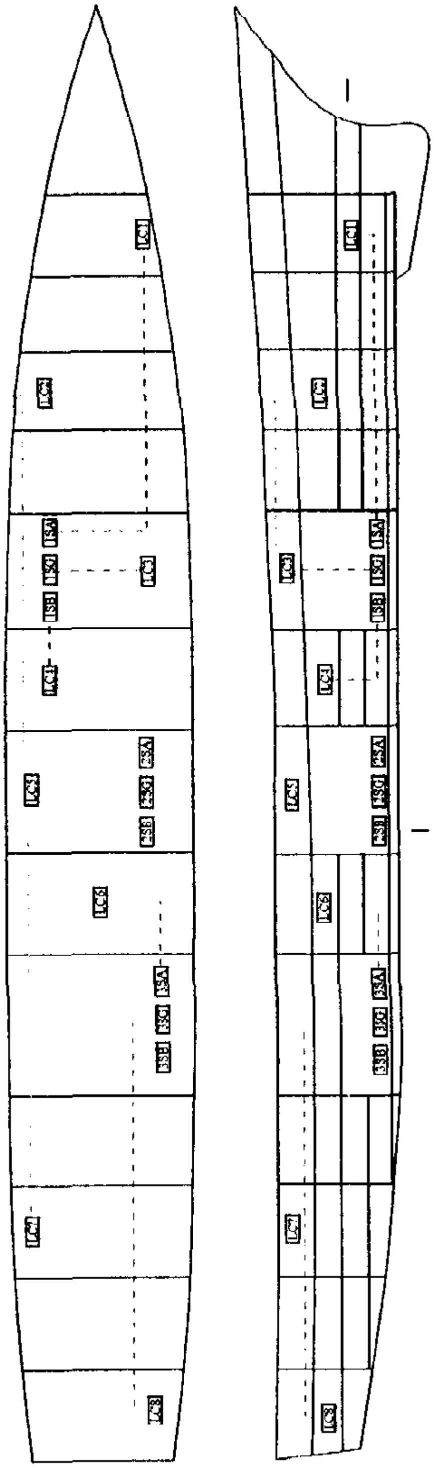


Figure 7-2. Load Center Locations.

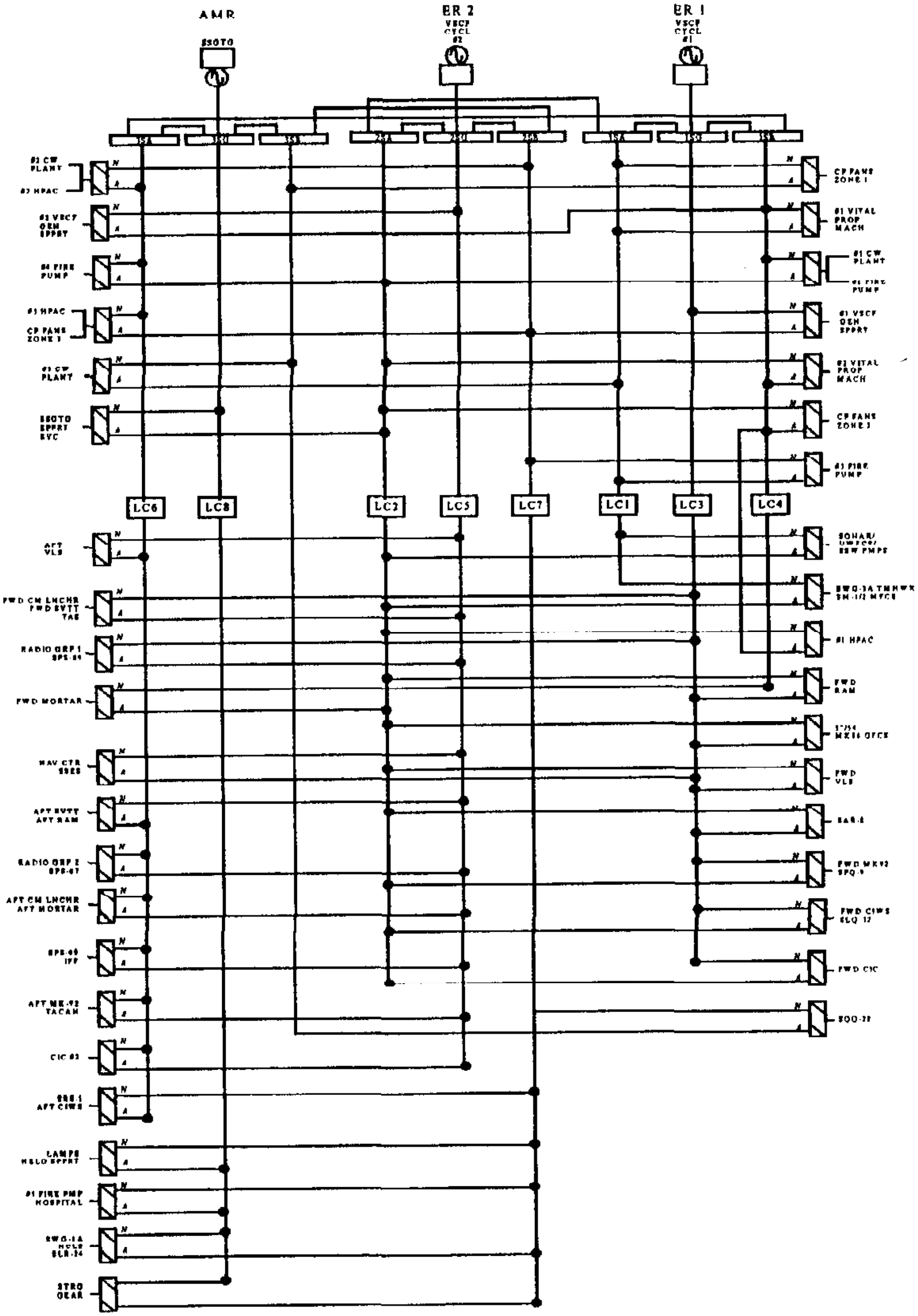


Figure 7-3. Electrical System Interconnectivity.

VIII. SHIP DESCRIPTORS

There is some overlap between the end of feasibility studies and the start of preliminary design. In some respects, all work performed after the first successful convergence of an ASSET run could be considered preliminary design. On the other hand, it could be argued that preliminary design began after the major modifications to the initial design concepts were completed and a revised cost ceiling was approved. One obvious departure from actual practice was our use of ASSET beyond the feasibility studies, into what traditionally is considered preliminary design. This adds to the "fog" which surrounds the delineation. Additionally, design aspects such as electrical plant design and combat system definition, which did not use ASSET in any substantial way, make it hard to say which work actions were feasibility studies and which were preliminary design.

At the completion of the design process, however, we have a ship design that would be typical of the work presented at completion of preliminary design. Clearly, the details and rigor of analysis is lacking due to the short time duration and minimal human resources available to complete the work. The previous chapters have shown some of the non-naval architectural design products from preliminary design. This chapter presents the naval architectural "ship descriptors". Some of these items were produced by ASSET whereas other were completed by members of the design team.

One of the many tasks, from the faculty, was to provide the following:

1) complete lines drawing, to include sheer, body and waterline plans;
2) displacement and other curves;
3) curve of static stability;
4) general arrangements drawings, showing arrangement for each deck;

5) detailed compartment arrangement drawings for:
   - CIC and
   - pilot house;
6) discussion of hull damage length chosen (and why);
7) floodable length curve illustrating damage length criterion is satisfied;
8) structural report consisting of:
   - weight curve,
   - load curve for hull, and
   - midships section design.

A. NAVAL ARCHITECTURAL CURVES

1. Hull Geometry

The ship's lines describe the form of the ship's hull, and are presented in a series of two-dimensional drawings refereed to as the lines drawing. The three basic projections are the sheer plan, the half-breadth plan, and the body plan. Figure 8-1 shows these projection of ships lines for the RDS-2010, without modifications made during preliminary design. These projections were produced manually, using data generated by the ASSET program. Note that ASSET did not include the hull mounted SONAR bow dome.

2. Hull Coefficients

The form coefficients which apply to this ship's hull form were calculated by ASSET and plotted as a function of draft. Figure 8-2 shows the variation of the block coefficient (C_B), prismatic coefficient (C_P) and waterplane area coefficient (C_{WP}) versus draft. Note the design draft was chosen to be 15 feet.

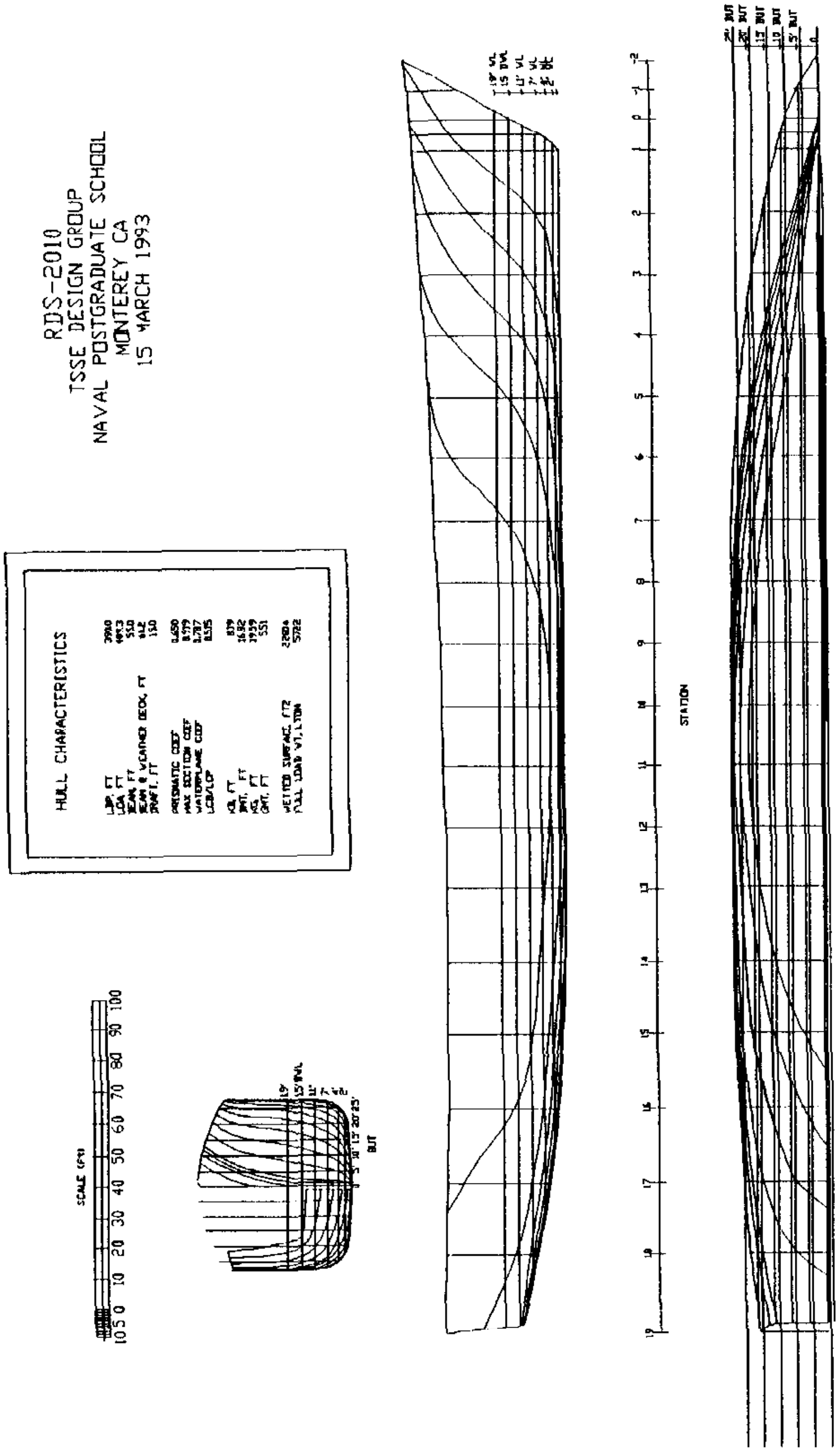


Figure 8-1. RDS-2010 Lines Drawing.

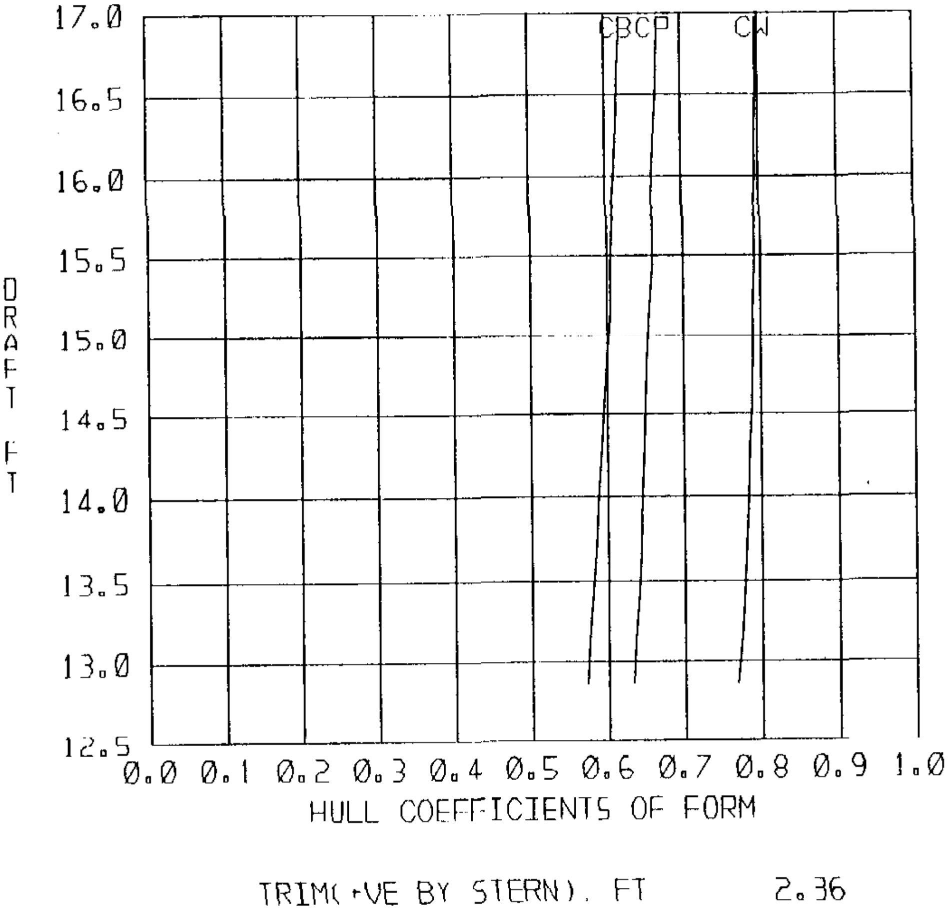


Figure 8-2. Hull Coefficients of Form.

3. Displacement and other curves

The hydrostatic curves, also known as the Curves of Form, were produced by ASSET for the RDS-2010 hull without the bow SONAR dome. These curves are shown in Figure 8-3 and include the following items as designated here:

A	Displacement in salt water (DISPL) - (*Note: the draft used for this and all the other curves is the mean draft to the bottom of the keel.*)
B	Moment to trim one inch (MT1)
C	Tons per inch immersion (TP1)
D	Transverse metacentric radius (BMT)
E	Longitudinal metacentric radius (BML)
F	Center of buoyancy above bottom of keel amidships (KB)
G	Change in displacement per unit trim by stern (CID1TS)
H	Wetted surface area (WSURF)
I	Longitudinal center of buoyancy (LCB)
J	Longitudinal center of flotation (LCF)

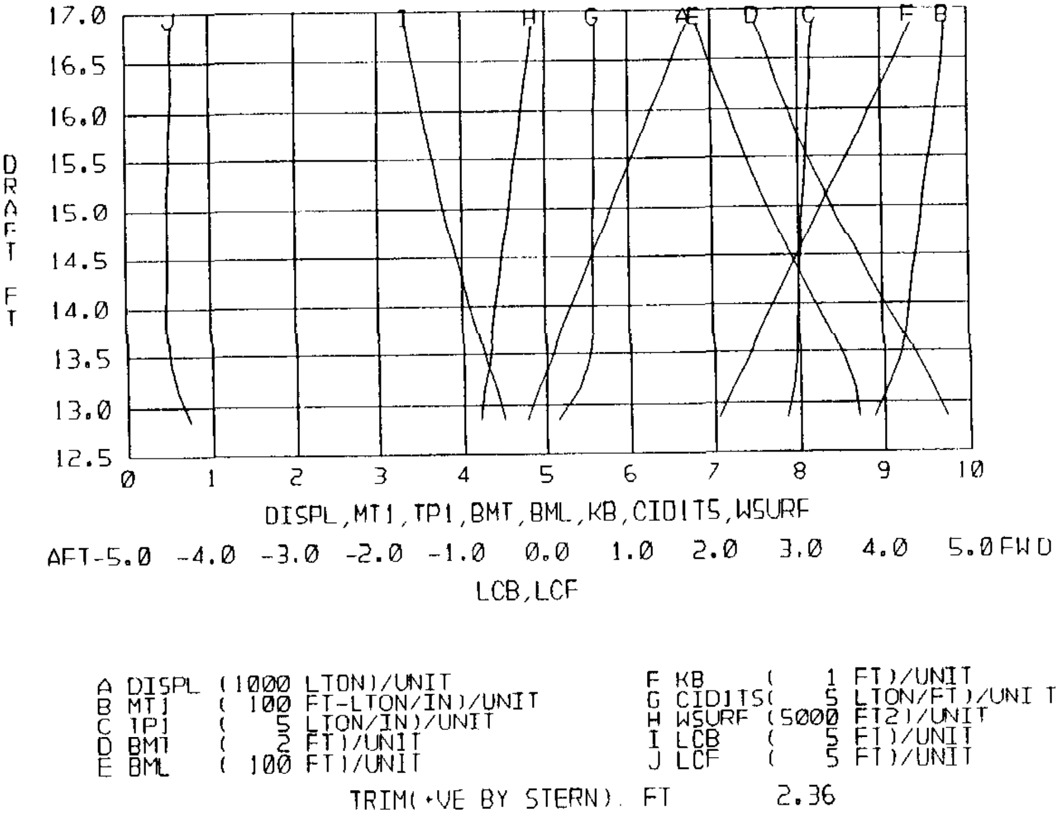


Figure 8-3. Displacement And Other Curves.

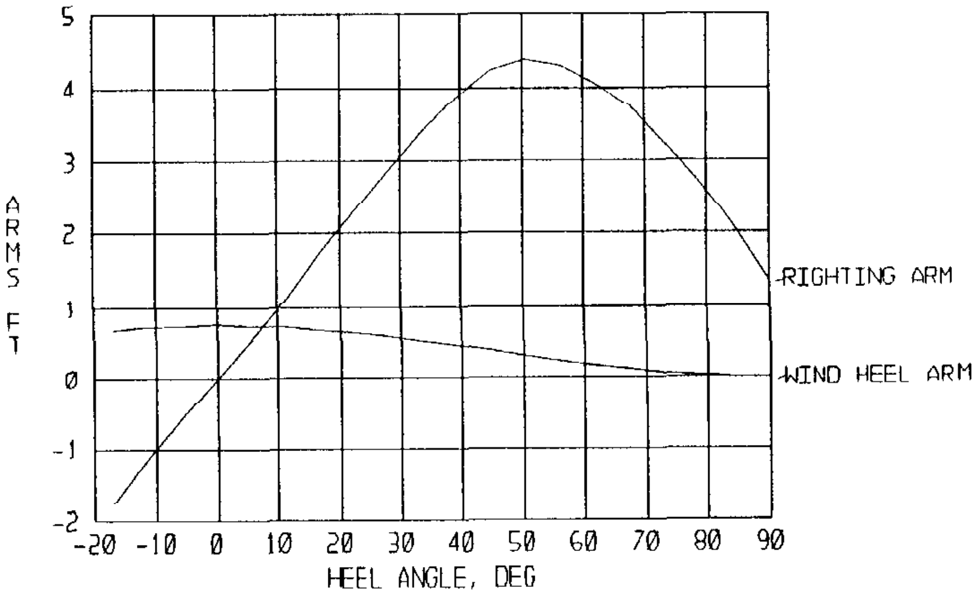
4. Static Stability

All ship designs require sufficient initial stability and buoyancy to enable the ship to withstand the effects of external influences and internal movements. *Intact criteria* consists of a number of requirements including withstanding the effect of beam winds, lifting of heavy weights over the side, towline pull, crowding of personnel to one side, high speed turning, and topside icing.

Beam wind, when combined with the ship's roll, is typically the governing case for intact stability. For this ship design, the ship must be expected to weather the full force of tropical cyclones. The criteria for adequate stability under adverse wind and sea conditions is based on a comparison of the ship's righting arm curve and the wind heeling arm curve. Figure 8-4 is the static stability curve and wind heeling arm curve produced by ASSET for the RDS-2010.

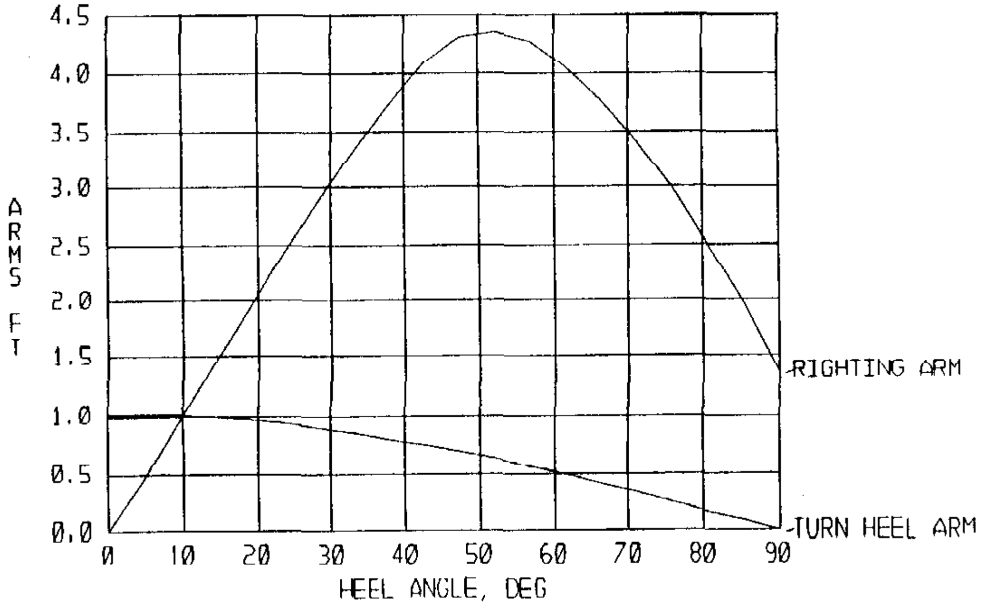
Stability is considered satisfactory if (1) the heeling arm at the intersection of the righting arm and heeling arm curves is not greater than 60% of the maximum righting arm; and (2) the area between the two curves to the right of their intersection is not less than 140% of the area between the two curves to the left of their intersection. Inspection of Figure 8-4 shows that both of these criteria are met.

To examine the high speed turn stability problem, the turn heeling arm curve is plotted on the same graph as the static stability curve. This is shown for the RDS-2010 in Figure 8-5. The following criteria must be satisfied to ensure adequate stability: (1) the angle of steady heel does not exceed 10 degrees, (2) the heeling arm at the intersection of the righting arm and heeling arm curves are not more than 60% of the maximum righting arm, and (3) the reserve of dynamic stability (area between the two curves to the right of their intersection) is not less than 40% of the total area under the righting arm curve. Examination of Figure 8-5 shows that all criteria are met.



```
                          INTACT STATIC STABILITY
DISPLACEMENT, LTON          5721.79     LCG LOC(+VE FWD MID), FT     -5.8
KG, FT                        19.59     WIND SPEED, KT              100.0
```

Figure 8-4. Static Stability Curve with Wind Heeling Arm.

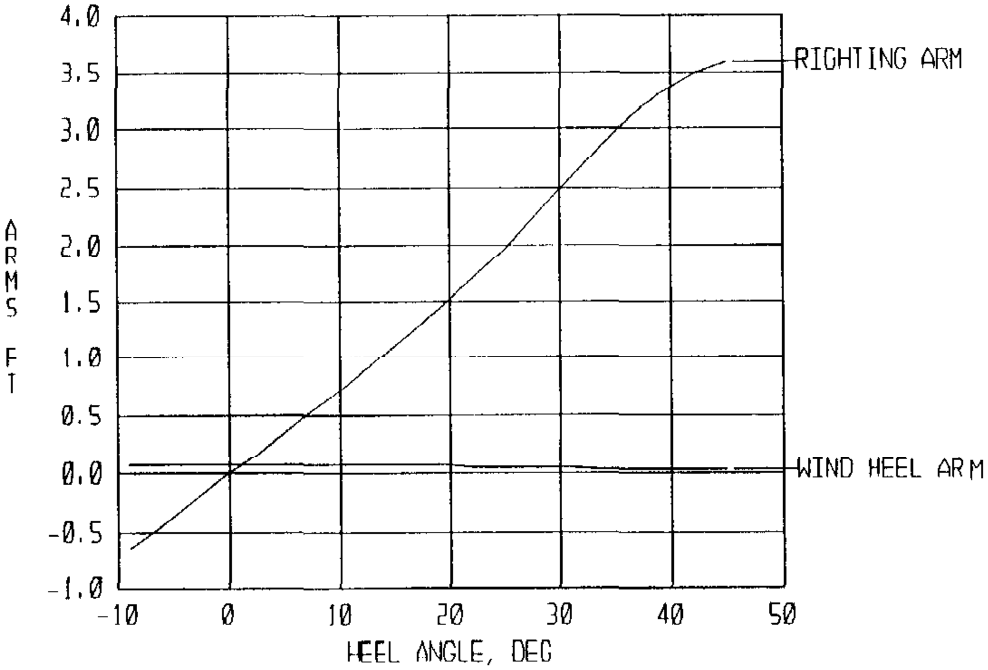


INTACT STATIC STABILITY

DISPLACEMENT, LTON	5721.79	LCG LOC(+VE FWD MID), FT	-5.8
KG, FT	19.59	TURN SPEED, KT	26.4
		TURN RADIUS, FT	818.6

Figure 8-5. Static Stability Curve with Turn Heeling Arm.

Additionally, the Damage (Underwater flooding) Criteria must be verified as satisfactory. For ships over 300 feet in length without a side protection system, such as the RDS-2010, the ship must be able to withstand flooding from a shell opening equal to 15% of the ship's length at any point fore and aft along the length. The following items must be met to satisfy this flooding criteria: (1) the static trimmed-heeled waterline after damage does not submerge the margin line; (2) the static heel angle without wind effects does not exceed 15 degrees; (3) adequate dynamic stability exists to absorb the energy imparted to the ship by moderately rough seas in combination with beam winds (this is the area between the righting arm curve and wind heel arm curve); (4) the righting arm curve is terminated at the 45 degree point. Figure 8-6 shows the righting arm curve and wind heel arm curve for the RDS-2010 as generated by the ASSET program.



DAMAGED STATIC STABILITY

DISPLACEMENT, LTON	5721.79	LCG LOC(+VE FWD MID), FT	-5.8
KG, FT	19.59		

Figure 8-6. Damaged Static Stability Curve.

B. ARRANGEMENTS

The ship design team was tasked with completing some internal and topside arrangements. Internal space allocation level of detail arrangements were completed for all internal spaces. In addition, detailed compartment arrangements were completed for the primary Combat Information Center and the pilot house. Finally, the topside arrangements were completed, ensuring proper placement of combat system sensors and engagement elements to allow for maximum combat effectiveness.

1. Internal Arrangements

Figures 8-7 through 8-13 show the general (space allocation) arrangements of the 03 through 01 deck levels, and the main through fourth deck levels, respectively. The goal here was to ensure that sufficient space was allocated for all functions as defined by the ASSET program and to ensure that the location of these spaces met the overall ship design goals. Specific emphasis was placed on ensuring the integrity of the enclaving philosophy.

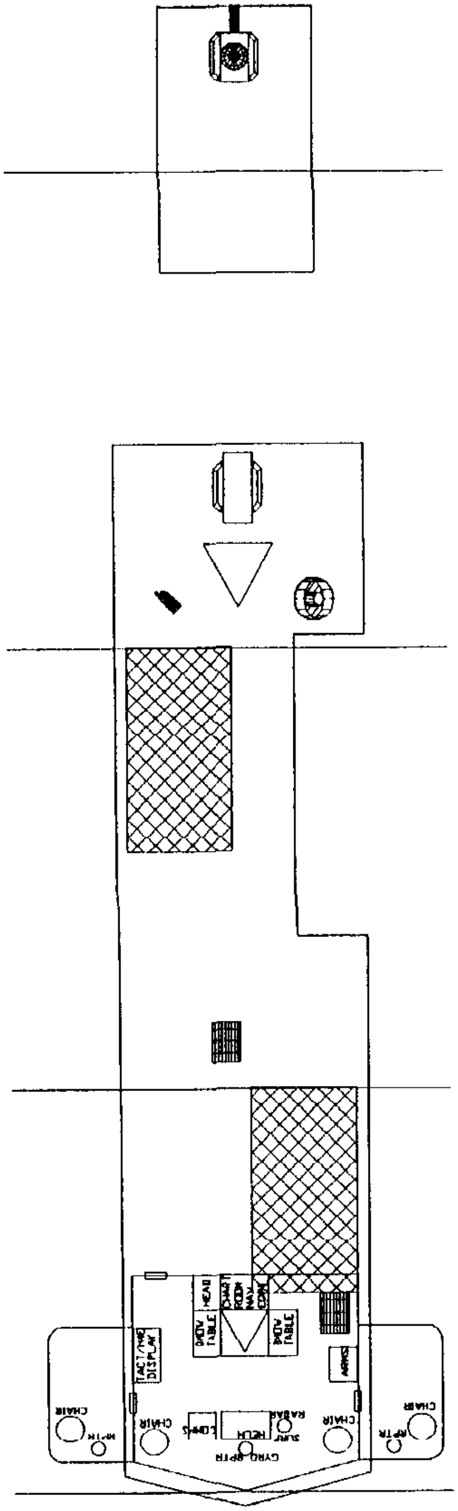


Figure 8-7. 03 Level General Arrangements.

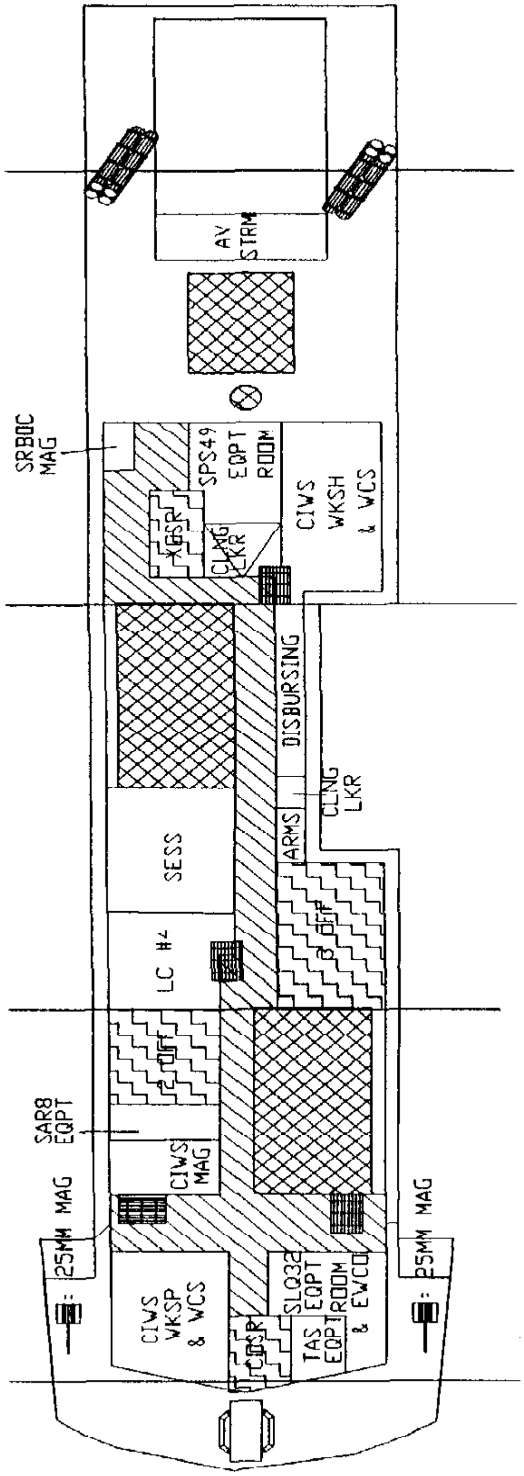


Figure 8-8. 02 Level General Arrangements.

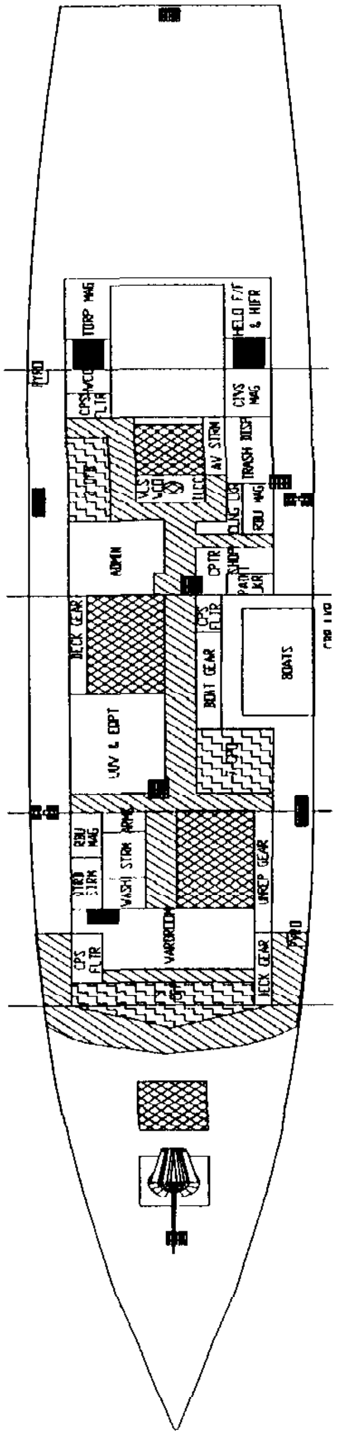


Figure 8-9. 01 Level General Arrangements.

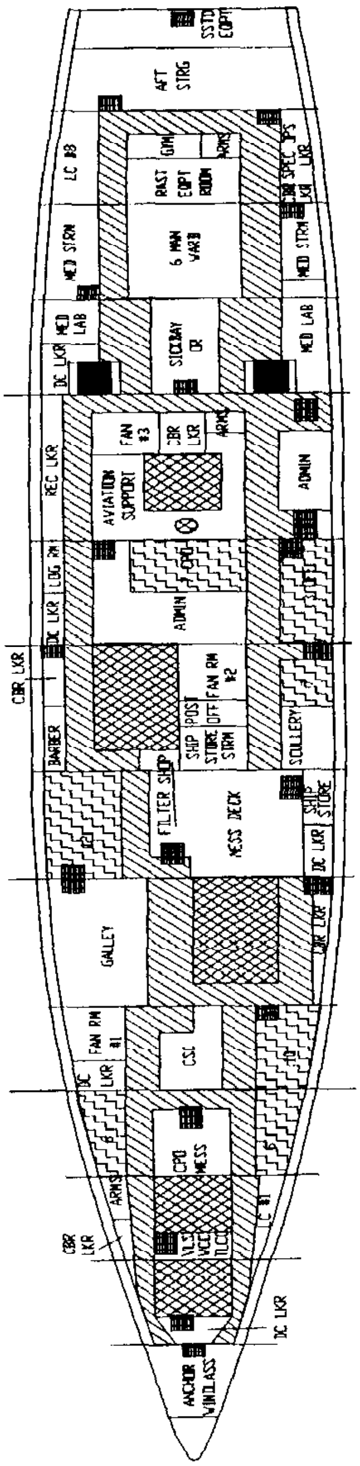


Figure 8-10. Damage Control Deck General Arrangements.

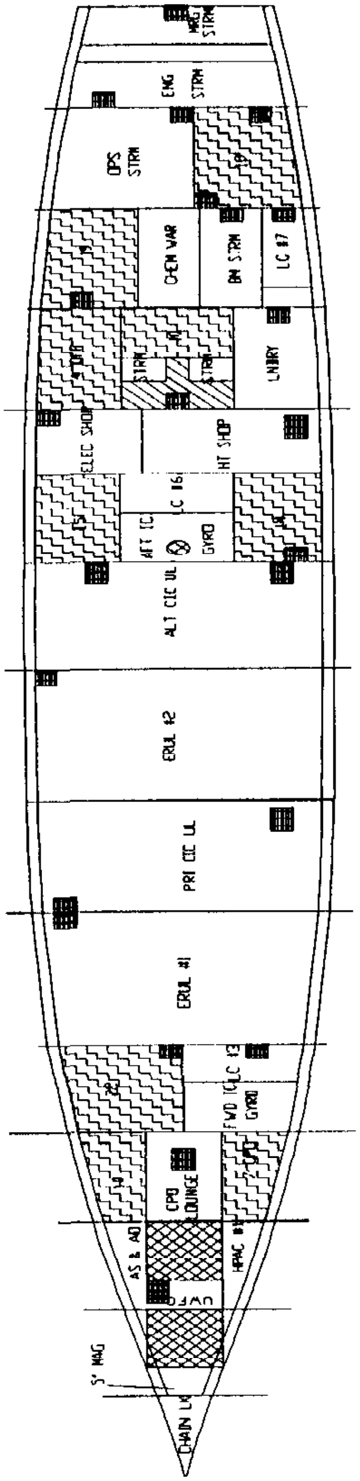


Figure 8-11. 2nd Deck General Arrangements.

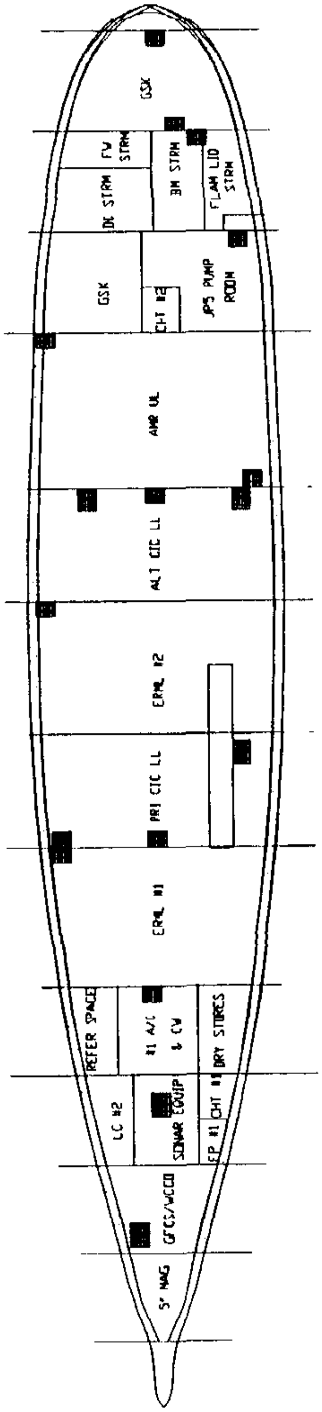


Figure 8-12. 3rd Deck General Arrangements.

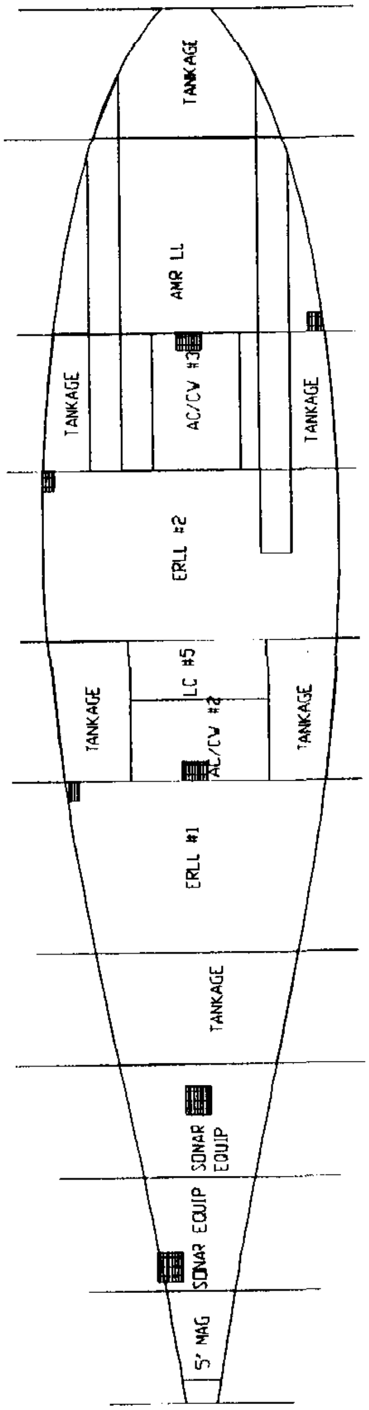
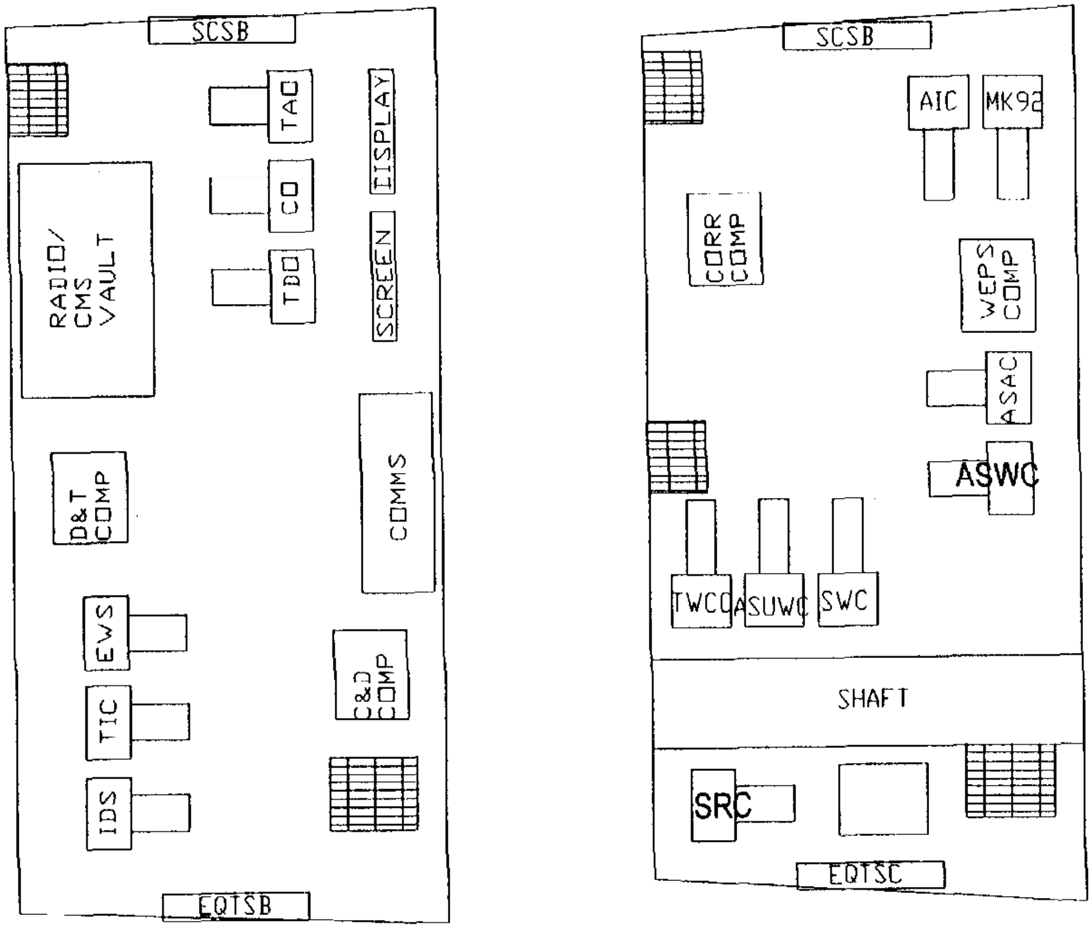


Figure 8-13. 4th Deck General Arrangements.

2. Detailed arrangement

Two spaces, the primary Combat Information Centers (CIC) and the pilot house, were arranged in detail. Figures 8-14 and 8-15 show these results.



PRI CIC U/L

PRI CIC L/L

Figure 8-14. Primary CIC Detailed Arrangement.

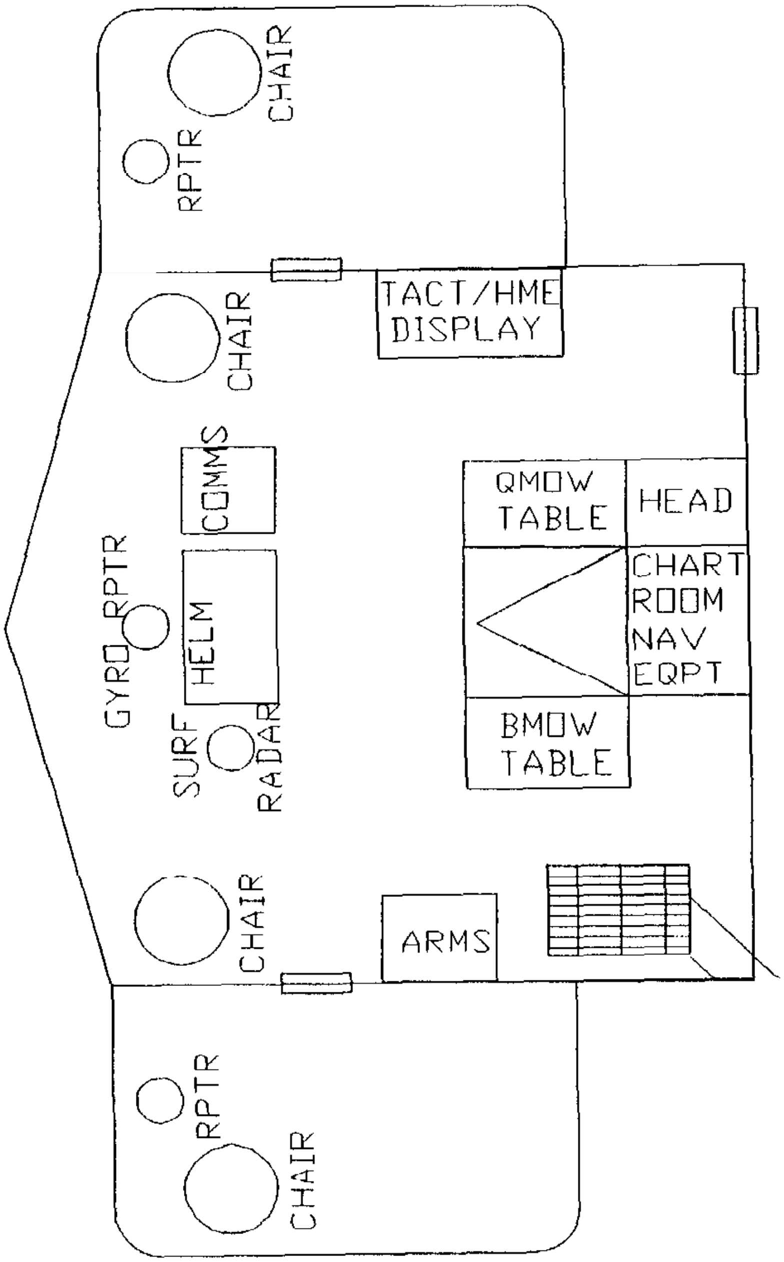


Figure 8-15. Pilothouse Detailed Arrangements.

3. Topside Arrangement

The goal in topside arrangements is to obtain a topside layout which maximizes combat system effectiveness and still allows for operational requirements. The design team felt that a need to follow a specific design process was required in order to support such a goal. The team agreed to use the following process:

a. review mission requirements and design constraints,
    (1) identifying elements needing to be high and
    (2) identifying elements needing clear arcs of fire;
b. identify required topside elements;
c. prioritize need/satisfaction for elements;
d. layout ship model;
e. assess ship performance; and
f. iterate until performance is acceptable.

Based on this process we felt that optimum locations were chosen for the topside components. Potentially competing requirements such as maintaining the enclaving scheme topside, ensuring adequate arcs of coverage for detection and engagement elements, while minimizing the overall impact on operational requirements, had to be reconciled. Figure 8-16 shows the location of the major topside components (primarily combat system detection, track and engagement elements).

During the topside arrangement phase, the arcs of coverage of the various weapons systems had to be checked for adequate coverage and minimal interference. This was done solely on a geometric scale and did not involve the use of any blockage assessment models.

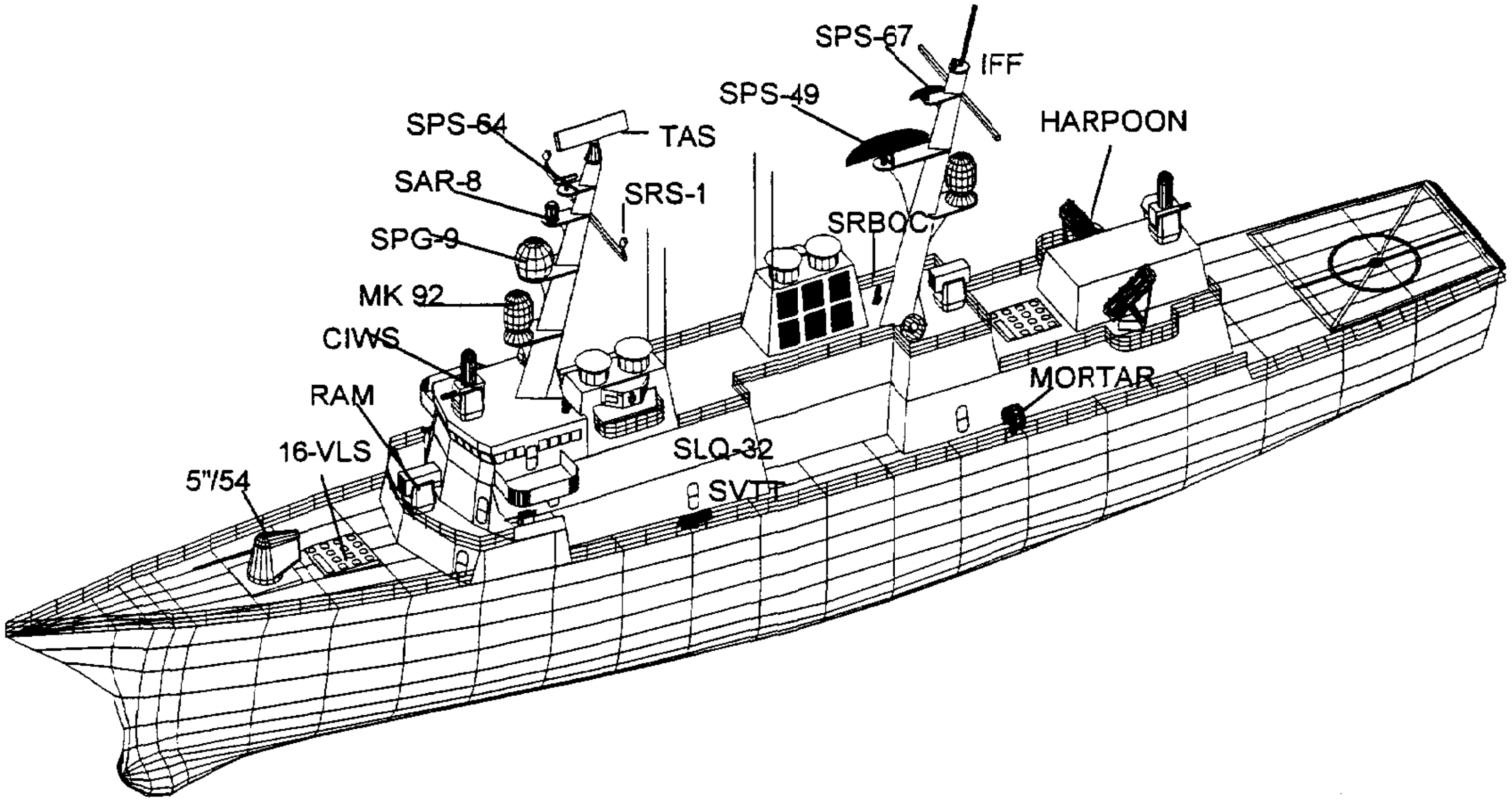
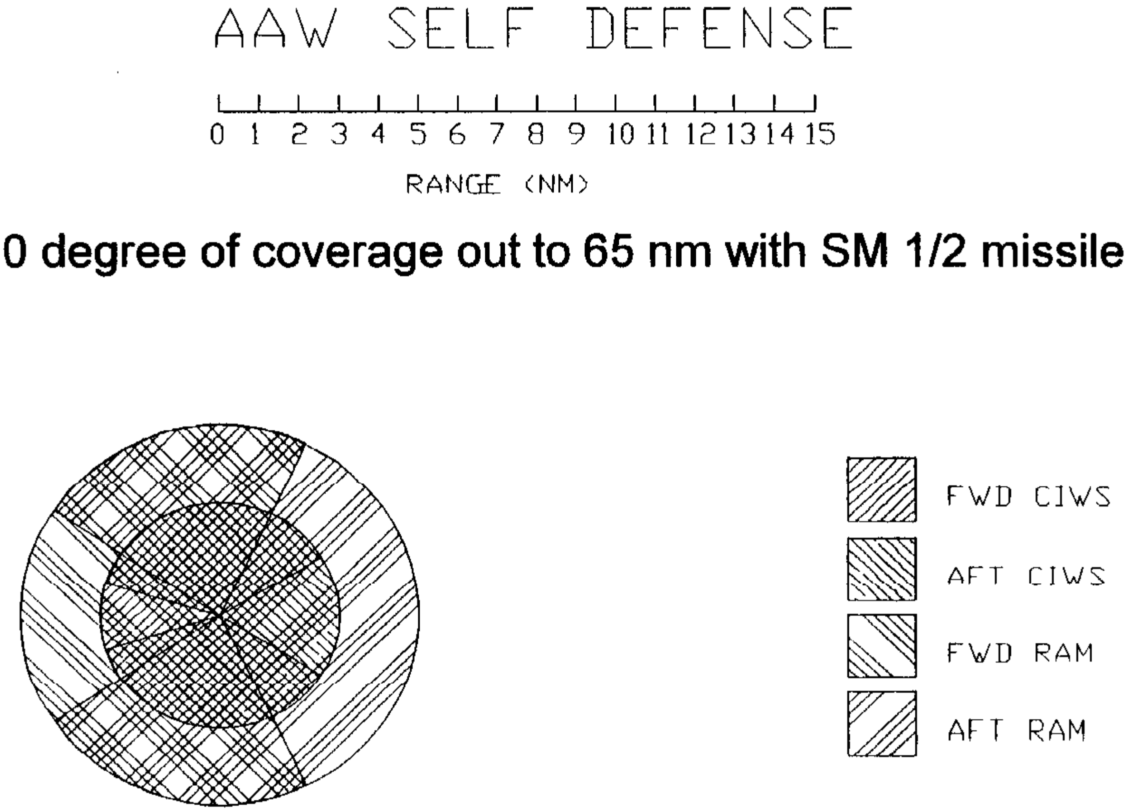


Figure 8-16. RDS-2010 Topside Arrangements.



360 degree of coverage out to 65 nm with SM 1/2 missiles

Figure 8-17. Arcs of coverage for AAW self-defense weapons.

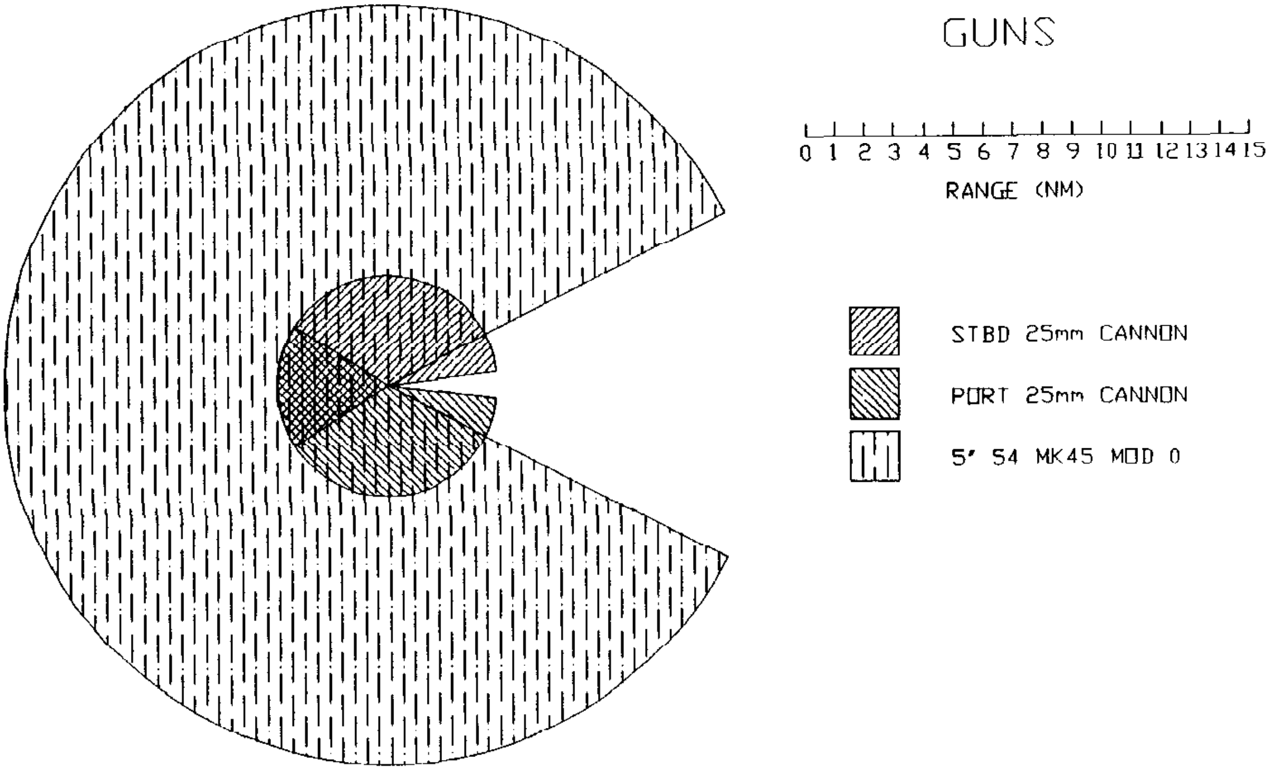


Figure 8-18. Arcs of coverage for ship's guns.

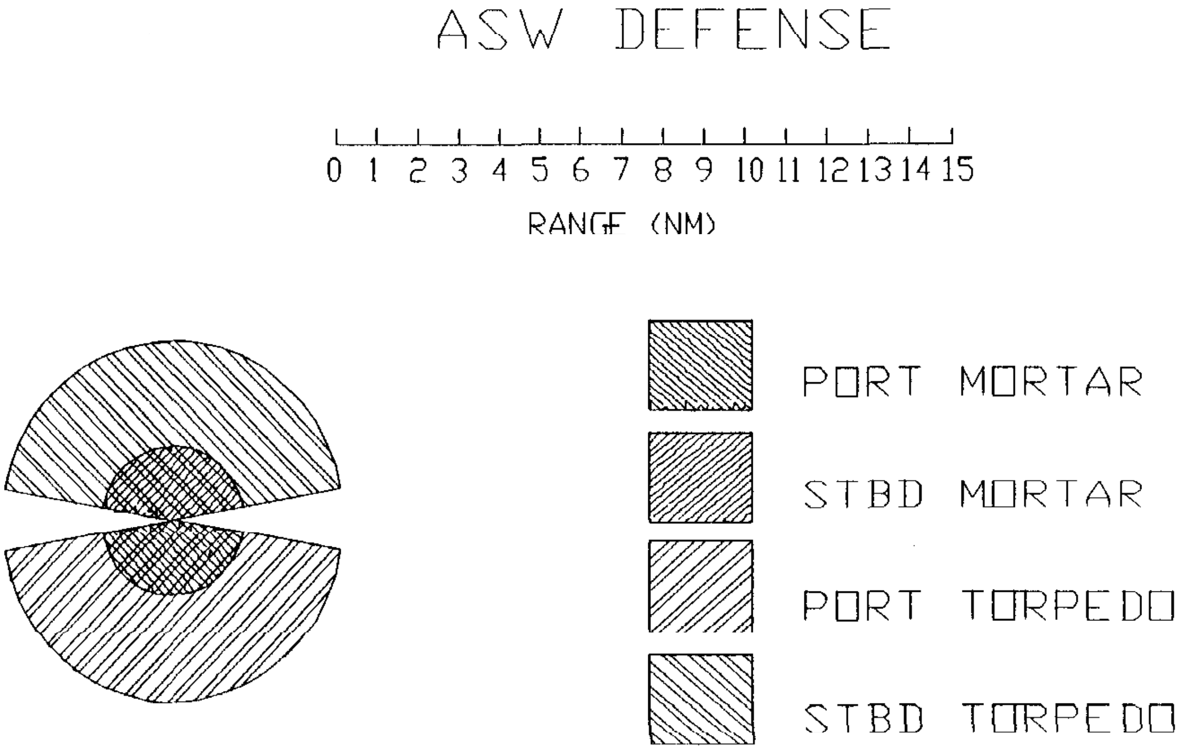


Figure 8-19. Arcs of coverage for ship's ASW defense weapons.

C. HULL DAMAGE AND FLOODABLE LENGTH

Before a discussion of hull damage and floodable length can begin, several items must be defined for the purpose of clarity. These items are:

Bulkhead deck -- The bulkhead deck is the uppermost deck to which the transverse watertight bulkheads extend.

Margin line -- The margin line is a line drawn parallel to, and a minimum of three inches below, the bulkhead deck at the side.

Permeability -- Permeability is the percentage of volume in a space that can be flooded. It is expressed as the ratio of available volume to total volume.

Floodable length -- Floodable length is the maximum length that a given longitudinal position within a ship can be symmetrically flooded at the prescribed permeability without sinking below the margin line.

Factor of subdivision -- The factor of subdivision is an arbitrary factor applied to the floodable length to obtain the permissible length of compartments within a ship. The factor of subdivision is prescribed by national and international rules and conventions as a function of ship length and type of service. Generally, the factor of subdivision ensures that one, two or three compartments must be flooded before the ship settles to the margin line. Ships designed to these rules are sometimes called one-, two-, or three-compartment ships with reference to their damaged-stability capabilities.

Permissible length -- The permissible length of a compartment within a ship is obtained by multiplying the value of the floodable length at the center of the compartment by the factor of subdivision.

Curve of floodable length -- The curve of floodable length is a curve which at every point in its length has an ordinate representing the length of ship that may be flooded with the center of length at that point without submerging the margin line.

1. Numerous considerations are involved in determining the optimum arrangement of subdivisions for a naval combatant, but the principal factors are:

a. ability to survive underwater damage;
b. protection of vital spaces against flooding;
c. interference of subdivision with arrangements;
d. interference of subdivision with access and systems;
e. provision for carrying liquids;
f. possibility of bow-collision damage; and
g. possibility of stranding.

There are always conflicts among these various factors, hence their relative importance must be determined.

