

Carderock Division Naval Surface Warfare Center

Bethesda, Md. 20084-5000

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Machinery Research and Development Directorate
Technical Report

CARDIVNSWC-TR-93/013 DD 21A—A Capable, Affordable, Modular 21st Century Destroyer

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by

William J. Levedahl, Samuel R. Shank, and William P. O'Reagan

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ABSTRACT

Future Navy ships must be superior but inexpensive. A new philosophy and configuration provide the 21st century destroyer, the DD 21A, with global range; reduced lightship displacement and cost; superior seakeeping; no seawater ballast; sharper turns and stops; and greatly reduced installed power, fuel consumption, and pollution. These benefits result from a new machinery-driven ship design paradigm centered on simplicity and efficiency. All main machinery is modular and outside the watertight hull, freeing midship areas for personnel. The tumble home (inward-sloped) hull is long and slender, requiring little power at maximum speed.

Two removable, prealigned and pretested propulsor modules are attached to the stern after hull construction and are replaceable pierside. Each module includes a steerable pod aligned to the water inflow. A streamlined strut connects each pod rigidly to a vertical steerable barrel. Two removable, power-producing modules are mounted in the helicopter hangar. Each module comprises a 25,400-hp (19.7-MW) intercooled, recuperated gas turbine; a 4-MW ship service alternator; and a 20-MW propulsion alternator.

These remarkable results are obtained by taking a reference destroyer from the advanced surface ship evaluation tool data bank and evaluating several progressive changes made to it.

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ADMINISTRATIVE INFORMATION

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ABBREVIATIONS

ASSET	Advanced surface ship evaluation tool
BFC	Battle force combatant
BLISS	Boundary layer, infrared-shielded (air induction-cooled system)
DIRELEC	Direct electric
EAR	Expanded area ratio
GRELEC	Geared electric
HM&E	Hull, mechanical, and electrical
ICR	Intercooled, recuperative (gas turbine)
LT	Long ton
PDSS	Propulsion-derived ship service (power)
REFDD	Reference destroyer
SSTG	Ship service turbogenerator
SWBS	Ship work breakdown structure

SUMMARY

Future Navy ships must be superior as well as inexpensive. A new philosophy and a new configuration provide this 21st century destroyer, the DD 21A, with immense performance and cost advantages. This ship has global range—more than three times that of Navy destroyers currently being built. It carries twice as many guns, 35 percent more missiles, and four hangared helicopters instead of none. It has the same continuous and endurance speeds, but only two-thirds the lightship displacement and cost. It has superior seakeeping, requires no seawater ballast, can turn sharply when going either ahead or astern, and can stop in a very short distance. Its two intercooled, recuperated turbines replace seven simple-cycle turbines, have less than half the installed power and fuel consumption, and produce far less pollution. The power system can support advanced weapons such as electrothermal-chemical guns.

These benefits result from a new machinery-driven ship design paradigm centered on simplicity and efficiency. All main machinery is modular, outside the watertight hull, and pierside replaceable. The tumble home (inward-sloped) hull is long and slender, requiring little power at maximum speed. The simple configuration inherently reduces fuel consumption and pollution and radar, sonar, infrared, and wake detectability. Because the superstructure is an integral part of a box-girder hull, structural weight is reduced and vulnerability is decreased.

Two removable, prealigned and pretested propulsor modules are attached to the stern after hull construction is complete and are replaceable at pierside without drydocking, thereby lowering maintenance costs. Each module includes a steerable pod aligned to the water inflow. An integrated machinery capsule, inserted into the front of the pod, drives contrarotating tractor propellers that reduce power requirement, wake detectability, and sonar detectability. The capsule comprises seals, thrust bearings, contrarotating ring-bicoupled epicyclic gears, and an ac electric motor. A streamlined strut connects each pod rigidly to a vertical steerable barrel containing the individually replaceable propulsor auxiliaries. The barrel is mounted in a large rolling-element bearing on the bottom of the module and is steered by a two-stage, geared orbital electric drive.

Two power modules are removable and are mounted in the helicopter hangar. Each module comprises a 26,400-hp (19.7-MW) intercooled, recuperated (ICR) gas turbine, a 4-MW ship service alternator, and a 20-MW propulsion alternator with a second, high-voltage winding for electrothermal guns. Short, light inlet and exhaust ducts with low pressure drop enhance turbine efficiency.

With the exception of the ICR engine, which is already under contract, only sixties technology and stress limits were used in the design. Advanced materials and technology show major additional benefits, which will be the subjects of future reports.

In order to explain these remarkable results, we take a reference destroyer from the advanced surface ship evaluation tool data bank and make several progressive changes to it. Effects of each change on weight, performance, and on hydrodynamic and thermodynamic losses are shown.

INTRODUCTION

Ever since the Navy replaced sails with steam, the powerplant has occupied the middle of ships, and long, heavy shafts have connected it to aft-mounted propellers. The

Great White Fleet of Teddy Roosevelt's era, the four-stacker destroyers of World War I, and the entire World War II fleet all shared this configuration. Nuclear power revolutionized submarines, but the C1W and D2G nuclear powerplants introduced into cruisers and destroyers merely substituted for the boilers, fuel tanks, and turbines of their fossil-fueled predecessors.

CONVENTIONAL GAS-TURBINE-POWERED MONOHULLS

When compact, aircraft-derivative gas turbines were introduced in the *Spruance* class (DD 963) destroyers in the seventies, it required a trained eye to distinguish the powerplant configuration from any of those preceding it. The *Ticonderoga* (CG 47) class cruisers of the eighties and the *Arleigh Burke* (DDG 51) class destroyers of the nineties retain this same powerplant configuration.

All of these powerplants were built and placed in the center of the hull, early in construction. Repairs were conducted in situ. Replacement of a gear would require cutting a large hole in the side of the hull, which would be prohibitively costly. Lightly loaded "safe" gears were, therefore, a high-weight legacy of the configuration. A second legacy was long, heavy shafting, which was costly to align; a third legacy was large ducts, which occupy much of the upper decks and superstructure. Highly desirable spaces near the center of gravity of the ship, where ride motion is minimal, were dedicated to machinery and ducting, not to personnel and their living and working quarters.

The corresponding design philosophy was that propulsion systems were preordained, of fixed cost and size, and that ship cost was best reduced by making the ship as short as possible. This philosophy of design was described by Sims¹ as central to the design of the *Arleigh Burke* class destroyers.

In 1990, Navy design teams were hard at work to develop a concept called the "battle force combatant" or BFC, a ship carrying two 5-in./54-caliber guns, two 61-cell vertical launch systems, and two hangared helicopters. The BFC was typically 520 ft long, having a displacement of 14,000 long tons (LT), and had a sustained speed of 30 kn at 80 percent power and an endurance range of 6,000 nmi at 20 kn.

The post-cold war shift emphasized less costly, rather than more capable, ships. Many groups started trying to find less expensive ways to build later versions of the *Arleigh Burke* destroyer. They found the task difficult.

21ST CENTURY SURFACE COMBATANTS

In 1991, VADM Kahune, then head of surface ship naval operations (OP-03), requested the identification of technologies that could lead to a long-range, capable, light, affordable (5,000 LT, \$500 million) destroyer for the 21st century. By this time, the use of high velocity electric guns appeared feasible within a decade. Development of inter-cooled and recuperated gas turbines was underway. High-powered, fast-switching transistors were a near-term certainty, and fiber optics would permit maintenance monitoring of all important machinery.

Considered as a whole, these requirements, desires, and capabilities suggested that a low-powered stealthy ship with the same speed and offensive armament of the BFC and upgradable for electric weapons deployment would be attractive for the 21st century, particularly if the ship were moderate in cost, had global range, maintained good seakeeping,

and polluted less. These goals and constraints are not met easily, if at all, by conventionally configured monohulls.

ANALYSIS PROCEDURE

A series of earlier works²⁻⁵ has shown a systems approach intended to meet just such goals. One major result was the Navy's integrated electric drive program, which was initiated in the late eighties. The current report extends the systems approach into the new philosophy, using the Navy's advanced surface ship evaluation tool (ASSET)⁶ to show the effects on a destroyer of sequentially introducing various propulsion options, radically modifying the hull and machinery configuration, and making several additional steps.

The final step is a modular monohull destroyer having a waterline length of 553 ft (169 m), which carries the main offensive weapons of the BFC, has a lightship weight of nearly 4,600 LT (4,700 tons), a range of 12,000 nmi (22,222 km), superior stealth, sea-keeping ability, a reduced environmental impact, and is powered by two gas turbines instead of seven. It is offered as a baseline for technology evaluation, in parallel with the short destroyer (which has the 466-ft [142-m] length of the *Arleigh Burke* class destroyers) the reference destroyer (REFDD) (which has the 529-ft [161-m] length of the *Spruance* and *Kidd* [DDG 993] class destroyers and the *Ticonderoga* class cruisers) and the 620-ft (189-m) BFC. Figures 1 and 2 are ASSET elevation and plan renditions of these four ships. They show the basic machinery configuration of each ship. Figure 3 shows the salient features of our proposed 21st century baseline destroyer (DD 21A).

In order to locate opportunities for improvement over current practice, we decided to analyze the weights, costs, and efficiencies of a mathematically modeled REFDD, which represents the philosophy with which much of our modern fleet was built.

We begin with the ASSET data bank—referring to the REFDD, a conventional, mechanically driven gas-turbine ship having a waterline length of 529 ft with separate ship service power generation—and assign it a 1,186-LT armament suite. Its weights and costs are tallied by ship work breakdown structure (SWBS) groups. A hydrodynamic and thermodynamic analysis of the propulsion process is then performed. This analysis shows where opportunities for improvement exist. Four efficiency-improving changes are then made to this open-shaft ship, each time creating a new ship with the same length, sustained speed, endurance range, and stability, while allowing no excess volume and maintaining a minimum freeboard. Weights, power losses, and seakeeping are tracked at each step. The fifth ship of the sequence incorporates all the major improvements typically assigned to open-shaft ships with integrated electric drive systems.

The subsystems and components used in the fifth open-shaft ship are then introduced into a ship having radically different hull and machinery configurations. The hull has a constant-angle tumble home (inward slope of the topsides), and all major machinery is modular and located outside the watertight portion of the hull. This new configuration has turbine-generator modules delivered to the helicopter deck and mounted in the helicopter hangar. Steerable-pod propulsor units attach to the stern. All subsystems are modular and are individually replaceable pierside for major maintenance. Further changes include adding an adjustable stern flap and sufficient fuel to double the endurance range. The final changes, which produce the DD 21A, include lengthening the

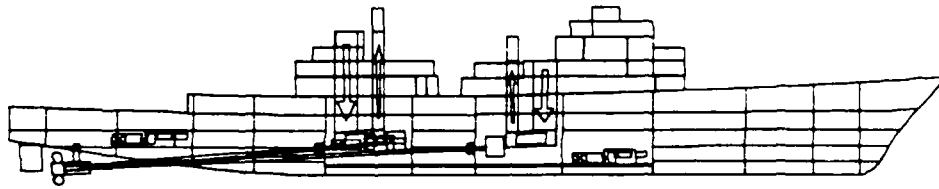


Figure 1a. Short destroyer.



Figure 1b. Reference destroyer.

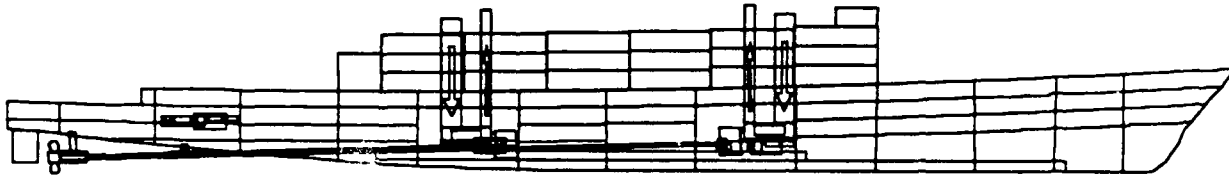


Figure 1c. Battleforce combatant.



Figure 1d. 21st century destroyer.

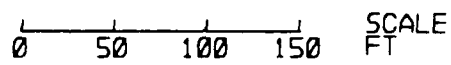


Figure 1. ASSET side view of the short destroyer, reference destroyer, battleforce combatant, and the DD 21A.

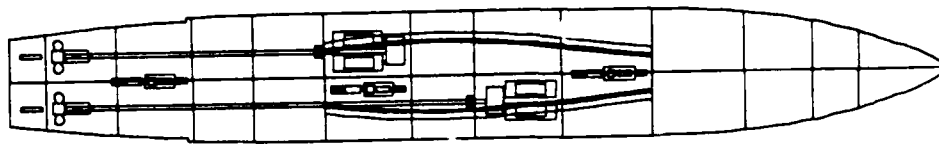


Figure 2a. Short destroyer.



Figure 2b. Reference destroyer.

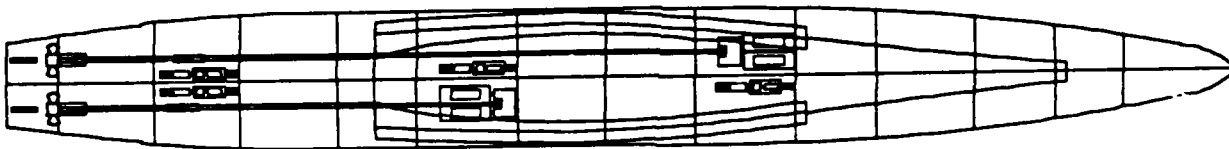


Figure 2c. Battleforce combatant.



Figure 2d. 21st century destroyer.

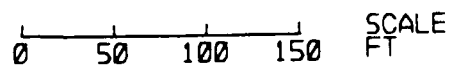


Figure 2. ASSET plan view of the short destroyer, reference destroyer, battleforce combatant, and the DD 21A.

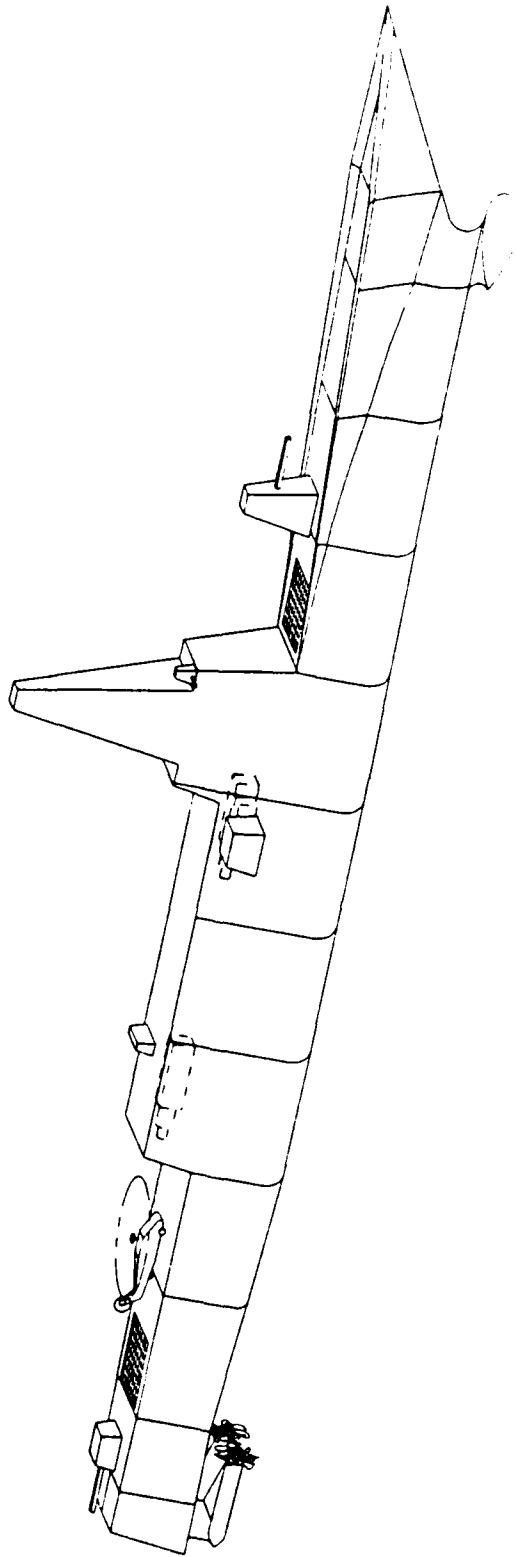


Figure 3. Isometric view of the DD 21A.

hull, eliminating all ballast, providing adequate fuel volume for 12,000 nmi, and using a composite steeple to house the radar and communications antennas.

BACKUP STUDIES

Several backup studies are contained in the appendixes.

- Appendix A is a compendium of combinations of the various features used on the REFDD, showing the ship impacts of substituting ICR engines for their simple-cycle LM2500 counterparts in each of four machinery configurations. This series addresses the perennial issues of whether electric drive renders ICR turbines ineffectual and whether ICR turbines render electric drive ineffectual. (Each reduces fuel so that the other has a smaller amount on which to exert its benefits, but both are necessary, as it turns out, for long-range ships.)

- Appendix B is the ASSET-generated ship/machinery data base covering each of the 10 destroyers in the previous series. Appendix B is a complete report of an ASSET ship impact study. It contains study ground rules, machinery option definitions, user inputs, and results.

- Appendix C is a mathematical model used to compute the relative turning abilities of several propulsor and steering system configurations.

- Appendix D is a study of the influence of the choice of appendage configuration on power required when the same steady-state turn radius is required for all cases. Open shafts with rudders, pods with separate rudders, pods with integrated rudders, and steerable pods are presented. This study shows the great powering advantage of steerable pods over their alternatives.

ASSUMED TOP-LEVEL REQUIREMENTS

Top-level assumptions were fundamental to the design goals established for the DD 21A.

- In the 21st century, the United States will have few foreign bases. The DD 21A must be able to reach any ocean in the world from a stateside base and perform its combat mission without refueling. The United States will not be able to afford to send stealthy oilers all over the world to act as semipermanent refueling stations, and not all destroyers will be members of fuel-rich carrier task forces. This imposes an endurance range of at least 12,000 nmi (22,222 km), preferably 15,000 nmi (27,777 km) for the 21st century destroyer.

- U.S. surface ships should arrive at distant locations unannounced. Propeller cavitation, which provides a ship's largest acoustic signature, should not occur below 25 kn. Infrared images from any angle above the horizon and radar return for other ships and sea-skimming missiles should be less than what is the current practice. In addition, the wake should be difficult to detect.

- Sustained speed at 80 percent power must be at least 30 kn, the traditional speed required for operating with aircraft carriers.

- Future combat systems to be accommodated include electro-thermal-chemical hypervelocity guns; electric rail guns; high-energy lasers or particle-beam weapons, any of which may require 1 to 100 megajoule pulses at intervals between 0.1 and 10 sec. The average power delivered to the pulse network during combat will be tens of megawatts.

- There is a high probability of littoral warfare in the future. Ship structures must be resistant to destruction by shallow-water mine explosions, which can cause whipping in current hull designs.

- Each ship enclave or compartment must be sealed off and self sufficient under emergency conditions. Emergency electric power must be capable of sustaining vital functions between the time of a powerplant failure and the time at which a replacement is brought online.

- Seakeeping in head seas must be better than that of any current Navy destroyer or cruiser, since mission durations are potentially longer and crew fatigue must be limited.

- In accordance with international pollution control limits, no fuel tank may be ballasted by dischargeable water, as was permitted for the REFDD. The current procedure of building excess clean tanks for ballast, which was used in the short destroyer, is wasteful of ship space, and carrying seawater increases fuel consumption late in the mission. Thus, the ship will be designed to have adequate transverse stability without fuel or ballast.

- There may be no tugs available to dock at foreign ports; thus, great maneuverability is required.

- The cost of carrying crews capable of major maintenance is prohibitive. Therefore, all machinery systems and weapons systems must be prealigned and pretested and must be pierside installable and removable with the aid of an auxiliary ship. (The corresponding reductions in manpower have not been included in the design.)

REFERENCE DESTROYER ANALYSIS

Figure 4 is a breakdown of the 5,887 LT lightship weight and the \$537 million cost of the delivered REFDD by SWBS weight groups. ASSET computed the costs in 1992 dollars for the follow ship (second ship) of a 50-ship fleet. These costs include a 112 percent addition to the fabrication cost to account for engineering, overhead, profit, etc. The cost and weight data are contained in table 1.

The cost of machinery is 63 percent of the lightship total, but its weight is only 31 percent thereof. By comparison, structures represent only 12 percent of the cost but 47.5 percent of the weight. In essence, the major cost of structure is its effect on the amount of machinery needed to propel it. Figure 5 illustrates this by showing the costs per ton of the various groups relative to that of structures. Propulsion machinery costs about 10 times as much per ton as structure.

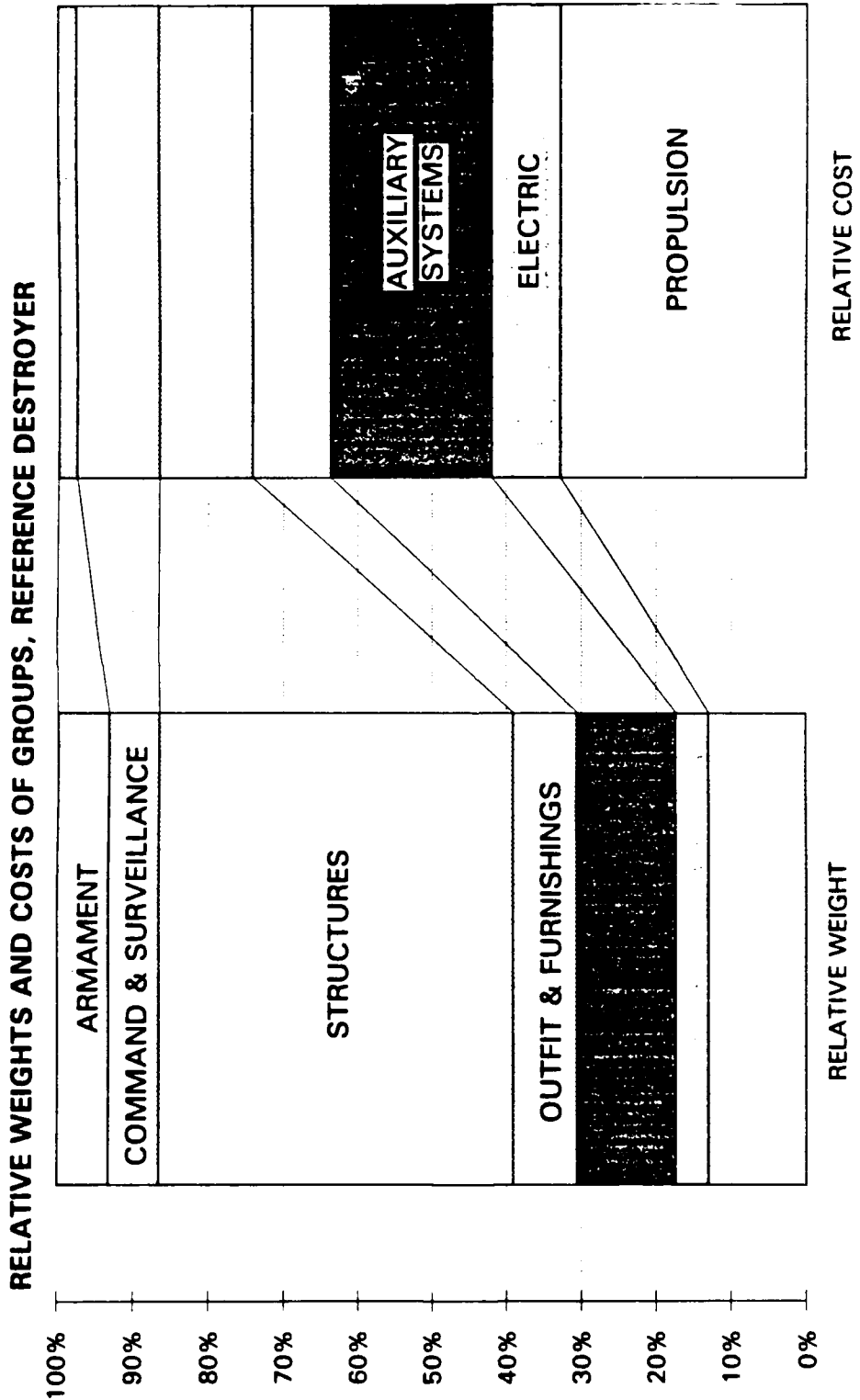


Figure 4. Weight and cost of the reference destroyer by SWBS groups.

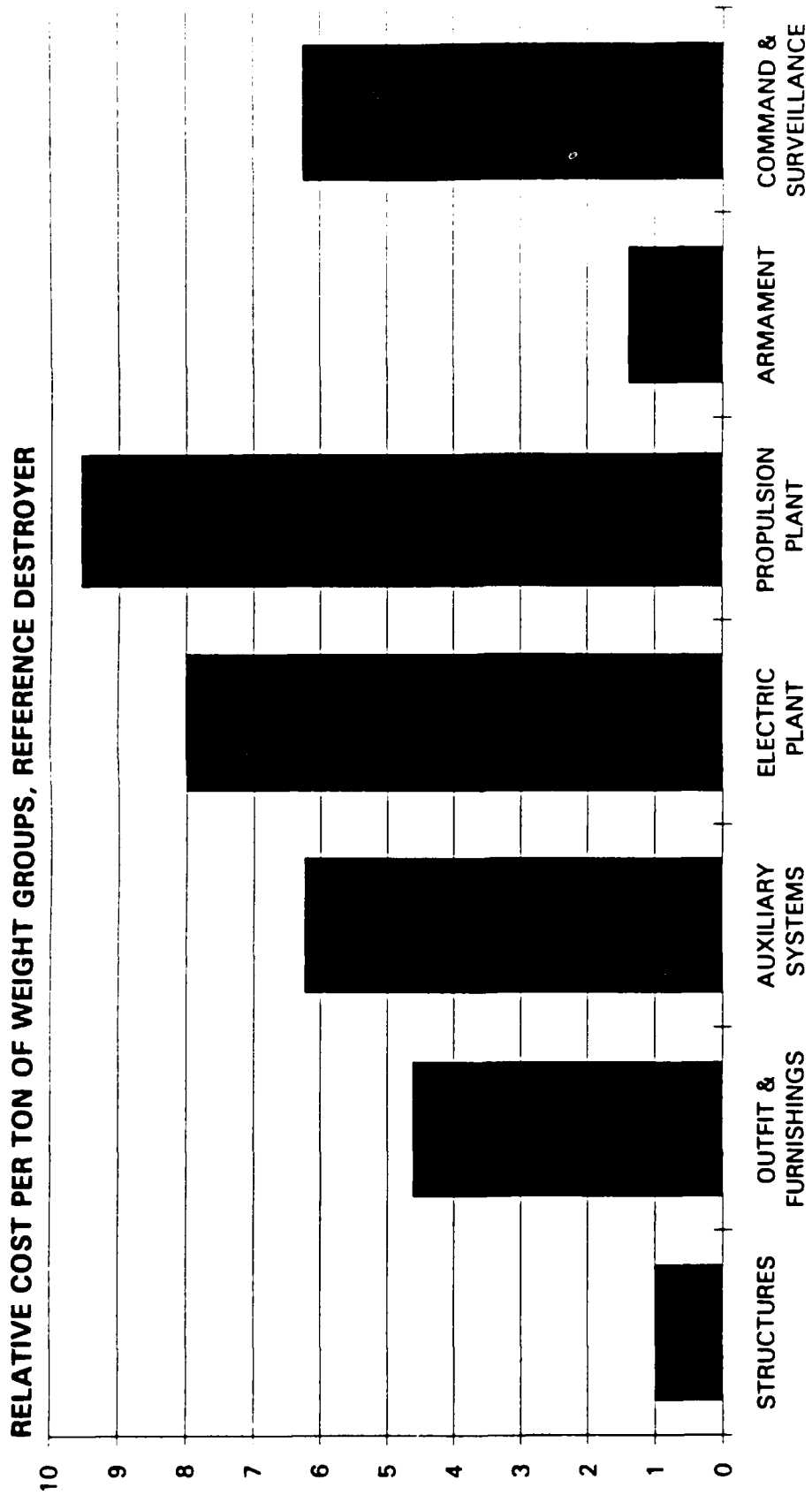


Figure 5. Relative costs per ton of SWBS groups 1 to 7.

Table 1. Weights and costs of the reference destroyer.

SWBS	Reference Destroyer	Weight (LT)	\$M (1992\$)
100	Structures	2,795.3	67.28
200	Propulsion Plant	763.4	175.52
300	Electric Plant	255.6	49.11
500	Auxiliary Systems	775.9	116.42
600	Outfit and Furnishings	508.4	56.42
400	Command and Surveillance	388.5	58.47
700	Armament	399.8	13.37
	Lightship Total	5,886.9	536.59

MACHINERY BREAKDOWN

The SWBS system is widely used and divides machinery into three categories: propulsion plant, electrical plant, and auxiliary machinery. Ships considered here differ importantly from those extant when the SWBS was developed, so that we chose a new breakdown of machinery into the following three categories: main machinery, shafting and ducting, and support machinery. Main machinery comprises all power-producing machinery and all major rotating entities, such as turbines, generators, gears, and propellers, as well as power-conditioning equipment and steering gear. Shafting and ducting are systems that transport air, exhaust gases, or torque from one place to another. Support machinery includes all auxiliaries not associated with propulsion or steering, as well as the electrical distribution system and lighting. In our study we treat all main machinery explicitly as a function of the power required to propel the ship. Shafting and ducting are treated explicitly as functions of ship configuration, philosophy, and power. Support machinery is treated by ASSET as a function of the sizes of ships, payload, main machinery, and crew.

Figure 6 shows both grouping systems for the machinery of the REFDD and shows that shafting and ducting are two-thirds as heavy as main machinery. Since the sizes of shafting and ducting depend directly on configuration, a major opportunity is presented.

POWER LOSSES

The effective power required to propel the ship, and its viscous, wavemaking, and appendage components are determined, as are the thermodynamic and other inefficiencies in the power system. The objective is to identify losses which are amenable to reduction.

ASSET breaks the effective power required by the hull into frictional and residuary resistance components. We regroup these into viscous and wavemaking components because the two are caused by separate phenomena and have different dependencies on shape and speed. For ships at low speeds, only viscous losses are important; at maximum and sustained speeds, large wavemaking resistance is added.

The power required to propel a bare hull through the water is described as such:

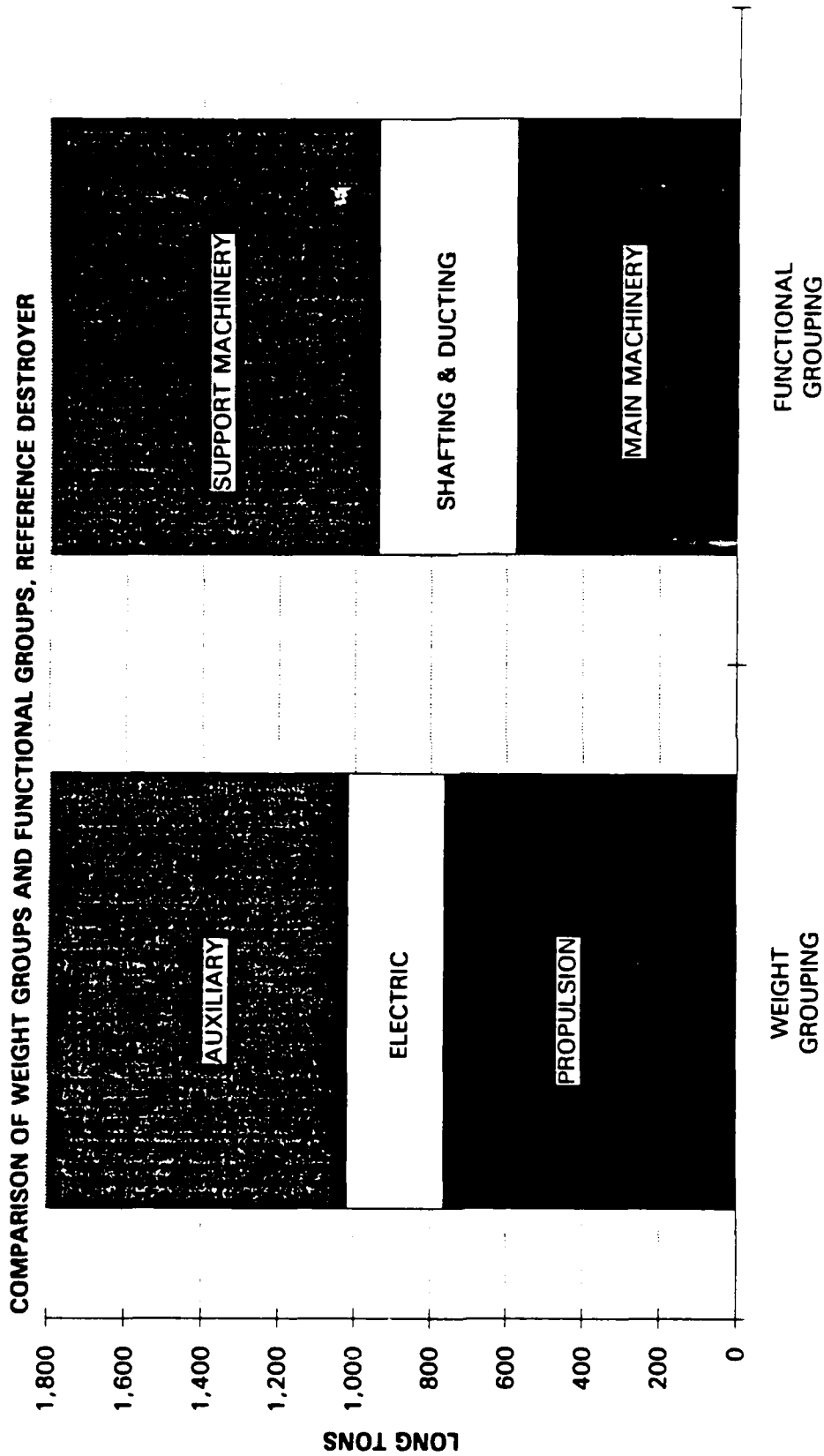


Figure 6. Comparison of two different groupings of machinery.

$$P_{\text{eff}} = \frac{\rho}{2} V^3 S C ,$$

where ρ is the density of seawater, V is ship velocity, S is the wetted surface area of the hull, and C is the resistance coefficient. The resistance coefficient used in ASSET has three components:

$$C = C_f + C_a + C_r ,$$

which are the friction coefficient, roughness allowance, and residuary resistance, respectively. The first two are essentially constant within our speed and size ranges and describe viscous drag, with values near 0.0015 and 0.0005.

The residuary resistance coefficient has two components not separated in ASSET.

$$C_r = C_{\text{profile}} + C_{\text{wavemaking}} = C_{\text{pr}} + C_w .$$

The profile-drag coefficient is a constant, dependent only on hull fatness and shape, and is a further measure of viscous drag. Our analyses of the Taylor series and of the Hamburg series have provided an approximation to profile resistance. Its value for destroyers varies over the range 0.0003 to 0.0007;

$$C_{\text{pr}} = 0.00014 C_p \frac{B}{H} + 0.014 C_{\nabla}^{0.75} ,$$

where C_p is the prismatic coefficient, B/H is the beam-to-draft ratio, and C_{∇} is the volumetric coefficient or "fatness." We combine the three viscous losses into a single coefficient C_v .

$$C_v = C_f + C_a + C_{\text{pr}} ,$$

and denote the wave resistance component C_w , so that

$$C_w = C - C_v .$$

The viscous drag coefficient is nearly constant over the speed range and has a value near

$$C_v \approx 0.0025 .$$

The wavemaking coefficient C_w is somewhat dependent on hull shape, heavily dependent on "fatness," and varies sharply with the dimensionless Froude number.

$$Fr = \frac{V}{gL^{0.5}} ,$$

where V is ship velocity, g is the gravitational constant, and L is length at the waterline. For the REFDD the Froude number is 0.26 at the 20-kn endurance speed and 0.39 at the 30-kn sustained speed. C_w is very small compared to C_v at Froude numbers below about 0.34, but then it rises sharply so that at Fr equals 0.45, its value is several times that of C_v .

The viscous effective power of the bare hull at maximum, sustained, and endurance speeds will be used here as the reference powers. A ship which had 100 percent efficient propulsion systems and no wave or appendage resistance would have, by our definition, an effectiveness of 1.0.