For the design of RDS-2010 the first four factors were considered to be most important thereby driving the design to have transverse bulkheads placed as shown in Figure 8-20. The standard rule used by the U.S Navy for floodable length calculations is that the ship be able to accept damage to the hull which results in an opening to the sea of fifteen percent of the length between perpendiculars without submerging the margin line. This value for the RDS-2010 is 58.5 feet. This means that the design must accept a damage length of 58.5 feet anywhere in the hull. This damage length requires that the RDS-2010 be a four-compartment ship.

2. Referring to Figure 8-20, it is seen that for a continuous permeability of 0.95 the design meets the required damage length and is in fact a four-compartment ship. If the permeability of each subdivision was updated to the actual value, the floodable length curve would move upward resulting in larger floodable lengths, improving the apparent survivability of the design. The plot of the floodable length curve shown in Figure 8-20

depicts the worst case scenario (total ship permeability equal to 0.95) to ensure that the design criteria were met.

Reference [5] provides more information on the construction of a floodable length curve.

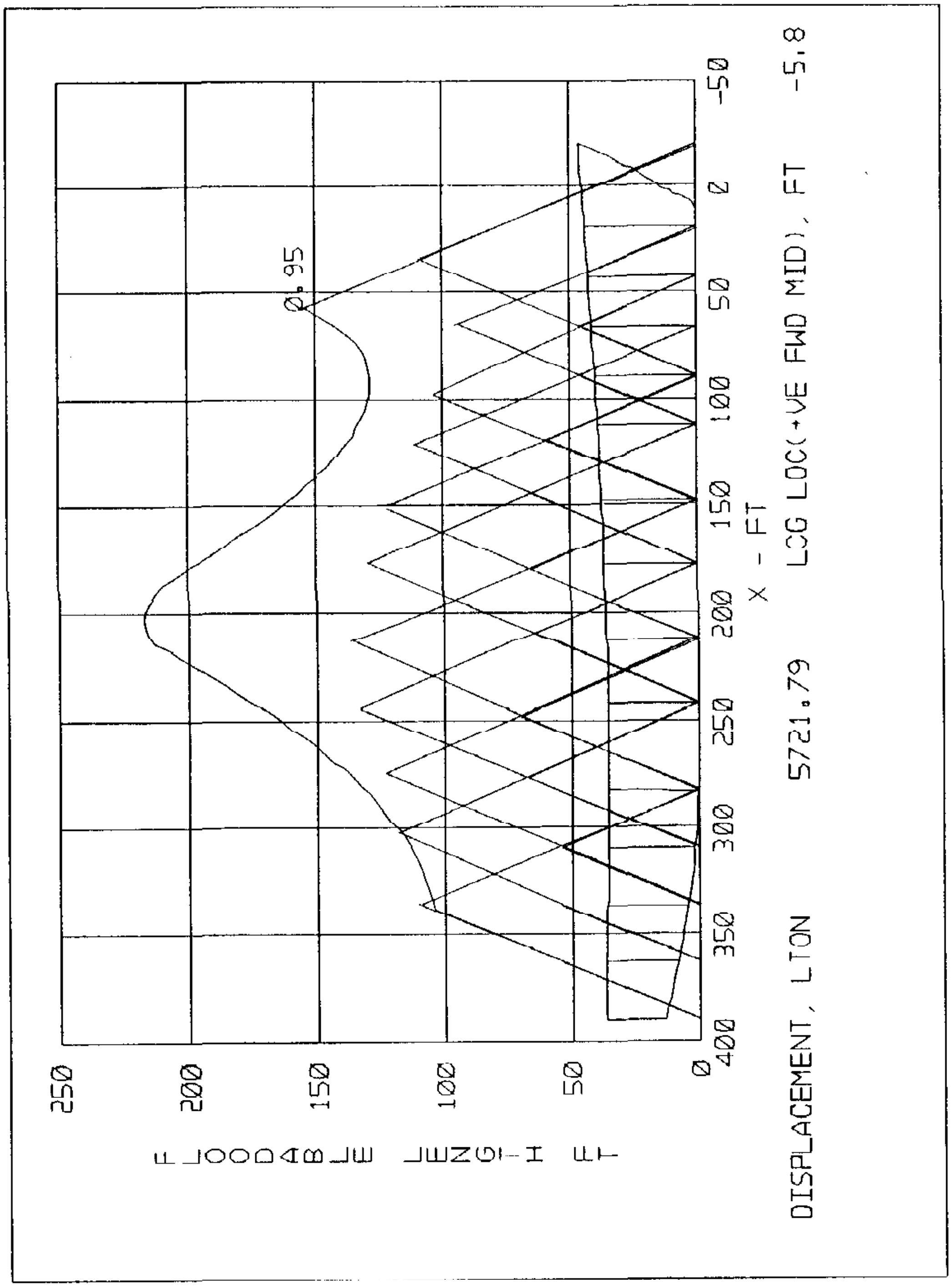


Figure 8-20. Floodable Length Curve.

D. SHIP STRUCTURE REPORT

1. Ship Structural Loads

The size and principal characteristics of a ship are determined primarily by its mission, intended service, and cost. In addition to basic functional considerations there are requirements such as stability, low resistance and high propulsive efficiency, good sea keeping, and navigational limitation on draft or beam, all of which influence the choice of dimensions and form. The ship's structure must be designed, within these and other basic constraints, to sustain all of the loads expected to arise in its seagoing environment. In contrast to land based structures, the ship does not rest on a fixed foundation but derives its entire support from buoyant forces exerted by a dynamic and ever changing ocean environment, which is both the friend and enemy of the ship.

The structural components of a ship are frequently designed to perform a multiplicity of functions in addition to that of providing the structural integrity of the ship. Furthermore, many strength members serve dual functions. For example, bulkheads that constitute substantially to the strength of the hull may also serve as watertight boundaries of internal compartments. Their locations are dictated primarily by the required tank volume or subdivision requirements.

The loads that the ship structure must be designed to withstand have many sources. There are static components which consist principally of the weight and buoyancy of the ship in calm waters. There are dynamic components caused by wave induced motions of the ship, and by slamming or springing in waves, as well as vibratory loads by the propeller and machinery, all of which range over different frequency ranges. An important characteristic of these load components is their variability with location and time (North Atlantic conditions in January are far from being the same as Mediterranean in July), and with the particular voyage (lightship versus fully loaded conditions).

Furthermore, the loads imparted by the sea are random in nature, and therefore the ship's structural behavior can be expressed only in probabilistic terms.

a. Four principal mechanisms are recognized as causing most of the cases of ship structural failure, aside from collision or grounding. These modes of failure are as follows:

(1) excessive tensile or compressive yield;

(2) buckling due to compressive or shear instability;

(3) fatigue cracking; and

(4) brittle fracture.

The problem of ship structural design then consists of the selection of material types, frame spacing, frame and stiffener sizes, and plate thicknesses, becoming an integrated part of the design spiral.

b. It is convenient to divide the loads acting on the ship structure into four main categories, based partly upon the nature of the load and partly upon the ship's response:

(1) Static loads are loads that change only when the weight of the ship changes. These include:

(a) weight of the ship and its contents;

(b) static buoyancy of the ship at rest or in motion;

(c) thermal loads resulting from temperature gradients within the hull; and

(d) concentrated loads caused by dry docking or grounding.

(2) Low frequency dynamic loads are loads that vary in time with periods ranging from a few seconds to several minutes, therefore they do not result in any

appreciable resonant amplification of the stresses induced in the structure. These can be broken down into the following components:

- (a) wave induced hull pressure variations;
- (b) hull pressure variations caused by transient ship motions; and
- (c) inertial reactions resulting from the acceleration of the mass of the ship and its contents.

(3) High frequency dynamic loads are time varying loads of sufficiently high frequency that they may induce vibratory response of the ship structure. Some of the exciting loads may be quite small in magnitude but, as a result of resonant amplification, can give rise to large stresses and deflections. Examples of such dynamic loads include the following:

- (a) hydrodynamic loads induced by propulsive devices;
- (b) loads imparted to the hull by reciprocating or unbalanced machinery;
- (c) hydrostatic loads resulting from interaction of appendages with the flow past the ship; and
- (d) wave induced loads due primarily to short waves whose frequency of encounter overlaps the lower natural frequencies of hull vibration, called *springing*.

(4) Impact loads are loads resulting from slamming or wave impact on the bow, including the effects of green water on deck. In a naval ship, weapon effects constitute a very important category of impact loads. Impact loads may induce transient hull vibration that is called *whipping*.

c. The most important classes of loads are the static loads resulting from the ship's weight and buoyancy, and the low frequency dynamic loads, while springing loads are important in very long flexible ships such as the Great Lakes carriers. In addition to the above four main categories, there may exist specialized operational loads, which may be the dominant loads for certain ship types. Examples of such loads, which may be either static or dynamic, are:

(1) ice loads in the case of a vessel intended for ice breaking or Arctic navigation;

(2) loads caused by impact with other vessels, as in the case of tugs and barges;

(3) impact of cargo handling equipment;

(4) structural thermal loads imposed by special cargo carried at extreme temperature and/or pressures;

(5) sloshing and impact loads on internal structures caused by movements of liquids in tanks; and

(6) aircraft or helicopter landing forces.

2.` Static loading.

The two main categories involved in static loading are the weight of the hull and its components and buoyancy, as shown in Figure 8-21. The individual loads may have both local and overall structural effects. A very heavy piece of machinery induces large local loads at the points of attachment to the ship; therefore its foundation must be designed to distribute these loads evenly into the hull structure. Simultaneously, the weight of this piece of machinery contributes to the distribution of shear forces and bending moments acting along the length of the hull.

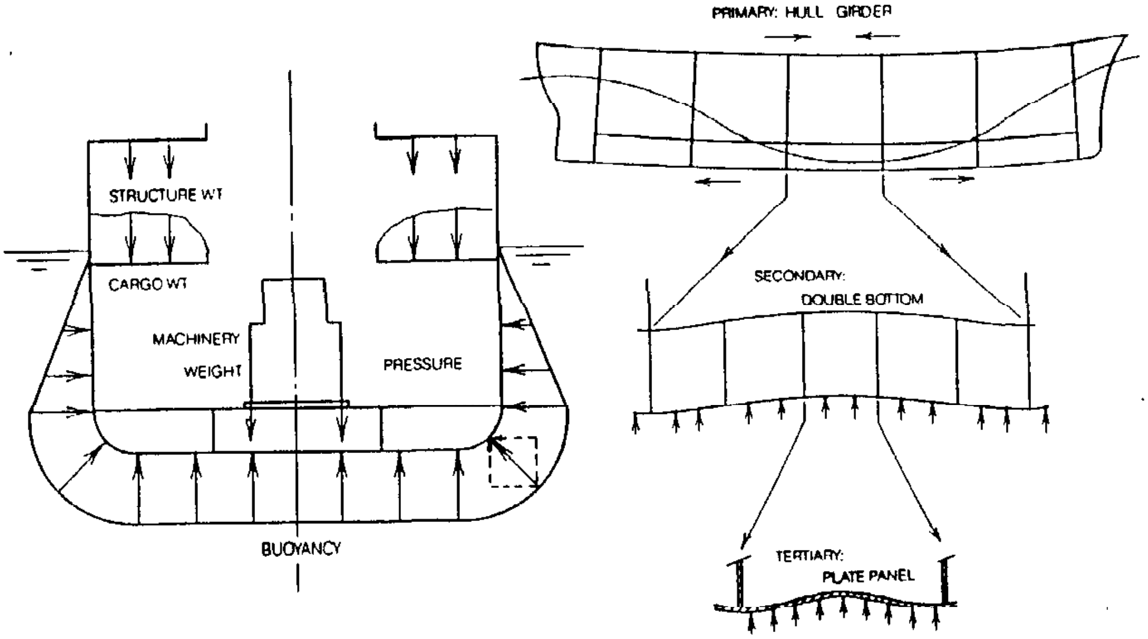


Figure 8-21. Static loads and structural response.

The geometrical arrangement and resulting stress and deflection patterns of typical ship structures are such that the associated response a usually divided into three components, as shown in Figure 8-21. The primary response is the response of the entire hull, when bending and twisting as a beam, under the external longitudinal distribution of vertical, lateral, and torsional loads. Study of this response constitutes the longitudinal strength calculations and are usually performed in ship structural analysis and design. The secondary response comprises the stress and deflection of a single panel of stiffened plating. The loading of the panel is normal to its plane, and the boundaries of the secondary panel are usually formed by other secondary panels, such as side shell and bulkheads. The tertiary response describes the out of plane deflection and associated stress of an individual panel, and its boundaries are formed by the stiffeners of the secondary panel of which it is a part. The last two responses can be evaluated using the familiar laws of structural member response from solid mechanics.

A typical longitudinal distribution of weight and buoyancy for a ship afloat in calm water is illustrated in Figure 8-22. In the lower part of this figure is plotted a curve (1) of buoyancy force per unit length, which is equal to the weight density, ρg, of the water times the sectional area. For any waterline shape, the buoyancy curve can be easily obtained from the Bonjean curves. The upper curve (2) of Figure 8-22 shows the longitudinal distribution of the weight force, which essentially consists of a book-keeping process in which every item aboard the ship is recorded and assigned to a particular location. The total load acting on the ship is

$$f(x) = b(x) - w(x),$$

where $b(x)$ is the buoyancy per unit length, and $w(x)$ the weight per unit length. The conditions for static equilibrium require that the integral of the total load over the ship length and the integral of the longitudinal moment of the load curve each be zero. As in standard beam calculations, the shear force at some location x_1 is equal to the integral of the load curve,

$$V(x_1) = \int_0^{x_1} f(x)dx;$$

and the bending moment is the integral of the shear force

$$M(x_1) = \int_0^{x_1} V(x)dx.$$

It can be observed that the shear force and bending moment are zero at the bow and the stern, as they ought to be since the ship is essentially a free-free beam resting on an elastic foundation. Besides the still water buoyancy curve at the design waterline, two other conditions are traditionally studied, as shown in Figure 8-22. The first is that of a wave of length equal to the length of the ship located with its crest at amidships, and this condition is called *hogging*. The second wave condition traditionally studied is that of a wave whose trough is located amidships, and this condition is called *sagging*. Although no dynamic affects are considered in the sagging and hogging conditions, they can be used to provide extreme loading conditions for comparative or design purposes when combined with the appropriate ship loading condition.

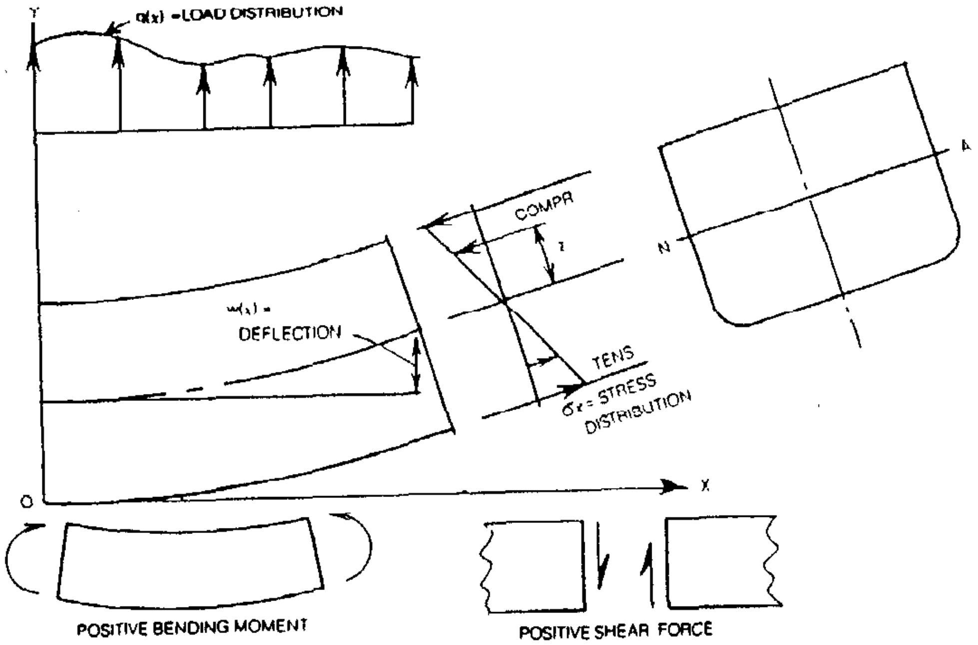


Figure 8-22. Static loads, shear, and bending moment.

3. Wave induced loading.

The principal wave induced loads are those previously referred to as low frequency dynamic loads or loads involving ship and wave motions that result in negligible dynamic stress amplification. The calculation of the bending moment, shear force, and torsional loading on a ship hull due to waves requires a knowledge of the time varying fluid pressure distribution over the wetted surface of the hull together with the distribution of the inertial reaction loads. The fluid loads depend on the wave induced motions of the water and the corresponding ship motions, which in turn depend on the fluid loads. One popular solution to this complicated problem involves the use of *strip theory*, where the ship a divided into narrow transverse strips. This allows the reduction of a three dimensional problem into a family of two dimensional problems that are easier to solve. The results then are integrated along the length of the hull.

a. One of the important assumptions of linear strip theory is that both the wave and ship motion amplitudes are, in some sense, small. As a result it is possible to consider the total instantaneous vertical force on a thin transverse strip to be composed of the sum of several terms that are computed independently of each other. Two of these forces are the still water buoyancy and weight of the element of the ship length, in other words the static loads from the previous section. The remaining forces are time varying and result from inertial reaction and from the water pressures, and can be divided into the following categories:

(1) A wave pressure force component computed as though the presence of the ship does not disturb either the incident waves or the dynamic pressure distribution in those waves. This is called the *Froude-Krylov* force.

(2) A wave pressure force component computed from the properties of the diffracted wave system. These waves result from the reflection and distortion of the

incident waves as they impinge upon the ship, and is called the *diffraction* force. Together with the Froude-Krylov force, it is sometimes referred to as the *wave exciting* force.

(3) A term proportional to the instantaneous vertical displacement of the ship strip from its mean position, as if in calm water. This is called the *hydrostatic* restoring force and is equal to the change in the mean static buoyancy of the element.

(4) A term proportional to the instantaneous vertical velocity of the element, called a *damping* force.

(5) A term proportional to the instantaneous vertical acceleration of the element called an *added mass* force. The added mass and damping forces are also known as the *radiation* forces since as a result of the ship motions, a wave system that radiates away from the ship is generated.

The first two of the above forces are computed as though the ship moves steadily forward through the waves but experiences no oscillatory motion response to the wave forces. The last three forces are computed as though the ship is undergoing its oscillatory wave induced motion while moving at a steady forward speed through calm water. Within the assumptions and limitations of linearity, such a breakdown is permissible.

In addition to the sum of the above forces $q(x)$, there must be added the inertial force $-m(x)a_z$ per unit length, where $m(x)$ is the mass of the strip and a_z is the vertical absolute acceleration of the ship strip. The wave induced loading per unit length is then

$$f_w(x) = q(x) - m(x)a_z,$$

and the wave induced shear force and bending moment are obtained by successive integrations of the load.

Figure 8-23 illustrates the different components of the load distribution at a fixed time for a typical Mariner class cargo ship moving through a simple sinusoidal wave

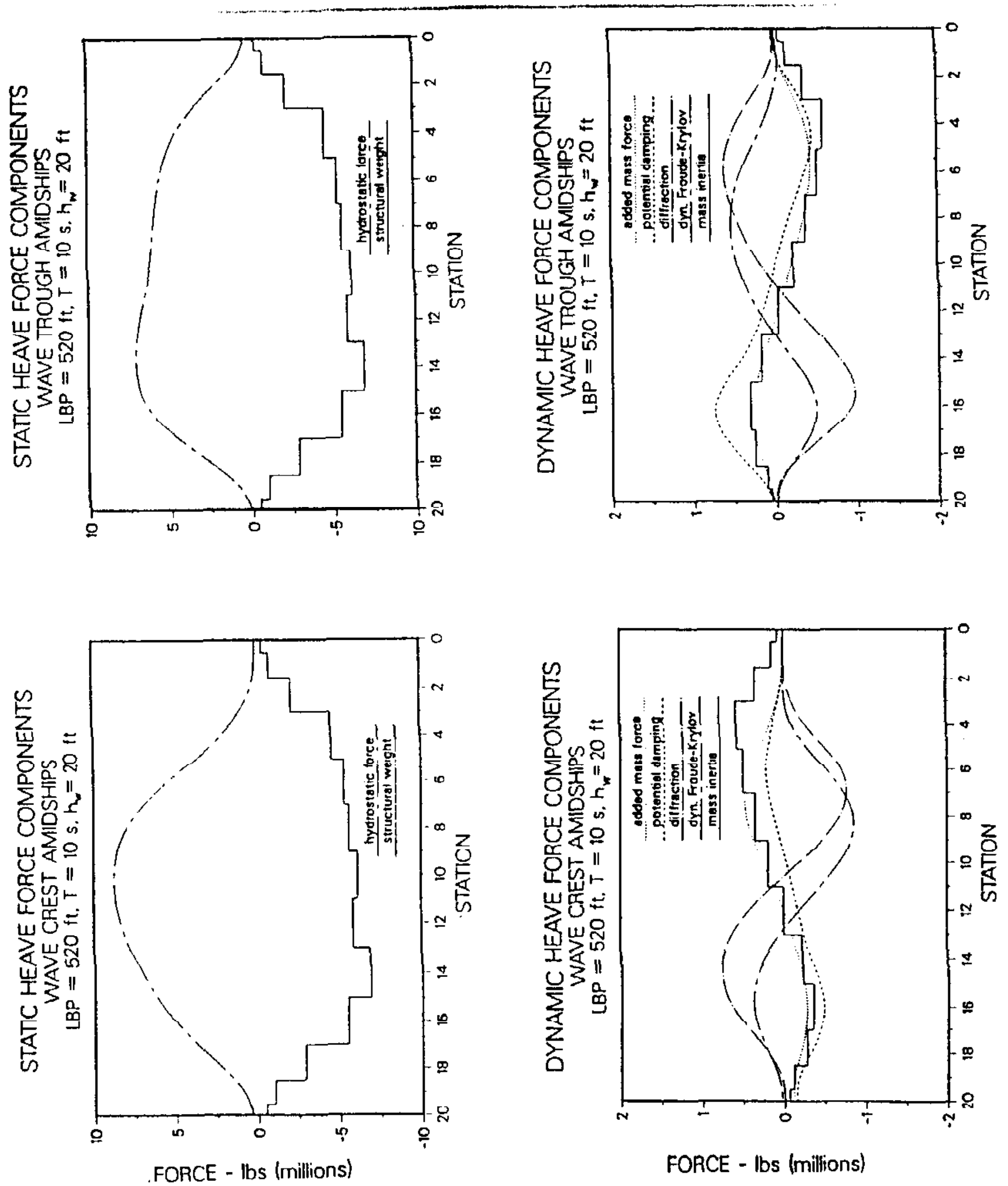


Figure 8-23. Typical wave induced ship loads.

of unit amplitude. We can see that the total loading consists of a number of tears of similar magnitude which may differ in sign and phase. There may be cancellation or reinforcement among the different components, with the result that the total loading may be larger or smaller than any individual component. This cancellation or reinforcement varies along the ship length and also varies with the frequency of wave encounter.

Although the above discussion was made with a view towards vertical ship motions (heave and pitch), a similar concept can be applied for the horizontal motions (sway and yaw). The transverse distribution of wave loads is also necessary to compute the secondary or tertiary response of structural components such as panels of stiffened or unstiffened plating.

b. Finally, the above deterministic load can be extended through the use of statistical analysis techniques, to reflect the probabilistic nature of wave loads. The statistical quantities that are usually of concern in ship strength investigations are divided into three categories:

(1) *Short-term mean and extreme values.* These refer to the period of time of a few hours during which the sea remains statistically stationary under normal climatic conditions.

(2) *Long term mean and extreme values.* These refer to a longer time period, days or years, during which the sea state may vary widely from calm to severe storm conditions. The long term response may be thought of as an accumulation of short term responses to different sea states, each having uniform or statistically stationary characteristics.

(3) *Cumulative cyclic values.* These refers to long term cyclic loading that may cause fatigue damage to the structure, even under moderate to low level of bending moment and stress.

B. LONGITUDINAL STRENGTH.

The term longitudinal strength refers to the overall structural behavior of a ship as a thin walled hollow beam under the influence of the previously mentioned bending moment and shear forces. Longitudinal strength calculations are predominantly used for midship section synthesis and the overall ship structural integrity evaluation.

In simple beam bending theory used in basic ship structural analysis, the following assumptions are made:

1. Kinematic assumptions from elementary Euler-Bernoulli beam theory, which neglect the bending from shear effects. The kinematics describe the deformation of the beam without regard to the forces on the beam.

    a. Plane sections remain plane before and after deformation, no shear or warping.

    b. Plane sections normal to the line of centroids remain normal before and after deformation, no shear. These two assumptions mean that $\gamma_{xy} = \gamma_{yx} = 0$.

    c. Strains are sufficiently small so that the cross sectional geometry does not change; no Poisson effects. This means that $\varepsilon_y = \varepsilon_z = \gamma_{yz} = 0$.

    d. Beam slopes are small.

    e. Beam cross section is prismatic. This is optional but is usually the case in ship structures.

2. Physics assumptions describe the material behavior.

    a. The material obeys Hooke's law; force is linearly proportional to displacement.

    b. The material is isotropic (has the same properties in every direction at one point) and homogeneous (material properties are the same at all points) in the y-z plane.

c. Stress field is one dimensional, the only significant stress is along the x-axis of the beam.

A sketch of the coordinate description and the positive bending moment convention is shown in Figure 8-24. The x-axis defines the centroid of the cross section provided the first moments of area are zero

$$\int_A ydydz = \int_A zdydz = 0.$$

For homogenous cross sections, the centroidal axis is the same as the *neutral* axis in bending, which is defined as the line or plane of zero strain. The differential equation for the elastic curve for a symmetrical beam is

$$EI_y w'' = M(x),$$

where w is the deflection, E the Young's modulus of elasticity of the material, I_y the second moment of area of the beam cross section around the y-axis through its centroid, and $M(x)$ the bending moment.

In terms of the load per unit length $f(x)$, the equation can be written as

$$EI_y w'''' = f(x).$$

Solution of this equation by multiple integrations, requires four boundary conditions, and since the ship is a free-free beam, these are zero shear and moment at the two end points.

The longitudinal stress at station x is related to the bending moment by

$$\sigma_x = -\frac{M(x)}{I_y} z,$$

where z is the vertical distance from the neutral axis. From the above equation it is clear that the extreme stresses are found at the top or bottom of the beam where z takes on its numerically largest values. For a positive bending moment, the top of the beam is in compression and the bottom is in tension.

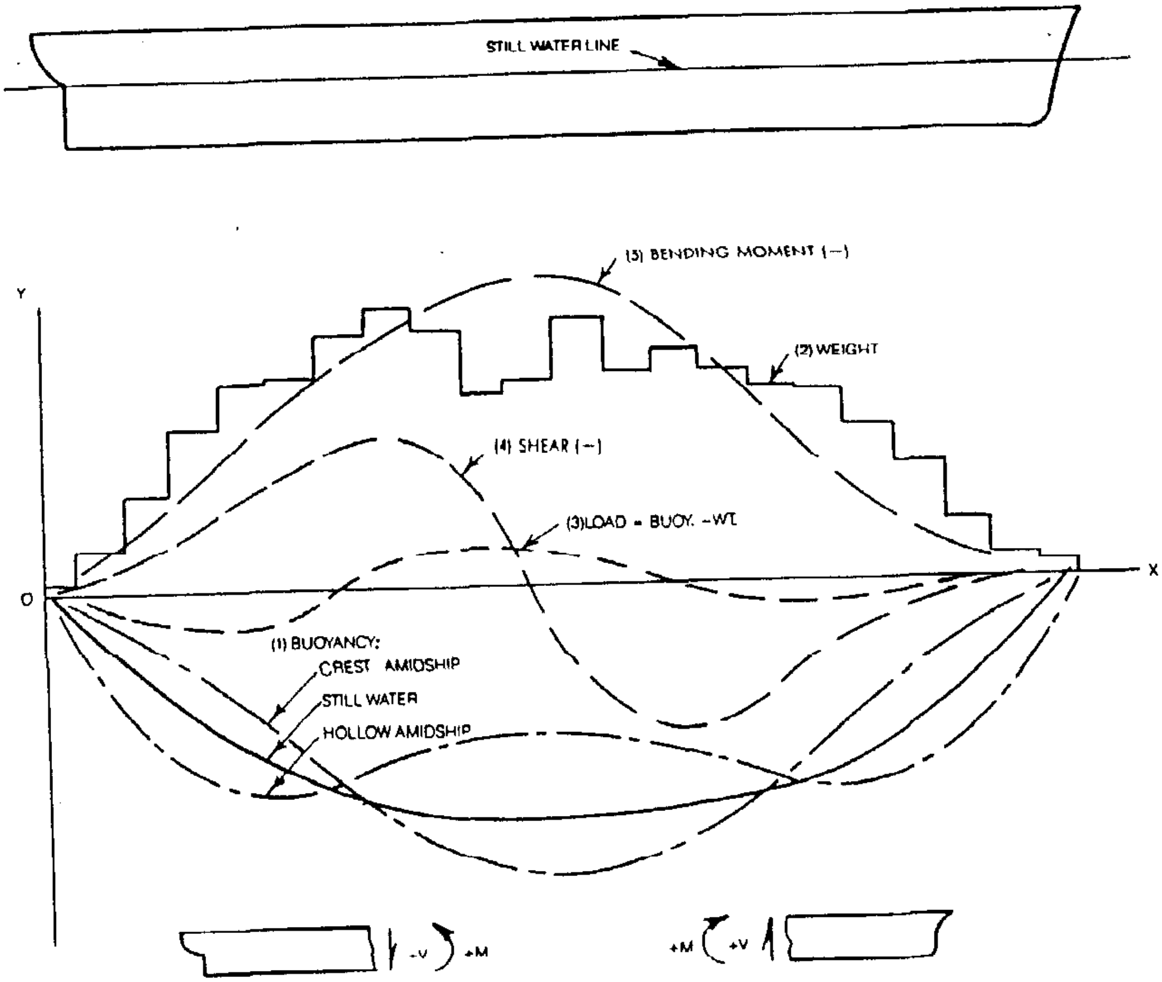


Figure 8-24. Coordinate description and sign convention.

One variation of the above beam equation is of importance in ship structures. It concerns beams composed of two or more material of different moduli of elasticity, for example, steel and aluminum, which may between the main hull and superstructure. In this case, the flexural rigidity EI_y is replaced by the integral $\int_A E(z)z^2dA$, and the neutral axis is located at a height such that

$$\int_A E(z)zdA = 0.$$

From the previous stress equation it can be seen that there is a discontinuity in the stress distribution, whereas the strain, $\varepsilon_x = \sigma_x / E$, will be continuous where two different materials join.

C. RDS 2010 ANALYSIS

A detailed structural analysis was performed on the RDS 2010, using the structural module contained in the ASSET program and is presented in the Feasibility Output Report, included as Appendix D. Detailed buoyancy, weight and load curves were produced using information from the ASSET output and are presented in Figure 8-25. The buoyancy curve was computed by converting the sectional area curve to a force per length curve by dividing the respective areas, at each station, by 35 tons/ft^3. The weight distribution curve was developed by using the one digit weight groups and their respective LCG's from the ASSET output, and converting them into uniform loads centered about their LCG's. The load curve was developed by taking the difference between these two forces. As Figure 8-25 displays, there are two critical points, located at the ship's quarters, that must be analyzed more fully in the later portions of preliminary design. The sharp load changes at these points may be reduced when a more detailed weight distribution is known. Once this updated weight distribution is developed, and these points still present a problem, the hull will have to be reinforced near the area of the critical points to compensate for the sharp changes in load.

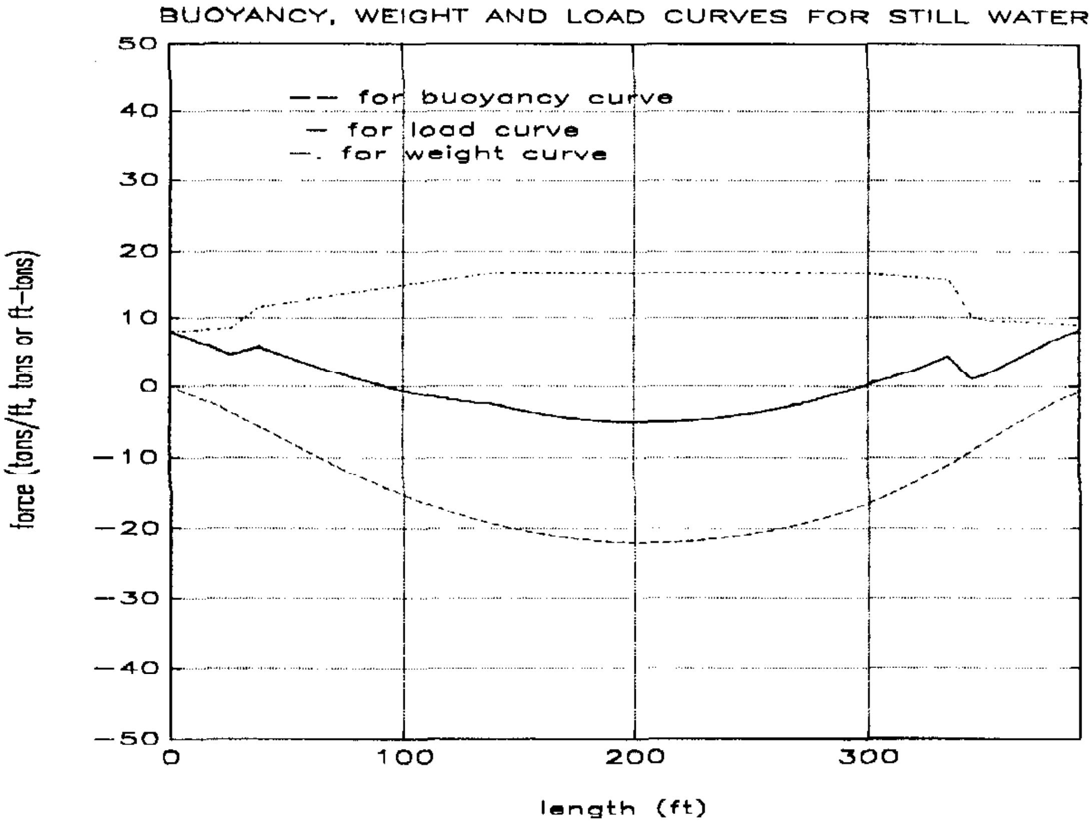


Figure 8-25. Still water force curves.

Figures 8-26 and 8-27 display the buoyancy, weight and load curves for the hogging and sagging conditions respectively. The two buoyancy curves for the two quasi-static conditions of hogging and sagging were developed by constructing Bonjean curves for the hull form, and balancing the hull on a trichoidal wave of the correct length and height. Due to the tools available to complete this task, and the time available, the hull form was not exactly "balanced" on the wave. The difference between the areas under the buoyancy and weight curves for the two cases is on the order of five percent, at most. The difficult task was to achieve equilibrium by aligning the centroids of the areas beneath the respective curves. The inability to achieve this equilibrium caused the shear force and bending moment curves to yield erroneous results.

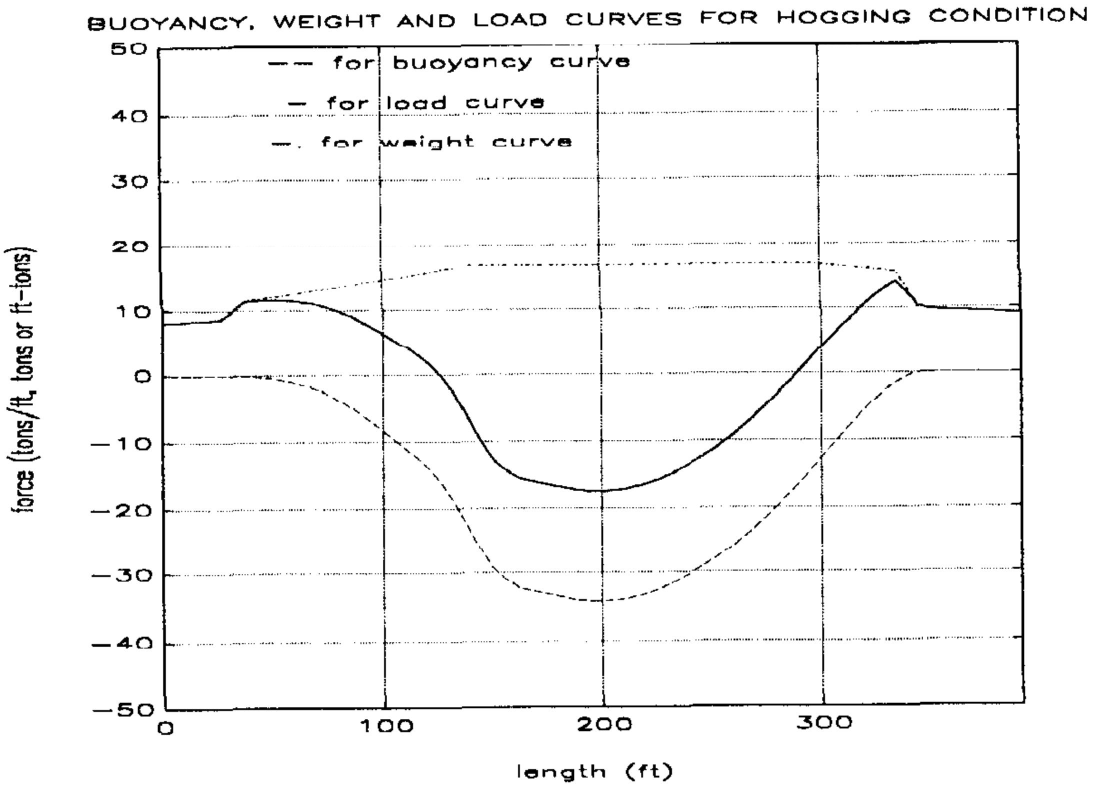


Figure 8-26. Hogging condition force curves.

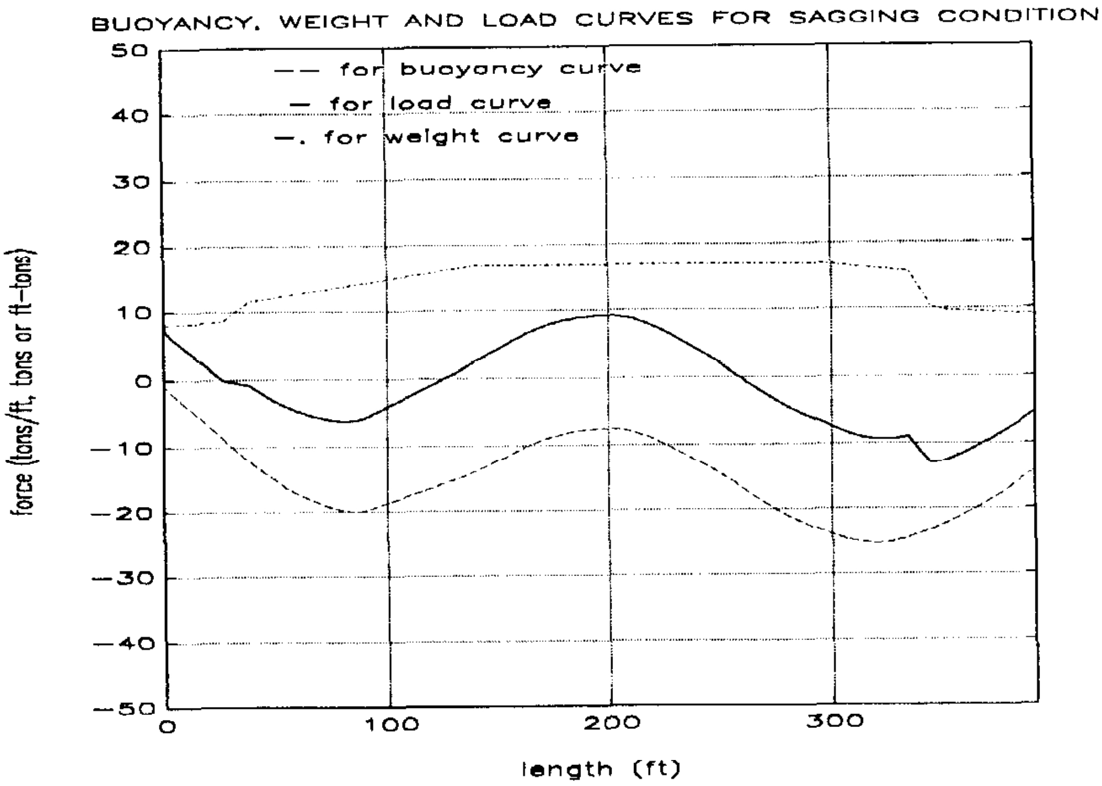


Figure 8-27. Sagging condition force curves.

As Figure 8-28 shows, the shear force and bending moment curves do not return to zero at the end of the ship. This error would be alleviated if the centroids of the respective areas could be aligned. Although the curves do not correctly represent the shear force and bending moment, the maximums of these are of the order needed for design purposes.

Using an early estimate for midship section design, the required design bending moment can be determined. The empirical formulas available to obtain this estimated moment are;

$$M = \frac{\Delta L}{C},$$

where C represents a constant depending on the ship type and bending condition (hogging or sagging);

$$BM_H = 0.000457(LBP)^{2.5}B$$

for the hogging condition;

$$BM_s = 0.000381(LBP)^{2.5}B.$$

A typical value of C for a ship of this type is approximately 30, for both bending conditions.

Using these equations, the design bending moment is approximately 80,000 FT-LTON. As Figure 8-28 displays, the bending moment using the erroneous curve is approximately 200,000 FT-LTON in still water. If the same bending moment curve was plotted for the hogging and sagging conditions it would be shown that the maximum bending moment value is approximately 250,000 FT-LTON. Further refinement of the weight distribution curve would bring these results closer to the estimated bending moment.

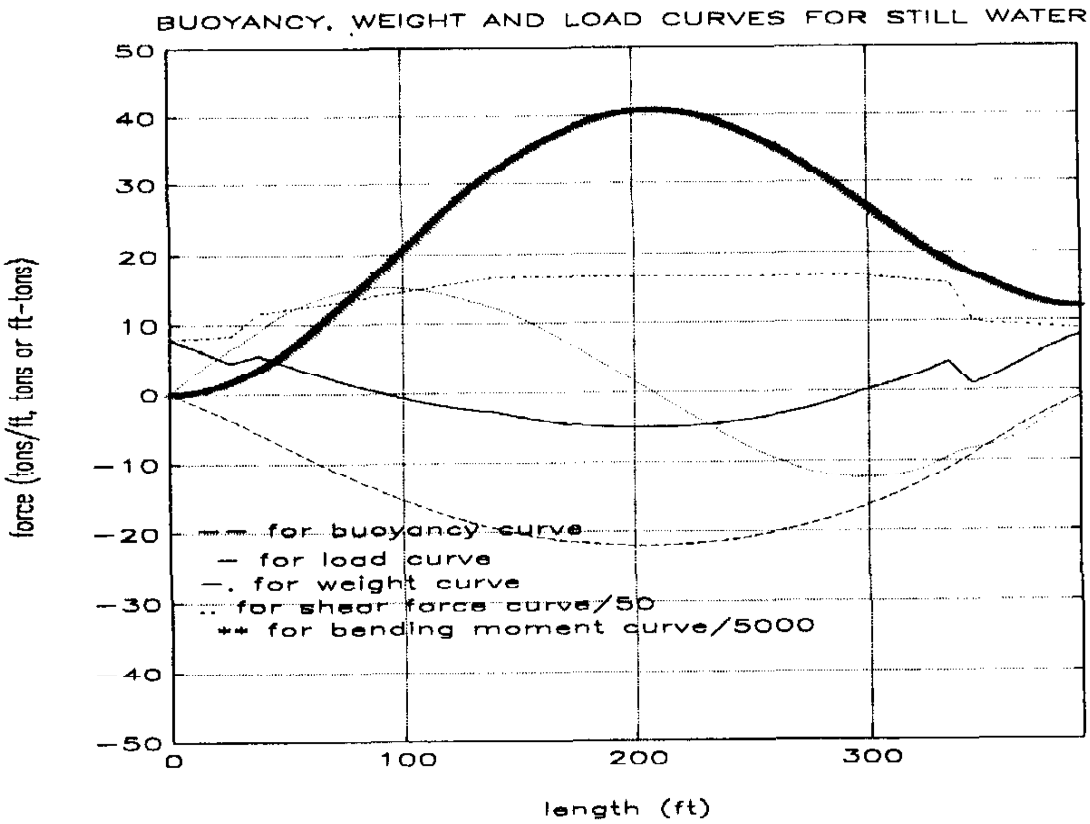


Figure 8-28. Still water force and bending moment curves.

D. MIDSHIP SECTION DESIGN

The midship section was designed, through thousands of iterations using the ASSET Hull Structures Module, and is shown in Figure 8-29. Information concerning the size and placement of scantlings and stiffeners can be found in the ASSET Feasibility Output Report, Appendix D.

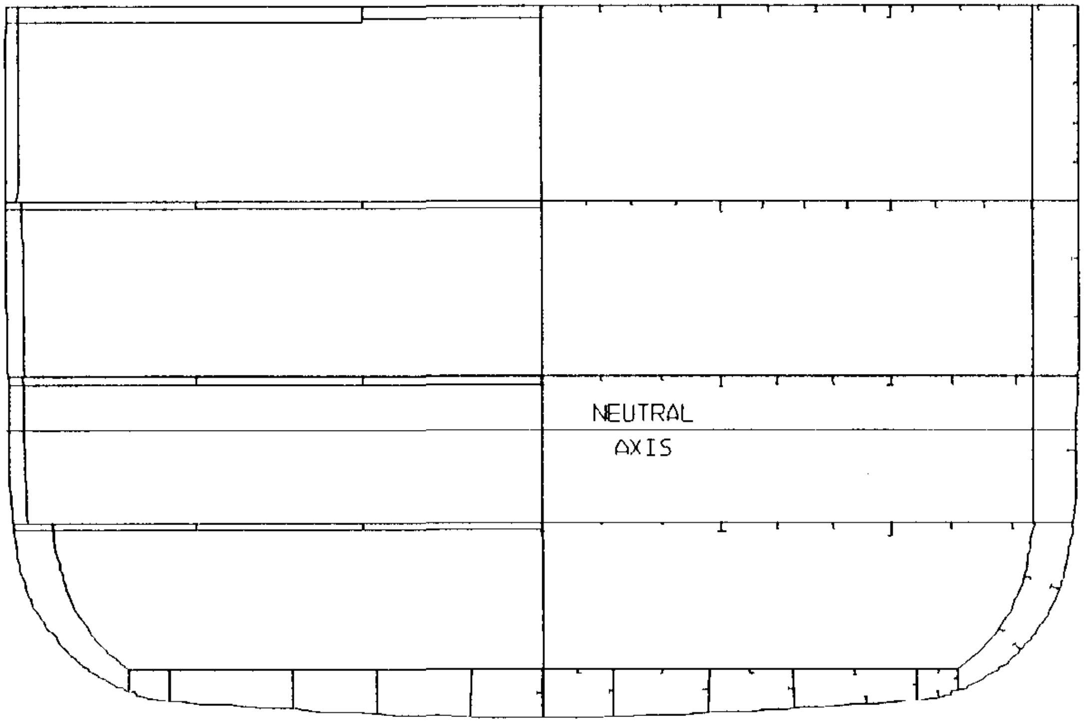


Figure 8-29. RDS 2010 Midship section design..

IX. DESIGN EVALUATION

Once the feasibility studies and preliminary design phase have been completed, the design team must step back and perform an evaluation of design efforts to date. The design is assessed in a number of ways, based on top level design specifications and mission requirements:

1) The ship meets stated performance goals, including
    (a) speed, endurance, and other performance based attributes; and
    (b) systems installed to perform designated missions.
2) The ship meets given cost and 'political' goals.
3) The ship meets stated survivability goals.

The first two elements above are actually part of the iterative design process. Assuming that the design requirements and goals were clearly stated and then implemented, then the design process will constantly revisit whether the design matches the original set of requirements. For instance, using the ASSET program, one input is desired cruising speed. The ship design which ASSET produces is iterated until this performance goal is met. Other performance based attributes are similarly met during the ASSET iterative cycle.

During the combat system definition process, the threat scenarios were evaluated to ensure the combat system was adequate. This included not only the systems installed, but numbers of engagement elements and number of rounds required.

The cost goal was not met, but the faculty raised to cost ceiling based on our analysis and the desire not to give up critical capabilities of the ship. The "political" goals are more subjective, as equally hard to design to as they are, to evaluate the success of meeting them.

The last item, meeting stated survivability goals still needs to be assessed in some manner, however. The total ship survivability assessment is divided into four phases:

1) *Cover and Deception* - the ability to remain undetected or prevent the enemy from obtaining a fire control solution accurate enough to launch a weapon
2) *Threat Destruction and Evasion* - the ability to intercept and destroy or divert threat weapons
3) *Damage Tolerant Design* - addresses the loss in mission capability due to weapons impact
4) *Damage Control and Repair* - addresses the ship's ability to recover mission capability lost due to the weapons hit

Note that the first two items are what is typically called the susceptibility, whereas the last two deal with the ship's vulnerability.

A low design priority was given to the cover and deception aspects for the most part. This is due to the ship's mission of operating close to shore. There was a conscious effort to reduce the ship's infrared and radar cross-sections, however. Oversized stacks were designed to reduce the gas turbine exhaust temperatures. Shaping of the ship's superstructure was done to reduce RCS. There is, however, no way for the design team to evaluate the effectiveness of these efforts.

The threat destruction and evasion capability is directly related to the types and numbers of defensive weapons placed on the ship. As shown in Chapter 4, threat scenario evaluations were completed in the AAW warfare area to ensure adequate numbers and types of AAW engagement elements. Similarly analysis still needs to be performed for the ASUW and ASW warfare areas.

The tolerance of the design to battle damage is addressed by the enclaving scheme and associated systems architectures. Similarly, the ability of the ship/crew to control and repair damage is directly related to the physical design attributes of the ship, including the survivability management system and automated damage control systems. Again, however, there is no firm method for the design team to assess the performance of these concepts.

The tools to evaluate the ship's systems readiness and survivability are:

1) readiness logic diagrams (RLDs);
2) system deactivation diagrams; and
3) physical arrangements of the ship.

The system deactivation diagrams are necessary and appropriate for detailed analysis for cause and effect of damage on specific elements and systems. However, the complexity of this approach precluded the design team from using this tool.

The design team did, however, develop a set of RLDs at the first level of detail for four mission areas (AAW, ASUW, ASW, and MOB). These were combined with the physical layout of the ship to perform a ship system survivability assessment at the enclave level of detail.

The RLDs were developed based on the required operational capabilities (ROCs) by mission/warfare category and the actual systems designed into the ship. Figures 9-1 through 9-4 show the RLDs for the AAW, ASUW, ASW, and MOB mission areas, respectively.

The "M" and "C" readiness rating levels apply to warfare and composite areas, respectively. Table 9-1 shows the relative definition of the mission readiness rating levels. The level indicates the readiness level rating due to a component or mission area

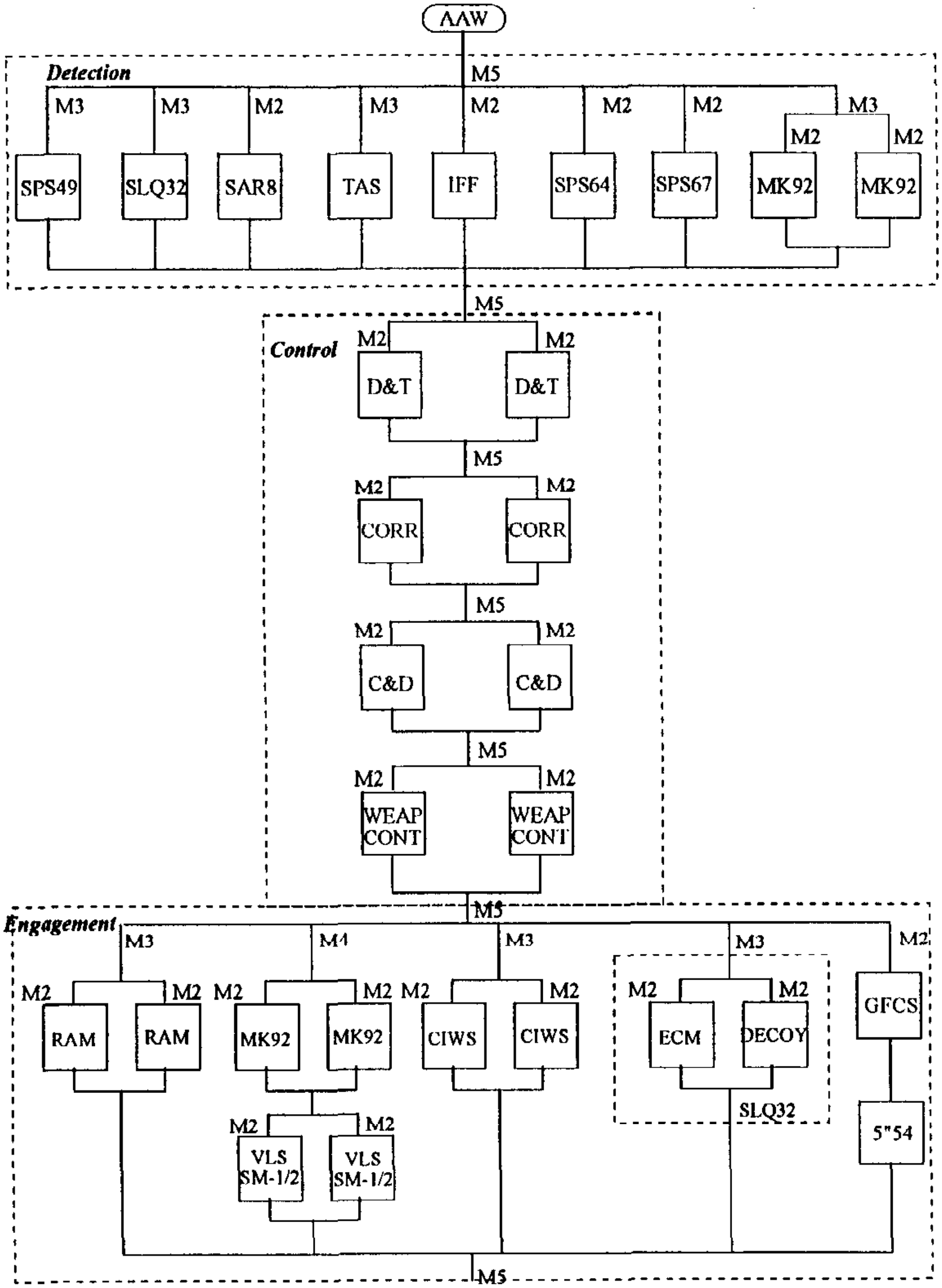


Figure 9-1. AAW Readiness Logic Diagram.

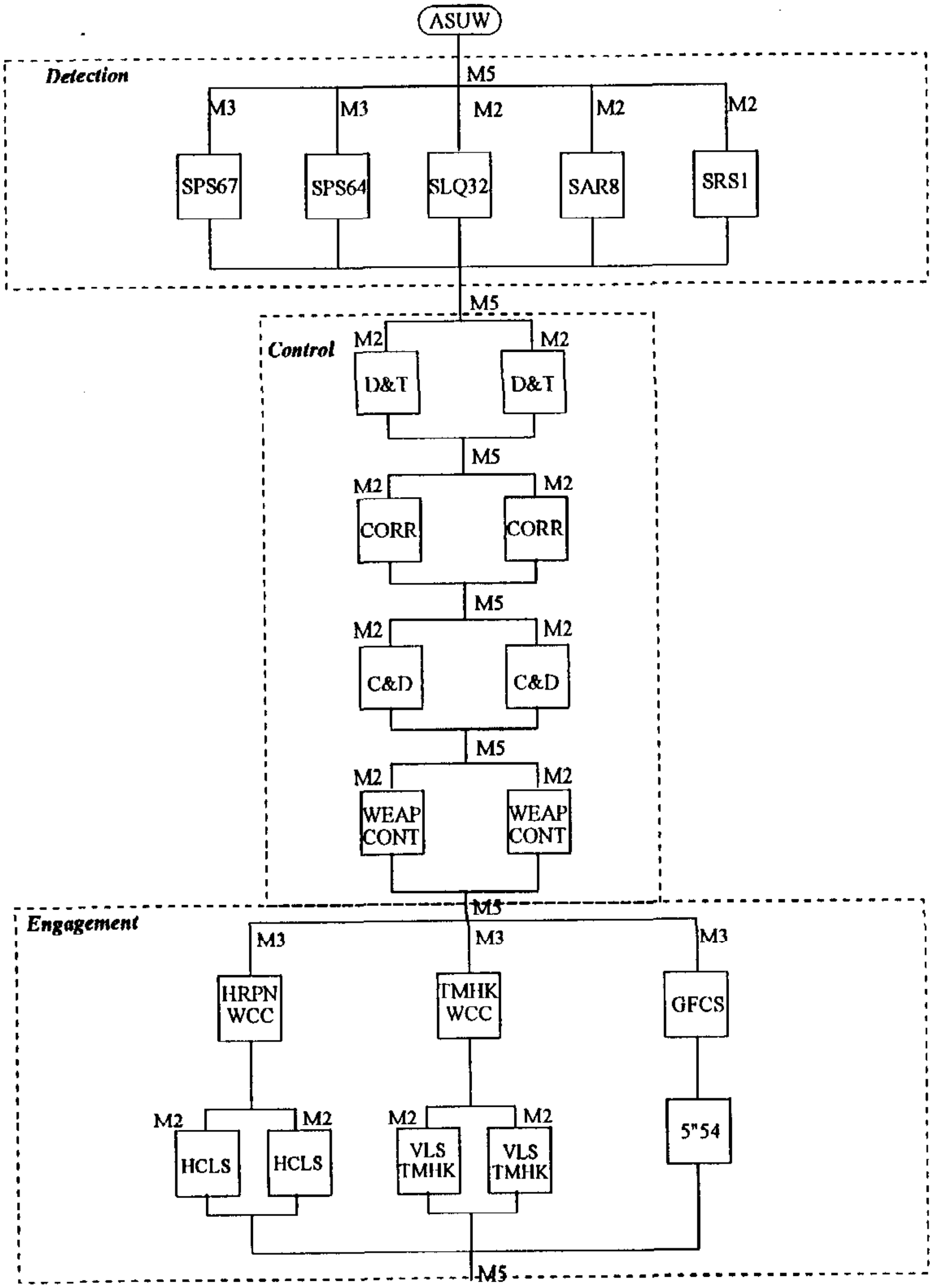


Figure 9-2. ASUW Readiness Logic Diagram.

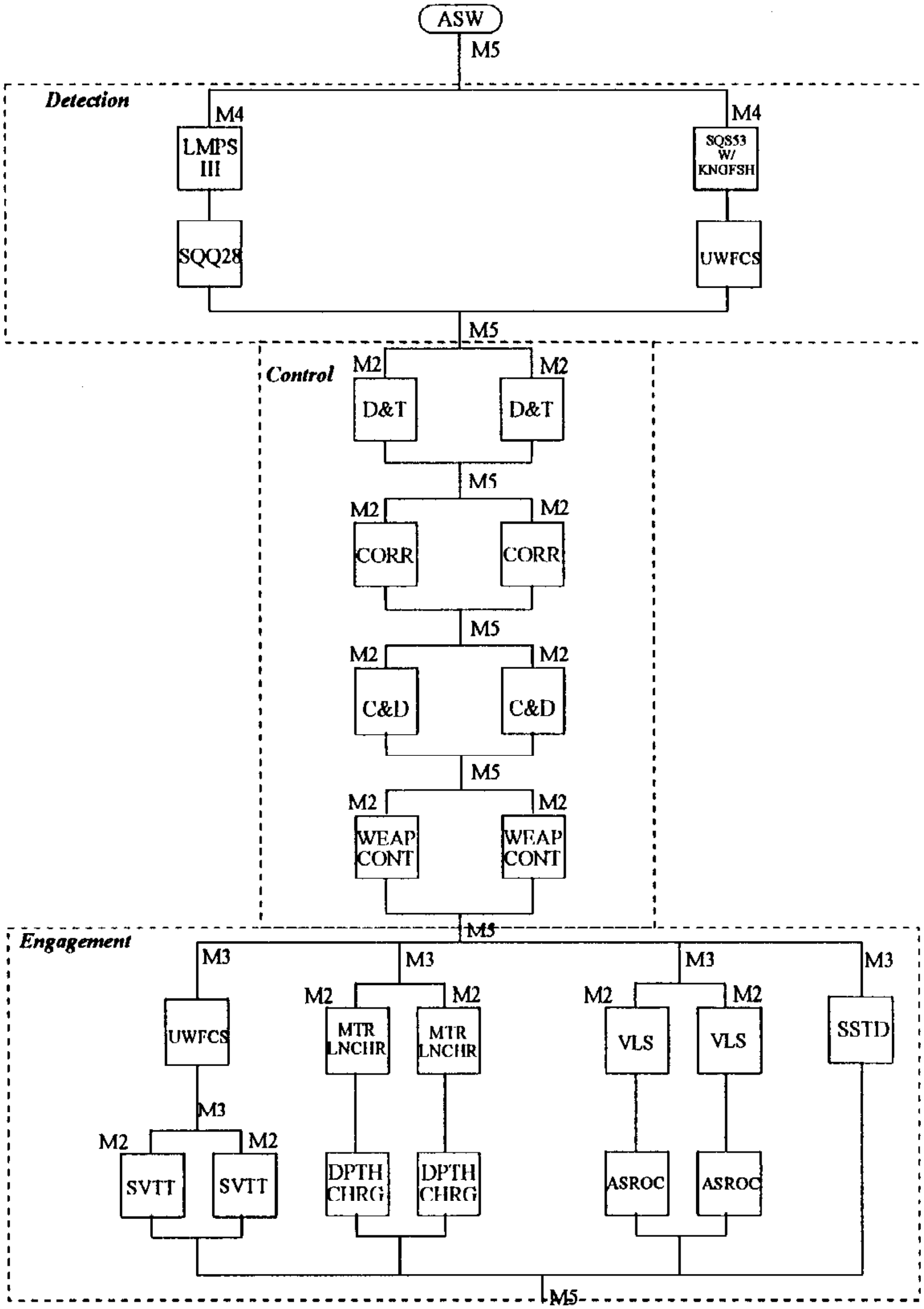
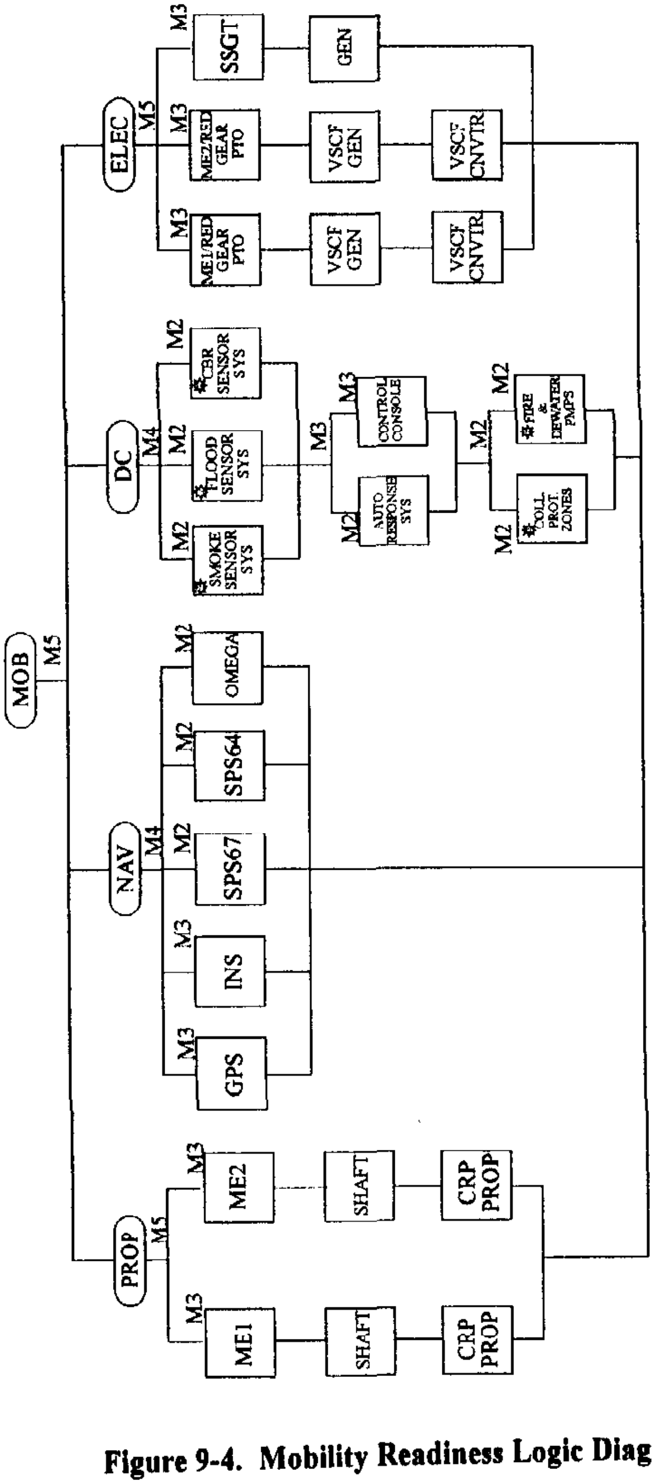


Figure 9-3. ASW Readiness Logic Diagram.