Figure 7 shows how losses are distributed at maximum, sustained, and endurance speeds. At maximum speed the wave resistance of the reference destroyer is greater than the viscous resistance. The resistance of propulsion appendages (including rudders) is

LOSS DISTRIBUTION , REFERENCE DESTROYER

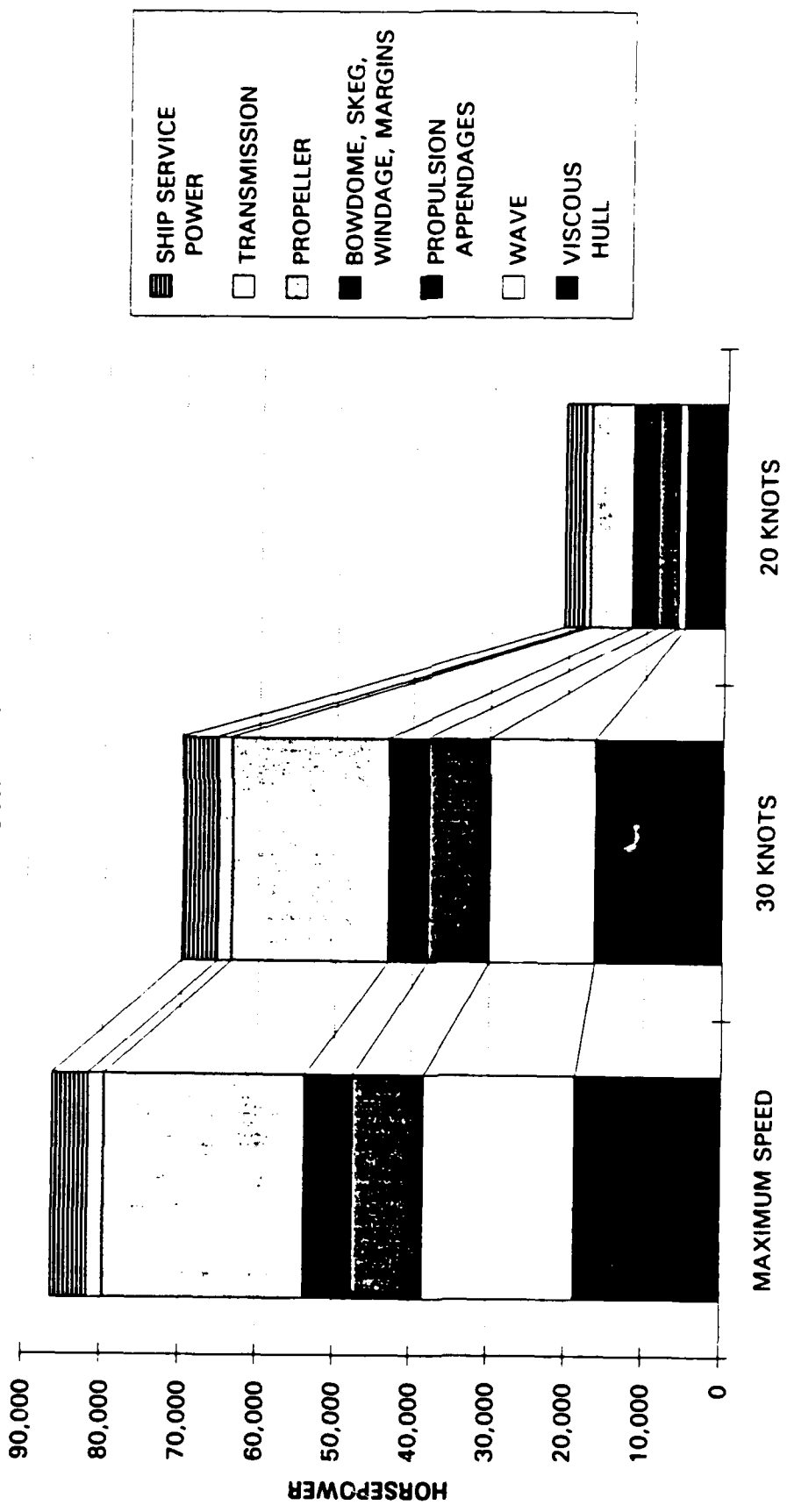


Figure 7. Distribution of power losses in the reference destroyer.

about 45 percent of the viscous hull resistance at all speeds. A miscellany of loss components over which we have little control is added: skeg, bow dome, windage resistances, and design margins. The margins include a multiplier of 1.11 on power at all speeds; an additional multiplier of 1.1 is applied at the 20-kn endurance speed. A correlation allowance for surface roughness ($C_a = 0.0005$) was used.

Power dissipation of the propulsion system at maximum speed is illustrated in the first column of figure 7. An effective horsepower of about 54,000, three times the hull viscous resistance, is reached. To put this in perspective, the resistance is about three times as high as that for a submarine of equal displacement and length.

The next loss, and the largest individual one so far, is the dissipation of the propeller, which has a propulsive coefficient—its system efficiency—near 0.68. Hydrodynamic losses 4.5 times that of the viscous drag, and well over 5 times the frictional drag, have accumulated. The hydrodynamic effectiveness is about 22 percent.

At sustained speed of 30 kn, which is the nominal design speed at 80 percent of maximum turbine propulsion power, the pattern has changed little, except that the relative value of wave resistance is less than at maximum speed. The other hydrodynamic losses have essentially dwindled with the cube of speed. They continue to drop in a similar manner to the 20-kn endurance speed. An exception is the bow dome, which has viscous drag but effectively reduces wave losses at higher speeds. Wavemaking resistance did not decrease to zero at the 20-kn speed because of transom submergence, a price paid for reducing wavemaking at higher speeds. The transmission losses are 2.5 percent at full power and 4 percent at 20 kn; ship service power requires about 5,000 turbine horsepower (3.8 MW) under combat conditions and about 3,000 hp (2.2 MW) at endurance cruise.

When the equivalent horsepower of hot gases going up the stack due to turbine inefficiency is included, the loss distribution is that shown in figure 8. The individual losses in horsepower are given in table 2. The LM2500 engine has a full-power efficiency of about 33 percent, so that losses are now treble the hydrodynamic power. The ship service turbines are about 20 percent efficient at the full power condition. The resultant maximum speed effectiveness is 6.7 percent, i.e., the energy in the fuel burned is about 15 times the basic viscous effective power of the ship. Clearly, great hydrodynamic and thermodynamic opportunities exist for improvement.

At the 20-kn speed, where endurance is calculated, wave drag is very low, but the propulsion turbine efficiency has dropped to 25 percent and the ship service turbine efficiency is 15 percent. The overall effectiveness is 5.4 percent.

The reference ship wave resistance, shafting resistance, propeller losses, and turbines are opportune targets for efficiency improvement; ducting and shafting weights are very large. The short destroyer requires, yet, 25 percent more power, even though it has less wetted surface and a lower viscous drag. Its effectiveness is about 5.1 percent at its maximum 31-kn speed.

CONVENTIONAL MACHINERY INSIDE CONVENTIONAL HULLS

The REFDD is the first or baseline ship in a 10-ship sequence showing the effects on weight and efficiency of each change. These 10 ships are summarized in two tables: Table 3 shows weights; table 4 shows hydrodynamic and thermodynamic losses.

Table 2. Power losses of the reference destroyer.

Reference Destroyer	Maximum Speed (hp)	30 kn (hp)	20 kn (hp)
Viscous Hull	18,772	16,346	5,022
Wave	19,595	13,624	922
Propulsion Appendages	9,245	8,043	2,681
Bow dome, Skeg, Windage, Margins	6,234	5,118	3,199
Propeller	25,860	20,447	5,486
Transmission	2,026	1,768	696
Ship Service Power	4,623	4,623	2,622
Main Turbine Stack Losses	177,485	157,041	58,614
Ship Service Turbine Stack Losses	16,814	16,814	14,295
Total	280,654	243,824	93,537

The first five machinery options consist of machinery arrangements that are basically configured like all previous ships. The powerplants are located in the center of the hull, and they have long shafts and large ducts.

REFERENCE DESTROYER

The REFDD is a conventional, mechanically driven, open-shaft destroyer with four LM2500 propulsion engines geared to two controllable reversible-pitch propellers and three 501K17 engines geared to three two-pole 60-Hz alternators. Figure 9 shows its ASSET machinery profile and the weights of the main machinery, ducting and shafting, and fuel required. This ship requires seawater ballast to replace fuel in the fuel tanks in order to retain stability and roll frequency throughout the mission.

PROPULSION-DERIVED SHIP SERVICE POWER

Propulsion-derived ship service (PDSS) power is introduced in figure 10. Two of the two-pole ship service alternators are replaced by 12-pole alternators connected to propulsion turbines or to the high-speed side of the reduction gear.⁷ Since full power must be produced by the alternator, even when engine speed drops by two-thirds, these alternators must have three times the capacity of those they replace. Cycloconverters were added because—for the systems in question—high quality 60-Hz power must be produced regardless of alternator speed. The combined efficiency of the alternator-cycloconverter is 80 percent instead of the 95 percent of the standard alternator. The advantage of this new, less efficient and heavier combination is that it is powered by an already-operating gas turbine with an incremental specific fuel consumption about one-third of the overall specific fuel consumption of the 501K turbines. The net result is a 60-percent reduction in ship service fuel consumption. The overall consequence is the elimination of two 501K engines, a 12-percent reduction in endurance fuel, and a 4-percent reduction in both power and machinery weight. Part of the fuel must still be compensated for by seawater introduced into the fuel tanks, but much can be introduced into clean tanks.

LOSS DISTRIBUTION, REFERENCE DESTROYER, INCLUDING STACK LOSSES

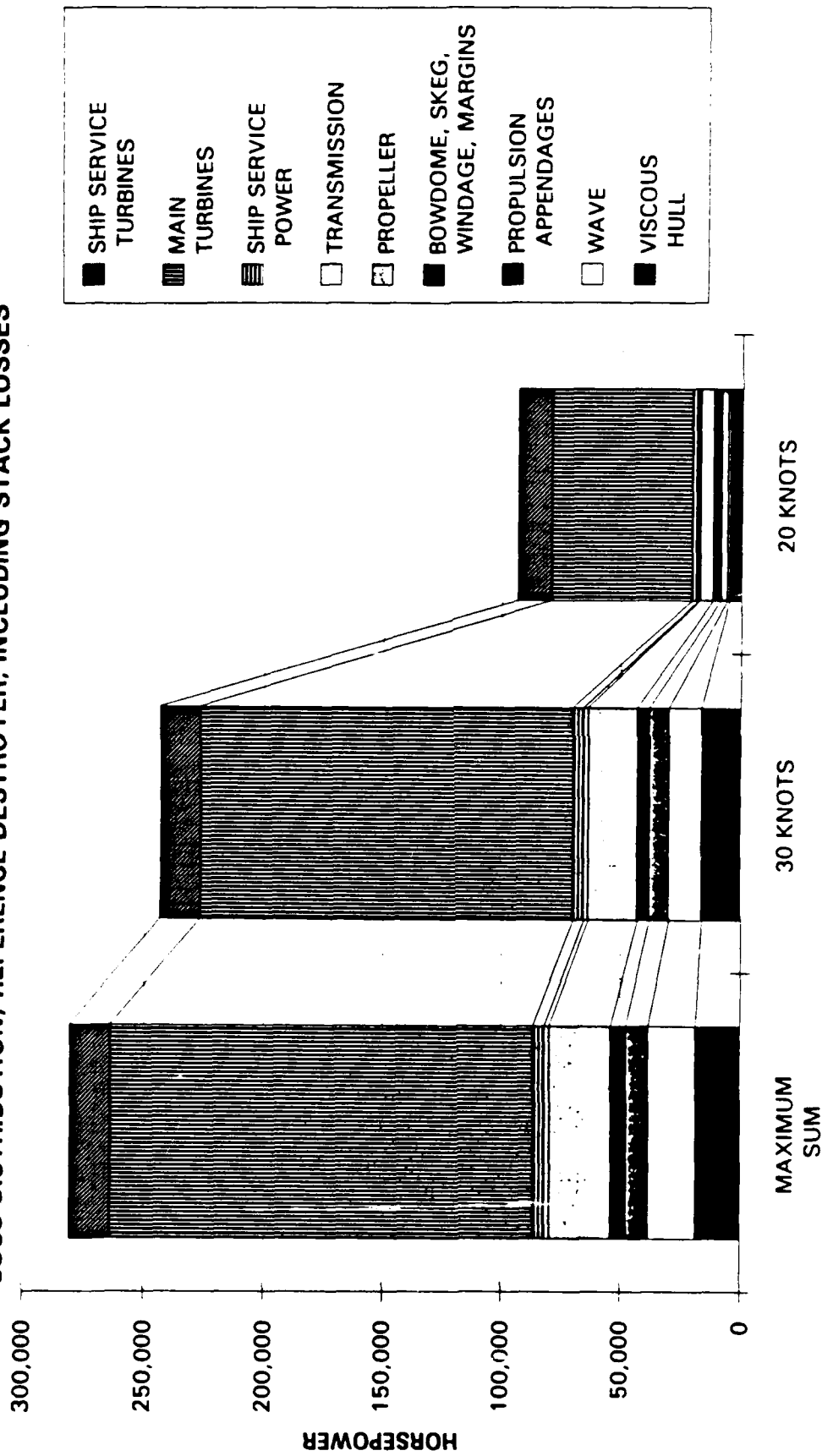


Figure 8. Distribution of power losses, including stack losses.

Table 3. Weight breakdown of 10 destroyers (measured in LT).

Reference Destroyer	Propulsion-Derived Service	Intercooled, Recuperative Turbine	Direct Electric Drive	Geared Electric Drive	Modular Power	No Ship Service Turbogenerator	20% Less Propeller Area	Add Flap	Double Range
Structures (Group 1)	2,749	2,794	2,871	2,890	2,160	2,081	2,080	2,078	2,089
Propulsion Plant (Group 2)	763	829	847	708	377	377	367	360	367
Electric Plant (Group 3)	234	234	253	245	233	187	187	185	187
Auxiliary Systems (Group 5)	765	754	771	751	593	575	575	630	639
Outfit and Furnishings (Group 6)	503	499	511	498	441	430	430	430	430
Command and Surveillance (Group 4)	389	389	391	389	386	385	385	385	385
Armament (Group 7)	400	400	400	400	400	400	400	400	400
Payloads	401	401	401	401	401	401	401	401	401
Usable Fuel	1,519	1,088	922	828	728	718	702	701	1,492
Lightship Displacement	5,801	5,896	6,045	5,679	4,589	4,438	4,423	4,467	4,496
Full Load Displacement	7,862	7,507	7,468	7,008	5,809	5,843	5,615	5,658	6,525
Military Payload	1,183	1,183	1,183	1,183	1,183	1,183	1,183	1,183	1,183
Main Machinery	558	688	749	591	404	369	360	410	410
Shafting and Ducting	359	295	290	283	72	71	70	70	70
Support Machinery	844	834	832	830	728	700	699	696	696
Total Machinery Foundations	359	295	368	358	72	71	70	70	70

Table 4. Power losses of 10 ships.

	Power Losses (hp)									
	REFDD	PDSS	ICR	Direct Electric	Geared Electric	Modular	No SSTG	Prop Area	Flap	Double Range
Maximum Speed	18,772	18,655	18,552	18,768	18,549	17,895	17,525	17,459	18,070	18,328
Viscous Hull										
Wave	19,595	18,147	16,580	16,292	14,645	8,892	8,454	8,384	5,682	8,497
Propulsion Appendages	9,245	8,897	8,519	5,840	5,987	3,509	3,507	3,486	3,486	3,480
Bow Dome, Skeg, Windage, Margins	6,234	6,066	5,975	5,618	5,322	4,3.3	4,253	4,245	4,209	4,370
Propeller	25,860	24,691	23,442	21,836	12,915	10,349	10,063	8,808	8,255	9,162
Transmission	2,026	1,940	1,858	5,184	4,602	3,468	3,392	3,280	3,280	3,401
Ship Service Power	4,623	4,780	4,730	4,602	4,418	4,362	3,908	3,854	3,894	3,894
Total Turbine Power	88,305	83,180	79,656	78,142	66,438	52,814	51,120	49,536	46,876	51,132
Main Turbines	177,486	171,297	111,392	109,978	83,772	73,660	71,568	69,350	64,980	68,940
Ship Service Turbines	16,814									
Total Equivalent Fuel Power	280,605	254,477	191,048	188,120	150,210	126,274	122,688	118,868	111,85	120,072
Effectiveness	0.0069	0.0733	0.0971	0.0998	0.1235	0.1401	0.1428	0.1469	0.1615	0.1526
30 kn										
Viscous Hull	16,346	16,193	16,012	16,221	15,816	14,991	14,847	14,822	15,341	15,448
Wave	13,624	12,581	11,419	11,211	9,887	5,688	5,347	5,297	2,875	5,411
Propulsion Appendages	8,043	7,738	7,599	5,073	5,188	3,040	3,029	3,018	3,018	3,018
Bow Dome, Skeg, Windage, Margins	5,118	4,963	4,623	4,574	4,278	3,515	3,459	3,456	3,427	3,619
Propeller	20,447	19,551	18,595	17,291	10,345	8,322	8,108	7,039	6,528	7,309
Transmission	1,768	1,698	1,620	4,462	4,030	3,046	2,982	2,882	2,673	2,985
Ship Service Power	4,623	4,756	4,706	4,608	4,424	4,362	3,906	3,892	3,892	3,894
Total Turbine Power	69,969	67,480	64,574	63,440	53,968	42,964	41,678	40,406	37,754	41,684
Main Turbines	157,041	171,297	90,406	149,456	75,955	60,150	58,349	58,350	53,134	56,246
Ship Service Turbines	16,814									
Total Equivalent Fuel Power	243,824	238,777	154,980	212,896	129,923	103,114	100,027	98,756	90,888	97,930
Effectiveness	0.0670	0.0678	0.1033	0.0762	0.1217	0.1454	0.1484	0.1501	0.1688	0.1577

20 kn	REFDD	PDSS	ICR	Direct Electric	Geared Electric	Modular	No SSTG	Prop Area	Flap	Double Range
Viscous Hull	5,022	4,974	4,974	4,983	4,859	4,605	4,561	4,553	4,565	4,575
Wave	922	611	636	629	520	374	265	226	229	440
Propulsion Appendages	2,681	2,595	2,742	1,874	1,726	1,160	1,153	1,152	1,152	1,152
Bow Dome, Skeg, Windage, Margins	3,199	3,145	3,094	2,940	2,849	2,641	2,606	2,593	2,593	2,711
Propeller	5,486	5,357	5,196	4,760	3,032	2,692	2,618	2,264	2,275	2,374
Transmission	696	676	658	1,710	1,702	1,458	1,426	1,372	1,363	1,446
Ship Service Power	2,622	2,642	2,616	2,632	2,530	2,278	2,228	2,222	2,222	2,222
Total Turbine Power	20,628	20,190	19,916	19,328	17,218	15,208	14,857	14,382	14,419	14,922
Main Turbines	58,614	56,682	35,508	27,346	24,743	21,829	21,462	21,200	21,270	21,333
Ship Service Turbines	14,295									
Total Equivalent Fuel Power	93,537	76,872	75,067	46,674	41,961	36,837	36,319	35,562	35,619	36,906
Effectiveness	0.0537	0.0647	0.0663	0.1066	0.1156	0.1250	0.1256	0.1280	0.1282	0.1240

Reference Destroyer

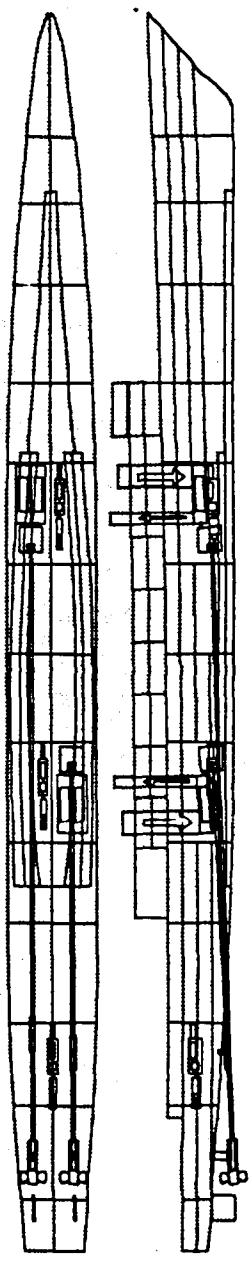
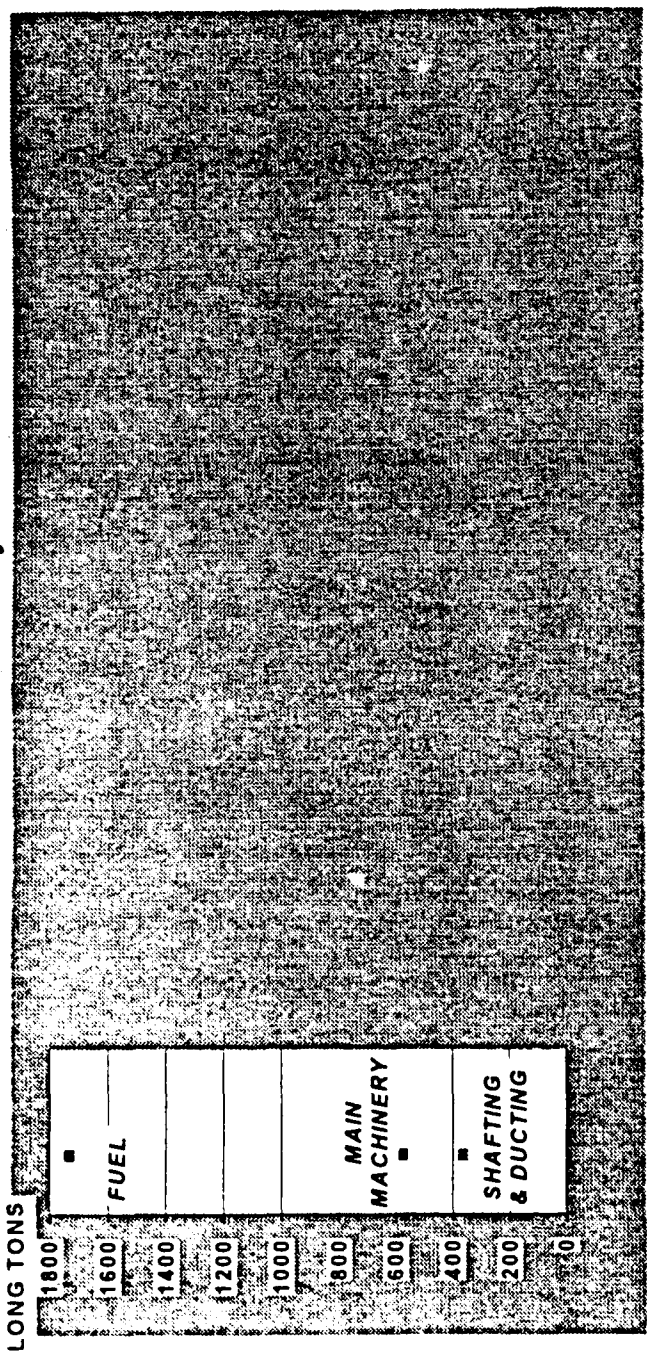


Figure 9. Reference destroyer configuration and weights.

Combined Propulsion & Ship Service - Remove 2 SSTG

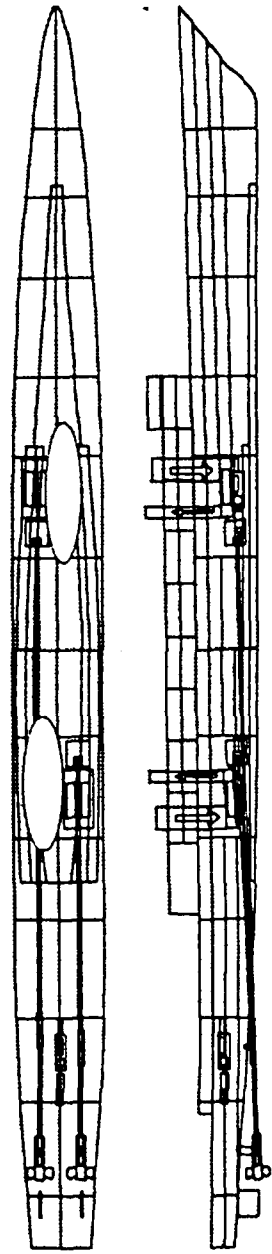
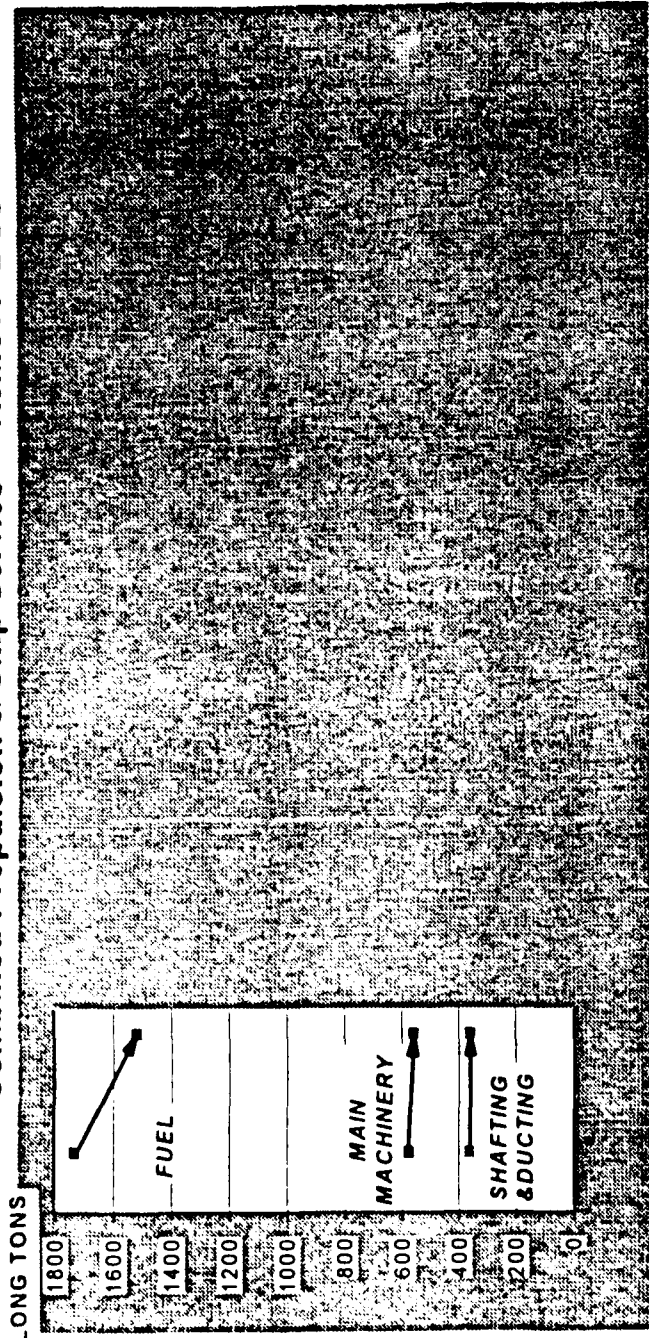


Figure 10. Propulsion-derived ship service configuration and weights.

INTERCOOLED, RECUPERATED GAS TURBINES

ICR gas turbines (figure 11) directly replace the simple-cycle LM2500 turbines in the preceding ship, which has propulsion-derived ship service.⁸ These engines are heavier, due to heat exchangers, but airflow is smaller, leading to reduced ducting. Compared to the previous step there is a 28-percent reduction in fuel consumption, due to the ICR's improved efficiency, and 4-percent reduction in required power, accompanied by a small increase in machinery and lightship weights. For this ship, and those which follow, there is sufficient tankage available to provide clean ballast to keep the ship at constant stability throughout the mission, whereas for the REFDD and its PDSS modifier, some of the fuel tanks needed to be ballasted with seawater.

DIRECT-DRIVE, SOLID STATE-CONTROLLED AC ELECTRIC MOTOR

A direct-drive, solid state-controlled ac electric motor (figure 12) replaces each locked-train double reduction gear. Since the motor can be reversed, fixed-pitch propellers with small shafting and struts replace heavier, controllable, reversible-pitch propellers and their larger shafting and struts. Since electrical cross-connection between the two shafts is now possible, three uprated propulsion engines and alternators replace the four propulsion engines of the previous case. A 28-ton battery energy storage system permits operation on one turbine for cruise, while providing interim ship service power between failure of the operating turbogenerator and startup of a replacement. A 15-percent reduction in fuel consumption is accompanied by a 2-percent reduction in required power. Machinery weight increases because of the large specific weight of electric machines with low rotor tip speeds.

High-voltage power for electrothermal guns can be produced from propulsion turbines on either mechanical or electric drive ships.⁹ On the electric drive ship, a second winding on the armature of an existing propulsion turbine becomes a low-weight, simple option: Power from the kinetic energy of the ship also becomes available using the armature as a transformer.

GEARED ELECTRIC DRIVE

Geared electric drive (figure 13) replaces the large-diameter, low-speed motor with a small-diameter, high-speed motor and a ring-ring, bicoupled, contrarotating epicyclic gear. Contrarotating propellers, shafting, and thrust bearings replace the fixed-pitch propellers and shafting. The sizable reduction in fuel is primarily due to the efficiency of the contrarotating propellers and partly due to improved motor efficiency. This is the first instance of major synergistic benefit, with reductions of 15 percent in required power, 10 percent in fuel consumption, 9 percent in machinery weight, and 6 percent in both lightship and full-load displacement.

The overall improvement over the REFDD in our final open-shaft ship includes an impressive 52 percent reduction in fuel consumption, but only 5 percent in machinery weight and 4 percent in lightship weight. These unbalanced improvements provide a 14-percent reduction in full-load displacement and a 25-percent reduction in required power. The latter figure justifies the reduction in the number of propulsion turbines from four to three. The benefits result from higher efficiency components and from the increase in system efficiency when one turbine, instead of four, is operational at the condition for which fuel consumption is calculated.

Four Intercooled, Recuperated Engines

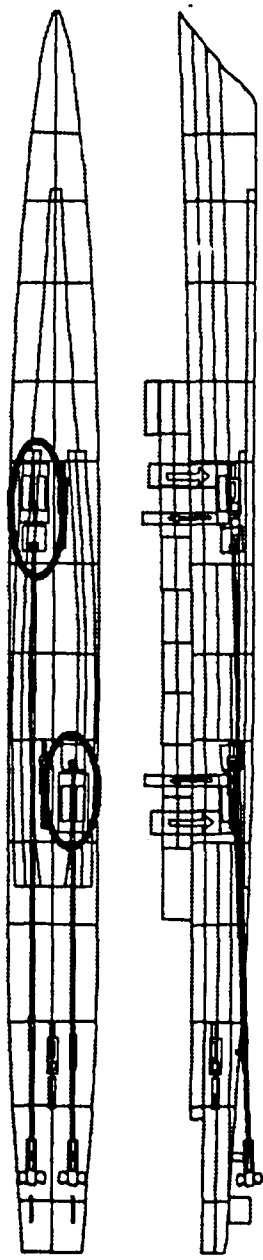
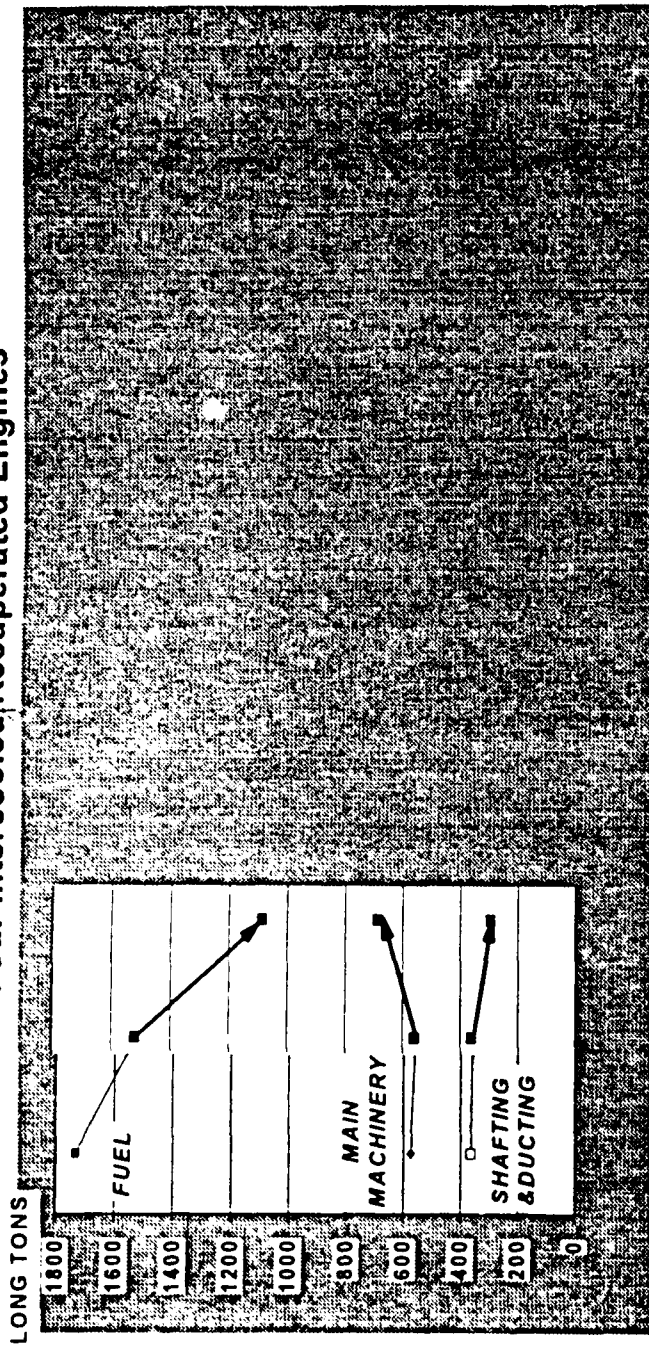


Figure 11. Intercooled, recuperated turbine configuration and weights.

Direct Electric Drive - Remove 1 ICR Engine

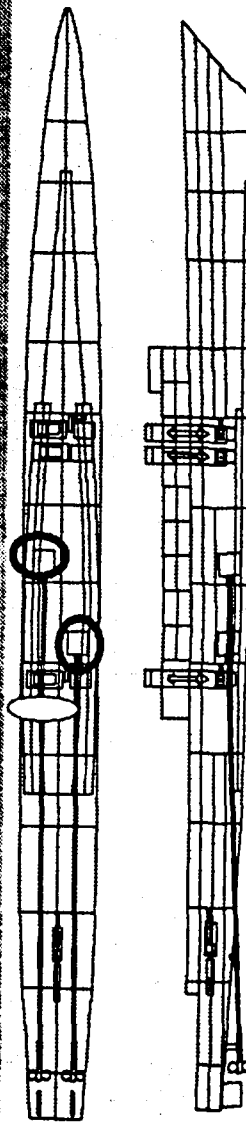
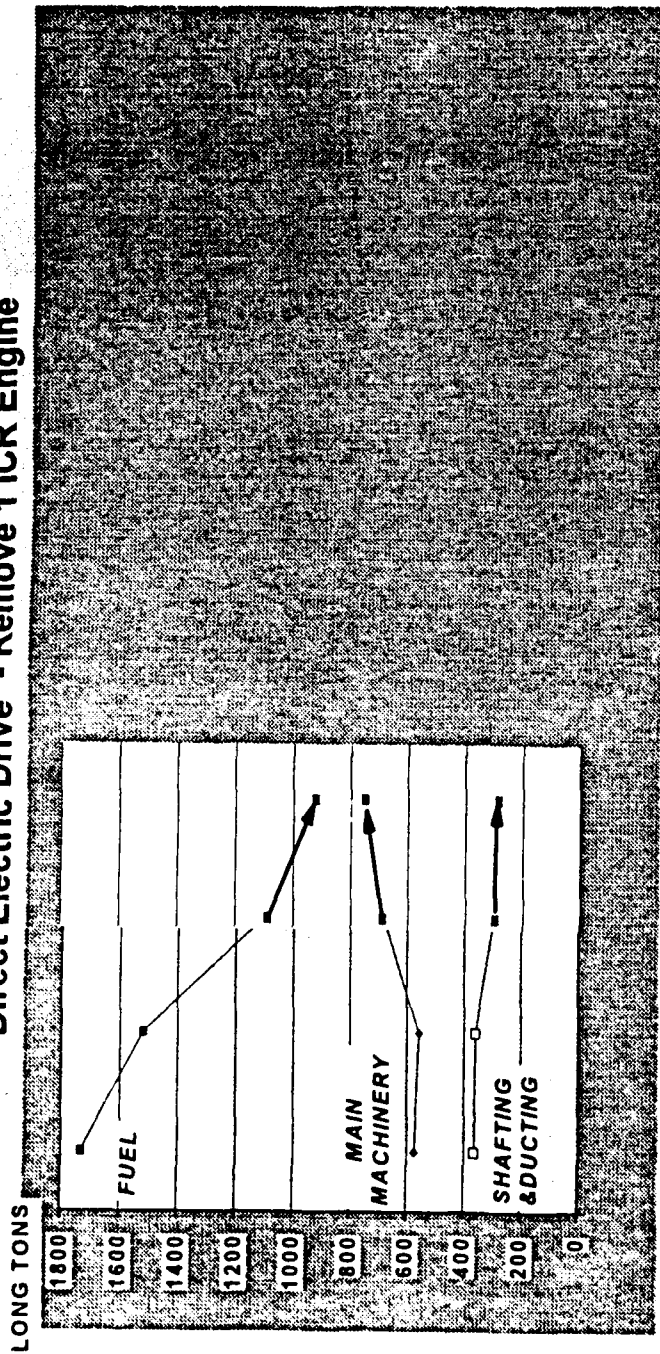


Figure 12. Direct electric drive configuration and weights.

Geared Contrarotating Electric Drive

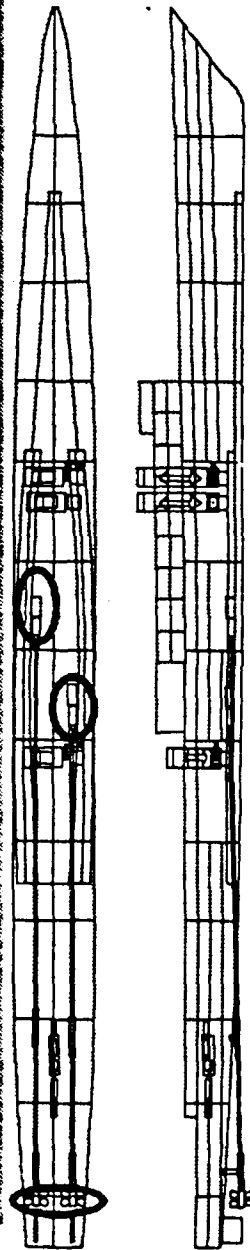
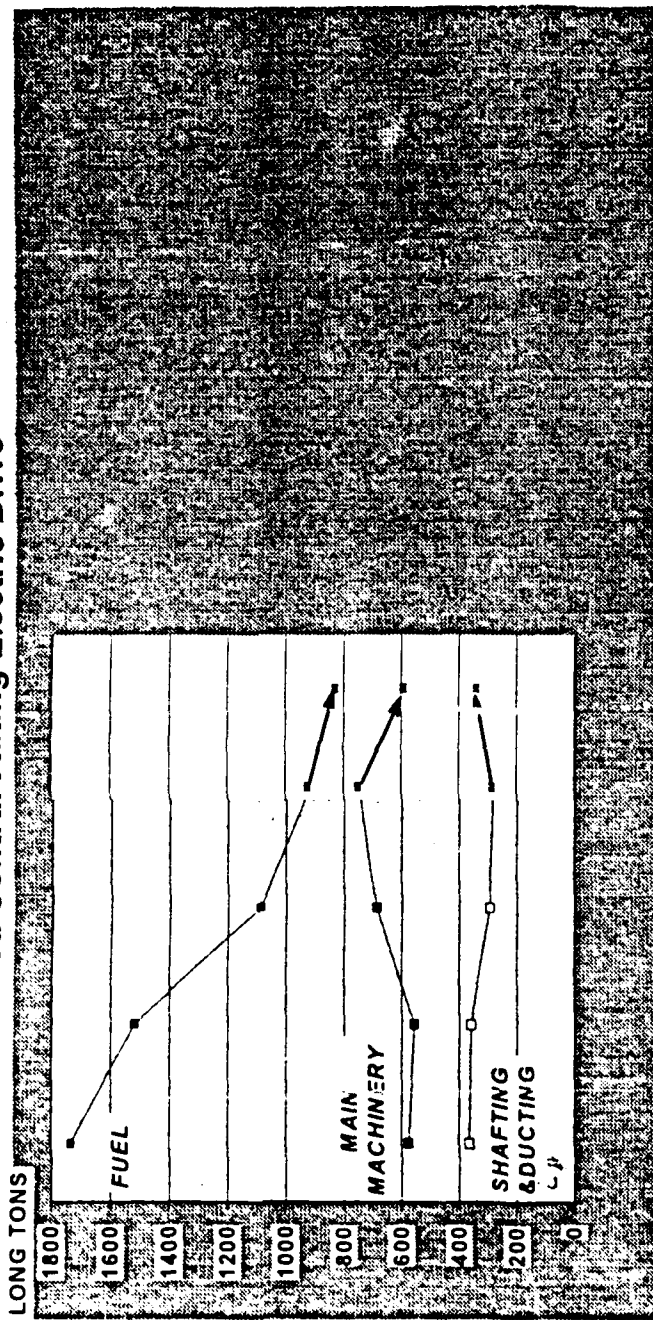


Figure 13. Geared electric drive configuration and weights.

This final, open-shaft ship is not a well-integrated, synergized, highly leveraged, affordable ship. While endless variants on the machinery types involved here could be introduced and a percent here and there could be added, the overall situation does not change substantially until a different approach is taken. Further, the changes made so far make only modest concessions to future requirements for longer range, greater stealth, less pollution, lower manning, easier maintenance, and greater simplicity.

MODULAR MACHINERY OUTSIDE TUMBLE HOME HULLS

After extracting the available benefits from conventional machinery and hull configurations, we take the radical step of reconfiguring the machinery from the fifth ship into modular packages and installing it outside the watertight confines of a new tumble home hull with integrated superstructure. A major characteristic of the new hull is its clean, uncluttered configuration that has no right-angled intersections and few protuberances and provides minimum radar scattering back toward either a surface ship, a sea-skimming missile, or a satellite. It also has few painted surfaces and weapons system components exposed to the elements, boding well for maintenance costs. Further, the entire continuous steel structure, which includes box girders extending upward into the superstructure, is effective in resisting hull bending stresses. The pilot house and antenna-containing steeple are one composite structure coupled to the hull. The steeple has radar-reflective coatings with narrow band-pass windows for the antennae. Waveguides and antenna leads in the corners of the steeple closely couple the antennae to the transmitters powering them, while minimally affecting the transmission and reception of other antennae, which are coaxial to them. Most importantly, the machinery modules require little shafting and ducting, with correspondingly increased system efficiency, and do not require drydocking for repair or replacement.

POD

This modular ship has a tumble home hull containing no major machinery. All ICR gas turbines are combined with propulsion alternators and ship service alternators to form power modules; these and the SSTG are mounted on the main deck in the helicopter hangar. The propellers and the seals, bearings, bicoupled contrarotating gears, and AC motors are built into capsules that fit into steerable pods, which are part of stern-mounted removable units. The 5-in. guns and the vertical launch missile systems are located on the main deck forward and aft. Close-in weapons systems are mounted atop the pilot house. A composite steeple of quadrilateral cross section atop the pilot house contains the radar and radio communications systems in a vertical coaxial configuration.

Figure 14 shows that the move to the modular ship is enormously synergistic. This ship retains all the previous machinery, except one ICR turbine and its propulsion alternator. The number of turbines decreases 25 percent, required power 23 percent, machinery weight 29 percent, fuel weight 12 percent, lightship weight 19 percent, full load displacement 17 percent, and ducting and shafting weight 81 percent from the preceding ship. Maneuverability and stealth increase enormously. The reduced resistance of the pod compared to open shafting is the primary hydrodynamic reason for this improvement. The reduction in weights of shafting and ducting which result from the new configuration also contribute much of the improvement.

Steerable Pod - Remove 1 ICR Engine

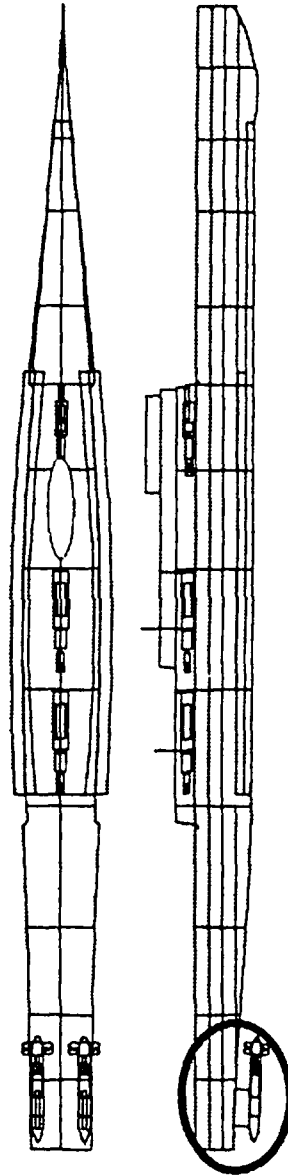
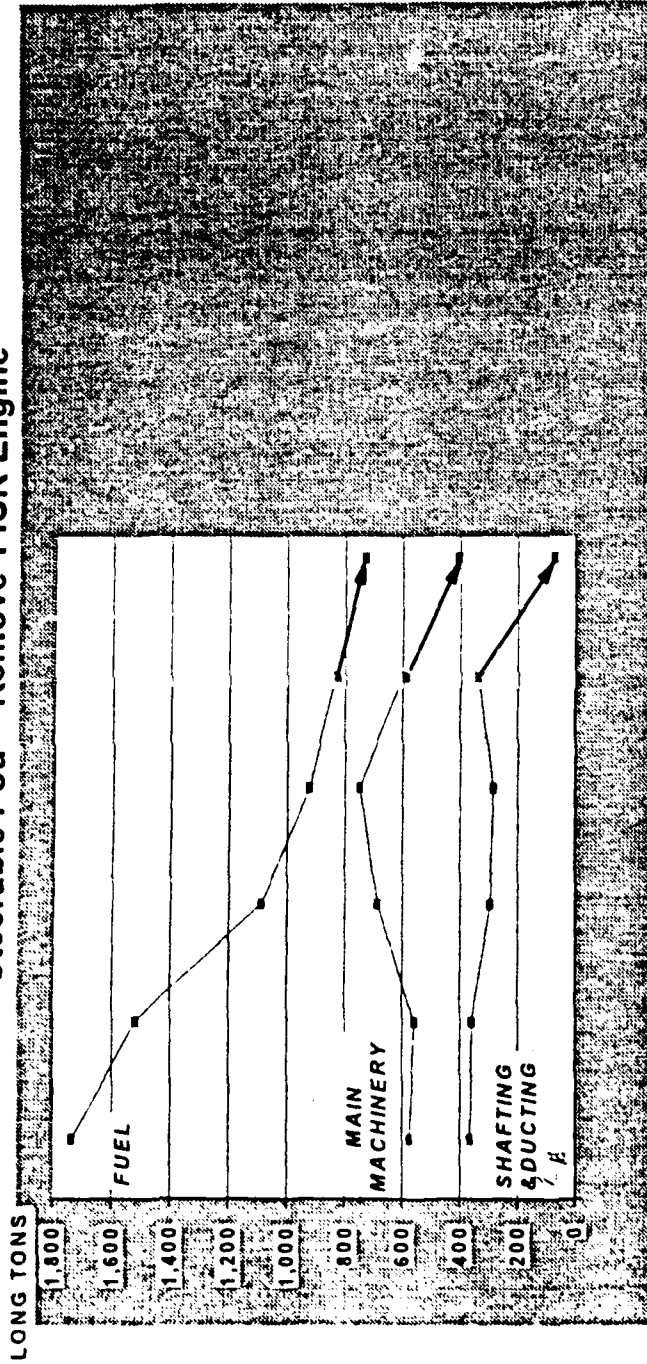


Figure 14. Modular destroyer configuration and v eights.

SHIP SERVICE TURBOGENERATOR ELIMINATION

Eliminating the independent SSTG reduces the number of turbines to two and reduces machinery weight 5 percent (figure 15). All other weights are reduced accordingly. This step shows the cost of doubly redundant ship service capability. (Appendix B shows that the dollar cost is 3 percent of ship procurement cost or nearly \$15 million.)

EXPANDED AREA RATIO

The propeller expanded area ratio was 1.0 in ships 5, 6, and 7, providing a calculated incipient cavitation speed of 28.6 kn, compared to the REFDD, which cavitated at all speeds. Reducing the area ratio to 0.8 reduces cavitation speed to 25.2 kn but decreases required power 3 percent and fuel consumption 2 percent (figure 16). This step illustrates the benefit of reducing the speed at which cavitation noise is first detected by 3.4 kn.

FLAP

Deploying a 24-ft (equal to the height of the transom), retractable flap has a major effect on the resistance at high speed because of the decreased Froude number and volumetric coefficient (figure 17). It also offers the opportunity to provide the best effective transom submergence and trim at all speeds, but this advantage was not included in the calculations. (Appropriate analytical techniques for calculating these benefits are not yet available.) The calculated reduction in required maximum power is 9 percent. The flap and mechanisms were estimated to weigh 50 tons, and a \$5 million cost reduction is also enjoyed (see appendix B). This step showed the benefit of increased hydrodynamic length.

DOUBLED RANGE

The flapped ship has excess power capability and a very small fuel load. Adding another 787 tons of fuel doubles the range to 12,000 miles and requires about the same horsepower as the 6,000-mile unflapped ship (see figure 18). This step shows the enormous increased range available with efficient ships of long waterline length. There is not enough tankage, however, to permit completely clean ballasting to compensate for all fuel burned.

The 10-ship sequence, showing the effects on weight and efficiency of each change, are summarized in several charts. Figure 19 shows the changes in required power and number of turbines; figure 20, the weights of the machinery and fuel; and figure 21, the lightship and full-load displacement. Figures 22 through 25 show the distribution of hydrodynamic and thermodynamic losses at maximum speed, at 30 kn, and at 20 kn, respectively.

DESIGN OF THE DD 21A

Lessons from the last 10-ship experimental series were used to design a new baseline destroyer, the DD 21A. The result is a high-performance, old-technology, lightly stressed destroyer model on which experiments can be made to determine the effects of further changes and additions. (Preliminary trials of new technology show this ship to be

Remove 1 SSTG

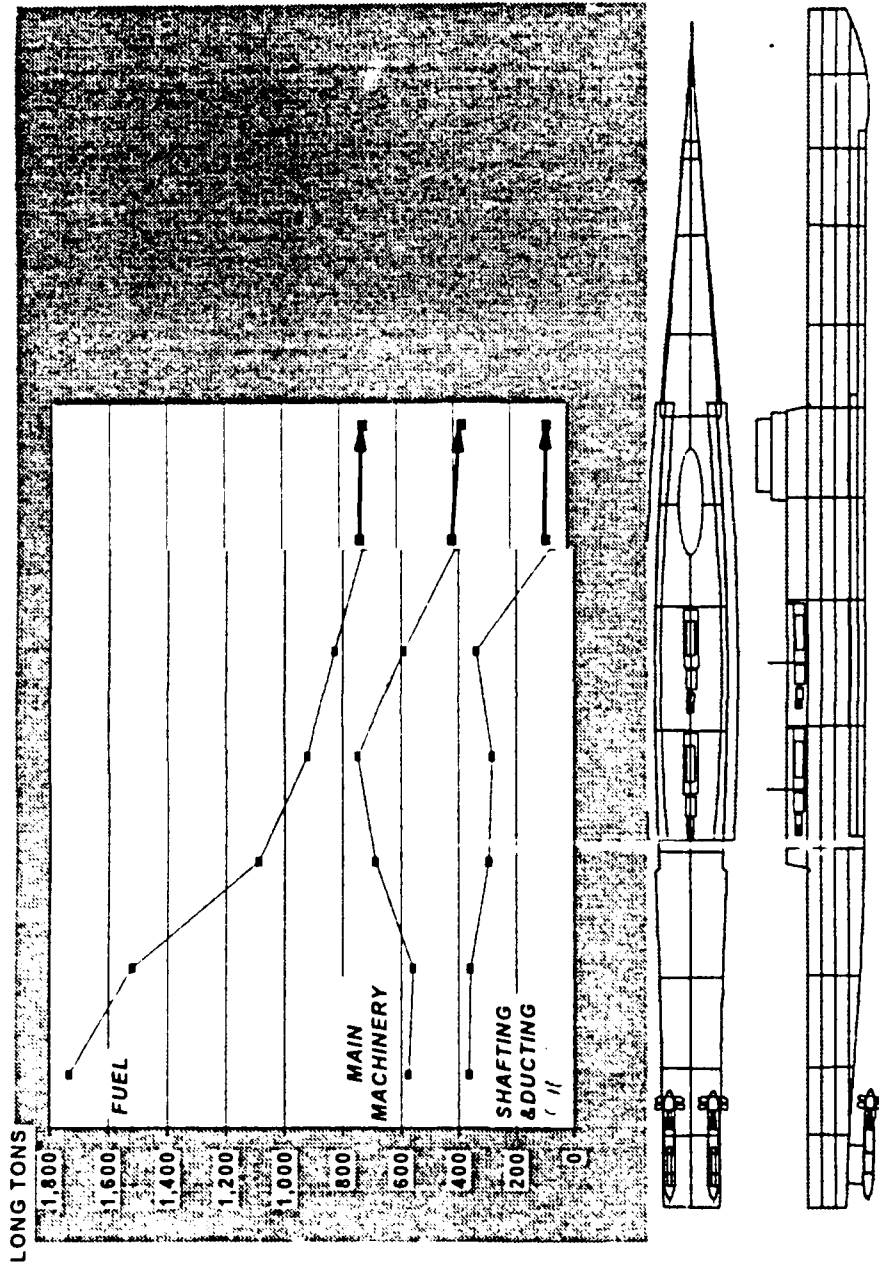


Figure 15. No SSTG configuration and weights.

Reduce Propeller Area by 20%

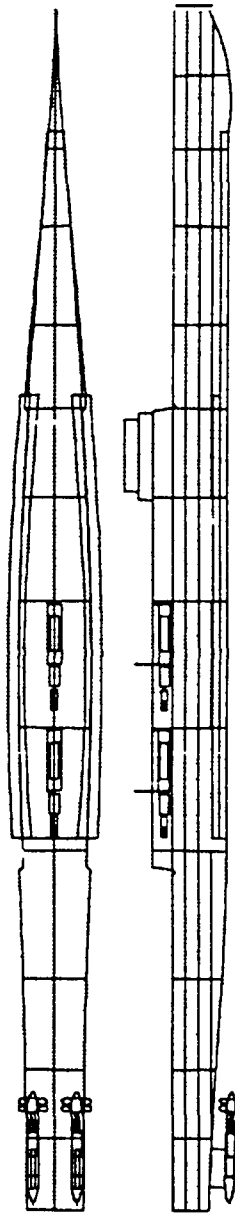
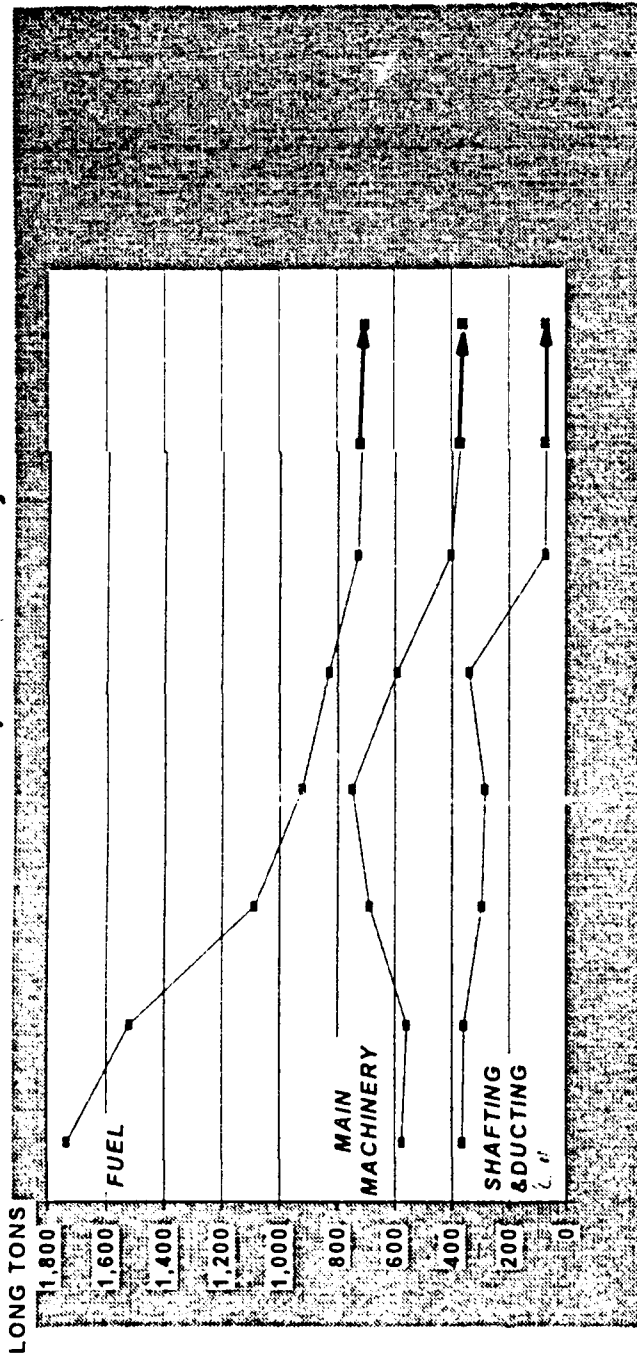


Figure 16. Reduced propeller area configuration and weights.

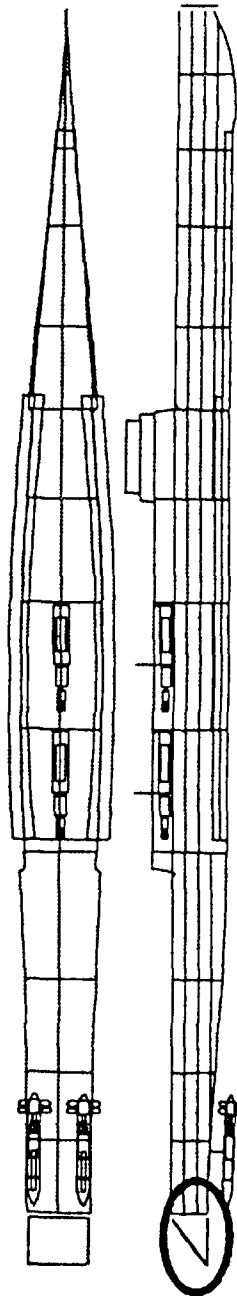
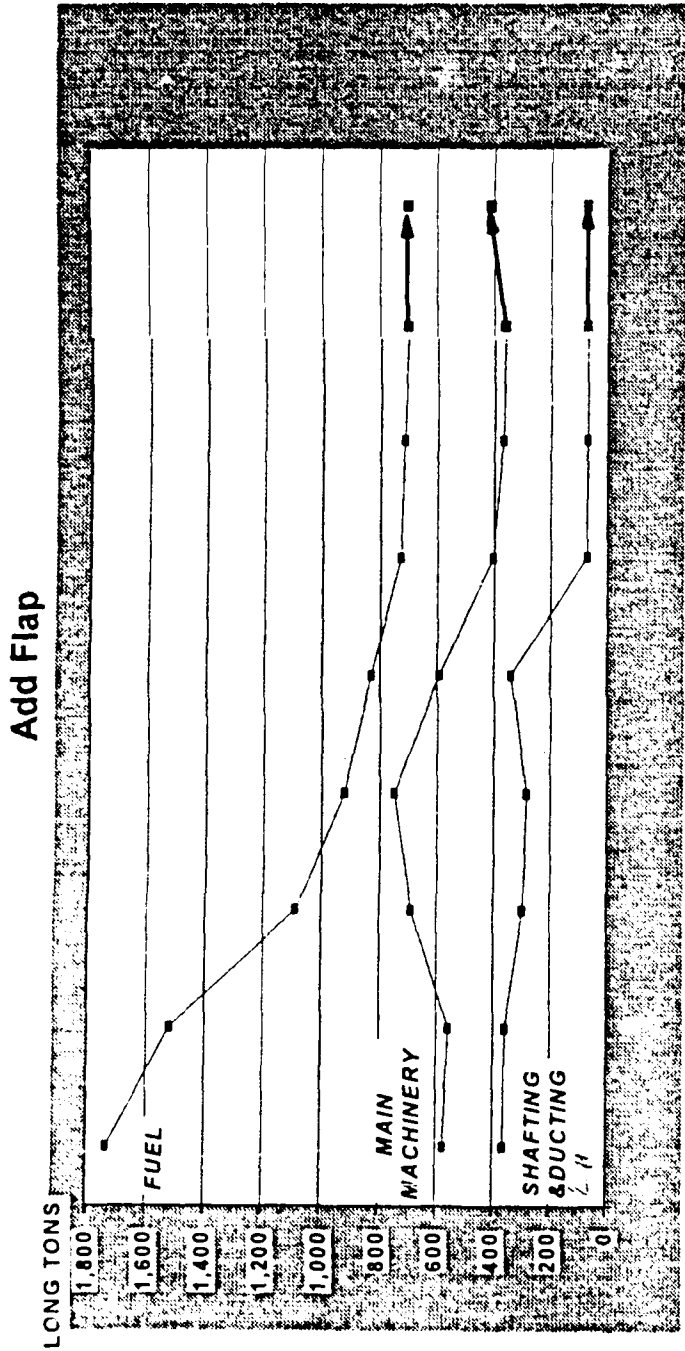


Figure 17. Flapped destroyer configuration and weights.

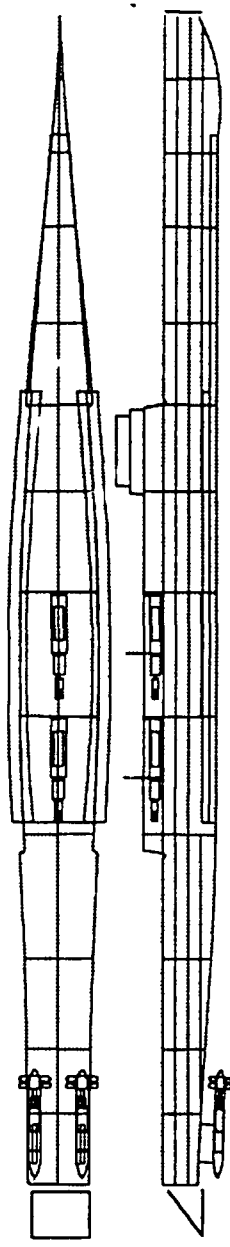
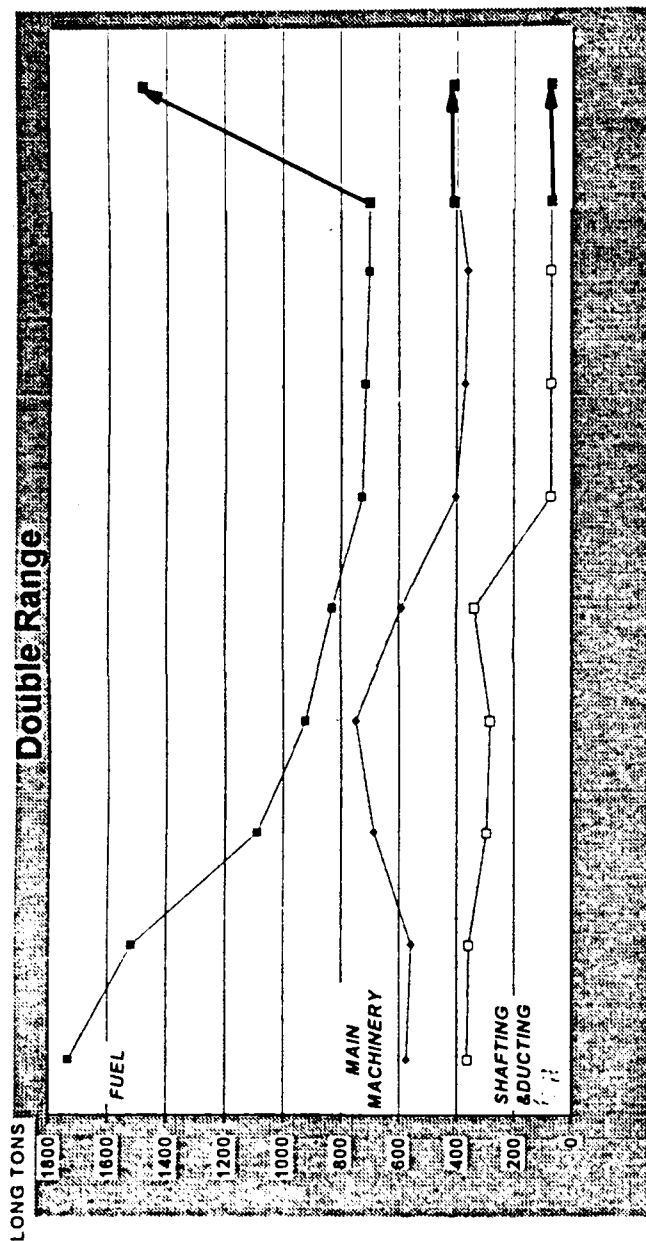


Figure 18. Doubled range configuration and weights.

REQUIRED POWER AND NUMBER OF TURBINES FOR 10 DESTROYERS

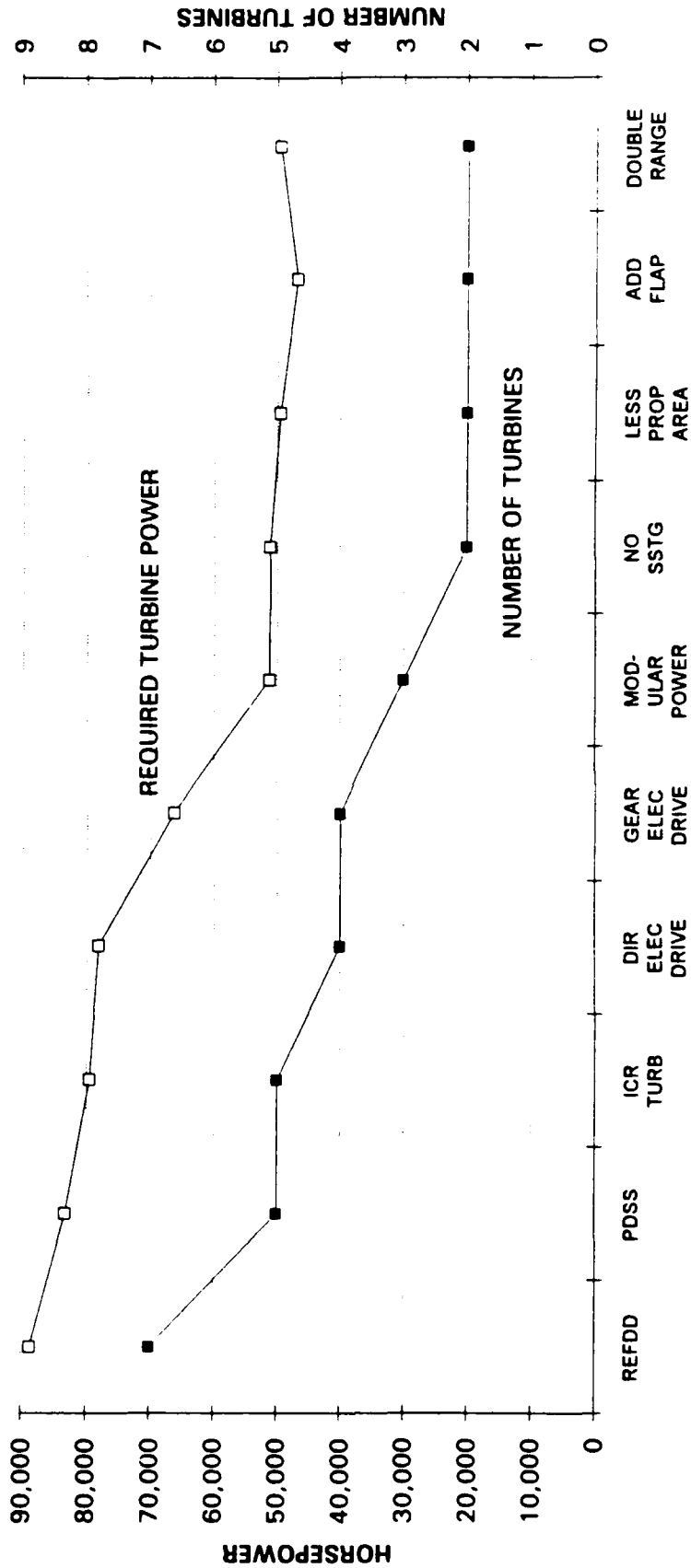


Figure 19. Turbine power required and number of turbines for 10 ships.

MACHINERY AND FUEL WEIGHTS, 10 DESTROYERS

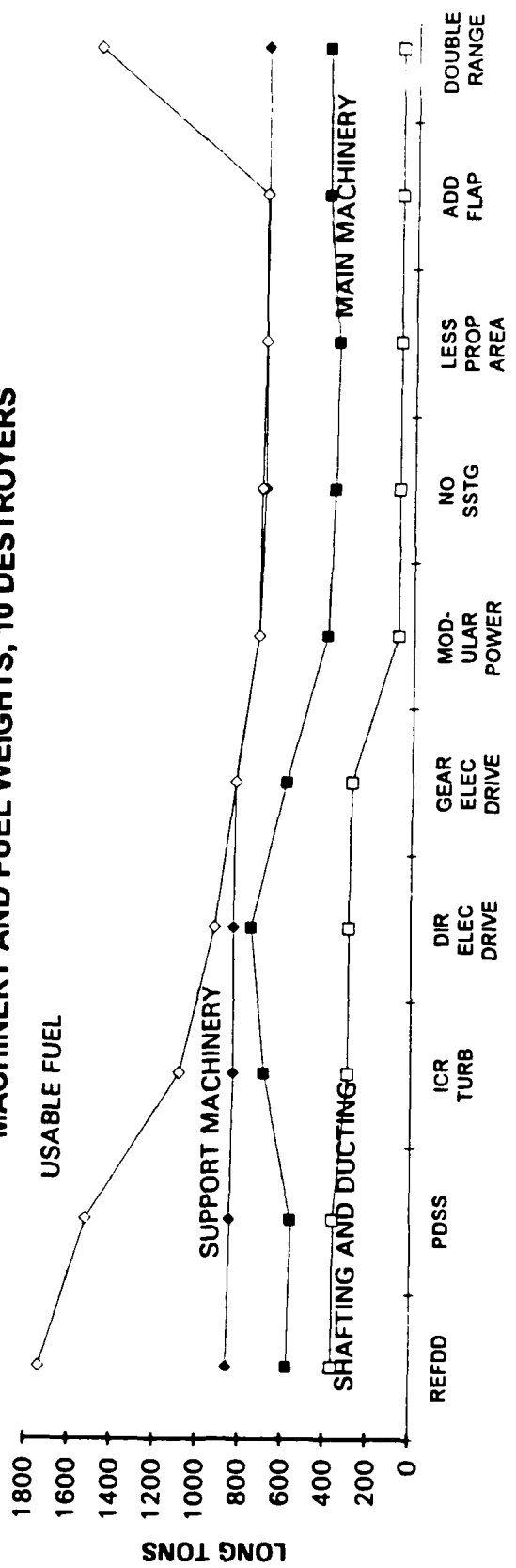


Figure 20. Machinery and fuel weights for 10 ships.

LIGHTSHIP AND FULL LOAD DISPLACEMENT OF 10 DESTROYERS

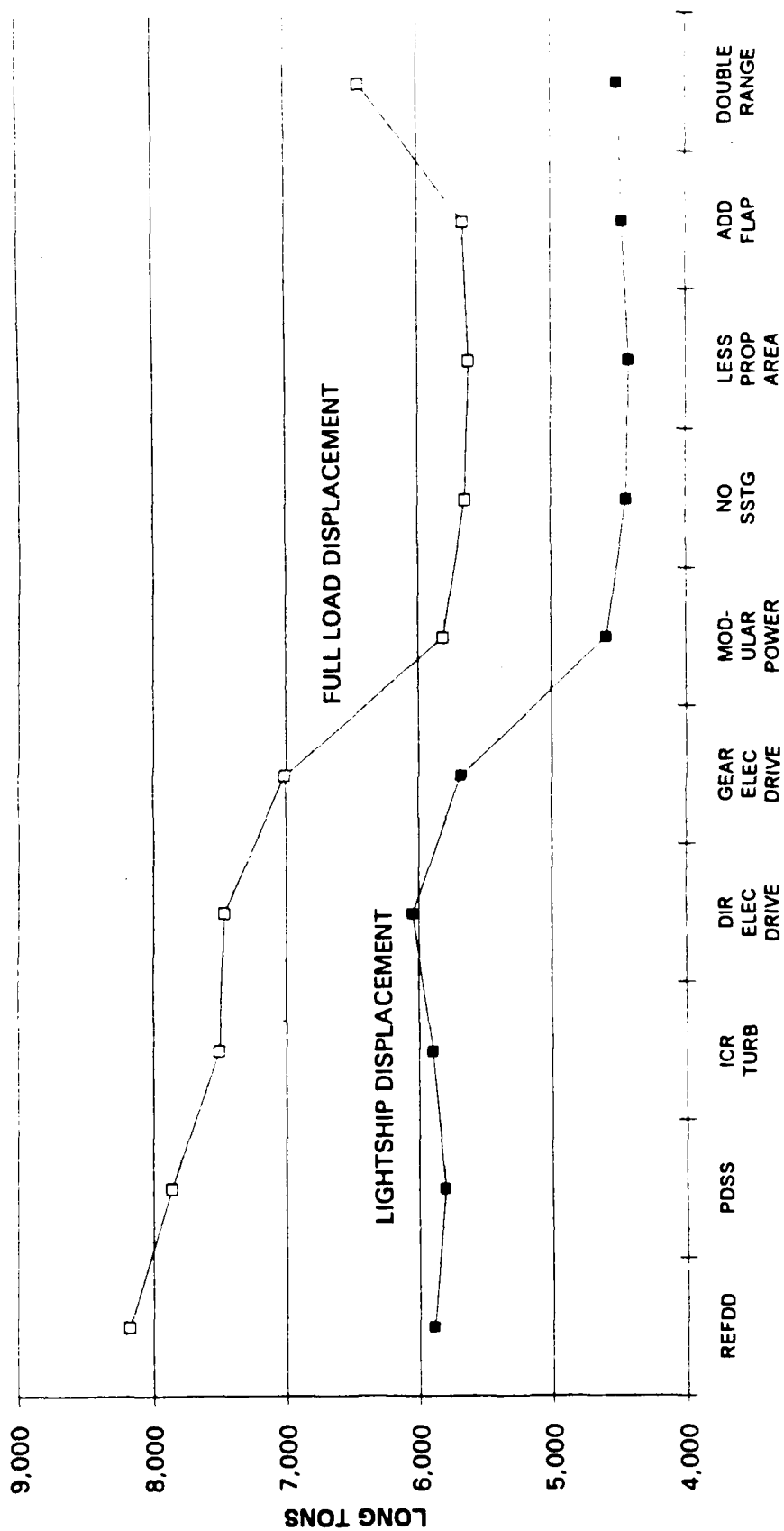


Figure 21. Lightship and full-load displacements for 10 ships.