✽ M value for loss of all functionality *within one enclave only*

Figure 9-4. Mobility Readiness Logic Diagram.

loss. The lower level values are rolled-up to produce the higher level values, and finally the composite scores.

TABLE 9-1. MISSION READINESS RATING LEVEL DEFINITIONS.

Rating Level	*Capability*
M1, C1	90-100%
M2, C2	70-89%
M3, C3	60-69%
M4, C4	1-59%
M5, C5	No Capability

Using these RLDs in conjunction with a physical layout of the ship, an enclave level readiness assessment was completed. This assessment reveals the ship's readiness condition due to the loss of a single enclave. Loss of an enclave means the loss of all elements functionality contained with the enclave (i.e., if the No. 1 Mk-92 is within enclave 2, then loss of enclave 2 means loss of any capability associated with the No. 1 Mk-92). Loss of an enclave does not decimate all system pass through capability, however. The assumption is that due to the redundancy designed into systems such as electrical distribution, fiber optic ring bus, fire main water, high pressure air, etc., that at least partial pass through capacity remains short of catastrophic ship damage. Any damage which is so severe to destroy not only all elements within an enclave, but also destroy all systems which merely pass through the enclave would likely result in immediate ship loss.

Within each enclave, each mission area (AAW, ASUW, ASW, and MOB) was evaluated using the RLDs to see what each area's readiness assessment score ("M" rating) was upon loss of the systems within that enclave. The individual mission area ratings were then rolled-up into a composite score to reveal the ship's total readiness condition resulting from loss of the enclave.

Figure 9-5 illustrates these results. Note that the ship is fairly well balanced, with each enclave loss resulting with a ship's composite score of C3. The exception is loss of enclave 5. The C5 rating for enclave 5 is due to the assumption that both screws are lost if enclave 5 is lost, resulting in total loss of propulsion. Arguments may be made that from an operational sense, loss of all propulsion does not result in a zero capable ship. From a combat system vantage, loss of enclave 5 only degrades the ship to a C3 level. This argument cannot be resolved until their is reconciliation between the present method of reporting readiness and a more appropriate scoring method usable for real-time, from the scene ship's readiness assessment reporting.

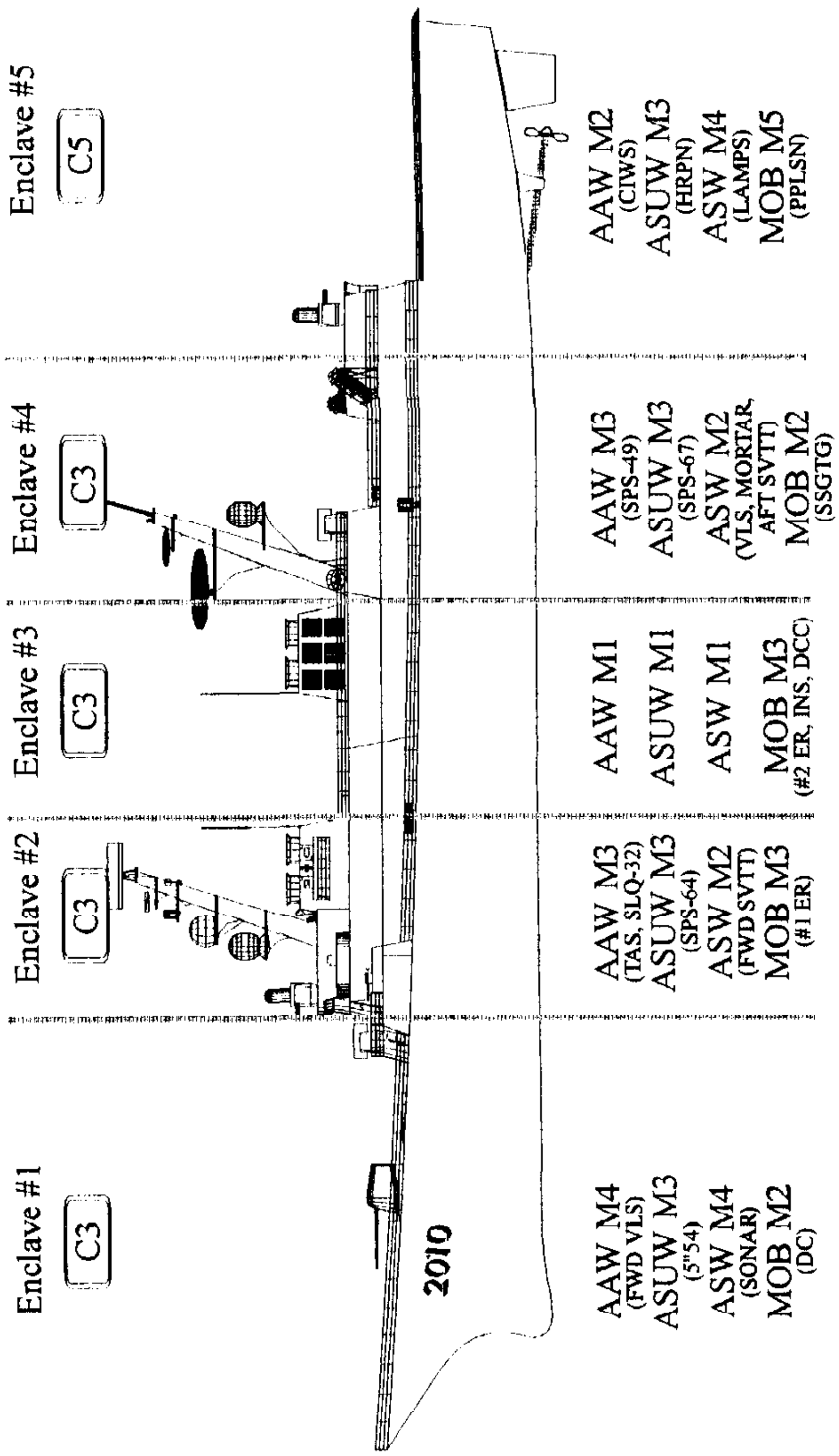


Figure 9-5. Enclave level survivability assessment.

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Appendices

A through D

DESIGN HISTORY

28 SEP 92 TS4002/4003 course sequence introduction given by Professors Charles N Calvano and Francis B Fassnacht. The design team consists of LCDR Dwight Alexander, LCDR Dean Cottle, LT Kent W. Kettell, and LT Jeff Riedel. Received a CNO Tentative Requirement Statement, written in operational/political terms for a new class of surface ship, FPS 2010. As a review of requirements determination and setting, the first objective is to assist the CNO in developing a formal acquisition requirements statement with which he can task NAVSEA to design and procure the ships.

29 SEP 92 It was agreed upon by the design team that LT Kettell would be the design team coordinator.

07 OCT 92 The design team completed the "Requirements Document for Force Projection Ship (FPS) 2010". The requirements were written such that the ship would not be required to conduct ASW screening operations during Battle Group transit. Additionally, it was not considered necessary for the FPS 2010 to capable of long range AAW.

08 OCT 92 The Force Projection Ship 2010 is renamed Regional Deterrence Ship (RDS) 2010, and the "Requirements for Regional Deterrence Ship (RDS) 2010" is released by the CNO (faculty) with a few major changes other than the name:

1) The ship is not required to deploy promptly, fully ready for extended operations.
2) The time on station reduced from 60 days to 20 days.
3) The ship would be required to support short duration covert operations.
4) The combat system would incorporate an appropriate SSES.
5) The ship should support flight operations of non-assigned joint forces helicopters.
6) The ship will carry a surgeon and have operating room facilities.

Additionally, it was clarified that approximately 10 of the RDS ships would be built.

Since to date there has been no clear recognition of specific threats for which the design team should be concerned when designing the combat system, it was agreed to that a list of most formidable threats would be generated prior to completing selection of the major ship elements.

19 OCT 92 Design team completed the major threat evaluation. This was a lengthy process in which the design team assumed the role of intelligence experts and determined the air launched, surface launched and sub-surface weapons which were deemed to impose the greatest threat. The process was lengthy in spite of the fact that sufficient information does not exist in the open literature. The parameters which seemed worthy of comparison were radar cross-section, speed, range, warhead size, guidance type and the profile of the trajectory. In the air and surface launched missile categories the plan to determine the most formidable threats was as follows:

a) three with the smallest radar cross-section,
b) three with the fastest speed,
c) three with the longest range, and
d) three with the largest warhead.

In a few cases there was overlap, but generally this provided a worthy selection for later evaluation. The next step was to eliminate some of the threats based on simple comparison with others within the same category. At this point there remained only ten missiles which were significantly threatening in one way or another. This is shown in Table I. The torpedo threats were determined in a similar manner using speed and range. The mine size was determined based on the need to detect mines of this size in order to maneuver around them in sufficient time in order to prevent either influence or contact. The mines smaller than this size were deemed to be less threatening based on the amount of explosive potential. To whittle the missile list down to a most fearsome four, the type of guidance package and the profile of the trajectory were considered. To account for advances in technology some of the characteristics of two weapons were merged to give a margin of safety. The missiles used therefore do not represent actual missiles, but ones very similar to actual ones. For security purposes the real names are not used and the categories do not necessarily portray exact values, however they are realistic.

22 OCT 92 Element selection rough draft was completed. It is apparent that some elements which do not currently exist will be needed in order to build a ship which has been designed at the total ship level, looking at the entire combat system. The combat system needs to be designed at the mission level in order to achieve a completely integrated shipboard combat system. At this time many new combat system elements can not be readily integrated into the chipboard combat system, reducing the performance that was expected. It is expected that some current system elements may have to undergo major modification in order to make them compatible in a systems sense.

06 NOV 92 Revised element selection portion of the analysis and tradeoff study is complete to the point of having a definitive threat scenario. Optimally, threat scenarios as related to ship design could very well encompass a whole course.

10 NOV 92 Completed initial round of threat scenario with basic elements. With this completed, the element selection process can be finalized.

12 NOV 92 Decision matrices for threat evaluation finalized.

13 NOV 92 Specific element selection process complete, although there may be continued tradeoff analyses performed in future work in order to accommodate the price margin. Next step is to present this material in a meaningful way.

17 NOV 92 Rough final draft of the results of the specific element selection analysis and tradeoff study completed. Commenced the feasibility process using the ASSET program. The abbreviated documentation of this program is sketchy.....terminals not working well for present system configuration....

19 NOV 92 Rough draft of the threat scenarios completed.

20 NOV 92 Adjustments made to specific element selection in order to accommodate the four threat scenarios. No fleet guidance was available for determining the minimum required loadout of weapons. Since this deterrence ship will be operating alone, it should be capable of defending itself in the four threat scenarios discussed while either help is coming from other regions or it makes a retreat to a less threatening environment.

24 NOV 92 All aspects of specific element selection complete, including the paperwork.

Received documentation for use of ASSET. Volume 1, the system manual provides good insight as to how the program should be used. Volume 2(A-E) must also be used in order to make decisions regarding how the envisioned ship will be constructed, outfitted, manned, and operated.

25 NOV 92 Completed revised draft of threat scenario.

04 DEC 92 Successfully completed an initialized feasible ship. The next step is to get the modules to converge individually so the synthesis portion of ASSET will be capable of running to convergence.

07 DEC 92 Convergence achieved on ASSET synthesis model. Although the ship does not have the all the same characteristics of the envisioned ship, the concept is predicable. The factors which affect a cost and stability will have to be optimized in order to determine if the ship is buildable at the requested price. In 2010 dollars, it seems that a small patrol boat may not even be economically feasible for $350 million.

11 DEC 92 Final draft of threat scenario complete. Because of the details involved in the tedious calculations, this paper was made readable for those individuals not having received prior experience in threat probabilities as applied to scenarios such as these..

17 DEC 92 Commenced effort to reduce cost to $350M.

06 JAN 93 Began drafting a detailed design philosophy which would provide a concrete basis for backing trade-off decisions

07 JAN 93 Commenced work on the general combat system architecture.

15 JAN 93 Completed the formal design philosophy.

20 JAN 93 Reached point of diminishing returns on cost reductions to reach the stringent $350M limit. Began draft of cost adjustment proposal. Stopped working with ASSET, and began working with AUTOCAD for the creation of a 3-D hull and superstructure.

21 JAN 93 Commenced enclaving effort in order to best locate systems and elements throughout the ship.

25 JAN 93 Decided to include the Integrated Readiness Assessment and Survivability Management Requirements as part of the Combat System Architecture.

08 FEB 93 Enclaving progressing such that topside layout must undergo several iterations before below decks enclaving can resume.

10 FEB 93 Commenced work on "Ship Descriptors".

16 FEB 93 Enclaving at the point where below decks arrangements can begin. Commenced drafting ROCs to be used in survivability assessment. In hindsight, the design team agreed that this portion should have been done much earlier had the usefulness of this type of document been understood.

18 FEB 93 Completed the General Combat System Architecture, including the one-line connectivity diagram, battle organization, and manning structure.

19 FEB 93 Commenced electrical system design.

01 MAR 93 ROCs finalized so that survivability assessment can proceed though RLDs.

04 MAR 93 Completed electrical system design.

05 MAR 93 Began making slides for design presentations.

08 MAR 93 Arrangements completed after several iterations, enclaving verified from keel to masts.

09 MAR 93 Completed survivability assessment. The ship is very well balanced.

12 MAR 93 Completed "Ship Descriptors" portion of design.

18 MAR 93 Formal presentation of ship design to Naval Postgraduate School.

23 MAR 93 Formal Washington, DC presentation of ship design to NAVSEA 05 at NC3, Crystal City.

08 APR 93 Formal presentation of ship design to Monterey chapter of Surface Navy Association.

21 APR 93 Completed master compilation of all design project reports into one report.

TS4002

Payload Selection Matrix

RDS-2010

Warfare Area	ASW		ASUW		AAW		EW	NAV	LAND STRK
Ship Option	*Sensor*	*Weapons/Cntrmsr*	*Sensor*	*Weapons*	*Sensor*	*Weapons/Cntrmsr*			
Options Considered	SQS-53 (LB) Kingfisher adjunct LAMPS UUV	Mk-50 Torp SSTD CSA/NAE/ADC RBU 6000/Hedgehog	SPS-67(pri) SPS-64 (bu) PRI=PRIMARY BU=BACKUP	SM-1/2 HARPOON 5"-54 25mm Chain Gun 7.62mm Mini Gun OTO 76mm Gun	LBPA SPS-48 SPS-49 IFF	SM-1/2 (RIM-66/67) w/ SPG-XX illuminator RAM (RIM-116) NSSM (RIM-7) Phalanx Goalkeeper Mk-38 Decoy Lnchr SRBOC LAD Torch	SLQ-32 (V3)	SPS-64 (pri) LN-66 (bu) Furuno TACAN	TOMAHAWK Blk III SWG-3(V) ATWCS
Option 1	SQS-53 (LB) with Kingfisher LAMPS w/UUV	Mk-50 Torp SSTD New Mortar System	SPS-67(pri) SPS-64 (bu)	SM-1/2 HARPOON 5"-54 25mm Chain Gun 7.62mm Mini Gun	SPS-49 MK-92 IFF	SM-1/2 (RIM-66/67) w/ SPG-XX illuminator RAM Phalanx Mk-38 Decoy Lnchr SRBOC LAD Torch	SLQ-32 (V3)	SPS-64 (pri) LN-66 (bu) TACAN	TOMAHAWK Blk III SWG-3(V) ATWCS
Option 2	SQS-53 (LB) with Kingfisher LAMPS	Mk-50 Torp SSTD New Mortar System	SPS-67(pri) SPS-64 (bu)	SM-1/2 HARPOON OTO 76mm Gun 25mm Chain Gun 7.62mm Mini Gun	SPS-49 SPS-48 IFF	SM-1/2 (RIM-66/67) w/ SPG-XX illuminator RAM Phalanx Mk-38 Decoy Lnchr SRBOC LAD Torch	SLQ-32 (V3)	SPS-64 (pri) LN-66 (bu) TACAN	TOMAHAWK Blk III SWG-3(V) ATWCS

Payload Selection Matrix

Equipment Cat.	COMMUNICATIONS		COMMAND & DECISION	WEAPONS		DETECTION SENSORS	COUNTER-MEASURES	FCS
Ship Option	U/W Telephone	SATCOM	ACDS (Self-developed)	SM-1/2	Phalanx	SAR-8	Mk-38 Decoy	MK-23 (TAS)
Options Considered	HF	JTIDS	SYS-1 (Modified)	RAM	Goalkeeper	WLR-9	Lnchr	MK-92
	UHF	JOTS		NSSM	Mk-50 Torp	Mk 23 (TAS)	SRBOC	SPG-XX Illuminator
	VHF	COPERNICUS		HARPOON	25mm Chain Gun	KAS-1 (CWDD)	LAD	
	SESS	LINK 11		5"-54	7.62mm Mini Gun	SQS-53 (LB)	Torch	
	TACAN	NTDS			76 mm Oto Melara	LAMPS III	SSTD	
					RBU 6000/Hedgehog	UUV	CSA/NAE/ADC	
					TOMAHAWK Blk III	LBPA	SLQ-32 (V3)	
					SWG-3(V) ATWCS	SPS-48/-49		
						Furuno		
						LN-66		
						IFF		
						SPS-64/-67		
Option 1	U/W Telephone	SATCOM	ACDS (Self-developed)	SM-1/2	Phalanx	SAR-8	Mk-38 Decoy	Self Developed
	HF	JTIDS	SYS-1 (Modified)	RAM	Mk-50 Torp	Mk 23 (TAS)	Lnchr	SPG-XX Illuminator
	UHF	JOTS		HARPOON	25mm Chain Gun	KAS-1 (CWDD)	SRBOC	
	VHF	COPERNICUS		5"-54	7.62mm Mini Gun	SQS-53 (LB)	LAD	
	SESS	LINK 11			New Mortar System	LAMPS III	Torch	
						UUV	SSTD	
	TACAN	NTDS			TOMAHAWK Blk III	SPS-64/-67	SLQ-32 (V3)	
					SWG-3(V) ATWCS	LN-66		
						SPS-48/MK-92		
						IFF		
Option 2	U/W Telephone	SATCOM	ACDS (Self-developed)	SM-1/2	Phalanx	SAR-8	Mk-38 Decoy	Self Developed
	HF	JTIDS	SYS-1 (Modified)	RAM	Mk-50 Torp	Mk 23 (TAS)	Lnchr	SPG-XX Illuminator
	UHF	JOTS		HARPOON	25mm Chain Gun	KAS-1 (CWDD)	SRBOC	
	VHF	COPERNICUS			7.62mm Mini Gun	SQS-53 (LB)	LAD	
	SESS	LINK 11			76 mm Oto Melara	LAMPS III	Torch	
	TACAN	NTDS			New Mortar System	SPS-64/-67	SSTD	
					TOMAHAWK Blk III	Furuno	SLQ-32 (V3)	
					SWG-3(V) ATWCS	SPS-48/-49		
						IFF		

Primary Air Search Sensor Matrix

Primary Air Search

		SPS-48		SPS-49		LBPA	
Category	Weighting	Parameter	Relative	Parameter	Relative	Parameter	Relative
Gain (Db)	0.20	39	0.96	29	0.73	40	1.00
Scan Rate (RPM)	0.50	15	1.00	12	0.80	10	0.67
Elevation (degrees)	0.20	65	1.00	30	0.46	65	1.00
Range (Nm)	0.20	230	0.77	300	1.00	200	0.67
Size (in^2)	0.50	44,232	1.00	49,248	0.90	100,000	0.44
Weight (abovedeck)	1.00	5,684	0.56	3,165	1.00	10,000	0.32
(belowdeck)	0.70	24,018	0.58	14,004	1.00	40,000	0.35
Cost ($ millions)	1.00	13	0.42	5	1.00	75	0.07
Summary			2.93		3.99		1.72

Secondary Air Search Sensor Matrix

Secondary Air Search

		SPS-48		Mk-92		LBPA	
Category	Weighting	Parameter	Relative	Parameter	Relative	Parameter	Relative
Gain (Db)	0.20	39	0.96	21	0.53	40	1.00
Scan Rate (RPM)	0.80	15	0.50	30	1.00	10	0.33
Elevation (degrees)	0.50	65	0.87	75	1.00	65	0.87
Range (Nm)	0.20	230	1.00	50	0.22	200	0.87
Size (in^2)	0.20	44,232	0.67	29,799	1.00	100,000	0.30
Weight (abovedeck)	1.00	5,684	0.34	1,950	1.00	10,000	0.20
(belowdeck)	0.70	24,018	0.42	10,000	1.00	40,000	0.25
Cost ($ millions)	1.00	13	0.77	10	1.00	75	0.13
Summary			2.76		4.35		1.64

Navigation Radar Matrix

Navigation Radar

		SPS-64		LN-66		Furuno	
Category	Weighting	Data	Relative	Data	Relative	Data	Relative
Gain (dB)	0.20	28.0	0.93	30.0	1.00	30.0	1.00
Scan Rate (RPM)	0.50	33.0	1.00	22.0	0.67	24.0	0.73
Vertical BW (deg)	0.20	22.0	0.88	22.0	0.88	25.0	1.00
Horizontal BW (deg)	0.20	0.7	1.00	2.0	0.35	2.4	0.29
Range (Nm)	0.50	50.0	0.69	72.0	1.00	50.0	0.69
Antenna Width (ft)	0.50	12.0	0.28	8.0	0.43	3.4	1.00
Weight (abovedeck)	1.00	332.0	0.15	50.0	1.00	50.0	1.00
(belowdeck)	1.00	200.0	0.25	50.0	1.00	50.0	1.00
Cost ($ millions)	1.00	0.3	0.33	0.1	1.00	0.1	1.00
Summary			2.29		4.49		4.67

Missile Selection Matrix

AAW Missiles

Category	Weighting	RAM RIM-115A		NSSM RIM-7			SM-1(ER) RIM-66B	
		Parameter	Relative	Parameter	Relative		Parameter	Relative
Range (nm)	1	5.17	0.07	14	0.18	0.18	76	1.00
Weight (lbs)	0.2	162	1.00	500	0.32	0.06	2961	0.05
Warhead (lbs)	0.6	5	0.04	67	0.49	0.29	137	1.00
Illumination Req'rd 0=yes, 1=no	0.4	1	1.00	0	0.00	0.00	0	0.00
Logistics Support	1	10	1.00	10	1.00	1.00	10	1.00
Summary			1.69		1.54			2.61

Value in summary column is the sum of the weighting factor x relative values

CIWS Selection Matrix

		Short Range Engagement of Sea Skimming Missile			
		Phalanx Mk-15		Goalkeeper	
Category	Weighting	Parameter	Relative	Parameter	Relative
Caliber (mm)	0.7	20	0.67	30	1.00
V muzzle (m/s)	0.5	1030	0.90	1150	1.00
Azimuth (deg)	0.2	310	0.86	360	1.00
Elevation (deg) (-)	0.2	-25	1.00	-25	1.00
(+)	0.2	80	0.94	85	1.00
Weight (LT)	1	6.18	1.00	9.7	0.64
Fire Rate (rnd/sec)	0.7	4500	1.00	4200	0.93
Range (nm)	1	0.81	0.50	1.61	1.00
Rounds	0.7	1562	1.00	1190	0.76
Logistics Commonality	1	10	1.00	2	0.20
Summary			5.38		4.82

Value in summary column is the sum of the weighting factor x relative values

Medium Cal Gun Selection Matrix

		Medium Caliber Gun			
		MK 54 Single 5"		MK 75 Oto Melara 76/62	
Category	Weighting	Parameter	Relative	Parameter	Relative
Caliber (mm)	1	127	1.00	76	0.60
V muzzle (m/s)	0.5	808	0.87	925	1.00
Azimuth (deg)	0.2	340	0.94	360	1.00
Elevation (deg) (-)	0.2	-15	1.00	-15	1.00
(+)	0.1	65	0.76	85	1.00
Trng.Rate (deg/s): Az.	0.2	30	0.43	70	1.00
Elev.	0.2	20	0.50	40	1.00
Weight (LT)	1	21.35	0.35	7.5	1.00
Fire Rate (rnd/sec)	0.4	20	0.24	85	1.00
Range (nm) ASUW	1	12.4	1.00	8.6	0.69
Range (nm) AAW	1	8	1.00	6.4	0.80
Rounds	0.5	20	0.25	80	1.00
Round Weight	1	70	1.00	14	0.20
Cost ($M)	1	7.7	1.00	3.5	0.45
Logistics Commonality	1	10	1.00	10	1.00
Summary			7.66		6.59

Value in summary column is the sum of the weighting factor x relative values

HULL GEOM MODULE

PRINTED REPORT NO. 1 - HULL GEOMETRY SUMMARY

```
MIN BEAM, FT               40.00
MAX BEAM, FT               55.00
HULL FLARE ANGLE, DEG       7.00
FORWARD BULWARK, FT         4.00

                 HULL PRINCIPAL DIMENSIONS (ON DWL)
                 ==================================
LBP, FT                        390.00   PRISMATIC COEF             0.650
LOA, FT                        409.31   MAX SECTION COEF           0.919
BEAM, FT                        55.00   WATERPLANE COEF            0.787
BEAM @ WEATHER DECK, FT         60.27   LCB/LCP                    0.515
DRAFT, FT                       15.01   HALF SIDING WIDTH, FT       1.00
DEPTH STA 0, FT                 45.00   DEPTH STA 3, FT            41.46
DEPTH STA 10, FT                36.50   DEPTH STA 20, FT           37.40
FREEBOARD @ STA 3, FT           30.46   BARE HULL DISPL, LTON    5493.55
STABILITY BEAM, FT              55.00   AREA BEAM, FT              54.17

      BARE HULL DATA ON LWL                   STABILITY DATA ON LWL
      =====================                   =====================
LGTH ON WL, FT                 389.99   KB, FT                      8.19
BEAM, FT                        55.00   BMT,  FT                   16.92
DRAFT, FT                       14.99   KG,  FT                    19.59
FREEBOARD @ STA 3, FT           30.48   PRISMATIC COEF             0.649
MAX SECTION COEF                0.921
WATERPLANE COEF                 0.788   GMT, FT                     5.51
WATERPLANE AREA, FT2         16904.38   GML, FT                   763.36
WETTED SURFACE, FT2          22804.14   BARE HULL DISPL, LTON    5496.68
APPENDAGE DISPL, LTON          225.04   FULL LOAD WT, LTON       5721.71
```

PRINTED REPORT NO. 2 - HULL OFFSETS

STATION NO. 1, AT X = -19.315 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	0.000	45.890
2	0.325	46.006
3	0.737	46.122
4	1.168	46.238
5	1.411	46.354

STATION NO. 2, AT X = -9.657 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	0.000	27.882
2	0.883	32.328
3	2.526	36.774
4	4.878	41.220
5	7.752	45.665

STATION NO. 3, AT X = 0.000 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	0.138	15.006
2	0.983	22.504
3	2.849	30.003
4	5.912	37.501
5	10.348	45.000

STATION NO. 4, AT X = 5.410 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	0.000	5.395
2	0.005	5.405
3	0.072	5.472
4	0.288	5.655
5	0.672	6.010
6	1.149	6.597
7	1.558	7.471
8	1.725	8.692
9	1.583	10.316
10	1.275	12.401
11	1.226	15.006
12	2.268	22.414
13	4.099	29.822
14	7.110	37.230
15	11.688	44.637

STATION NO. 5, AT X = 10.819 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	0.000	0.000
2	0.073	0.015
3	0.337	0.120
4	0.680	0.405
5	1.028	0.960
6	1.335	1.876
7	1.563	3.241
8	1.705	5.147
9	1.801	7.683
10	1.965	10.939
11	2.410	15.006
12	3.610	22.325
13	5.376	29.644
14	8.297	36.963
15	12.960	44.282

STATION NO. 6, AT X = 30.636 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	0.762	0.000
2	0.851	0.015
3	1.216	0.120
4	1.805	0.405
5	2.574	0.960
6	3.449	1.876
7	4.315	3.241
8	5.063	5.147
9	5.670	7.683
10	6.270	10.939
11	7.209	15.006
12	8.753	22.015
13	10.148	29.024
14	12.538	36.033
15	17.065	43.042

STATION NO. 7, AT X = 50.453 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	0.000
2	1.942	0.042
3	2.082	0.062
4	2.661	0.206
5	3.668	0.596
6	5.056	1.356
7	6.659	2.608
8	8.220	4.476
9	9.546	7.083
10	10.695	10.552
11	12.104	15.006
12	13.741	21.729
13	14.742	28.453
14	16.487	35.176
15	20.356	41.899

STATION NO. 8, AT X = 70.271 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	0.000
2	4.040	0.135
3	4.202	0.156
4	4.885	0.299
5	6.088	0.686
6	7.775	1.441
7	9.760	2.685
8	11.743	4.541
9	13.471	7.132
10	14.942	10.579
11	16.531	15.006
12	18.093	21.468
13	18.775	27.930
14	19.931	34.392
15	22.916	40.854

STATION NO. 9, AT X = 90.088 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	0.000
2	6.746	0.256
3	6.930	0.276
4	7.696	0.418
5	9.031	0.802
6	10.886	1.551
7	13.063	2.785
8	15.235	4.626
9	17.113	7.196
10	18.655	10.615
11	20.193	15.006
12	21.566	21.251
13	22.021	27.455
14	22.719	33.680
15	24.822	39.905

STATION NO. 10, AT X = 109.905 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	0.000
2	9.751	0.390
3	9.955	0.410
4	10.785	0.550
5	12.193	0.931
6	14.110	1.673
7	16.320	2.896
8	18.479	4.720
9	20.285	7.267
10	21.683	10.655
11	22.992	15.006
12	24.114	21.018
13	24.426	27.030
14	24.812	33.041
15	26.157	39.053

STATION NO. 11, AT X = 129.722 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	0.000
2	12.745	0.523
3	12.965	0.543
4	13.839	0.682
5	15.268	1.059
6	17.155	1.795
7	19.272	3.006
8	21.273	4.814
9	22.860	7.337
10	23.983	10.695
11	24.967	15.006
12	25.823	20.829
13	26.056	26.652
14	26.254	32.476
15	27.001	38.299

STATION NO. 12, AT X = 149.539 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	0.000
2	15.419	0.642
3	15.652	0.662
4	16.548	0.800
5	17.956	1.174
6	19.751	1.903
7	21.700	3.105
8	23.470	4.898
9	24.783	7.400
10	25.600	10.730
11	26.244	15.006
12	26.841	20.665
13	27.028	26.324
14	27.119	31.982
15	27.432	37.641

STATION NO. 13, AT X = 169.356 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	0.000
2	17.464	0.733
3	17.705	0.753
4	18.608	0.890
5	19.978	1.262
6	21.665	1.986
7	23.439	3.181
8	24.992	4.962
9	26.068	7.449
10	26.634	10.757
11	26.989	15.006
12	27.344	20.525
13	27.467	26.043
14	27.487	31.562
15	27.535	37.081

STATION NO. 14, AT X = 189.174 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	0.000
2	18.524	0.780
3	18.804	0.797
4	19.726	0.915
5	20.977	1.235
6	22.414	1.858
7	23.923	2.885
8	25.365	4.418
9	26.539	6.556
10	27.129	9.402
11	27.367	15.006
12	27.522	20.409
13	27.565	25.812
14	27.552	31.215
15	27.535	36.618

STATION NO. 15, AT X = 208.991 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	0.000
2	18.416	0.776
3	18.714	0.794
4	19.693	0.920
5	21.018	1.263
6	22.538	1.932
7	24.130	3.034
8	25.643	4.678
9	26.858	6.972
10	27.425	10.026
11	27.516	15.006
12	27.571	20.317
13	27.568	25.629
14	27.544	30.940
15	27.535	36.252

STATION NO. 16, AT X = 228.808 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	0.000
2	17.126	0.718
3	17.466	0.739
4	18.580	0.882
5	20.090	1.272
6	21.823	2.031
7	23.640	3.282
8	25.369	5.149
9	26.763	7.754
10	27.429	11.220
11	27.525	15.006
12	27.595	20.250
13	27.578	25.494
14	27.537	30.738
15	27.535	35.982

STATION NO. 17, AT X = 248.625 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	0.000
2	14.653	0.608
3	15.061	0.633
4	16.409	0.804
5	18.239	1.269
6	20.344	2.175
7	22.557	3.668
8	24.677	5.896
9	26.415	9.005
10	27.319	13.142
11	27.422	15.006
12	27.586	20.207
13	27.583	25.408
14	27.528	30.609
15	27.535	35.810

STATION NO. 18, AT X = 272.187 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	0.263
2	10.133	0.670
3	10.371	0.689
4	11.386	0.827
5	13.205	1.201
6	15.791	1.928
7	18.871	3.128
8	21.954	4.917
9	24.514	7.415
10	26.227	10.738
11	27.098	15.006
12	27.469	20.187
13	27.538	25.369
14	27.497	30.551
15	27.535	35.732

STATION NO. 19, AT X = 295.750 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	1.145
2	1.834	1.183
3	2.069	1.202
4	3.304	1.334
5	5.968	1.695
6	10.113	2.396
7	15.157	3.553
8	20.006	5.278
9	23.595	7.687
10	25.514	10.891
11	26.399	15.006
12	27.043	20.202
13	27.208	25.399
14	27.183	30.595
15	27.259	35.791

STATION NO. 20, AT X = 319.313 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	2.819
2	1.151	2.831
3	1.971	2.917
4	3.777	3.148
5	6.712	3.599
6	10.597	4.342
7	14.892	5.451
8	18.880	6.999
9	21.964	9.059
10	23.934	11.703
11	25.103	15.006
12	26.067	20.251
13	26.343	25.497
14	26.340	30.742
15	26.463	35.988

STATION NO. 21, AT X = 342.875 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	5.490
2	1.118	5.499
3	1.768	5.566
4	3.214	5.746
5	5.599	6.099
6	8.829	6.679
7	12.536	7.545
8	16.193	8.754
9	19.306	10.362
10	21.581	12.427
11	22.998	15.006
12	24.355	20.335
13	24.848	25.664
14	24.962	30.992
15	25.187	36.321

STATION NO. 22, AT X = 366.438 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	9.290
2	1.076	9.295
3	1.523	9.335
4	2.573	9.444
5	4.376	9.655
6	6.917	10.004
7	9.987	10.524
8	13.228	11.250
9	16.232	12.216
10	18.608	13.457
11	19.998	15.006
12	21.823	20.452
13	22.680	25.899
14	23.064	31.345
15	23.470	36.792

STATION NO. 23, AT X = 390.000 FT

POINT	HALF BEAM, FT	WATERLINE, FT
1	1.000	13.698
2	1.024	13.699
3	1.237	13.708
4	1.868	13.733
5	3.082	13.781
6	4.938	13.861
7	7.363	13.980
8	10.141	14.146
9	12.918	14.367
10	15.196	14.651
11	16.287	15.006
12	18.602	20.604
13	19.925	26.203
14	20.695	31.801
15	21.352	37.400

```
PRINTED REPORT NO. 3 - HULL BOUNDARY CONDITIONS

LBP, FT                    390.00   LCB/LBP                    0.515
BEAM, FT                    55.00   LCF/LBP                    0.555
DRAFT, FT                   15.01   HALF SIDING WIDTH, FT       1.00
DEPTH STA 0, FT             45.00    DEPTH STA 3, FT            41.46
DEPTH STA 10, FT            36.50   DEPTH STA 20, FT           37.40
RAISED DECK HT, FT           0.00   PRISMATIC COEF             0.650
WATERPLANE COEF             0.787   MAX SECTION COEF           0.919
NO POINTS BELOW DWL           11.   FWD KEEL/BL LIMIT          0.028
NO POINTS ABOVE DWL            4.   AFT KEEL/BL LIMIT          0.637
POINT DIST FAC ABOVE DWL    3.000   BOW ANGLE, DEG             50.00
POINT DIST FAC BELOW DWL    1.000   BOW SHAPE FAC              0.000
BOW OVERHANG                0.050   STA 20 SECTION COEF        0.700
STERN OVERHANG              0.009   HULL FLARE ANGLE, DEG         7.

                  SECTIONAL AREA AND DWL CURVES
                  =============================
                             AREA         DWL
                             ----         ---
STA 0 ORDINATE              0.000        0.005
STA 0 SLOPE                -1.189       -1.352
STA 20 ORDINATE             0.039        0.591
STA 20 SLOPE                1.084        1.173
PARALLEL MID LGTH           0.000        0.000
STA MAX ORDINATE           10.500       11.300
STA MAX AREA SLOPE          0.000        0.000
TENSOR NO 1                 0.000        0.000
TENSOR NO 2                 0.000        0.000
TENSOR NO 3                 0.000        0.000
TENSOR NO 4                 0.000        0.000
TENSOR/POLY SWITCH          0.000        0.000

DECK AT EDGE CURVE                  FLAT OF BOTTOM CURVE
==================                  ====================
STATION 0 OFFSET            0.376   STA OF TRANS START          1.500
STA 0 SLOPE                -1.800   SLOPE-STA OF TRANS START   -0.190
STA 10 OFFSET               1.000   STA OF START OF MID         8.688
STA 10 SLOPE                0.000   STA OF END OF MID          13.414
STATION 20 OFFSET           0.775   STA OF TRANS END           15.542
STA 20 SLOPE                0.693   SLOPE-STA OF TRANS END      0.000
PARALLEL MID LGTH           0.271   FLAT OF BOT ANGLE, DEG      2.550
STA OF PARALLEL MID        11.242   ELLIPSE RATIO               1.000

                        SLOPES AT SECTION CURVES
                        ========================
                             BOT          DWL          DAF
                             ---          ---          ---
STA 0 ORDINATE, DEG         8.000       87.000       55.364
STA 0 SLOPE                17.900      113.117       76.563
STA 10 ORDINATE, DEG        1.016       89.000       90.000
STA 10 SLOPE                0.475        0.000        0.000
STA 20 ORDINATE, DEG        1.000       62.158       82.404
STA 20 SLOPE                5.000       23.238       12.842
PARALLEL MID LGTH           0.000        0.000        0.000
STA OF PARALLEL MID        10.500       10.918        9.455
```

PRINTED REPORT NO. 4 - MARGIN LINE

```
MIN FREEBOARD MARGIN, FT     0.25

DIST FROM FP   HT ABOVE BL
     FT            FT
   -19.31        46.10
    -9.66        45.42
     0.00        44.75
     5.41        44.39
    10.82        44.03
    30.64        42.79
    50.45        41.65
    70.27        40.60
    90.09        39.65
   109.90        38.80
   129.72        38.05
   149.54        37.39
   169.36        36.83
   189.17        36.37
   208.99        36.00
   228.81        35.73
   248.63        35.56
   272.19        35.48
   295.75        35.54
   319.31        35.74
   342.88        36.07
   366.44        36.54
   390.00        37.15
```

PRINTED REPORT NO. 5 - HULL SECTIONAL AREA CURVE

```
STATION   LOCATION.FT   AREA.FT2
   1         -19.31        0.00
   2          -9.66        0.00
   3           0.00        0.00
   4           5.41       25.69
   5          10.82       52.50
   6          30.64      158.70
   7          50.45      271.48
   8          70.27      382.65
   9          90.09      485.27
  10         109.90      574.11
  11         129.72      646.09
  12         149.54      700.07
  13         169.36      736.36
  14         189.17      755.95
  15         208.99      759.89
  16         228.81      748.75
  17         248.63      722.26
  18         272.19      668.83
  19         295.75      585.81
  20         319.31      470.15
  21         342.88      324.39
  22         366.44      164.23
  23         390.00       30.00
```

HULL SUBDIV MODULE

PRINTED REPORT NO. 1 - SUMMARY

```
SHAFT SUPPORT TYPE IND-OPEN STRUT
LBP, FT                       390.00     HULL AVG DECK HT, FT         9.95
DEPTH STA 10, FT               36.50     NO INTERNAL DECKS               3
HULL VOLUME, FT3             598974.     NO TRANS BHDS                  13
MR VOLUME, FT3               118500.     NO LONG BHDS                    6
TANKAGE VOL REQ, FT3          62536.     NO MACHY RMS                    3
EXCESS TANKAGE, FT3               0.     NO PROP SHAFTS                  2
ARR AREA LOST TANKS, FT2      2557.1
HULL ARR AREA AVAIL, FT2     42299.5
```

PRINTED REPORT NO. 2 - TRANSVERSE BULKHEADS

```
NO TRANS BHDS                  13
TRANS BHD SPACING(/LBP)     0.075

BULKHEAD   DISTANCE     DISTANCE     MR FWD
   NO      FROM FP,FT  FROM FP/LBP   BHD LOC
========   ==========  ===========   ========
   1          19.50       0.050
   2          42.76       0.110
   3          66.02       0.169
   4          89.29       0.229
   5         112.55       0.289        MMR
   6         148.33       0.380
   7         177.58       0.455        MMR
   8         213.15       0.547
   9         242.40       0.622        AMR
  10         282.88       0.725
  11         309.66       0.794
  12         336.44       0.863
  13         363.22       0.931
```

PRINTED REPORT NO. 3 - LONGITUDINAL BULKHEADS

```
NO LONG BHDS                   6
LBP, FT                   390.00
HALF BREADTH, FT           27.54

           -/P,+/S     FWD     AFT     UPPER    LOWER
BULKHEAD   DIST OFF    BHD     BHD     DECK     DECK
   NO      CL, FT      ID      ID       ID       ID
========   ========    ===     ===     =====    =====
   1         25.61      3       6        0        3
   2        -25.61      3       6        0        3
   3         25.61      6       9        0        3
   4        -25.61      6       9        0        3
   5         25.61      9      12        0        3
   6        -25.61      9      12        0        3
```

PRINTED REPORT NO. 4 - INTERNAL DECKS AND INNER BOTTOM

```
NO INTERNAL DECKS               3      --------- INNER BOTTOM ----------
DEPTH STA 10, FT            36.50      CVK HT, FT                   2.50
HULL AVG DECK HT, FT         9.95      HORZ OFFSET HT, FT          10.00
RAISED DECK HT, FT           0.00      HORZ OFFSET, FT              2.00
                                       FLAT FWD LOC, FT            19.50
INT   DIST FROM   DECK                 FLAT AFT LOC, FT           315.73
DECK   BL AT      SHEER                OFFSET FWD LOC, FT          19.50
 NO   .5 LBP,FT   FRAC                 OFFSET AFT LOC, FT         315.73
====  =========   =====
  1      26.50     1.0
  2      17.50     0.0
  3      10.00     0.0
 IB       2.50

INT    AVL ARR    AVL ARR    USABLE     VOIDS     ARR AREA
DECK    AREA       VOL       TANKAGE              LOST TO
 NO     FT2        FT3        FT3        FT3      TANKS,FT2
====   =======    =======    =======    =====     =========
  1    18233.8    187964.        0.        0.          0.0
  2    13384.3    135036.     1058.      540.          0.0
  3     9086.2     74163.     2095.     2031.          0.0
 IB     1595.2     23545.    18793.        0.       2557.1
HOLD                         40590.       88.
       -------    -------    -------    -----     ---------
TOTAL  42299.5    420708.    62536.     2659.       2557.1
```

PRINTED REPORT NO. 5 - LARGE OBJECT SPACES

```
FOREPEAK VOID VOL, FT3        734.
FOREPEAK TANKAGE, FT3        1469.
CHAIN LOCKER VOL, FT3        2203.
SEWAGE VOL REQ, FT3           385.
SHAFT ALLEY VOL, FT3         3011.
MR AFT BHD POS, FT         282.88
INNER BOT VOL, FT3          26241.

            FWD  UPR     LGTH     LGTH      HT       HT        MR      INNER
MR          BHD  DECK    AVL      RQD       AVL      RQD       VOL    BOT VOL
NO   TYPE   ID   ID      FT       FT        FT       FT        FT3     FT3
===  ====  ===  ====   ======   ======    ======   ======   =======  =======
 1   MMR    5    1     35.78    35.78     26.50    23.49     43855.    3674.
 2   MMR    7    1     35.57    35.57     26.50    22.83     45123.    4310.
 3   AMR    9    2     40.48    40.48     17.50    17.50     29522.    3935.
                                                           --------  -------
                                                 TOTAL     118500.   11919.
```

PRINTED REPORT NO. 6 - HULL COMPARTMENT ARRANGEABLE AREA

```
  AREAS FOR EACH HULL COMPARTMENT:

DECK HT, FT ABL       26.5      17.5      10.0       2.5
COMP  1, FT2         346.5
COMP  2, FT2         528.3     367.5     288.7      92.4
COMP  3, FT2         750.1     636.8     528.5     239.7
COMP  4, FT2         942.1     867.0     749.7     404.1
COMP  5, FT2        1090.7    1041.5     935.4     574.9
COMP  6, FT2        1861.6     MMR       MMR       MMR
COMP  7, FT2        1599.3    1578.9    1532.5    1172.2
COMP  8, FT2        1960.8     MMR       MMR       MMR
COMP  9, FT2        1613.0    1612.5    1593.6    1207.6
COMP 10, FT2        2230.4    2218.0     AMR       AMR
COMP 11, FT2        1454.4    1431.1    1334.9     449.0
COMP 12, FT2        1398.6    1358.0    1186.8      12.4
COMP 13, FT2        1299.2    1229.2     869.9
COMP 14, FT2        1158.9    1043.7      66.2
```

DECKHOUSE MODULE

PRINTED REPORT NO. 1 - DECKHOUSE SUMMARY

```
LBP, FT                      390.00   DKHS LENGTH OA, FT             89.49
BEAM, FT                      55.00   DKHS MAX WIDTH, FT             43.04
AREA BEAM, FT                 54.17   DKHS HT (W/O PLTHS), FT        55.65
DKHS FWD LIMIT-          STA    4.6   OTHER ARR AREA REQ, FT2     41663.04
DKHS AFT LIMIT           STA    9.2   HULL ARR AREA AVAIL, FT2    42299.48
DKHS AVG DECK HT, FT           8.50   DKHS ARR AREA REQ, FT2       7744.25
DKHS NO LVLS                      3   HANGER ARR AREA REQ, FT2     1700.00
DKHS AVG SIDE CLR, FT          6.00   PLTHS ARR AREA REQ, FT2       671.93
DKHS AVG SIDE ANG, DEG         7.00

DKHS NO PRISMS                   20   DKHS MAX ARR AREA, FT2      17095.67
DKHS ARR AREA DERIV, FT2     429.74   DKHS ARR AREA AVAIL, FT2     7828.90
DKHS MIN ALW BEAM, FT         31.25   DKHS VOLUME, FT3            67163.65
BRIDGE L-O-S OVER BOW, FT    239.08   DKHS WEIGHT, LTON             114.10
DKHS SIDE CLR OFFSET, FT         6.   DKHS VCG, FT                   47.88
DKHS SIDE ANG OFFSET, DEG        7.
```

PRINTED REPORT NO. 2 - SUPERSTRUCTURE DECKHOUSES

```
NO OF SS DECKHOUSE BLKS        20
DKHS VOLUME, FT3            67164.
DKHS ARR AREA AVAIL, FT2    7828.9

                               D E C K H O U S E   N U M B E R
                                1         2         3         4         5
DIST FROM BOW, FT             89.70     97.34    104.98    112.61    120.25
LENGTH, FT                     7.64      7.64      7.64      7.64      7.64
DIST FROM CL, FT
  FWD/PORT/BTM               -18.79    -19.37    -19.87    -20.30    -20.66
  AFT/PORT/BTM               -19.37    -19.87    -20.30    -20.66    -20.94
  FWD/STBD/BTM                18.79     19.37     19.87     20.30     20.66
  AFT/STBD/BTM                19.37     19.87     20.30     20.66     20.94
  FWD/PORT/TOP               -17.75    -18.32    -18.83    -19.26    -19.62
  AFT/PORT/TOP               -18.32    -18.83    -19.26    -19.62    -19.90
  FWD/STBD/TOP                17.75     18.32     18.83     19.26     19.62
  AFT/STBD/TOP                18.32     18.83     19.26     19.62     19.90
DIST ABV BASELINE FWD, FT     39.92     39.58     39.26     38.94     38.65
DIST ABV BASELINE AFT, FT     39.58     39.26     38.94     38.65     38.36
HEIGHT, FT                     8.50      8.50      8.50      8.50      8.50
VOLUME, FT3                   2458.     2528.     2587.     2637.     2677.
ARR AREA, FT2                 283.5     291.7     298.9     304.9     309.8

                               D E C K H O U S E   N U M B E R
                                6         7         8         9        10
DIST FROM BOW, FT            127.89    135.53    143.17    150.80     89.70
LENGTH, FT                     7.64      7.64      7.64      7.64      7.64
DIST FROM CL, FT
  FWD/PORT/BTM               -20.94    -21.16    -21.33    -21.45    -17.75
  AFT/PORT/BTM               -21.16    -21.33    -21.45    -21.52    -18.32
  FWD/STBD/BTM                20.94     21.16     21.33     21.45     17.75
  AFT/STBD/BTM                21.16     21.33     21.45     21.52     18.32
  FWD/PORT/TOP               -19.90    -20.12    -20.29    -20.40    -16.70
  AFT/PORT/TOP               -20.12    -20.29    -20.40    -20.48    -17.28
  FWD/STBD/TOP                19.90     20.12     20.29     20.40     16.70
  AFT/STBD/TOP                20.12     20.29     20.40     20.48     17.28
DIST ABV BASELINE FWD, FT     38.36     38.10     37.84     37.60     48.42
DIST ABV BASELINE AFT, FT     38.10     37.84     37.60     37.38     48.42
HEIGHT, FT                     8.50      8.50      8.50      8.50      8.50
VOLUME, FT3                   2708.     2731.     2748.     2758.     2274.
ARR AREA, FT2                 313.6     316.6     318.8     320.2     267.5
```

```
                              D E C K H O U S E   N U M B E R
                              11      12      13      14      15
DIST FROM BOW, FT            97.34  104.98  112.61  120.25  127.89
LENGTH, FT                    7.64    7.64    7.64    7.64    7.64
DIST FROM CL, FT
  FWD/PORT/BTM              -18.32  -18.83  -19.26  -19.62  -19.90
  AFT/PORT/BTM              -18.83  -19.26  -19.62  -19.90  -20.12
  FWD/STBD/BTM               18.32   18.83   19.26   19.62   19.90
  AFT/STBD/BTM               18.83   19.26   19.62   19.90   20.12
  FWD/PORT/TOP              -17.28  -17.78  -18.21  -18.57  -18.86
  AFT/PORT/TOP              -17.78  -18.21  -18.57  -18.86  -19.07
  FWD/STBD/TOP               17.28   17.78   18.21   18.57   18.86
  AFT/STBD/TOP               17.78   18.21   18.57   18.86   19.07
DIST ABV BASELINE FWD, FT    48.08   47.76   47.44   47.15   46.86
DIST ABV BASELINE AFT, FT    48.08   47.76   47.44   47.15   46.86
HEIGHT, FT                    8.50    8.50    8.50    8.50    8.50
VOLUME, FT3                  2344.   2405.   2456.   2498.   2530.
ARR AREA, FT2                275.8   282.9   288.9   293.8   297.7

                              D E C K H O U S E   N U M B E R
                              16      17      18      19      20
DIST FROM BOW, FT           135.53  143.17  150.80  158.44   89.70
LENGTH, FT                    7.64    7.64    7.64   20.75   30.56
DIST FROM CL, FT
  FWD/PORT/BTM              -20.12  -20.29  -20.40  -21.52  -11.75
  AFT/PORT/BTM              -20.29  -20.40  -20.48  -21.54  -14.05
  FWD/STBD/BTM               20.12   20.29   20.40   21.52   11.75
  AFT/STBD/BTM               20.29   20.40   20.48   21.54   14.05
  FWD/PORT/TOP              -19.07  -19.24  -19.36  -19.43  -10.70
  AFT/PORT/TOP              -19.24  -19.36  -19.43  -19.45  -13.01
  FWD/STBD/TOP               19.07   19.24   19.36   19.43   10.70
  AFT/STBD/TOP               19.24   19.36   19.43   19.45   13.01
DIST ABV BASELINE FWD, FT    46.60   46.34   46.10   37.38   55.65
DIST ABV BASELINE AFT, FT    46.60   46.34   46.10   36.84   55.65
HEIGHT, FT                    8.50    8.50    8.50   17.00    8.50
VOLUME, FT3                  2555.   2574.   2586.  14679.   6431.
ARR AREA, FT2                300.6   302.8   304.3  1700.0   756.6
```

PRINTED REPORT NO. 3 - DECKHOUSE STRUCTURE WEIGHT SUMMARY

```
DKHS STRUCT DENSITY, LBM/FT3 4.18     HANGER VOL, FT3            14450.

                       WT-LTON   VCG-FT   LCG-FT
                       =======   ======   ======
   CALCULATED SWBS150   114.1     47.88   132.61

                          VCG
          DECK    VOLUME  FROM BL
          HOUSE   FT3     FT
          -----   ------  -------
          NO. 1    2458.   44.05
          NO. 2    2528.   43.71
          NO. 3    2587.   43.39
          NO. 4    2637.   43.08
          NO. 5    2677.   42.79
          NO. 6    2708.   42.51
          NO. 7    2731.   42.25
          NO. 8    2748.   42.00
          NO. 9    2758.   41.76
          NO.10    2274.   52.63
          NO.11    2344.   52.29
          NO.12    2405.   51.97
          NO.13    2456.   51.66
          NO.14    2498.   51.36
          NO.15    2530.   51.08
          NO.16    2555.   50.81
          NO.17    2574.   50.55
          NO.18    2586.   50.32
          NO.19   14679.   45.60
          NO.20    6431.   59.84
                 ---------  -------
                  67164.   47.88
```

HULL STRUCT MODULE

PRINTED REPORT NO. 1 - SUMMARY

```
---------------------- HULL STRENGTH AND STRESS ----------------------
HOGGING BM, FT-LTON          75500.     PRIM STRESS KEEL-HOG, KSI     8.84
SAGGING BM, FT-LTON          62944.     PRIM STRESS KEEL-SAG, KSI     7.37
MIDSHIP MOI, FT2-IN2        281961.     PRIM STRESS DECK-HOG, KSI    13.06
DIST N.A. TO KEEL, FT         14.74     PRIM STRESS DECK-SAG, KSI    10.89
DIST N.A. TO DECK, FT         21.77     HULL MARGIN STRESS, KSI       2.24
SEC MOD TO KEEL, FT-IN2      19134.     SEC MOD TO DECK, FT-IN2      12949.

HULL STRUCTURE COMPONENTS
                   MATERIAL   NO OF     NO
                     TYPE    SEGMENT
                   ----------------------
  WET. DECK       HY 80        3         1
  SIDE SHELL      HY 80        4         1
  BOTTOM SHELL    HY 80        6         1
  INNER BOTTOM    HY 80        6         1
  INT. DECK       HY 80        3         3
  STRINGER, SHEER HY 80        1         1
  LONG BULKHEAD   HY 80                  6
  TRANS BULKHEAD  HY 80                 13

HULL STRUCTURE WEIGHT
SWBS   COMPONENT                  WEIGHT, LTON    VCG, FT
-------------------------------------------------------------
100  HULL STRUCTURE                 1245.3         19.23
  110    SHELL+SUPPORT                661.0         15.65
  120    HULL STRUCTURAL BHD          209.0         16.47
  130    HULL DECKS                   253.7         33.16
  140    HULL PLATFORM/FLATS          121.6         14.39
```

PRINTED REPORT NO. 2 - HULL STRUCTURES WEIGHT

```
SWBS          COMPONENT                        WT-LTON       VCG-FT
====          =========                      ===========  ===========
*100  HULL STRUCTURES                         1245.3        19.23
*  110  SHELL + SUPPORTS                          661.0        15.65
     111  PLATING                                    330.8        19.88
     113  INNER BOTTOM                               135.4         3.07
     115  STANCHIONS                                   8.1        18.25
     116  LONG FRAMING                                59.4          .93
     117  TRANS FRAMING                              102.4        18.11
   120  HULL STRUCTURAL BULKHDS                   209.0        16.47
     121  LONG BULKHDS                                80.7        10.28
     122  TRANS BULKHDS                               97.9        20.37
     123  TRUNKS + ENCLOSURES                         30.4        20.37
   130  HULL DECKS                                253.7        33.16
     131  MAIN DECK                                  141.1        37.76
     132  2ND DECK                                   112.6        27.40
     133  3RD DECK
     134  4TH DECK
     135  5TH DECK+DECKS BELOW
     136  01 HULL DECK
   140  HULL PLATFORMS/FLATS                      121.6        14.39
     141  1ST PLATFORM                                71.9        17.46
     142  2ND PLATFORM                                49.7         9.95
     143  3RD PLATFORM
     144  4TH PLATFORM
     145  5TH PLAT+PLATS BELOW

          * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS
```

PRINTED REPORT NO. 3 - WEATHER DECK

```
DECK MTRL TYPE-HY 80
STRINGER PLATE MTRL TYPE-HY 80
                                      SHELL     STRINGER PLATE
  MODULUS OF ELASTICITY, KSI        29600.0       29600.0
  DENSITY, LBM/FT3                   489.02        489.02
  YIELD STRENGTH, KSI                 80.00         80.00
  MAX PRIMARY STRENGTH, KSI           23.52         23.52
  ALLOWABLE WORKING STRENGTH, KSI     55.00         55.00

                            MAX      MIN
STIFFENER SPACING, IN      48.00     24.00
STRINGER PLATE WIDTH, FT    6.00

SEGMENT GEOMETRY
      --------NODE COORD, FT-------------------SCND. LOAD, FT--
  SEG     YIB      ZIB      YOB      ZOB        HEAD1    HEAD2
   1      0.00    36.51     9.28    36.51       8.64
   2      9.28    36.51    21.54    36.51       8.63
   3     21.54    36.51    27.54    36.51       8.62

SEGMENT SCANTLINGS
        ----------------SCANTLINGS OF STIFFENED PLATES-----------------
                 STIFFENERS                 CATLG NO.OF  PLATE  SPACING
  SEG   ---------INXINXIN/IN--------------   NO   STIFF TK, IN    IN
   1 *R   3.920X   2.000X   0.120/   0.180   2.    2    0.4375    37.12
   2 *R   3.920X   2.000X   0.120/   0.180   2.    4    0.3438    29.41
   3 *R   3.002X   2.000X   0.125/   0.188   1.    3    0.3438    24.00
   NOTE: *R STANDS FOR ROLLED SHAPE

SEGMENT PROPERTIES
      ----------------PROPERTIES OF STIFFENED PLATES------------------
      ------AREA------   N.A. TO    -----SEC MOD-----            SMEAR
        TOTAL    SHEAR    PLATE        PLATE   FLANGE   WT/FT     RATIO
  SEG     IN2      IN2      IN          IN3     IN3    LBF/FT
   1    17.12     0.54      0.38       25.95    2.37     58.14     0.05
   2    10.99     0.53      0.42       22.22    2.31     37.33     0.09
   3     9.00     0.44      0.38       13.35    1.60     30.57     0.09
```

PRINTED REPORT NO. 4 - SIDE SHELL

```
SIDE SHELL MTRL TYPE-HY 80
SHEER STRAKE MTRL TYPE-HY 80
                                     SHELL     SHEER STRAKE
  MODULUS OF ELASTICITY, KSI       29600.0       29600.0
  DENSITY, LBM/FT3                  489.02        489.02
  YIELD STRENGTH, KSI                80.00         80.00
  MAX PRIMARY STRENGTH, KSI          23.52         23.52
  ALLOWABLE WORKING STRENGTH, KSI    55.00         55.00

                           MAX      MIN
STIFFENER SPACING, IN     48.00    24.00
SHEER STRAKE WIDTH, FT     6.00

SEGMENT GEOMETRY
      --------NODE COORD, FT-------------------SCND. LOAD, FT--
   SEC     YUPR      ZUPR      YLWR      ZLWR       HEAD1    HEAD2
    1      27.54     36.51     27.55     30.51       7.81
    2      27.55     30.51     27.56     26.50      12.00
    3      27.56     26.50     27.48     17.50      18.51
    4      27.48     17.50     27.23     10.00      26.76

SEGMENT SCANTLINGS
        ----------------SCANTLINGS OF STIFFENED PLATES-----------------
                 STIFFENERS                     CATLG NO.OF  PLATE  SPACING
  SEG   ---------INXINXIN/IN--------------   NO   STIFF TK, IN    IN
   1 *R   3.002X   2.000X   0.125/   0.188   1.     3   0.3438    24.00
   2 *R   3.002X   2.000X   0.125/   0.188   1.     1   0.3125    24.06
   3 *R   3.920X   2.000X   0.120/   0.180   2.     2   0.3438    36.01
   4 *R   4.920X   2.000X   0.120/   0.180   4.     1   0.4375    45.02
   NOTE: *R STANDS FOR ROLLED SHAPE

SEGMENT PROPERTIES
      ----------------PROPERTIES OF STIFFENED PLATES---------------
      ------AREA------   N.A. TO    -----SEC MOD-----             SMEAR
        TOTAL    SHEAR    PLATE        PLATE   FLANGE   WT/FT     RATIO
  SEG    IN2      IN2      IN           IN3      IN3    LBF/FT
   1     9.00     0.44     0.38        13.35     1.60    30.57     0.09
   2     8.27     0.44     0.38        13.05     1.58    28.08     0.10
   3    13.26     0.53     0.38        25.01     2.31    45.03     0.07
   4    20.70     0.66     0.39        39.33     3.01    70.29     0.05
```