LOSSES AT MAXIMUM SPEED

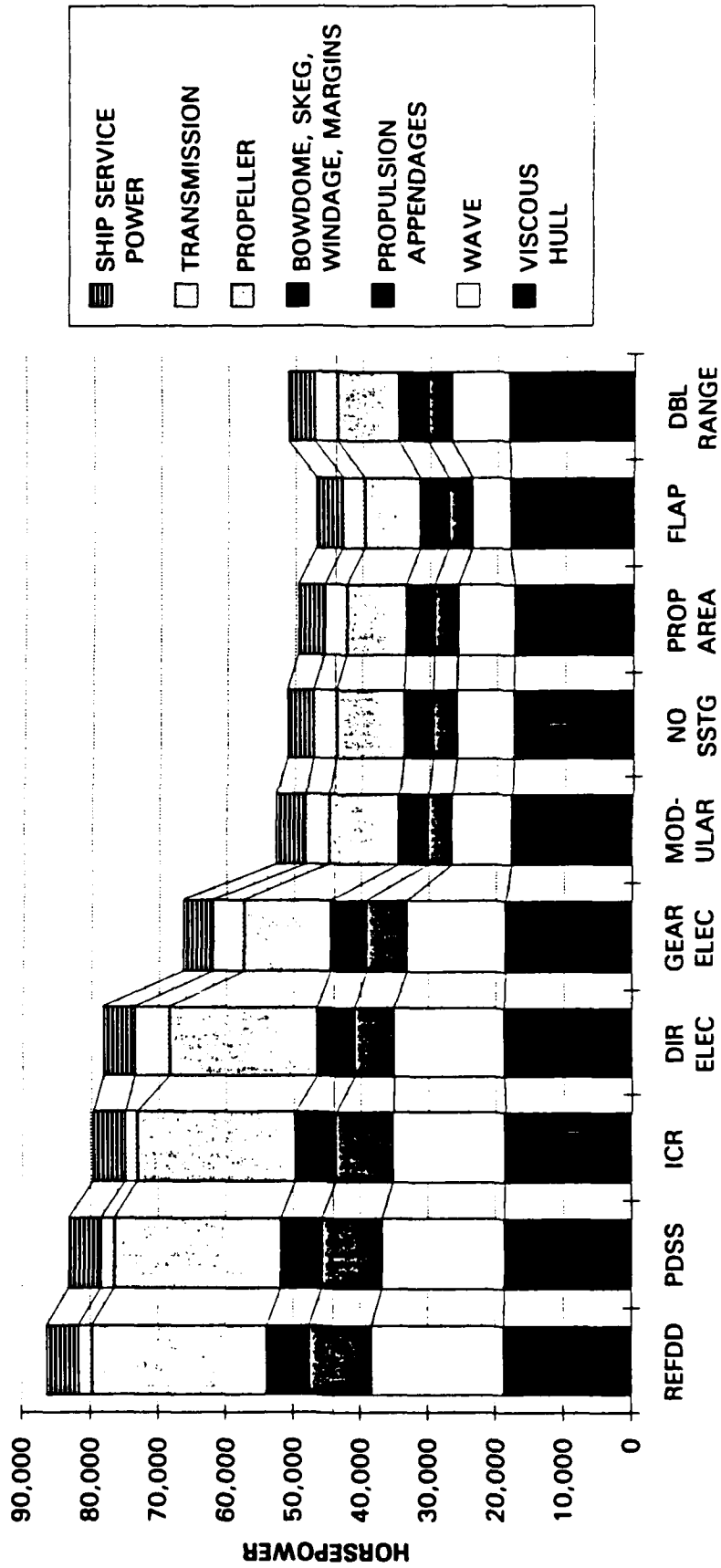


Figure 22. Losses at maximum speed of 10 ships.

LOSSES AT 30 KNOTS

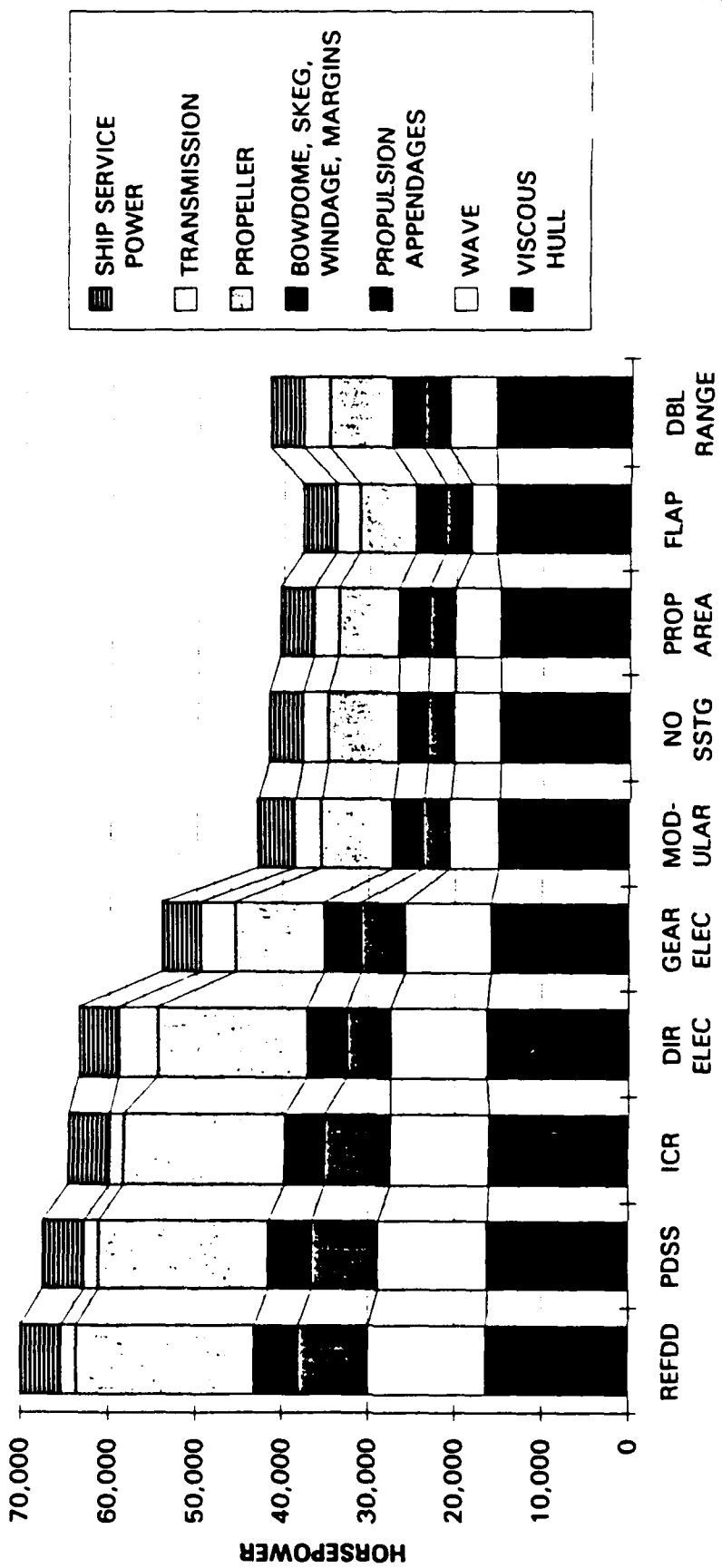


Figure 23. Losses at 30 kn of 10 ships.

LOSSES AT 20 KNOTS

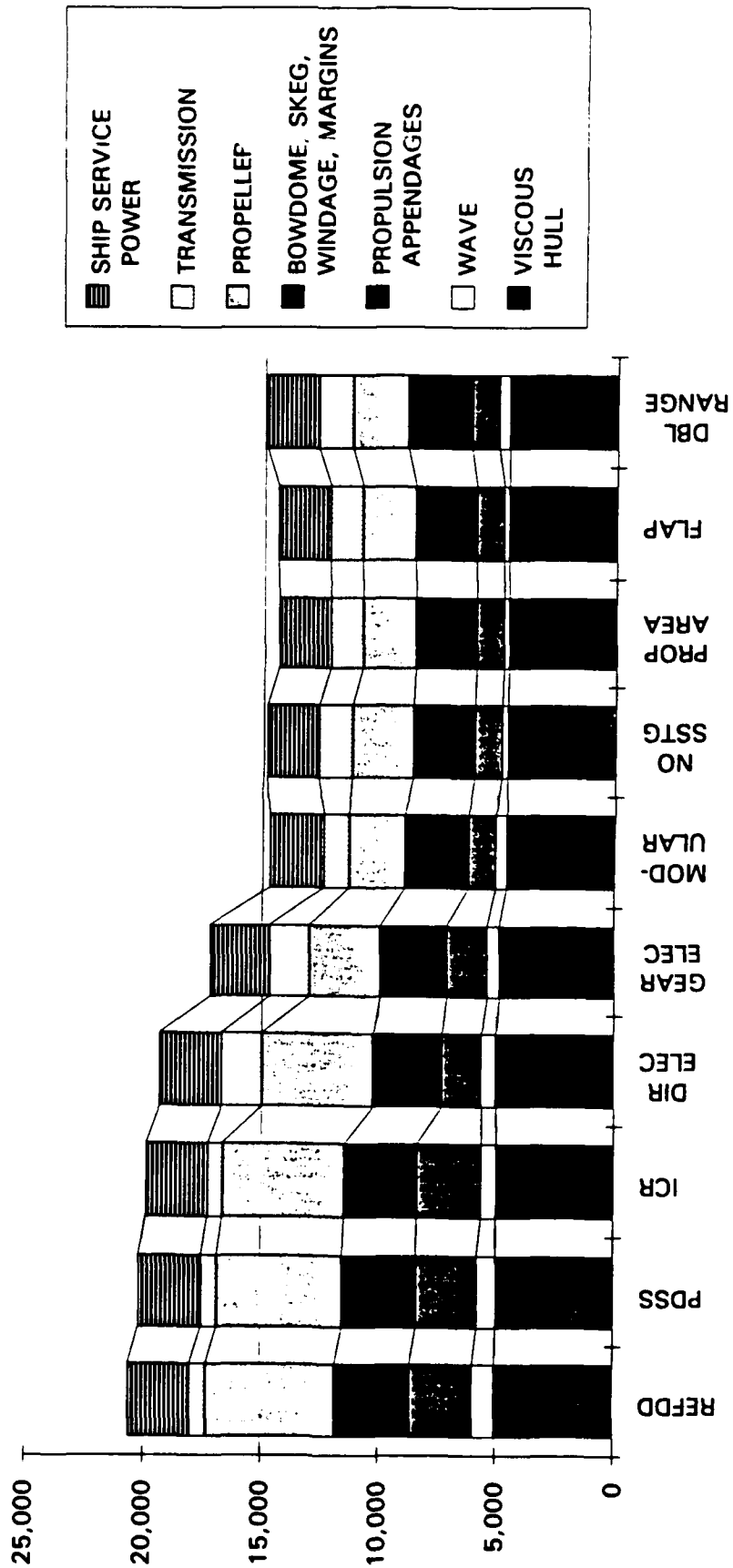


Figure 24. Losses at 20 kn of 10 ships.

LOSSES AT 20 KNOTS, INCLUDING STACK LOSSES

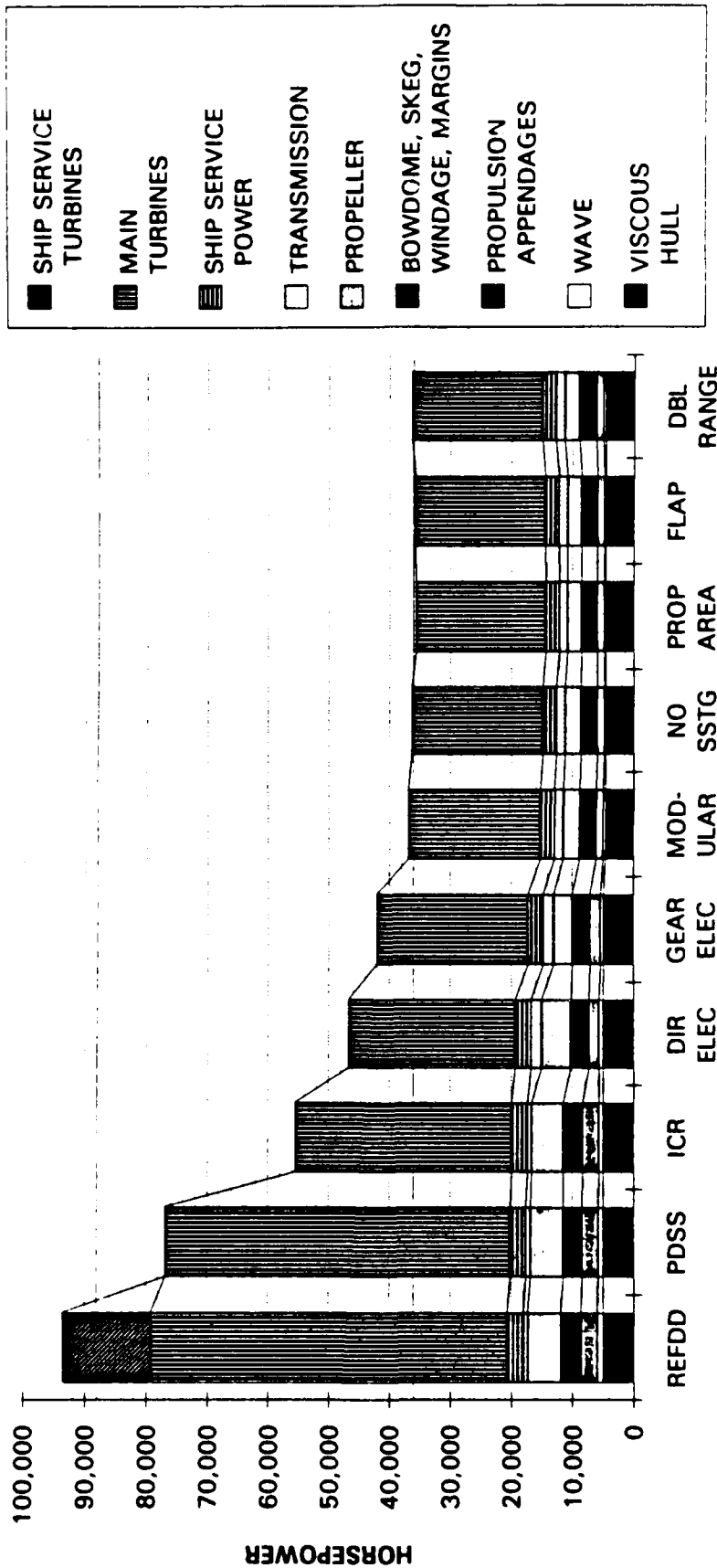


Figure 25. Losses at 20 kn of 10 ships, including stack losses.

very conducive to some types of change, notably those involving improved auxiliary machinery.)

The DD 21A design includes the basic features of the 10th ship in the preceding series, with the hull length increased to 553 ft (169 m), the total length of the 10th ship with flap deployed. The metacentric height is 4.6 ft with no burnable fuel aboard, compared with 4.17 ft for the fully loaded reference destroyer. Thus, the beam is somewhat larger than that required, and no seawater ballast is needed at the end of the mission. When fuel for 12,000 nmi endurance range is added, the draft increases 1.94 ft, but the metacentric height is only 10 percent higher (5.06 ft), thanks to tumble home. The roll frequency will increase less than 5 percent, resulting in a negligible change in ride comfort.

A steeple of composite structure atop the pilot house supports vertically coaxial (and, therefore, noninterfering) radar and communications antennae in an enclosed environment. Each level of the steeple is selectively shielded with narrow band-pass metallic sheets on the inner surface of the steeple. This material passes specific radar/radio frequencies with little attenuation, while enemy radar is reflected upward at the same angle as that which strikes the rest of the hull. Maintenance of the antennae and their actuators is minimized by the closed environment.

STRUCTURAL CONCEPT

The structural concept behind the hull is illustrated in figure 26, which shows the girder structure and forward, midship, and after cross-sections of the hull. Among the many advantages of this configuration is the continuity of load carrying by the box girders past the helicopter guideways, vertical launchers, gun barbets, etc. Another advantage is the relatively smooth transition made to the superstructure, with its large contribution to the section modulus and a corresponding reduction in hull weight. The continuity of these girders as continuous and unobstructed passageways for cables and piping will simplify hull assembly and ease the difficulty of identifying and isolating faults.

WEAPONS SYSTEMS

Weapons systems, consisting of two 61-cell vertical launch systems (64 cells without at-sea resupply capability), two 5-in./54 caliber guns, and two Phalanx close-in weapons systems, are mounted after completion of the hull structure and are pierside replaceable, as are the radar and communications antennae (figure 27).

MACHINERY MODULES

Two separate propulsor units and two power modules are also mounted after completion of the hull structure and are shown in figure 28. Figure 29 shows the assembled ship in top and side views. Figure 30 is a rear view, and figure 31 shows the addition of a retractable stern flap. Figure 32 shows the DD 21A deck plans. Figure 33 is an enlarged view of the helicopter hangar.

DESIGN METHODOLOGY

The following precepts were used in developing the 21st century destroyer design.

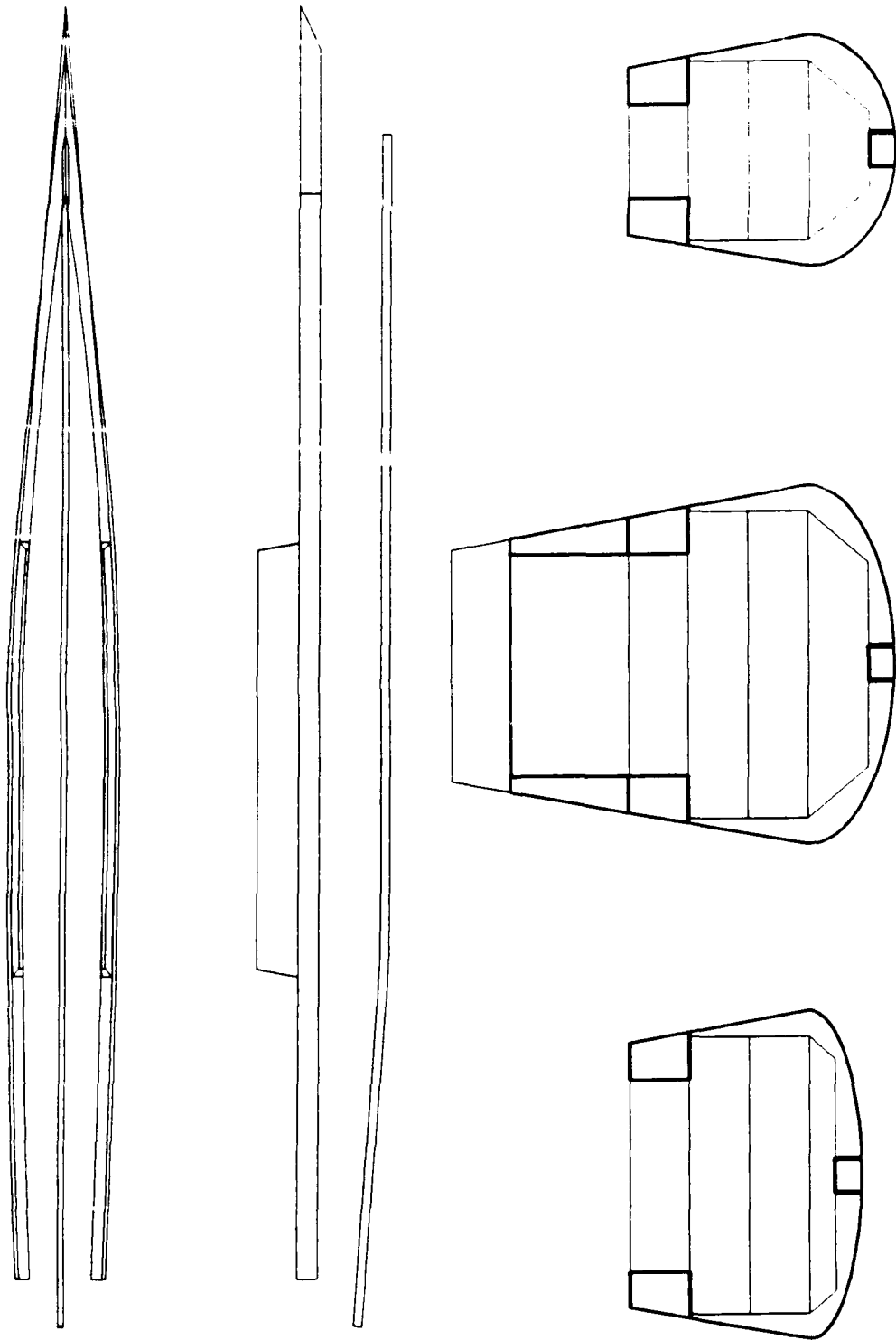


Figure 26. DD 21A hull girder and bulkhead configurations.

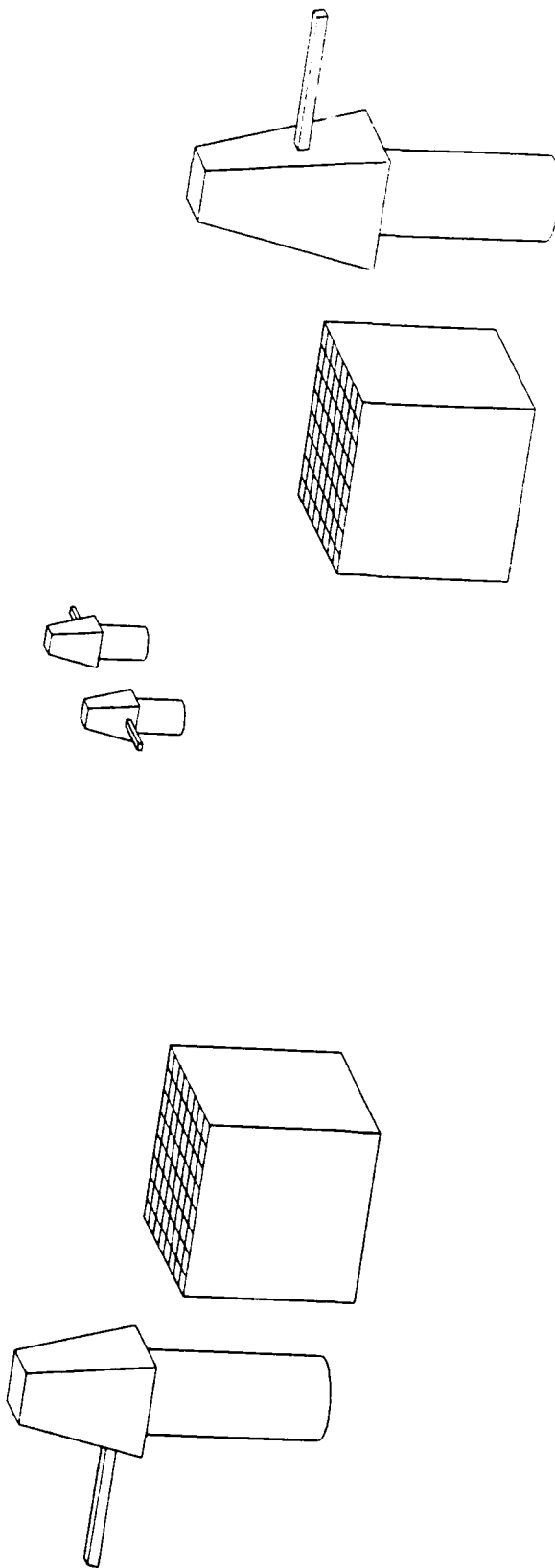


Figure 27. DD 21A removable weapons.

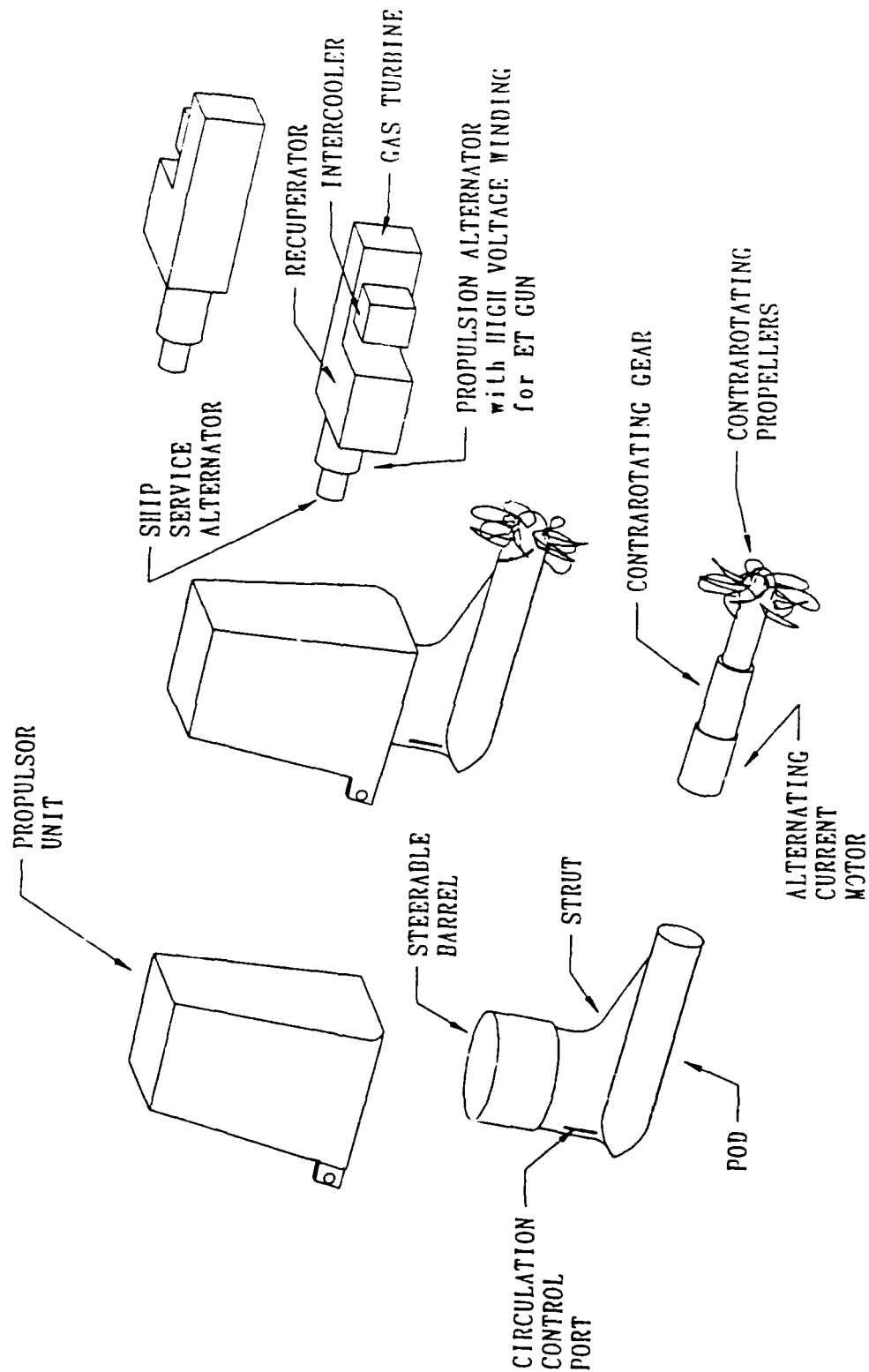


Figure 28. DD 21A removable machinery modules.

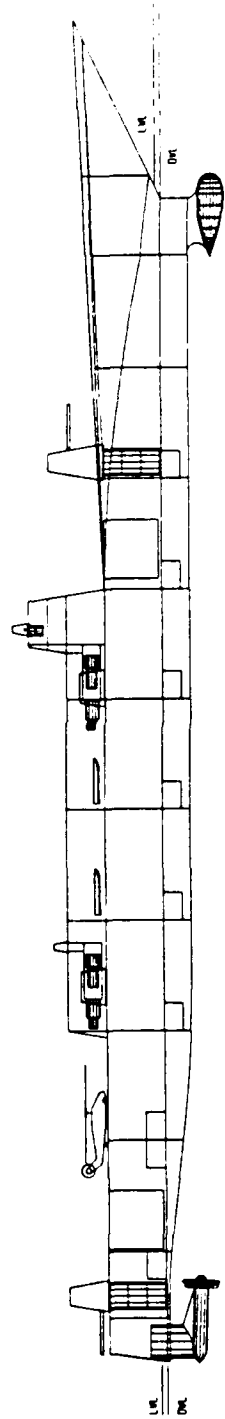


Figure 29. DD 21A side view.

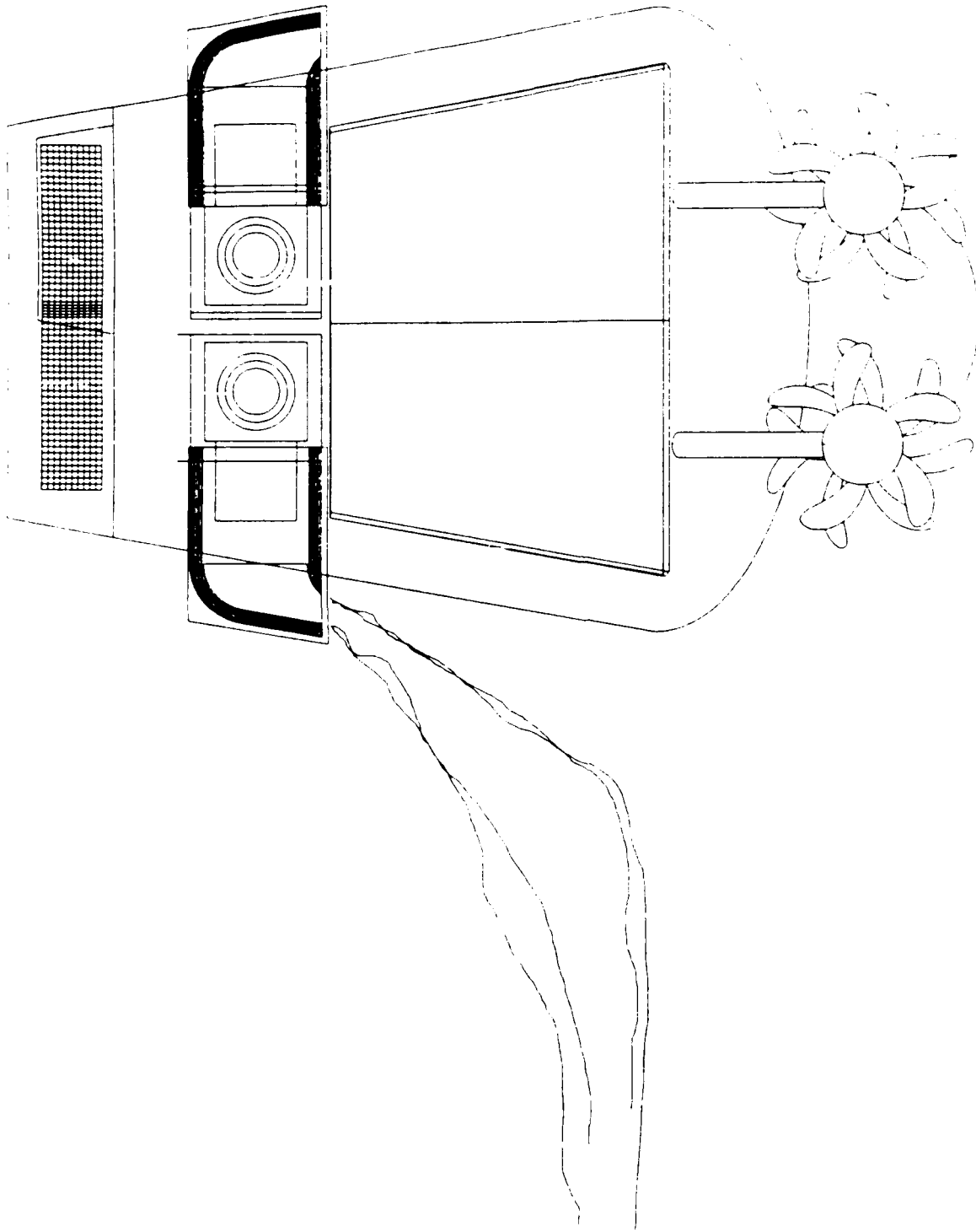


Figure 30. DD 21A rear view.

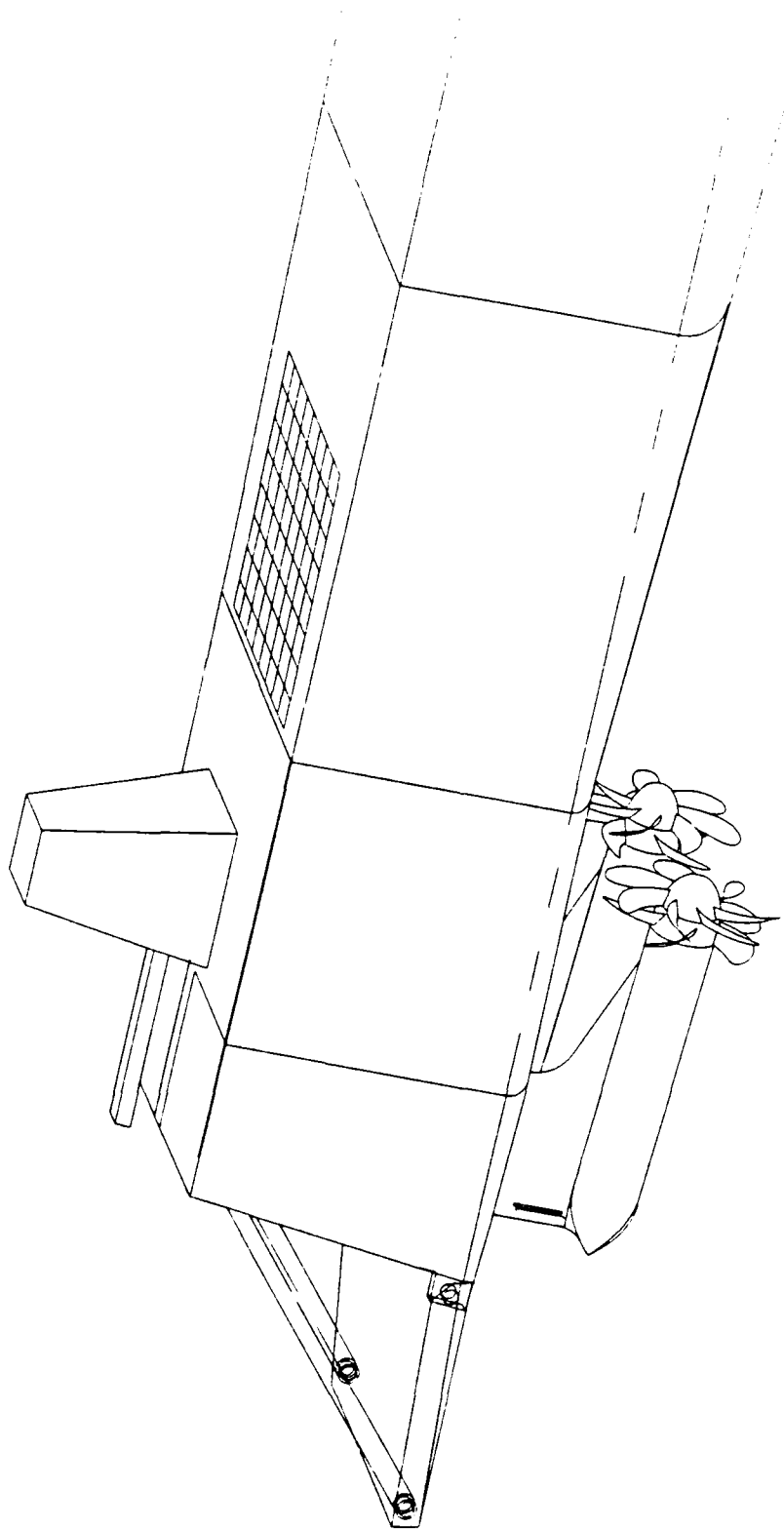


Figure 31. DD 21A with flap.

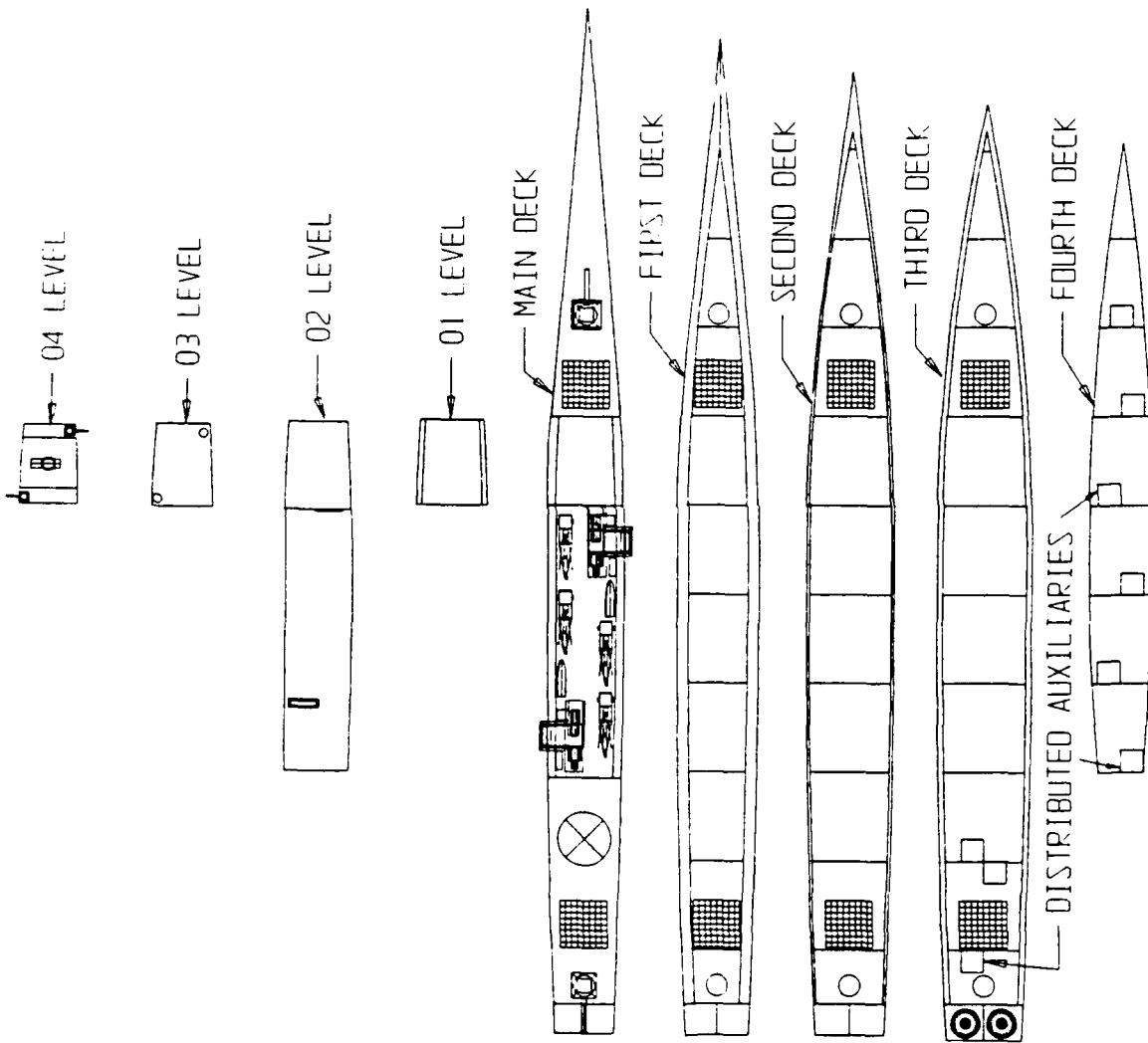


Figure 32. DD 21A deck plans.