PRINTED REPORT NO. 5 - BOTTOM SHELL

```
BOTTOM SHELL MTRL TYPE-HY 80
  MODULUS OF ELASTICITY, KSI           29600.0
  DENSITY, LBM/FT3                       489.02
  YIELD STRENGTH, KSI                     80.00
  MAX PRIMARY STRENGTH, KSI               23.52
  ALLOWABLE WORKING STRENGTH, KSI         55.00

                               MAX       MIN
STIFFENER SPACING, IN         48.00     24.00

SEGMENT GEOMETRY
      --------NODE COORD, FT-------------------SCND. LOAD, FT--
  SEG      YUPR      ZUPR      YLWR      ZLWR        HEAD1     HEAD2
   1      27.23     10.00     21.38      1.45        35.56
   2      21.38      1.45     19.27      0.86        39.44
   3      19.27      0.86     12.94      0.53        39.84
   4      12.94      0.53      8.59      0.34        42.08
   5       8.59      0.34      3.72      0.12        42.93
   6       3.72      0.12      0.00      0.00        42.12

SEGMENT SCANTLINGS
        ----------------SCANTLINGS OF STIFFENED PLATES----------------
                   STIFFENERS                     CATLG NO.OF  PLATE  SPACING
  SEG    ---------INXINXIN/IN--------------        NO   STIFF TK, IN    IN
   1 *R   4.920X   3.000X   0.120/   0.180     6.     2   0.4375    43.58
   2 *R   3.002X   2.000X   0.125/   0.188     1.     1   0.3438    13.56
   3 *R   4.920X   2.000X   0.120/   0.180     4.     1   0.5000    31.02
   4 *R   4.920X   2.000X   0.120/   0.180     4.     1   0.4375    25.18
   5 *R   4.920X   3.000X   0.120/   0.180     6.     1   0.5625    33.12
   6 *R   3.920X   2.000X   0.120/   0.180     2.     1   0.3438    20.72
   NOTE: *R STANDS FOR ROLLED SHAPE

SEGMENT PROPERTIES
      ----------------PROPERTIES OF STIFFENED PLATES-----------------
      ------AREA------   N.A. TO    -----SEC MOD-----              SMEAR
       TOTAL    SHEAR     PLATE       PLATE   FLANGE    WT/FT     RATIO
  SEG   IN2      IN2       IN          IN3     IN3      LBF/FT
   1   20.26    0.66      0.45       45.93    4.05     68.79      0.06
   2    5.41    0.44      0.51        9.32    1.59     18.38      0.16
   3   16.51    0.67      0.47       33.15    3.05     56.06      0.06
   4   12.02    0.66      0.52       28.90    2.99     40.80      0.09
   5   19.82    0.68      0.52       41.05    4.15     67.31      0.06
   6    8.00    0.53      0.51       17.73    2.30     27.18      0.12
```

PRINTED REPORT NO. 6 - INNER BOTTOM

```
INNER BOTTOM MTRL TYPE-HY 80
  MODULUS OF ELASTICITY, KSI          29600.0
  DENSITY, LBM/FT3                     489.02
  YIELD STRENGTH, KSI                   80.00
  MAX PRIMARY STRENGTH, KSI             23.52
  ALLOWABLE WORKING STRENGTH, KSI       55.00

                              MAX       MIN
STIFFENER SPACING, IN        48.00     24.00

SEGMENT GEOMETRY
      --------NODE COORD, FT-------------------SCND. LOAD, FT--
  SEG     YUPR      ZUPR      YLWR      ZLWR        HEAD1     HEAD2
   1     25.23     10.00     21.38      2.50         3.14     38.99
   2     21.38      2.50     19.27      2.50         2.64     39.70
   3     19.27      2.50     12.94      2.50         3.26     38.21
   4     12.94      2.50      8.59      2.50         2.97     35.25
   5      8.59      2.50      3.72      2.50         3.05     33.02
   6      3.72      2.50      0.00      2.50         2.88     30.70

SEGMENT SCANTLINGS
        ----------------SCANTLINGS OF STIFFENED PLATES-----------------
                 STIFFENERS                        CATLG NO.OF  PLATE  SPACING
  SEG   ---------INXINXIN/IN--------------          NO   STIFF TK, IN    IN
   1 *R   3.920X   2.000X   0.120/   0.180    2.     2    0.3750    34.92
   2 *R   3.002X   2.000X   0.125/   0.188    1.     1    0.2188    12.64
   3 *R   3.920X   2.000X   0.120/   0.180    2.     1    0.4375    38.00
   4 *R   3.002X   2.000X   0.125/   0.188    1.     1    0.4375    26.10
   5 *R   3.002X   2.000X   0.125/   0.188    1.     1    0.5000    29.24
   6 *R   3.002X   2.000X   0.125/   0.188    1.     1    0.3438    22.30
   NOTE: *R STANDS FOR ROLLED SHAPE

SEGMENT PROPERTIES
      ----------------PROPERTIES OF STIFFENED PLATES-----------------
      ------AREA------    N.A. TO    -----SEC MOD-----              SMEAR
       TOTAL    SHEAR     PLATE        PLATE    FLANGE    WT/FT     RATIO
  SEG   IN2      IN2        IN          IN3       IN3     LBF/FT
   1   13.97     0.54      0.38       24.94      2.33     47.45      0.07
   2    3.52     0.43      0.62        6.79      1.52     11.94      0.27
   3   17.50     0.54      0.38       26.22      2.37     59.45      0.05
   4   12.17     0.45      0.37       14.40      1.65     41.33      0.07
   5   15.37     0.46      0.37       15.07      1.70     52.20      0.05
   6    8.42     0.44      0.39       12.80      1.60     28.59      0.10
```

PRINTED REPORT NO. 7 - INTERNAL DECKS

```
NUMBER OF INTERNAL DECKS   3
INTERNAL DECK MTRL TYPE-HY 80
  MODULUS OF ELASTICITY, KSI        29600.0
  DENSITY, LBM/FT3                   489.02
  YIELD STRENGTH, KSI                 80.00
  MAX PRIMARY STRENGTH, KSI           23.52
  ALLOWABLE WORKING STRENGTH, KSI     55.00

SEGMENT GEOMETRY
      --------NODE COORD, FT-------------------SCND. LOAD, FT--
  SEG     YIB       ZIB       YOB       ZOB         HEAD1     HEAD2
DECK NO.1
  SEG
   1      0.00     26.50      9.28     26.50        2.67     25.40
   2      9.28     26.50     17.90     26.50        2.67     29.87
   3     17.90     26.50     27.56     26.50        2.67     34.36
DECK NO.2
  SEG
   1      0.00     17.50      9.28     17.50        2.67     25.40
   2      9.28     17.50     17.90     17.50        2.67     29.87
   3     17.90     17.50     27.48     17.50        2.67     34.36
DECK NO.3
  SEG
   1      0.00     10.00      9.28     10.00        2.67     25.40
   2      9.28     10.00     17.90     10.00        2.67     29.87
   3     17.90     10.00     27.23     10.00        2.67     34.36

SEGMENT SCANTLINGS
        ----------------SCANTLINGS OF STIFFENED PLATES-----------------
                  STIFFENERS                       CATLG NO.OF  PLATE  SPACING
  SEG    ---------INXINXIN/IN--------------         NO   STIFF TK, IN    IN
DECK NO.1
    1 *R   3.002X   2.000X   0.125/   0.188   1.     3    0.2500    27.84
   2 *R   4.920X   2.000X   0.120/   0.180   4.     3    0.2500    25.86
   3 *R   4.920X   2.000X   0.120/   0.180   4.     3    0.2813    29.00
DECK NO.2
   1 *R   3.002X   2.000X   0.125/   0.188   1.     2    0.2500    37.12
   2 *R   3.920X   2.000X   0.120/   0.180   2.     2    0.2500    34.47
   3 *R   3.920X   2.000X   0.120/   0.180   2.     2    0.2813    38.33
DECK NO.3
   1 *R   3.002X   2.000X   0.125/   0.188   1.     2    0.2500    37.12
   2 *R   3.920X   2.000X   0.120/   0.180   2.     2    0.2500    34.47
   3 *R   3.920X   2.000X   0.120/   0.180   2.     2    0.2813    37.31
   NOTE: *R STANDS FOR ROLLED SHAPE

SEGMENT PROPERTIES
      ----------------PROPERTIES OF STIFFENED PLATES-----------------
      ------AREA------   N.A. TO    -----SEC MOD-----             SMEAR
        TOTAL    SHEAR    PLATE        PLATE   FLANGE    WT/FT    RATIO
  SEG    IN2      IN2       IN          IN3     IN3     LBF/FT
DECK NO.1
   1     7.71     0.43     0.36        13.28    1.56     26.18     0.11
   2     7.46     0.64     0.60        22.89    2.88     25.35     0.15
   3     9.16     0.65     0.53        26.72    2.90     31.10     0.12
DECK NO.2
   1    10.03     0.43     0.31        15.97    1.56     34.06     0.08
   2     9.50     0.52     0.41        22.01    2.26     32.26     0.10
   3    11.66     0.53     0.37        24.70    2.28     39.60     0.08
DECK NO.3
   1    10.03     0.43     0.31        15.97    1.56     34.06     0.08
   2     9.50     0.52     0.41        22.01    2.26     32.26     0.10
   3    11.38     0.53     0.38        24.28    2.28     38.63     0.08
```

PRINTED REPORT NO. 8 - STRENGTH AND STRESS OF STIFFENED PLATE AT DESIGN LOAD

SEG	-PRIMARY STRESS-		-LOCAL STRESS-		--------STRENGTH--------		
	TENSION KSI	COMP. KSI	BEND. KSI	SHEAR KSI	BUCKL. KSI	ULTIMATE KSI	COLUMN KSI
WET DECK							
1	13.10	10.92	11.62	4.21	14.87	35.67	32.39
2	13.10	10.92	9.44	3.40	14.62	35.41	44.06
3	13.10	10.92	11.09	3.34	21.96	42.01	31.59
SIDE SHELL							
1	12.17	10.15	10.05	3.03	21.96	42.01	31.59
2	10.61	8.85	15.64	4.71	18.05	38.73	33.71
3	8.59	7.16	24.73	8.93	9.76	29.69	39.05
4	6.71	5.91	34.32	12.96	10.10	30.15	40.63
BOT SHELL							
1	7.54	8.27	32.78	16.66	10.79	31.03	48.94
2	7.90	9.31	28.89	8.65	63.82	64.00	45.34
3	7.94	9.42	34.79	13.14	27.81	46.20	47.08
4	8.15	10.02	30.33	11.39	32.31	48.99	53.81
5	8.23	10.25	29.36	14.95	30.86	48.13	50.33
6	8.16	10.03	32.57	11.69	29.47	47.27	51.46
INNER BOT							
1	7.42	7.93	50.15	18.11	12.34	32.92	37.87
2	7.77	8.93	28.32	8.42	32.05	48.84	52.95
3	7.77	8.93	52.61	19.05	14.19	34.96	31.71
4	7.77	8.93	47.68	14.50	30.06	47.64	24.93
5	7.77	8.93	48.65	14.96	31.29	48.38	20.69
6	7.77	8.93	36.75	11.08	25.43	44.58	33.61
INT DECK NO. 1							
1	9.99	8.33	38.93	11.75	8.63	28.11	35.00
2	9.99	8.33	23.02	8.60	10.00	30.02	61.63
3	9.99	8.33	29.43	11.02	10.07	30.11	58.24
INT DECK NO. 2							
1	0.00	0.00	51.76	15.66	4.85	21.64	27.50
2	0.00	0.00	39.05	14.09	5.63	23.16	46.88
3	0.00	0.00	49.54	17.90	5.76	23.42	41.98
INT DECK NO. 3							
1	0.00	0.00	51.76	15.66	4.85	21.64	27.50
2	0.00	0.00	39.05	14.09	5.63	23.16	46.88
3	0.00	0.00	48.23	17.42	6.08	24.00	42.64

PRINTED REPORT NO. 9 - FACTOR OF SAFETY OF STIFFENED PLATE AT DESIGN LOAD

```
        --PLATE-  -STIFFENER- --------STIFFENED PLATE-----------
SEG     BUCKLING     SHEAR    COMP+BEND  ULTIMATE  TENSION+BEND.
WET DECK
   1       1.30       7.84       1.40       1.01        2.22
   2       1.28       9.70       1.85       1.37        2.44
   3       1.89       9.87       1.39       1.14        2.27
SIDE SHELL
   1       2.04      10.89       1.51       1.23        2.48
   2       1.84       7.00       1.48       1.33        2.09
   3       1.17       3.70       1.38       1.39        1.65
   4       1.39       2.55       1.19       1.69        1.34
BOT SHELL
   1       1.11       1.98       1.18       1.56        1.36
   2       5.39       3.81       1.20       2.45        1.49
   3       2.51       2.51       1.07       1.97        1.29
   4       2.78       2.90       1.21       2.27        1.43
   5       2.62       2.21       1.19       2.06        1.46
   6       2.42       2.82       1.13       1.99        1.35
INNER BOT
   1       5.14       1.82       1.10       5.19        1.10
   2       9.85       3.92       1.94       7.95        1.94
   3       5.82       1.73       1.05       4.55        1.05
   4      10.68       2.28       1.15       4.22        1.15
   5      11.09       2.21       1.13       3.55        1.13
   6      10.80       2.98       1.50       6.36        1.50
INT DECK
NO. 1
   1       3.68       2.81       1.41       4.20        1.41
   2       1.02       3.84       1.70       1.89        1.67
   3       1.01       2.99       1.40       1.76        1.40
INT DECK
NO. 2
   1       1.87       2.11       1.06       2.29        1.06
   2       2.73       2.34       1.41       5.27        1.41
   3       2.46       1.84       1.11       4.19        1.11
INT DECK
NO. 3
   1       1.87       2.11       1.06       2.29        1.06
   2       2.73       2.34       1.41       5.27        1.41
   3       2.62       1.89       1.14       4.40        1.14
```

PRINTED REPORT NO. 10 - GIRDER PROPERTIES, STRENGTH ,STRESSES AND FACTOR OF SAFETY

```
DECK MTRL TYPE-HY 80          BOT MTRL TYPE-HY 80

HULL LOADS IND-CALC
GIRDER/STIFF.,POSITION
       ------COORDINATE, FT-----  --SCND. LOAD, FT--
               YLOC      ZLOC       HEAD1    HEAD2
WET DECK
GIRDER
   1           0.00     36.51       8.56
   2           9.28     36.51       8.40
   3          17.90     36.51       8.40
INT DECK  1.
GIRDER
   1           0.00     26.50       2.76      8.87
   2           9.28     26.50       2.76     13.51
   3          17.90     26.50       2.76     17.82
INT DECK  2.
GIRDER
   1           0.00     17.50       2.76     16.67
   2           9.28     17.50       2.76     21.31
   3          17.90     17.50       2.76     25.62
INT DECK  3.
GIRDER
   1           0.00     10.00       2.76     23.16
   2           9.28     10.00       2.76     27.80
   3          17.90     10.00       2.76     32.11
BOTTOM
GIRDER
   1           0.00      0.00       0.29     40.51
   2           3.72      0.12       0.29     40.39
   3           8.59      0.34       0.37     40.17
   4          12.94      0.53       0.37     39.98
   5          19.27      0.86       0.29     40.58
   6          21.38      1.45       0.29     41.12
BOTTOM
STIFF.
   1           0.00      1.25       0.29     39.26
   2           3.72      1.31       0.29     39.20
   3           8.59      1.42       0.37     39.09
   4          12.94      1.52       0.37     38.99
   5          19.27      1.68       0.19     39.76
   6          21.38      1.98       0.19     40.56

       ---------------SCANTLINGS OF GDR/STF AND PLATE-----------
SUPPORT
              GIRDER/STIFFENER              CATLG  PLATE    WIDTH
       ------------INXINXIN/IN------------   NO   TK, IN   IN
WET DECK
GIRDER
   1 *R   6.990X   3.000X   0.180/   0.310   17.   0.4375   111.35
   2 *R   6.990X   3.000X   0.180/   0.310   17.   0.3438   107.39
   3 *R   6.990X   3.000X   0.180/   0.310   17.   0.3438   109.54
INT DECK  1.
GIRDER
   1 *R   4.990X   2.000X   0.180/   0.310    9.   0.2500   111.35
   2 *R   6.950X   2.000X   0.180/   0.250   11.   0.2500   107.39
   3 *R   5.950X   4.000X   0.180/   0.250   15.   0.2500   109.71
INT DECK  2.
GIRDER
   1 *R   5.950X   4.000X   0.180/   0.250   15.   0.2500   111.35
   2 *R   6.990X   3.000X   0.180/   0.310   17.   0.2500   107.39
   3 *R   5.990X   5.000X   0.180/   0.310   21.   0.2500   109.21
INT DECK  3.
GIRDER
   1 *R   5.990X   5.000X   0.180/   0.310   21.   0.2500   111.35
   2 *R   6.990X   5.000X   0.180/   0.310   23.   0.2500   107.39
   3 *R   8.990X   3.000X   0.250/   0.310   27.   0.2500   107.68
BOTTOM
GIRDER
   1     30.000X  13.408X   0.344/   0.344         0.3438    41.43
   2     28.547X  13.408X   0.344/   0.344         0.3438    53.84
   3     25.940X  17.063X   0.438/   0.438         0.4375    58.30
   4     23.614X  17.063X   0.438/   0.438         0.4375    56.19
   5     19.636X   8.533X   0.219/   0.219         0.3438    44.58
   6     12.594X   8.533X   0.219/   0.219         0.3438    27.12
BOTTOM
STIFF.
   1 *R   3.002X   2.000X   0.125/   0.188    1.   0.3438    15.00
   2 *R   3.002X   2.000X   0.125/   0.188    1.   0.3438    15.00
   3 *R   3.002X   2.000X   0.125/   0.188    1.   0.4375    15.00
   4 *R   3.002X   2.000X   0.125/   0.188    1.   0.4375    15.00
   5 *R   3.002X   2.000X   0.125/   0.188    1.   0.2188    15.00
   6 *R   3.002X   2.000X   0.125/   0.188    1.   0.2188    15.00
   NOTE: *R STANDS FOR ROLLED SHAPE

      ----------------PROPERTIES OF GDR/STF AND PLATES----------------
      ------AREA------  N.A. TO   -----SEC MOD-----              SMEAR
       TOTAL   SHEAR    PLATE        PLATE  FLANGE   WT/FT     RATIO
        IN2     IN2       IN          IN3     IN3    LBF/FT
WET DECK
GIRDER
   1   50.97    1.39      0.45      158.96    9.80   173.08     0.05
   2   39.17    1.38      0.47      148.13    9.68   133.02     0.06
   3   39.91    1.38      0.46      150.03    9.68   135.53     0.06
INT DECK  1.
GIRDER
   1   29.40    1.00      0.32       75.70    4.59    99.84     0.06
   2   28.66    1.34      0.42      111.20    6.60    97.32     0.07
   3   29.56    1.16      0.45      108.81    8.18   100.37     0.08
INT DECK  2.
GIRDER
   1   29.97    1.16      0.45      110.00    8.18   101.77     0.08
   2   29.10    1.36      0.52      128.98    9.57    98.81     0.08
   3   29.99    1.18      0.57      122.29   11.58   101.85     0.10
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INT DECK  3.
GIRDER
   1   30.53    1.18      0.56      124.18   11.59   103.67     0.10
   2   29.73    1.36      0.66      142.83   13.69   100.95     0.11
   3   30.11    2.39      0.75      172.22   14.74   102.25     0.12
BOTTOM
GIRDER
   1   19.53   10.55     15.34      188.73  188.73    66.34     0.00
   2   19.03   10.05     14.62      177.21  177.21    64.64     0.00
   3   26.28   11.73     13.41      241.18  241.18    89.24     0.00
   4   25.26   10.71     12.24      215.56  215.56    85.79     0.00
   5    9.10    4.42      8.98       67.07   53.66    30.89     0.00
   6    7.56    2.88      5.71       40.15   30.81    25.66     0.00
BOTTOM
STIFF.
   1    5.91    0.44      0.49        9.98    1.59    20.06     0.15
   2    5.91    0.44      0.49        9.98    1.59    20.06     0.15
   3    7.31    0.45      0.48       10.85    1.64    24.83     0.11
   4    7.31    0.45      0.48       10.85    1.64    24.83     0.11
   5    4.03    0.43      0.56        7.80    1.53    13.69     0.23
   6    4.03    0.43      0.56        7.80    1.53    13.69     0.23

      ----------------STRENGTH AND STRESSES OF GDR.STF------------
                                 AT DESIGN LOAD
     -PRIMARY STRESS-    -LOCAL STRESS-   --------STRENGTH--------
      TENSION   COMP.    BEND.    SHEAR  BUCKL.  ULTIMATE  COLUMN
       KSI      KSI      KSI      KSI     KSI     KSI      KSI
WET DECK
GIRDER
   1   13.10    10.92    22.02     7.94   64.60   64.62    29.90
   2   13.10    10.92    21.08     7.61   64.60   64.62    37.42
   3   13.10    10.92    21.50     7.76   64.60   64.62    36.87
INT DECK  1.
GIRDER
   1    9.99     8.33    48.71    11.48   75.34   76.75    17.44
   2    9.99     8.33    49.81    12.56   64.89   64.85    34.54
   3    9.99     8.33    54.10    19.55   71.10   70.88    35.36
INT DECK  2.
GIRDER
   1    0.00     0.00    51.35    18.56   71.10   70.88    34.95
   2    0.00     0.00    54.15    19.55   64.60   64.62    45.02
   3    0.00     0.00    54.67    22.55   70.89   70.63    45.02
INT DECK  3.
GIRDER
   1    0.00     0.00    50.40    25.40   70.89   70.63    44.58
   2    0.00     0.00    49.38    25.51   64.60   64.62    52.90
   3    0.00     0.00    53.12    16.81   68.07   67.67    59.40
BOTTOM
GIRDER
   1    8.00     9.60     2.01     1.85   56.22   59.92    80.00
   2    7.99     9.57     2.78     2.51   61.01   61.93    80.00
   3    7.97     9.51     2.20     2.32   74.01   74.69    80.00
   4    7.95     9.46     2.36     2.43   75.79   77.49    80.00
   5    7.92     9.37     7.63     4.75   53.15   58.78    80.00
   6    7.87     9.21     8.20     4.50   74.63   75.64    80.00
BOTTOM
STIFF.
   1    7.89     9.27    31.76     9.53   77.31   80.00    43.26
   2    7.88     9.25    31.71     9.51   77.31   80.00    43.26
   3    7.87     9.22    30.61     9.24   77.31   80.00    39.00
   4    7.86     9.19    30.53     9.22   77.31   80.00    39.00
   5    7.85     9.15    33.51    10.00   77.31   80.00    50.37
   6    7.82     9.07    34.18    10.20   77.31   80.00    50.37

      ------------------FACTOR OF SAFETY OF GDR,STF-----------
                                AT DESIGN LOAD
      --PLATE-  -STIFFENER- --------STIFFENED PLATE-----------
      BUCKLING     SHEAR    COMP+BEND  ULTIMATE  TENSION+BEND.
WET DECK
GIRDER
   1     5.56      4.16       1.06       1.66       1.57
   2     5.55      4.34       1.22       2.08       1.61
   3     5.55      4.25       1.20       2.05       1.59
INT DECK  1.
GIRDER
   1    49.66      2.87       1.13       8.82       1.13
   2    42.78      2.63       1.10      14.77       1.10
   3    34.04      1.69       1.02      12.00       1.02
INT DECK  2.
GIRDER
   1    36.25      1.78       1.07      12.63       1.07
   2    31.33      1.69       1.02      14.11       1.02
   3    26.66      1.20       1.01      11.96       1.01
INT DECK  3.
GIRDER
   1    29.36      1.30       1.09      13.04       1.09
   2    26.59      1.29       1.11      14.07       1.11
   3    29.16      1.96       1.04      17.22       1.04
BOTTOM
GIRDER
   1    54.37     17.87      27.32      46.36      27.31
   2    42.76     13.14      19.80      34.73      19.80
   3    65.55     14.24      25.02      52.93      25.02
   4    62.55     13.55      23.31      51.16      23.31
   5    16.95      6.94       7.21      15.00       7.21
   6    23.11      7.34       6.71      18.74       6.71
BOTTOM
STIFF.
   1    29.75      3.46       1.73      13.32       1.73
   2    29.79      3.47       1.73      13.34       1.73
   3    32.48      3.57       1.80      13.11       1.80
   4    32.56      3.58       1.80      13.14       1.80
   5    22.98      3.30       1.64      11.98       1.64
   6    22.52      3.23       1.61      11.74       1.61
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PRINTED REPORT NO. 11 - LONGITUDINAL BULKHEADS

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  NUMBER OF LONG BHD  6
  LONG BHD MTRL TYPE-HY 80
  MODULUS OF ELASTICITY, KSI           29600.0
  DENSITY, LBM/FT3                      489.02
  YIELD STRENGTH, KSI                    80.00
  MAX PRIMARY STRENGTH, KSI              23.52
  ALLOWABLE WORKING STRENGTH, KSI        55.00

                               MAX        MIN
STIFFENER SPACING, IN         48.00      24.00
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SEGMENT GEOMETRY
      --------NODE COORD, FT-------------------SCND. LOAD, FT--
  SEG     YUPR      ZUPR      YLWR      ZLWR        HEAD1     HEAD2
BHD NO.1
  SEG
   1     25.61     36.51     25.61     26.50        21.42
   2     25.61     26.50     25.61     17.50        29.21
   3     25.61     17.50     25.61     10.00        35.71
BHD NO.2
  SEG
   1     25.61     36.51     25.61     26.50        21.42
   2     25.61     26.50     25.61     17.50        29.21
   3     25.61     17.50     25.61     10.00        35.71
BHD NO.3
  SEG
   1     25.61     36.51     25.61     26.50        21.42
   2     25.61     26.50     25.61     17.50        29.21
   3     25.61     17.50     25.61     10.00        35.71
BHD NO.4
  SEG
   1     25.61     36.51     25.61     26.50        21.42
   2     25.61     26.50     25.61     17.50        29.21
   3     25.61     17.50     25.61     10.00        35.71
BHD NO.5
  SEG
   1     25.61     36.51     25.61     26.50        21.42
   2     25.61     26.50     25.61     17.50        29.21
   3     25.61     17.50     25.61     10.00        35.71
BHD NO.6
  SEG
   1     25.61     36.51     25.61     26.50        21.42
   2     25.61     26.50     25.61     17.50        29.21
   3     25.61     17.50     25.61     10.00        35.71


SEGMENT SCANTLINGS
        ----------------SCANTLINGS OF STIFFENED PLATES---------------
STIFFENERS                    CATLG NO.OF  PLATE  SPACING
  SEG   ---------INXINXIN/IN-------------   NO   STIFF TK, IN     IN
BHD NO.1
  SEG
   1 *R   3.002X   2.000X   0.125/   0.188    1    4    0.2500     24.02
   2 *R   3.002X   2.000X   0.125/   0.188    1    3    0.3125     27.00
   3 *R   3.920X   2.000X   0.120/   0.180    2    2    0.2500     30.00
BHD NO.2
  SEG
   1 *R   3.002X   2.000X   0.125/   0.188    1    4    0.2500     24.02
   2 *R   3.002X   2.000X   0.125/   0.188    1    3    0.3125     27.00
   3 *R   3.920X   2.000X   0.120/   0.180    2    2    0.2500     30.00
BHD NO.3
  SEG
   1 *R   3.002X   2.000X   0.125/   0.188    1    4    0.2500     24.02
   2 *R   3.002X   2.000X   0.125/   0.188    1    3    0.3125     27.00
   3 *R   3.920X   2.000X   0.120/   0.180    2    2    0.2500     30.00
BHD NO.4
  SEG
   1 *R   3.002X   2.000X   0.125/   0.188    1    4    0.2500     24.02
   2 *R   3.002X   2.000X   0.125/   0.188    1    3    0.3125     27.00
   3 *R   3.920X   2.000X   0.120/   0.180    2    2    0.2500     30.00
BHD NO.5
  SEG
   1 *R   3.002X   2.000X   0.125/   0.188    1    4    0.2500     24.02
   2 *R   3.002X   2.000X   0.125/   0.188    1    3    0.3125     27.00
   3 *R   3.920X   2.000X   0.120/   0.180    2    2    0.2500     30.00
BHD NO.6
  SEG
   1 *R   3.002X   2.000X   0.125/   0.188    1    4    0.2500     24.02
   2 *R   3.002X   2.000X   0.125/   0.188    1    3    0.3125     27.00
   3 *R   3.920X   2.000X   0.120/   0.180    2    2    0.2500     30.00
   NOTE: *R STANDS FOR ROLLED SHAPE


SEGMENT PROPERTIES
      -----------------PROPERTIES OF STIFFENED PLATES-----------------
      ------AREA------   N.A. TO    -----SEC MOD-----              SMEAR
       TOTAL    SHEAR     PLATE       PLATE    FLANGE   WT/FT     RATIO
  SEG   IN2      IN2       IN          IN3      IN3     LBF/FT
BHD NO.1
  SEG
   1    6.76     0.43      0.39       12.01     1.55     22.94     0.12
   2    9.19     0.44      0.36       13.98     1.59     31.21     0.09
   3    8.38     0.52      0.44       19.92     2.26     28.46     0.12
BHD NO.2
  SEG
   1    6.76     0.43      0.39       12.01     1.55     22.94     0.12
   2    9.19     0.44      0.36       13.98     1.59     31.21     0.09
   3    8.38     0.52      0.44       19.92     2.26     28.46     0.12
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BHD NO.3
  SEG
   1    6.76     0.43      0.39       12.01     1.55     22.94     0.12
   2    9.19     0.44      0.36       13.98     1.59     31.21     0.09
   3    8.38     0.52      0.44       19.92     2.26     28.46     0.12
BHD NO.4
  SEG
   1    6.76     0.43      0.39       12.01     1.55     22.94     0.12
   2    9.19     0.44      0.36       13.98     1.59     31.21     0.09
   3    8.38     0.52      0.44       19.92     2.26     28.46     0.12
BHD NO.5
  SEG
   1    6.76     0.43      0.39       12.01     1.55     22.94     0.12
   2    9.19     0.44      0.36       13.98     1.59     31.21     0.09
   3    8.38     0.52      0.44       19.92     2.26     28.46     0.12
BHD NO.6
  SEG
   1    6.76     0.43      0.39       12.01     1.55     22.94     0.12
   2    9.19     0.44      0.36       13.98     1.59     31.21     0.09
   3    8.38     0.52      0.44       19.92     2.26     28.46     0.12

          ----------STRENGTH AND STRESSES-----------
                      AT DESIGN LOAD
         --LOCAL STRESS--    --------STRENGTH--------
           BEND.    SHEAR    BUCKL.   ULTIMATE COLUMN
             KSI      KSI       KSI       KSI      KSI
BHD NO. 1
  SEG
   1       28.39     8.55     11.59     32.02     38.70
   2       42.67    12.87     14.33     35.11     30.58
   3       40.69    14.66      7.43     26.29     49.76
BHD NO. 2
  SEG
   1       28.39     8.55     11.59     32.02     38.70
   2       42.67    12.87     14.33     35.11     30.58
   3       40.69    14.66      7.43     26.29     49.76
BHD NO. 3
  SEG
   1       28.39     8.55     11.59     32.02     38.70
   2       42.67    12.87     14.33     35.11     30.58
   3       40.69    14.66      7.43     26.29     49.76
BHD NO. 4
  SEG
   1       28.39     8.55     11.59     32.02     38.70
   2       42.67    12.87     14.33     35.11     30.58
   3       40.69    14.66      7.43     26.29     49.76
BHD NO. 5
  SEG
   1       28.39     8.55     11.59     32.02     38.70
   2       42.67    12.87     14.33     35.11     30.58
   3       40.69    14.66      7.43     26.29     49.76
BHD NO. 6
  SEG
   1       28.39     8.55     11.59     32.02     38.70
   2       42.67    12.87     14.33     35.11     30.58
   3       40.69    14.66      7.43     26.29     49.76


        -----------------------FACTOR OF SAFETY-------------------
                               AT DESIGN LOAD
        --PLATE-  -STIFFENER- --------STIFFENED PLATE-----------
        BUCKLING     SHEAR    COMP+BEND  ULTIMATE  TENSION+BEND.
BHD NO. 1  SEG
   1       6.14       3.86       1.94       6.57        1.94
   2       5.77       2.56       1.29       4.32        1.29
   3       3.14       2.25       1.35       5.53        1.35
BHD NO. 2  SEG
   1       6.14       3.86       1.94       6.57        1.94
   2       5.77       2.56       1.29       4.32        1.29
   3       3.14       2.25       1.35       5.53        1.35
BHD NO. 3   SEG
   1       6.14       3.86       1.94       6.57        1.94
   2       5.77       2.56       1.29       4.32        1.29
   3       3.14       2.25       1.35       5.53        1.35
BHD NO. 4   SEG
   1       6.14       3.86       1.94       6.57        1.94
   2       5.77       2.56       1.29       4.32        1.29
   3       3.14       2.25       1.35       5.53        1.35
BHD NO. 5   SEG
   1       6.14       3.86       1.94       6.57        1.94
   2       5.77       2.56       1.29       4.32        1.29
   3       3.14       2.25       1.35       5.53        1.35
BHD NO. 6   SEG
   1       6.14       3.86       1.94       6.57        1.94
   2       5.77       2.56       1.29       4.32        1.29
   3       3.14       2.25       1.35       5.53        1.35
```

PRINTED REPORT NO. 12 - TRANSVERSE BULKHEADS

```
TRANS BHD MTRL TYPE-HY 80
  MODULUS OF ELASTICITY, KSI          29600.0
  DENSITY, LBM/FT3                     489.02
  YIELD STRENGTH, KSI                   80.00
  MAX PRIMARY STRENGTH, KSI             23.52
  ALLOWABLE WORKING STRENGTH, KSI       55.00

                                 MAX      MIN
STIFFENER SPACING, IN           48.00    24.00

SEGMENT GEOMETRY
      --------NODE COORD, FT-------------------SCND. LOAD, FT--
  SEG      YUPR     ZUPR      YLWR     ZLWR        HEAD1     HEAD2
   1       0.00    36.51      0.00    26.50        22.40
   2       0.00    26.50      0.00    17.50        30.15
   3       0.00    17.50      0.00    10.00        36.52
   4       0.00    10.00      0.00     2.50        41.09

SEGMENT SCANTLINGS
        ----------------SCANTLINGS OF STIFFENED PLATES-----------------
                  STIFFENERS                    CATLG NO.OF  PLATE  SPACING
  SEG   ---------INXINXIN/IN--------------       NO   STIFF TK, IN    IN
   1 *R   6.950X   3.000X   0.180/   0.250     14    12    0.1875    30.03
   2 *R   6.990X   3.000X   0.180/   0.310     17    12    0.1875    27.00
   3 *R   6.950X   3.000X   0.180/   0.250     14     9    0.2188    30.00
   4 *R   6.990X   3.000X   0.180/   0.310     17     9    0.2188    30.00
   NOTE: *R STANDS FOR ROLLED SHAPE

SEGMENT PROPERTIES
      ----------------PROPERTIES OF STIFFENED PLATES------------------
      ------AREA------   N.A. TO    -----SEC MOD-----                SMEAR
        TOTAL    SHEAR    PLATE          PLATE    FLANGE   WT/FT     RATIO
  SEG    IN2      IN2      IN             IN3      IN3     LBF/FT
   1    7.69     1.33     1.40          33.98     7.98     26.12      0.37
   2    7.31     1.35     1.66          31.98     9.12     24.84      0.44
   3    8.62     1.34     1.28          38.53     8.05     29.28      0.31
   4    8.81     1.35     1.41          39.93     9.25     29.93      0.34

          ----------STRENGTH AND STRESSES-----------
                       AT DESIGN LOAD
        --LOCAL STRESS--   --------STRENGTH--------
          BEND.    SHEAR   BUCKL.  ULTIMATE COLUMN
           KSI      KSI     KSI      KSI      KSI
  SEG
   1      52.61    11.49    7.43    26.29    49.76
   2      49.29    13.06    7.43    26.29    49.76
   3      54.96    15.28    7.43    26.29    49.76
   4      54.87    20.11    7.43    26.29    49.76

        -----------------------FACTOR OF SAFETY------------------
                                  AT DESIGN LOAD
        --PLATE-  -STIFFENER- --------STIFFENED PLATE-----------
        BUCKLING     SHEAR    COMP+BEND  ULTIMATE  TENSION+BEND.
  SEG
   1       3.14       2.87       1.05       5.53        1.35
   2       3.14       2.53       1.12       5.53        1.35
   3       3.14       2.16       1.00       5.53        1.35
   4       3.14       1.64       1.00       5.53        1.35
```

PRINTED REPORT NO. 13 - SIDE AND BOTTOM FRAMES

```
FRAME SPACING, FT            6.00

SEGMENT GEOMETRY
      --------NODE COORD, FT------------------SCND. LOAD, FT--
  SEG     YUPR      ZUPR      YLWR      ZLWR        HEAD1     HEAD2
SIDE FRAME
  SEG
   1      27.54     36.51     27.56     26.50       14.01
   2      27.56     26.50     27.48     17.50       23.01
   3      27.48     17.50     27.23     10.00       30.51
BOT FRAME
  SEG
   1      27.23     10.00     21.38      1.45       39.06
   2      21.38      1.45     19.27      0.86       39.65
   3      19.27      0.86     12.94      0.53       39.98
   4      12.94      0.53      8.59      0.34       40.17
   5       8.59      0.34      3.72      0.12       40.39
   6       3.72      0.12      0.00      0.00       40.51

SEGMENT SCANTLINGS
        ----------------SCANTLINGS OF STIFFENED PLATES-----------------
                  STIFFENERS                    CATLG     PLATE      SPAN
        ----------INXINXIN/IN--------------      NO      TK, IN      FT
SIDE FRAME
  SEG
   1 *R    6.990X    5.000X   0.180/   0.310   23.       0.3438     10.01
   2 *R    9.990X    3.000X   0.250/   0.310   31.       0.3125      9.00
   3 *R    8.930X    3.000X   0.250/   0.370   30.       0.3438      7.50
BOT FRAME
  SEG
   1      24.000X   14.625X   0.375/   0.375             0.4375     13.07
   2      16.115X    8.533X   0.219/   0.219             0.3438      2.20
   3      21.625X   17.063X   0.438/   0.438             0.5000      6.34
   4      24.777X   17.063X   0.438/   0.438             0.4375      4.36
   5      27.244X   19.500X   0.500/   0.500             0.5625      4.88
   6      29.273X   13.408X   0.344/   0.344             0.3438      3.72
   NOTE: *R STANDS FOR ROLLED SHAPE

SEGMENT PROPERTIES
      ----------------PROPERTIES OF STIFFENED PLATES-----------------
      ------AREA------    N.A. TO    -----SEC MOD-----               SMEAR
        TOTAL    SHEAR     PLATE        PLATE    FLANGE    WT/FT     RATIO
  SEG    IN2      IN2       IN           IN3      IN3     LBF/FT
SIDE FRAME
  SEG
   1    27.63     1.38      0.75       126.28    13.79     93.84      0.12
   2    25.94     2.65      1.03       163.10    17.45     88.09      0.15
   3    28.13     2.41      0.91       158.78    16.61     95.54      0.14
BOT FRAME
  SEG
   1    20.88     9.30     11.89       184.62   169.99     70.92      0.14
   2     8.33     3.65      7.33        53.19    41.74     28.28      0.14
   3    25.46     9.87     10.84       213.63   197.54     86.45      0.14
   4    25.77    11.22     12.83       228.27   228.27     87.51      0.14
   5    34.34    14.15     13.68       353.07   330.33    116.62      0.14
   6    19.28    10.30     14.98       182.94   182.94     65.49      0.14

        STRESS AND FACTOR OF SAFETY
        -STRESS, KSI-    ------FOS-----
        BENDING  SHEAR   BENDING  SHEAR
SIDE FRAME
  SEG
   1    52.33    19.68     1.05    1.68
   2    54.82    15.08     1.00    2.19
   3    52.88    18.33     1.04    1.80
BOT FRAME
  SEG
   1    34.95    10.60     1.57    3.11
   2     3.80     4.61    14.47    7.15
   3     7.26     4.96     7.57    6.65
   4     3.10     3.01    17.73   10.95
   5     2.61     2.69    21.05   12.27
   6     2.84     2.83    19.36   11.68
```

PRINTED REPORT NO. 14 - DECK BEAMS

```
FRAME SPACING, FT            6.00

SEGMENT GEOMETRY
       --------NODE COORD, FT------------------SCND. LOAD, FT--
  SEG      YIB      ZIB      YOB      ZOB        HEAD1    HEAD2
WET DECK      SEG
   1      0.00    36.51     9.28    36.51        8.56
   2      9.28    36.51    27.54    36.51        8.40
DECK NO.  1   SEG
   1      0.00    26.50     9.28    26.50        2.76
   2      9.28    26.50    17.90    26.50        2.76
   3     17.90    26.50    27.56    26.50        2.81
DECK NO.  2   SEG
   1      0.00    17.50     9.28    17.50        2.76
   2      9.28    17.50    17.90    17.50        2.76
   3     17.90    17.50    27.48    17.50        2.81
DECK NO.  3   SEG
   1      0.00    10.00     9.28    10.00        2.76
   2      9.28    10.00    17.90    10.00        2.76
   3     17.90    10.00    27.23    10.00        2.81


SEGMENT SCANTLINGS
         ----------------SCANTLINGS OF STIFFENED PLATES-----------------
                   STIFFENERS                   CATLG     PLATE      SPAN
         ---------INXINXIN/IN--------------     NO      TK, IN      FT
WET DECK      SEG
   1 *R   6.950X   2.000X   0.180/   0.250    11.       0.4375     9.28
   2 *R   9.930X   5.000X   0.250/   0.370    43.       0.3438    18.26
DECK NO.  1   SEG
   1 *R   3.920X   2.000X   0.120/   0.180     2.       0.2500     9.28
   2 *R   3.920X   2.000X   0.120/   0.180     2.       0.2500     8.62
   3 *R   4.920X   2.000X   0.120/   0.180     4.       0.2813     9.67
DECK NO.  2   SEG
   1 *R   3.920X   2.000X   0.120/   0.180     2.       0.2500     9.28
   2 *R   3.920X   2.000X   0.120/   0.180     2.       0.2500     8.62
   3 *R   4.920X   2.000X   0.120/   0.180     4.       0.2813     9.58
DECK NO.  3   SEG
   1 *R   3.920X   2.000X   0.120/   0.180     2.       0.2500     9.28
   2 *R   3.920X   2.000X   0.120/   0.180     2.       0.2500     8.62
   3 *R   3.920X   2.000X   0.120/   0.180     2.       0.2813     9.33
   NOTE: *R STANDS FOR ROLLED SHAPE


SEGMENT PROPERTIES
        ----------------PROPERTIES OF STIFFENED PLATES-----------------
        ------AREA------   N.A. TO    -----SEC MOD-----               SMEAR
          TOTAL    SHEAR    PLATE       PLATE    FLANGE    WT/FT      RATIO
  SEG      IN2      IN2      IN          IN3      IN3      LBF/FT
WET DECK        SEG
   1     33.31     1.37     0.48      101.72     6.75    113.12      0.06
   2     29.13     2.66     1.28      196.84    26.91     98.94      0.18
DECK NO.  1    SEG
   1     18.88     0.52     0.27       34.93     2.27     64.12      0.05
   2     18.88     0.52     0.27       34.93     2.27     64.12      0.05
   3     21.25     0.65     0.31       48.39     2.93     72.18      0.05
DECK NO.  2    SEG
   1     18.88     0.52     0.27       34.93     2.27     64.12      0.05
   2     18.88     0.52     0.27       34.93     2.27     64.12      0.05
   3     21.25     0.65     0.31       48.39     2.93     72.18      0.05
DECK NO.  3    SEG
   1     18.88     0.52     0.27       34.93     2.27     64.12      0.05
   2     18.88     0.52     0.27       34.93     2.27     64.12      0.05
   3     21.13     0.53     0.27       35.24     2.29     71.77      0.04

         STRESS AND FACTOR OF SAFETY
         -STRESS, KSI-    ------FOS-----
         BENDING  SHEAR   BENDING  SHEAR
WET DECK        SEG
   1     53.95    11.15     1.02    2.96
   2     54.77    11.12     1.00    2.97
DECK NO.  1  SEG
   1     51.53     9.47     1.07    3.49
   2     44.45     8.79     1.24    3.75
   3     44.06     8.13     1.25    4.06
DECK NO.  2    SEG
   1     51.53     9.47     1.07    3.49
   2     44.45     8.79     1.24    3.75
   3     43.30     8.05     1.27    4.10
DECK NO.  3
  SEG
   1     51.53     9.47     1.07    3.49
   2     44.45     8.79     1.24    3.75
   3     52.73     9.63     1.04    3.43
```

PRINTED REPORT NO. 15 - LONGITUDINAL BULKHEAD VERTICAL STIFFENERS

```
  NUMBER OF LONG BHD  6

FRAME SPACING, FT            6.00

SEGMENT GEOMETRY
      --------NODE COORD, FT------------------SCND. LOAD, FT--
 SEG      YUPR     ZUPR     YLWR     ZLWR       HEAD1    HEAD2
LBHD NO.1   SEG
  1      25.61    36.51    25.61    26.50       21.46
  2      25.61    26.50    25.61    17.50       29.31
  3      25.61    17.50    25.61    10.00       35.75
LBHD NO.2   SEG
  1      25.61    36.51    25.61    26.50       21.46
  2      25.61    26.50    25.61    17.50       29.31
  3      25.61    17.50    25.61    10.00       35.75
LBHD NO.3   SEG
  1      25.61    36.51    25.61    26.50       21.46
  2      25.61    26.50    25.61    17.50       29.31
  3      25.61    17.50    25.61    10.00       35.75
LBHD NO.4   SEG
  1      25.61    36.51    25.61    26.50       21.46
  2      25.61    26.50    25.61    17.50       29.31
  3      25.61    17.50    25.61    10.00       35.75
LBHD NO.5   SEG
  1      25.61    36.51    25.61    26.50       21.46
  2      25.61    26.50    25.61    17.50       29.31
  3      25.61    17.50    25.61    10.00       35.75
LBHD NO.6   SEG
  1      25.61    36.51    25.61    26.50       21.46
  2      25.61    26.50    25.61    17.50       29.31
  3      25.61    17.50    25.61    10.00       35.75

SEGMENT SCANTLINGS
        ----------------SCANTLINGS OF STIFFENED PLATES----------------
                  STIFFENERS                     CATLG    PLATE     SPAN
 SEG    ---------INXINXIN/IN--------------        NO      TK, IN     FT
LBHD NO.1   SEG
   1 *R   9.930X   4.000X   0.250/   0.370   38.       0.2500    10.01
   2 *R   9.930X   4.000X   0.250/   0.370   38.       0.3125     9.00
   3 *R   9.990X   4.000X   0.250/   0.310   35.       0.2500     7.50
LBHD NO.2   SEG
   1 *R   9.930X   4.000X   0.250/   0.370   38.       0.2500    10.01
   2 *R   9.930X   4.000X   0.250/   0.370   38.       0.3125     9.00
   3 *R   9.990X   4.000X   0.250/   0.310   35.       0.2500     7.50
LBHD NO.3   SEG
   1 *R   9.930X   4.000X   0.250/   0.370   38.       0.2500    10.01
   2 *R   9.930X   4.000X   0.250/   0.370   38.       0.3125     9.00
   3 *R   9.990X   4.000X   0.250/   0.310   35.       0.2500     7.50
LBHD NO.4   SEG
   1 *R   9.930X   4.000X   0.250/   0.370   38.       0.2500    10.01
   2 *R   9.930X   4.000X   0.250/   0.370   38.       0.3125     9.00
   3 *R   9.990X   4.000X   0.250/   0.310   35.       0.2500     7.50
LBHD NO.5   SEG
   1 *R   9.930X   4.000X   0.250/   0.370   38.       0.2500    10.01
   2 *R   9.930X   4.000X   0.250/   0.370   38.       0.3125     9.00
   3 *R   9.990X   4.000X   0.250/   0.310   35.       0.2500     7.50
LBHD NO.6   SEG
   1 *R   9.930X   4.000X   0.250/   0.370   38.       0.2500    10.01
   2 *R   9.930X   4.000X   0.250/   0.370   38.       0.3125     9.00
   3 *R   9.990X   4.000X   0.250/   0.310   35.       0.2500     7.50
   NOTE: *R STANDS FOR ROLLED SHAPE

SEGMENT PROPERTIES
      ------------------PROPERTIES OF STIFFENED PLATES-----------------
      ------AREA------   N.A. TO    -----SEC MOD-----               SMEAR
       TOTAL    SHEAR    PLATE          PLATE   FLANGE    WT/FT     RATIO
 SEG    IN2      IN2       IN            IN3      IN3     LBF/FT
LBHD NO.1   SEG
  1    22.00    2.64      1.40        148.06    22.70     74.71      0.22
  2    26.50    2.65      1.22        176.22    22.92     89.99      0.18
  3    21.75    2.64      1.30        144.10    20.28     73.86      0.21
LBHD NO.2  SEG
  1    22.00    2.64      1.40        148.06    22.70     74.71      0.22
  2    26.50    2.65      1.22        176.22    22.92     89.99      0.18
  3    21.75    2.64      1.30        144.10    20.28     73.86      0.21
LBHD NO.3   SEG
  1    22.00    2.64      1.40        148.06    22.70     74.71      0.22
  2    26.50    2.65      1.22        176.22    22.92     89.99      0.18
  3    21.75    2.64      1.30        144.10    20.28     73.86      0.21
LBHD NO.4   SEG
  1    22.00    2.64      1.40        148.06    22.70     74.71      0.22
  2    26.50    2.65      1.22        176.22    22.92     89.99      0.18
  3    21.75    2.64      1.30        144.10    20.28     73.86      0.21
LBHD NO.5
 SEG
  1    22.00    2.64      1.40        148.06    22.70     74.71      0.22
  2    26.50    2.65      1.22        176.22    22.92     89.99      0.18
  3    21.75    2.64      1.30        144.10    20.28     73.86      0.21
LBHD NO.6   SEG
  1    22.00    2.64      1.40        148.06    22.70     74.71      0.22
  2    26.50    2.65      1.22        176.22    22.92     89.99      0.18
  3    21.75    2.64      1.30        144.10    20.28     73.86      0.21

       STRESS AND FACTOR OF SAFETY
       -STRESS, KSI-    ------FOS-----
       BENDING  SHEAR   BENDING  SHEAR
LBHD NO.1  SEG
  1    50.64    15.73     1.09    2.10
  2    54.27    19.20     1.01    1.72
  3    52.41    19.63     1.05    1.68
LBHD NO.2  SEG
  1    50.64    15.73     1.09    2.10
  2    54.27    19.20     1.01    1.72
  3    52.41    19.63     1.05    1.68
LBHD NO.3  SEG
  1    50.64    15.73     1.09    2.10
  2    54.27    19.20     1.01    1.72
  3    52.41    19.63     1.05    1.68
LBHD NO.4  SEG
  1    50.64    15.73     1.09    2.10
  2    54.27    19.20     1.01    1.72
  3    52.41    19.63     1.05    1.68
LBHD NO.5  SEG
  1    50.64    15.73     1.09    2.10
  2    54.27    19.20     1.01    1.72
  3    52.41    19.63     1.05    1.68
LBHD NO.6  SEG
  1    50.64    15.73     1.09    2.10
  2    54.27    19.20     1.01    1.72
  3    52.41    19.63     1.05    1.68
```

APPENDAGE MODULE

PRINTED REPORT NO. 1 - SUMMARY

```
APPENDAGE DISP, LTON         225.0
SHELL DISP, LTON              24.5
RUDDER TYPE IND              SPADE
SKEG DISP, LTON                1.5
NO RUDDERS                       2
SKEG AFT LIMIT/LBP          0.8078
AVG RUDDER CHORD, FT          9.83
SKEG THK, FT                  1.00
RUDDER THK, FT                1.10
SKEG PROJECTED AREA, FT2      50.8
RUDDER SPAN, FT              11.95
RUDDER PROJECTED AREA, FT2   117.4
RUDDER DISP, LTON              4.9
BILGE KEEL DISP, LTON          8.9
BILGE KEEL LGTH, FT         135.14
SHAFT SUPPORT DISP, LTON      13.6
SHAFT DISP, LTON               4.7
PROP TYPE IND                   CP
PROP BLADE DISP, LTON          1.9
NO PROP SHAFTS                   2
PROP DIA, FT                 15.50
SONAR DISP, LTON             165.0
```

PRINTED REPORT NO. 2 - APPENDAGE BUOYANCY AND WEIGHT

```
                                 ----CENTER OF BUOYANCY----
 APPENDAGE           DISP, LTON   X, FT      Y, FT      Z, FT
==========           ==========  ======     ======     ======
SHELL                   24.5     200.85       0.00       8.58
SKEG                     1.5     299.09       0.00       0.72
BILGE KEELS*             8.9     195.00      26.78       7.38
OPEN STRUTS*            13.6     363.91      11.63      -0.54
PROPULSION SHAFTS*       4.7     335.70      11.63       0.74
PROP BLADES*             1.9     370.42      11.63      -1.59
SONAR DOME             165.0      14.00       0.00      -3.20
RUDDERS*                 4.9     383.09      11.63       5.43
                     ==========
TOTAL, LTON            225.0
         * TRANSVERSE C.B. PER SIDE IS SHOWN

SWBS114, SHLL APNDG, LTON   13.18     SWBS565, ROLL FINS, LTON     0.00
```

RESISTANCE MODULE

PRINTED REPORT NO. 1 - SUMMARY

```
RESID RESIST IND            TAYLOR    BILGE KEEL IND            PRESENT
FRICTION LINE IND             ITTC    SHAFT SUPPORT TYPE IND OPEN STRUT
ENDUR DISP IND            AVG DISP    PRPLN SYS RESIST IND         CALC
ENDUR CONFIG IND             NO TS    PROP TYPE IND                  CP
SONAR DRAG IND                HULL    SONAR DOME IND            PRESENT
SKEG IND                   PRESENT    RUDDER TYPE IND             SPADE
FULL LOAD WT, LTON          5721.7    CORR ALW                  0.00050
AVG ENDUR DISP, LTON        5459.4    DRAG MARGIN FAC             0.110
USABLE FUEL WT, LTON         996.2    TRAILSHAFT PWR FAC           1.15
NO FIN PAIRS                    0.    PRPLN SYS RESIST FRAC
PROP TIP CLEAR RATIO          0.25      MAX SPEED                 0.128
NO PROP SHAFTS                  2.      SUSTN SPEED               0.141
PROP DIA, FT                 15.50      ENDUR SPEED               0.190

CONDITION SPEED------------EFFECTIVE HORSEPOWER, HP------------    DRAG
           KT     FRIC     RESID  APPDG  WIND  MARGIN   TOTAL       LBF
MAX       26.49   7722.   15441.* 4293.  276.   3051.  30783.   378714.
SUSTN     25.26   6726.   11663.  3691.  239.   2455.  24773.   319605.
ENDUR     16.00   1749.    2384.* 1054.   62.    577.   5827.   118673.
 * DENOTES EXTRAPOLATED VALUE.
```

PRINTED REPORT NO. 2 - SPEED-POWER MATRIX

```
                 SPEED AND POWER FOR FULL LOAD DISP
                ===================================
FULL LOAD WT, LTON          5721.7
SPEED     ------------EFFECTIVE HORSEPOWER, HP------------    DRAG
 KT          FRIC     RESID   APPDG  WIND  MARGIN    TOTAL     LBF
 2.00          4.        6.      4.    0.      2.      16.   2627.
 4.00         32.       45.     28.    1.     12.     117.   9539.
 6.00        104.      152.     80.    3.     37.     376.  20424.
 8.00        239.      360.    172.    8.     86.     863.  35153.
10.00        456.      702.    310.   15.    163.    1646.  53653.
12.00        774.     1228.    504.   26.    279.    2811.  76328.
14.00       1210.     2186.    774.   41.    463.    4674. 108801.
16.00       1784.     2555.   1066.   61.    601.    6067. 123559.
18.00       2512.     3536.   1453.   86.    835.    8422. 152467.
20.00       3412.     4994.   1933.  119.   1150.   11607. 189119.
22.00       4501.     6706.   2497.  158.   1525.   15386. 227901.
24.00       5797.     8895.   3161.  205.   1986.   20044. 272155.
26.00       7317.    13797.*  4043.  261.   2796.   28214. 353610.
28.00       9077.    21196.*  5132.  325.   3930.   39661. 461572.


                 SPEED AND POWER FOR AVE ENDUR DISP
                ===================================
AVE ENDUR DISP, LTON    5459.4
SPEED     ------------EFFECTIVE HORSEPOWER, HP------------    DRAG
 KT          FRIC     RESID   APPDG  WIND  MARGIN    TOTAL     LBF
 2.00          4.        6.*     4.    0.      2.      16.   2602.
 4.00         31.       45.*    27.    1.     11.     116.   9444.
 6.00        102.      150.*    80.    3.     37.     372.  20217.
 8.00        234.      357.*   171.    8.     85.     854.  34793.
10.00        447.      696.*   309.   15.    161.    1629.  53093.
12.00        759.     1211.*   503.   26.    275.    2773.  75307.
14.00       1187.     2105.*   768.   41.    451.    4553. 105966.
16.00       1749.     2384.*  1054.   62.    577.    5827. 118673.
18.00       2463.     3285.*  1437.   88.    800.    8073. 146158.
20.00       3346.     4574.*  1907.  120.   1094.   11041. 179891.
22.00       4414.     6150.*  2463.  160.   1451.   14637. 216811.
24.00       5685.     8234.*  3121.  208.   1897.   19145. 259951.
26.00       7175.    12824.*  3987.  264.   2667.   26918. 337367.
28.00       8901.    19881.*  5057.  330.   3759.   37928. 441409.
 * DENOTES EXTRAPOLATED VALUE.
```

PRINTED REPORT NO. 3 - SHIP GEOMETRIC DATA FOR RESISTANCE COMPUTATIONS

```
                                   FULL LOAD        AVE ENDUR DISP
BARE HULL DISP, LTON                 5661.7            5399.4
APPENDAGE DISP, LTON                   60.0              60.0
TOTAL DISP, LTON                     5721.7            5459.4
LBP, FT                              390.00            390.00
WL LENGTH, FT                        389.99            389.74
BEAM AT MAX AREA STA, FT              55.00             55.09
DRAFT AT MAX AREA STA, FT             14.99             14.44
WETTED SURF FOR RESID RESIST
 TAYLOR WITH SONAR DOME DISP, FT2   22803.2           22323.3
WETTED SURF FOR FRIC RESIST
 BARE HULL+S.D. WETTED SURF, FT2    24204.1           23734.1
 SONAR DOME WETTED SURF, FT2         1400.0            1400.0
SKEG WETTED SURF AREA, FT2            101.7             101.7
WIND FRONT AREA, FT2                 2037.9            2067.8

FROUDE WETTED SURF COEF              6.8458            6.9268
LENGTH-BEAM RATIO                    7.0902            7.0751
BEAM-DRAFT RATIO                     3.6701            3.8141
PRISMATIC COEF                       0.6492            0.6436
MAX SECTION COEF                     0.9211            0.9168
DISP-LENGTH RATIO                   95.4517           91.2076
LCB-LENGTH RATIO                     0.4947            0.4918
HALF ANG ENTRANCE, DEG                11.39             11.70
HALF ANG RUN, DEG                      8.96             14.40
TRANSOM BUTTOCK ANG, DEG              11.19             11.19
BOW SECT AREA COEF                   0.0000            0.0000
TRANSOM SECT AREA COEF               0.0387            0.0174
TRANSOM BREADTH COEF                 0.5919            0.4954
TRANSOM DEPTH COEF                   0.0860            0.0516
```

PRINTED REPORT NO. 4 - APPENDAGE DATA

```
SKEG IND                    PRESENT
SKEG AREA, FT2                 50.8
SHAFT SUPPORT TYPE IND OPEN STRUT
NO STRUTS PER SHAFT              1.          MAIN        INTMD
STRUT DIMENSIONS                            ------      --------
  STRUT CHORD, FT                             2.92
  STRUT THICKNESS, FT                         0.58
  BARREL LENGTH, FT                          12.40
  BARREL DIA, FT                              4.72

NO PROP SHAFTS                   2.
WET SHAFT LGTH (PORT), FT    63.25
WET SHAFT LGTH (STBD), FT    58.91
INTRMDT SHAFT DIA, FT         1.37
PROP TYPE IND                   CP
PROP DIA, FT                 15.50
SONAR DOME IND             PRESENT
SONAR DRAG IND                HULL
SONAR SECT AREA, FT2         215.0
SONAR WETTED SURF, FT2      1400.0
SONAR DISP, LTON             165.0
SONAR CB AFT FP, ,A2          ********
         ABV BL, ,A2            14.00
SONAR WETTED SURF, FT         -3.2
SONAR DISP,
RUDDER AREA, FT2             117.4
ROLL FIN AREA, FT2
```

PROPELLER MODULE

PRINTED REPORT NO. 1 - SUMMARY

```
PROP TYPE IND                CP     PROP SERIES IND          TROOST
MAX SPEED, KT             26.49     ENDUR SPEED, KT           16.00
MAX EHP (/SHAFT), HP     15391.     ENDUR EHP (/SHAFT), HP    2913.
MAX SHP (/SHAFT), HP     23516.     ENDUR SHP (/SHAFT), HP    4381.
MAX PROP RPM              176.6     ENDUR PROP RPM            103.2
MAX PROP EFF              0.689     ENDUR PROP EFF            0.700
SUSTN SPEED, KT           25.26     PROP DIA, FT              15.50
SUSTN EHP (/SHAFT), HP   12387.     NO BLADES                    5.
SUSTN SHP (/SHAFT), HP   18770.     PITCH RATIO                1.27
SUSTN PROP RPM            165.7     EXPAND AREA RATIO         0.790
SUSTN PROP EFF            0.695     CAVITATION NO              1.66
NO PROP SHAFTS              2.0
TOTAL PROPELLER WT, LTON  41.43
```

PRINTED REPORT NO. 2 - PROPELLER CHARACTERISTICS

```
NO PROP SHAFTS               2.
PROP DIA, FT              15.50
NO BLADES                    5.
PITCH RATIO                1.27
EXPAND AREA RATIO         0.790
THRUST DED COEF           0.055
TAYLOR WAKE FRAC          0.020
HULL EFFICIENCY           0.964
REL ROTATE EFF            0.985

                          ----------- CONDITIONS ----------
CHARACTERISTICS           MAXIMUM    SUSTAINED    ENDURANCE
============================================================
SPEED, KT                   26.49        25.26        16.00
RPM                         176.6        165.7        103.2
THRUST/SHAFT, LBF         200380.      169105.       62791.
EHP/SHAFT, HP              15391.       12387.        2913.
TORQUE/SHAFT, FT-LBF      689169.      586322.      219597.
SHP/SHAFT, HP              23516.       18770.        4381.
ADVANCE COEF (J)            0.961        0.976        0.992
THRUST COEF (KT)            0.201        0.193        0.185
TORQUE COEF (10KQ)          0.447        0.432        0.417
OPEN WATER EFFY             0.689        0.695        0.700
PC                          0.655        0.660        0.665
```

PRINTED REPORT NO. 3 - CAVITATION CHARACTERISTICS

```
MAX SPEED OF ADV, KT        25.96
MAX THRUST, LBF           200380.
MAX PROP RPM                176.6
PROP DIA, FT                15.50
HUB DEPTH, FT               16.58
STD CAV NO                   1.66
LOCAL CAV NO (.7R)           0.27
MEAN THRUST LOADING COEF     0.12
EXPAND AREA RATIO           0.790
MIN EAR REQUIRED            0.948
BACK CAV ALLOWED, PERCENT     5.0
```