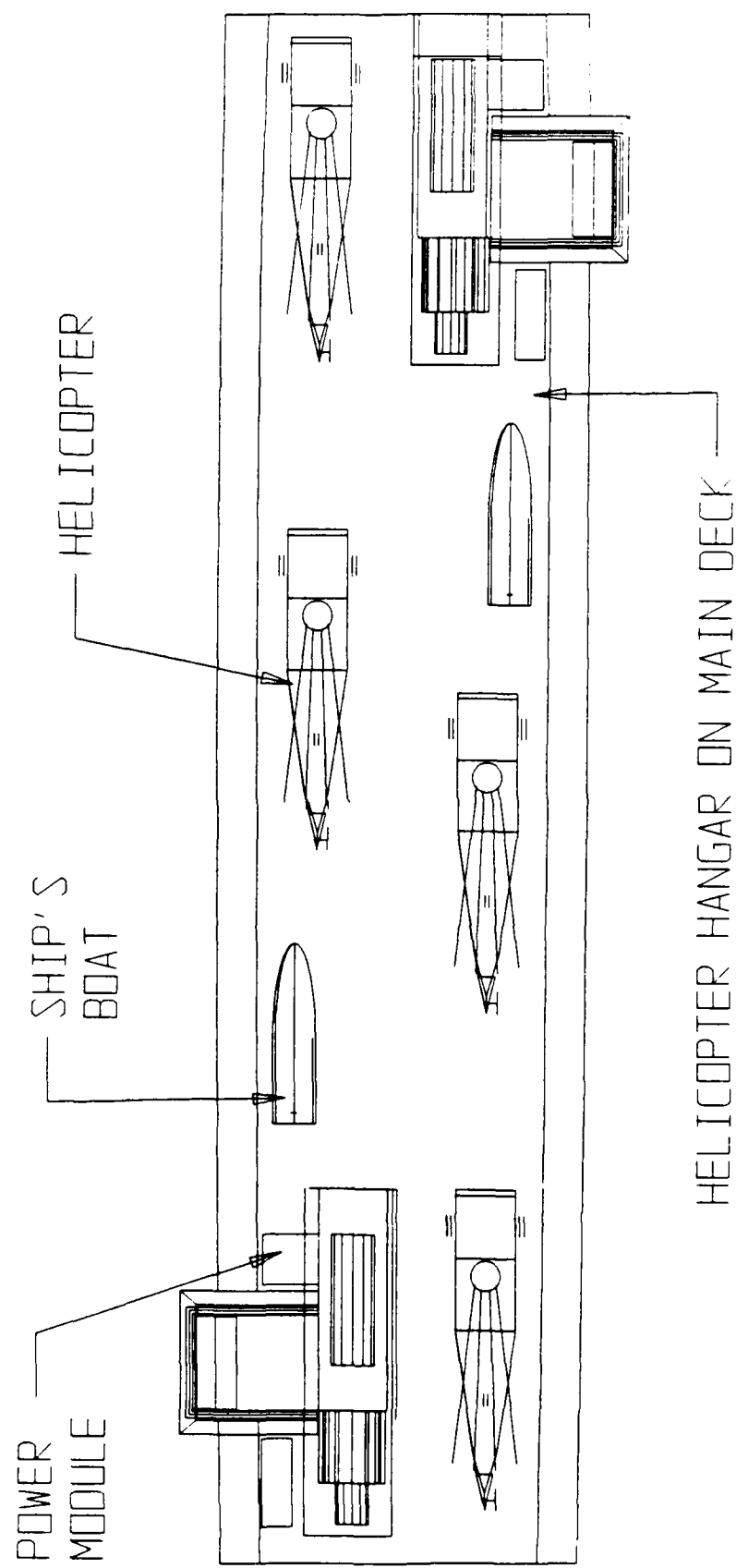


Figure 33. DD 21A helicopter hangar plan.

Reduce Engine Power Required

Reduce engine power required at maximum speed in view of the following:

- A study of the Taylor series of cruisers¹⁰ and the Hamburg C series of destroyers¹¹ shows that the resistance of a properly selected destroyer hull (without appendages) at maximum or sustained speed will not exceed:

$$\frac{\text{Resistance}}{\text{Weight}} = 0.25 (Fr-0.3) ,$$

over the range $0.35 \leq Fr \leq 0.45$. We selected a Froude number (Fr) of 0.38 at the 30-kn sustained speed in order to reduce the cost of installed power, which results in a 553-ft (169-m) design waterline. With a stem angle 26 degrees from the horizontal, the waterline length increases with the addition of fuel, further reducing the Froude number at the heavily loaded condition.

- A steerable, cylindrical pod of the minimum diameter and length consistent with acoustic requirements and motor diameter produces less than half the resistance of open shafting. A streamlined strut connects each pod rigidly to a steerable, barrel-shaped auxiliary machinery room. Manned entry into the rear of the pod from the machinery room is through the after-part of the strut. Access forward is via the forward extension of the strut. The strut has the maximum possible longitudinal length to minimize interference drag. The pod is angled downward to provide axial inflow into the propeller during straight-ahead operation.
- Lightly loaded, contrarotating tractor propellers, facing directly into the undisturbed flow stream outside the hull boundary layer, provide high efficiency and no cavitation at speeds up to 25 kn, except during sharp turns and rapid accelerations. The propellers operate at specific speeds near 1.2 instead of the often recommended "maximum efficiency," with a specific speed near 1.0, in order to keep machinery weight and size modest at any chosen propeller efficiency and cavitation limit. Seven blades forward and five aft minimize both tip cavitation and acoustic signature.
- ICR gas turbines are used because they greatly increase efficiency, reduce airflow, and reduce exhaust gas temperature and infrared detectability. Their additional weight is far more than compensated by fuel savings.
- One engine can provide full ship service power and propulsion power at speeds up to at least 25 kn. A ship service alternator and a propulsion alternator are mounted on each turbine shaft. Ship service power at anchor is provided by the ICR engine far more efficiently than by current SSTG sets and without their additional weight and expense.
- A battery energy storage system powers vital loads during the short time between the potential failure of a single operating engine and the startup and the bringing online of the other engine. This system uses ordinary lead acid batteries and large inverters, for a total weight of 28 tons. The batteries and inverters should be distributed appropriately throughout the auxiliary machinery rooms.
- The sonar dome doubles as a bow bulb, which best reduces high-speed resistance when it is mounted as far forward as possible. It must also be mounted low enough not to emerge in a seaway when fuel is low.

Modular Machinery

All machinery systems must be modular, pierside installable or replaceable, and must not impinge on the prime central parts of the hull or weather deck. This requirement leads to the use of electric drive, which permits the propulsor modules and the power modules to be independently located. The concept described here is for a simple electric drive system, using technology developed in the sixties.

- Compact electric ac propulsion motors, contrarotating ring-ring bicoupled gears, thrust bearings, and seals combine into a single, rigid, pretested propulsor capsule, which drives the contrarotating propellers. The propulsor capsule is slid into a streamlined cylindrical pod, with one acoustically compliant mounting point forward and one aft.

- Synchronous ac electric drive, with identical high-speed, four-pole alternators and motors, provides reasonable efficiency with great simplicity and low cost. No solid state control is used, thereby minimizing cost, size, weight, acoustic signatures, and power losses. Pole-switching of the motors provides eight virtual poles for operation at 6- to 18-kn speeds, and dampc. shields provide induction-motor torque for startup and low-speed reversing.

- Ring-ring bicoupled contrarotating gears with four planets in the first stage and seven in the second stage power contrarotating propellers at a reduction ratio of 33.4 to 1. At maximum speed, the propellers rotate at 107.8 r/min. In the seven-planet second stage, each of the double-helical planets meshes with both sun and ring gears. The 28 meshes are out of phase, and each planet has about 100 teeth so that the individual tooth engagements produce very small torsional accelerations. Flexible spindles and flexible-tooth ring-gear holders greatly attenuate these vibrations before they reach the shafts and propellers. Even low k factors ($1\% \text{ lbf/in}^2$ equals 1 MPa) permit modest gear size because of the compactness of the basic design.

- The turbine, the ship service alternator, and the propulsion alternator (with an optional second high-voltage winding for advanced electric guns) are built into a module which can be loaded pierside onto the helicopter deck and rolled into the hangar for installation or replacement.

Global Endurance

A 12,000-nmi range is required for global endurance, but the intent is to reach 15,000 nmi by taking full advantage of the ship configuration. A continuous speed of at least 30 kn is available throughout the mission. Maximum speed varies from 31.9 kn fully loaded with maximum fuel to 33.7 kn at the end of the mission. If credit is taken for the weight, space, and power savings that result from the use of distributed auxiliaries, this performance will increase considerably.

Stealth

Stealth is a paramount requirement. Stealth is divided here into four components: acoustic signature, wake detectability, radar return, and infrared signature.

Acoustic Signature. Acoustic signature is primarily due to propeller noise for ships operating at endurance speed and above. Propeller noise is dominated by cavitation when it occurs, and cavitation is avoided at all speeds below 25 kn, a speed achievable with a

single turbine. The use of contrarotating propellers with seven blades forward and five aft avoids tip cavitation, and with sufficient blade area, back cavitation does not appear until higher speeds.

Wake Detectability. The wake signature is sharply decreased by the use of contrarotating propellers, which avoids the major wake vortex that usually brings subsurface water to the surface, which is often at a different temperature. The low power requirement also produces less wake.

Radar Return. A constant tumble home angle throughout the hull topsides, continued uninterrupted into the superstructure and steeple, minimizes the number of angles from which high radar return is received. This feature, combined with the elimination of right angles at any intersections, decreases detectability from ships, from surface-skimming missiles, and from satellites. A clean outer surface enhances the low radar cross-section; most deck machinery, bits, bollards, cleats, etc., will be hidden from view, and stanchions, lifelines, etc., will be carefully designed, be nonmetallic, and, possibly, be retractable. Antennae will be contained within weapons when possible. They are conformal and mounted on the pilot house, superstructure, or steeple in other cases. Rotating mechanical antennae are coaxial and contained within the steeple. Figure 34 shows how the relative radar cross-section of a square piece of metal six deck heights (54 ft) on a side changes with incidence angle in the range from zero to 20 degrees for 31.9 mm and 319 mm wavelengths. The reduction in cross-section is down over 40 dB (a factor of more than 10,000) at our chosen 10- to 12-degree tumble home, compared to a vertically sided ship.

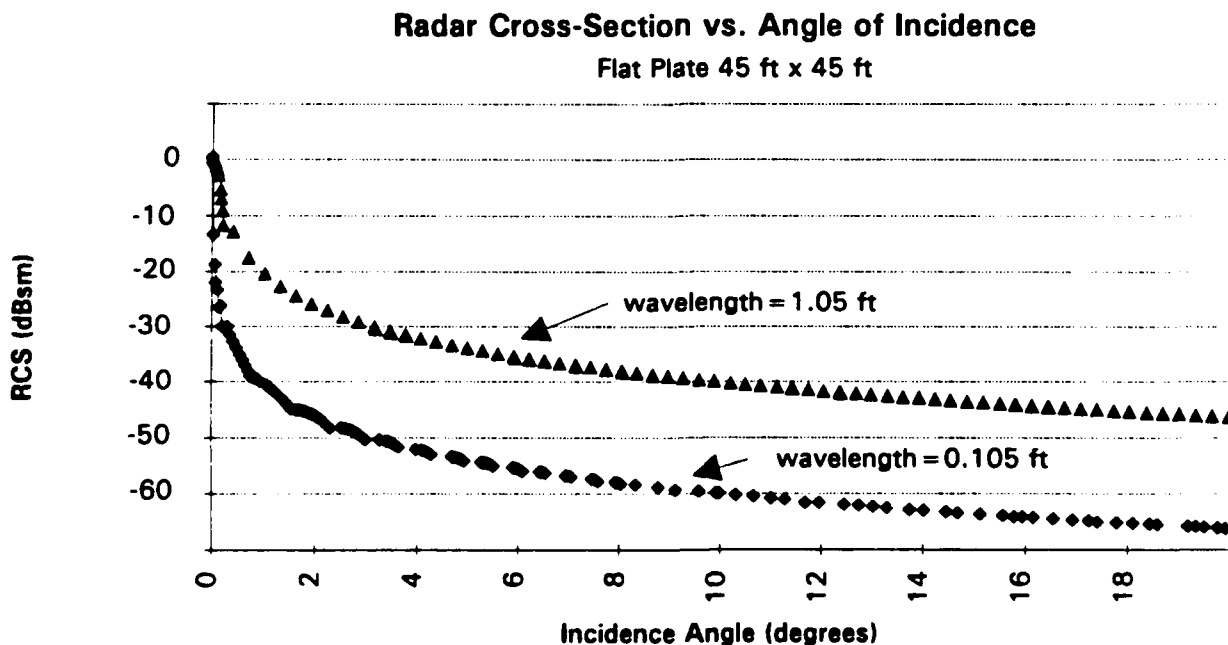


Figure 34. Radar cross-section as function of tumble home angle.

Infrared Signature. This tumble home configuration also permits mounting the engines above the girder, exhausting downward and abeam, without the ducting extending beyond the waterline beam of the ship and without occupying ship volume. A short-duct, boundary layer, infrared shielded (BLISS), air induction-cooled exhaust system, minimizes infrared detectability from any point above the horizon. The exhaust gases from the ICR engine are at low temperature, the BLISS system dilutes them with cool air, and the exhaust is projected downward and outward toward the surface, so that the plume will have very low visibility to other ships or to low-flying missiles. The BLISS shields comprise several parallel layers of stainless steel. If the side exhaust were temporarily swamped by a rogue wave, the exhaust gases will escape via the infrared shields.

A short vertical uptake is an alternative exhaust system, which would have higher infrared visibility from above but would permit operation of the engine pierside or in a nested ship configuration. It is possible that both of these two exhaust configurations could be installed and either used at the commander's discretion.

Seakeeping

Crew comfort is ensured by adequate transverse stability, tolerably low roll frequency, good seakeeping in heavy head seas, and crew working and living quarters near the ship's center of gravity.

The hull is designed to have adequate transverse stability at the design point with zero fuel. Tumble home above the design waterline prevents a rapid increase in roll frequency as fuel is added. A large waterplane forward, together with a long waterline, ensure good head-seas seakeeping. Banishing all major machinery and ducting from the watertight hull has made the center of the ship available for personnel.

Steering

The steering system of this ship is intended to be uniquely capable, since the ship may have to operate in harbors without tugs and may have to do precise stationkeeping. Steerable pods provide unexcelled maneuverability.

Each steerable pod drive and its auxiliary systems are combined into a detachable, pretested, shore-maintainable unit, which can be removed and replaced pierside. There are two of these units per ship, and both attach to the stern. The units form naturally shaped extensions to the hull. The upper part of each unit is available to deploy towed sonar arrays. Provision is made to extend a fixed or retractable flap from the bottom of the unit. The barrel contains individually replaceable auxiliary machinery components that support the propulsor system.

A streamlined strut connects each pod rigidly to a steerable barrel-shaped auxiliary machinery room. The barrel contains individually replaceable auxiliary machinery that supports the propulsor system and is steered by orbitally geared electric motors. Manned entry into the rear of the pod from the machinery room is through the after-part of the strut. Access forward is via the forward extension of the strut.

Steering during major maneuvers is done using a high-ratio orbital drive, which is integral with the moderately loaded, large-diameter roller bearing (see figures 35 and 36) that supports the entire rotatable pod and barrel system and transmits thrust to the structure. Normal steering corrections are quietly made by preferential ejection of cooling

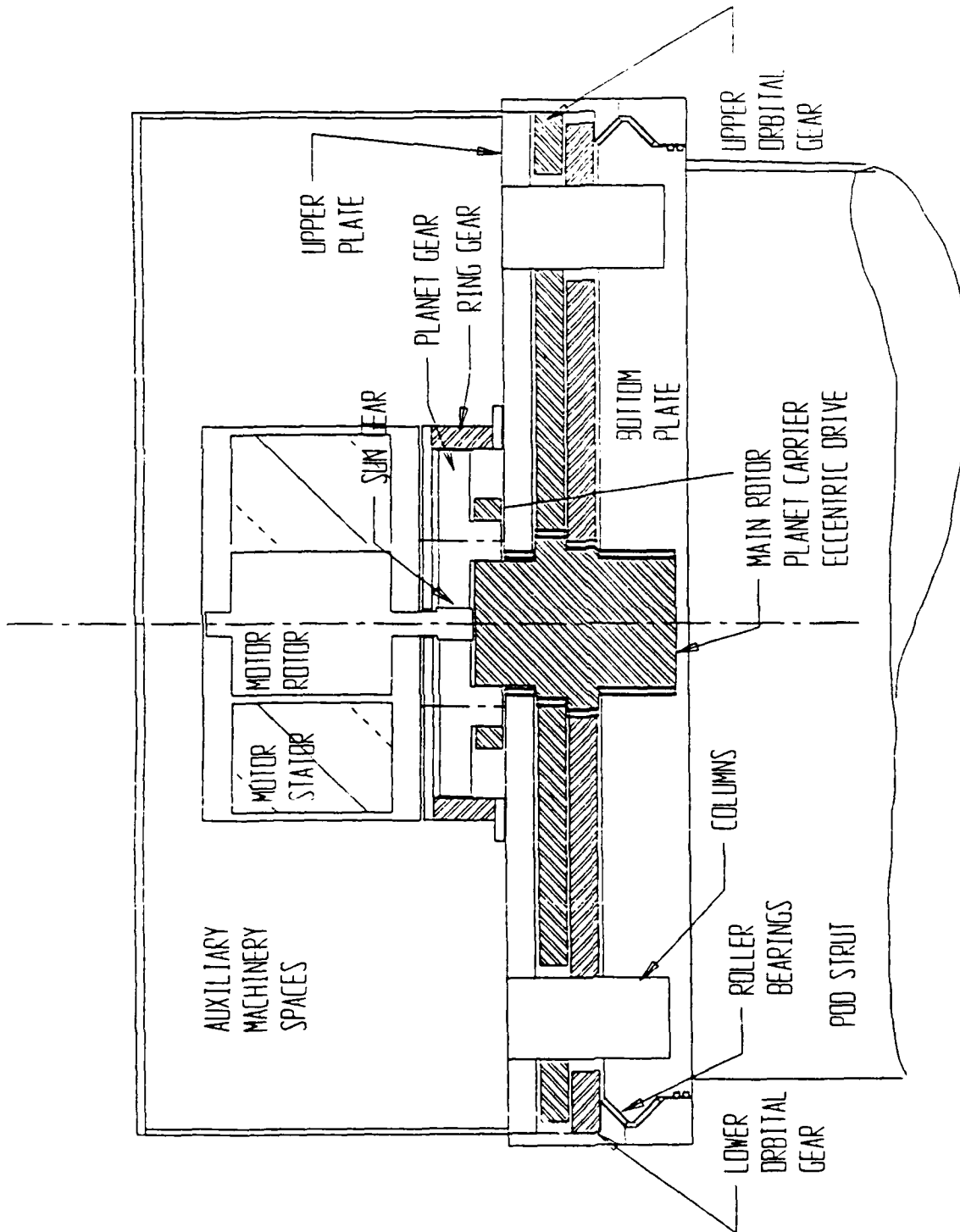
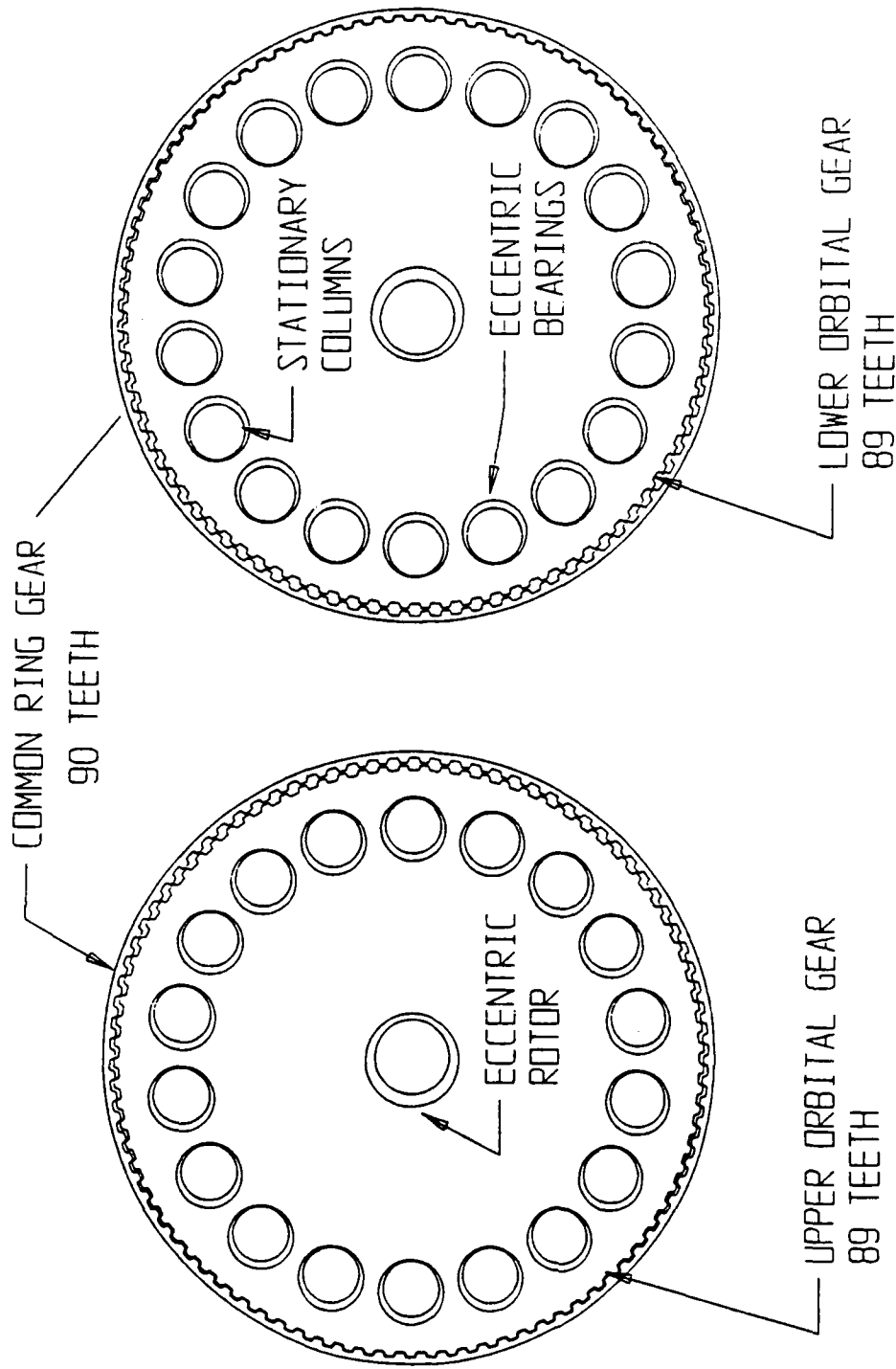


Figure 35. Weight and cost of the reference destroyer by SWBS groups.



BALANCED DOUBLE ORBITAL GEAR

Figure 36. Relative costs per ton of SWBS groups 1 to 7.

water through the port or starboard after-sides of the struts, providing circulation control via the Coanda effect (figure 37).

The steering system can rotate the pod rapidly to provide fast turning or crashback. The pods are mounted on vertical, steerable-barrel stern units. The rear ends of the pods are short enough to not interfere so that 270-degree rotation is possible. Fast crashback is achieved by rotating the pods in opposite directions (figure 38); a very short ahead reach is possible even without using throttle control. If a barrel rotational rate of 12 degrees/sec is provided, the deceleration is smooth and reasonably fast, averaging 3 ft/sec^2 , or about 0.09 g. The result is a stop in less than 16 sec and an ahead reach well below one ship length. By comparison, the blades of a controllable, reversible pitch propeller would not yet have finished changing pitch in 16 sec. Since the pilothouse is located high enough so that an obstruction can be seen one ship length ahead, the officer of the deck can stop the ship before hitting any visible object.

Sharp turns are made by rotating the pods through large angles. Excellent maneuverability at sea or in the harbor are ensured. Figure 39 shows some of the pod configurations useful for turning. The normal modes are illustrated in the second through fourth pictures, with the pods rotated at 15, 30, and 45 degrees. Figure 40 shows the corresponding steady-state turning radii of about 4, 2, and 1.4 ship lengths for each of these three modes. The radius of the turn is approximately R/L equals $\csc \theta$, where θ is the turning angle of the pod. For rudder-steered destroyers, the corresponding radius is approximately R/L equals $1.5 \csc \theta$, and the angle is frequently limited to 40 degrees.

The seventh picture shows the two pods at 45 and 135 degrees, respectively, providing a net thrust at 90 degrees and a turning radius of about one ship length, a potentially useful condition for harbor maneuvering or stationkeeping. By comparison, open shaft ships with maximum rudder angles of 40 degrees have minimum turning radii that exceed 2.3 ship lengths. The podded destroyer is highly maneuverable when steaming astern, while ships with rudders are notoriously balky astern.

Survivability

Future surface combatants should be able to survive shallow-water mine explosions and low-level missile attacks—the most likely new challenges—as well as tolerate chemical and biological warfare and nuclear fallout radiation.

A box-girder hull increases the probability of survival after a shallow-water mine explosion because it resists whipping deformations of the hull. The box girder also serves as a continuous duct along each side of the hull just below the weather deck and carries all longitudinal electrical communications and piping. The midship space between the two box girders is relatively well protected against shrapnel and would be a good location for the combat information center.

A basic damage stability requirement exists. The ship must be stable with any two adjacent compartments flooded. This requirement appears superficially more difficult to meet because the tumble home configuration reduces the beam at the surface as the ship submerges. The fundamental "saving grace" is that there are no main machinery systems below the weather deck, so that the usual long machinery compartments do not exist. The ship can be compartmented freely to meet the damage-stability requirement. The basic stability of the unballasted hull, moreover, is far greater than that of conventional hulls and remains greater throughout the load range.

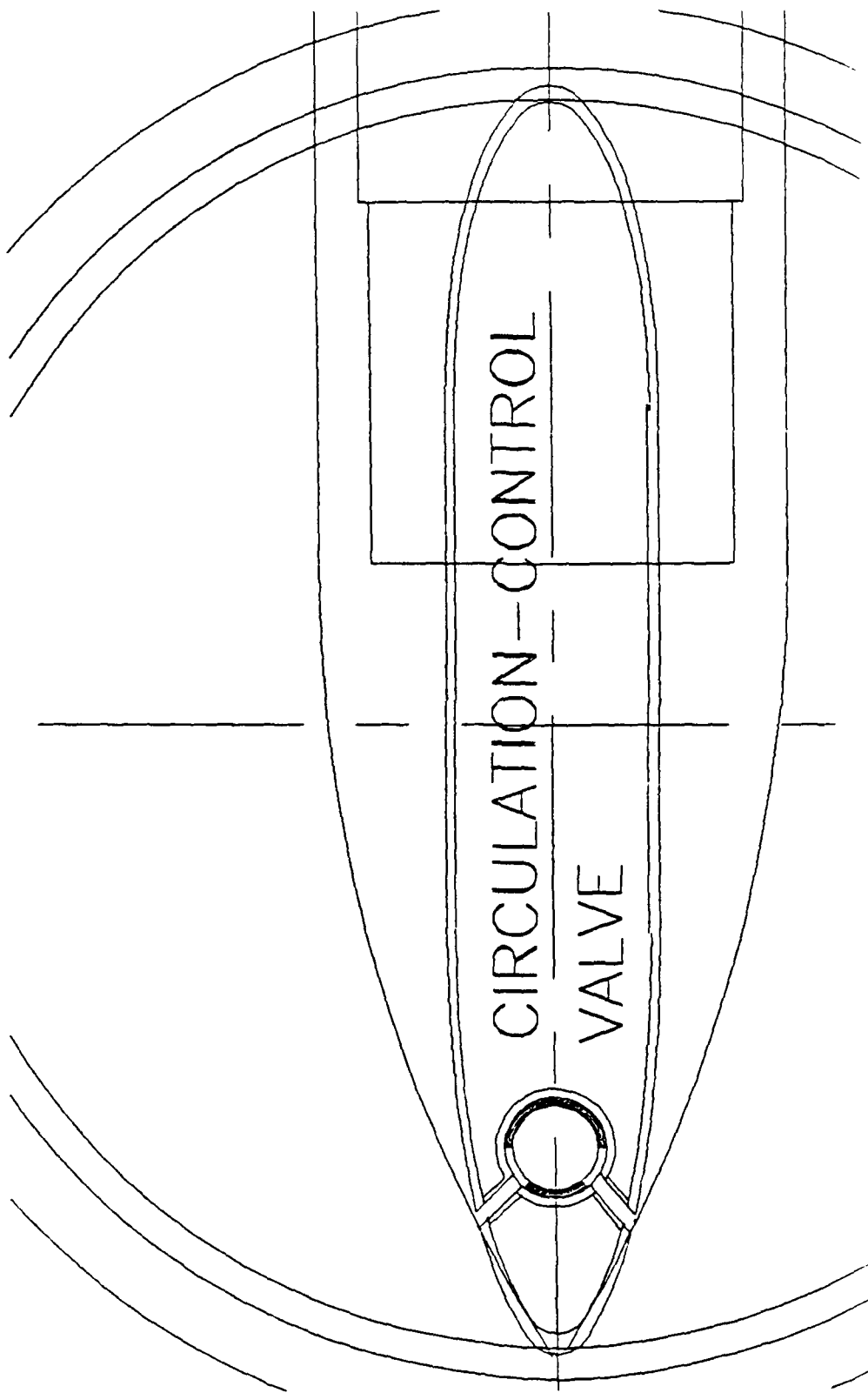


Figure 37. Circulation control of pod strut for steering.

CRASHBACK FROM 31.7 KNOTS, CONSTANT THROTTLE SETTING

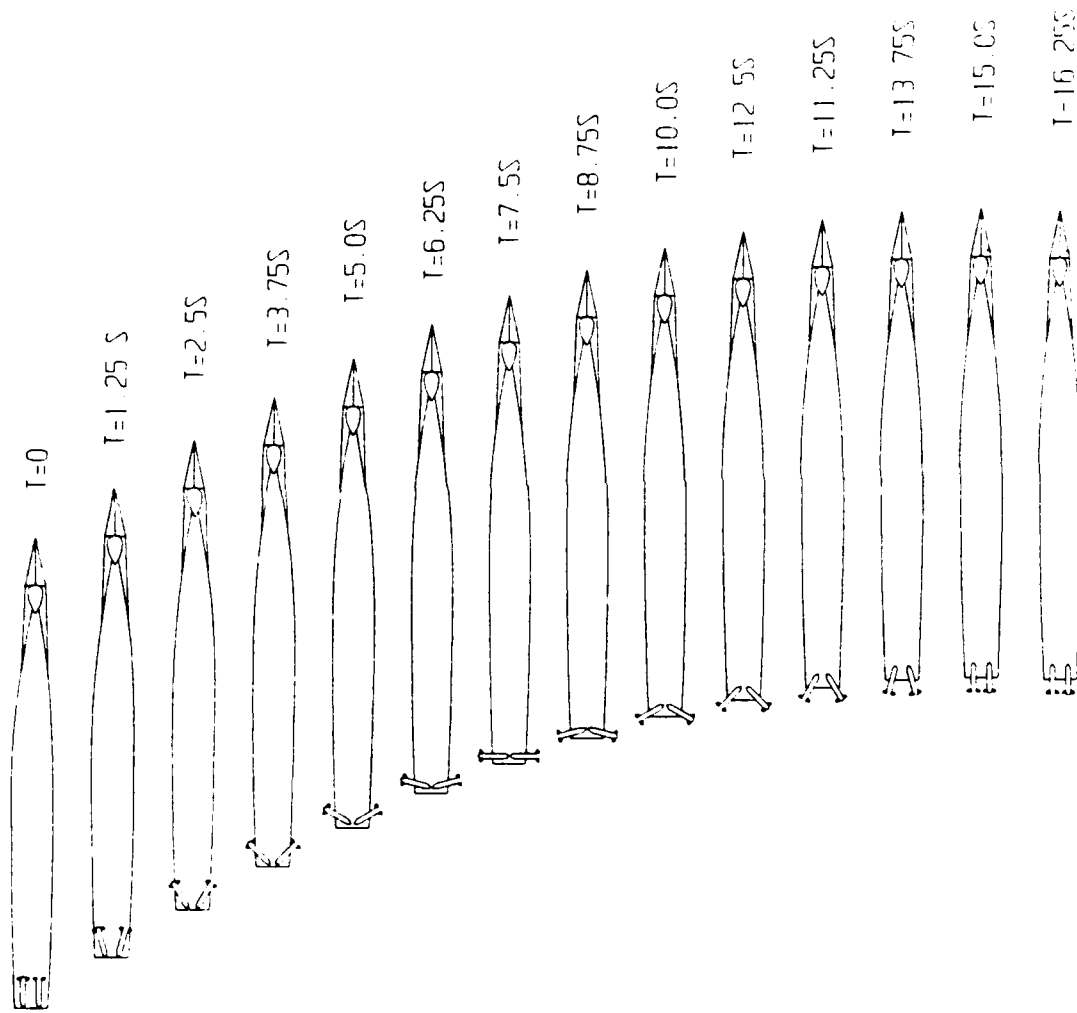


Figure 38. Crashback maneuver.

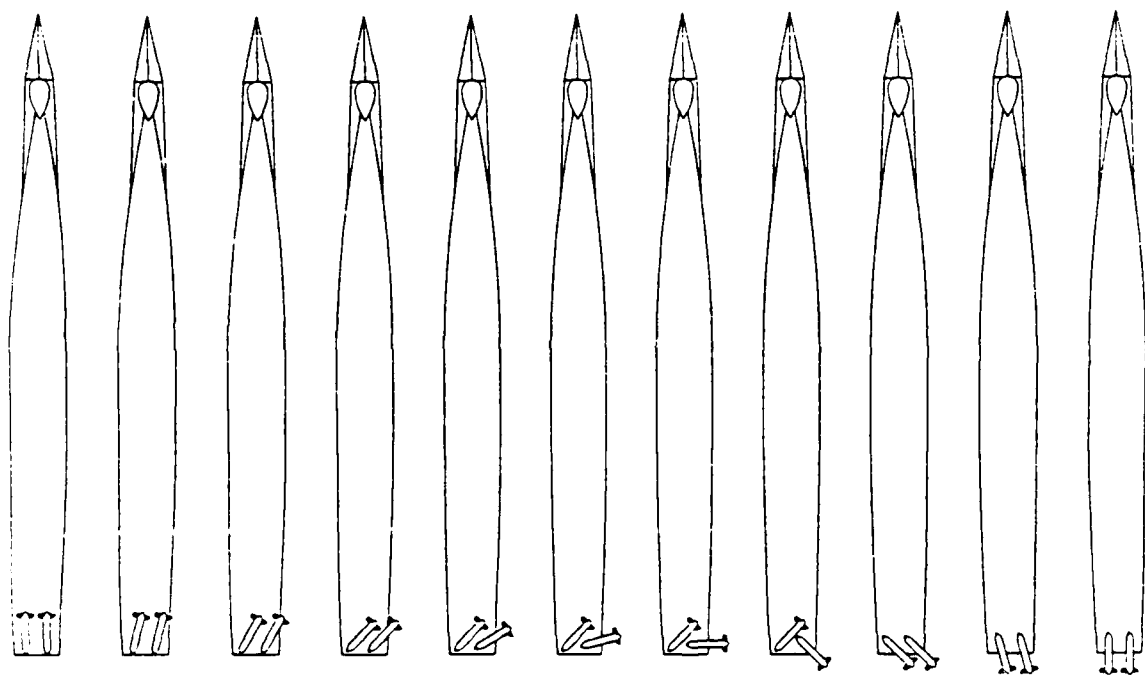


Figure 39. Turning configurations.