PRINTED REPORT NO. 4 - PROPELLER ARRANGEMENT

```
PROP DIA, FT                15.50
FULL LOAD DRAFT, FT         14.99
HUB DEPTH FROM DWL, FT      16.58
LONG LOC FROM AP, FT        19.58
HUB POS FROM CL, FT         11.63
TIP CLR FROM BL, FT         -9.34
TIP CLR FROM MAX HB, FT      8.22
TIP CLR FROM HULL BOT, FT    3.88
TOTAL PROPELLER WT, LTON    41.43
```

MACHINERY MODULE

PRINTED REPORT NO. 1 - SUMMARY

```
TRANS TYPE IND                 MECH     MAX SPEED, KT               26.49
SHAFT SUPPORT TYPE IND OPEN STRUT       SUSTN SPEED, KT             25.26
NO PROP SHAFTS                   2.     ENDUR SPEED, KT             16.00
MAX MARG ELECT LOAD, KW       3361.     ENDURANCE, NM               4950.
AVG 24 HR ELECT LOAD, KW      1509.     USABLE FUEL WT, LTON        996.2
SWBS 200 GROUP WT, LTON       521.4
SWBS 300 GROUP WT, LTON       182.4
                                           NO     NO ONLINE  NO ONLINE
ARRANGEMENT OR SS GEN          TYPE     INSTALLED MAX+SUSTN  ENDURANCE
-------------------------  ----------  --------- ---------  ---------
MECH PORT ARR IND             M2-LTDR       1          1          1
MECH STBD ARR IND           M2-LTDR/F       1          1          1
SEP SS GEN                  2500. KW        1          0          0
VSCF SS CYCLO               2000. KW        2          2          2

                      MAIN ENG          SEC ENG             SS ENG
                   ---------------  ---------------    ---------------
ENG SELECT IND               GIVEN                                CALC
ENG MODEL IND          RR/DDA-SPEY                            GE-LM500
ENG TYPE IND                    GT                                  GT
ENG SIZE IND                 GIVEN                               GIVEN
NO INSTALLED                     4                 0                 1
ENG PWR AVAIL, HP           13240.                               4500.
ENG RPM                     4800.0                              7000.0
ENG SFC, LBM/HP-HR           0.424                                .481
ENG LOAD FRAC                0.993                                .784
```

PRINTED REPORT NO. 2 - MACHINERY EQUIPMENT LIST

```
 NO                                  WEIGHT   LENGTH    WIDTH    HEIGHT
EACH        ITEM                      LTON      FT       FT        FT
---- ------------------------------ -------- -------- -------- --------
     PROPULSION PLANT
  4    MAIN ENGINE (BARE)                2.5    12.24     4.80     4.80
  4    MAIN ENGINE ENCLOSURE MODULE      6.7    22.32     8.30     7.60
  2    LTDR GEAR (01)                   42.1     9.16    14.99    12.37
  2    VSCF COMB/STEP-UP GEAR (04)        .2      .38     6.81     5.37
  2    THRUST BEARING                    5.7     3.02     4.22     4.22
  2    PROPELLER SHAFT

     ELECTRIC PLANT
  1    SS ENGINE (BARE)                   .6     7.20     2.80     2.80
  1    SS ENGINE ENCLOSURE MODULE        2.9    16.39     5.60     6.63
  1    SS REDUCTION GEAR (17)            1.2     4.85     2.45     4.03
  1    SEPARATE SS GENERATOR             9.1     8.59     3.60     5.10
  4    VSCF SS GENERATOR                 2.4     4.87     2.00     2.00
  2    VSCF SS CYCLOCONVERTER            7.1
```

PRINTED REPORT NO. 3 - ENGINES

```
                      MAIN ENG          SEC ENG      SS ENG
                  ---------------   ---------------    ---------------
ENG SELECT IND              GIVEN                                 CALC
ENG TYPE IND                   GT                                   GT
ENG MODEL IND         RR/DDA-SPEY                             GE-LM500
ENG SIZE IND                GIVEN                                GIVEN
NO INSTALLED                    4                 0                  1
ENG BARE WT, LTON             2.5                                   .6
ENG LENGTH, FT              12.24                                 7.20
ENG WIDTH, FT                4.80                                 2.80
ENG HEIGHT, FT               4.80                                 2.80
ENG PWR AVAIL, HP          13240.                               4500.0
ENG RPM                    4800.0                               7000.0
ENG MASS FL, LBM/SEC        106.4                                 31.3
ENG EXH TEMP, DEGF          830.0                               1013.0
ENG SFC EQN IND             OTHER                                OTHER
ENG SFC, LBM/HP-HR          0.424                                 .481

MAX SPEED CONDITION
-------------------
NO OPERATING                    4                 0                  0
ENG PWR, HP                13153.                                   .0
ENG RPM                    4800.0                               7000.0
ENG MASS FL, LBM/SEC        106.1                                   .0
ENG EXH TEMP, DEGF          828.5
ENG SFC, LBM/HP-HR           .425

SUSTN SPEED CONDITION
---------------------
NO OPERATING                    4                 0                  0
ENG PWR, HP                10736.                                   .0
ENG RPM                    4503.4                               7000.0
ENG MASS FL, LBM/SEC         98.2                                   .0
ENG EXH TEMP, DEGF          787.7
ENG SFC, LBM/HP-HR           .446

ENDUR SPEED CONDITION
---------------------
NO OPERATING                    2                 0                  0
ENG PWR, HP                 6101.                                   .0
ENG RPM                    2806.3                               7000.0
ENG MASS FL, LBM/SEC         79.0                                   .0
ENG EXH TEMP, DEGF          714.8
ENG SFC, LBM/HP-HR           .540

NOTE - ENGINE OPERATING DATA ARE BASED ON USE OF DFM FUEL.
```

PRINTED REPORT NO. 4 - GEARS

NO EACH	ITEM	WEIGHT LTON	LENGTH FT	WIDTH FT	HEIGHT FT
	2-STAGE REDUCTION GEARS				
2	LTDR GEAR (01)	42.1	9.16	14.99	12.37
2	VSCF COMB/STEP-UP GEAR (04)	.2	.38	6.81	5.37
1	SS REDUCTION GEAR (17)	1.2	4.85	2.45	4.03

REDUCTION GEAR DESIGN FACTORS AND DIMENSIONS	1ST STAGE	2ND STAGE	SS
REDUCTION RATIO	3.24	8.40	3.89
K FACTOR	100.0	120.0	175.0
FACE WIDTH RATIO	1.000	2.000	2.300
CASING WT FACTOR	.750	.750	3.000
GEAR FACE WIDTH, FT	1.16	2.43	1.12
PINION GEAR DIA, FT	1.16	1.22	.49
REDUCTION GEAR DIA, FT	3.76	10.22	1.89

PRINTED REPORT NO. 5 - ELECTRIC PROPULSION AND VSCF EQUIPMENT

MOTORS AND GENERATORS

	PRPLN GENERATOR	PRPLN MOTOR	VSCF GENERATOR
INSTALLED NUMBER	0	0	4
TYPE			AC
FREQUENCY CONTROL			
DRIVE			GEARED
ROTOR COOLING			LIQUID
ROTOR TIP SPEED, FT/MIN			24500.
STATOR COOLING			LIQUID
ARM ELECT LOAD, AMP/IN			2000.
POWER RATING, MW			2.00
ROTATIONAL SPEED, RPM			7650.
NUMBER OF POLES			12.
LENGTH, FT			4.9
WIDTH, FT			2.0
HEIGHT, FT			2.0
WEIGHT, LTON			2.4

OTHER ELECTRIC PROPULSION AND VSCF EQUIPMENT

	WEIGHT LTON
VSCF CYCLOCONVERTERS	14.2

PRINTED REPORT NO. 6 - SHIP SERVICE GENERATORS

```
ELECT LOAD DES MARGIN FAC    0.100
ELECT LOAD SL MARGIN FAC     0.200
ELECT LOAD IMBAL FAC         0.900
MAX MARG ELECT LOAD, KW     3360.8
MAX STANDBY LOAD, KW        1993.7
24 HR AVG ELECT LOAD, KW    1509.1

                         VSCF SS CYCLOCONVERTERS
                         =======================
                            NO        NO        REQ       AVAIL    LOADING
     CONDITION            INSTALL   ONLINE   KW/CYCLO  KW/CYCLO    FRAC
--------------------     --------  --------  --------  --------  --------

WINTER BATTLE                2         2        1479.     2000.     0.740
WINTER CRUISE                2         2        1680.     2000.     0.840
SUMMER CRUISE                2         2        1272.     2000.     0.636
ENDURANCE(24 HR AVG)         2         2         755.     2000.     0.377

                         SEPARATE SS GENERATORS
                         ======================
                            NO        NO        REQ       AVAIL    LOADING
     CONDITION            INSTALL   ONLINE    KW/GEN    KW/GEN     FRAC
--------------------     --------  --------  --------  --------  --------

WINTER BATTLE                1         0           .      2500.     0.000
WINTER CRUISE                1         0           .      2500.     0.000
SUMMER CRUISE                1         0           .      2500.     0.000
ENDURANCE(24 HR AVG)         1         0           .      2500.     0.000

                                 TOTALS
                         ======================
                                                REQ       AVAIL    LOADING
     CONDITION                                   KW        KW        FRAC
--------------------                          --------  --------  --------

WINTER BATTLE                                   2958.     4000.     0.740
WINTER CRUISE                                   3361.     4000.     0.840
SUMMER CRUISE                                   2545.     4000.     0.636
ENDURANCE(24 HR AVG)                            1509.     4000.     0.377
```

PRINTED REPORT NO. 7 - INTAKE DUCTS

```
INLET TYPE IND-PLENUM
DUCT SILENCING IND-BOTH
GT ENG ENCL IND-90 DBA

                         MAIN ENG   SEC ENG   SS ENG
                         --------  --------  --------
ENG TYPE                       GT                  GT
INLET DUCT XSECT AREA,FT2    78.2        .0      20.9
INLET DUCT XSECT LTH, FT     9.42        .0       6.5
INLET DUCT XSECT WID, FT     8.30        .0       3.2

                              MMR1
                              ====

                         ----MAIN ENG-----  -----SEC ENG-----
                          WT,LTON  VCG,FT    WT,LTON  VCG,FT
                         -------- --------  -------- --------
INLET                         0.7    51.65
INLET DUCTING                 1.4    39.05
INLET SILENCER                2.0    43.01
GT COOLING SUPPLY             1.4    32.09
GT BLEED AIR SUPPLY           3.1    27.97

                              MMR2
                              ====

                         ----MAIN ENG-----  -----SEC ENG-----
                          WT,LTON  VCG,FT    WT,LTON  VCG,FT
                         -------- --------  -------- --------
INLET                         0.7    32.39
INLET DUCTING                 0.7    27.52
INLET SILENCER                2.0    40.09
GT COOLING SUPPLY             0.7    23.12
GT BLEED AIR SUPPLY           3.1    20.80

NOTE - NUMERIC DATA PRESENTED ABOVE ARE ON A PER ENGINE BASIS.

            TRUNK AREA AND VOLUME REQUIREMENTS
            ===== ==== === ====== ============
                       -----AREA,FT2----  ---VOLUME,FT3----
  ENGINE CATEGORY         HULL     DKHS      HULL     DKHS
--------------------   -------- --------  -------- --------
MAIN ENGINES             383.6    383.6     3836.    3292.
SECONDARY ENGINES          0.0      0.0        0.       0.
SHIP-SERVICE ENGINES      60.2      0.0      550.       0.
                       -------- --------  -------- --------
               TOTALS    443.8    383.6     4386.    3292.
```

PRINTED REPORT NO. 8 - EXHAUST DUCTS

```
EXHAUST IR SUPPRESS IND-PRESENT
DUCT SILENCING IND-BOTH
GT ENG ENCL IND-90 DBA

EXHAUST STACK TEMP, DEGF    350.0
EDUCTOR DESIGN FAC          1.000

                           MAIN ENG   SEC ENG   SS ENG
                           --------  --------  --------
ENG TYPE                         GT                  GT
ENG EXH TEMP, DEG              829.                959.
ENG MASS FL, LBM/SEC          106.1                28.5
EXH DUCT GAS TEMP, DEG         743.                857.
EXH DUCT GAS DEN, LBM/FT3    0.0325               .0297
EXH DUCT MASS FL, LBM/SEC     121.3                32.5
EXH DUCT AREA, FT2             34.7                10.2

                                MMR1
                                ====

                           ----MAIN ENG-----  -----SEC ENG-----
                           WT,LTON  VCG,FT    WT,LTON  VCG,FT
                           -------- --------  -------- --------
EXH DUCT (TO BOILER/REG)
EXH BOILER (RACER)
EXH REGENERATOR
EXH DUCT (TO STACK)             5.6    38.56
EXH SILENCER                    6.3    48.19
EXH STACK                       1.9    61.95
EXH SPRAY RING                   .9    43.31
EXH EDUCTOR                     5.4    62.83

                                MMR2
                                ====

                           ----MAIN ENG-----  -----SEC ENG-----
                           WT,LTON  VCG,FT    WT,LTON  VCG,FT
                           -------- --------  -------- --------
EXH DUCT (TO BOILER/REG)
EXH BOILER (RACER)
EXH REGENERATOR
EXH DUCT (TO STACK)             2.7    28.09
EXH SILENCER                    6.3    45.27
EXH STACK                       1.9    42.69
EXH SPRAY RING                   .9    29.44
EXH EDUCTOR                     5.4    43.57

NOTE - NUMERIC DATA PRESENTED ABOVE ARE ON A PER ENGINE BASIS.

            TRUNK AREA AND VOLUME REQUIREMENTS
            ===== ==== === ====== ============
                        -----AREA,FT2----  ---VOLUME,FT3----
  ENGINE CATEGORY         HULL     DKHS      HULL     DKHS
--------------------  -------- --------  -------- --------
MAIN ENGINES             492.4    492.4     4924.    4226.
SECONDARY ENGINES          0.0      0.0        0.       0.
SHIP-SERVICE ENGINES     116.0      0.0     1061.       0.
                      -------- --------  -------- --------
              TOTALS     608.5    492.4     5985.    4226.
```

PRINTED REPORT NO. 9 - PROPELLERS AND SHAFTS

```
PROP TYPE IND-CP
PROP DIA, FT                 15.50
HUB DIA, FT                  4.72
PROP BLADE WT, LTON           7.6
PROP HUB WT, LTON            13.2
BEND STRESS CON FAC          1.700
OVRHG PROP MOM ARM RATIO     0.340
EQUIV FP PROP WT, LTON       16.5
ALLOW BEND STRESS, LBF/IN2  6000.
FATIGUE LIMIT, LBF/IN2     47500.
YIELD POINT, LBF/IN2       75000.
TORQUE MARGIN FAC            1.200
OFF-CENTER THRUST FAC        2.000
NO STRUTS PER SHAFT              1

                                  PORT SHAFT
                                  ==========
                            PROP    INTERMED    LINE
                           SECTION   SECTION   SECTION
                           --------  --------  --------
ANGLE, DEG                    3.58      3.58      3.58
LENGTH, FT                   13.18     82.01    127.21
DIAMETER, FT                  2.41      1.37      1.18
BORE RATIO                    .550      .667      .667
WEIGHT, LTON                  12.3      19.8      19.2
LCG, FT                     361.07    313.57    209.16
TCG, FT                     -11.63    -11.63    -11.63
VCG, FT                      -1.00      1.97      8.51
FACTOR OF SAFETY                        2.00      1.75

                                  STBD SHAFT
                                  ==========
                            PROP    INTERMED    LINE
                           SECTION   SECTION   SECTION
                           --------  --------  --------
ANGLE, DEG                    4.21      4.21      4.21
LENGTH, FT                   13.18     99.26     67.15
DIAMETER, FT                  2.41      1.37      1.18
BORE RATIO                    .550      .667      .667
WEIGHT, LTON                  12.3      24.0      10.1
LCG, FT                     361.07    305.01    222.02
TCG, FT                      11.63     11.63     11.63
VCG, FT                       -.90      3.23      9.33
FACTOR OF SAFETY                        2.00      1.75
```

PRINTED REPORT NO. 10 - STRUTS, PODS, AND RUDDERS

```
 PROP DIA, FT                15.50
 NO STRUTS PER SHAFT            1
 NO SHAFTS                      2
 OVRHG PROP MOM ARM RATIO    0.340

                               STRUTS
                               ======
                            MAIN    INTERMED
                            STRUT     STRUT
                          --------  --------
 WALL THICKNESS, FT            .22
 CHORD, FT                    2.92
 THICKNESS, FT                 .58
 BARREL LTH, FT              12.40
 BARREL DIA, FT               4.72


                              RUDDERS
                              =======
 RUDDER TYPE IND-SPADE
 RUDDER SIZE IND-GIVEN
 RUDDER WT (PER), LTON        17.0
 RUDDER DISP (PER), LTON       2.5

                          CHORD,FT  THICK,FT   SPAN,FT
                          --------  --------  --------
 SPADE RUDDER                 9.83      1.10     11.95
1
```

PRINTED REPORT NO. 11 - ELECTRIC LOADS

```
                                      WINTER    WINTER    SUMMER
                                      CRUISE    BATTLE    CRUISE
PAYLOAD LOADS                           KW        KW        KW
-------------                         --------  --------  --------
COMMAND AND SURVEILLANCE (60 HZ)       401.3     523.9     401.3
COMMAND AND SURVEILLANCE (400 HZ)        0.0       0.0       0.0
ARMAMENT (60 HZ)                        73.5     148.4      73.5
ARMAMENT (400 HZ)                        0.0       0.0       0.0
OTHER PAYLOAD (60 HZ)                    0.0       0.0       0.0
OTHER PAYLOAD (400 HZ)                   0.0       0.0       0.0

  SUB-TOTAL                            474.8     672.3     474.8

NON-PAYLOAD LOADS (* INDICATES USER ADJUSTED VALUE)
-----------------
PROPULSION AND STEERING                258.9     300.3     168.3
LIGHTING                               136.8     134.0     136.8
MISCELLANEOUS ELECTRIC                  46.1      40.1      46.1
HEATING                                717.9     366.1      35.9
VENTILATION                            292.8     225.4     292.8
AIR CONDITIONING                       283.2     266.2     422.6
AUXILIARY BOILER AND FRESH WATER       180.5     133.6     180.5
FIREMAIN                                66.6      93.9      66.6
UNREP AND HANDLING                      12.0       2.9      12.0
MISC AUXILIARY MACHINERY                52.5*     34.0*     52.5*
SERVICES AND WORK SPACES                67.2      22.2      67.2
  SUBTOTAL                            2114.4    1618.7    1481.2
  TOTAL                               2589.2    2291.0    1956.0
  TOTAL (INCLUDING MARGINS)           3360.8    2958.0    2544.9

MAX MARG ELECT LOAD                   3360.8
24 HR AVG ELECT LOAD                  1509.1
CONNECTED ELECT LOAD                  6861.5
ANCHOR ELECT LOAD                     1993.7
VITAL ELECT LOAD                      1423.5
EMERGENCY ELECT LOAD                   959.8
MAX STBY ELECT LOAD                   1993.7
```

PRINTED REPORT NO. 12 - POWERING

```
100 PCT POWER TRANS EFF     0.9781*
25 PCT POWER TRANS EFF      0.9643*
  * VALUES DO NOT INCLUDE CP PROP TRANSMISSION EFFICIENCY MULTIPLIER

                              MAX       SUSTN     ENDUR
                             SPEED      SPEED     SPEED
                            --------  --------  --------
SHIP SPEED, KT                26.49     25.26     16.00
PROP RPM                      176.6     165.7     103.2
NO OP PROP SHAFTS                 2         2         2
EHP (/SHAFT), HP             15391.    12387.     2913.
PROPULSIVE COEF               0.655     0.660     0.665
ENDUR PWR ALW                   1.0       1.0       1.1
SHP (/SHAFT), HP             23516.    18769.     4819.
TRANS EFFY                    0.978     0.976     0.964
CP PROP TRANS EFFY MULT       0.997     0.997     0.997
PROPUL PWR (/SHAFT), HP      24114.    19292.     5013.
PD GEN PWR (/SHAFT), HP       2192.     2181.     1088.
BHP (/SHAFT), HP             26306.    21472.     6101.
```

PRINTED REPORT NO. 13 - HULL STRUCTURE AND MISCELLANEOUS WEIGHT

```
SWBS          COMPONENT                         WT,LTON LCG,FT VCG,FT
====          =========                         ======= ====== ======
  160  SPECIAL STRUCTURES
    161  CASTINGS, FORGINGS, AND WELDMENTS         55.7 279.73   7.28
    162  STACKS AND MASTS                           7.6 163.10  52.32
  180  FOUNDATIONS
    182  PROPULSION PLANT FOUNDATIONS              91.2 169.67   9.16
    183  ELECTRIC PLANT FOUNDATIONS                32.6 198.72  20.34

          * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS
```

PRINTED REPORT NO. 14 - PROPULSION PLANT WEIGHT

```
SWBS          COMPONENT                         WT,LTON LCG,FT VCG,FT
====          =========                         ======= ====== ======
200  PROPULSION PLANT                             521.4 214.40  15.43
  210  ENERGY GENERATING SYSTEM (NUCLEAR)           0.0   0.00   0.00
  220  ENERGY GENERATING SYSTEM (NON-NUCLEAR)       0.0   0.00   0.00
  230  PROPULSION UNITS                            68.6 162.83  16.79
    233  PROPULSION INTERNAL COMBUSTION ENGINES     0.0   0.00   0.00
    234  PROPULSION GAS TURBINES                   68.6 162.83  16.79
    235  ELECTRIC PROPULSION                        0.0   0.00   0.00
  240  TRANSMISSION AND PROPULSOR SYSTEMS         264.3 255.39   6.38
    241  PROPULSION REDUCTION GEARS                84.5 162.60  13.30
    242  PROPULSION CLUTCHES AND COUPLINGS          0.0   0.00   0.00
    243  PROPULSION SHAFTING                       97.6 293.46   3.59
    244  PROPULSION SHAFT BEARINGS                 29.8 256.47   6.09
    245  PROPULSORS                                52.4 333.58   0.58
  250  PRPLN SUPPORT SYS (EXCEPT FUEL+LUBE OIL)   116.8 164.75  37.87
    251  COMBUSTION AIR SYSTEM                     31.2 159.41  32.26
    252  PROPULSION CONTROL SYSTEM                 12.9 162.83  23.72
    256  CIRCULATING AND COOLING SEA WATER SYSTEM   5.8 245.70  13.14
    259  UPTAKES (INNER CASING)                    66.8 160.59  45.37
  260  PRPLN SUPPORT SYS (FUEL+LUBE OIL)           36.1 156.91  12.53
    261  FUEL SERVICE SYSTEM                        9.4 143.33  10.79
    262  MAIN PROPULSION LUBE OIL SYSTEM           19.0 162.83  12.00
    264  LUBE OIL FILL, TRANSFER, AND PURIF         7.6 158.83  16.00
  290  SPECIAL PURPOSE SYSTEMS                     35.7 230.55   9.35
    298  OPERATING FLUIDS                          30.4 234.00   8.00
    299  REPAIR PARTS AND SPECIAL TOOLS             5.3 210.60  17.16

          * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS
```

PRINTED REPORT NO. 15 - ELECTRIC PLANT WEIGHT

```
SWBS            COMPONENT                          WT,LTON LCG,FT VCG,FT
====            =========                          ======= ====== ======
300  ELECTRIC PLANT                                  182.4 208.17  24.73
  310  ELECTRIC POWER GENERATION                      59.8 199.43  18.08
    311  SHIP SERVICE POWER GENERATION                59.8 199.43  18.08
    313  BATTERIES AND SERVICE FACILITIES              0.0   0.00   0.00
    314  POWER CONVERSION EQUIPMENT                    0.0   0.00   0.00
  320  POWER DISTRIBUTION SYSTEMS                     89.7 208.91  27.58
    321  SHIP SERVICE POWER CABLE                     64.3 206.70  27.00
    324  SWITCHGEAR AND PANELS                        25.4 214.50  29.03
  330  LIGHTING SYSTEM                                22.4 205.08  33.15
    331  LIGHTING DISTRIBUTION                        13.1 206.70  32.85
    332  LIGHTING FIXTURES                             9.3 202.80  33.58
  340  POWER GENERATION SUPPORT SYSTEMS                6.3 245.86  20.53
    342  DIESEL SUPPORT SYSTEMS                        0.0   0.00   0.00
    343  TURBINE SUPPORT SYSTEMS                       6.3 245.86  20.53
  390  SPECIAL PURPOSE SYSTEMS                         4.2 277.05  20.17
    398  OPERATING FLUIDS                              1.2 199.43  18.08
    399  REPAIR PARTS AND SPECIAL TOOLS                3.0 308.10  21.00

         * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS
```

PRINTED REPORT NO. 16 - MACHINERY ROOMS

```
NO MAIN MACHINERY ROOMS        2
NO AUX MACHINERY ROOMS         1
NO OTHER MACHINERY ROOMS       0

                         BULKHEAD LOCATIONS
                         ==================
MR  MR      ---------FWD BHD--------  ---------AFT BHD--------
NO  ID      BHD NO   X, FT    X/LBP   BHD NO   X, FT    X/LBP
-- -----    ------ -------- --------  ------ -------- --------
 1 MMR1        5.   112.55    0.289       6.   148.33    0.380
 2 MMR2        7.   177.58    0.455       8.   213.15    0.547
 3 AMR1        9.   242.40    0.622      10.   282.88    0.725

                              DIMENSIONS
                              ==========
MR  MR      ---LENGTH, FT----  ----WIDTH, FT----  ---HEIGHT, FT----
NO  ID       AVAIL     REQ      AVAIL     REQ      AVAIL     REQ
-- -----    -------- --------  -------- --------  -------- --------
 1 MMR1       35.78    35.78     52.20    43.10     28.95    23.49
 2 MMR2       35.57    35.57     55.15    43.10     26.88    22.83
 3 AMR1       40.48    40.48     54.88     6.35     17.50    17.50
```

PRINTED REPORT NO. 17 - MACHINERY ARRANGEMENTS

```
            CLEARANCES (MACHINERY TO MACHINERY)
            ===================================
ENG TO ENG CLR, FT            2.50
ENG TO GEAR CLR, FT           1.00
  OR ENG TO GEN CLR
  OR GEAR TO GEN CLR
MTR TO GEAR CLR, FT           2.50
PRPLN ARR TO SS ARR CLR, FT   6.00
AISLE WIDTH CLR, FT           2.50
PORT/CL TB TO GEAR CLR, FT   -3.02
STBD TB TO GEAR CLR, FT      -3.02

            SEPARATIONS (BETWEEN HULL AND MACHINERY)
            ========================================
LONG (TO BHD), FT             0.75
TRANS (TO SIDE SHELL), FT     0.75
VERT (TO HULL BOT), FT        0.75
RADIAL (TO POD), FT           0.75

                        ARRANGEMENTS
                        ============
                                             NO     NO ONLINE  NO ONLINE
      ARRANGEMENT               TYPE      INSTALLED MAX+SUSTN  ENDURANCE
-------------------------  ---------- --------- ---------  ---------
MECH PORT ARR IND             M2-LTDR         1         1          1
MECH STBD ARR IND           M2-LTDR/F         1         1          1
SHIP SERVICE ARR                   GT         1         0          0

            MACHINERY COMPONENT LOCATIONS
            =============================
                   --------CG LOC, FT--------
COMPONENT   MR ID     X        Y        Z
----------  -----  -------- -------- --------
MAIN ENG    MMR1    124.68   -17.02    18.25
MAIN ENG    MMR1    124.68    -6.22    18.25
MAIN ENG    MMR2    200.99    17.02    15.33
MAIN ENG    MMR2    200.99     6.22    15.33
SS ENG      AMR1    254.86     0.00    14.60

                        SHAFTING
                        ========
             ----END POINT LOC, FT-----
SHAFT TYPE      X        Y        Z     SHAFT ANGLE, DEG
----------  -------- -------- --------  ----------------
PORT SHAFT   145.68   -11.63    12.49        3.58
STBD SHAFT   188.54    11.63    11.80        4.21
```

PRINTED REPORT NO. 18 - MACHINERY SPACE REQUIREMENTS

```
           MACHINERY ROOM VOLUME REQUIREMENTS
           ========= ==== ====== ============
 VOLUME CATEGORY                                   VOLUME, FT3
 ---------------                                   -----------
SWBS GROUP 200                                     110148.
  PROPULSION POWER GENERATION                         41391.
    PROPULSION ENGINES                                   30487.
    PROPULSION REDUCTION GEARS AND GENERATORS            10905.
  DRIVELINE MACHINERY                                     0.
    REDUCTION AND BEVEL GEARS WITH Z-DRIVE                   0.
    ELECTRIC PROPULSION MOTORS AND GEARS                     0.
    REMOTELY-LOCATED THRUST BEARINGS                         0.
  PROPELLER SHAFT                                      9985.
  ELECTRIC PROPULSION MISCELLANEOUS EQUIPMENT             0.
    CONTROLS                                                 0.
    BRAKING RESISTORS                                        0.
    MOTOR AND GENERATOR EXCITERS                             0.
    SWITCHGEAR                                               0.
    POWER CONVERTERS                                         0.
    DEIONIZED COOLING WATER SYSTEMS                          0.
    RECTIFIERS                                               0.
    HELIUM REFRIGERATION SYSTEMS                             0.
  PROPULSION AUXILIARIES                              58771.
    PROPULSION LOCAL CONTROL CONSOLES                     3387.
    CP PROP HYDRAULIC OIL POWER MODULES                   2967.
    FUEL OIL PUMPS                                       31237.
    LUBE OIL PUMPS                                        3500.
    LUBE OIL PURIFIERS                                   14363.
    ENGINE LUBE OIL CONDITIONERS                          1127.
    SEAWATER COOLING PUMPS                                2190.

SWBS GROUP 300                                      24878.
  ELECTRIC PLANT POWER GENERATION                      5037.
    ELECTRIC PLANT ENGINES                                3342.
    ELECTRIC PLANT GENERATORS AND GEARS                   1695.
  SHIP SERVICE SWITCHBOARDS                           18649.
  CYCLOCONVERTERS                                      1191.

SWBS GROUP 500                                      34871.
  AUXILIARY MACHINERY                                 34871.
    AIR CONDITIONING PLANTS                               7316.
    AUXILIARY BOILERS                                     5066.
    FIRE PUMPS                                            3822.
    DISTILLING PLANTS                                    11984.
    AIR COMPRESSORS                                       4959.
    ROLL FIN PAIRS                                           0.
    SEWAGE PLANTS                                         1724.

           ARRANGEABLE AREA REQUIREMENTS
           =========== ==== ============
                                           ----------FT2----------
SSCS         GROUP NAME                     HULL/DKHS   DKHS ONLY
-----  ------------------------------      ----------  ----------
3.4X   AUXILIARY MACHINERY DELTA              5167.6         0.0
3.511  SHIP SERVICE POWER GENERATION             0.0         0.0
4.132  INTERNAL COMB ENG COMB AIR                0.0         0.0
4.133  INTERNAL COMB ENG EXHAUST                 0.0         0.0
4.142  GAS TURBINE ENG COMB AIR                443.8       383.6
4.143  GAS TURBINE ENG EXHAUST                 608.5       492.4

NOTE: * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS
```

PRINTED REPORT NO. 19 - SURFACE SHIP ENDURANCE CALCULATION FORM

```
DESIGN MODE IND-ENDURANCE
ENDUR DISP IND-AVG DISP
ENDUR DEF IND-USN
SHIP FUEL TYPE IND-JP-5
SHIP FUEL LHV, BTU/LBM      18300.
DFM FUEL LHV, BTU/LBM       18360.

(1)  ENDURANCE REQUIRED, NM                                  6000.
(2)  ENDURANCE SPEED, KT                                     16.00
(3)  FULL LOAD DISPLACEMENT, LTON                           5721.7
(3A) AVERAGE ENDURANCE DISPLACEMENT, LTON                   5459.4
(4)  RATED FULL POWER SHP, HP                               47032.
(5)  DESIGN ENDURANCE POWER SHP @ (2)&(3A), HP               8763.
(6)  AVERAGE ENDURANCE POWER (SHP), HP                       9639.
     (5) X 1.10
(7)  RATIO, AVG END SHP/RATED F.P. SHP                     0.20494
     (6)/(4)
(8)  AVERAGE ENDURANCE BHP, HP                              12202.
     (8A)+(8B)
(8A) AVERAGE PRPLN ENDURANCE BHP, HP                        10026.
     (6)/TRANSMISSION EFFICIENCY
(8B) SHIP SERV PWR SUPPLIED BY PRPLN ENG, HP                 2176.
(9)  24 HOUR AVERAGE ELECTRIC LOAD, KW                       1509.
(9A) 24 HOUR AVERAGE ELECTRIC LOAD PORTION
     SUPPLIED BY SS ENG, KW                                     0.
(10) CALCULATED PROPULSION FUEL RATE @(8), LBM/HP-HR         0.540
(11) CALC PRPLN FUEL CONSUMPTION, LBM/HR                    6583.6
     (10)X(8)
(12) CALC SS GEN FUEL RATE @ (9A), LBM/KW-HR                 0.000
(13) CALC SS GEN FUEL CONSUMPTION, LBM/HR                      0.0
     (12)X(9A)
(14) CALC FUEL CONSUMPTION FOR OTHER SERVICES, LBM/HR          0.0
(15) TOTAL CALC ALL-PURPOSE FUEL CONSUMPTION, LBM/HR        6583.6
     (11)+(13)+14)
(16) CALC ALL-PURPOSE FUEL RATE, LBM/HP-HR                   0.683
     (15)/(6)
(17) FUEL RATE CORRECTION FACTOR BASED ON (7)               1.0400
(18) SPECIFIED FUEL RATE, LBM/HP-HR                          0.710
     (16)X(17)
(19) AVG ENDURANCE FUEL RATE, LBM/HP-HR                      0.746
     (18)X1.05
(20) ENDURANCE FUEL (BURNABLE), LTON                         996.2 *
     (1)X(6)X(19)/(2)X2240
(21) TAILPIPE ALLOWANCE FACTOR                                0.95
(22) ENDURANCE FUEL LOAD, LTON                              1048.6
     (20)/(21)
```

PRINTED REPORT NO. 20 - MACHINERY MARGINS

```
PROPULSION PLANT
----------------
MAIN ENG MAX LOAD FRAC       0.993
TORQUE MARGIN FAC            1.200

ELECTRIC PLANT
--------------
SS ENG MAX LOAD FRAC         0.784
ELECT LOAD DES MARGIN FAC    0.100
ELECT LOAD SL MARGIN FAC     0.200
ELECT LOAD IMBAL FAC         0.900
MACHINERY MODULE               15.700 CPU SECONDS.
```

WEIGHT MODULE

```
PRINTED REPORT NO.  1 - SUMMARY

                       W E I G H T       LCG      VCG     RESULTANT ADJ
SWBS    G R O U P     LTON  PER CENT     FT       FT    WT-LTON  VCG-FT
====    =========    ====== ========   ======   =====  =======  ======
100  HULL STRUCTURE  1809.4    31.6    168.02   19.46     54.2     .39
200  PROP PLANT       521.4     9.1    214.40   15.43
300  ELECT PLANT      182.4     3.2    208.17   24.73
400  COMM + SURVEIL   354.8     6.2    148.20   24.01    145.6    1.13
500  AUX SYSTEMS      520.6     9.1    214.50   23.50     19.0     .10
600  OUTFIT + FURN    299.4     5.2    195.00   24.01
700  ARMAMENT         105.6     1.8    175.50   34.65    103.7     .63
M11  D+B WT MARGIN    474.2     8.3    183.19   20.92
                                                -----
     D+B KG MARGIN                          +    2.61
======================================================================
  L I G H T S H I P  4267.8    74.6    183.19   23.53    322.4    2.25
======================================================================
F00  FULL LOADS      1453.9    25.4    252.69    8.03    127.3     .61
F10  CREW + EFFECTS    22.4            183.30   27.86
F20  MISS REL EXPEN   100.3            171.60   32.32
F30  SHIPS STORES      27.4            210.60   20.90
F40  FUELS + LUBRIC  1275.4            262.81    5.56
F50  FRESH WATER       28.5                      5.25
F60  CARGO
M24  FUTURE GROWTH
======================================================================
  FULL LOAD WT       5721.8   100.0    200.85   19.59    449.7    2.87
======================================================================
```

PRINTED REPORT NO. 2 - HULL STRUCTURES WEIGHT

```
 SWBS         COMPONENT                          WT-LTON      VCG-FT
 ====         =========                        ============ ===========
*100  HULL STRUCTURES                         1809.4        19.46
*  110  SHELL + SUPPORTS                         674.2         15.47
     111  PLATING                                   330.8         19.88
     113  INNER BOTTOM                              135.4          3.07
     114  SHELL APPENDAGES                           13.2          6.50
     115  STANCHIONS                                  8.1         18.25
     116  LONGIT FRAMING                             59.4           .93
     117  TRANSV FRAMING                            102.4         18.11
   120  HULL STRUCTURAL BULKHDS                  209.0         16.47
     121  LONGIT STRUCTURAL BULKHDS                  80.7         10.28
     122  TRANSV STRUCTURAL BULKHDS                  97.9         20.37
     123  TRUNKS + ENCLOSURES                        30.4         20.37
     124  BULKHEADS, TORPEDO PROTECT SYS
   130  HULL DECKS                               253.7         33.16
     131  MAIN DECK                                 141.1         37.76
     132  2ND DECK                                  112.6         27.40
     133  3RD DECK
     134  4TH DECK
     135  5TH DECK+DECKS BELOW
     136  01 HULL DECK
     137  02 HULL DECK
     138  03 HULL DECK
     139  04 HULL DECK
   140  HULL PLATFORMS/FLATS                     121.6         14.39
     141  1ST PLATFORM                               71.9         17.46
     142  2ND PLATFORM                               49.7          9.95
     143  3RD PLATFORM
     144  4TH PLATFORM
     145  5TH PLAT+PLATS BELOW
     149  FLATS
   150  DECK HOUSE STRUCTURE                     114.1         47.88
   160  SPECIAL STRUCTURES                       213.5         11.85
     161  CASTINGS+FORGINGS+EQUIV WELDMT             55.7          7.28
     162  STACKS AND MACKS                            7.6         52.32
     163  SEA CHESTS                                  4.5          3.70
*    164  BALLISTIC PLATING                          29.2         31.90
     165  SONAR DOMES                                85.7         -1.50
     166  SPONSONS
     167  HULL STRUCTURAL CLOSURES                   24.2         26.65
     168  DKHS STRUCTURAL CLOSURES                    1.0         39.85
     169  SPECIAL PURPOSE CLOSURES+STRUCT             5.5         40.08
   170  MASTS+KINGPOSTS+SERV PLATFORM             -9.9         43.73
     171  MASTS,TOWERS,TETRAPODS                     -9.9         43.73
     172  KINGPOSTS AND SUPPORT FRAMES
     179  SERVICE PLATFORMS
   180  FOUNDATIONS                              215.4         16.42
     181  HULL STRUCTURE FOUNDATIONS
     182  PROPULSION PLANT FOUNDATIONS               91.2          9.16
     183  ELECTRIC PLANT FOUNDATIONS                 32.6         20.34
     184  COMMAND+SURVEILLANCE FDNS                  22.0         30.70
     185  AUXILIARY SYSTEMS FOUNDATIONS              52.1         17.54
     186  OUTFIT+FURNISHINGS FOUNDATIONS              9.5         23.71
     187  ARMAMENT FOUNDATIONS                        7.9         28.11
   190  SPECIAL PURPOSE SYSTEMS                   17.9          4.00
     191  BALLAST+BOUYANCY UNITS
     197  WELDING AND RIVETS
     198  FREE FLOODING LIQUIDS                      17.9          4.00

          * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS
```

PRINTED REPORT NO. 3 - PROPULSION PLANT WEIGHT

```
SWBS           COMPONENT                            WT-LTON        VCG-FT
====           =========                          ============  ============
200  PROPULSION PLANT                              521.4          15.43
  210  ENERGY GEN SYS (NUCLEAR)
  220  ENERGY GENERATING SYSTEM (NONNUC)
    221  PROPULSION BOILERS
    222  GAS GENERATORS
    223  MAIN PROPULSION BATTERIES
    224  MAIN PROPULSION FUEL CELLS
  230  PROPULSION UNITS                              68.6          16.79
    231  STEAM TURBINES
    232  STEAM ENGINES
    233  DIESEL ENGINES
    234  GAS TURBINES                                   68.6          16.79
    235  ELECTRIC PROPULSION
    236  SELF-CONTAINED PROPULSION SYS
    237  AUXILIARY PROPULSION DEVICES
  240  TRANSMISSION+PROPULSOR SYSTEMS               264.3           6.38
    241  REDUCTION GEARS                                84.5          13.30
    242  CLUTCHES + COUPLINGS
    243  SHAFTING                                       97.6           3.59
    244  SHAFT BEARINGS                                 29.8           6.09
    245  PROPULSORS                                     52.4            .58
    246  PROPULSOR SHROUDS AND DUCTS
    247  WATER JET PROPULSORS
  250  SUPPORT SYSTEMS                              116.8          37.87
    251  COMBUSTION AIR SYSTEM                          31.2          32.26
    252  PROPULSION CONTROL SYSTEM                      12.9          23.73
    253  MAIN STEAM PIPING SYSTEM
    254  CONDENSERS AND AIR EJECTORS
    255  FEED AND CONDENSATE SYSTEM
    256  CIRC + COOL SEA WATER SYSTEM                    5.8          13.14
    258  H.P. STEAM DRAIN SYSTEM
    259  UPTAKES (INNER CASING)                         66.8          45.37
  260  PROPUL SUP SYS- FUEL, LUBE OIL                36.1          12.53
    261  FUEL SERVICE SYSTEM                             9.4          10.79
    262  MAIN PROPULSION LUBE OIL SYSTEM                19.0          12.00
    264  LUBE OIL HANDLING                               7.6          16.00
  290  SPECIAL PURPOSE SYSTEMS                       35.7           9.35
    298  OPERATING FLUIDS                               30.4           8.00
    299  REPAIR PARTS + TOOLS                            5.3          17.16

           * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS
```

PRINTED REPORT NO. 4 - ELECTRIC PLANT WEIGHT

SWBS	COMPONENT	WT-LTON	VCG-FT
300	ELECTRIC PLANT, GENERAL	182.4	24.73
310	ELECTRIC POWER GENERATION	59.8	18.08
311	SHIP SERVICE POWER GENERATION	59.8	18.08
320	POWER DISTRIBUTION SYS	89.7	27.58
321	SHIP SERVICE POWER CABLE	64.3	27.00
324	SWITCHGEAR+PANELS	25.4	29.03
330	LIGHTING SYSTEM	22.4	33.15
331	LIGHTING DISTRIBUTION	13.1	32.85
332	LIGHTING FIXTURES	9.3	33.58
340	POWER GENERATION SUPPORT SYS	6.3	20.53
343	TURBINE SUPPORT SYS	6.3	20.53
390	SPECIAL PURPOSE SYS	4.2	20.17
398	ELECTRIC PLANT OP FLUIDS	1.2	18.08
399	REPAIR PARTS+SPECIAL TOOLS	3.0	21.00

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

PRINTED REPORT NO. 5 - COMMAND+SURVEILLANCE WEIGHT

	SWBS	COMPONENT	WT-LTON	VCG-FT
	400	COMMAND+SURVEILLANCE	354.8	24.01
*	410	COMMAND+CONTROL SYS	13.4	28.41
*	420	NAVIGATION SYS	14.8	43.95
	430	INTERIOR COMMUNICATIONS	23.7	25.62
*	440	EXTERIOR COMMUNICATIONS	26.4	38.40
	450	SURF SURV SYS (RADAR)	21.2	56.40
*	451	SURFACE SEARCH RADAR	1.9	65.82
*	452	AIR SEARCH RADAR	17.4	55.35
*	455	IDENTIFICATION SYSTEMS (IFF)	1.9	56.75
*	460	UNDERWATER SURVEILLANCE SYSTEMS	61.9	11.28
	470	COUNTERMEASURES	44.9	33.48
*	471	ACTIVE + ACTIVE/PASSIVE ECM	6.0	61.50
*	473	TORPEDO DECOYS	10.6	33.40
*	474	DECOYS (OTHER)	1.6	58.50
	475	DEGAUSSING	26.6	25.62
	476	MINE COUNTERMEASURES		
	480	FIRE CONTROL SYS	42.1	47.06
*	481	GUN FIRE CONTROL SYSTEMS	14.5	69.16
*	482	MISSILE FIRE CONTROL SYSTEMS	20.0	35.90
*	483	UNDERWATER FIRE CONTROL SYSTEMS	3.8	41.30
*	484	INTEGRATED FIRE CONTROL SYSTEMS	3.9	27.50
	489	WEAPON SYSTEM SWITCHBOARDS		
	490	SPECIAL PURPOSE SYS	106.4	4.55
*	491	ELCTRNC TEST,CHKOUT,MONITR EQPT	4.6	39.00
	492	FLIGHT CNTRL+INSTR LANDING SYS		
	493	NON-COMBAT DATA PROCESSING SYS		
	494	METEOROLOGICAL SYSTEMS		
*	495	SPEC PURPOSE INTELLIGENCE SYS	8.3	55.78
	498	C+S OPERATING FLUIDS	86.5	-3.90
	499	REPAIR PARTS+SPECIAL TOOLS	7.0	25.62

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

PRINTED REPORT NO. 6 - AUXILIARY SYSTEMS WEIGHT

	SWBS	COMPONENT	WT-LTON	VCG-FT
	500	AUXILIARY SYSTEMS, GENERAL	520.6	23.50
	510	CLIMATE CONTROL	131.0	24.97
	511	COMPARTMENT HEATING SYSTEM	6.8	24.76
	512	VENTILATION SYSTEM	47.2	32.39
	513	MACHINERY SPACE VENT SYSTEM	8.4	33.23
	514	AIR CONDITIONING SYSTEM	60.6	18.78
	516	REFRIGERATION SYSTEM	2.3	13.97
	517	AUX BOILERS+OTHER HEAT SOURCES	5.7	21.90
	520	SEA WATER SYSTEMS	94.8	21.38
	521	FIREMAIN+SEA WATER FLUSHING SYS	53.3	22.49
	522	SPRINKLING SYSTEM	3.5	25.28
	523	WASHDOWN SYSTEM	1.8	40.22
	524	AUXILIARY SEAWATER SYSTEM		
	526	SCUPPERS+DECK DRAINS	1.3	38.07
	527	FIREMAIN ACTUATED SERV, OTHER		
	528	PLUMBING DRAINAGE	13.3	25.38
*	529	DRAINAGE+BALLASTING SYSTEM	21.6	12.96
	530	FRESH WATER SYSTEMS	35.9	24.72
	531	DISTILLING PLANT	5.0	20.94
*	532	COOLING WATER	14.7	32.21
	533	POTABLE WATER	7.5	21.74
	534	AUX STEAM + DRAINS IN MACH BOX	8.7	16.75
	535	AUX STEAM + DRAINS OUT MACH BOX		
	536	AUXILIARY FRESH WATER COOLING		
	540	FUELS/LUBRICANTS,HANDLING+STORAGE	46.8	17.35
	541	SHIP FUEL+COMPENSATING SYSTEM	42.9	15.23
*	542	AVIATION+GENERAL PURPOSE FUELS	3.9	40.78
	543	AVIATION+GENERAL PURPOSE LUBO		
	544	LIQUID CARGO		
	545	TANK HEATING		
	549	SPEC FUEL+LUBRICANTS HANDL+STOW		
	550	AIR,GAS+MISC FLUID SYSTEM	34.5	24.93
	551	COMPRESSED AIR SYSTEMS	16.3	22.38
	552	COMPRESSED GASES		
	553	O2 N2 SYSTEM		
	554	LP BLOW		
	555	FIRE EXTINGUISHING SYSTEMS	18.3	27.19
	556	HYDRAULIC FLUID SYSTEM		
	557	LIQUID GASES, CARGO		
	558	SPECIAL PIPING SYSTEMS		
	560	SHIP CNTL SYS	50.2	10.47
	561	STEERING+DIVING CNTL SYS	16.3	20.94
	562	RUDDER	33.9	5.43
	565	TRIM+HEEL SYSTEMS		
	568	MANEUVERING SYSTEMS		
	570	UNDERWAY REPLENISHMENT SYSTEMS	17.9	34.94
	571	REPLENISHMENT-AT-SEA SYSTEMS	10.8	37.78
	572	SHIP STORES+EQUIP HANDLING SYS	7.1	30.63
	573	CARGO HANDLING SYSTEMS		
	574	VERTICAL REPLENISHMENT SYSTEMS		
	580	MECHANICAL HANDLING SYSTEMS	66.2	36.73
	581	ANCHOR HANDLING+STOWAGE SYSTEMS	29.6	29.50
	582	MOORING+TOWING SYSTEMS	7.7	36.10
	583	BOATS,HANDLING+STOWAGE SYSTEMS	18.2	51.39
	584	MECH OPER DOOR,GATE,RAMP,TTBL SYS		
	585	ELEVATING + RETRACTING GEAR		
	586	AIRCRAFT RECOVERY SUPPORT SYS		
	587	AIRCRAFT LAUNCH SUPPORT SYSTEM		
*	588	AIRCRAFT HANDLING,SERVICING,STOWAGE	10.7	32.18
	589	MISC MECH HANDLING SYSTEMS		
	590	SPECIAL PURPOSE SYSTEMS	43.2	18.33
	591	SCIENTIFIC+OCEAN ENGINEERING SYS		
	592	SWIMMER+DIVER SUPPORT+PROT SYS		
	593	ENVIRONMENTAL POLLUTION CNTL SYS	5.2	7.81
	594	SUBMARINE RESC+SALVG+SURVIVE SYS		
	595	TOW,LAUNCH,HANDLE UNDERWATER SYS		
	596	HANDLING SYS FOR DIVER+SUBMR VEH		
	597	SALVAGE SUPPORT SYSTEMS		
	598	AUX SYSTEMS OPERATING FLUIDS	35.4	19.76
	599	AUX SYSTEMS REPAIR PARTS+TOOLS	2.7	19.79

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

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PRINTED REPORT NO.  7 - OUTFIT+FURNISHINGS WEIGHT

SWBS          COMPONENT                          WT-LTON       VCG-FT
====          =========                       ============  ===========
600  OUTFIT+FURNISHING,GENERAL                 299.4         24.01
  610  SHIP FITTINGS                               15.0          42.76
    611  HULL FITTINGS                                6.1           34.96
    612  RAILS,STANCHIONS+LIFELINES                   7.1           45.68
    613  RIGGING+CANVAS                               1.8           57.86
  620  HULL COMPARTMENTATION                       77.9          21.26
    621  NON-STRUCTURAL BULKHEADS                    25.2           27.67
    622  FLOOR PLATES+GRATING                        40.2           15.23
    623  LADDERS                                      6.5           24.78
    624  NON-STRUCTURAL CLOSURES                      4.9           26.96
    625  AIRPORTS,FIXED PORTLIGHTS,WINDOWS            1.1           47.65
  630  PRESERVATIVES+COVERINGS                    107.8          22.47
    631  PAINTING                                    33.3           19.02
    632  ZINC COATING
    633  CATHODIC PROTECTION                          1.1            6.00
    634  DECK COVERINGS                              26.3           25.15
    635  HULL INSULATION                             32.8           29.37
    636  HULL DAMPING                                 6.7           -2.50
    637  SHEATHING                                    3.0           30.80
    638  REFRIGERATION SPACES                         4.6           18.08
    639  RADIATION SHIELDING
  640  LIVING SPACES                               26.7          25.49
    641  OFFICER BERTHING+MESSING                     7.8           33.67
    642  NON-COMM OFFICER B+M                         5.1           25.81
    643  ENLISTED PERSONNEL B+M                      10.3           19.94
    644  SANITARY SPACES+FIXTURES                     2.8           21.48
    645  LEISURE+COMMUNITY SPACES                      .8           28.98
  650  SERVICE SPACES                              15.1          26.12
    651  COMMISSARY SPACES                            6.6           28.61
    652  MEDICAL SPACES                               1.5           25.74
    653  DENTAL SPACES
    654  UTILITY SPACES                                .6           28.98
    655  LAUNDRY SPACES                               3.4           23.90
    656  TRASH DISPOSAL SPACES                        3.0           22.70
  660  WORKING SPACES                              28.2          27.43
    661  OFFICES                                      5.4           25.85
    662  MACH CNTL CENTER FURNISHING                  1.3           20.46
    663  ELECT CNTL CENTER FURNISHING                 6.9           36.46
    664  DAMAGE CNTL STATIONS                         3.7           31.43
    665  WORKSHOPS,LABS,TEST AREAS                   10.8           21.96
  670  STOWAGE SPACES                              26.5          21.48
    671  LOCKERS+SPECIAL STOWAGE                      8.1           27.72
    672  STOREROOMS+ISSUE ROOMS                      18.4           18.74
    673  CARGO STOWAGE
  690  SPECIAL PURPOSE SYSTEMS                      2.2          23.53
    698  OPERATING FLUIDS                              .2           27.19
    699  REPAIR PARTS+SPECIAL TOOLS                   2.0           23.17

          * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS
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PRINTED REPORT NO. 8 - ARMAMENT WEIGHT

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 SWBS          COMPONENT                      WT-LTON        VCG-FT
 ====          =========                   =============  ============
 700  ARMAMENT                               105.6        34.65
*  710  GUNS+AMMUNITION                          53.5        34.74
     711  GUNS
     712  AMMUNITION HANDLING
     713  AMMUNITION STOWAGE
*  720  MISSLES+ROCKETS                          35.3        34.23
*    721  LAUNCHING DEVICES                        20.7         26.61
*    722  MISSILE,ROCKET,GUID CAP HANDL SYS         1.0         31.78
     723  MISSILE+ROCKET STOWAGE
     724  MISSILE HYDRAULICS
     725  MISSILE GAS
     726  MISSILE COMPENSATING
     727  MISSILE LAUNCHER CONTROL
     728  MISSILE HEAT,COOL,TEMP CNTRL
     729  MISSILE MONITOR,TEST,ALINEMENT
   730  MINES
     731  MINE LAUNCHING DEVICES
     732  MINE HANDLING
     733  MINE STOWAGE
*  740  DEPTH CHARGES                             5.0        39.40
     741  DEPTH CHARGE LAUNCHING DEVICES
     742  DEPTH CHARGE HANDLING
     743  DEPTH CHARGE STOWAGE
*  750  TORPEDOES                                 2.7        38.78
     751  TORPEDO TUBES
     752  TORPEDO HANDLING
     753  TORPEDO STOWAGE
*  760  SMALL ARMS+PYROTECHNICS                   7.7        30.94
     761  SMALL ARMS+PYRO LAUNCHING DEV             1.0         33.22
     762  SMALL ARMS+PYRO HANDLING
     763  SMALL ARMS+PYRO STOWAGE                    .9         33.22
   770  CARGO MUNITIONS
     772  CARGO MUNITIONS HANDLING
     773  CARGO MUNITIONS STOWAGE
*  780  AIRCRAFT RELATED WEAPONS                  1.4        37.78
     782  AIRCRAFT RELATED WEAPONS HANDL
     783  AIRCRAFT RELATED WEAPONS STOW
   790  SPECIAL PURPOSE SYSTEMS
     792  SPECIAL WEAPONS HANDLING
     793  SPECIAL WEAPONS STOWAGE
     797  MISC ORDINANCE SPACES
     798  ARMAMENT OPERATING FLUIDS
     799  ARMAMENT REPAIR PART+TOOLS

           * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS
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PRINTED REPORT NO. 9 - LOADS WEIGHT (FULL LOAD CONDITION)

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 SWBS         COMPONENT                           WT-LTON      VCG-FT
 ====         =========                         ============ ============
 F00  LOADS                                     1453.9         8.03
   F10  SHIPS FORCE                                22.4          27.86
     F11  OFFICERS                                    3.8           27.86
     F12  NON-COMMISSIONED OFFICERS                   3.5           27.86
     F13  ENLISTED MEN                               15.1           27.86
     F14  MARINES
     F15  TROOPS
     F16  AIR WING PERSONNEL
     F19  OTHER PERSONNEL
   F20  MISSION RELATED EXPENDABLES+SYS           100.3          32.32
*    F21  SHIP AMMUNITION                            93.9           31.78
     F22  ORD DEL SYS AMMO
*    F23  ORD DEL SYS (AIRCRAFT)                      6.4           40.28
     F24  ORD REPAIR PARTS (SHIP)
     F25  ORD REPAIR PARTS (ORD)
     F26  ORD DEL SYS SUPPORT EQUIP
     F29  SPECIAL MISSION RELATED SYS
   F30  STORES                                     27.4          20.90
     F31  PROVISIONS+PERSONNEL STORES                22.4           20.40
     F32  GENERAL STORES                              5.0           23.11
     F33  MARINES STORES (SHIPS COMPLEM)
     F39  SPECIAL STORES
   F40  LIQUIDS, PETROLEUM BASED                 1275.4           5.56
     F41  DIESEL FUEL MARINE                       1048.6            5.01
*    F42  JP-5                                       27.0           10.00
     F43  GASOLINE
     F44  DISTILLATE FUEL
     F45  NAVY STANDARD FUEL OIL (NSFO)
*    F46  LUBRICATING OIL                           199.7            7.81
     F49  SPECIAL FUELS AND LUBRICANTS
   F50  LIQUIDS, NON-PETRO BASED                   28.5           5.25
     F51  SEA WATER
     F52  FRESH WATER                                28.5            5.25
     F53  RESERVE FEED WATER
     F54  HYDRAULIC FLUID
     F55  SANITARY TANK LIQUID
     F56  GAS (NON FUEL TYPE)
     F59  MISC LIQUIDS, NON-PETROLEUM
   F60  CARGO
     F61  CARGO, ORDINANCE + DELIVERY SYS
     F62  CARGO, STORES
     F63  CARGO, FUELS + LUBRICANTS
     F64  CARGO, LIQUIDS, NON-PETROLEUM
     F65  CARGO, CRYOGENIC+LIQUEFIED GAS
     F66  CARGO, AMPHIBIOUS ASSAULT SYS
     F67  CARGO, GASES
     F69  CARGO, MISCELLANEOUS
   M24  FUTURE GROWTH MARGIN

          * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS
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SPACE MODULE

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PRINTED REPORT NO.  1 - SUMMARY

COLL PROTECT SYS-PARTIAL SONAR DOME-PRESENT    UNIT COMMANDER-NONE

FULL LOAD WT, LTON          5721.8     HAB STANDARD FAC              0.000
TOTAL CREW ACC               192.      PASSWAY MARGIN FAC            0.000
HULL AVG DECK HT, FT         9.95      AC MARGIN FAC                 0.000
MR VOLUME, FT3             118500.     SPACE MARGIN FAC              0.000
                                  AREA FT2                    VOL FT3
                          PAYLOAD   TOTAL     TOTAL          TOTAL
                          REQUIRED  REQUIRED  AVAILABLE      ACTUAL
                          --------  --------  ---------      --------
DKHS ONLY                  3858.0    7744.3    7828.9         67164.
HULL OR DKHS               7081.3   41663.0   42299.5        598974.
                          --------  --------  ---------      --------
TOTAL                     10939.3   49407.3   50128.4        666138.