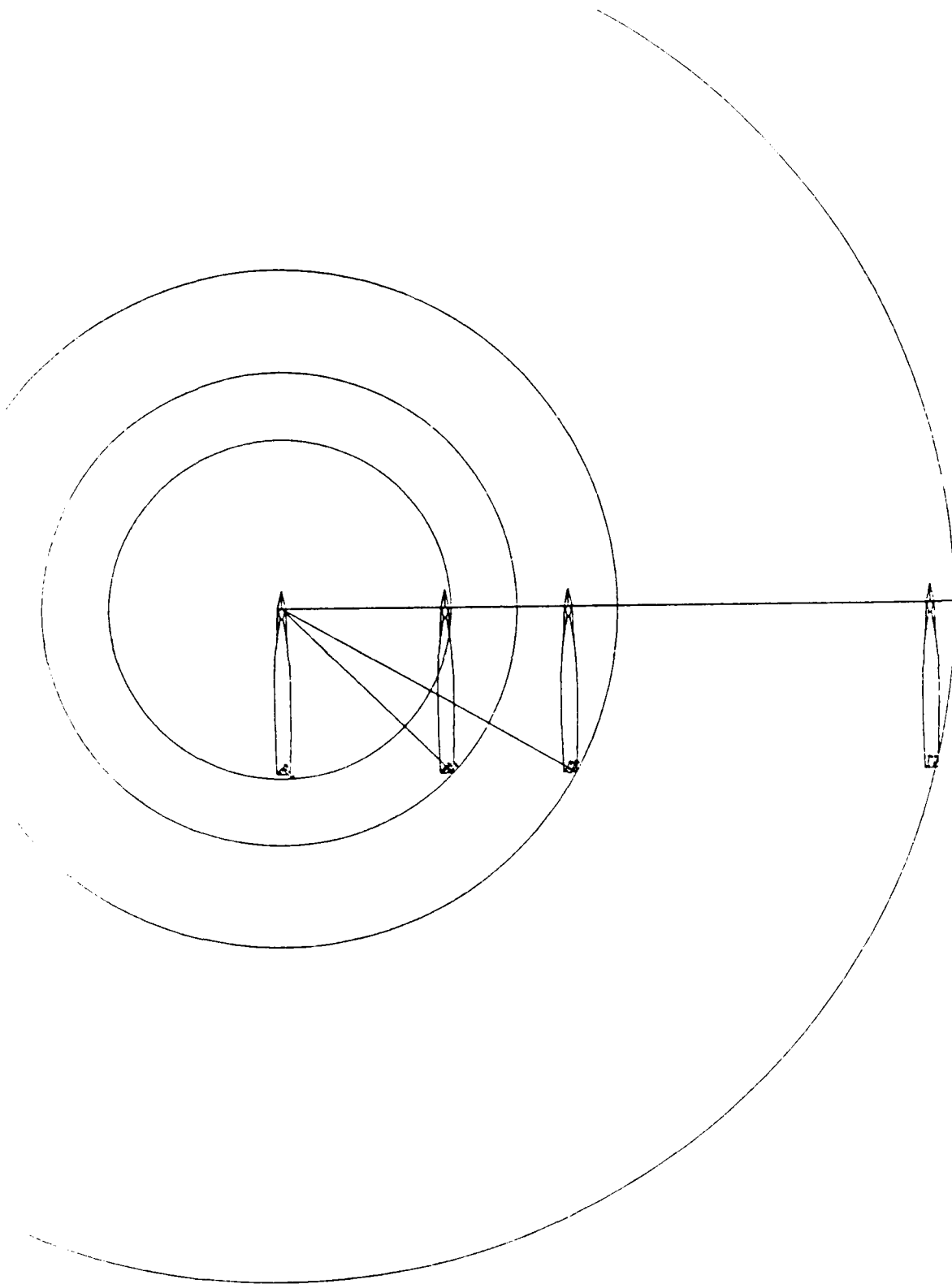


Figure 40. Steady-state turning circles.

The ship is also capable of resisting chemical, biological, or nuclear warfare. Each compartment is an enclave that contains its own auxiliary machinery module and is self sufficient, except for long-term electric power. No air, gas, or liquid lines penetrate the compartments, except those from the box girder with a shutoff valve on each side of the girder.

Affordability

Low initial cost and low operating cost are of prime importance. Compared to current destroyers, the ship carries more than twice the payload per dollar of ship cost more than three times as far and at less than half the fuel cost per mile of current destroyers.

The ship is simplified by reducing the number and types of machinery systems aboard. It has only two engines, with a total installed power of 53,600 hp, although it carries essentially the BFC weapons payload.

Manpower reductions should be possible because of the mechanical simplicity of the ship and the intent to perform all major maintenance ashore.

Cost benefits of many of the advances incorporated here, such as distributed auxiliary systems, the continuous box girders containing all longitudinal lines, and the avoidance of shaft alignment requirements, were not included in our estimate because the computational capability was not yet available to us.

Adaptability

Advanced technologies which could benefit the DD 21A include dc electric transmission lines, electric propulsion motors less than 6 ft in diameter (including superconductive drive), electric pulsed-power weapons, high/variable-speed auxiliary systems, fiber-optic condition monitoring, stern wedges, and variable-angle flaps. These and many other advances should be evaluated using the DD 21A as a basis of comparison.

COMPARISON OF THE DD 21A WITH CONVENTIONAL SURFACE COMBATANTS

The DD 21A is compared to both the short destroyer and the REFDD. These three destroyers represent three different philosophies which had their origins in three different eras, about 15 years apart: the early sixties, the late seventies, and the early nineties. We present the REFDD at the center, with the short destroyer on its left and the DD 21A on its right. The reason for this sequence is that the philosophies behind the latter two are diametrically opposed, and the earlier REFDD is philosophically intermediate.

PERFORMANCE

Figure 41 compares the performances of the three. Figures 42 through 45 compare their hydrodynamic and thermodynamic losses, figures 46 and 47 show their group weights, figure 48 shows their areas and volumes, and figure 49 shows their costs. The corresponding data are in tables 5 and 6.

PERFORMANCE OF THREE DESTROYERS

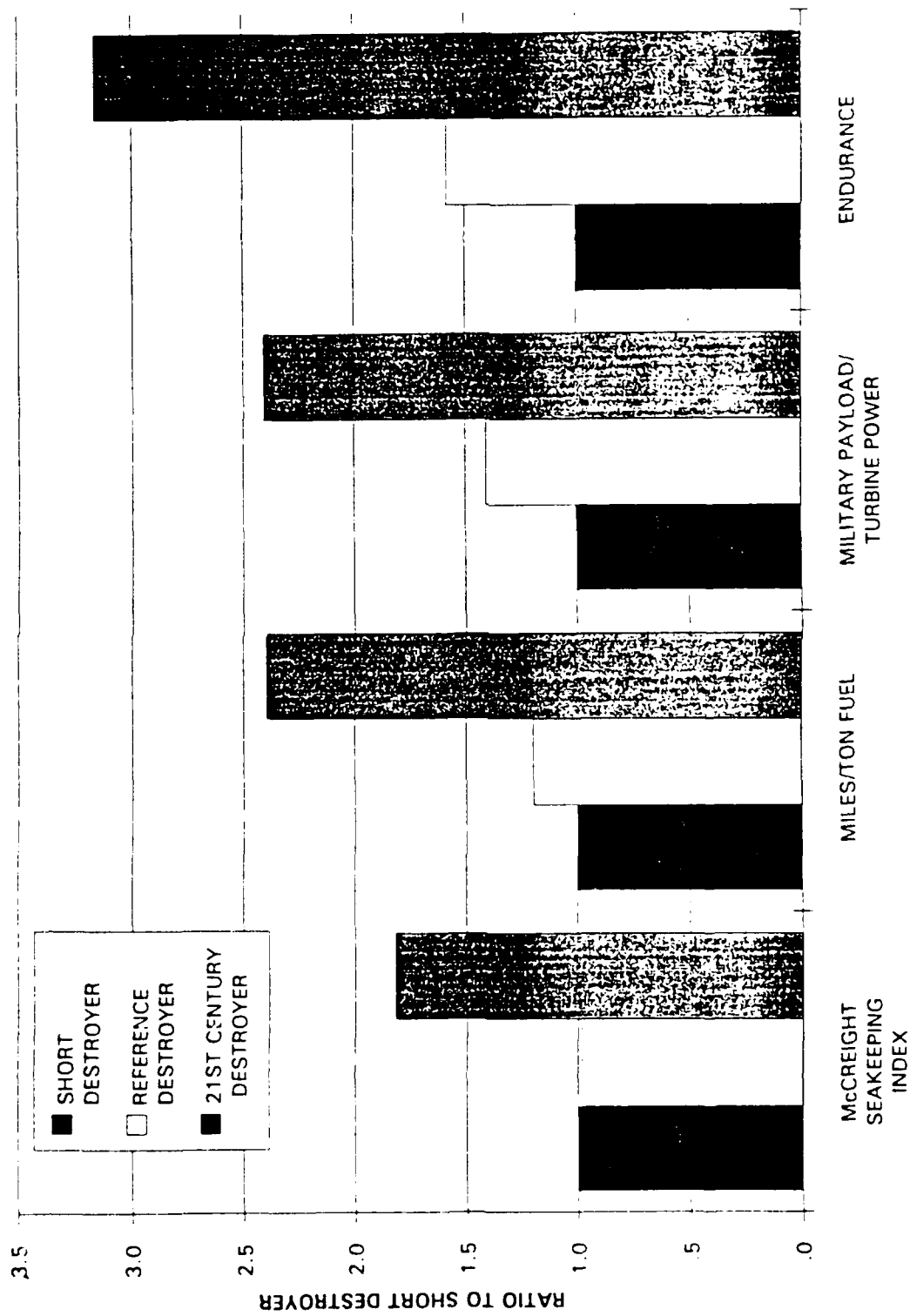


Figure 41. Performance of the short destroyer, the reference destroyer, and the DD 21A.

POWER DISSIPATION AT MAXIMUM SPEED

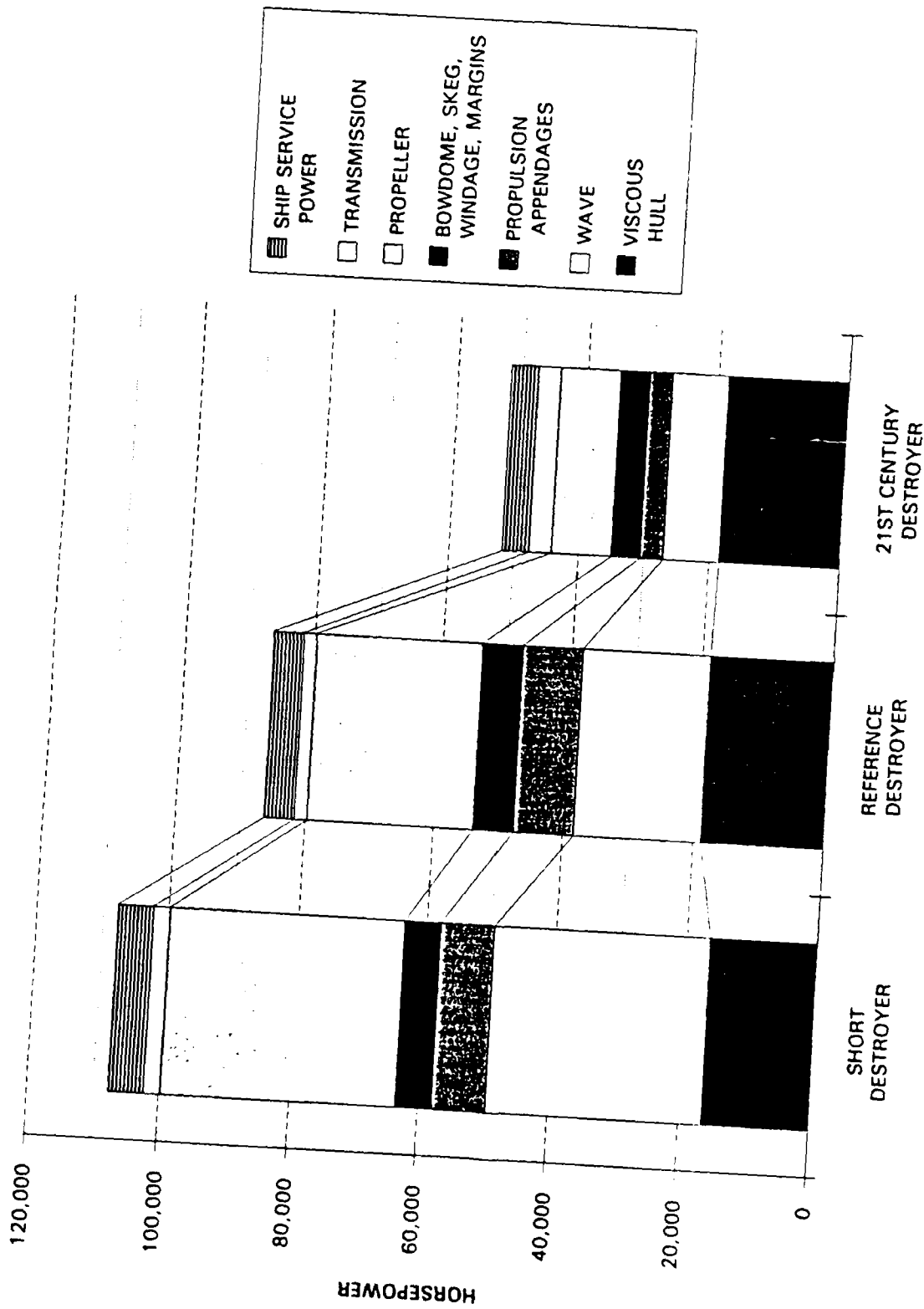


Figure 42. Loss distributions of three ships at maximum speed.

POWER DISSIPATION AT 30 KNOTS

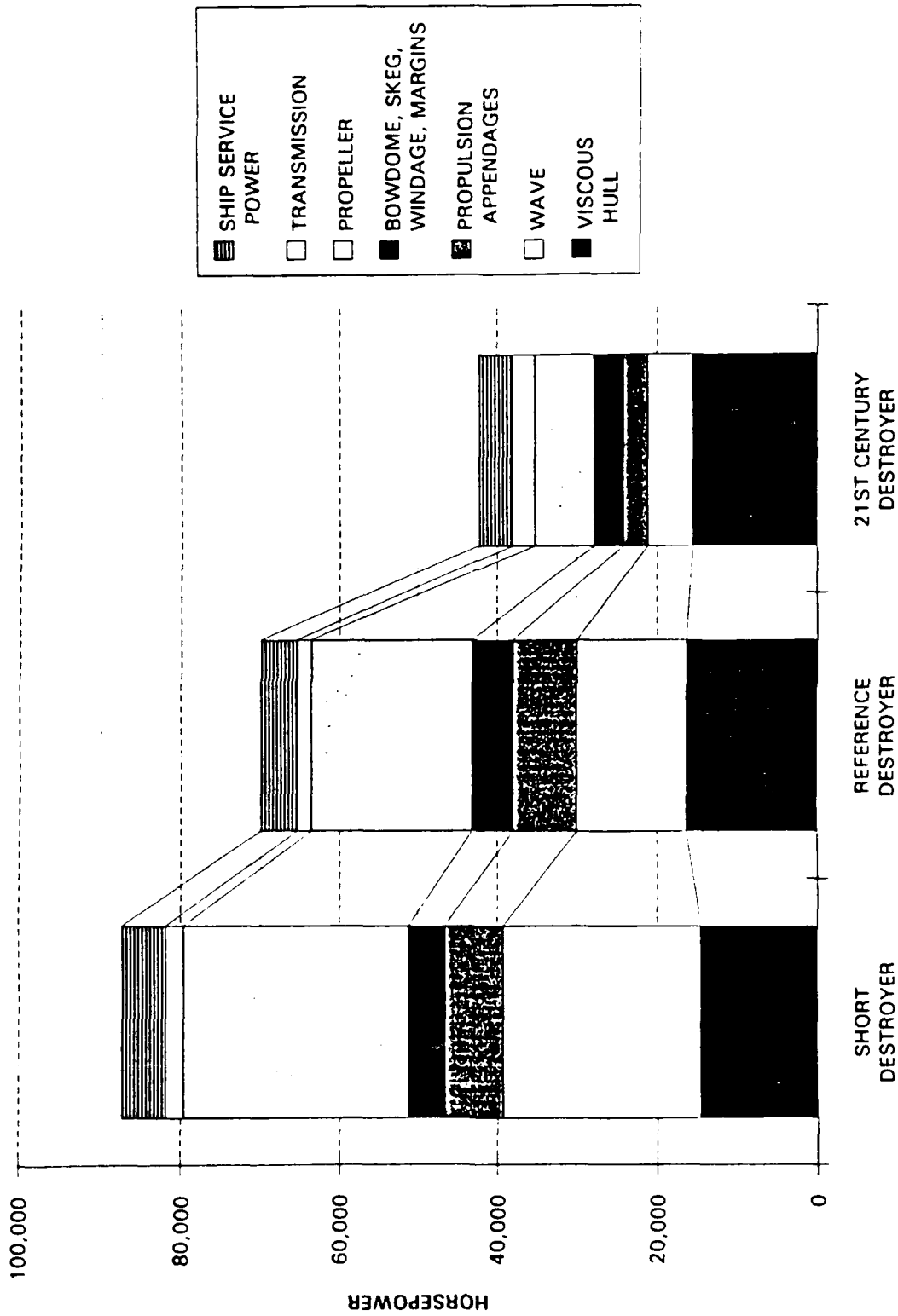


Figure 43. Loss distribution of three ships at 30 kn.

POWER DISSIPATION AT 20 KNOTS

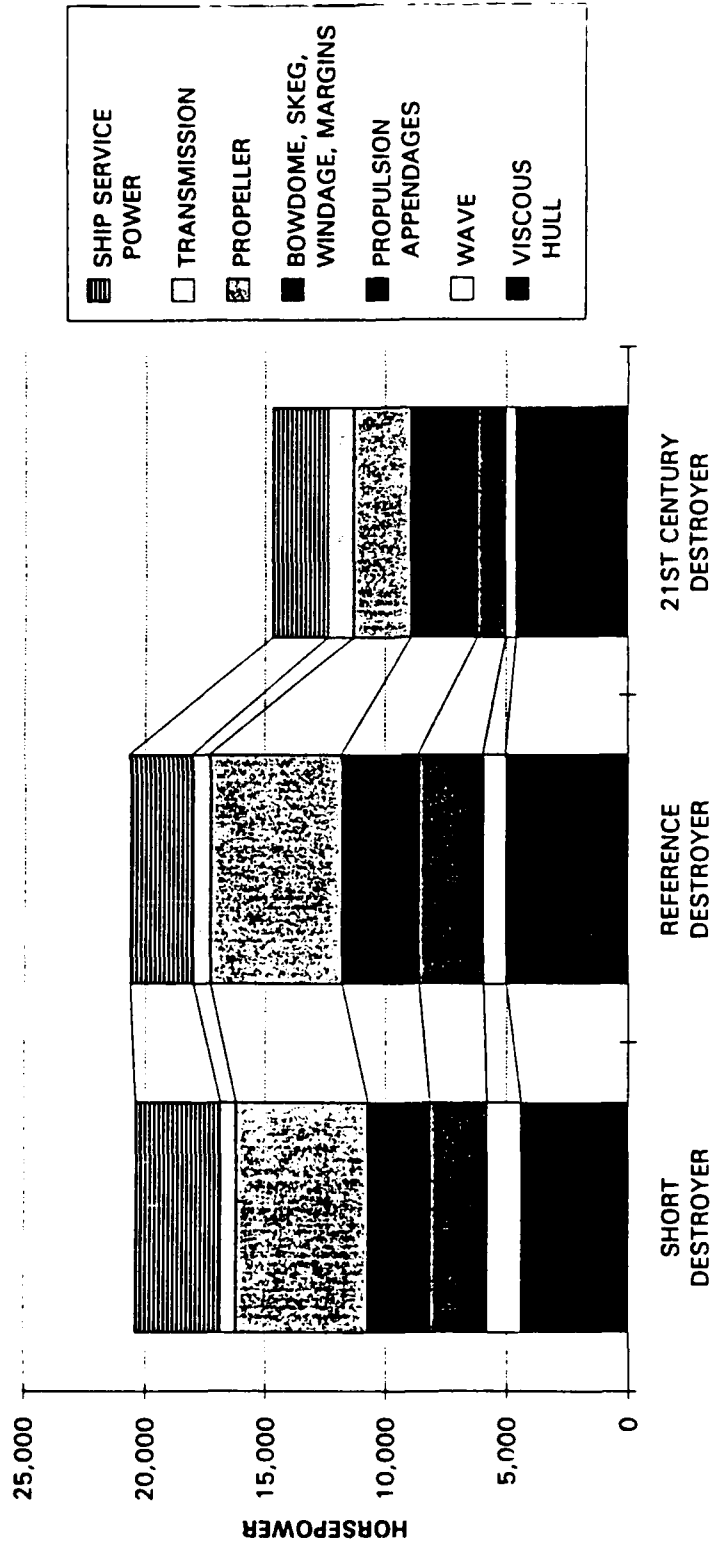


Figure 44. Loss distribution of three ships at 20 kn.

POWER DISSIPATION AT 20 KNOTS, INCLUDING TURBINES

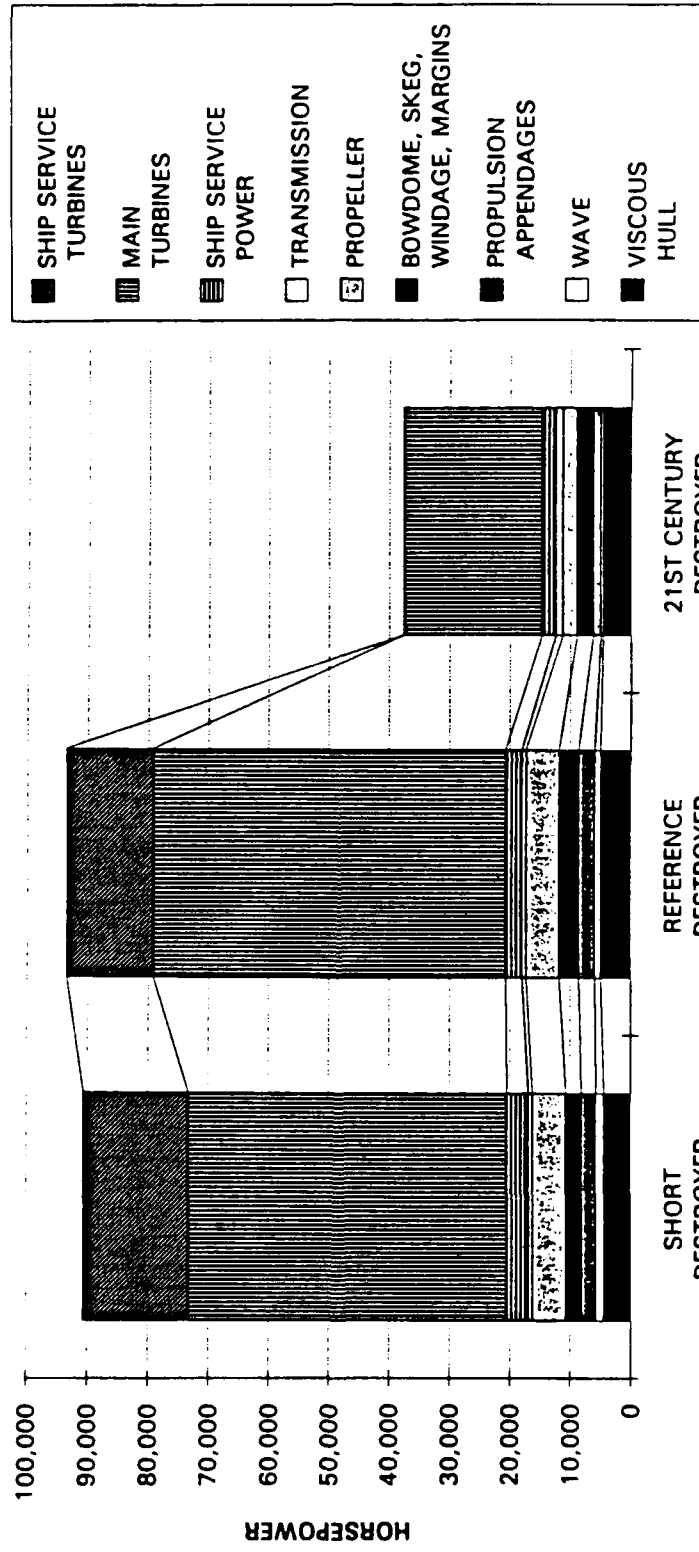


Figure 45. Loss distribution of three ships at 20 kn, including stack losses.

SUPPORT AREAS FOR THREE DESTROYERS

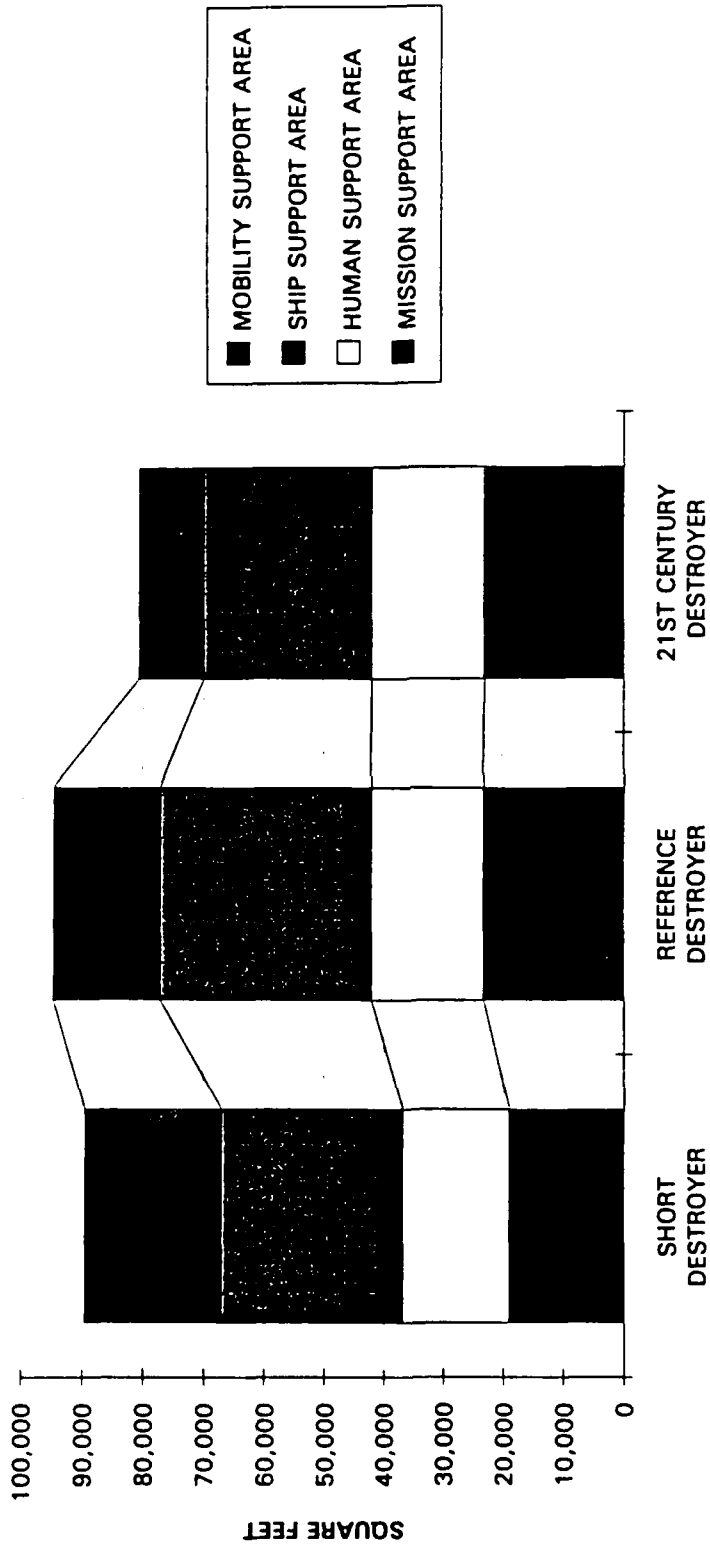


Figure 4j. Mission support areas for three destroyers.

GROUP WEIGHTS FOR THREE DESTROYERS

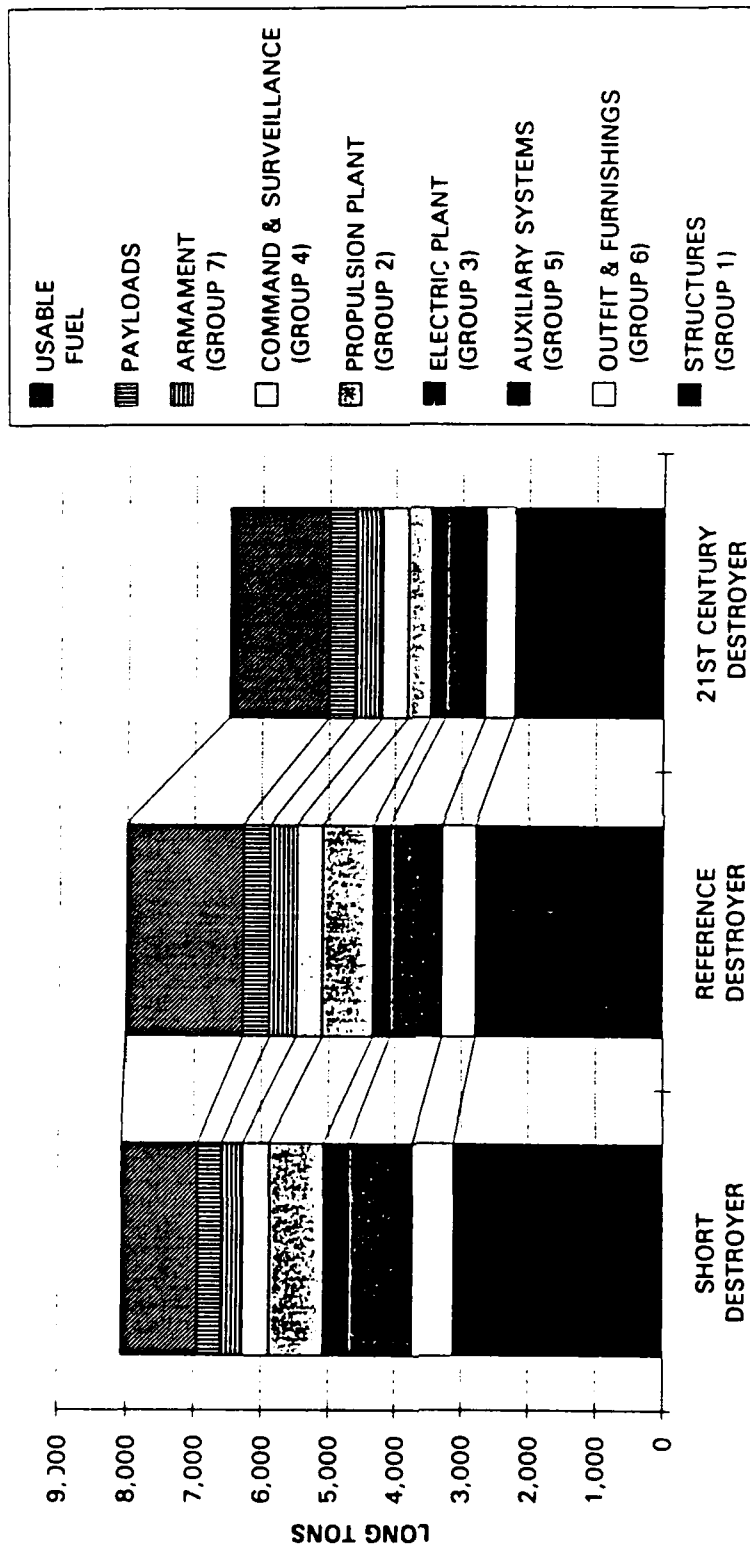


Figure 47. Full-load SWBS weight distributions for three destroyers.

HULL, MECHANICAL AND ELECTRICAL GROUPS, THREE DESTROYERS

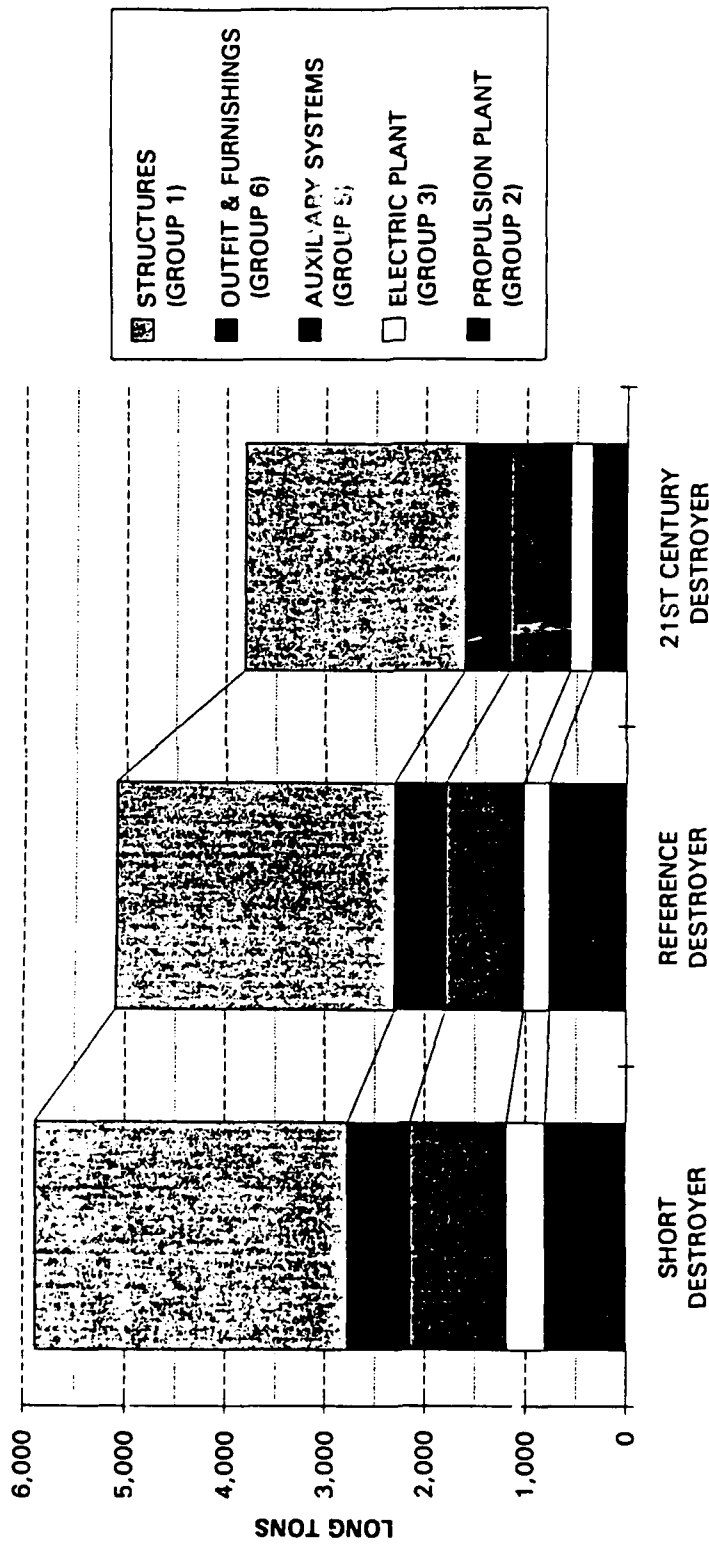


Figure 48. HM&E SWBS weight distributions for three destroyers.

HM&E FUNCTIONAL WEIGHT DISTRIBUTIONS FOR THREE DESTROYERS

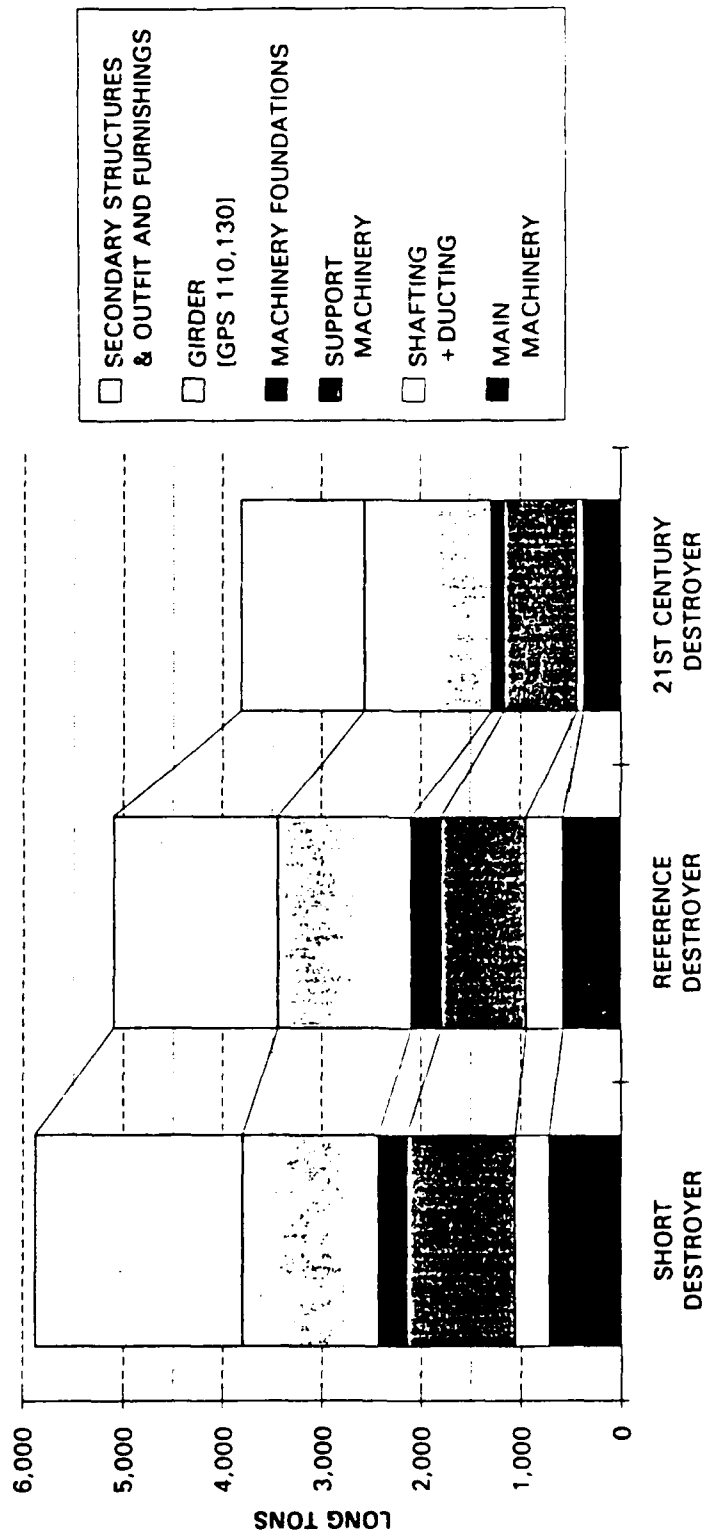


Figure 49. HM&E functional weight distributions for three destroyers.

Table 5. Losses for three destroyers.

Short Destroyer	Losses (hp)		
	Maximum Speed	30 Kn	20 Kn
Viscous Hull	16,416	14,598	4,395
Wave	33,122	24,632	1,407
Propulsion Appendages	8,318	7,364	2,355
Bow Dome, Skeg, Windage, Margins	5,570	4,575	2,583
Propeller	36,354	28,471	5,489
Transmission	2,536	2,212	651
Ship Service Power	5,460	5,460	3,518
Total Turbine Power	107,776	87,312	20,398
Main Turbine Losses	197,811	170,980	52,891
Ship Service Turbine Losses	17,351	17,351	17,351
Total Short Destroyer Losses	322,938	275,643	90,640
Short Destroyer Effectiveness	0.51	0.053	0.048
Reference Destroyer	Maximum Speed	30 Kn	20 Kn
Viscous Hull	18,772	16,346	5,022
Wave	19,595	13,624	922
Propulsion Appendages	9,245	8,043	2,681
Bow Dome, Skeg, Windage, Margins	6,234	5,118	3,199
Propeller	25,860	20,447	5,486
Transmission	2,026	1,768	696
Ship Service Power	4,623	4,623	2,622
Total Turbine Power	86,355	69,969	20,628
Main Turbine Losses	177,485	157,041	58,614
Ship Service Turbine Losses	16,814	16,814	14,295
Total REFDD Losses	280,604	243,824	93,557
REFDD Effectiveness	0.067	0.067	0.054
REFDD/Short Destroyer Effectiveness	1.32	1.27	1.11
DD 21A	Maximum Speed	30 Kn	20 Kn
Viscous Hull	18,468	15,569	4,578
Wave	8,528	5,538	450
Propulsion Appendages	3,544	3,059	1,163
Bow Dome, Skeg, Windage, Margins	4,376	3,650	2,732
Propeller	9,246	7,410	2,386
Transmission	3,418	2,838	1,089
Ship Service Power	4,166	4,138	2,296
Total Turbine Power	51,746	42,202	14,694
Main Turbine Losses	73,978	59,083	22,969
Total DD 21A Losses	125,724	101,285	37,665
DD 21A Effectiveness	0.147	0.154	0.122
DD 21A/Short Destroyer Effectiveness	2.89	2.90	2.51

Table 6. Weights for three destroyers.

	Short Destroyer	Reference Destroyer	DD 21A Destroyer
Structures (Group 1)	3,114.9	2,795.3	2,208.7
Propulsion Plant (Group 2)	804.8	763.4	344.7
Electric Plant (Group 3)	379.7	255.6	220
Auxiliary Systems (Group 5)	958.5	775.9	601.2
Outfit and Furnishings (Group 6)	623.3	508.4	441.7
Command And Surveillance (Group 4)	402.1	388.5	386.9
Armament (Group 7)	309.8	399.8	399.6
Payloads	357.4	401.3	401.3
Usable Fuel	1,127.6	1,734	1,487
Lightship Displacement	6,626.1	5,887	4,603
Full Load Displacement	8,308.3	8,173.9	6,621.5
Military Payload	1,055.6	1,186	1,186
Structure, Outfit, and Furnishings	3,738.2	3,303.7	2,650.4
Main Machinery	715.1	574.5	365.7
Shafting Plus Ducting	341.3	364	70.3
Support Machinery	1,086.6	856.5	729.9
Total Ship Volume (Ft ³)	1,011,117.3	1,036,367	826,243
Asset Cost, Follow Ship, \$M	653.893	534.349	429.688
Required Turbine Horsepower	107,776	86,355	51,746
McCreight Seakeeping Index	14.095	13.856	25.523

Each of these three ships is constrained to the same 30-kn sustained speed at 80 percent turbine power, and endurance is calculated at 20 kn. A correlation allowance (for roughness) of C_a equals 0.0005, adds about 33 percent to the friction coefficient. A powering margin of 1.11 is applied, and an additional multiplier of 1.1 is used to calculate power required at endurance cruise. Zero weight margins characterize all the designs. The design of the entire power train, including the rating of the engine, is based on the 30-kn sustained speed. The shafting, ducting, and gears of the reference destroyer are lighter than those of gas turbine ships in the Navy, which have higher sustained speeds. The range of the high-resistance short destroyer is constrained by the amount of fuel it can carry and still make speed with its uprated LM2500 engines.

The 529-ft REFDD can easily reach a 30-kn sustained speed, and its endurance easily reaches 6,000 nmi with relatively low design power. It has large acoustic radar and infrared signatures, however, and fuel tanks must be ballasted with seawater. Seakeeping is poor for a ship of that length, primarily because the waterplane forward is small. Size is adequate for two guns, two hangared helicopters, and two 64-cell vertical launch systems. ASSET calculates the follow ship cost at \$537 million.

The short destroyer represents the philosophy of trying to save cost by shortening the hull and tightening space. By comparison, the result is one gun instead of two, one-and-one-half vertical launch systems instead of two, no hangared helicopters, 25 percent higher power required to make 30 kn, and a calculated range of 3,800 nmi when constrained to make this sustained speed. It is stealthier than the REFDD, has a slightly better seakeeping characteristic because of a larger waterplane forward, and has only clean water ballast. It has better protection against nuclear blasts and has a complete col-

lective protective system. It costs 20 percent more than the REFDD, although a design goal had been to cost 25 percent less.

The DD 21A has an entirely different philosophy: to place major machinery entirely outside the watertight hull and to have it all preassembled, prealigned, and pierside installable and removable. It also tries to save cost by reducing losses wherever possible—in particular, reducing hydrodynamic losses—and to achieve global (12,000-mile) endurance. It carries the same weapons as the BFC and the REFDD and should be stealthier than the short destroyer because of inherent design characteristics. Although ASSET does not give credit for easier-to-assemble and alignment-free construction, it shows that the DD 21A destroyer is one-third lighter and is cheaper than the short destroyer. In order to understand the differences among these ships, they are evaluated rather thoroughly. Figure 41 summarizes the performance differences among the three ships on a relative basis. The superiority of the DD 21A over the short destroyer is large and consistent in all steady operating measures of performance. Even when fuel for 12,000 miles is aboard, the engines in the DD 21A are rated at less than the full nominal power of the ICR engines. Moreover, at the end of the mission the zero-fuel sustained speed is nearly 32 kn, even at the reduced engine rating. This ship clearly has extra potential.

The improvement in seakeeping over both of the earlier designs is very large. It results partly from the large waterplane forward, partly from the large beam-to-draft ratio, and partly from the longer hull. Combined with the opening up of the center of the hull for personnel, the comfort of this ship should be unmatched by any other modern surface combatant.

POWER LOSS DISTRIBUTION

Reduction of turbine horsepower required to carry a ton of payload was our major intent, and it was successful beyond our expectations; the payload per installed horsepower is 2.4 times the short destroyer value. An equal increase in distance traveled per ton of fuel helped immensely in reaching our goal of 3.15 times the short destroyer endurance.

Figure 42 illustrates the reasons for the immense reduction in turbine power requirement of the DD 21A. Although its viscous hull resistance is 6.4 percent larger because of its increased length and wetted surface, the much "fatter" short destroyer's wave resistance is twice its viscous resistance and is four times as high as the wave resistance of the DD 21A, due to the latter's lower Froude number and slender (low volumetric coefficient) hull. The propulsion appendages of the DD 21A have less than half the resistance, and the propeller losses are less than one-third as large. Even the ship service power is lower by 25 percent because of the smaller ship size. The net result is a 52-percent reduction in turbine power required. Further, the DD 21A is 0.6 kn faster (31.9 kn vs. 31.3 kn) at maximum power and full load and 2.4 kn faster without fuel at the end of the mission.

Figure 43 shows the same trends at the 30-kn sustained speed, which was the point at which both ships must have available 80 percent of the maximum-speed shaft power. The results are similar to those at maximum power except for a lessening in relative importance of the wave resistance at 30 kn.

Figure 44 shows the 20-kn condition. Here, the wave resistance was trivial, the short destroyer is at its best, the transmission inefficiency of the electric drive is at its

lowest, and the turbine power required is only 28 percent less for the DD 21A. Figure 45, however, shows the advantage of combined propulsion and ship service plus intercooled recuperated turbines. Only 36.3 percent as much heat went out of the stacks of the DD 21A compared to the short destroyer, and its raw fuel mileage is 2.55 times as high. The combination of greatly improved hydrodynamics and greatly improved thermodynamics is clearly valuable. Table 5 shows these trends in detail, with the effectiveness of the DD 21A higher by a factor of 2.5 to 2.9 over the short destroyer over the entire speed range.

SPACE AND WEIGHT

Space and weight are now investigated. Combatant ships are constrained more by area than by any other single factor. Topside area is reserved almost entirely for weapons systems and turbine ducting. The need for longitudinal stack-up length is important because many functions may not be allowed to overlap. Providing a longer hull is beneficial in other ways than reducing the Froude number. The major penalty for a longer hull is the greater bending moment because of the longer and higher critical wave and the greater girder stiffness needed to combat it.

Space aboard ship is conventionally split into four support areas plus machinery volume. The areas required by most functions aboard ship are nearly independent of deck height. The four areas are mission support, human support, ship support, and mobility support. For convenience, the machinery volumes are divided by the average deck height to place all space in a single accounting scheme, i.e., area. Propulsion system areas so derived were added to mobility support.

Figure 46 shows the mission support areas for the three destroyers. The human support areas are about the same for all three ships. The mission support area is larger for the REFDD and the DD 21A than for the short destroyer because of the larger weapons systems. The DD 21A has less than half the mobility support area of the short destroyer, since the areas are about proportional to required horsepower. In toto, the DD 21A is 10 percent smaller in area. It is 18 percent smaller in total ship volume because the deck heights are uniform and constant, which is not possible in ships that have large machinery boxes. Thus, the DD 21A uses space much more effectively than its predecessors.

Having packaged the required space, power, and fuel, the weights for each of the three ships are now analyzed. Figure 47 shows the total weight distribution of the fully loaded ships, categorized according to the SWBS.

For the hull, mechanical, and electrical (HM&E) portions of the ship, which includes everything but military payload and fuel, the weight breakdown by SWBS groups is shown in figure 48.

Figure 49 shows a breakdown of HM&E weight by functions for the three destroyers. Here, the machinery foundations and the hull structural girder are separated. The platforms and outfit and furnishings, which includes other secondary structures, are grouped together.

The girder weight for the DD 21A is slightly less than, instead of greatly more than, the short destroyer because the effective section modulus is larger for the long DD 21A than for the short destroyer. The DD 21A has much less foundation weight, corresponding to the lower machinery weight. The secondary structures all decrease sympathetically

with the general decrease in hull areas. Together, the HM&E weight is only two-thirds as great as that of the short destroyer.

COST

Figure 50 shows the lightship weight and cost breakdowns for the three destroyers. The total lightship weight and cost of the DD 21A are both about two-thirds those of the short destroyer, but the subsets vary importantly.

Figure 51 shows the HM&E part of the hull only because everything else is part of the military payload. Here the relative improvement of the DD 21A over the short destroyer is further accentuated.

PAYLOAD

Finally, the ship is viewed as a carrier of valuable payload. The relative values of payload weight to ship weight and of payload value to ship cost are poignant measures of how well each philosophy works. Figure 52 illustrates that the DD 21A has nearly twice the weight ratio and nearly twice the value ratio of the short destroyer. That the DD 21A carries a payload of value more than double its own cost is an indication of good economics, particularly when it can carry it more than three times as far as the competition.

CONCLUSIONS

Simplicity, efficiency, and modularity of integrated electric drive machinery, properly applied to a destroyer, can vastly increase performance and affordability. All main machinery modules are mounted outside the watertight hull, after, thereby permitting major maintenance without drydocking. Ducting and shafting are sharply reduced. A second major facet of the approach is to integrate superstructures into the hull, preferably with tumble home configuration, greatly reducing weight and improving survivability. A third is to make the hull long and slender to minimize hull resistance at the maximum speed and to decrease required power.

Two subsystems are essential: the first is a propulsor module attached to the stern, which features small-diameter steerable pods with electrically driven, contrarotating tractor propellers; the second is a power module, consisting of intercooled recuperated gas turbines powering both propulsion and ship service alternators, mounted above the watertight hull. A major benefit is freeing the midship hull for personnel.

RECOMMENDATIONS

This destroyer approach can also be applied to other ships, including frigates, auxiliary ships, aircraft carriers, and supertankers, perhaps using common subsystems.

The ship described here, while greatly superior to those now being built, uses sixties technology and is far from being an optimum or best ship. A propulsion engineer can greatly improve the drive train, both by improving its configuration and by applying advanced technology. A hydrodynamicist can greatly improve the hull and appendage shapes and the propeller blade configuration and can add well-designed flaps or stern wedges. A structural engineer can greatly improve hull damage resistance and weight. A

LIGHTSHIP GROUP WEIGHTS AND COSTS OF THREE DESTROYERS

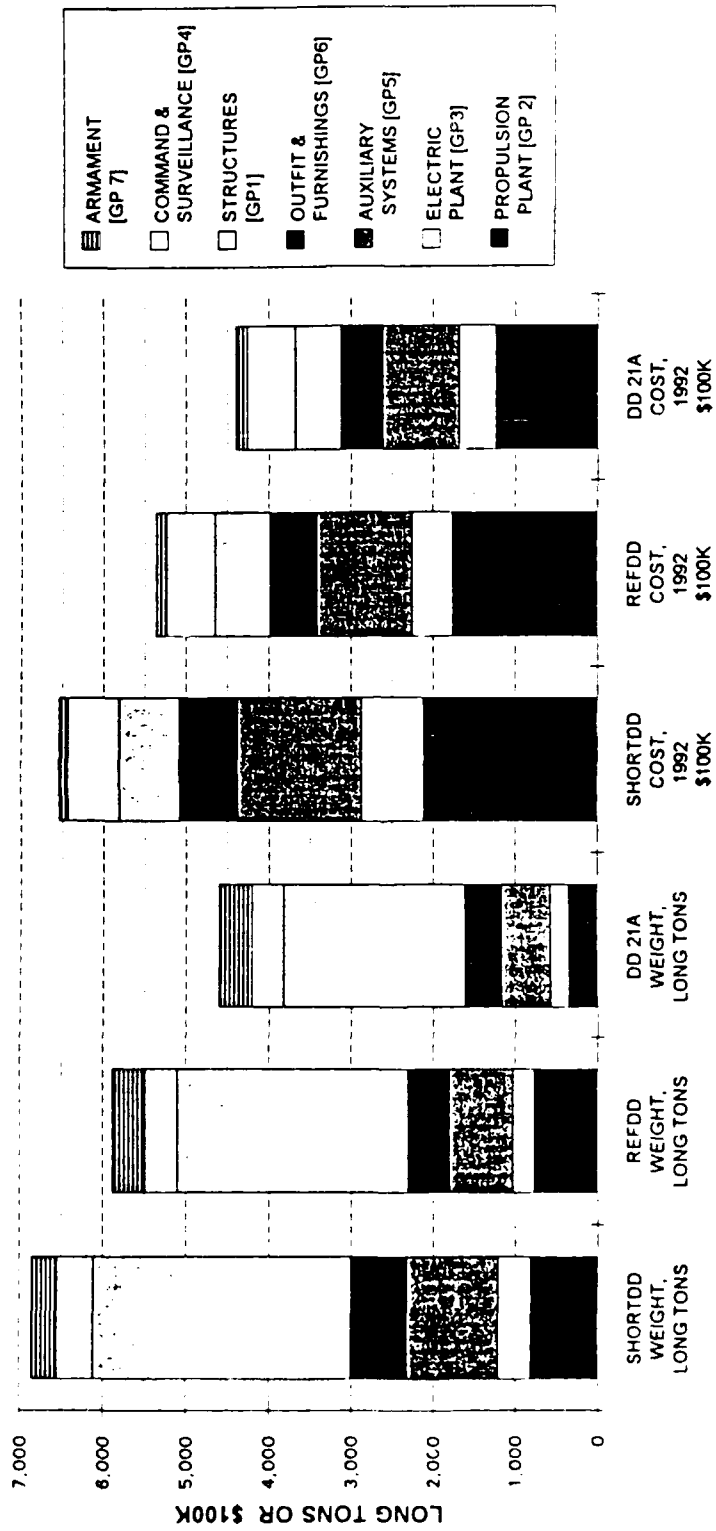


Figure 50. Lightship SWBS weight and cost distributions for three destroyers.

HM&E GROUP WEIGHTS AND COSTS OF THREE DESTROYERS

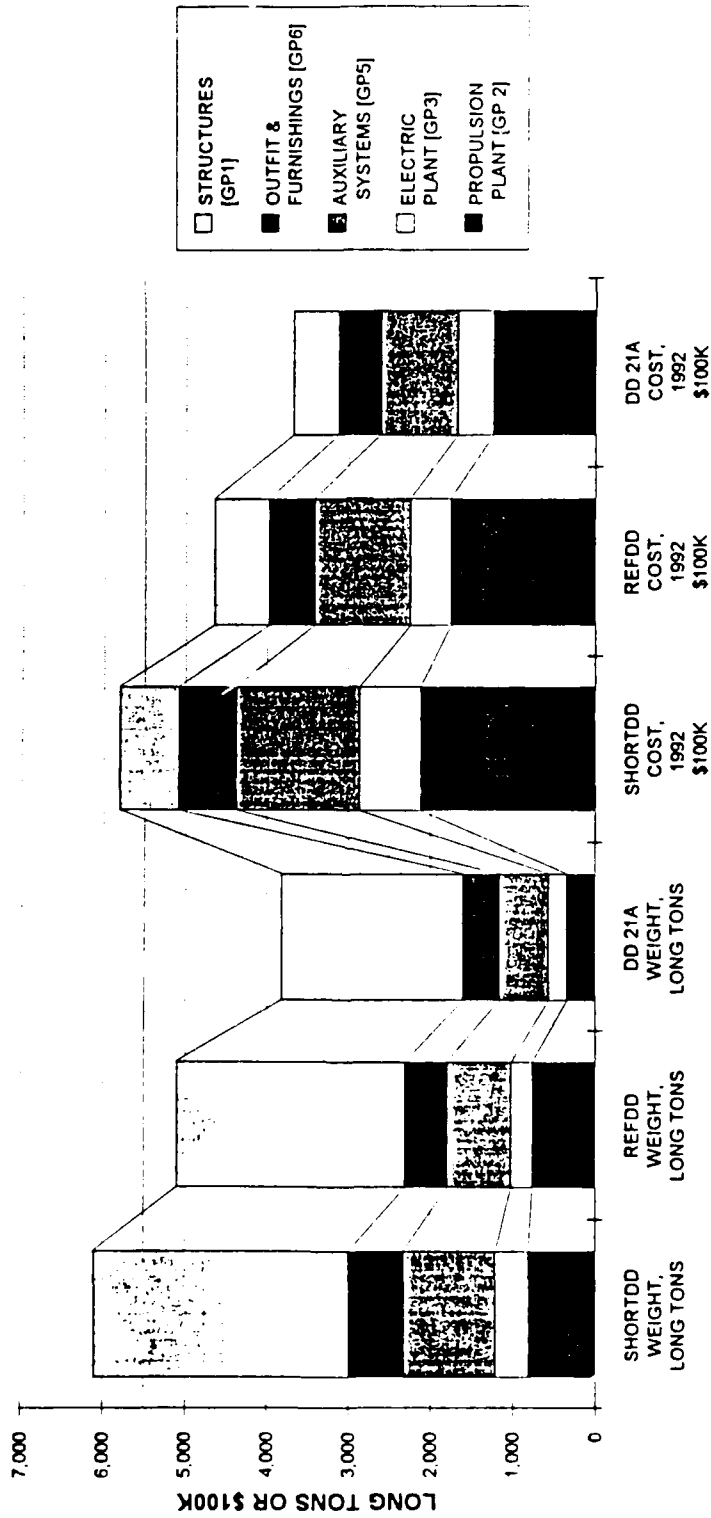


Figure 51. HM&E SWBS weight and cost distributions for three destroyers.

RATIO OF MILITARY PAYLOAD WEIGHT TO HM&E WEIGHT AND
RATIO OF MILITARY PAYLOAD VALUE TO HM&E COST

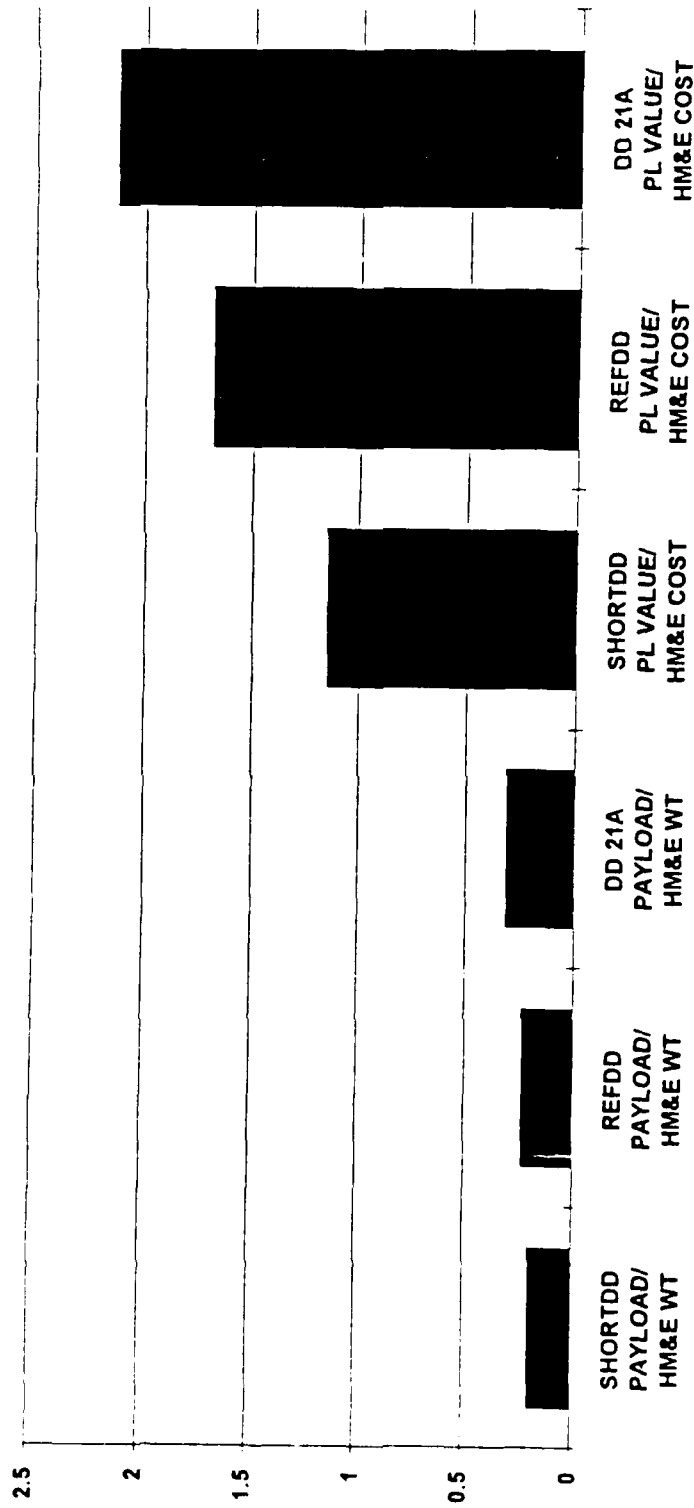


Figure 52. Ratios of payload-to-HM&E weights and payload-to-HM&E costs.

weapons engineer can greatly improve the selection and orientation of the weapons. Stealth experts, in several different categories, can greatly decrease the detectability of this ship.

We are aware that recent advances in auxiliary machinery can greatly improve the ship. These advances are not explicitly included in the benefits described in our analysis, since the algorithms to describe them are not available to ASSET. Auxiliary systems and electric systems, not directly addressed in this report, represent about one-third of the total calculated cost of the DD 21A. The expected 20- to 40-percent reduction in their sizes, weights, costs, and power requirements would be leveraged by their incorporation into the ship for yet greater overall savings and performance. Many opportunities exist to improve the ASSET program by providing detailed algorithms where current ones are sketchy or creating new algorithms where none now exist.

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APPENDIX A
COMPARISON OF LM2500 AND ICR ENGINES

We now evaluate the questions: does the existence of an ICR engine eliminate the need for electric drive? does the existence of electric drive eliminate the need for an ICR engine?

Over the years there has been considerable controversy about the relative values of electric drive and intercooled-recuperated engines, and whether one negates any need for the other. The answer to this question is very ship specific, according to our results.

The study in the main body of this report certainly answers that question for modular ships, where the main machinery must be external to the watertight hull. Only with small-diameter electric drive can full advantage be taken of this configuration. (It is possible, but unlikely, that a pneumatic, hydraulic, or mechanical transmission can have the requisite flexibility of location, as well as satisfactory efficiency and acoustics.) Thus, in such configurations, electric drive is a *sine qua non*, and the question of whether to use a simple cycle engine or an ICR engine is the only question. We have not treated that question directly in the main study, because at global range of 12,000-15,000 miles and only two engines the answer is a clear *ICR!* Thus for a highly cost-conscious, high performance, high endurance design *both electric drive and ICR engines are necessary.*

The following appended study was conducted with the REFERENCE DD. The starting point was a standard LM2500 gas-turbine power plant on the REFDD. The maximum required power was 20,421 HP from each of the four LM2500 propulsion engines and 2311 HP from each of the three 501K-17 ship-service engines, for a total required power of 88,618 HP (86,307 if we do not include the third or "emergency" ship-service engine). On a 6,000 mile mission this ship consumed 1420.1 LT of propulsion fuel and 313.5 LT of ship service fuel.

An alternative power plant resulted from the substitution of intercooled recuperated (ICR) engines for the LM2500s. The heat exchangers (intercooler and recuperator) significantly increase the weight of each engine from 21.6 long tons to 97.4 LT. Part of this weight is compensated by reductions in the ducting weight, since the lower fuel consumption is accompanied by lower air consumption. Moreover, the exhaust gases are much cooler in the recuperated system and thus are denser and permit further reduction in exhaust duct cross section. Thus the lightship is about 100 tons heavier with the ICR engines. Propulsion fuel weight is reduced by 26.3%. Thanks to this reduction, the full load displacement is reduced by nearly 5% with a corresponding reduction in maximum power required.

We now have two ships with identical performance, endurance, and stability. Three sequential improvements were made to each ship. Table A-1 and figures A 1-3 show the required power, number of turbines, machinery and fuel weights, and lightship and full load displacements of this series.

The first improvement is to eliminate two of the ship service turboalternators, and replace them with two turboalternators geared to the propeller shafts. These latter alternators must produce full power over the engines' entire operating speed range, which is from 1200 to 3600 rpm, and must therefore have at least three times the capacity of their constant-speed predecessors. Additionally, the frequency must be held constant at 60 Hz, so solid-state frequency changers are installed. The net electrical efficiency is thus reduced from 95% to 80%. The

fuel consumption, however, is reduced greatly because the operating efficiency of the ship service turbines was only about 15%, while the *incremental* efficiency of the LM2500 engine is near 40%, and that of the ICR engine is well above 45%. A 215 ton decrease in total fuel consumption and a 312 ton+ reduction in full load displacement is noted for the LM2500. For the ICR engine the decrease in total fuel consumption is 272 tons, resulting again in a 312 ton reduction in total displacement. This is an impressive reduction from the initial 313.5 tons of ship service fuel. At this point the LM2500 ship has 88% and the ICR ship 63% of the fuel consumption of the REFERENCE SHIP.

We next introduce a rudimentary electric drive, consisting of a large-diameter, direct coupled multipole motor on each propeller shaft and an alternator on each engine. The alternators are coupled to the motors via a flexible solid-state control, so that direction of power flow and ratios of speeds are completely controllable. Fixed pitch propellers replace the heavier, larger-hub controllable reversible propellers. Three uprated engines can now be used, in cross-connected configuration, for full-power operation. One engine can be used at the 20 knot endurance speed to provide all propulsion and ship service power; four engines (two propulsion and two ship service) are the norm with the baseline ships. In order to permit operation on one engine, a 28 LT battery energy storage system is installed to power vital loads after any failure of the operating engine until an alternate can be started and brought on line.

The result is a 20.9% decrease in fuel for the LM2500 and a 15.3% decrease in fuel for the ICR. Since the LM2500 started with a much larger fuel load, electric drive saved it 317 tons compared to 166 tons for the ICR. In neither case, however, is the net result entirely beneficial. The large motor, the large and noisy solid state devices, and the battery energy storage system combine to raise the total machinery weight more than 50 tons. It is of interest to note that the ducting is not greatly lighter for the three engines than it was for four, because nearly the same total power and thus nearly the same total airflow is required both cases.

It is this last step which seems of little value to the proponents of ICR-engines-only. The proponents of direct-electric-drive-only consider that this step is the correct one, but for LM2500 engines. In fact, from these charts alone, there is little except 100 tons of fuel to differentiate the second ICR step from the third LM2500 step. And this point is the one at which the debate is often held.

The data presented here, however, show that progression to the geared contrarotating electric drive is so enormously beneficial that it is here, rather than at the third step, that the debate should occur. At this point electric drive has benefited the concept to the point that fuel consumption with LM2500 engines is as low as for mechanical-drive ICR engines, and all of the weights and power requirements are far better. Electric drive would clearly win the either/or debate.

However, the fuel consumption reduction of another 25% by adding the ICR engines to the geared electric drive show that the AND option is yet superior.

Another point which is now clearly valid: the use of geared electric drive and of ICR engines make possible the very inexpensive DD21A concept without introducing new machinery technology. Since the same

concepts that make possible the DD21A also offer the maximum enhancement to open-shaft destroyers, the decision would seem obvious.

With respect to the reference ship, the geared electric LM2500 ship requires 23.4% less power, 36.1% less fuel, and has a 7.3% smaller machinery and 5.2% smaller lightship weights. The corresponding ICR ship requires 25.1% less power, 52.2% less fuel and has 5% less machinery and 3.5% less lightship weights. We finally have an open shaft ship with an advantage. This advantage is not evenly distributed, however. The fuel cost improvements described here are profound from the viewpoint of the fuel-short 1973+ and 1982+ eras. They are less impressive to people concerned only with first cost, however, since the usual measure of improvement, lightship weight, is little affected. The 25% reduction in required power should be considered important, since required power is truly the most important single indicator of first cost.

This last ship also offers a modest reductions in infrared signature, due to the smaller airflow and lower exhaust temperatures of the ICR engines. An increase of cavitation inception speed may be of some importance. Maintenance should be reduced since four engines have replaced seven.

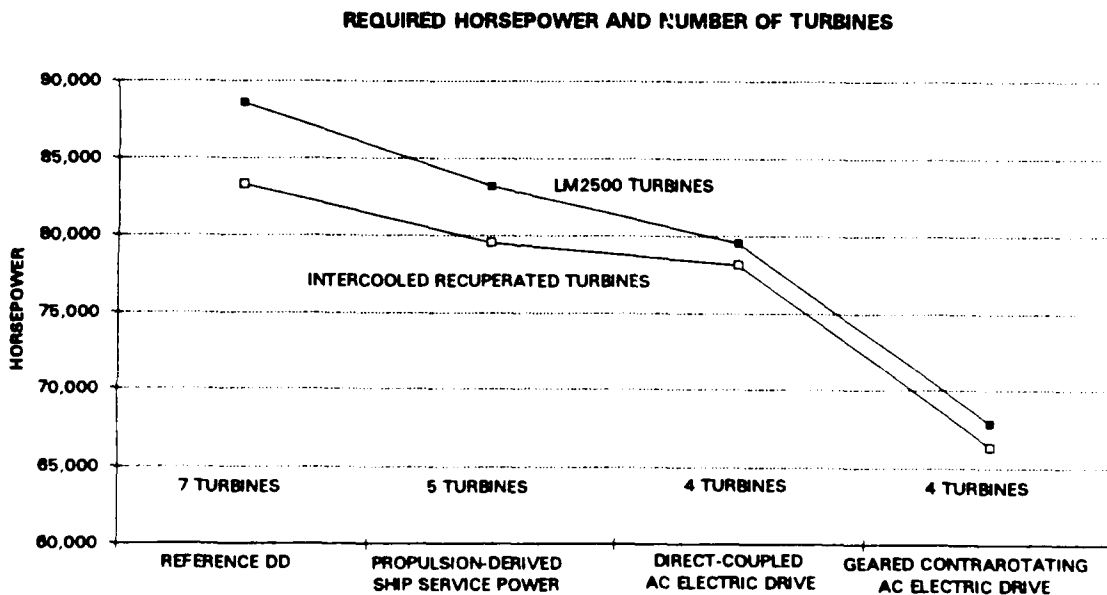


Fig. A.1. Required power and number of turbines for 4 ships

MACHINERY AND FUEL WEIGHTS, LONG TONS,
FOR FOUR DESTROYERS

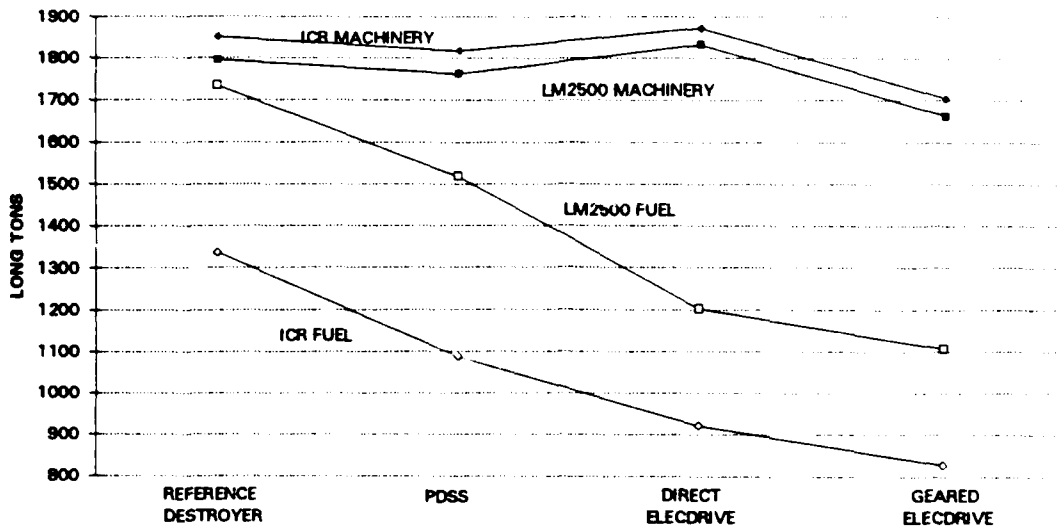


Fig. A.2. Machinery and fuel weight for 4 ships

LIGHTSHIP AND FULL LOAD DISPLACEMENTS FOR
FOUR DESTROYERS, LONG TONS

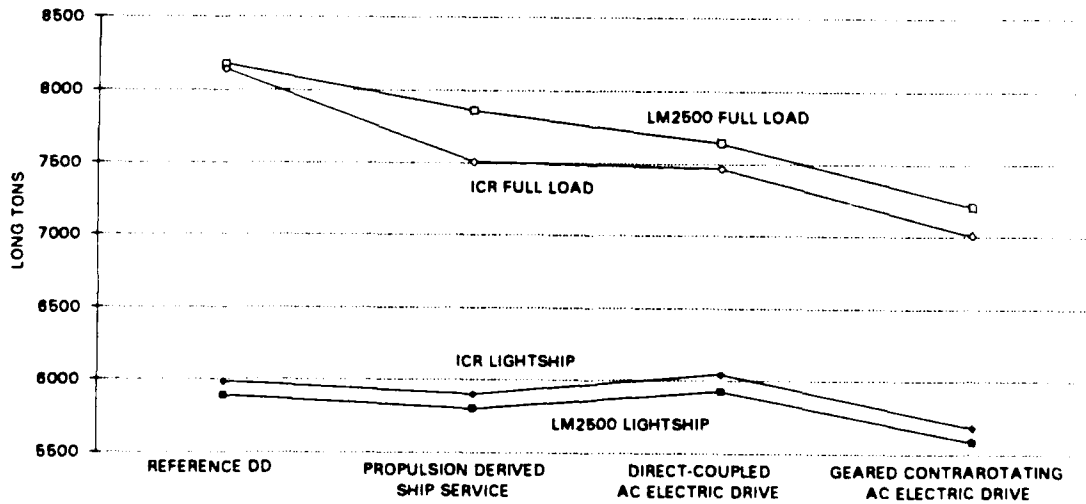


Fig. A.3. Lightship and full load displacement for 4 ships

TABLE A1. Weight, Power, and Turbine Number Data for 4 Ships

	LM HP	LM MACH	LM LTSHIP	LM FUEL	LM DISP
REFERENCE SHIP	88,617	1,794	5,887	1,733	8,173
SS PROPUL DERIVED	83,186	1,761	5,801	1,519	7,862
DIRECT ELEC DRIVE	79,554	1,832	5,928	1,201	7,646
GEARED ELEC DRIVE	67,856	1,663	5,581	1,107	7,202

	ICR HP	ICR MACH	ICR LTSHIP	ICRFUEL	ICR DISP
REFERENCE SHIP	83,279	1,850	5,984	1,337	8,141
SS PROPUL DERIVED	79,566	1,817	5,898	1,088	7,506
DIRECT ELEC DRIVE	78,142	1,871	6,044	921	7,467
GEARED ELEC DRIVE	66,348	1,704	5,679	828	7,006

**APPENDIX B
ASSET SHIP AND MACHINERY DATA BASE
FOR EVALUATIONS OF 21ST CENTURY SURFACE COMBATANTS**

ABSTRACT

A series of ten ship/machinery options are quantified using the Advanced Surface Ship Evaluation Tool (ASSET) to provide a data base from which new naval surface combatant ship designs can be analyzed. The series starts with a conventional reference ship and includes combinations of ten (10) machinery options in two (2) distinctly different hulls.