                                 TOTAL     DKHS     PERCENT
SSCS     GROUP                 AREA FT2  AREA FT2  TOTAL AREA
-------------                  --------  --------  ----------
 1. MISSION SUPPORT            12296.5    4542.6     24.9
 2. HUMAN SUPPORT              10978.3     384.4     22.2
 3. SHIP SUPPORT               23264.3    1941.3     47.1
 4. SHIP MOBILITY SYSTEM        2868.2     876.0      5.8
 5. UNASSIGNED                                        0.0
                               --------  --------  ----------
                 TOTAL         49407.3    7744.3    100.0
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PRINTED REPORT NO. 2 - MISSION SUPPORT AREA

```
                                             TOTAL            DKHS
 SSCS           GROUP                      AREA FT2         AREA FT2
 ---------------------                 ---------------- ----------------
 1.    MISSION SUPPORT                  12296.5          4542.6
 1.1     COMMAND,COMMUNICATION+SURV        6888.7          1131.9
 1.11      EXTERIOR COMMUNICATIONS            150.0
*1.111       RADIO                              150.0
 1.112       UNDERWATER SYSTEMS
 1.12      SURVEILLANCE SYS                  2611.0           291.0
*1.121       SURFACE SURV (RADAR)               669.0           291.0
 1.122       UNDERWATER SURV (SONAR)           1942.0
 1.13      COMMAND+CONTROL                   2501.9           671.9
*1.131       COMBAT INFO CENTER                1830.0
 1.132       CONNING STATIONS                   671.9           671.9
 1.1321        PILOT HOUSE                        591.9           591.9
 1.1322        CHART ROOM                          80.0            80.0
 1.14      COUNTERMEASURES                   1134.0           169.0
*1.141       ELECTRONIC                         570.0           169.0
*1.142       TORPEDO                            564.0
 1.143       MISSILE
 1.15      INTERIOR COMMUNICATIONS            459.6
 1.16      ENVIRONMENTAL CNTL SUP SYS          32.2
 1.2     WEAPONS                           3145.3          1698.0
*1.21      GUNS                              2152.0          1162.0
*1.22      MISSILES                           993.3           536.0
 1.23      ROCKETS
 1.24      TORPEDOS
 1.25      DEPTH CHARGES
 1.26      MINES
 1.27      SPECIAL WEAPONS
 1.3     AVIATION                          1866.0          1700.0
*1.31      AVIATION LAUNCHING+RECOVERY         10.0
 1.311       LAUNCHING+RECOVERY AREAS
 1.312       LAUNCHING+RECOVERY EQUIP
 1.33      AIRCRAFT HANDLING
*1.34      AIRCRAFT STOWAGE                  1700.0          1700.0
 1.36      AVIATION MAINTENANCE
*1.37      AVIATION ORDNANCE                  156.0
 1.372       CONTROL
 1.373       HANDLING
 1.374       STOWAGE
 1.38      AVIATION FUEL SYS
 1.39      AVIATION STORES
 1.6     INTERMEDIATE MAINT FAC
 1.641       STOWAGE-WEAPONS
 1.7     FLAG FACILITIES
 1.73      HANDLING
 1.74      STOWAGE
 1.8     SPECIAL MISSIONS
*1.9     SM ARMS,PYRO+SALU BAT              396.5            12.7
 1.911       SM ARMS (LOCKER)                    55.3
 1.921       PYROTECHNICS (LOCKER)               12.7            12.7
 1.932       SALUTING BAT (MAGAZINE)             18.7
 1.95      LANDING FORCE EQUIP                106.9

           * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS
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PRINTED REPORT NO. 3 - HUMAN SUPPORT AREA

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                                            TOTAL          DKHS
SSCS           GROUP                      AREA FT2         AREA FT2
--------------------                  ---------------- ----------------
2.    HUMAN SUPPORT                    10978.3          384.4
2.1     LIVING                            6347.5           340.0
2.11      OFFICER LIVING                    1821.0           340.0
2.111       BERTHING                          1596.0           260.0
2.1111        SHIP OFFICER                      1596.0           260.0
2.1115        FLAG OFFICER
2.112       SANITARY                           225.0            80.0
2.1121        SHIP OFFICER                       225.0            80.0
2.1125        FLAG OFFICER
2.12      CPO LIVING                         930.0
2.121       BERTHING                           744.0
2.122       SANITARY                           186.0
2.13      CREW LIVING                       3425.1
2.131       BERTHING                          2940.0
2.132       SANITARY                           485.1
2.1332      RECREATION (LIBRARY)
2.14      GENERAL SANITARY FACILITIES        110.0
2.141       LADIES RETIRING RM                  80.0
2.142       BRIDGE WASHROOM+WC                  15.0
2.143       DECK WASHROOM+WC                    15.0
2.15      SHIP RECREATION FAC                 61.4
2.152       MOTION PIC FILM+EQUIP               38.4
2.153       PHYSICAL FITNESS                    23.0
2.154       BAND EQUIP RM
2.2     COMMISSARY                        3154.4
2.21      FOOD SERVICE                      1935.8
2.211       OFFICER (MESS+LOUNGE)              582.1
2.212       CPO (MESS+LOUNGE)                  535.6
2.213       CREW (MESS+LOUNGE)                 818.1
2.22      COMMISSARY SERVICE SPACES          788.2
2.23      FOOD STORAGE+ISSUE                 430.5
2.231       CHILL PROVISIONS                   158.1
2.232       FROZEN PROVISIONS                   57.2
2.233       DRY PROVISIONS                     215.1
2.234       ISSUE
2.3     MEDICAL+DENTAL (MEDICAL)           300.0
2.4     GENERAL SERVICES                   686.7
2.41      SHIP STORE SPACES                  246.6
2.411       SHIP STORE                         106.0
2.412       CLOTHING+SM STORES ISSUE            17.0
2.415       SHIP STORE STORES                  123.6
2.42      LAUNDRY FACILITIES                 293.8
2.43      DRY CLEANING+TAILOR SHOP
2.44      BARBER SERVICE                      80.0
2.46      POSTAL SERVICE                      54.4
2.47      BRIG
2.48      RELIGIOUS                           12.0
2.5     PERSONNEL STORES                   171.4            44.4
2.51      BAGGAGE                             35.0
2.52      WARDROOM STOREROOM                  14.4            14.4
2.53      CPO STORE ROOM                      12.0
2.54      COMMANDING OFFICER STRM             40.0
2.55      FOUL WEATHER GEAR (LOCKER)          30.0            30.0
2.57      FOLDING CHAIR STOREROOM             40.0
2.6     CBR PROTECTION                     138.4
2.7     LIFESAVING (LIFEJACKETS)            20.0
2.9     POLLUTION CNTL SYS (SEWAGE)        159.9

          * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS
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PRINTED REPORT NO. 4 - SHIP SUPPORT AREA

SSCS	GROUP	TOTAL AREA FT2	DKHS AREA FT2
3.	SHIP SUPPORT	23264.3	1941.3
3.1	SHIP CNTL SYS(STEERING+DIVING)	619.7	
3.2	DAMAGE CNTL	473.8	
3.21	DAMAGE CNTL CENTRAL		
3.22	REPAIR STATIONS	243.1	
3.25	FIRE FIGHTING	230.7	
3.3	SHIP ADMINISTRATION	1299.0	
3.4	AUXILIARY MACHINERY	7852.9	789.5
3.41	ENGINEERING AUX	2073.3	789.5
3.411	A/C+REFRIGERATION	1640.2	789.5
3.4111	A/C (INC VENT)	1542.0	789.5
3.4112	REFRIGERATION	98.2	
3.417	PUMP+COMPRESSOR RM	433.1	
3.42	DECK AUXILIARIES	612.0	
3.421	ANCHOR HANDLING	378.9	
3.422	LINE HANDLING	233.1	
3.4X	AUXILIARY MACHINERY DELTA	5167.6	
3.5	ELECTRICAL	127.9	
3.51	POWER GENERATION		
3.511	SHIP SERVICE POWER GEN		
3.512	EMERGENCY GENERATORS		
3.514	400 HERTZ		
3.52	PWR DIST+CNTL	2.9	
3.54	DEGAUSSING	125.0	
3.6	SHIP MAINTENANCE	1438.9	
3.61	ENGINEERING DEPT	816.3	
3.611	AUX (FILTER CLEANING)	90.0	
3.612	ELECTRICAL	133.2	
3.613	MECH (GENERAL WK SHOP)	533.1	
3.614	TEST LAB	60.0	
3.615	NUCLEONICS		
3.62	OPERATIONS DEPT (ELECT SHOP)	472.7	
3.63	WEAPONS DEPT (ORDNANCE SHOP)	79.9	
3.64	DECK DEPT (CARPENTER SHOP)	70.0	
3.7	STOREROOMS+ISSUE RMS	3540.0	354.0
3.71	SUPPY DEPT	1780.7	
3.711	HAZARDOUS MATL (FLAM LIQ)	133.2	
3.712	SPECIAL CLOTHING	72.5	
3.713	GEN USE CONSUM+REPAIR PART	1166.4	
3.714	HANDLING(STORE CONV TRUNK)	408.5	
3.72	ENGINEERING DEPT	333.1	
3.73	OPERATIONS DEPT	519.3	46.6
3.74	DECK DEPT (BOATSWAIN STORES)	906.9	307.4
3.8	ACCESS (INTERIOR-NORMAL)	7912.2	797.7

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

PRINTED REPORT NO. 5 - SHIP MOBILITY SYSTEM AREA

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                                                   TOTAL          DKHS
SSCS           GROUP                              AREA FT2       AREA FT2
--------------------                           --------------- ---------------
4.     SHIP MOBILITY SYSTEM                      2868.2          876.0
4.1      PROPULSION SYSTEM                         2868.2          876.0
4.11       STEAM (CONVENTIONAL)
4.112-3      COMBUSTION AIR-EXHAUST
4.114        CONTROL
4.12       STEAM (NUCLEAR)
4.122-3      COMBUSTION AIR-EXHAUST
4.124        CONTROL
4.13       DIESEL
4.132        COMBUSTION AIR
4.133        EXHAUST
4.134        CONTROL
4.14       GAS TURBINE                               2868.2          876.0
4.142        COMBUSTION AIR                             827.3          383.6
4.143        EXHAUST                                   1100.9          492.4
4.144        CONTROL                                    940.0
4.3      FUEL-NUCLEAR (CORE REMOVAL)

           * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS
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PRINTED REPORT NO. 6 - REQUIRED TANKAGE

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POLLUTION CNTRL IND-PRESENT

    ENDURANCE FUEL, FT3       46244.
    AVIATION FUEL, FT3         1191.
    FRESH WATER, FT3           1028.
    SEWAGE, FT3                 385.
    WASTE OIL WATER, FT3        925.
    CLEAN BALLAST, FT3        12763.
                             --------
    TANKAGE VOL REQ, FT3      62536.
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DESIGN SUMMARY

PRINTED REPORT NO. 1 - SUMMARY

```
 PRINCIPAL CHARACTERISTICS - FT          WEIGHT SUMMARY - LTON
LBP                         390.0    GROUP 1 - HULL STRUCTURE   1809.4
LOA                         409.3    GROUP 2 - PROP PLANT        521.4
BEAM, DWL                    55.0    GROUP 3 - ELECT PLANT       182.4
BEAM, WEATHER DECK           60.3    GROUP 4 - COMM + SURVEIL    354.8
DEPTH @ STA 10               36.5    GROUP 5 - AUX SYSTEMS       520.6
DRAFT TO KEEL DWL            15.0    GROUP 6 - OUTFIT + FURN     299.4
DRAFT TO KEEL LWL            15.0    GROUP 7 - ARMAMENT          105.6
FREEBOARD @ STA 3            30.5    ---------------------------------
GMT                           5.5    SUM GROUPS 1-7             3793.6
CP                          0.650    DESIGN MARGIN               474.2
CX                          0.919    ---------------------------------
                                     LIGHTSHIP WEIGHT           4267.8
SPEED(KT):  MAX= 26.5  SUST= 25.3    LOADS                      1453.9
ENDURANCE:  4950.0 NM AT 16.0 KTS    ---------------------------------
                                     FULL LOAD DISPLACEMENT     5721.8
TRANSMISSION TYPE:           MECH    FULL LOAD KG:  FT            19.6
MAIN ENG: 4 GT        @ 13240.0 HP
                                     MILITARY PAYLOAD WT - LTON  639.0
SHAFT POWER/SHAFT:      23516.1 HP   USABLE FUEL WT - LTON       996.2
PROPELLERS: 2 - CP  - 15.5 FT DIA
                                          AREA SUMMARY - FT2
SEP GEN:  1 GT        @  2500.0 KW   HULL AREA             -   42299.5
PD GEN:   2 V5CF      @  2000.0 KW   SUPERSTRUCTURE AREA   -    7828.9
                                     ---------------------------------
24 HR LOAD                  1509.1   TOTAL AREA                50128.4
MAX MARG ELECT LOAD         3360.8
                                          VOLUME SUMMARY  - FT3
          OFF  CPO  ENL      TOTAL   HULL VOLUME           -  598974.2
MANNING    21   24  147        192   SUPERSTRUCTURE VOLUME -   67163.6
ACCOM      21   24  147        192   ---------------------------------
                                     TOTAL VOLUME             666137.8
```

PRINTED REPORT NO. 2 - MANNING AND ACCOMMODATION SUMMARY

```
               SHIPS   AIR   FLAG STAFF   TOTAL     TOTAL
               CREW   DETACH   /OTHER    MANNING  ACCOMMODATION
-----------------------------------------------------------------
OFFICERS        17.      4.       0.        21.       21.
CPO             23.      1.       0.        24.       24.
OEM            135.     12.       0.       147.      147.
-----------------------------------------------------------------
TOTAL          175.     17.       0.       192.      192.
```

PAYLOAD AND ADJUSTMENTS

ROW	PAYLOAD AND ADJUSTMENT NAME
1	RDS CIC
2	COOLING EQUIPMENT ROOM
3	RDS RADIO COMMS
4	TACAN
5	SESS
6	SATCOM
7	SPS-67 SURFACE SEARCH RADAR
8	SPS-64 SURFACE SEARCH/NAV RADAR
9	SPS-49 AIR SEARCH RADAR
10	MK 92 MFCS
11	MK 92 MFCS
12	IFF
13	RDS1 NAV SYSTEM
14	SQQ-28 LAMPS MK III ELEC
15	SLQ-32(V)3 ACTIVE/PASSIVE ECM+COOLING EQUIP RM
16	SLQ-32(V)3 MK 36 DLS W/ 4 LAUNCHERS
17	MK 36 DLS SRBOC CANNISTERS-100RDS
18	AN/SLR-24 SSTD--1XTOWED DECOY+2XCM LAUNCHERS
19	MOD(X) COUNTERMEASURES--24RNDS
20	MK86 5" GFCS W/SPQ-9
21	TOMAHAWK WEAPON CONTROL SYSTEM
22	MK116 UFCS
23	MK(X) INTEGRATED FCS
24	2X MK16 20MM CIWS [VULCAN-PHALANX]+WORKSHOPS
25	MK16 CIWS WCS
26	MK16 20MM CIWS AMMO--1600RDS
27	2X EX-35 SEA VULCAN 25MM MOUNT W/ STINGER
28	25MM AMMO 2000RDS + 4X STINGER MISSILES
29	1X MK45 5 IN/54 GUN [HAND SO]
30	MK45 5 IN AMMO - 600 RDS
31	MK45 5 IN/54 GUN HY-80 ARMOR LEVEL II
32	2X MK31 RAM PDMS
33	RIM-116 ROLLING AIRFRAME MISSILES -- 42 RDS
34	2X HARPOON SSM QUAD HCLS [LVL II HARDENED]
35	AN/SWG-1 HARPOON LAUNCH CONTROL SYS IN CIC
36	HARPOON MISSILES 8 RDS
37	MK41 VLS 29-CELL W/3 THAWK,23 SM-1/2,3 VLASROC
38	MISSILES 3 TOMAHAWK + 23 SM-1/2 + 3 VLASROC
39	VLS WEAPON CONTROL SYSTEM
40	VLS WEAPON HANDLING
41	29 CELL ARMOR LEVEL III HY-80
42	29 CELL MAGAZINE DEWATERING SYSTEM
43	2X MK32 SVTT ON DECK
44	MK50 TORPEDO -- 6 RDS
45	SMALL ARMS AND PYRO STORAGE
46	SMALL ARMS AMMO 7.62MM + PYRO
47	1X LAMPS MK III HELOS + HANGER
48	HELO REARM AND MAGAZINE
49	HELO FUEL JP-5
50	HIFR
51	RAST SYSTEM
52	UUV --STORAGE AND HANDLING
53	1X UUV
54	MORTAR SYSTEM -- LAUNCHER
55	DEPTH CHARGES - 50 RDS
56	FURUNO RADAR
57	MK23 TAS
58	AN/SAR-8
59	SRS-1 COMBAT DF
60	OPERATIONAL READINESS AND TEST SYSTEM
61	DOUBLE HULL CORRECTION (FOR FUEL)
62	HELO DECK CORRECTION
63	DOUBLE HULL CORRECTION (INSULATION-LOST SPACE)

ROW	WT KEY	WT ADD	WT FAC LTON	VCG KEY
1	W410	13.38	D6.5	-10.00
2	W532	4.00	D10	-20.00
3	W440	15.00	D3	-3.50
4	W440	2.44	MAST	-26.00
5	W495	2.68	D10	6.00
6	W440	9.00	D10	5.00
7	W451	1.75	D10	30.00
8	W451	.13	MAST	1.00
9	W452	9.00	D6.5	10.00
10	W482	6.29	MAST	-1.40
11	W482	6.29	D15	-10.00
12	W455	1.94	MAST	1.10
13	W420	6.53	MAST	-16.00
14	W460	3.46	D10	3.00
15	W471	6.03	D10	25.00
16	W474	1.63	D10	22.00
17	WF21	2.20	D10	22.00
18	W473	10.63	D20	-4.00
19	WF21	5.00	D20	4.00
20	W481	13.50	D10	34.00
21	W482	5.61	D10	-7.80
22	W483	3.80	D10	4.80
23	W484	3.85	D10	-9.00
24	W710	13.20	D10	21.00
25	W481	1.00	D10	14.50
26	WF21	8.39	D10	20.00
27	W710	3.50	D10	12.00
28	WF21	1.37	D10	9.00
29	W710	36.80	D3	-16.20
30	WF21	33.10	D3	-28.40
31	W164	20.20	D3	-8.00
32	W720	8.20	D10	14.00
33	WF21	3.86	D10	14.00
34	W720	5.40	D10	2.70
35	W482	1.10	D10	-5.80
36	WF21	15.80	D10	6.20
37	W721	20.70	D6.5	-11.80
38	WF21	11.00	D6.5	-9.20
39	W482	.70	D15	-7.80
40	W722	1.00	D15	-4.00
41	W164	9.00	D6.5	-10.00
42	W529	.40	D6.5	-10.80
43	W750	2.70	D15	3.00
44	WF21	2.10	D15	3.00
45	W760	5.85	D10	-6.30
46	WF21	4.10	D10	-6.00
47	WF23	6.35	D15	4.50
48	W780	1.35	D15	2.00
49	WF42	27.00	BL	10.00
50	W542	3.90	D15	5.00
51	W588	9.46	D15	-4.00
52	W588	1.20	D20	-2.00
53	W460	.70	D20	-2.00
54	W740	5.00	D20	2.00
55	WF21	7.00	D20	3.00
56	W420	.50	MAST	-9.00
57	W452	5.50	D10	29.00
58	W452	2.90	MAST	2.00
59	W495	5.63	D10	25.60
60	W491	4.60	D10	2.50
61	WF46	189.00	BL	7.50
62	W110	25.00	D15	16.00
63	W100	.00	BL	20.00

ROW	AREA KEY	---AREA ADD, FT2--	
		HULL/SS	SS/ONLY
1	A1131	1830.00	.00
2	NONE	.00	.00
3	A1111	150.00	.00
4	NONE	81.00	.00
5	NONE	.00	.00
6	NONE	.00	.00
7	A1121	.00	.00
8	NONE	.00	.00
9	A1121	.00	170.00
10	NONE	.00	.00
11	NONE	.00	.00
12	NONE	.00	.00
13	NONE	.00	.00
14	NONE	.00	.00
15	A1141	51.00	169.00
16	NONE	.00	.00
17	NONE	104.00	31.00
18	A1142	352.00	.00
19	A1142	212.00	.00
20	A1121	378.00	.00
21	NONE	.00	.00
22	NONE	.00	.00
23	NONE	.00	.00
24	A1210	.00	321.00
25	A1210	.00	464.00
26	A1210	.00	257.00
27	A1210	.00	120.00
28	NONE	.00	.00
29	A1210	285.00	.00
30	A1210	705.00	.00
31	NONE	.00	.00
32	A1220	.00	536.00
33	NONE	.00	.00
34	NONE	.00	.00
35	NONE	.00	.00
36	NONE	.00	.00
37	A1220	4.25	.00
38	A1220	322.00	.00
39	A1220	56.00	.00
40	A1220	75.00	.00
41	NONE	.00	.00
42	NONE	.00	.00
43	NONE	.00	.00
44	NONE	.00	.00
45	A1900	203.00	.00
46	NONE	.00	.00
47	A1340	.00	1700.00
48	A1370	156.00	.00
49	NONE	.00	.00
50	NONE	44.00	.00
51	A1310	10.00	.00
52	NONE	45.00	.00
53	NONE	.00	.00
54	NONE	.00	.00
55	NONE	.00	.00
56	NONE	.00	.00
57	A1121	.00	70.00
58	A1121	.00	51.00
59	A1141	350.00	.00
60	NONE	.00	.00
61	NONE	1600.00	.00
62	NONE	.00	.00
63	NONE	3200.00	.00

ROW	KW KEY	---KW ADD, KW----------------		
		W CRUISE	W BATTLE	S CRUISE
1	C+S	17.40	17.40	17.40
2	MAUX	8.00	8.00	8.00
3	C+S	10.50	14.50	10.50
4	C+S	1.00	1.70	1.00
5	C+S	3.00	3.00	3.00
6	C+S	10.00	10.00	10.00
7	C+S	3.20	4.00	3.20
8	C+S	.20	.20	.20
9	C+S	79.00	79.00	79.00
10	C+S	50.30	85.50	50.30
11	C+S	50.30	85.50	50.30
12	C+S	3.00	4.00	3.00
13	C+S	4.60	6.60	4.60
14	C+S	5.30	5.50	5.30
15	C+S	11.10	29.30	11.10
16	NONE	1.20	1.20	1.20
17	NONE	.00	.00	.00
18	NONE	17.00	21.00	17.00
19	NONE	.00	.00	.00
20	C+S	17.00	17.00	17.00
21	C+S	11.50	11.50	11.50
22	C+S	4.90	6.20	4.90
23	C+S	3.00	3.00	3.00
24	ARM	14.00	42.00	14.00
25	ARM	3.20	10.40	3.20
26	NONE	.00	.00	.00
27	ARM	.50	2.00	.60
28	NONE	.00	.00	.00
29	ARM	36.60	50.20	36.60
30	NONE	.00	.00	.00
31	NONE	.00	.00	.00
32	ARM	10.00	32.00	10.00
33	NONE	.00	.00	.00
34	ARM	.00	.00	.00
35	C+S	12.10	12.10	12.10
36	NONE	.00	.00	.00
37	ARM	7.50	7.50	7.50
38	NONE	.00	.00	.00
39	C+S	15.00	18.00	15.00
40	NONE	.00	.00	.00
41	NONE	.00	.00	.00
42	NONE	.00	.00	.00
43	ARM	.60	1.10	.60
44	NONE	.00	.00	.00
45	NONE	.00	.00	.00
46	NONE	.00	.00	.00
47	C+S	2.80	2.80	2.80
48	ARM	.00	2.20	.00
49	NONE	.00	.00	.00
50	NONE	1.00	1.00	1.00
51	MAUX	1.30	1.30	1.30
52	MAUX	1.00	1.00	1.00
53	NONE	.00	.00	.00
54	ARM	1.00	1.00	1.00
55	NONE	.00	.00	.00
56	C+S	.10	.10	.10
57	C+S	22.00	36.00	22.00
58	C+S	6.00	10.00	6.00
59	C+S	7.00	10.00	7.00
60	C+S	12.00	12.00	12.00
61	NONE	.00	.00	.00
62	NONE	.00	.00	.00
63	NONE	.00	.00	.00

PERFORMANCE ANALYSIS

PRINTED REPORT NO. 1 - SUMMARY

```
PERF DISP IND             FULL LOAD    MAIN ENG NO                    4.
TOWED BODY IND                 NONE    MAIN ENG TYPE IND              GT
SHIP FUEL TYPE IND             JP-5    MAIN ENG PWR AVAIL, HP     13240.
PROP TYPE IND                    CP    SEC ENG NO                     0.
NO PROP SHAFTS                   2.    SEC ENG TYPE IND
SIG WAVE HT, FT                0.00    SEC ENG PWR AVAIL, HP           .
MONTHS IN SERVICE              0.00    SS ENG NO                      1.
HULL FOULING FAC              0.011    SS ENG TYPE IND                GT
PROP FOULING FAC              0.000    24 HR AVG ELECT LOAD, KW   1509.1
ANNUAL FUEL USAGE, BBL           0.    TRANS TYPE IND               MECH

                       SPEED PERFORMANCE SUMMARY

                        REQ   PRPLN               FUEL     FUEL
SPEED   DRAG    RANGE   BHP   ENG O/L    SFC      FLOW     CONS   PROP TRNSP
 KT      LBF      NM     HP    MN SC  LBM/HP-HR LTON/HR NM/LTON COEF  EFF
----------------------------------------------------------------------------
16.0  121097. 6509.  9318.   2  0     .610       2.44       6.5 0.664  67.5
17.0  133170. 6280. 10861.   2  0     .577       2.69       6.3 0.665  61.6
18.0  149390. 5939. 12894.   2  0     .543       3.01       6.0 0.665  54.9
19.0  171606. 5485. 15648.   2  0     .511       3.44       5.5 0.663  47.8
20.0  185361. 5285. 17726.   2  0     .492       3.76       5.3 0.665  44.4
21.0  206871. 4940. 20762.   2  0     .471       4.22       5.0 0.664  39.8
22.0  223398. 3906. 23424.   4  0     .553       5.59       3.9 0.665  36.9
23.0  242897. 3753. 26579.   4  0     .529       6.08       3.8 0.666  34.0
24.0  266843. 3568. 30450.   4  0     .506       6.68       3.6 0.665  31.0
25.0  303013. 3294. 36110.   4  0     .481       7.53       3.3 0.662  27.2
26.0  347426. 3003. 43240.   4  0     .457       8.60       3.0 0.658  23.6
26.5  372310. 2858. 47329.   4  0     .447       9.20       2.9 0.656  22.0
```

PRINTED REPORT NO. 2 - MISSION PERFORMANCE SUMMARY

```
ANNUAL FUEL USAGE, BBL      56172.

       MISSION PROFILE                          FUEL     FUEL
     SPEED           SIG WAV          RANGE     FLOW     CONS   PROPUL  TRNSP
  KT  PERCENT     HT-FT  PERCENT       NM     LTON/HR  NM/LTON  COEF     EFF
------------------------------------------------------------------------------
  6.0   11.9       0.0     1.7
 14.0   46.6       4.0    15.7
 20.0   35.6       6.5    11.6        5773.    2.98       5.8  0.655     96.6
 25.0    4.4      10.2    42.0
 30.0    1.5      17.0    29.0
------------      ------------
    15.9              10.6
```

PRINTED REPORT NO. 3 - DETAILED MISSION PERFORMANCE

```
SIG WAVE HT, FT =  0.0    SPEED PROBABILITY  DRAG     REQ PROP FUEL CONS
PROBABILITY OF              KT      PCNT      LBF        HP     NM/LTON
OCCURANCE, PCNT =  1.7    ----------------------------------------------
                            6.0     11.9    20038.      588.       6.5
                           14.0     46.6   106890.     7307.       6.6
                           20.0     35.6   185361.    17726.       5.3
                           25.0      4.4   303013.    36110.       3.3
                           27.1      1.5   404997.    52960.       2.7

SIG WAVE HT, FT =  4.0    SPEED PROBABILITY  DRAG     REQ PROP FUEL CONS
PROBABILITY OF              KT      PCNT      LBF        HP     NM/LTON
OCCURANCE, PCNT = 15.7    ----------------------------------------------
                            6.0     11.9    20080.      590.       6.5
                           14.0     46.6   107117.     7324.       6.6
                           20.0     35.6   185756.    17767.       5.3
                           25.0      4.4   303659.    36194.       3.3
                           27.1      1.5   405128.    52960.       2.7

SIG WAVE HT, FT =  6.5    SPEED PROBABILITY  DRAG     REQ PROP FUEL CONS
PROBABILITY OF              KT      PCNT      LBF        HP     NM/LTON
OCCURANCE, PCNT = 11.6    ----------------------------------------------
                            6.0     11.9    20181.      593.       6.5
                           14.0     46.6   107656.     7365.       6.6
                           20.0     35.6   186690.    17864.       5.3
                           25.0      4.4   305187.    36392.       3.3
                           27.1      1.5   405437.    52960.       2.7

SIG WAVE HT, FT = 10.2    SPEED PROBABILITY  DRAG     REQ PROP FUEL CONS
PROBABILITY OF              KT      PCNT      LBF        HP     NM/LTON
OCCURANCE, PCNT = 42.0    ----------------------------------------------
                            6.0     11.9    20481.      603.       6.4
                           14.0     46.6   109254.     7488.       6.5
                           20.0     35.6   189462.    18151.       5.2
                           25.0      4.4   309717.    36981.       3.3
                           27.0      1.5   406627.    52960.       2.7

SIG WAVE HT, FT = 17.0    SPEED PROBABILITY  DRAG     REQ PROP FUEL CONS
PROBABILITY OF              KT      PCNT      LBF        HP     NM/LTON
OCCURANCE, PCNT = 29.0    ----------------------------------------------
                            6.0     11.9    21628.      641.       6.3
                           14.0     46.6   115370.     7962.       6.3
                           20.0     35.6   200067.    19259.       5.0
                           25.0      4.4   327054.    39256.       3.1
                           26.6      1.5   410068.    52960.       2.6
```

HYDROSTATIC ANALYSIS

PRINTED REPORT NO. 1 - SUMMARY

```
DISPLACEMENT, LTON           5721.8    MAX AREA STA LOC FM FP,FT  213.05
LCG LOC(+VE FWD MID), FT      -5.85    AREA AT MAX AREA STA, FT2   756.5
MIDSHIP DRAFT, FT             14.85    BEAM AT MAX AREA STA, FT    55.06
TRIM(+ BY STERN), FT           2.36    DRAFT AT MAX AREA STA, FT   14.96
KG, FT                        19.59    BLOCK COEF                  0.599
SHIP LBP, FT                 390.00    PRISMATIC COEF              0.653
METACENTRIC HT(GM), FT         5.57    SECTIONAL AREA COEF         0.918
WATERPLANE AREA,FT2         16895.4    WATERLINE LENGTH, FT       389.37
WETTED SURF AREA, FT2       22701.1
```

PRINTED REPORT NO. 2 - HYDROSTATIC VARIABLES OF FORM

```
         TOTAL    APPDG    TOTAL
DRAFT   VOLUME   VOLUME    DISPL       LCB        KB      LCF
  FT       FT3      FT3     LTON        FT        FT       FT
12.85  166615.    7829.   4763.6     -2.53      7.04   -21.27
13.14  171350.    7842.   4899.0     -3.06      7.21   -22.01
13.43  176113.    7853.   5035.1     -3.57      7.38   -22.45
13.71  180896.    7862.   5171.9     -4.08      7.54   -22.63
14.00  185691.    7868.   5309.0     -4.55      7.71   -22.61
14.28  190495.    7871.   5446.3     -5.01      7.88   -22.58
14.57  195306.    7871.   5583.9     -5.44      8.04   -22.55
14.85  200129.    7871.   5721.8     -5.85      8.20   -22.52
15.14  204963.    7871.   5860.0     -6.24      8.37   -22.48
15.43  209809.    7871.   5998.5     -6.62      8.53   -22.45
15.71  214666.    7871.   6137.4     -6.97      8.69   -22.40
16.00  219536.    7871.   6276.6     -7.31      8.85   -22.36
16.28  224416.    7871.   6416.1     -7.64      9.02   -22.31
16.57  229307.    7871.   6556.0     -7.95      9.18   -22.27
16.85  234209.    7871.   6696.1     -8.25      9.34   -22.22

       -------------HULL ONLY-------------
        WETTED    BLOCK  PRISMATIC  WPLANE    WPLANE
DRAFT  SURFACE    COEFF    COEFF     COEFF     AREA       TP1
  FT       FT2      -        -         -        FT2    LTON/IN
12.85  20985.3    0.571    0.633     0.768   16511.1    39.34
13.14  21281.5    0.575    0.636     0.773   16625.1    39.61
13.43  21549.2    0.579    0.639     0.777   16707.3    39.81
13.71  21793.6    0.583    0.642     0.780   16762.2    39.94
14.00  22019.8    0.587    0.645     0.782   16794.3    40.01
14.28  22246.1    0.591    0.647     0.784   16822.3    40.08
14.57  22473.3    0.595    0.650     0.786   16855.8    40.16
14.85  22701.1    0.599    0.653     0.788   16895.4    40.25
15.14  22928.9    0.603    0.655     0.790   16936.1    40.35
15.43  23156.8    0.606    0.658     0.791   16977.8    40.45
15.71  23384.6    0.609    0.660     0.793   17019.4    40.55
16.00  23612.3    0.612    0.662     0.794   17060.1    40.65
16.28  23839.7    0.615    0.665     0.796   17099.4    40.74
16.57  24067.1    0.617    0.667     0.797   17137.8    40.83
16.85  24294.5    0.620    0.669     0.798   17175.2    40.92

DRAFT   CID1TS  LONG BM  TRNSV BM  LONG KM  TRNSV KM     MT1
  FT   NM/LTON     FT       FT        FT       FT    FT-LTON/IN
12.85    25.74   870.75    19.50    877.79    26.54    886.3
13.14    26.83   863.81    19.14    871.02    26.35    904.2
13.43    27.49   852.24    18.79    859.61    26.17    916.9
13.71    27.81   837.30    18.42    844.85    25.97    925.3
14.00    27.84   820.01    18.03    827.72    25.74    930.2
14.28    27.84   803.28    17.66    811.16    25.53    934.8
14.57    27.86   787.43    17.30    795.47    25.34    939.5
14.85    27.89   772.30    16.96    780.50    25.17    944.2
15.14    27.92   757.79    16.64    766.16    25.01    948.8
15.43    27.94   743.88    16.35    752.42    24.88    953.5
15.71    27.95   730.55    16.06    739.25    24.75    958.1
16.00    27.96   717.72    15.78    726.58    24.64    962.6
16.28    27.97   705.29    15.52    714.31    24.53    966.9
16.57    27.98   693.30    15.26    702.48    24.44    971.2
16.85    27.98   681.73    15.01    691.07    24.35    975.4
```

PRINTED REPORT NO. 3 - FLOODABLE LENGTH

```
 LOCATION   PERM
 FROM FP,FT 0.95
   57.79  154.20
   58.50  152.81
   78.00  131.13
   97.50  128.71
  117.00  135.73
  136.50  149.48
  156.00  169.10
  175.50  193.63
  195.00  215.00
  214.50  213.55
  234.00  186.49
  253.50  160.31
  273.00  139.46
  292.50  123.54
  312.00  112.33
  331.50  105.51
  337.93  104.14
```

PRINTED REPORT NO. 4 - INTACT STATIC STABILITY

```
INTACT WIND SPEED, KT        100.00     LAT RESIST CENTER, FT          7.43
SAIL AREA, FT2              11380.3     TURN SPEED, KT                26.49
SAIL AREA FACTOR               1.25     TURN RADIUS, FT              818.63
SAIL AREA CTR ABV WL, FT      16.98     TURN HEEL ANGLE, DEG          10.04
WIND ARM RATIO                 0.17     TURN ARM RATIO                 0.23
WIND AREA RATIO                7.20     TURN AREA RATIO                0.79
WIND LEVER ARM, FT             0.75     TURN LEVER ARM, FT             1.02
WIND LIMITING KG, FT          24.08     TURN LIMITING KG, FT          21.72

        TABLE OF INTACT RIGHTING ARMS(GZ), DRAFTS, AND TRIMS, FT

HEEL, DEG   0.00   5.00 10.00 20.00 30.00 40.00 50.00 60.00 70.00 80.00
=======================================================================
GZ          0.00   0.49  1.00  2.05  3.04  3.90  4.38  4.16  3.50  2.56
TRIM        2.36   2.35  2.28  1.83  0.86 -0.72 -2.90 -6.37-12.74-30.10
DRAFT      14.85  14.84 14.79 14.56 13.97 12.65 10.24  6.37 -0.93-22.26
```

PRINTED REPORT NO. 5 - DAMAGED STATIC STABILITY

```
LAT RESIST CENTER, FT         10.26     DAMAGED WIND SPEED, KT        34.02
SAIL AREA, FT2               8959.1     STATIC HEEL ANGLE, DEG         0.00
SAIL AREA FACTOR               1.25     AREA RATIO                    21.01
SAIL AREA CTR ABV WL, FT      14.71     MIN WL-MRGN LINE SEP, FT      15.36
WIND LEVER ARM, FT             0.07     LIMITING KG, FT               24.49

      COMPARTMENT DESCRIPTIONS
COMP  SYMMETRY  PERM   FBHD,FT  ABHD,FT
  1      0     0.950   -19.31    19.50
  2      0     0.950    19.50    42.76
  3      0     0.950    42.76    66.02
  4      0     0.950    66.02    89.29
  5      0     0.950    89.29   112.55
  6      0     0.950   112.55   148.33
  7      0     0.950   148.33   177.58 *
  8      0     0.950   177.58   213.15 *
  9      0     0.950   213.15   242.40 *
 10      0     0.950   242.40   282.88
 11      0     0.950   282.88   309.66
 12      0     0.950   309.66   336.44
 13      0     0.950   336.44   363.22
 14      0     0.950   363.22   390.00
* DENOTES COMPARTMENT IS DAMAGED.

        TABLE OF DAMAGED RIGHTING ARMS(GZ), DRAFTS, AND TRIMS, FT

HEEL, DEG     0.0   5.0  10.0  15.0  20.0  25.0  30.0  35.0  40.0  45.0
=======================================================================
GZ           0.00  0.35  0.71  1.10  1.52  1.97  2.48  2.98  3.37  3.60
TRIM        -2.36 -2.37 -2.40 -2.44 -2.54 -2.73 -3.04 -3.45 -3.90 -4.32
DRAFT       20.53 20.52 20.48 20.43 20.34 20.21 19.99 19.67 19.29 18.89
```

PRINTED REPORT NO. 6 - APPENDAGES

```
                              TOTAL    TOTAL           CENTROID
   APPENDAGE        RADIUS    VOLUME   DISP     -----COORDINATES, FT-----
                      FT       FT3     LTON        X        Y         Z
 1 SHELL             5.89      857.    24.5     200.85     0.00      8.58
 2 SKEG              2.30       51.     1.5     299.09     0.00      0.72
 3 BILGE KEEL        3.33      155.     4.4     195.00    26.78      7.38
 4 BILGE KEEL        3.33      155.     4.4     195.00   -26.78      7.38
 5 PROP ETC          4.39      355.    10.1     357.93    11.63     -0.34
 6 PROP ETC          4.39      355.    10.1     357.93   -11.63     -0.34
 7 SONAR DOME       11.13     5771.   165.0      14.00     0.00     -3.20
 8 RUDDER            2.74       86.     2.5     383.09    11.63      5.43
 9 RUDDER            2.74       86.     2.5     383.09   -11.63      5.43
```

SEAKEEPING ANALYSIS

PRINTED REPORT NO. 1 - SUMMARY

```
                                                     FULL LOAD
                                                    ----------
BALES RANK
 RANK OF THE SYNTHESIZED SHIP (ACTUAL DISP)           7.746
 RANK OF THE SYNTHESIZED SHIP (NORMALIZED)            3.206
 RANK OF THE CLOSEST DATA BASE HULL (NORMALIZED)      3.460
 ID NO OF CLOSEST DATA BASE SHIP                          3
MCCREIGHT RANK
 RANK OF THE SYNTHESIZED SHIP (ACTUAL SHIP)           5.083
 RANK OF THE CLOSEST DATA BASE HULL                   5.654
 ID NO OF CLOSEST DATA BASE SHIP                         34
```

PRINTED REPORT NO. 2 - SHIP GEOMETRY DATA

```
FULL LOAD WT, LTON  5721.8

                              FULL LOAD
                             ----------
ACTUAL SHIP
 LBP, FT                       390.00
 BEAM, FT                       54.87
 DRAFT, FT                      14.99
 VERT PRISMATIC COEF (FWD)     0.8464
 VERT PRISMATIC COEF (AFT)     0.6943
 WATERPLANE COEF (FWD)         0.6711
 WATERPLANE COEF (AFT)         0.9088
 WP AREA AFT MIDSHIPS, FT2    9723.66
 LCB FROM FP, FT               196.16
 LCF FROM FP, FT               216.54
 BML, FT                       806.48
 CUT-UP PT FROM FP, FT         248.63

NORMALIZED SHIP
 DISP, LTON                    4232.1
 LBP, FT                       352.70
 BEAM, FT                       49.62
 DRAFT, FT                      13.55
 CUT-UP PT FROM FP, FT         224.85
```

MANNING ANALYSIS

NOTE-THIS INTERIM MANNING MODEL PROVIDES GROSS TREND ANALYSIS BASED ON HISTORICAL MANNING DATA OF EXISTING SHIPS. REQUESTS FOR SHIP MANNING DETERMINATION SHOULD BE DIRECTED TO NAVSEA.

PRINTED REPORT NO. 1 - SUMMARY

TOTAL MMHRS REQ/WK	14125.6	NO WATCH STATIONS	37.
TOTAL MMHRS AVAIL/WK	11316.0	NO WATCHSTANDERS	111.
DEFERRED MMHRS/WK	2809.6	NO NON-WATCHSTANDERS	47.

	OFFICERS	CPO	ENLISTED	TOTAL
REQ MANNING	21.	17.	215.	253.
AVAIL MANNING	21.	24.	147.	192.
DIFFERENCE	0.	7.	-68.	-61.
ACCOMMODATIONS	21.	24.	147.	192.

PRINTED REPORT NO. 2 - MANNING AND ACCOMMODATION SUMMARY

	SHIPS CREW	AIR DETACH	FLAG STAFF /OTHER	ACCOMMODATION
OFFICERS	17.	4.	0.	21.
CPO	23.	1.	0.	24.
OEM	135.	12.	0.	147.
TOTAL	175.	17.	0.	192.

PRINTED REPORT NO. 3 - DEPARTMENTAL MANNING ANALYSIS

DEPARTMENT	MANNING FACTOR	OFFICERS	CPO	ENLISTED	TOTAL
CO/EXEC/NAV/MED	1.0	3.	3.	13.	19.
OPERATIONS	1.0	3.	3.	60.	66.
COMBAT	1.0	5.	5.	54.	64.
ENGINEERING	1.0	4.	3.	44.	51.
SUPPLY	1.0	2.	2.	32.	36.
AVIATION	1.0	4.	1.	12.	17.
FLAG STAFF/OTHER	---	0.	0.	0.	0.
REQ MANNING		21.	17.	215.	253.
AVAIL MANNING		21.	24.	147.	192.
DIFFERENCE		0.	7.	-68.	-61.

PRINTED REPORT NO. 4 - WEEKLY FUNCTIONAL WORKLOAD ANALYSIS

FUNCTION	WORKLOAD FACTOR	WEEKLY MHRS REQ	WEEKLY MHRS AVAIL	PERCENT
OPERATIONAL MANNING (OM)	1.0	5756.2		40.8
PLANNED MAINTENANCE (PM) + CORRECTIVE MAINTENANCE (CM)	1.0	1871.7		13.3
OWN UNIT SUPPORT (OUS)	1.0	2911.9		20.6
FACILITY MAINTENANCE (FM)	1.0	1196.3		8.5
PRODUCTIVITY ALLOWANCE (PA)	1.0	1196.0		8.5
SERVICE DIVERSION ALLOWANCE (SDA) + TRAINING (T)	1.0	1193.5		8.4
TOTAL MMHRS REQ/WK		14125.6		100.0
WATCHSTANDERS (74HRS/MAN-WK)			8214.0	
NON-WATCHSTANDERS (66HRS/MAN-WK)			3102.0	
TOTAL MMHRS AVAIL/WK			11316.0	80.1
DEFERRED MMHRS/WK			2809.6	19.9

COST ANALYSIS

```
NOTE-THIS INTERIM MODULE PROVIDES GUIDANCE FOR DECISIONS
     REGARDING SHIP DESIGN TRADEOFFS AND COMPARATIVE
     EVALUATIONS. REQUESTS FOR ESTIMATES OF SHIP COSTS
     FOR BUDGETARY PURPOSES SHOULD BE DIRECTED TO NAVSEA.
```

PRINTED REPORT NO. 1 - SUMMARY

```
YEAR $                        1992.   NO OF SHIPS ACQUIRED          10.
INFLATION ESCALATION FAC     1.384    SERVICE LIFE, YR             30.0
LEARNING RATE                0.970    ANNUAL OPERATING HRS       2500.0
FUEL COST, $/GAL             0.800    MILITARY P/L, LTON          545.4
PAYLOAD FUEL RATE, LTON/HR    0.33    LIGHTSHIP WT, LTON         4267.9
SHIP FUEL RATE, LTON/HR       1.00    FULL LOAD WT, LTON         5721.8

                                       COSTS(MILLIONS OF DOLLARS)
COST ITEM                             TOT SHIP + PAYLOAD  =  TOTAL
---------                             --------   --------   --------
LEAD SHIP                                576.6      232.5*     809.1
FOLLOW SHIP                              269.5      206.5*     476.0
AVG ACQUISITION COST/SHIP(10 SHIPS)      259.1      209.1*     468.2
LIFE CYCLE COST/SHIP(30 YEARS)                                1266.1
TOTAL LIFE CYCLE COST(30 YEARS)                              12661.1
DISCOUNTED LIFE CYCLE COST/SHIP                                 84.2**
DISCOUNTED TOTAL LIFE CYCLE COST                               842.4**

 *ESTIMATED VALUE
**DISCOUNTED AT 10 PERCENT
```

PRINTED REPORT NO. 2 - UNIT ACQUISITION COSTS

```
                                                        LEAD     FOLLOW
                                                        SHIP       SHIP
SWBS                                           KN      COSTS      COSTS
GROUP                      UNITS  INPUTS    FACTORS     $K         $K
=========================================================================
100    HULL STRUCTURE       LTON    1809.4    1.00     15377.     14454.
200    PROPULSION PLANT     HP     52960.0    2.35     39611.     37234.
300    ELECTRIC PLANT       LTON     182.4    1.00     11860.     11148.
400    COMMAND+SURVEILLANCE LTON     354.8    3.15     17741.     16677.
500    AUX SYSTEMS          LTON     520.6    1.53     26717.     25114.
600    OUTFIT+FURNISHINGS   LTON     299.4    1.00     11924.     11209.
700    ARMAMENT             LTON     105.6    1.00      1153.      1084.
       MARGIN               LTON     474.2             15548.     14615.
800    DESIGN+ENGINEERING                    26.06    216856.     23962.
900    CONSTRUCTION SERVICES                  4.25     35844.     33693.
-------------------------------------------------------------------------
     TOTAL CONSTRUCTION COST                          392629.    189189.
=========================================================================
         CONSTRUCTION COST                            392629.    189189.
         PROFIT(10.0 PERCENT OF CONSTRUCTION COST)     39263.     18919.
         PRICE                                        431892.    208108.
         CHANGE ORDERS(12/8 PERCENT OF PRICE)          51827.     16649.
         NAVSEA SUPPORT(2.5 PERCENT OF PRICE)          10797.      5203.
         POST DELIVERY CHARGES(5 PERCENT OF PRICE)     21595.     10405.
         OUTFITTING(4 PERCENT OF PRICE)                17276.      8324.
         H/M/E + GROWTH(10 PERCENT OF PRICE)           43189.     20811.
     TOTAL SHIP COST                                  576576.    269500.
     ESTIMATED PAYLOAD COST                           232489.    206457.
=========================================================================
SHIP PLUS PAYLOAD COST                                809064.    475957.
ADJUSTED FIRST UNIT SHIP COST, $K    286701.9
COMBAT SYSTEM WEIGHT,  LTON             545.4
PROPULSION SYSTEM WEIGHT, LTON          521.4
ADJUSTED FIRST UNIT SHIP COST EQUALS
 FOLLOW SHIP TOTAL COST DIVIDED BY      0.940
```

PRINTED REPORT NO. 3 - LIFE CYCLE COSTS

```
IOC YEAR                    2010.    PAYLOAD FUEL RATE, LTON/HR    0.33
R+D PROGRAM LENGTH, YRS       0.     SHIP FUEL RATE, LTON/HR       1.00
NUMBER OF SHIPS ACQUIRED     10.     TECH ADV COST, $M             0.00
SERVICE LIFE, YRS            30.     ADDL FACILITY COST, $M        0.00
NO OF OFFICERS/SHIP          21.     DEFERRED MMHRS REQ, HR/WK      0.
NO OF ENLISTED MEN/SHIP     171.     PRODUCTION RATE, SHIPS/YR     2.00

                                 30 - YEAR SYSTEMS COST
                              (MILLIONS OF YEAR 1992 DOLLARS)
                       SHIP  PAYLOAD    OTHER    TOTAL   SYSTEM    TOTAL
COST ELEMENT         NONREC   NONREC   NONREC   NONREC    RECUR   SYSTEM
------------       -------- -------- -------- -------- -------- --------
R+D TOTAL                0.       0.       0.       0.                0.
  DESIGN+DEVELMNT        0.                0.       0.                0.
  TEST+EVALUATION        0.       0.       0.       0.                0.

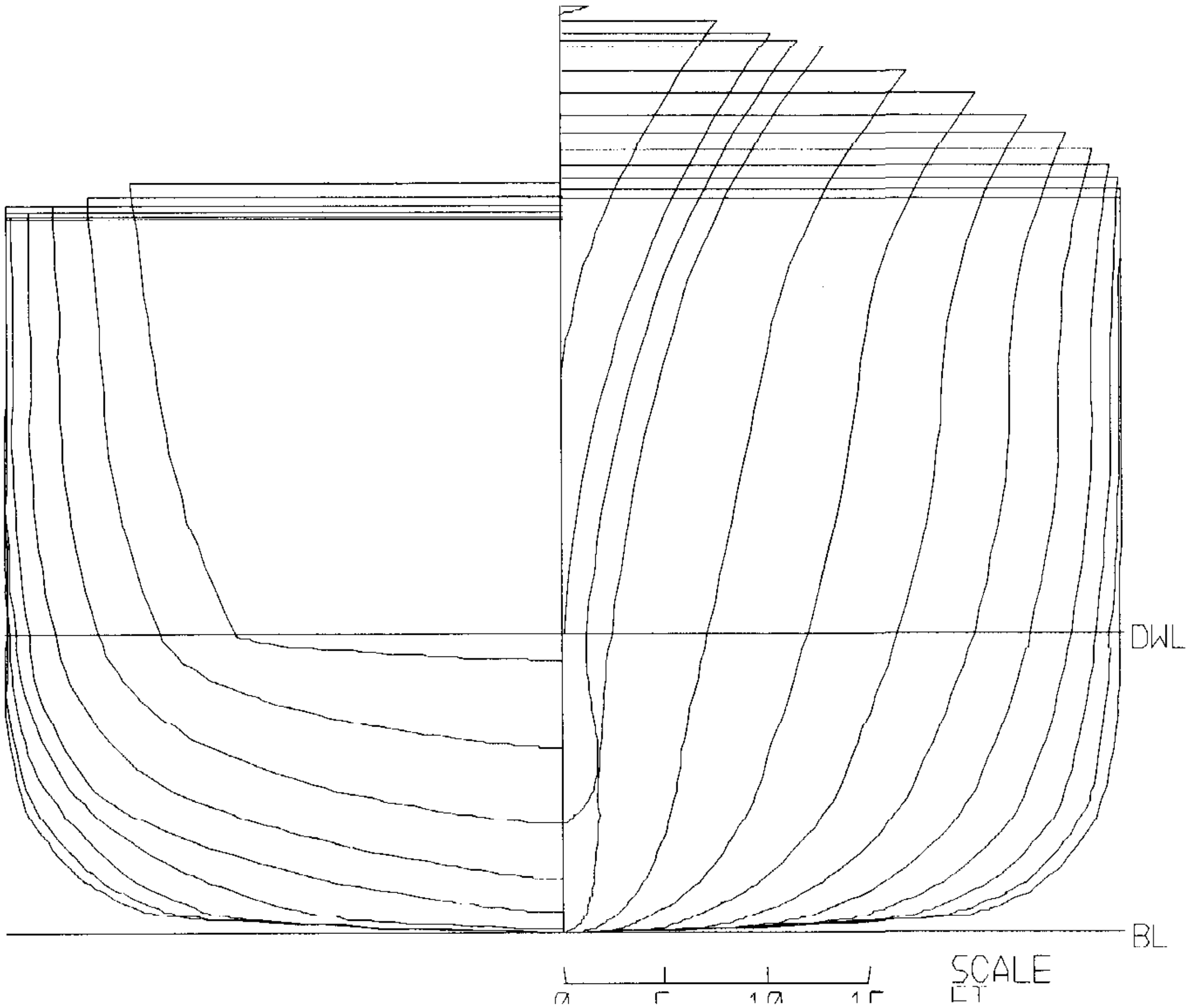
INVESTMENT            2798.    2781.       4.    5583.             5583.
  EQUIPMENT           2721.    2509.             5229.             5229.
    PRIME             2591.    2091.             4682.             4682.
    SUPPORT            130.     418.              548.              548.
  FACILITIES                               0.       0.                0.
  INITIAL SPARES        78.     272.              350.              350.
  ASSOCIATED SYS                           4.       4.                4.

OPERATIONS+SUPPRT                                         7405.    7405.
  PERSONNEL                                               1048.    1048.
  OPERATIONS                                               716.     716.
  MAINTENANCE                                             2174.    2174.
  ENERGY                                                   204.     204.
  REPL SPARES                                             2272.    2272.
  MAJOR SUPPORT                                            976.     976.
  ASSOCIATED SYS                                            15.      15.

LESS RESIDUAL VALUE                                                 327.
------------------------------------------------------------------------
LIFE CYCLE TOTAL SYSTEMS COST                                     12661.
DISCOUNTED AT 10 PERCENT                                            842.

COST PER VEHICLE-UNDISCOUNTED     1266.
COST PER VEHICLE-DISCOUNTED         84.
```

ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - 1/15/93 10.49.05
GRAPHIC DISPLAY NO. 1 - BODY PLAN



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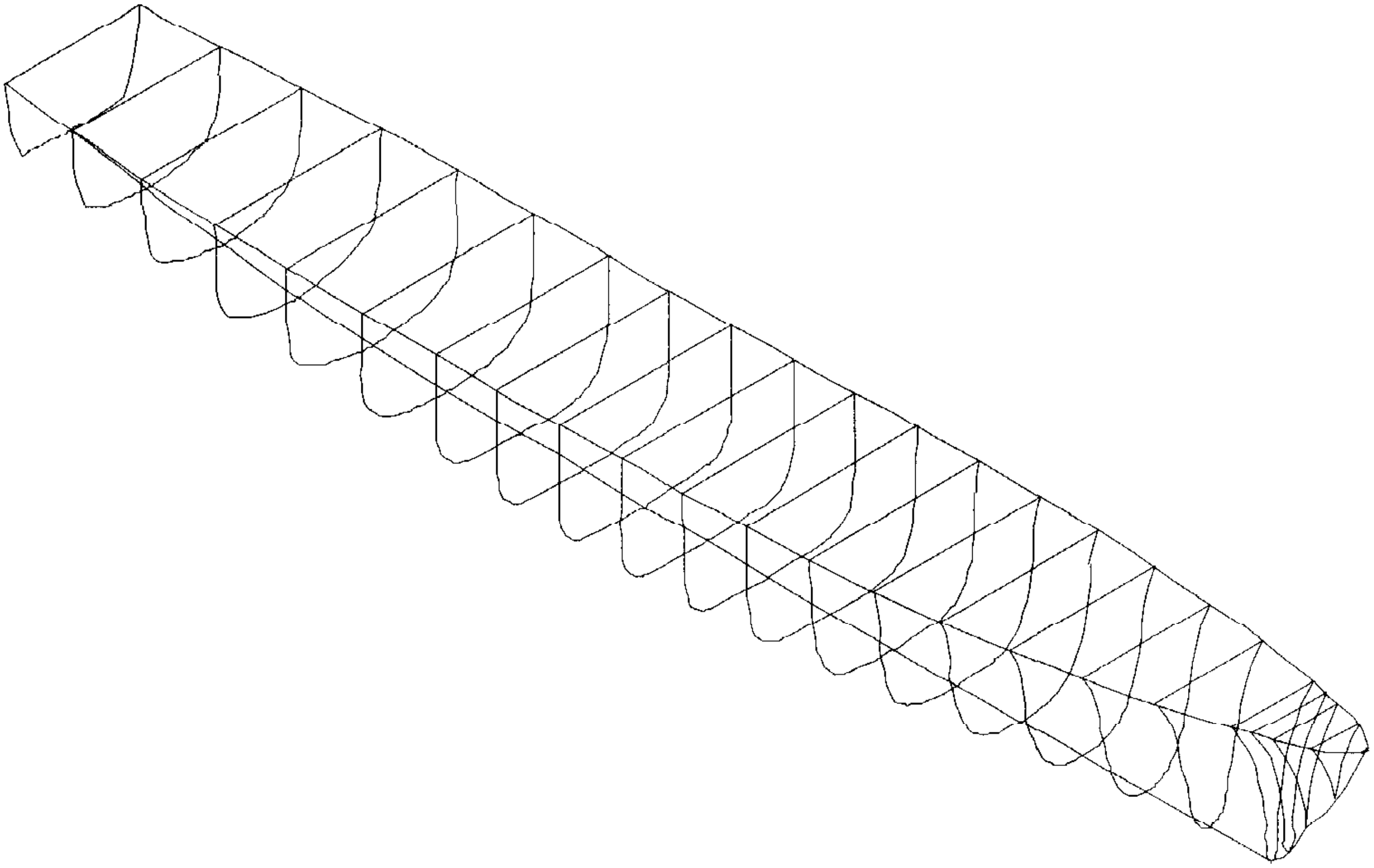
ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - 1/15/93 10.49.05.
GRAPHIC DISPLAY NO. 2 - HULL ISOMETRIC VIEW



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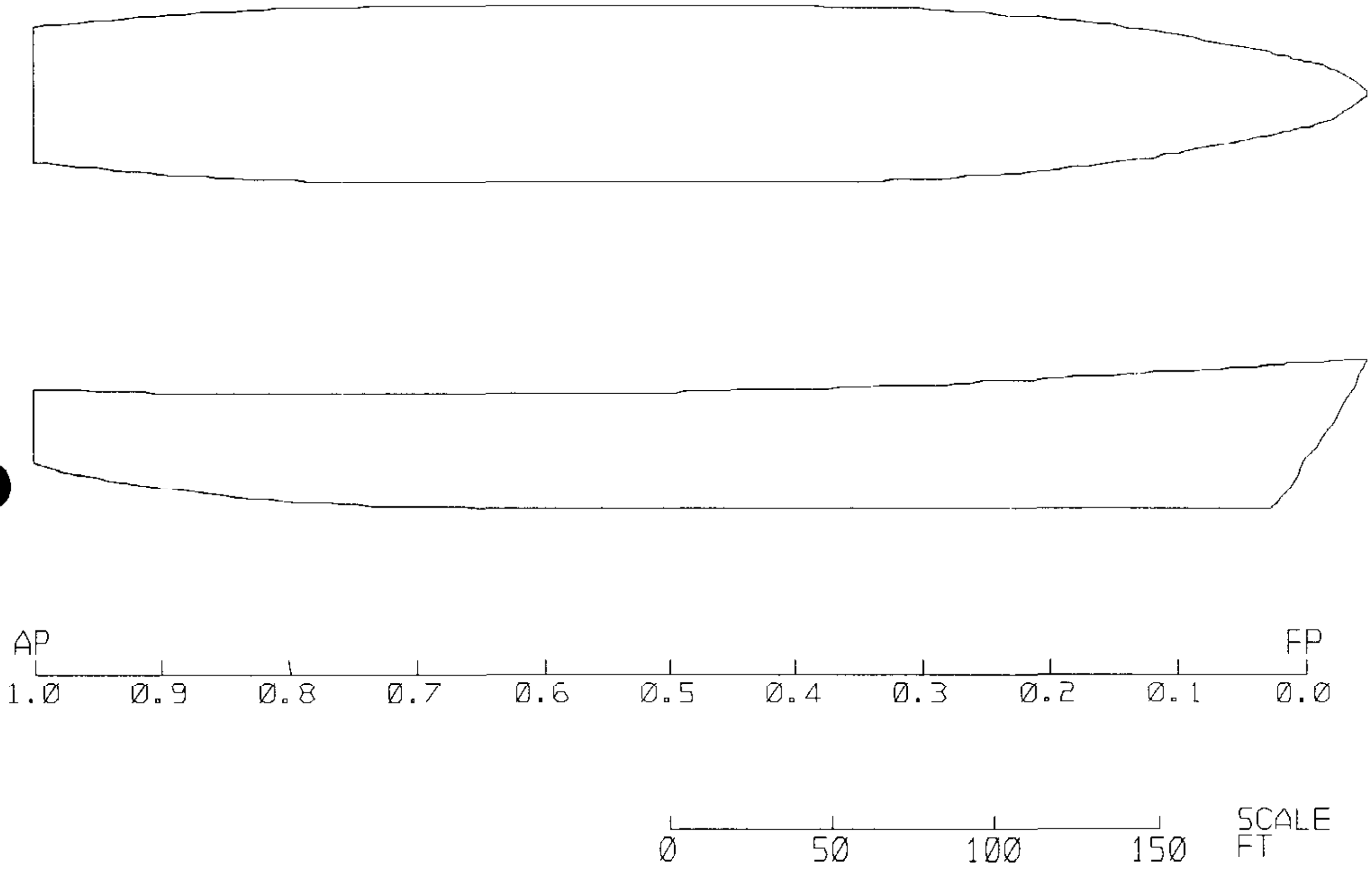
ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - 1/15/93 10.49.05.
GRAPHIC DISPLAY NO. 3 - HULL PROFILE AND WEATHER DECK PLAN VIEW



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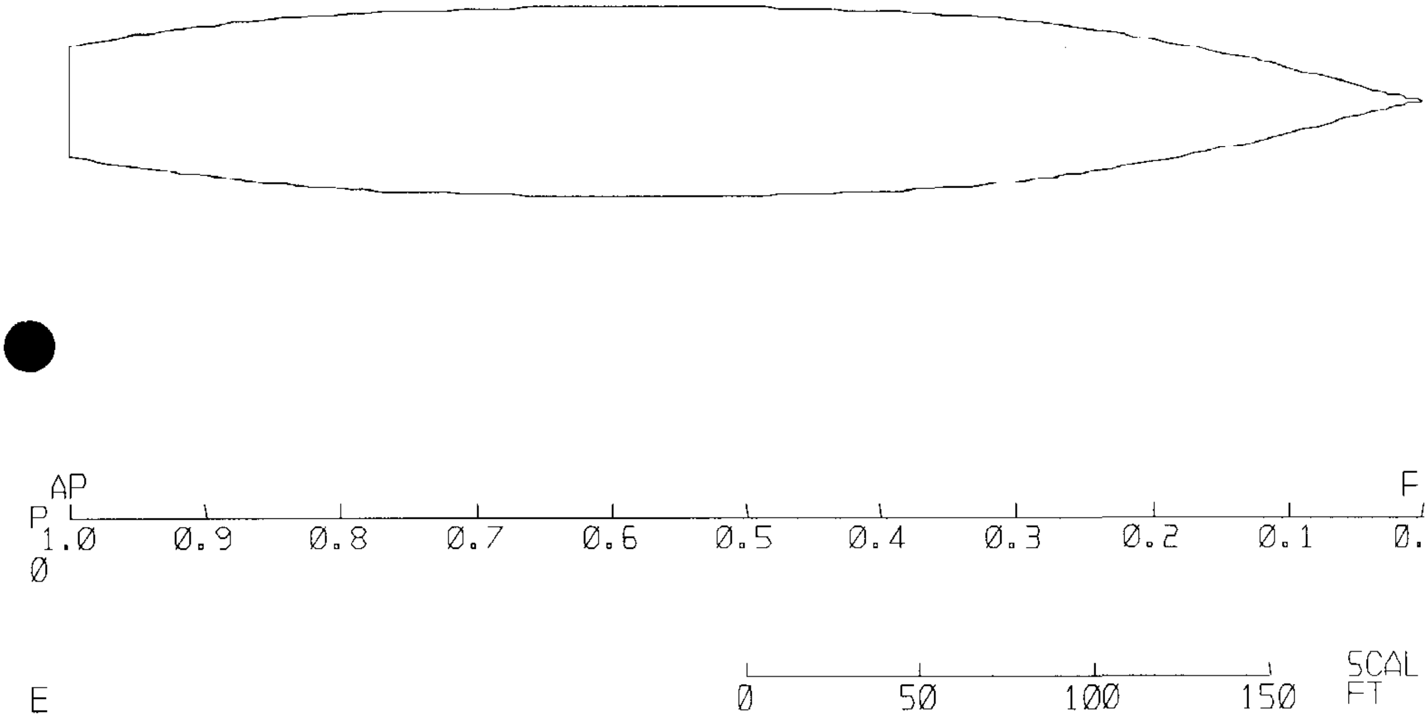
ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - 1/15/93 10.49.05.
GRAPHIC DISPLAY NO. 4 - DESIGN WATERLINE PLAN VIEW



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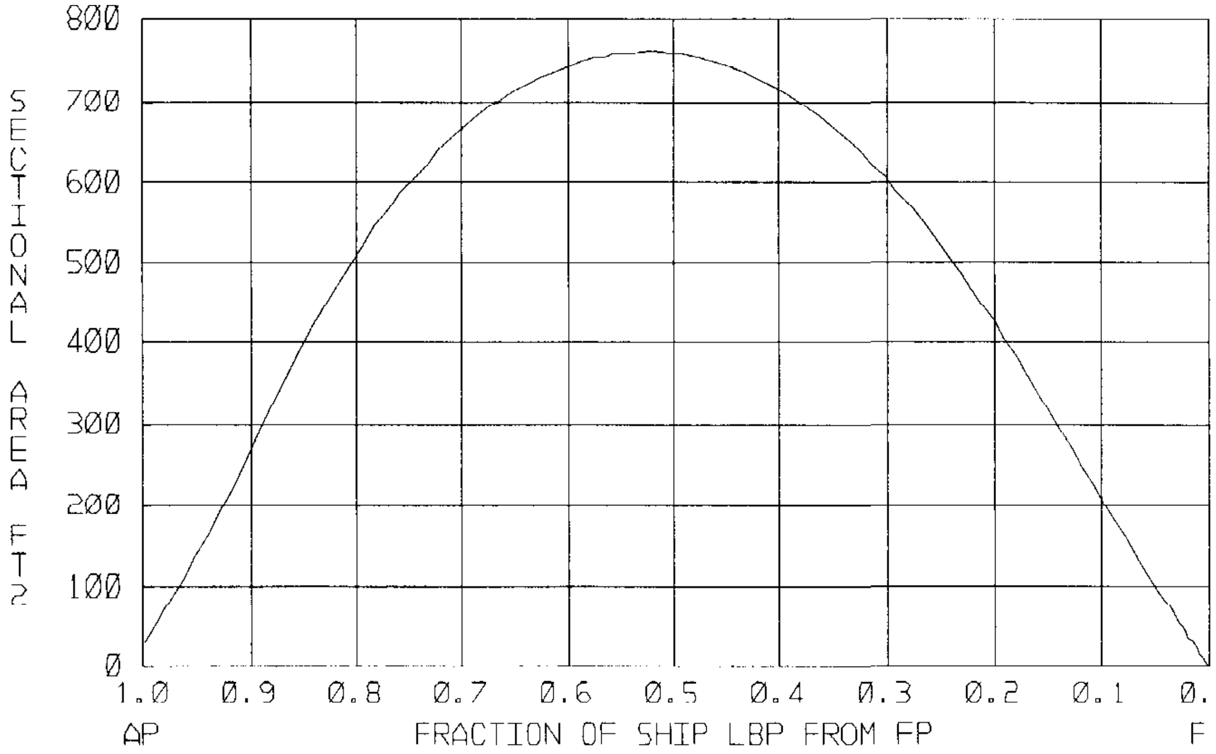
ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - 1/15/93 10.49.05.
GRAPHIC DISPLAY NO. 5 - HULL SECTIONAL AREA CURVE



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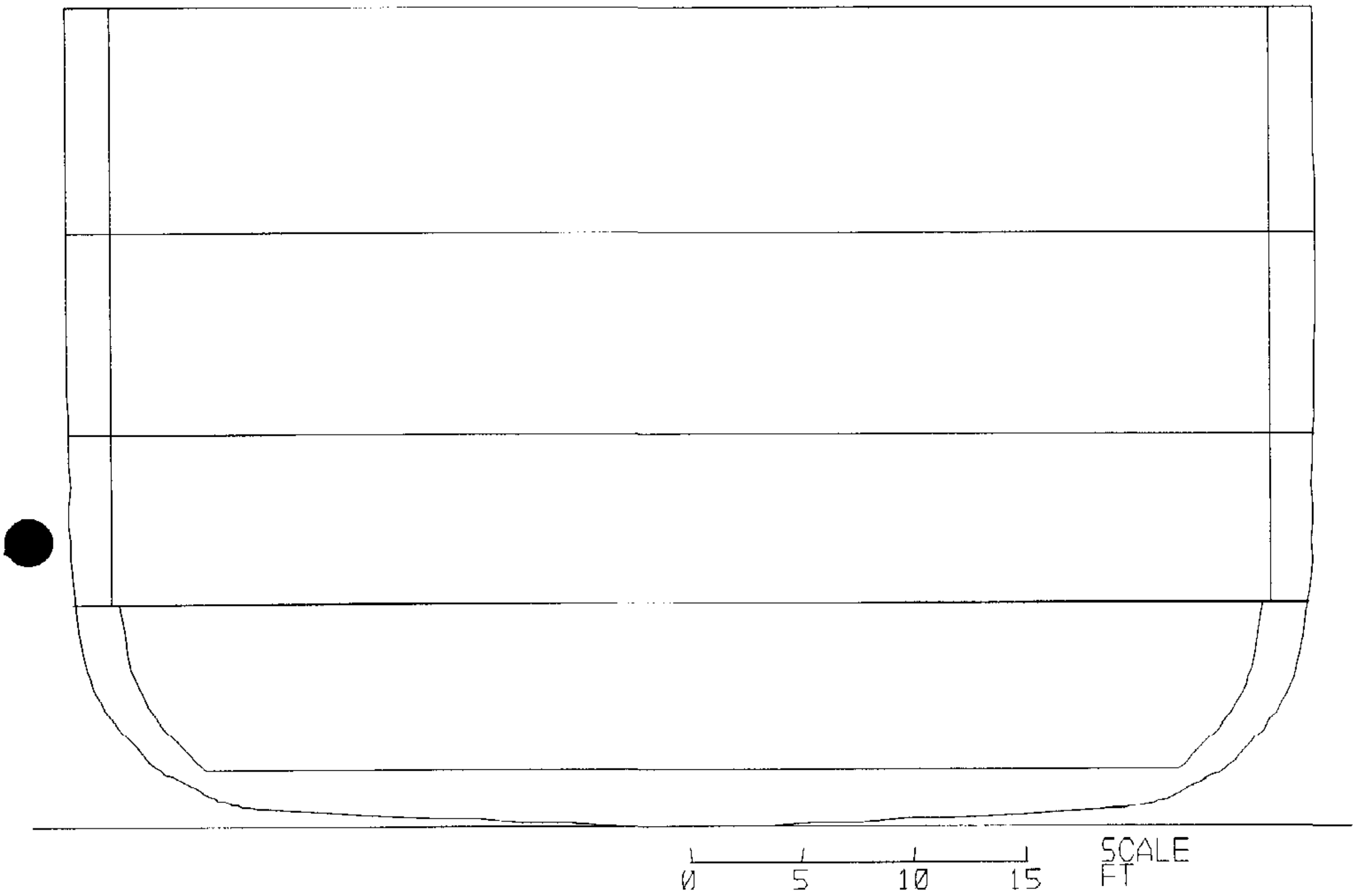
P

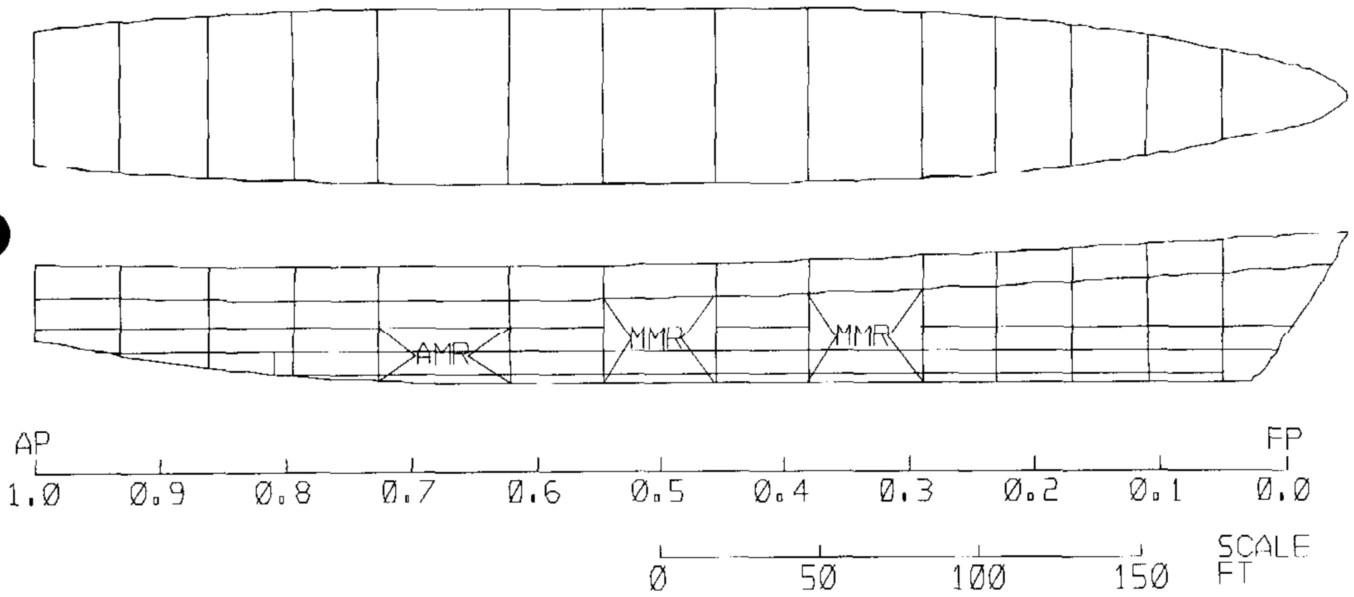
ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE - 1/14/93 14.14.14.
GRAPHIC DISPLAY NO. 1 - MIDSHIP SECTION



I)

ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE - 1/14/93 14.14.14.
GRAPHIC DISPLAY NO. 2 - HULL DECKS AND PLATFORMS
MAIN DECK

TOTAL AREA, FT2	19563.4
HULL VOLUME, FT3	598970.



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ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE -  1/14/93 14.14.14.
          GRAPHIC DISPLAY NO. 3 - HULL DECKS AND PLATFORMS
                            2ND DECK
                      (INTERNAL DECK NO. 1)

           TOTAL AREA, FT2                      18233.8
           UNUSABLE AREA FWD, FT2                   0.0
           UNUSABLE AREA AFT, FT2                   0.0
           LOST MR AREA, FT2                        0.0
           LOST REQ TANKAGE AREA, FT2               0.0
                                               --------
           AVL ARR AREA, FT2                    18233.8
```

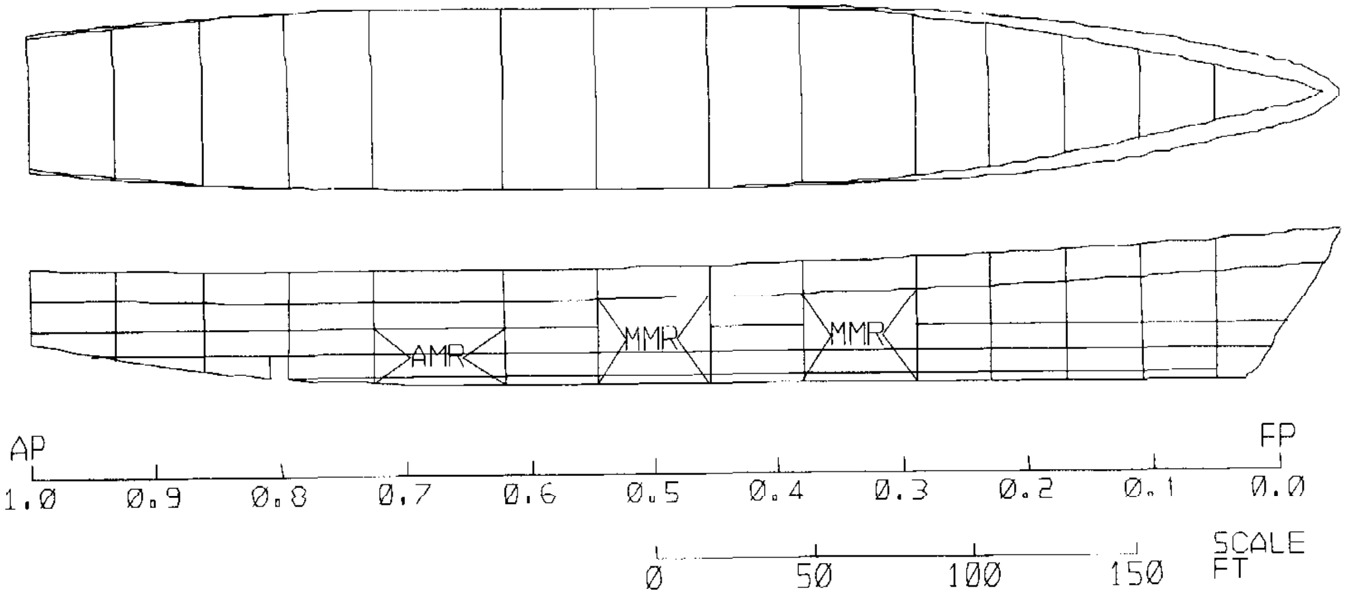

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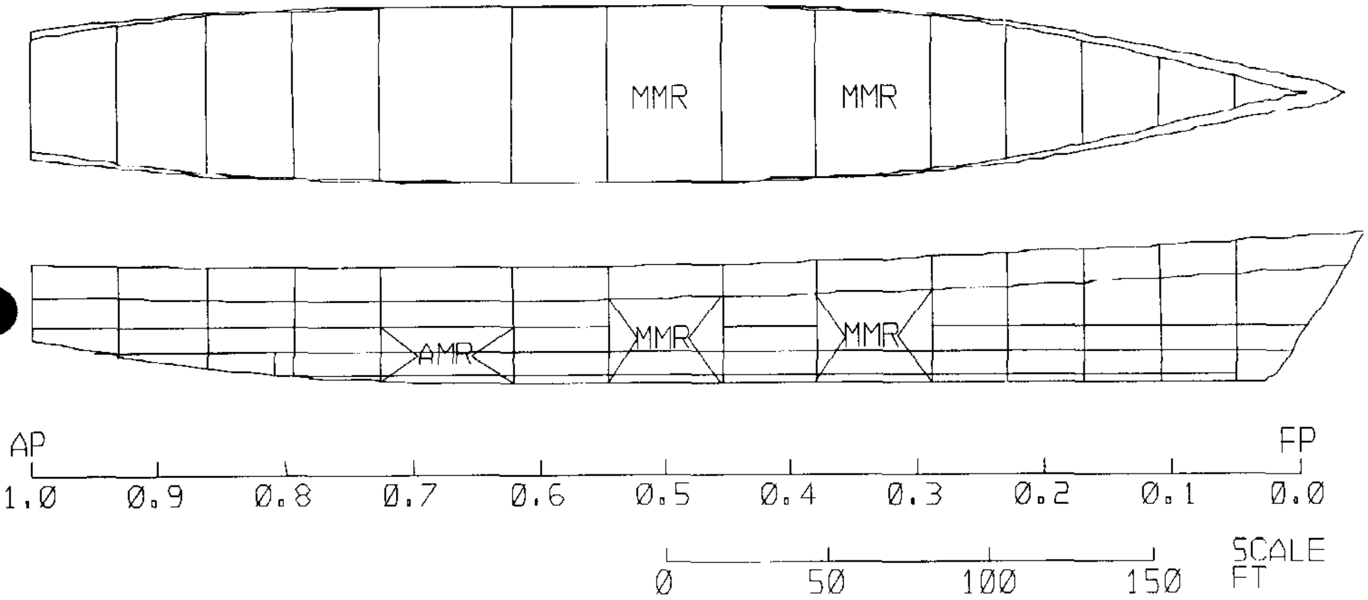
ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE -  1/14/93 14.14.14.
        GRAPHIC DISPLAY NO. 4 - HULL DECKS AND PLATFORMS
                          1ST PLATFORM
                      (INTERNAL DECK NO. 2)

            TOTAL AREA, FT2                      17254.4
            UNUSABLE AREA FWD, FT2                -100.3
            UNUSABLE AREA AFT, FT2                   0.0
            LOST MR AREA, FT2                    -3769.9
            LOST REQ TANKAGE AREA, FT2               0.0
                                                --------
            AVL ARR AREA, FT2                    13384.2
```



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ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE -  1/14/93 14.14.14.
         GRAPHIC DISPLAY NO. 5 - HULL DECKS AND PLATFORMS
                          2ND PLATFORM
                     (INTERNAL DECK NO. 3)

              TOTAL AREA, FT2                     14928.3
              UNUSABLE AREA FWD, FT2                -70.8
              UNUSABLE AREA AFT, FT2                 -7.2
              LOST MR AREA, FT2                   -5764.2
              LOST REQ TANKAGE AREA, FT2              0.0
                                                  --------
              AVL ARR AREA, FT2                    9086.1
```
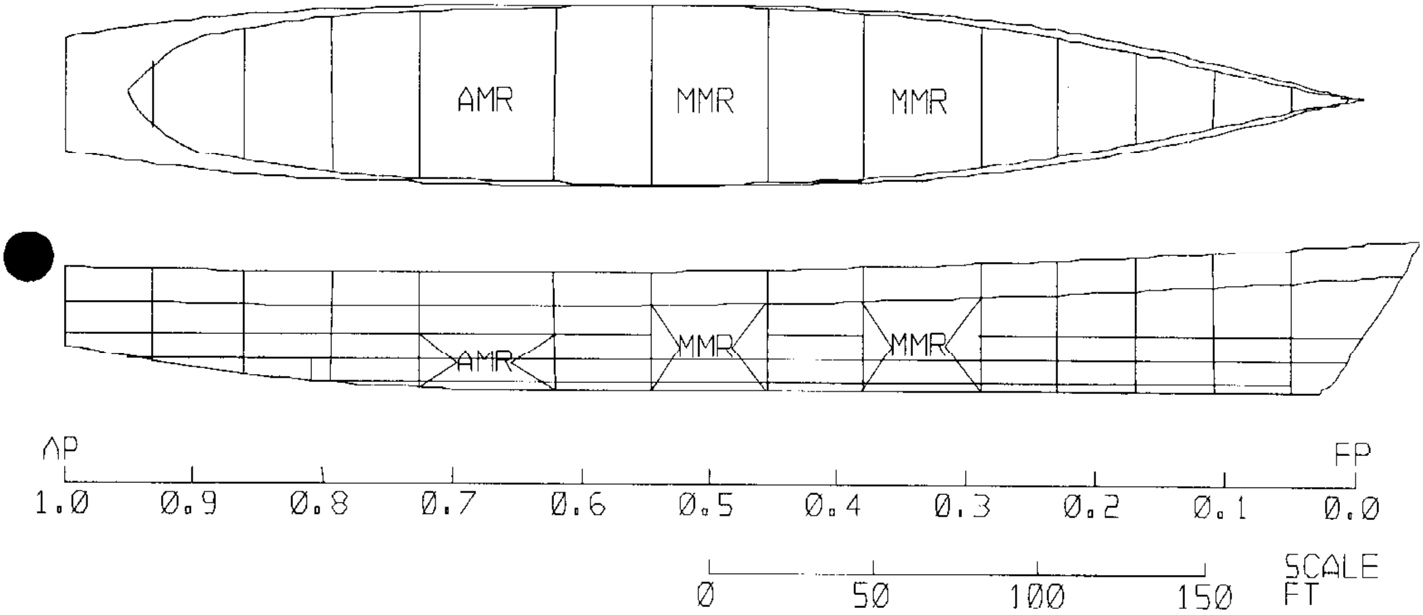
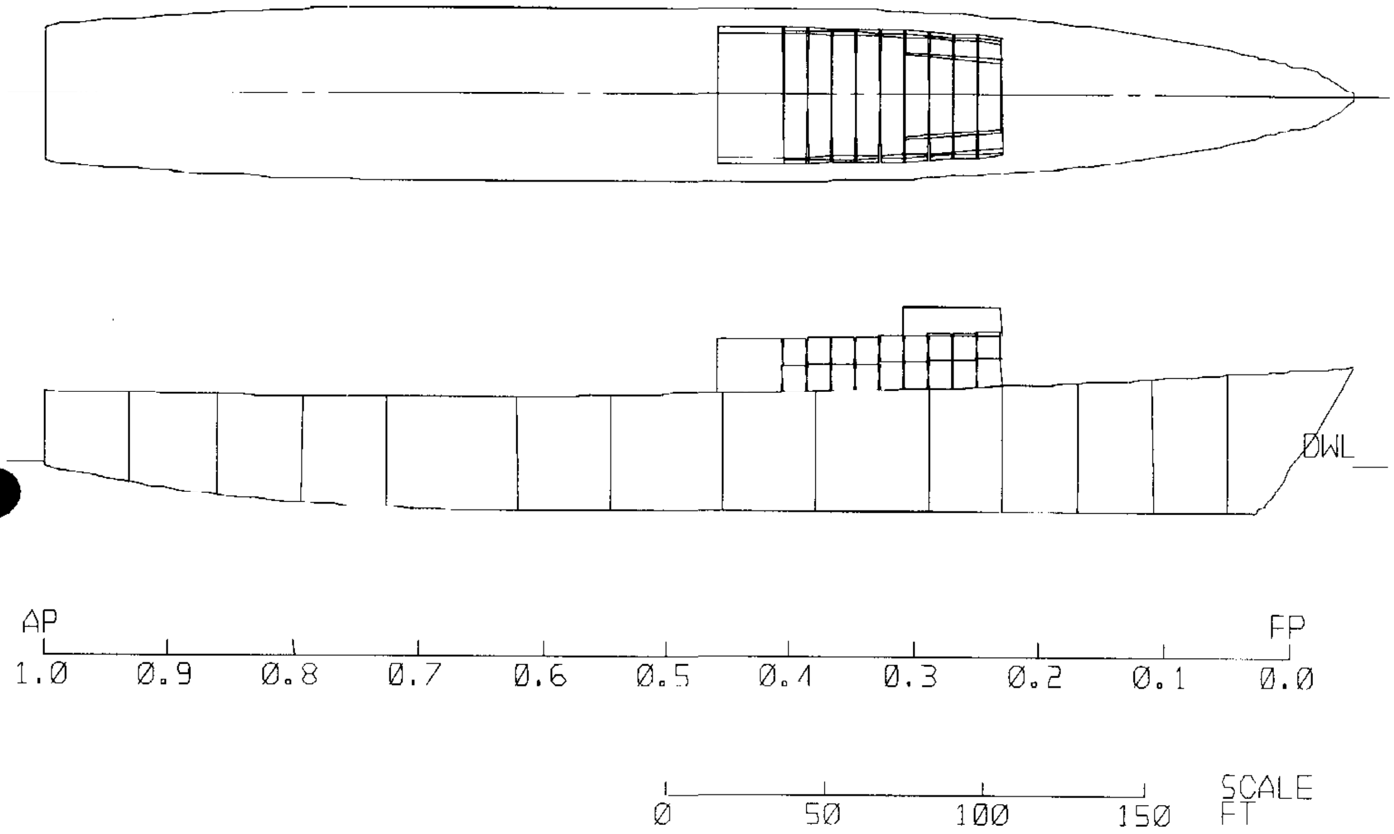



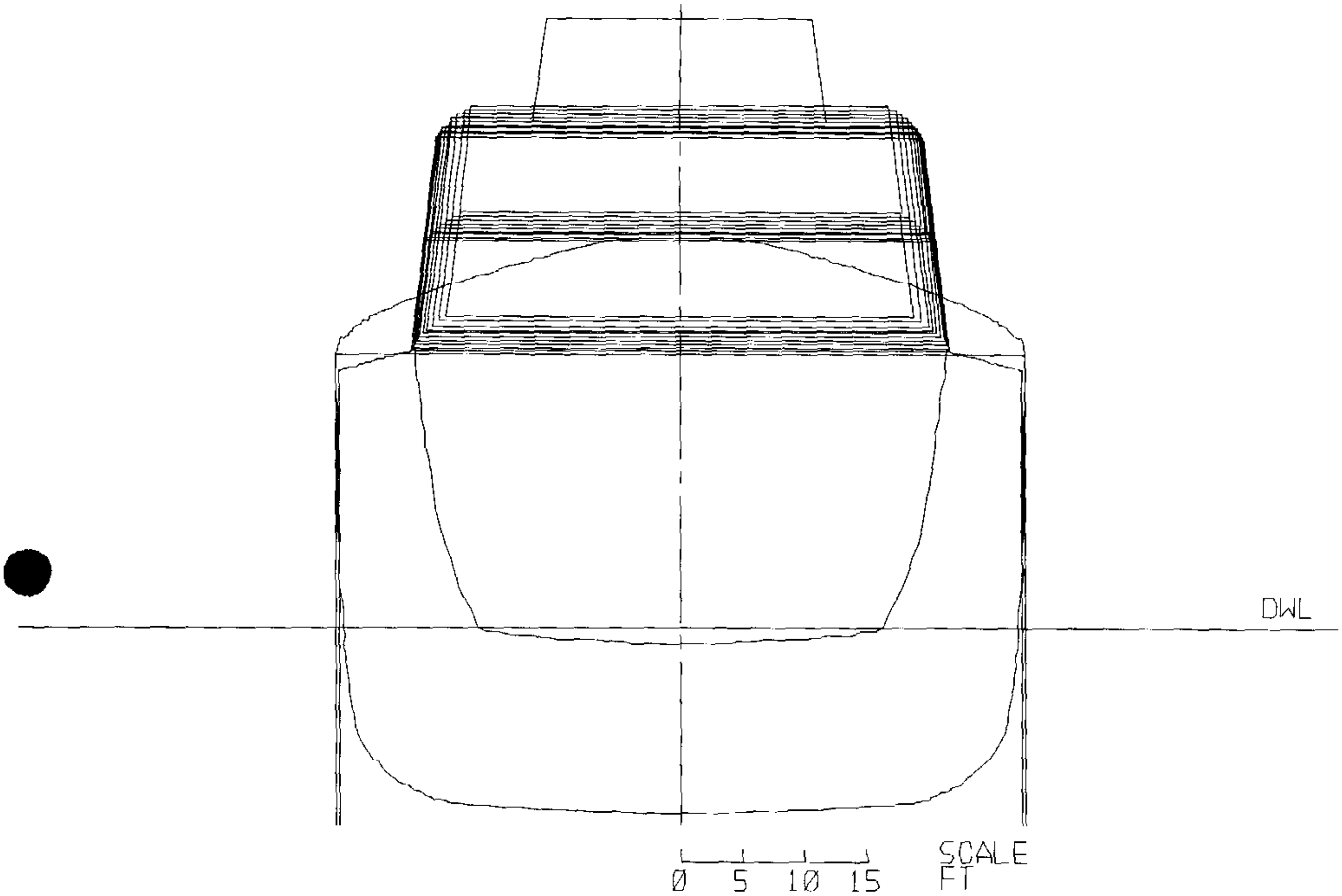
I)

ASSET/MONOSC VERSION 3.2 - DECKHOUSE MODULE - 1/15/93 09.09.51.
GRAPHIC DISPLAY NO. 1 - DECKHOUSE PROFILE AND PLAN VIEWS



I>

ASSET/MONOSC VERSION 3.2 - DECKHOUSE MODULE - 1/15/93 09.09.51.
GRAPHIC DISPLAY NO. 2 - DECKHOUSE END VIEW



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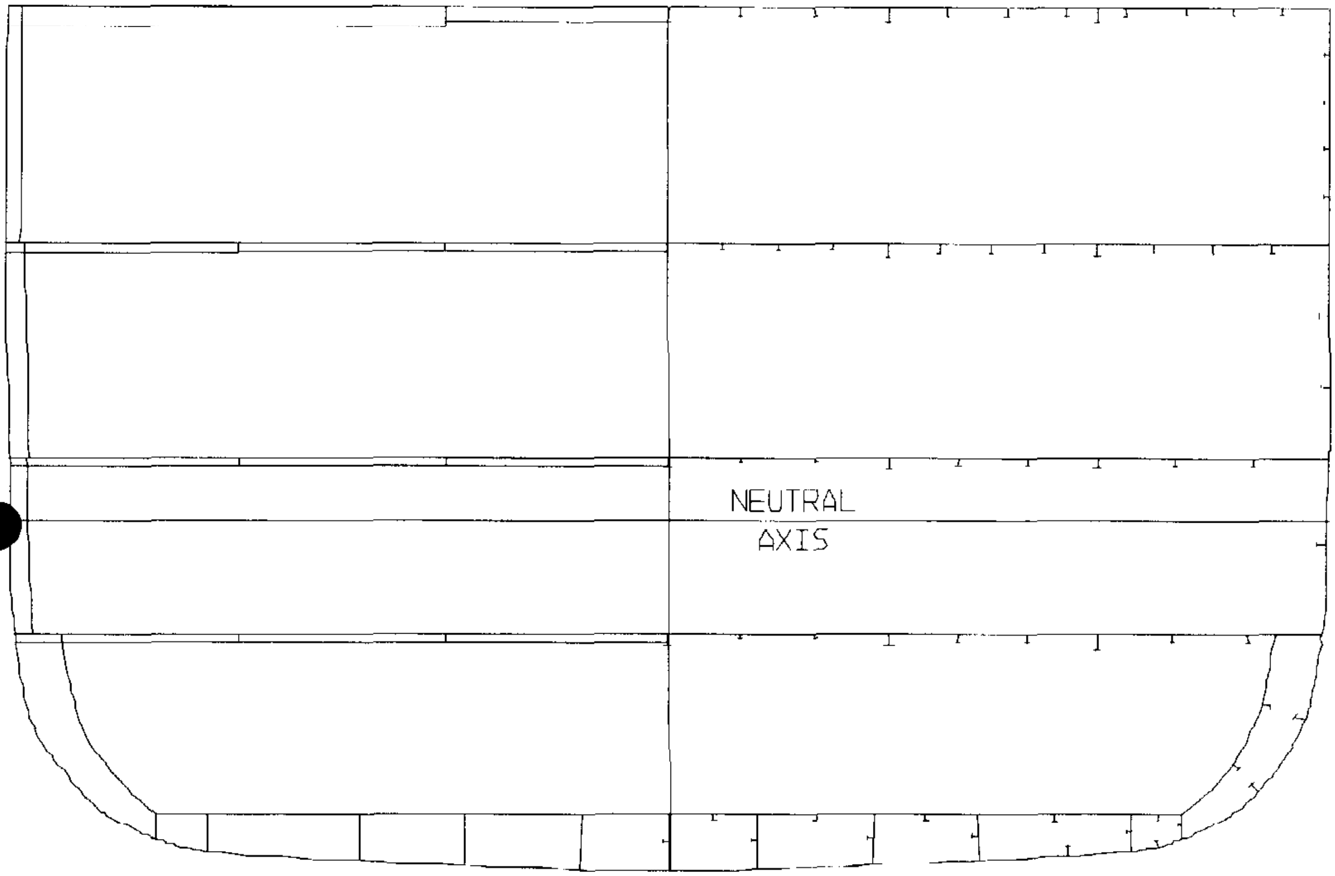
ASSET/MONOSC VERSION 3.2 HULL STRUCT MODULE 1/15/93 09.11.27.

GRAPHIC DISPLAY NO. 1 - MIDSHIP SECTION



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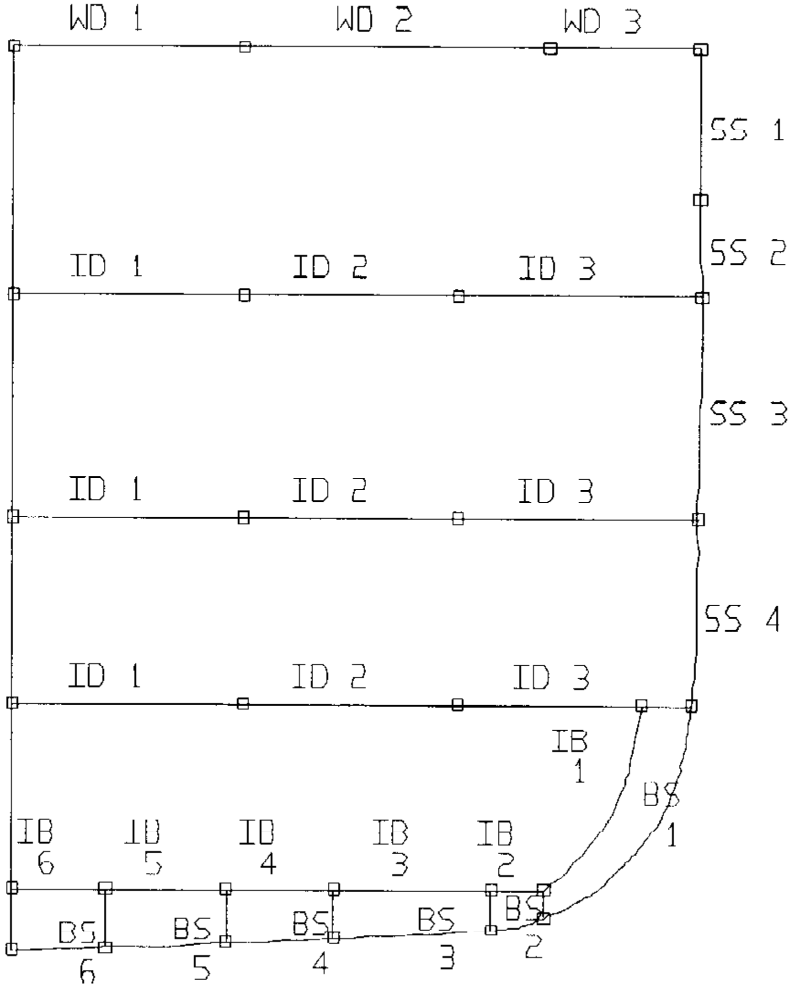
ASSET/MONOSC VERSION 3.2 - HULL STRUCT MODULE - 1/15/93 09.11.27.
GRAPHIC DISPLAY NO. 2 - SEGMENT NODF POINTS



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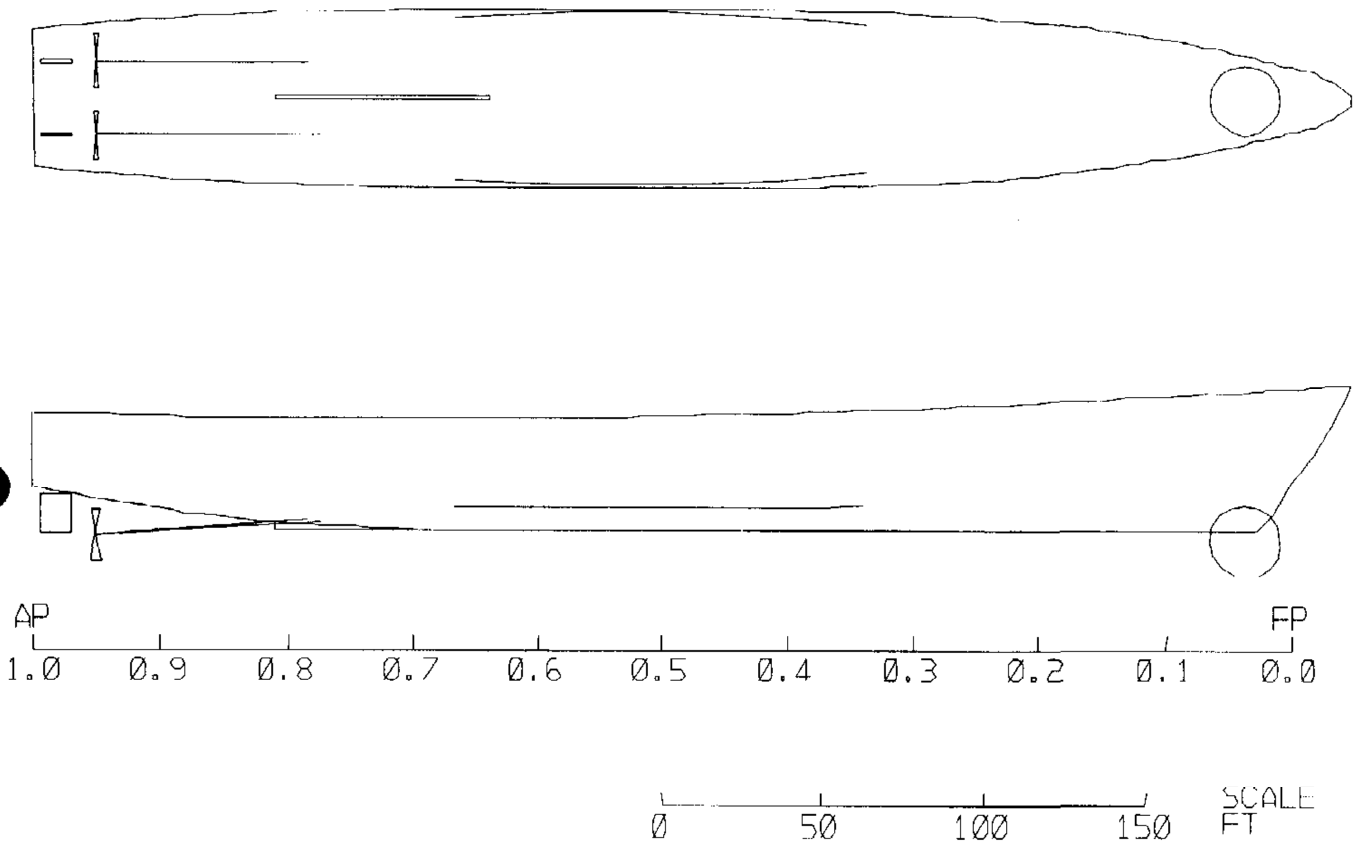
ASSET/MONOSC VERSION 3.2 - APPENDAGE MODULE - 1/15/93 09.12.59.
GRAPHIC DISPLAY NO. 1 - HULL PROFILE AND PLAN VIEW WITH APPENDAGES



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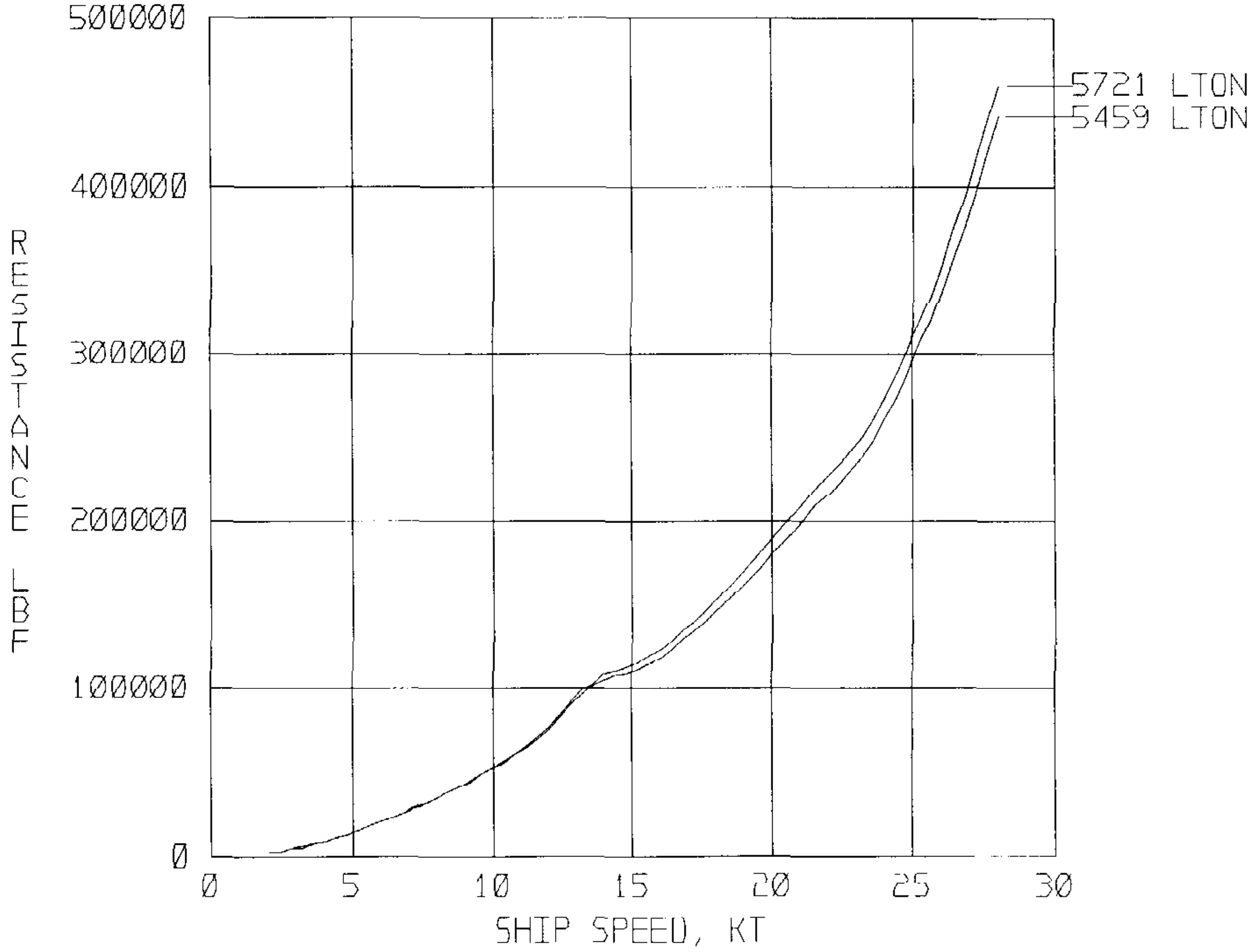
ASSET/MONOSC VERSION 3.2 - RESISTANCE MODULE - 1/15/93 09.13.38.
GRAPHIC DISPLAY NO. 1 - RESISTANCE VERSUS SPEED



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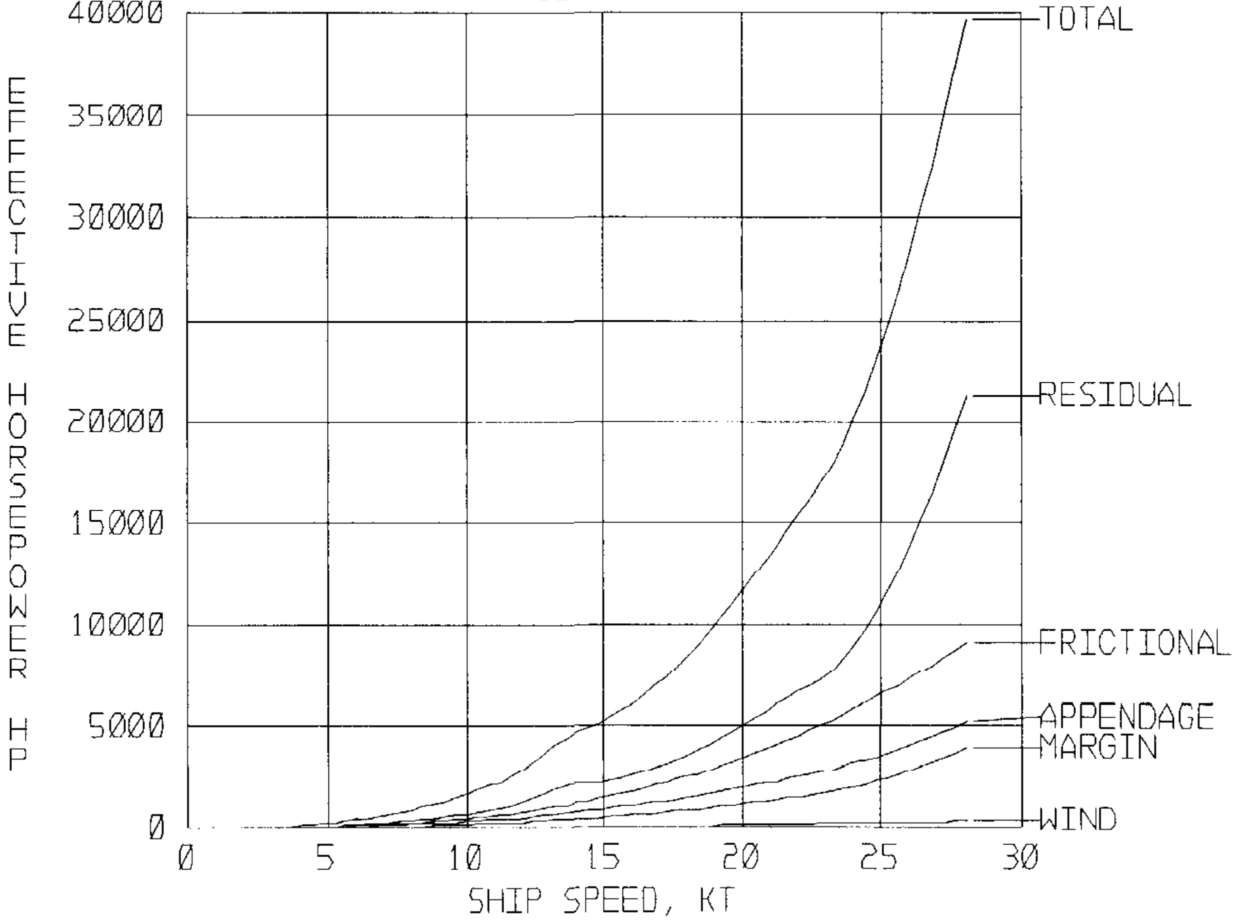
ASSET/MONOSC VERSION 3.2 - RESISTANCE MODULE - 1/15/93 09.13.38.

GRAPHIC DISPLAY NO. 2 - EHP VERSUS SPEED

PAGE 1 OF 2



DISPLACEMENT = 5721 LTON

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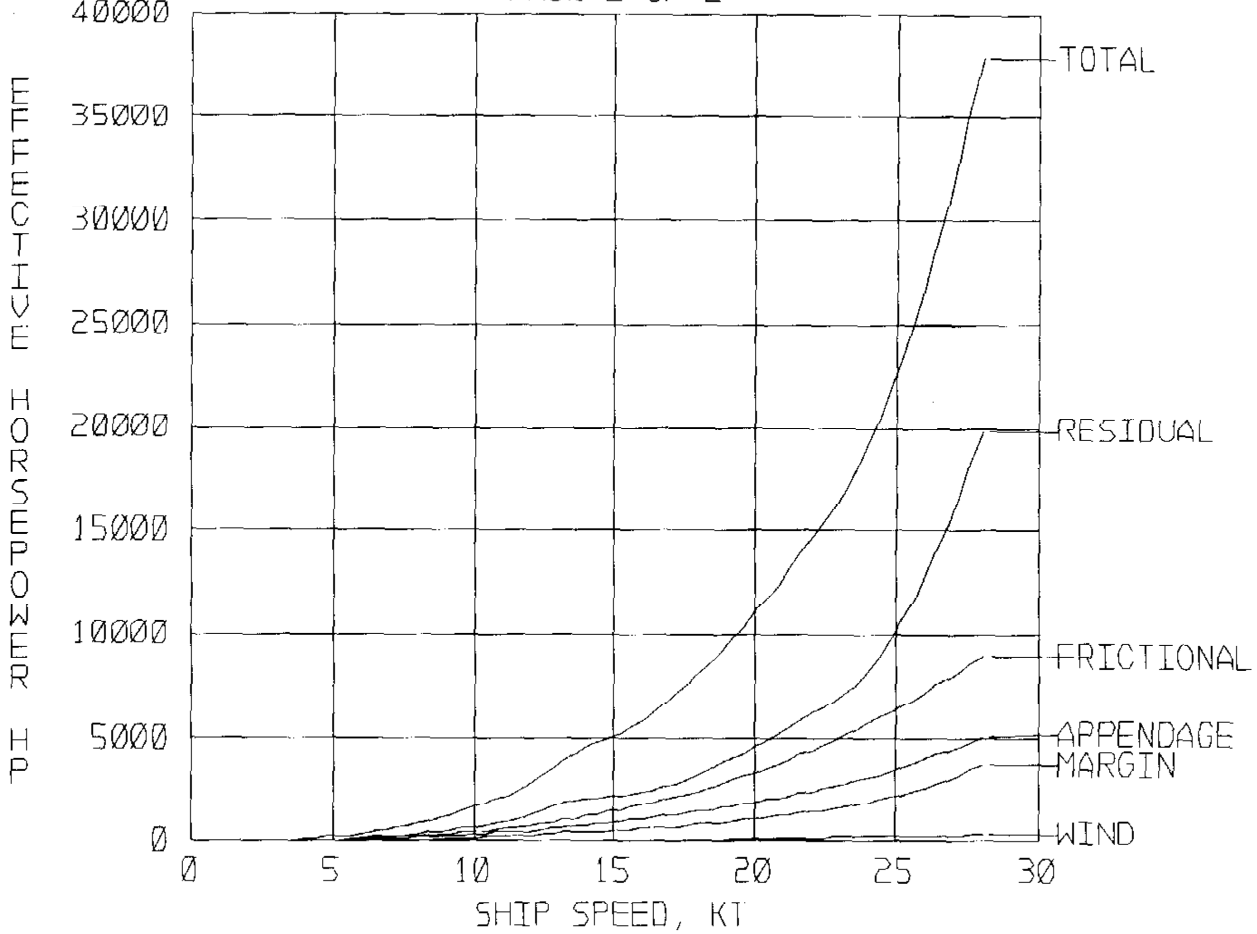
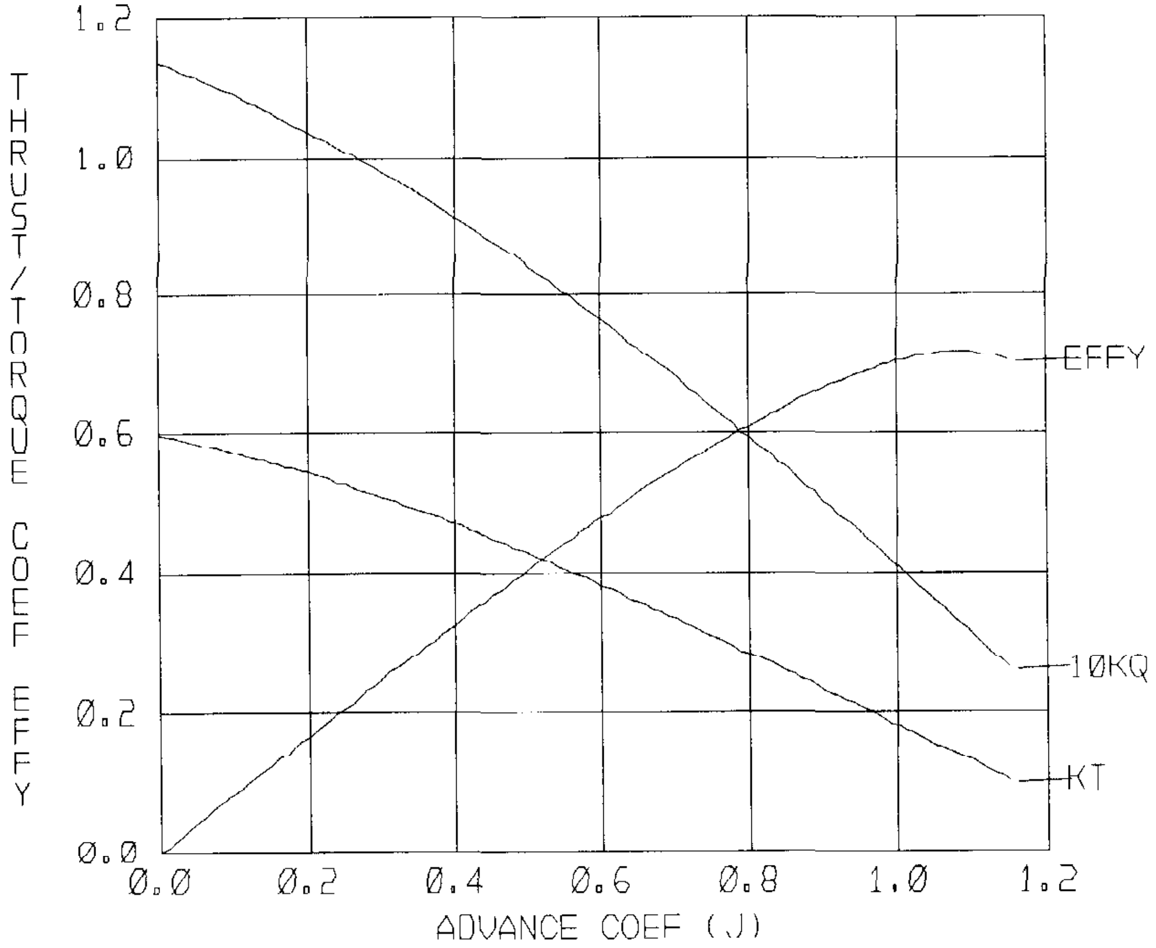
ASSET/MONOSC VERSION 3.2 - RESISTANCE MODULE - 1/15/93 09.13.38.
GRAPHIC DISPLAY NO. 2 - EHP VERSUS SPEED
PAGE 2 OF 2



DISPLACEMENT = 5459 LTON

ASSET/MONOSC VERSION 3.2 - PROPELLER MODULE - 1/15/93 09.15.05.

GRAPHIC DISPLAY NO. 1 - OPEN WATER DIAGRAM



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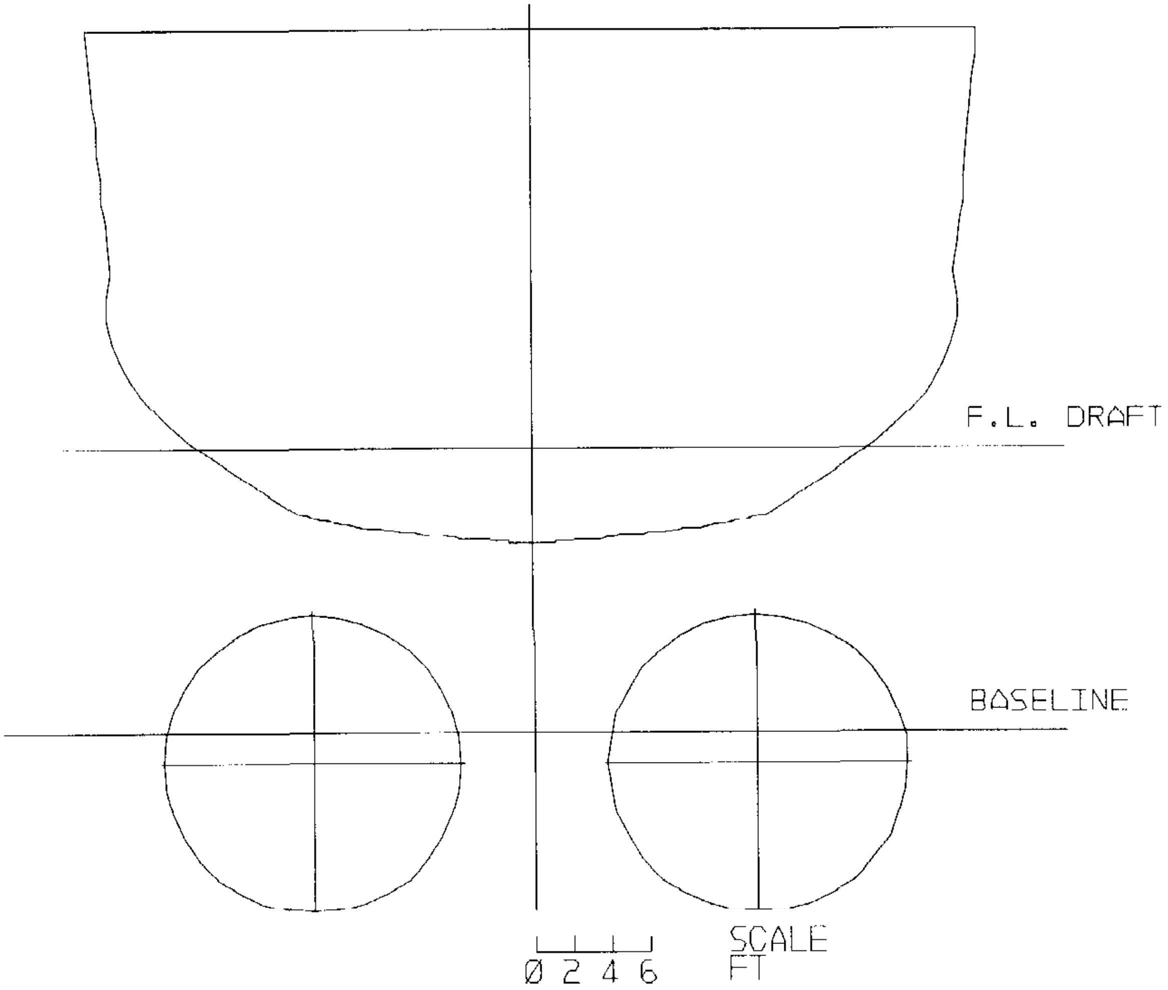
ASSET/MONOSC VERSION 3.2 - PROPELLER MODULE - 1/15/93 09.15.05.
GRAPHIC DISPLAY NO. 2 - TRANSVERSE SECTION



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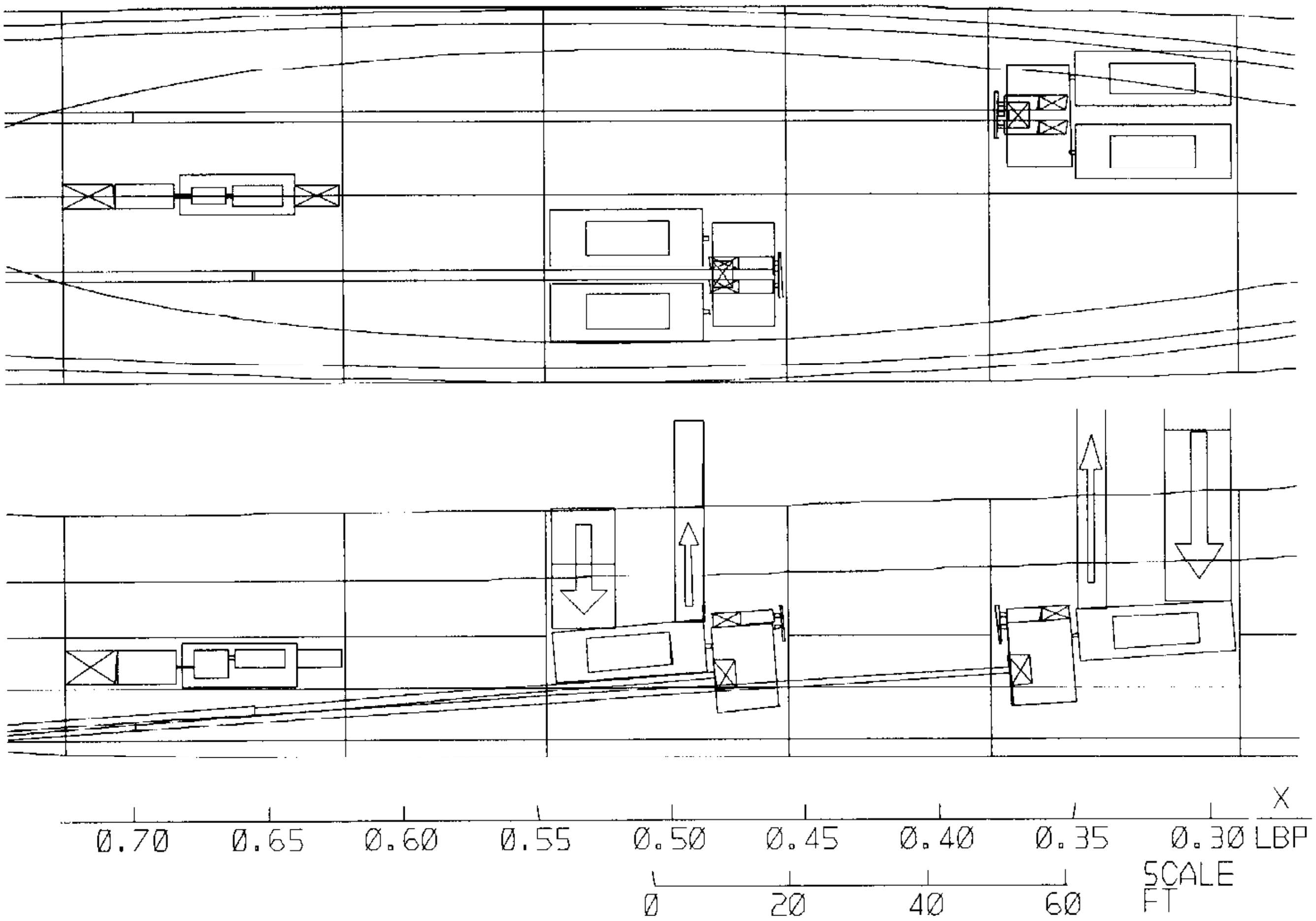
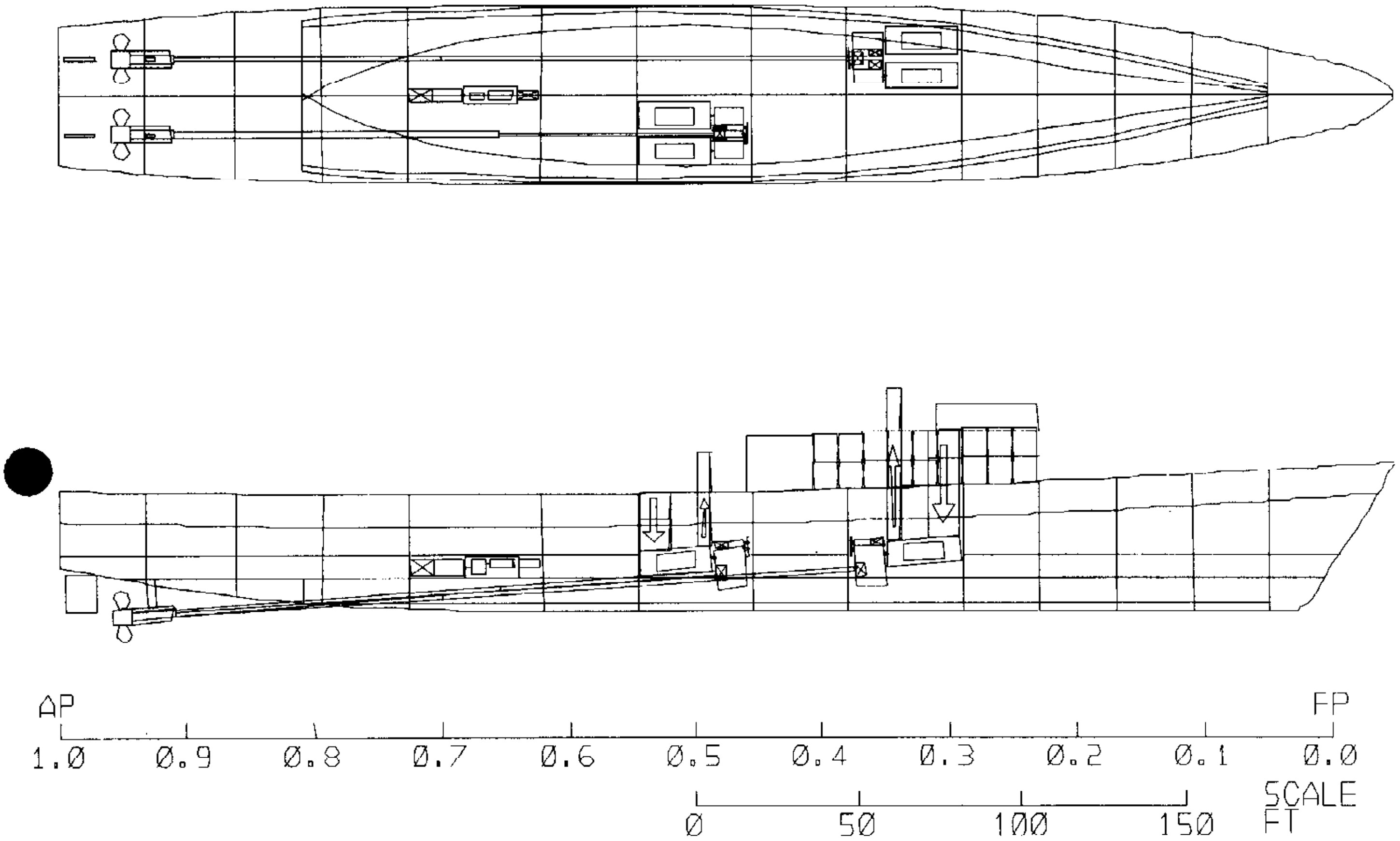
ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 1/15/93 09.21.02.
GRAPHIC DISPLAY NO. 2 - MACHINERY BOX



ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 1/15/93 09.21.02.
GRAPHIC DISPLAY NO. 1 SHIP MACHINERY LAYOUT



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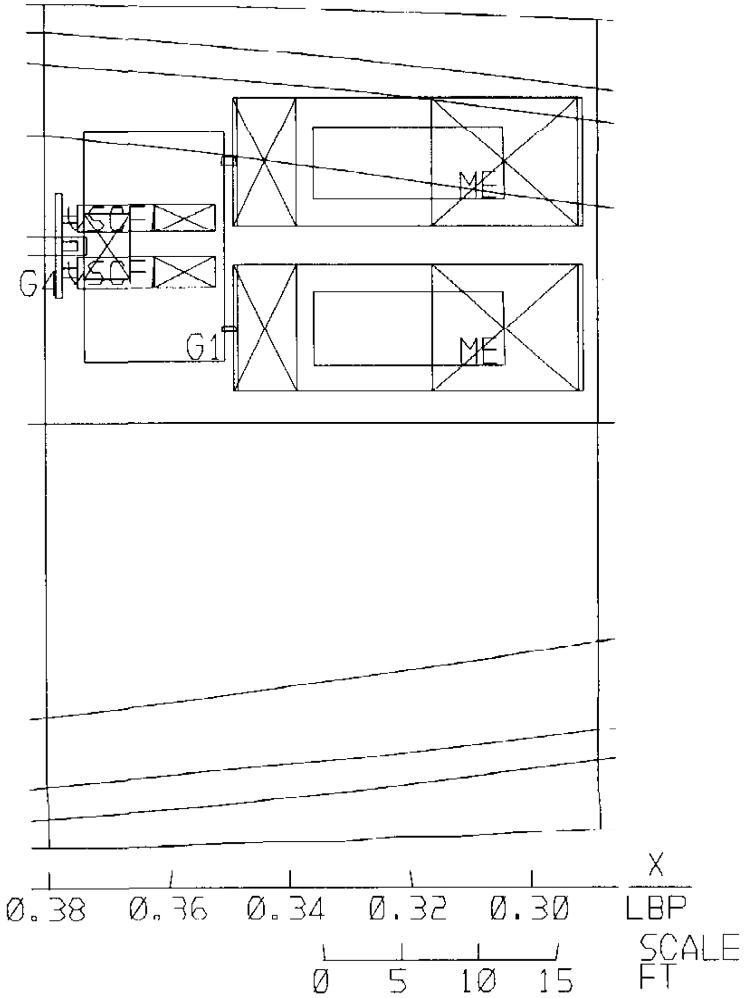
ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 1/15/93 09.21.02.
GRAPHIC DISPLAY NO. 3 - MR PLAN VIEWS (MMR1)
PAGE 1 OF 3



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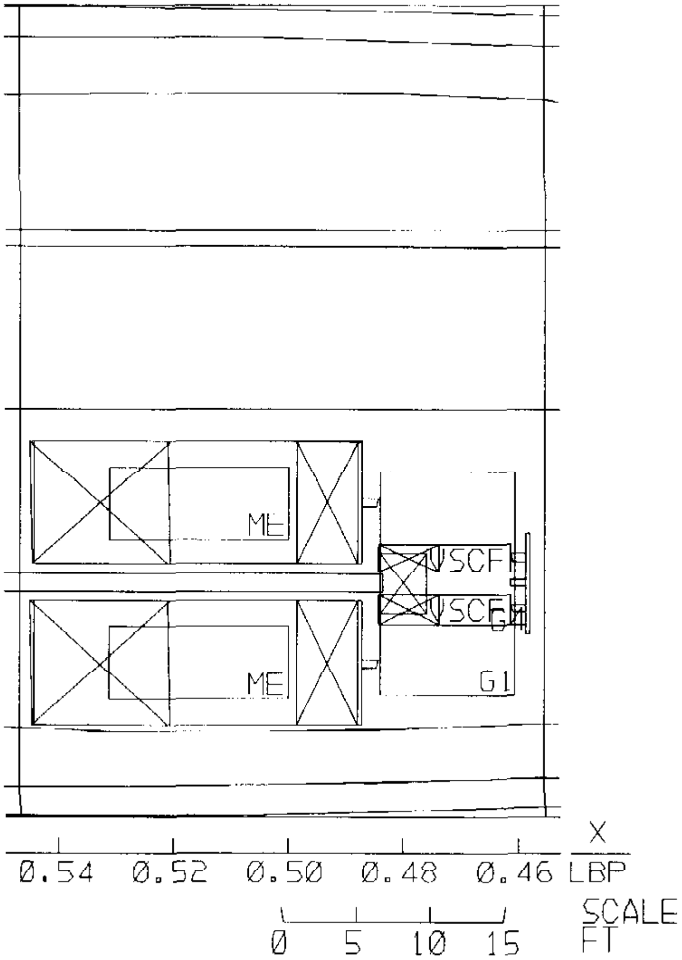
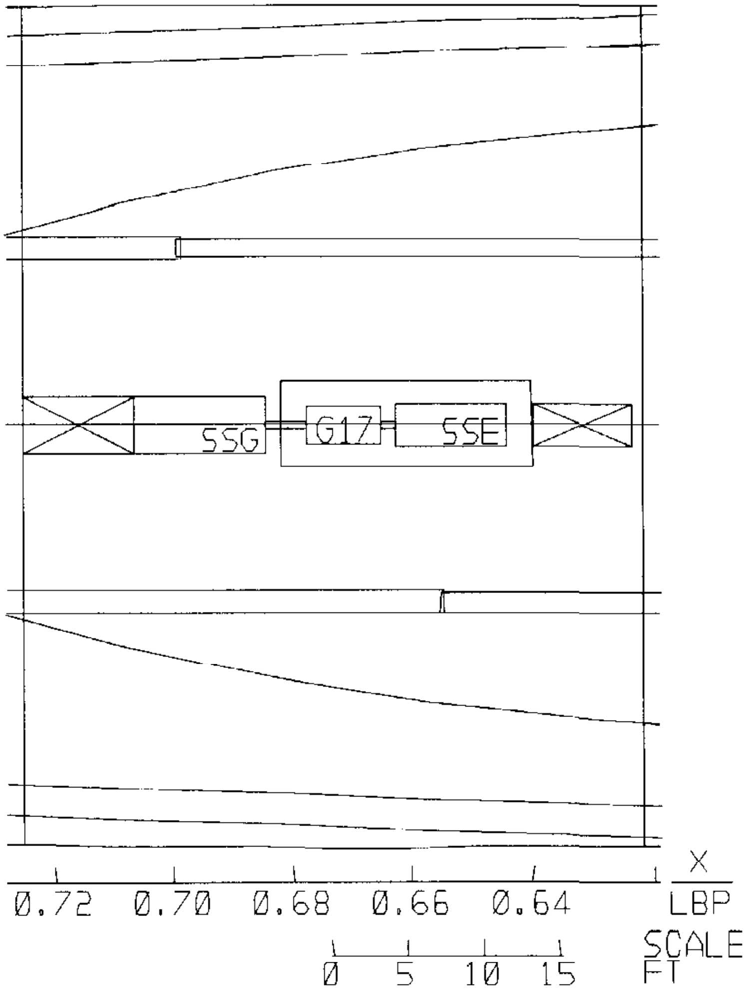
ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 1/15/93 09.21.02.
GRAPHIC DISPLAY NO. 3 - MR PLAN VIEWS (MMR2)
PAGE 2 OF 3



ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 1/15/93 09.21.02.
GRAPHIC DISPLAY NO. 3 - MR PLAN VIEWS (AMR1)
PAGE 3 OF 3



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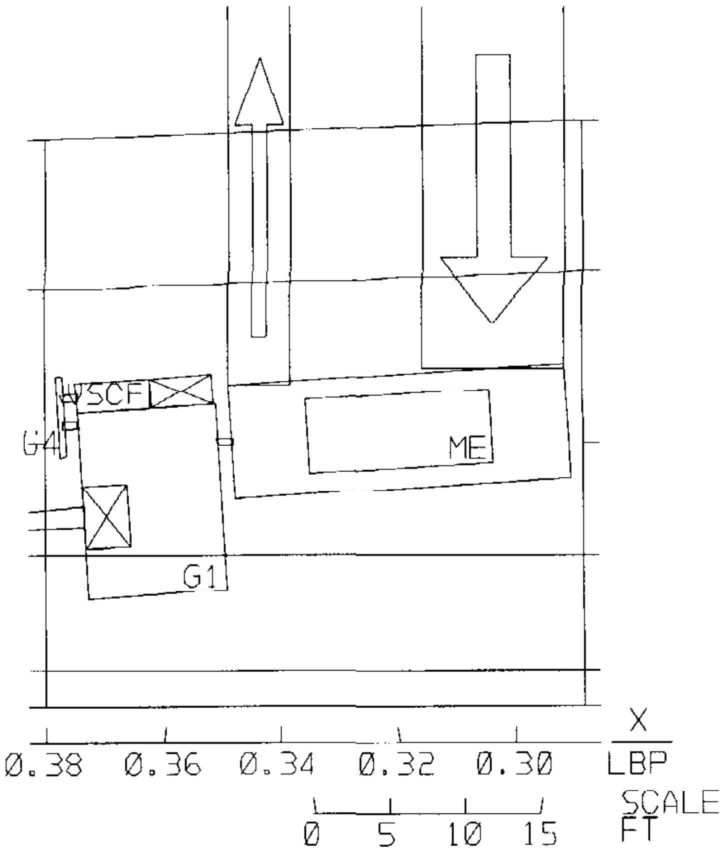
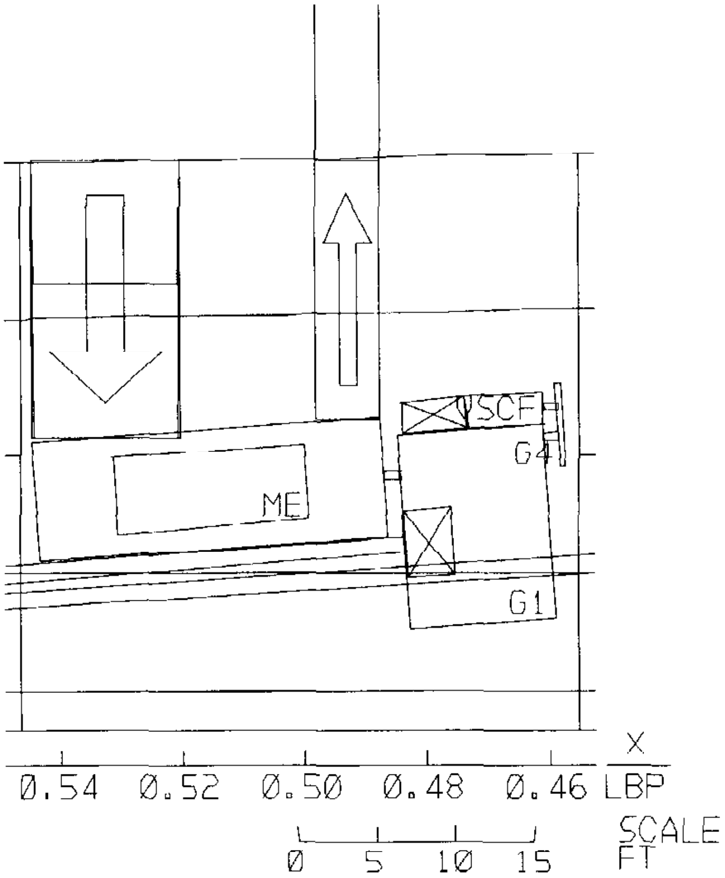
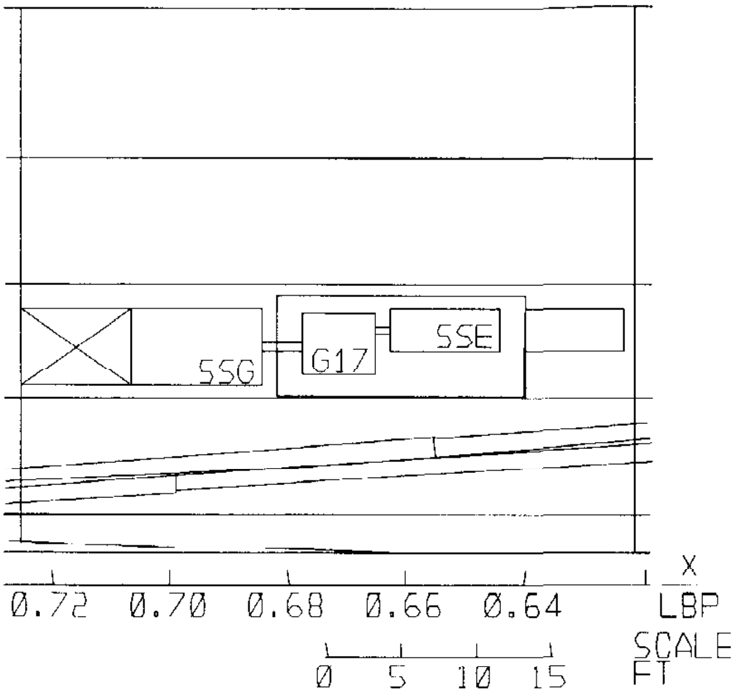
ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 1/15/93 09.21.02.
GRAPHIC DISPLAY NO. 4 - MR PROFILE VIEWS (MMR1)
PAGE 1 OF 3



ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 1/15/93 09.21.02.
GRAPHIC DISPLAY NO. 4 - MR PROFILE VIEWS (MMR2)
PAGE 2 OF 3



ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 1/15/93 09.21.02.
GRAPHIC DISPLAY NO. 4 - MR PROFILE VIEWS (AMR1)
PAGE 3 OF 3



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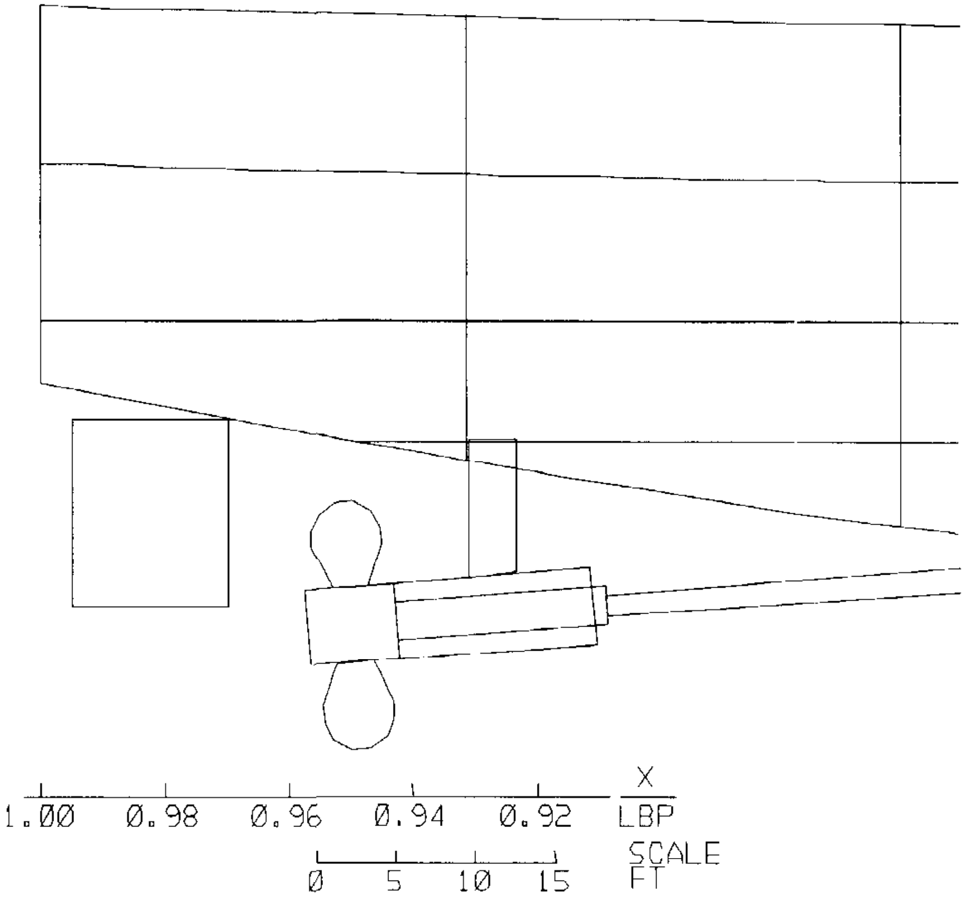
ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 1/15/93 09.21.02.
GRAPHIC DISPLAY NO. 5 - PROPULSION APPENDAGES PROFILE VIEW



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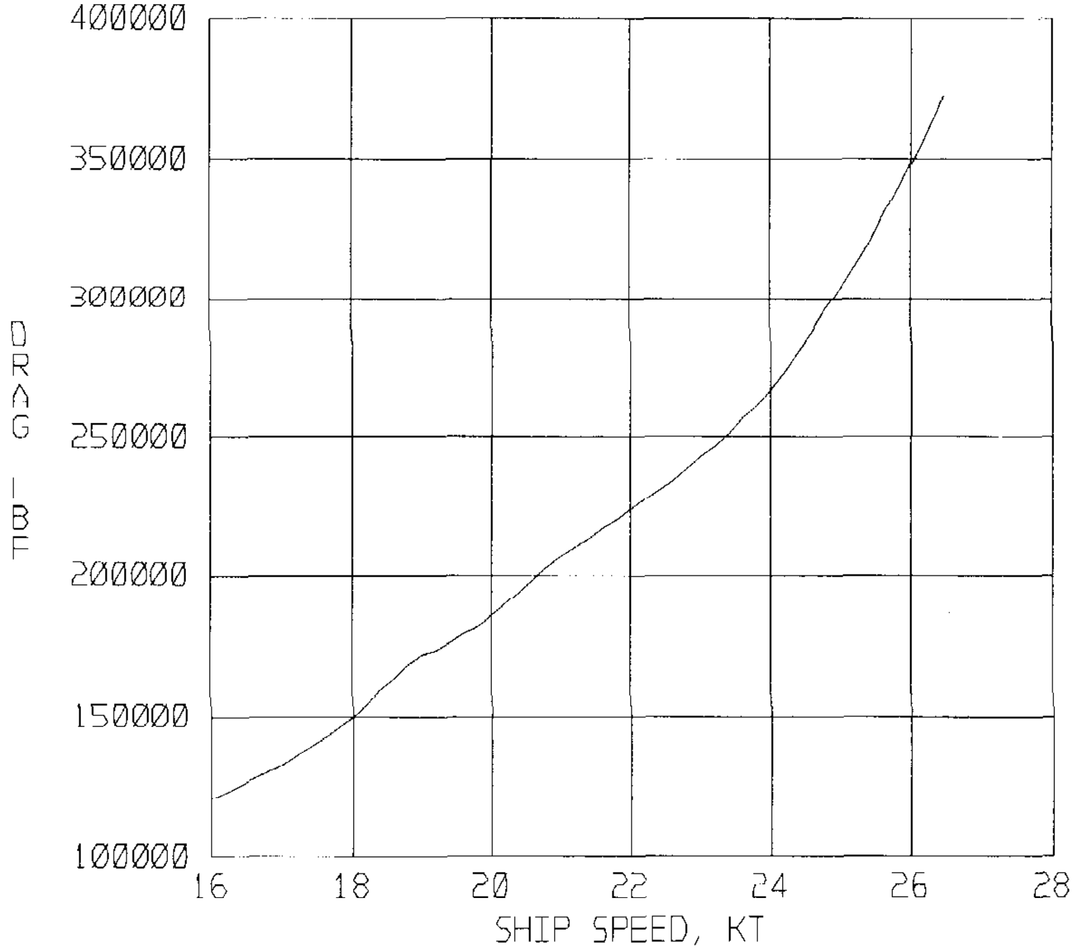
ASSET/MONOSC VERSION 3.2 - PERFORMANCE ANALYSIS - 1/15/93 09.27.26.

GRAPHIC DISPLAY NO. 1 - DRAG VERSUS SPEED



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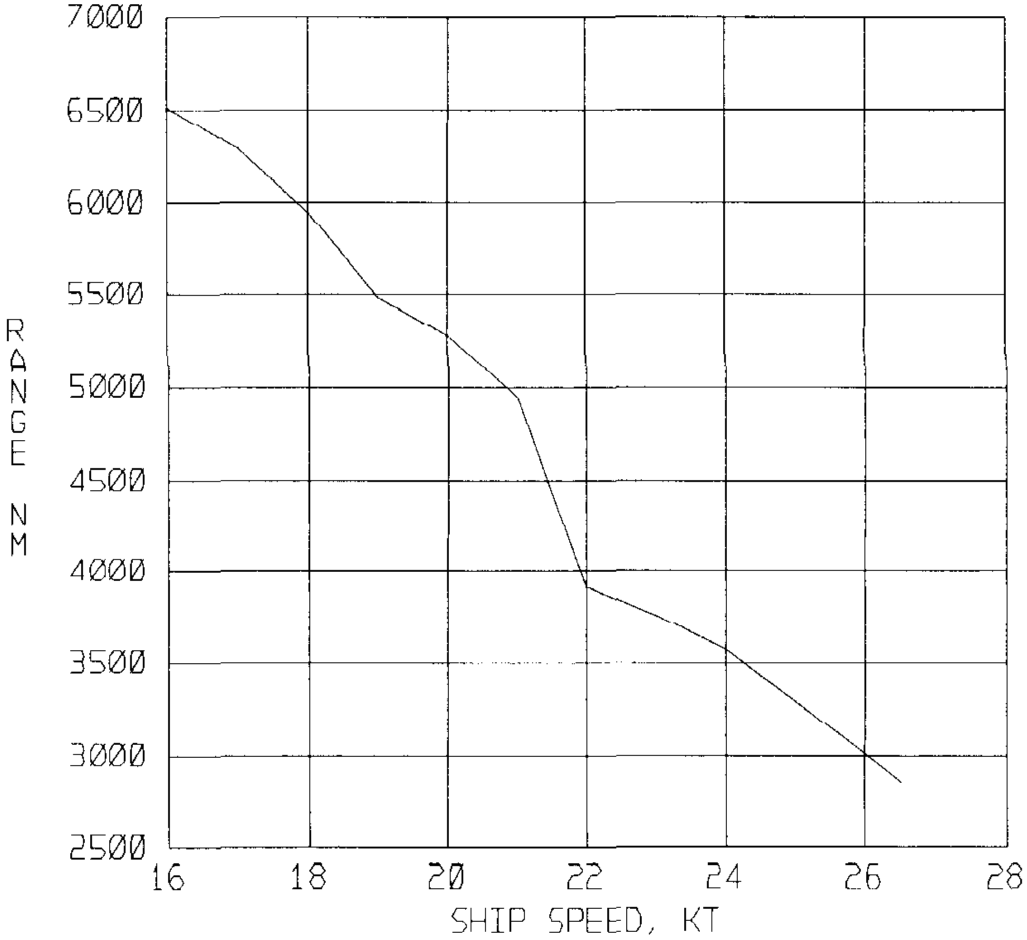
ASSET/MONOSC VERSION 3.2 - PERFORMANCE ANALYSIS - 1/15/93 09.27.26.

GRAPHIC DISPLAY NO. 2 - RANGE VERSUS SPEED



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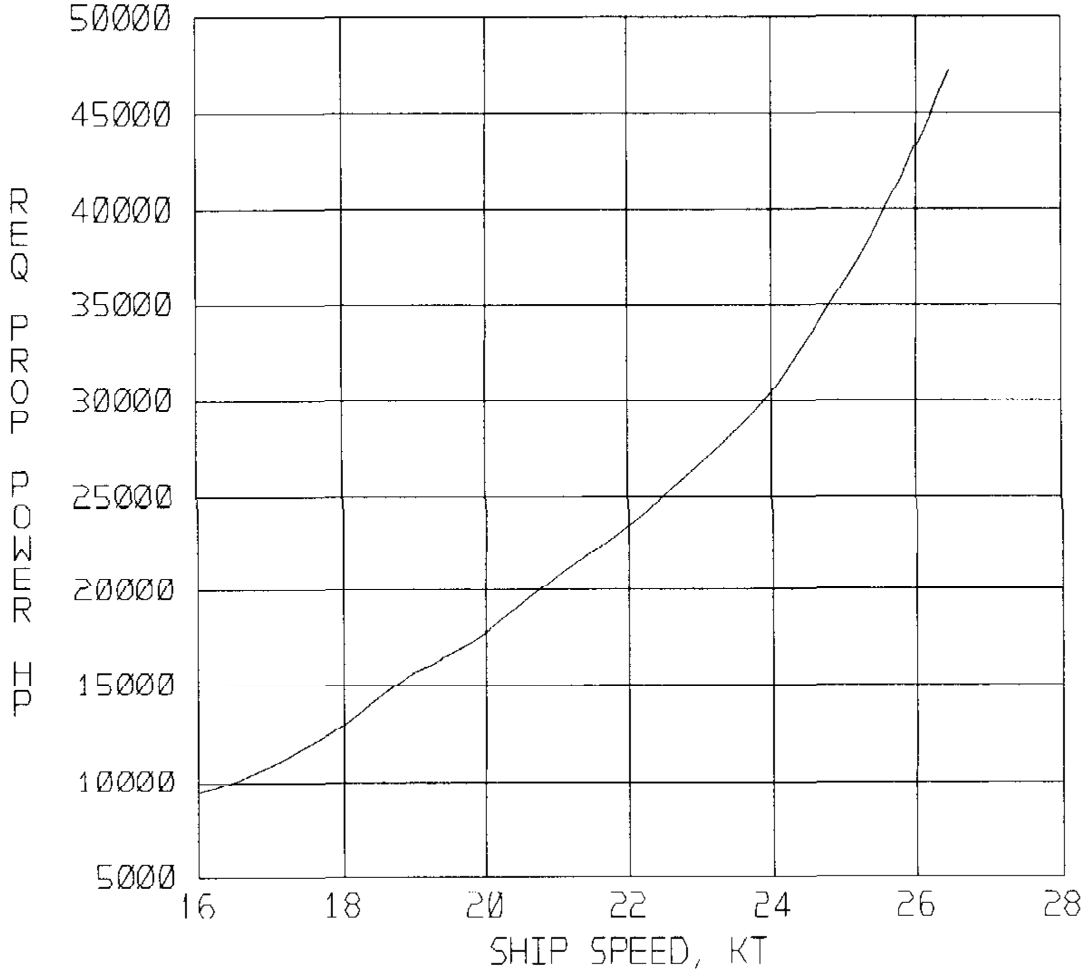
ASSET/MONOSC VERSION 3.2 - PERFORMANCE ANALYSIS - 1/15/93 09.27.26.

GRAPHIC DISPLAY NO. 3 - TOTAL POWER VERSUS SPEED



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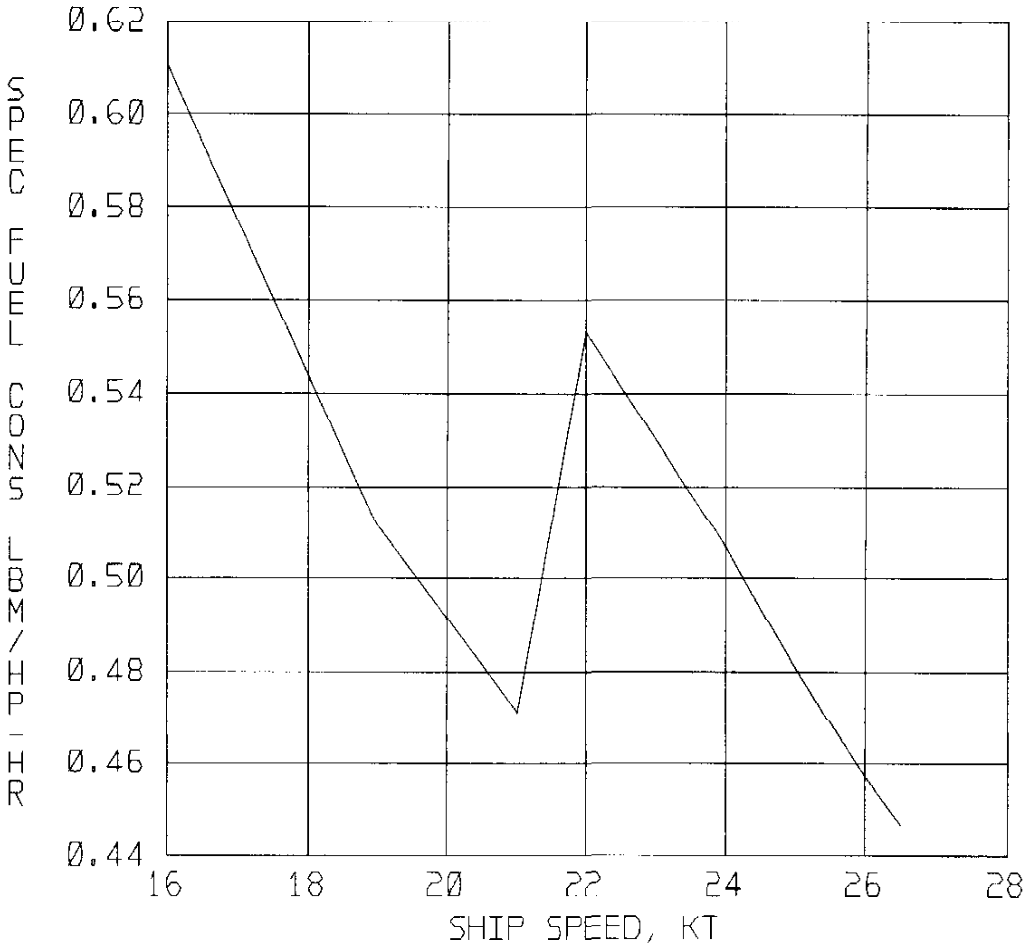
ASSET/MONOSC VERSION 3.2 - PERFORMANCE ANALYSIS - 1/15/93 09.27.26.

GRAPHIC DISPLAY NO. 4 - SFC VERSUS SPEED



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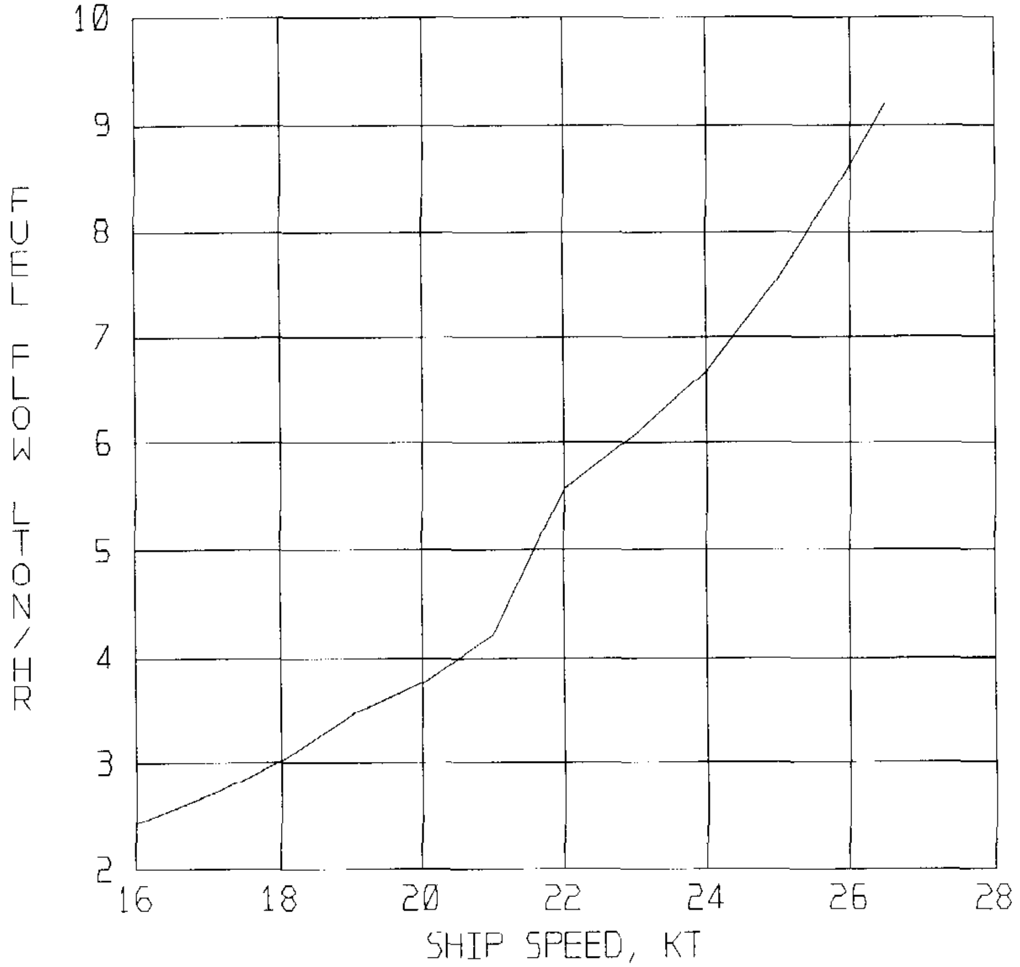
ASSET/MONOSC VERSION 3.2 - PERFORMANCE ANALYSIS - 1/15/93 09.27.26.
GRAPHIC DISPLAY NO. 5 - FUEL FLOW VERSUS SPEED



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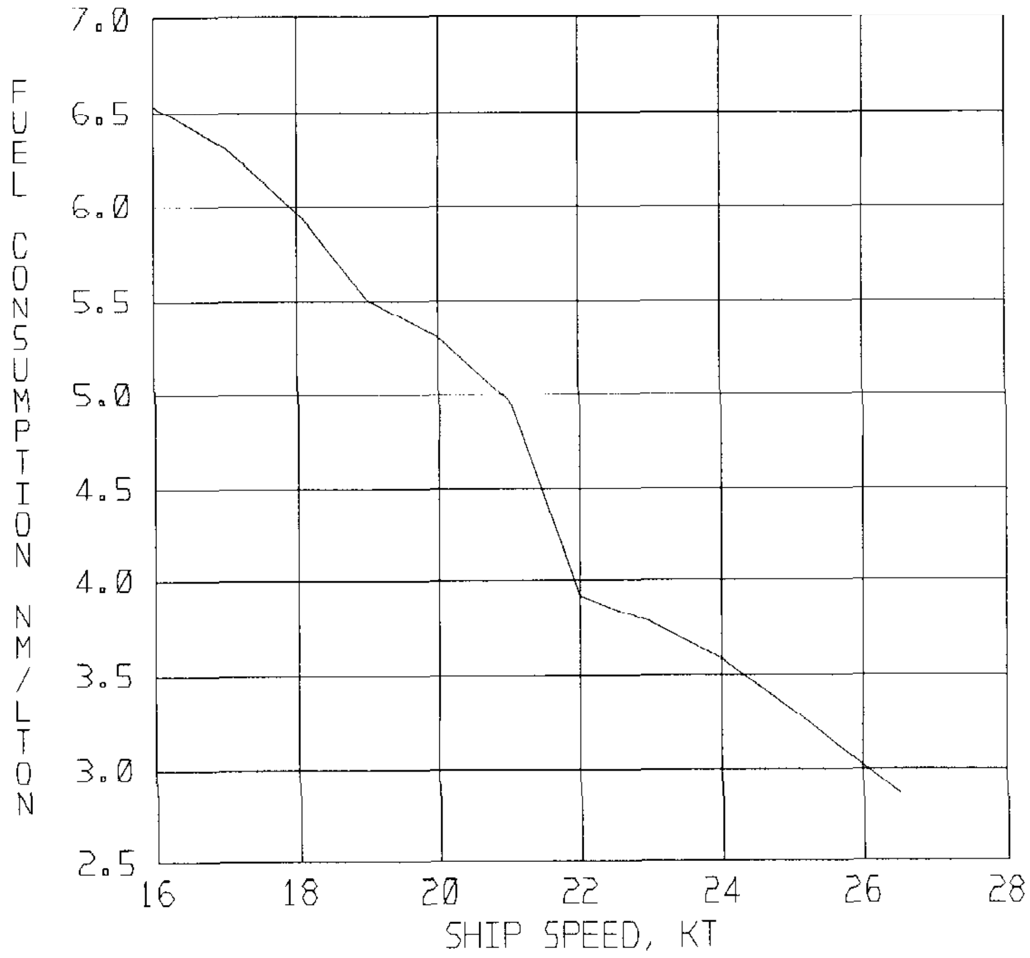
ASSET/MONOSC VERSION 3.2 - PERFORMANCE ANALYSIS - 1/15/93 09.27.26.

GRAPHIC DISPLAY NO. 6 - FUEL CONSUMPTION VERSUS SPEED



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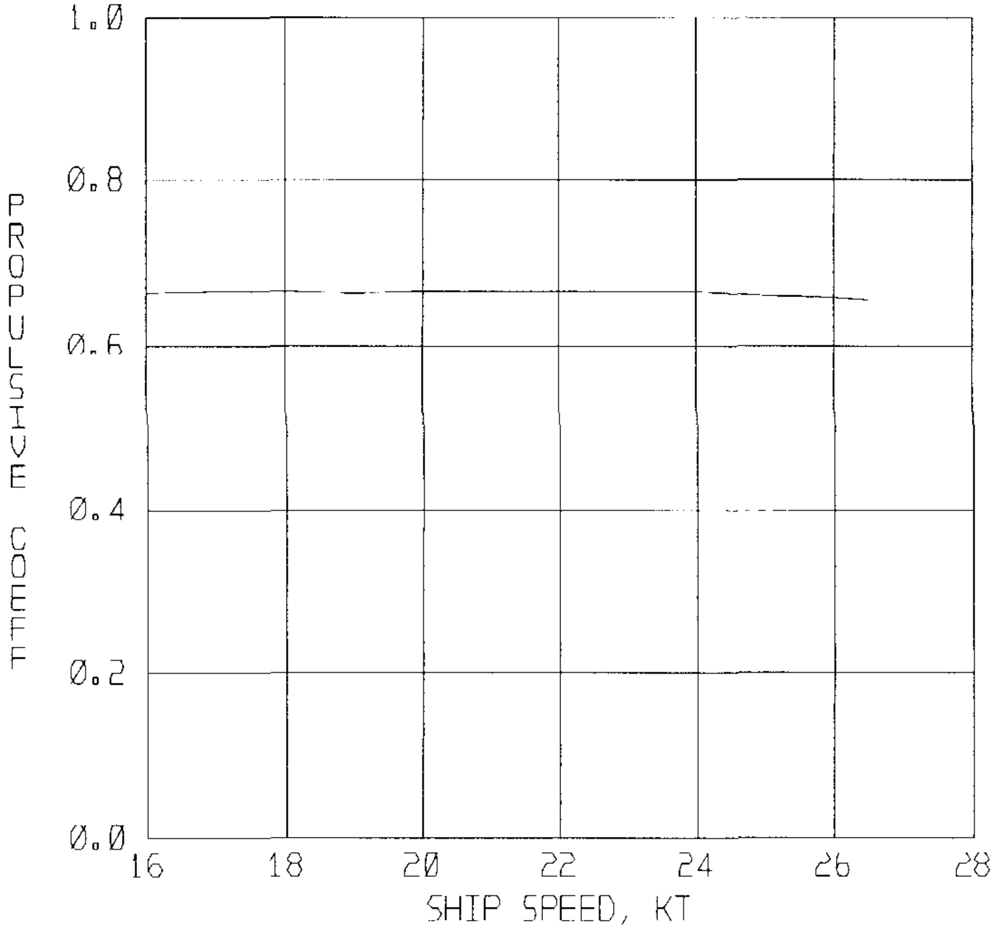
ASSET/MONOSC VERSION 3.2 - PERFORMANCE ANALYSIS - 1/15/93 09.27.26.

GRAPHIC DISPLAY NO. 7 - PROPULSIVE COEFFICIENT VERSUS SPEED



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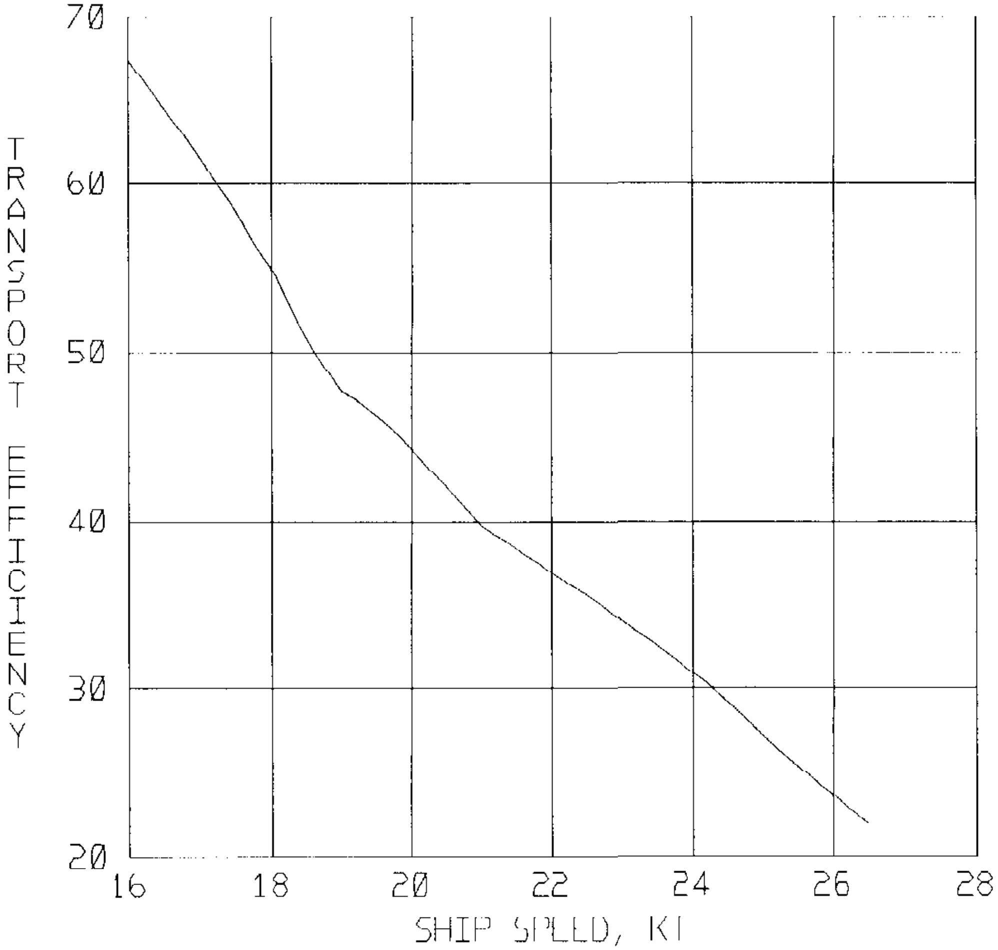
ASSET/MONOSC VERSION 3.2 - PERFORMANCE ANALYSIS - 1/15/93 09.27.26.
GRAPHIC DISPLAY NO. 8 - TRANSPORT EFFICIENCY VERSUS SPEED



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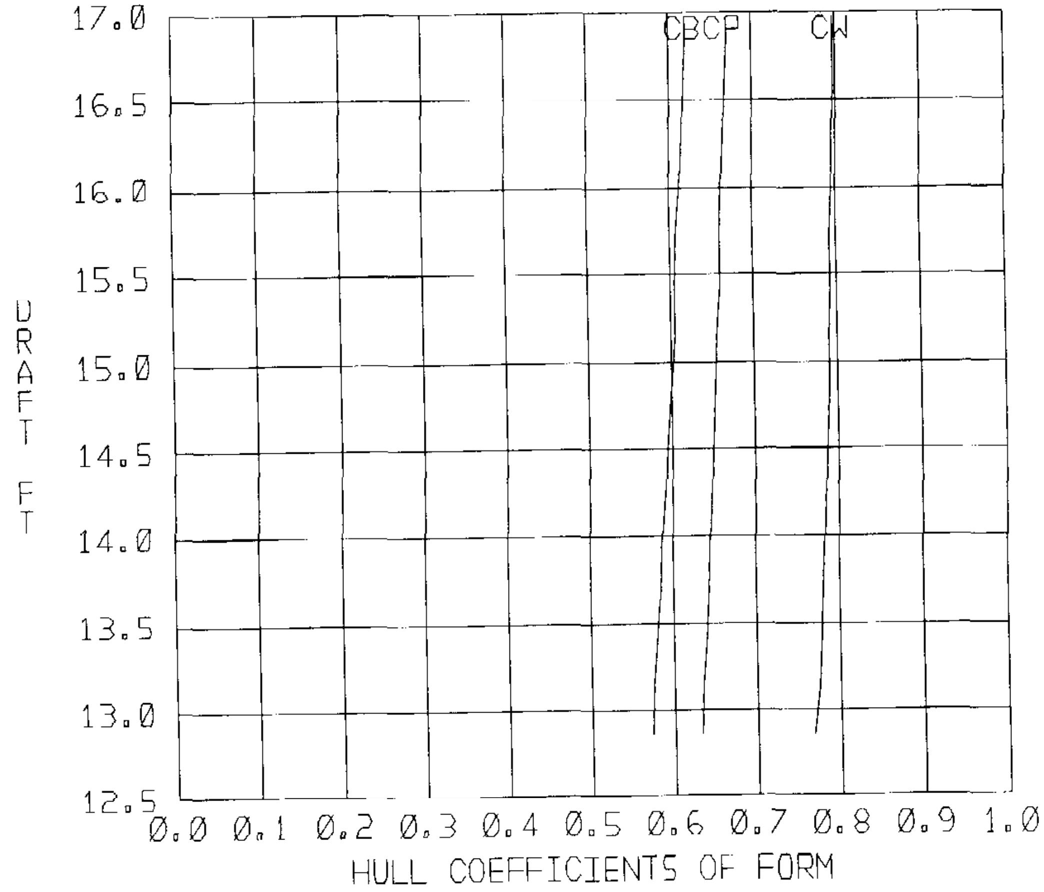
ASSET/MONOSC VERSION 3.2 - HYDROSTATIC ANALYSIS - 1/15/93 09.45.14.

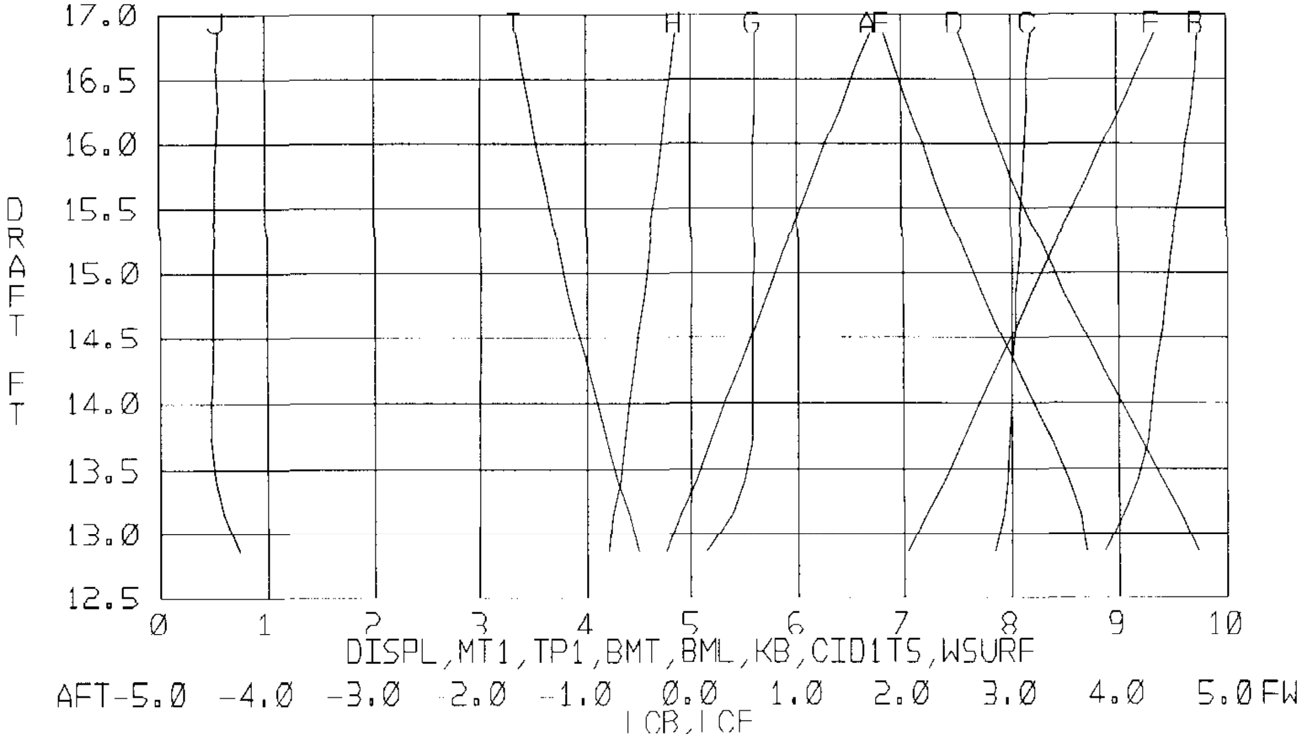
GRAPHIC DISPLAY NO. 1 - HULL COEFFICIENTS OF FORM



TRIM(+VE BY STERN), FT 2.36 APPENDAGE IND-WITH

ASSET/MONOSC VERSION 3.2 - HYDROSTATIC ANALYSIS - 1/15/93 09.45.14.

GRAPHIC DISPLAY NO. 2 - HYDROSTATIC VARIABLES OF FORM



```
A DISPL  (1000 LTON)/UNIT              F KB      (    1 FT)/UNIT
B MT1    ( 100 FT-LTON/IN)/UNIT        G CID1TS(    5 LTON/FT)/UNI
C TP1    (   5 LTON/IN)/UNIT           H WSURF (5000 FT2)/UNIT
D BMT    (   2 FT)/UNIT                I LCB    (    5 FT)/UNIT
E BML    ( 100 FT)/UNIT                J LCF    (    5 FT)/UNIT
TRIM(+VE BY STERN), FT        2.36      APPENDAGE IND-WITH
```

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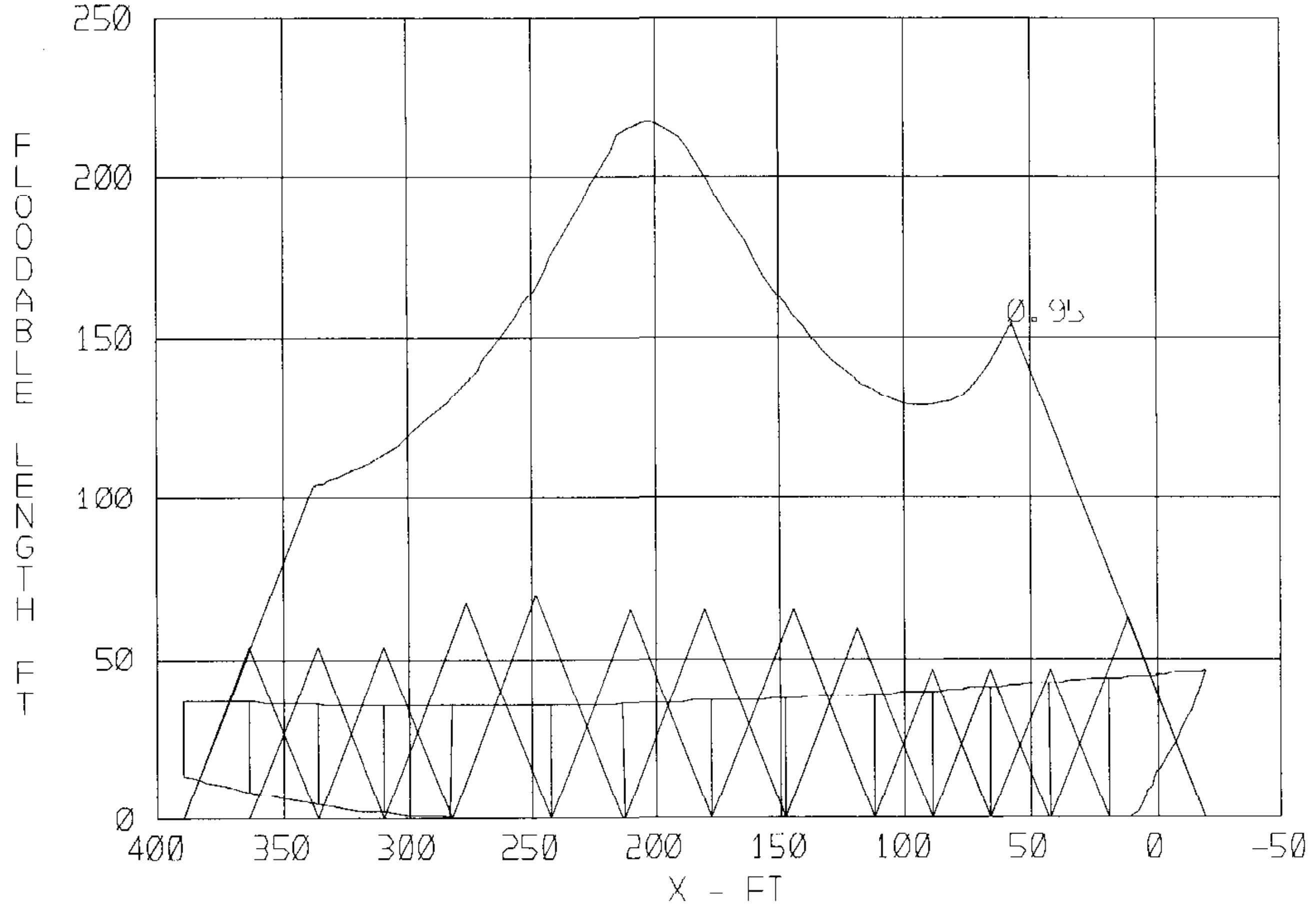
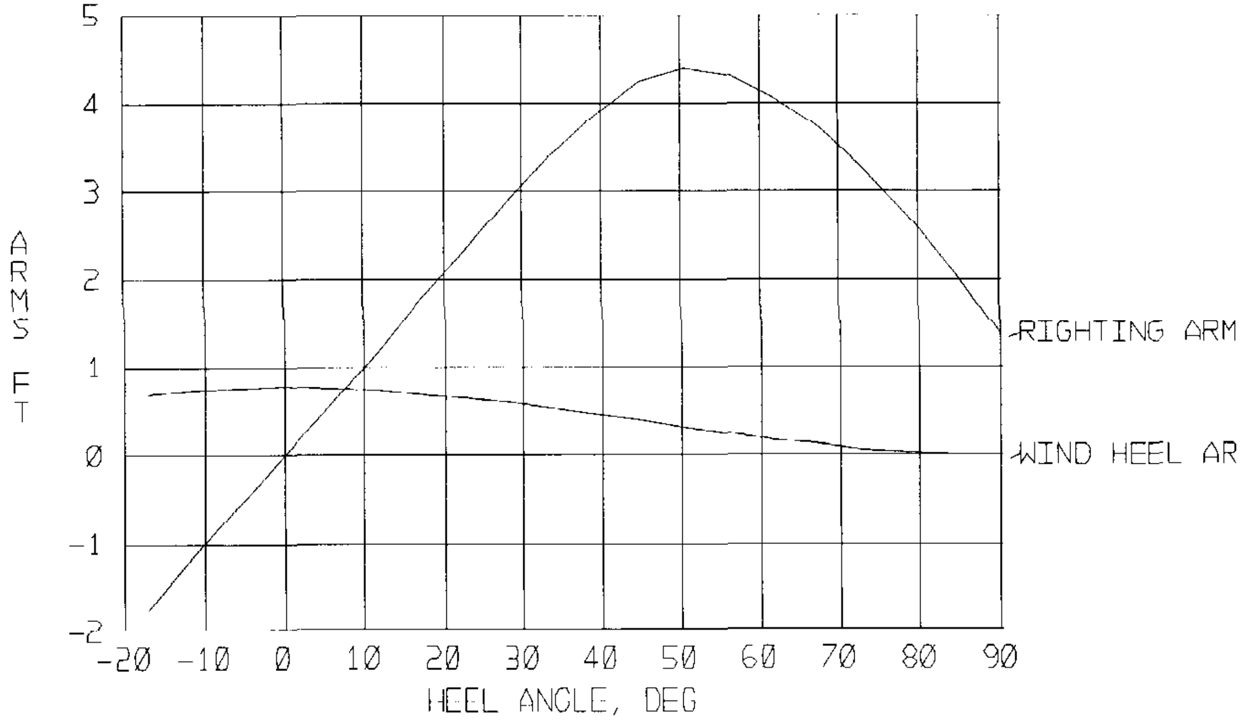
ASSET/MONOSC VERSION 3.2 - HYDROSTATIC ANALYSIS - 1/15/93 09.45.14.
GRAPHIC DISPLAY NO. 3 - FLOODABLE LENGTH



DISPLACEMENT, LTON 5721.79 LCG LOC(+VE FWD MID), FT -5.8
5 APPENDAGE IND-WITH

```
I>
  ASSET/MONOSC VERSION 3.2 - HYDROSTATIC ANALYSIS -  1/15/93 09.45.14.
 GRAPHIC DISPLAY NO. 4 - INTACT STATIC STABILITY WITH WIND HEELING ARM
```

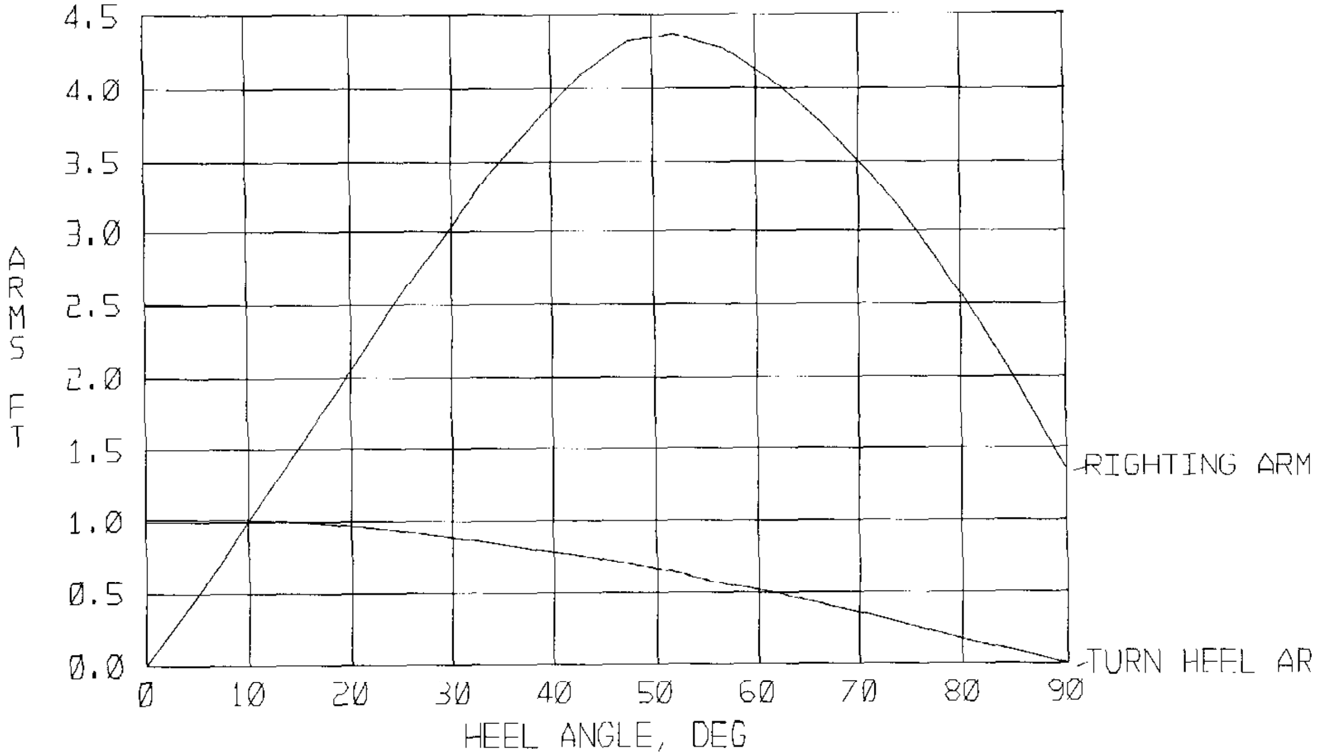


```
                     INTACT STATIC STABILITY

  DISPLACEMENT, LTON          5721.79    LCG LOC(+VE FWD MID), FT     -5.8
 5KG, FT                        19.59    WIND SPEED, KT              100.0
 0APPENDAGE IND-WITH
```

I) 3

ASSET/MONOSC VERSION 3.2 - HYDROSTATIC ANALYSIS - 1/15/93 09.45.14.
GRAPHIC DISPLAY NO. 5 - INTACT STATIC STABILITY WITH TURN HEELING ARM



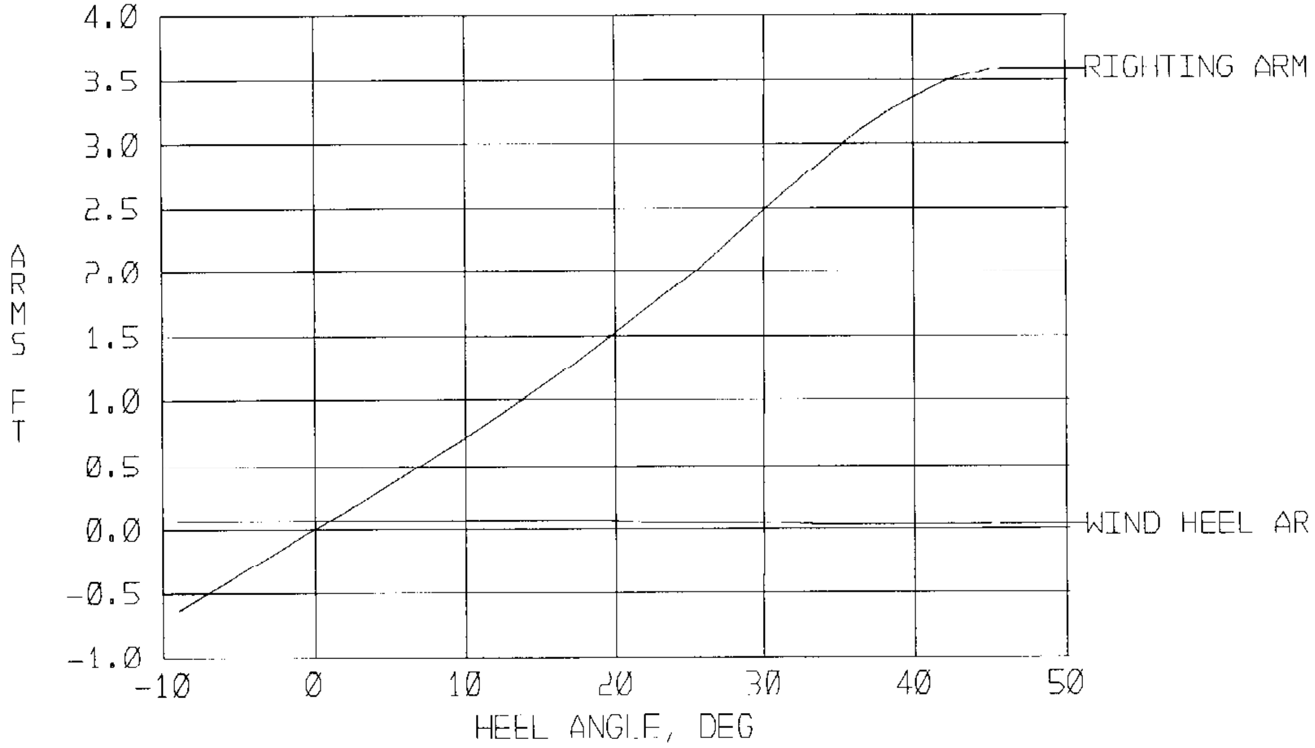
M

INTACT STATIC STABILITY

DISPLACEMENT, LTON	5721.79	LCG LOC(+VE FWD MID), FT	-5.8
5 KG, FT	19.59	TURN SPEED, KT	26.4
9 APPENDAGE IND-WITH		TURN RADIUS, FT	818.6

I>

ASSET/MONOSC VERSION 3.2 - HYDROSTATIC ANALYSIS - 1/15/93 09.45.14.
GRAPHIC DISPLAY NO. 6 - DAMAGED STATIC STABILITY



DAMAGED STATIC STABILITY

DISPLACEMENT, LTON	5721.79	LCG LOC(+VE FWD MID), FT	-5.8
5 KG, FT	19.59	APPENDAGE IND-WITH	

DAMAGED COMPARTMENTS 7PS/8PS/9PS

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