The series leads to a unique design where all main machinery is outside a tumble home hull. All engines are located in the helicopter hangar and the driveline is housed in a steerable propulsion pod. As compared to the reference ship, the new hull is slender with a 10 % increase in length-to-beam ratio. The installed power is reduced by almost 50 %. With intercooled, recuperated engines, it has enough tankage to double the conventional range. This results in triple the payload delivery capability (ton-miles per installed horsepower). The tumble home hull permits relatively uniform static stability from full load to fuel burn out, thus, no sea water ballast is required.

This new design is expected to be Small, Efficient and also Affordable with Main Machinery Outside her Tumble Home Hull and have Extended Range. The acronym "SEA MOTHER" is provided to help the reader remember these unique attributes.

This design is proposed as a new baseline for evaluating machinery options in surface combatant ships of the 21st century.

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INTRODUCTION

A series of ship/machinery options are quantified using the Advanced Surface Ship Evaluation Tool (ASSET) to provide a data base from which new naval surface combatant ship designs can be analyzed.

A recent ASNE paper, "A Capable, Affordable 21st-Century Destroyer", by Dr. William J. Levedahl, utilized this data base exclusively to analyze machinery/ship impacts and to develop a design rationale for the next generation of naval ships.

This data base is intended to have uses beyond the Levedahl application:

It makes the information accessible to non-users of the complex ASSET program.

It serves as a demonstration of the robust machinery/ship integration capability of ASSET.

This complete ASSET application package (rationale, machinery options, hull forms, commands, adjustments and results) is a learning aid to individuals becoming ASSET users.

The series starts with a conventional reference ship and includes combinations of ten (10) machinery options in two (2) distinctly different hulls.

The machinery/ship options are quantified through ASSET synthesis according to a set of ground rules established to insure that "equal mission capability" is maintained from one option to another. This is offered as an acceptable method of performing technology evaluation.

The series leads to a particular unconventional ship/machinery design. This design is proposed as a new baseline for evaluating machinery options for surface combatant ships of the 21st century. This new design is expected to be:

Small, Efficient and Affordable with

Main Machinery Outside her Tumble Home Hull with Extended Range.

The acronym "SEA MOTHER" is provided to help the reader remember these unique attributes.

ASSET

ASSET is a family of interactive computer programs useful in the feasibility and early preliminary design phases of Navy surface ships. A separate but similiar program exists for each of several ship types. A series of computational modules addressing hull geometry, hull structure, resistance, propulsors, machinery, weight, space, hydrostatics, seakeeping, manning and cost exist within each ship type program. ASSET MONOSC Version 3.2 is used to quantify this particular series of monohull, surface combatant, ship/machinery options.

This effort utilizes version 3.2 of the program. It is noted that version 3.4 (under development and soon to be released) simplifies the locating of and space accounting for electric propulsion engine/generator sets placed above the conventional machinery box.

ASSET is a large, complex and relatively user unfriendly program. MONOSC version 3.4, a single ship type, on a personal computer, with a single data bank of ten ships requires about 8.0 megabytes of disk space. This is comparable to typical software such as Excel 4.0 (6.0 megabytes) or Windows 3.1 (11.0 megabytes).

Enhanced Machinery Module

This version of the ASSET program contains the Enhanced Machinery Module which rationally integrates machinery into the ship design process. It provides the only machinery/ship impact tool accessible to Naval headquarters, research and educational activities.

The Enhanced Machinery Module provides machinery size, location and ship space characteristics as functions of machinery arrangement, component selection, system operation, design variables and margins. It reflects the NSWC's corporate knowledge of machinery technology and parametrically describes all main propulsion and electric plant machinery. It emphasizes user interaction, machinery arrangement flexibility, machinery/ship graphics and engine/transmission/propulsor options. The module includes intercooled recuperated gas turbine engines, electric drive, contrarotation, pod propulsion and propulsion derived ship service systems.

Hull/Machinery Options

The following summarizes the hull and machinery options included within. More detail is included with each individual option result:

- (I) Conventional 529' Monohull w/ Vertical Sides.....
 - (1) 4-LM2500 Propulsion Engines,
2-LTDR Gears,
2-CRP Propellers,
2-Spade Rudders,
Transom Stern,
3-Separate SSTG Sets
 - (2) Add 2 PDSS Systems,
Remove 2 SSTG Sets
 - (3) Replace LM2500's with WR-21 ICR Engines
 - (4) Add Direct Electric Drive,
Remove LTDR gears,
Remove 1-ICR Engine,
Replace CRP's with FP's
 - (5) Replace Direct with Geared Electric Drive,
Replace FP's with CR Propellers

- (II) Unconventional 529' Monohull w/ 10 deg. Tumble Home....
 - (6) Move Main Machinery Outside Hull,
Move Engines to Helicopter Hangar,
Move Drive Line to Steerable POD,
Remove 1-ICR Engine,
Remove Spade Rudders
 - (7) Remove the remaining SSTG Set
 - (8) Reduce the Propeller Expanded Area Ratio (EAR)
 - (9) Add a Retractable Transom Flap
 - (10) Add Fuel to Double the Ship's Range

- (III) Unconventional 553' Monohull w/ 12 deg. Tumble Home....
 - (11) Remove Flap,
Decrease Maximum Section Coefficient,
Add 25 degree Stem Angle,
Remove Solid State Motor Controls,
Design Ship Stable To Fuel Burn Out
 - (12) Run with Fuel Removed to Verify Stability

Ground Rules

The ASSET synthesis process is guided by the following set of ground rules which insure "equal mission capability" and are recommended for technology evaluations:

- Payload - Each ship carries an 1183 L.ton upgraded Destroyer payload with two 61-cell Vertical Launch Systems, a hangared helicopter with space for three spares, two 5 inch/54 caliber guns, and two Phalanx Close In Weapons Systems.
- Range - Each ship makes 6000 N.miles at 20 knots except for those exploiting excess available tankage where the range is doubled to 12000 N.miles.
- Speed - All ships are designed to make 30 Knots sustained speed at 80% of installed power. This is accomplished by allowing the propulsion engines to be over-rated or under-rated.
- Stability - Each ship has a GMT/B of .075, accomplished by iterations on the beam, except for DD21A, which retains excess stability.
- Length - The length-between-perpendiculars of all ships is 529 feet except for that of the new design, 21st Century Baseline, where the length is 553 feet.
- Area - No excess area is allowed in any ship. This is accomplished mainly through deckhouse reduction but also by increased tumble home in the 21st Century Baseline.
- Freeboard - A minimum freeboard at midships of 22 feet is required for all ships.
- Deckhouse - All ships have a steel deckhouse.

21st Century Baseline

The series of 10 machinery/ship options lead to a unique ship design ("SEA MOTHER") which is proposed as an attractive baseline for evaluating surface combatant ship designs of the 21st century. When compared to the original baseline SEA MOTHER has the following attributes:

- Small
 - * 22 % reduction in lightship weight
 - * 11 % reduction in deck area
 - * 20 % reduction in volume

- Efficient
 - * 215 % increase in payload ton-miles per installed brake horsepower

- Affordable
 - * 42 % reduction in installed power

- Long Legs
 - * 100 % increase in range

- Environmentally Friendly
 - * Uses no sea water ballast, is stable empty
 - * Reduces fuel consumption and exhaust emissions

- Modular
 - * All main machinery located outside of hull

- Quiet
 - * Multi-bladed contrarotating propellers aimed directly into undisturbed flow stream to raise cavitation inception speed

- Stealthy
 - * 12 degree tumble home hull and deckhouse provides reduced radar cross section

Ship/Machinery Data Base

The remainder of the report is devoted to the data base and contains the following information for each ship/machinery option:

ASSET Synthesis Techniques

Hull Specification, Body Plan, and Isometric

Machinery Option Specification and Special Modeling

Machinery Arrangement Specification and Graphic Output

Machinery Box and Machinery Room Graphic Output

ASSET Ship/Machinery Printed Reports:

DESIGN SUMMARY
HULL GEOMETRY SUMMARY
SPACE SUMMARY
RESISTANCE SUMMARY
HULL SUBDIVISION SUMMARY
MACHINERY SUMMARY
POWERING
MACHINERY HULL STRUCTURE WEIGHT
PROPULSION PLANT WEIGHT
ELECTRIC PLANT WEIGHT
MACHINERY SPACE REQUIREMENTS
SHIP WEIGHT SUMMARY
SEAKEEPING ANALYSIS SUMMARY
COST ANALYSIS SUMMARY
UNIT ACQUISITION COSTS

CONVENTIONAL MONOHULLS

The first five machinery options are installed in a conventional monohull and are conventionally arranged. Most machinery is in the machinery box (a series of machinery rooms located near midships). Main machinery rooms (MMRs) are separated by three bulkheads. Large trunks, containing intake and exhaust ducts, run from the tops of the MMRs up through the hull and deckhouse. Gears and/or motors are placed low to minimize the shaft angles. Shafts run from the MMRs to the strut-supported port/starboard propellers. A standby ship service gas turbine driven generator is located near the stern.

This conventional machinery arrangement and the five machinery options are handled straightforwardly in the ASSET Machinery Module. The first option exists in ASSET reference banks as "DESTROYER". This study starts with "DESTROYER" and makes the modifications specified herein. The user directly specifies each of the five options. No external calculations/adjustments are needed.

ASSET Synthesis.....

The following ASSET synthesis procedure meets the ground rules:

All ships have the same payload as input through PAYLOAD AND ADJUSTMENTS. All ships have a 6000 n.mile range accomplished by:

DESIGN MODE IND = ENDURANCE
ENDURANCE = 6000.

Each ship is designed to have the exact power necessary to make a 30 knot sustained speed. This permits the rating of engines to be based on power required. This method of analysis is employed with ASSET technology evaluations. The engines physical size does not change but the rest of the propulsion plant is sized by power required rather than rated power. This is accomplished by:

SUSTN SPEED IND = GIVEN
SUSTN SPEED = 30.

The conventional monohull surface combatant-type hull offsets are generated in ASSET for a user specified beam. The hull is designed such that the displacement on the design waterline equals the full load displacement. All this is accomplished by:

HULL OFFSETS IND = GENERATE
HULL BC IND = CONV DD
HULL DIM IND = T

Each ship is designed to have no excess area, this is accomplished by automatically varying the deckhouse size:

DKHS GEOM IND = GENERATE
DKHS SIZE IND = AUTO X

Each ship has the same ratio of transverse metacentric height to beam (GMT/B). This is accomplished by iterative guessing of the beam until GMT/B AVAIL = .075. The conventional monohull is designed to be stable at full load, thus

ENDUR DISP IND = FULL LOAD

Compensating ballast begins as soon as fuel is used. "Dirty" ballast for simple cycle gas turbines and "clean" ballast in the excess tankage resulting from the reduced fuel and tankage requirements of ICR's.

Machinery Options.....

The following machinery options are installed in the conventional monohull ship:

- REFDD - A mechanically-driven open-shaft and strut system. Four LM2500 gas turbine propulsion engines driving two controllable-reversible pitch propellers through a pair of locked train double reduction gears. Ship service power is supplied by three separate 2-pole, 60 Hz alternators driven by geared 501K17 gas turbines.
- PDSS - Two of the separate ship service turbine-generator sets are removed. They are replaced by two variable-speed, constant-frequency, propulsion-derived ship service systems. Each system consists of a pair of 12-pole, variable frequency, liquid-cooled alternators gear driven by the propulsion reduction gear and a cycloconverter providing high-quality 60 Hz power. These PDSS alternators operate over a 3:1 speed range.
- ICR - The LM2500 simple-cycle propulsion gas turbines are replaced by intercooled recuperated gas turbines. The PDSS system remains.

DIREL - The mechanical transmission is replaced by an electrical transmission. Fixed-pitch propellers are directly driven by a solid-state controlled, reversible, air-cooled AC motor located similarly to the reduction gears. Electrical cross-connect of the two shafts permits three heavily loaded engines to replace the four more lightly loaded engines of the preceding ship. Each engine drives an air-cooled propulsion alternator. Two of the engines supply ship service power by driving PDSS alternators through a step-up gear. The solid-state controls permit these PDSS alternators to operate over a 1.5:1 speed range.

GRELEC - The direct drive motors of the preceding ship are replaced by high-speed geared motors. Contrarotating propellers are driven through a contrarotating driveline including contrarotating shafting, thrust bearings and contrarotating bicoupled epicyclic gears. The propeller expanded area ratio is increased to .80 (from .73).

Ship/Machinery Graphics and Data.....

An ASSET hull body plan and isometric view of the conventional monohull is shown on succeeding pages followed by information on each machinery option installed including ASSET modeling details, machinery arrangements and representative ASSET printed reports. These ships are available to all ASSET users on:

MSSF2 USERDISK:[SHANK.ASSET]JACK2V32.BNK

I) ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - 3/22/93 14.53.33.
GRAPHIC DISPLAY NO. 1 - BODY PLAN

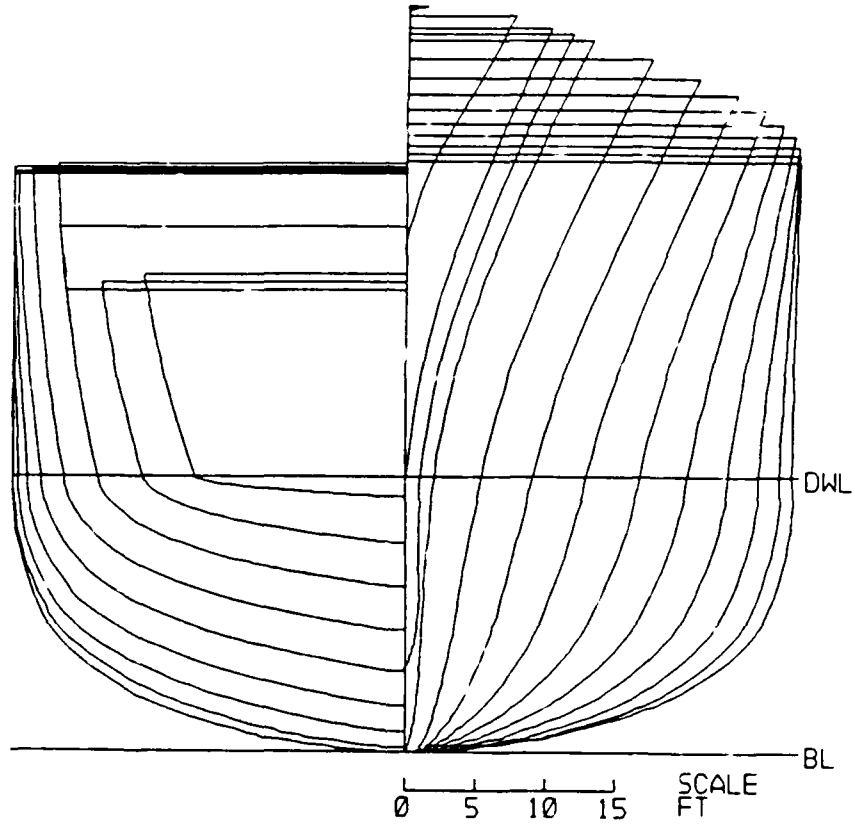


Fig. B.1. Conventional Monohull Body Plan

I) ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - 3/22/93 14.53.33.
GRAPHIC DISPLAY NO. 2 - HULL ISOMETRIC VIEW

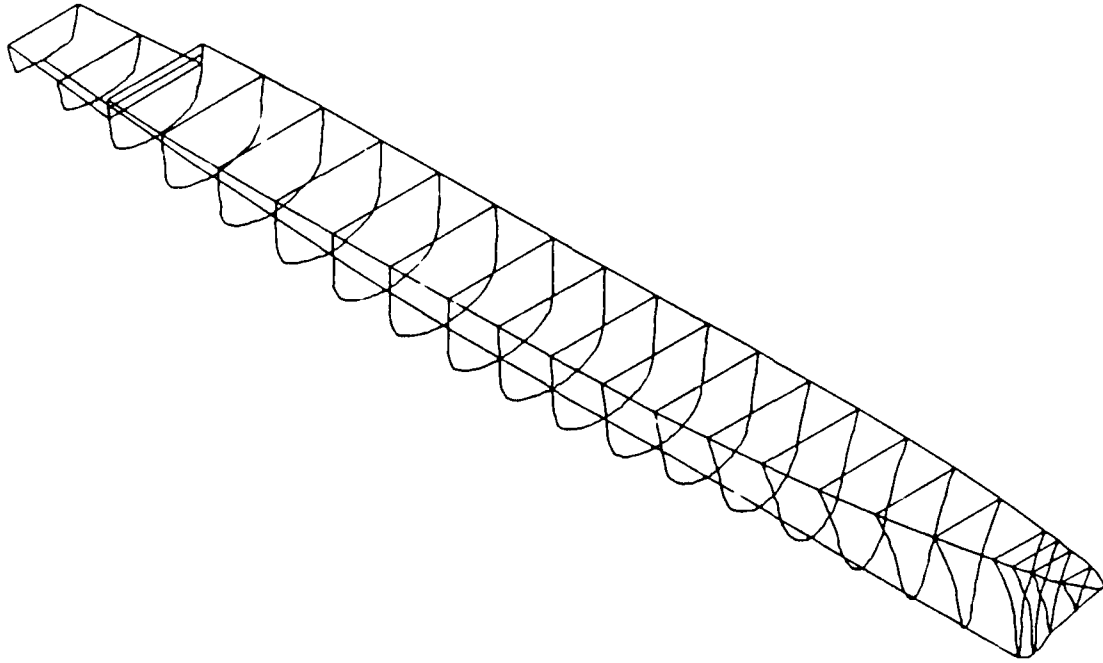


Fig. B.2. Conventional Monohull Isometric View

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REFDD: 4-LM2500 Gas Turbine Propulsion Engines (20421 hp)-
 2-Locked Train Double Reduction Gears
 2-Controllable-Reversible Pitch Propellers (17', .73EAR)
 2-Strut-Supported Open Shafts
 2-Spade Rudders
 Transom Stern
 6000 N.Mile Range
 3-501K17 Separate SSTG Sets (2000 kw)

This machinery option is available in the ASSET Machinery Module and is contained in the reference ship "DESTROYER" whose payload, deckhouse, sustained speed and endurance are modified to develop REFDD. This mechanically-driven open-shaft and strut system has four LM2500 gas turbine propulsion engines driving two controllable-reversible pitch propellers through a pair of locked train double reduction gears. Ship service power is supplied by three separate 2-pole, 60 Hz alternators driven by geared 501K17 gas turbines.

The reduction gears are located as low as possible and a maximum shaft angle of 3.5 degrees (starboard shaft) results.

This machinery is directly specified in ASSET as follows:

MACHINERY ROOMS

	MR TYPE TBL	= (10X 1)*10
1	MMR	
2	AMR	
3	AMR	
4	MMR	
5	OMR	
	MR FWD BHD ID ARRAY	= (10X 1)
1	5.000	
2	6.000	
3	7.000	
4	8.000	
5	11.00	
	MR UPR DECK ID ARRAY	= (10X 1)
1	1.000	
2	2.000	
3	3.000	
4	1.000	
5	1.000	

PROPULSION PLANT

ARRANGEMENTS

ARRANGEMENT TYPES

MECH PORT ARR IND = M2-LTDR
MECH STBD ARR IND = M2-LTDR/F

ARRANGEMENT NUMBER

MECH ARR NO ARRAY = (10X 2)

1 1.000 0.0000E+00
2 0.0000E+00 0.0000E+00
3 0.0000E+00 0.0000E+00
4 0.0000E+00 1.000
5 0.0000E+00 0.0000E+00

SS ARR NO ARRAY = (10X 1)

1 1.000
2 0.0000E+00
3 0.0000E+00
4 1.000
5 1.000

ARRANGEMENT OPERATION

SEP SS GEN OP ARRAY = (2X 1)

1 2.000
2 2.000

ARRANGEMENT CG

MACHY KG IND = GIVEN
MAIN ENG KG ARRAY = (4X 1)

1 0.5000
2 0.4300

SS ENG KG ARRAY = (6X 1)

1 0.3333
2 0.3333
3 0.6190

MACHY CLR ARRAY = (7X 1) FT

1 0.8000
2 1.750
3 0.0000E+00
4 6.000
5 2.800
6 -3.629
7 -3.629

HULL CLR ARRAY = (4X 1) FT

1 1.000
2 1.000
3 1.000
4 1.000

PROPULSION UNITS
 ENGINE CONFIG FACTORS
 GT ENG ENCL IND = 90 DBA
 MAIN ENGINES
 MAIN ENG SELECT IND = GIVEN
 MAIN ENG MODEL IND = GE-LM2500-21
 MAIN ENG SIZE IND = GIVEN

 TRANSMISSION
 TRANSMISSION FACTORS
 TRANS TYPE IND = MECH
 TRANS EFF IND = CALC
 TRANS EFF ARRAY = (2X 1)
 1 0.9781
 2 0.9643
 GEARS
 GEAR IMPEDANCE MASS IND = PRESENT
 GEAR K FAC ARRAY = (17X 2)
 1 100.0 132.0
 17 175.0
 GEAR FACE RATIO ARRAY = (17X 2)
 1 1.050 2.190
 17 2.300
 GEAR CASING WT FAC ARRAY = (17X 1)
 1 0.7500
 17 3.000

 PROPULSION SHAFTING
 SHAFT SUPPORT TYPE IND = OPEN STRUT
 SHAFT SYS SIZE IND = CALC
 SHAFT BORE RATIO ARPAY = (3X 1)
 1 0.6670
 2 0.6670
 3 0.5500
 TORQUE MARGIN FAC = 1.20000
 PROP OFF-CNTR THRUST FAC = 1.00000
 SHAFT SAFETY FAC ARRAY = (2X 1)
 1 1.750
 2 2.000
 SHAFT SIGMA ARRAY = (3X 1) KSI
 1 6000.
 2 0.4750E+05
 3 0.7500E+05
 PROPULSION SHAFT BEARINGS
 THRUST BRG LOC IND = CALC

```

PROPELLER
  POWERING
    THRUST DED COEF           = 0.400000E-01.
    TAYLOR WAKE FRAC         = 0.000000E+00
    REL ROTATE EFF           = 0.950000
    PROPULSIVE COEF IND      = CALC
  PROPELLER FACTORS
    PROP TYPE IND            = CP
    PROP SERIES IND          = GIVEN
    PROP DIA IND             = GIVEN
    PROP DIA                 = 17.0000      FT
    PROP AREA IND            = GIVEN
    EXPAND AREA RATIO        = 0.730000
    BLADE NUMBER ARRAY
1  5.000
    PROP LOC IND             = GIVEN
    PROP TIP CLEAR RATIO     = 0.270165
    PROP LOC ARRAY           = ( 3X 1)      FT
2  496.0
3  12.75
3  1.417
  OPEN WATER PROP DATA
    PROP ID IND              = PROP 4660
    ADVANCE COEF ARRAY
1  0.2000
2  0.4000
3  0.6000
4  0.7000
5  0.8000
6  0.9000
7  1.000
8  1.100
9  1.200
10 1.400
    THRUST COEF ARRAY        = ( 10X 6)
1  0.7300
2  0.6250
3  0.5200
4  0.4700
5  0.4200
6  0.3600
7  0.3100
8  0.2500
9  0.1900
10 0.7000E-01
    TORQUE COEF ARRAY        = ( 10X 6)
1  0.1475
2  0.1270
3  0.1080
4  0.9900E-01
5  0.9000E-01
6  0.8000E-01
7  0.7000E-01
8  0.6000E-01
9  0.4900E-01
10 0.2500E-01

```

PITCH RATIO ARRAY = (1X 6)
 1 1.540
 PROPELLER STRUCTURE
 BLADE ROOT BEND STRESS = 11.5000 KSI
 PROP HUB SOLIDITY FAC = 0.500000

 PROPULSION SUPPORT SYS
 INLET TYPE IND = HIGH HAT
 DUCT SILENCING IND = BOTH
 EXHAUST IR SUPPRESS IND = PRESENT
 EXHAUST STACK TEMP = 350.000 DEGF
 EDUCTOR DESIGN FAC = 1.00000
 FUEL SYS TYPE IND = NON-COMP

ELECTRIC PLANT

ELECTRIC LOADS
 400 HZ ELECT LOAD FAC = 0.200000
 ELECT LOAD DES MARGIN FAC = 0.500000E-01
 ELECT LOAD SL MARGIN FAC = 0.500000E-01
 SS GENERATORS
 SS GENERATOR FACTORS
 SS SYS TYPE IND = SEP
 ELECT LOAD IMBAL FAC = 0.900000
 FREQ CONV IND = NEW
 SS GENERATOR SIZE
 SS GEN SIZE IND = GIVEN
 SEP SS GEN KW = 2000.00 KW
 SS ENGINES
 SS ENG SELECT IND = GIVEN
 SS ENG MODEL IND = DDA-501-K17
 SS ENG TYPE IND = GT
 SS ENG SIZE IND = GIVEN

I) ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 3/22/93 14.41.26.
GRAPHIC DISPLAY NO. 1 - SHIP MACHINERY LAYOUT

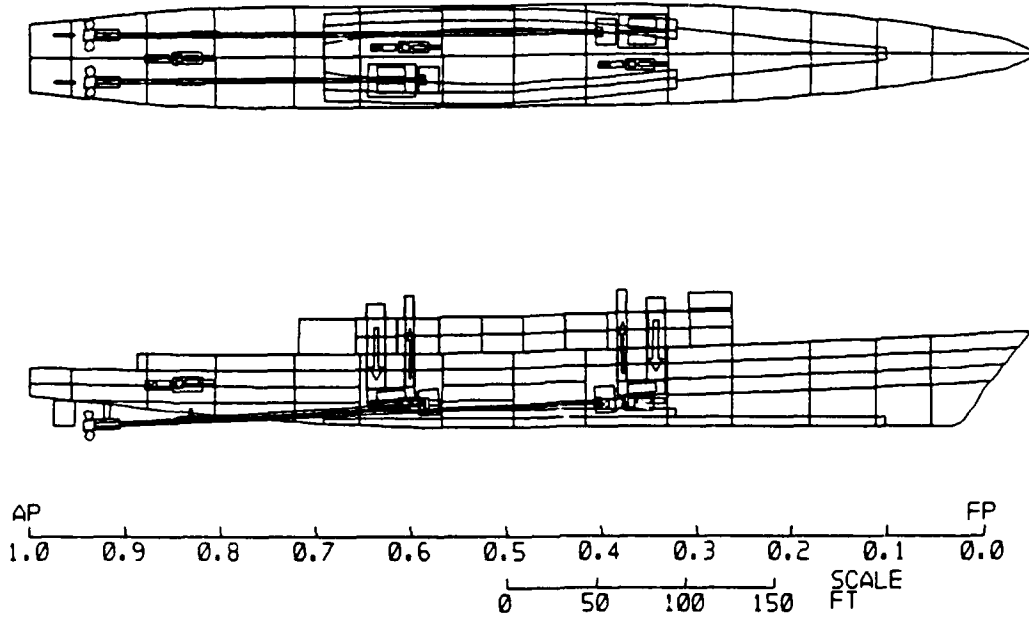


Fig. B.3. "REFDD" Machinery Arrangement

B-20

I> ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 3/22/93 14.41.26.
GRAPHIC DISPLAY NO. 2 - MACHINERY BOX

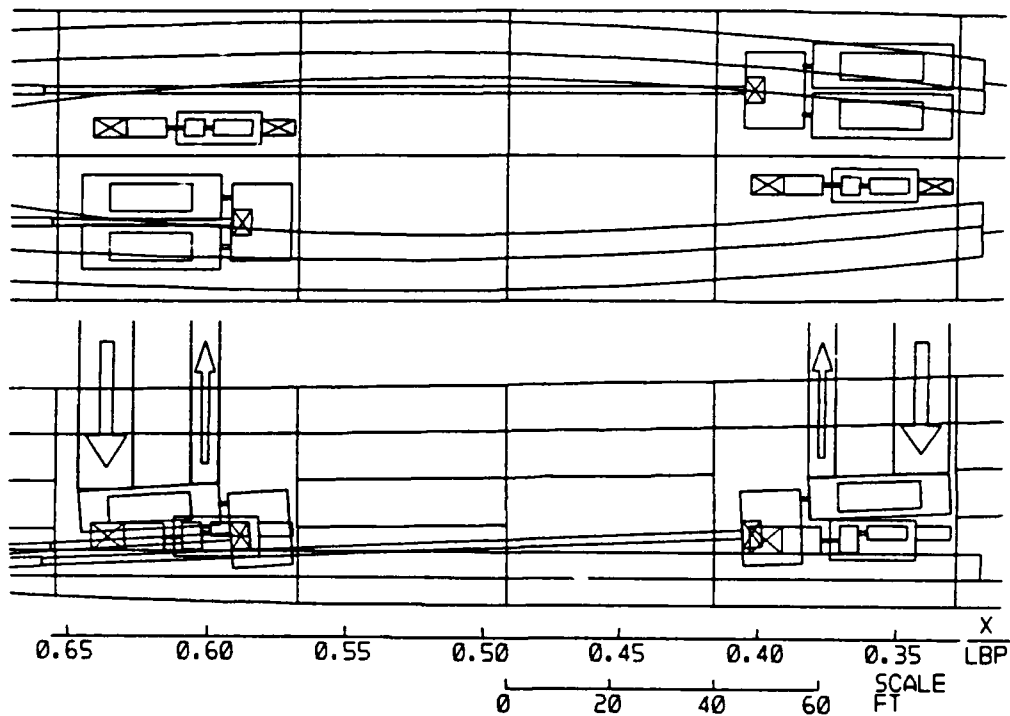


Fig. B.4. "REFDD" Machinery Box

I) ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 3/22/93 14.41.26.
 GRAPHIC DISPLAY NO. 3 - MR PLAN VIEWS (MMR1)
 PAGE 1 OF 5

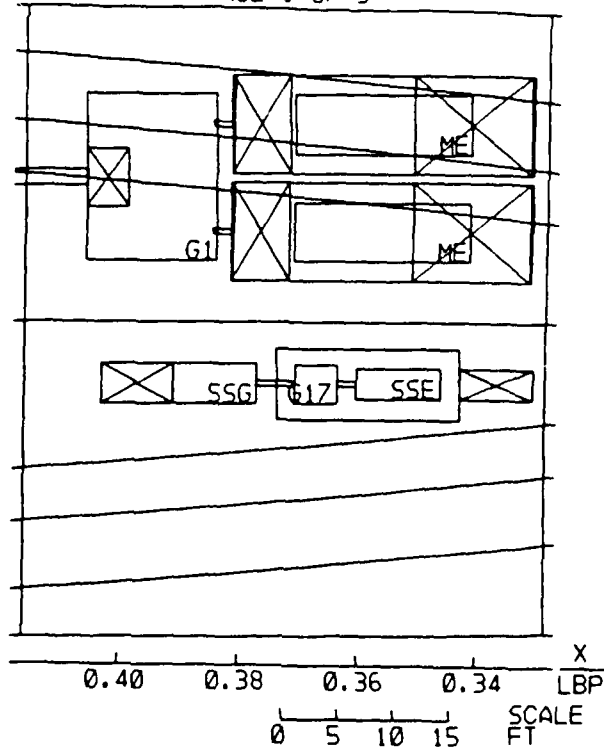


Fig. B.5. "REFDD" Main Machinery Room Plan View

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ASSET/MONOSC VERSION 3.2 - DESIGN SUMMARY - REFDD

PRINTED REPORT NO. 1 - SUMMARY **

PRINCIPAL CHARACTERISTICS - FT		WEIGHT SUMMARY - LTON	
LBP	529.0	GROUP 1 - HULL STRUCTURE	2795.3
LOA	555.6	GROUP 2 - PROP PLANT	763.4
BEAM, DWL	55.5	GROUP 3 - ELECT PLANT	255.6
BEAM, WEATHER DECK	55.5	GROUP 4 - COMM + SURVEIL	388.5
DEPTH @ STA 10	42.0	GROUP 5 - AUX SYSTEMS	775.9
DRAFT TO KEEL DWL	19.6	GROUP 6 - OUTFIT + FURN	508.4
DRAFT TO KEEL LWL	19.6	GROUP 7 - ARMAMENT	399.8
FREEBOARD @ STA 3	32.0	-----	
GMT	4.2	SUM GROUPS 1-7	5887.0
CP	0.576	DESIGN MARGIN	0.0
CX	0.836	-----	
SPEED(KT): MAX= 31.5 SUST= 30.0		LIGHTSHIP WEIGHT	5887.0
ENDURANCE: 6000.0 NM AT 20.0 KTS		LOADS	2286.9
TRANSMISSION TYPE: MECH		-----	
MAIN ENG: 4 GT	@ 20421.0 HP	FULL LOAD DISPLACEMENT	8173.9
SHAFT POWER/SHAFT: 39826.5 HP		FULL LOAD KG: FT	22.1
PROPELLERS: 2 - CP - 17.0 FT DIA		MILITARY PAYLOAD WT - LTON	1182.7
SEP GEN: 3 GT @ 2000.0 KW		USABLE FUEL WT - LTON	1733.6
24 HR LOAD 1858.1		AREA SUMMARY - FT ²	
MAX MARG ELECT LOAD 3696.3		HULL AREA	- 55529.2
MANNING		SUPERSTRUCTURE AREA	- 21232.1
OFF	CPO	ENL	TOTAL
22	19	229	270
ACCUM	25	21	252
			298
		TOTAL AREA	76761.3
		VOLUME SUMMARY - FT ³	
		HULL VOLUME	- 817721.5
		SUPERSTRUCTURE VOLUME	- 218635.5

		TOTAL VOLUME	1036357.1

** MAIN ENG REQUIRED POWER IS REPORTED

PRINTED REPORT NO. 1 - HULL GEOMETRY SUMMARY

HULL OFFSETS IND-GENERATE	MIN BEAM, FT	30.00
HULL DIM IND-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-CONV DD		

HULL PRINCIPAL DIMENSIONS (ON DWL)

LBP, FT	529.00	PRISMATIC COEF	0.576
LOA, FT	555.58	MAX SECTION COEF	0.836
BEAM, FT	55.55	WATERPLANE COEF	0.734
BEAM @ WEATHER DECK, FT	55.55	LCB/LCP	0.515
DRAFT, FT	19.60	HALF SIDING WIDTH, FT	1.00
DEPTH STA 0, FT	51.59	BOT RAKE, FT	0.00
DEPTH STA 3, FT	47.58	RAISED DECK HT, FT	9.00
DEPTH STA 10, FT	42.00	RAISED DECK FWD LIM, STA	
DEPTH STA 20, FT	34.06	RAISED DECK AFT LIM, STA	17.77
FREEBOARD @ STA 3, FT	31.98	BARE HULL DISPL, LTON	7925.37
STABILITY BEAM, FT	55.53	AREA BEAM, FT	53.38

BARE HULL DATA ON LWL

STABILITY DATA ON LWL

LGTH ON WL, FT	529.00	KB, FT	11.63
BEAM, FT	55.55	BMT, FT	14.69
DRAFT, FT	19.59	KG, FT	22.05
FREEBOARD @ STA 3, FT	31.99	FREE SURF COR, FT	0.10
PRISMATIC COEF	0.576	SERV LIFE KG ALW, FT	0.00
MAX SECTION COEF	0.836		
WATERPLANE COEF	0.737	GMT, FT	4.17
WATERPLANE AREA, FT2	21669.19	GM1, FT	1180.32
WETTED SURFACE, FT2	31369.77	GMT/B AVAIL	0.075
		GMT/B REQ	0.075
BARE HULL DISPL, LTON	7929.89		
APPENDAGE DISPL, LTON	244.00		
FULL LOAD WT, LTON	8173.89		

PRINTED REPORT NO. 1 - SUMMARY

COLL PROTECT SYS-NONE	SONAR DOME-PRESENT	UNIT COMMANDER-NONE	
FULL LOAD WT, LTON	8173.9	HAB STANDARD FAC	0.260
TOTAL CREW ACC	298.	PASSWAY MARGIN FAC	0.000
HULL AVG DECK HT, FT	10.01	AC MARGIN FAC	0.000
MR VOLUME, FT3	180785.	SPACE MARGIN FAC	0.000

	PAYLOAD	AREA FT2	TOTAL	VOL FT3
	REQUIRED	REQUIRED	AVAILABLE	TOTAL
				ACTUAL
DKHS ONLY	5874.0	13447.8	21232.1	218636.
HULL OR DKHS	15757.0	63313.7	55529.2	817722.
TOTAL	21631.0	76761.4	76761.3	1036357.

SSCS	GROUP	TOTAL AREA FT2	DKHS AREA FT2	PERCENT TOTAL AREA
1.	MISSION SUPPORT	23315.3	6574.5	30.4
2.	HUMAN SUPPORT	18836.7	886.0	24.5
3.	SHIP SUPPORT	30009.2	3604.2	39.1
4.	SHIP MOBILITY SYSTEM	4600.2	2383.1	6.0
5.	UNASSIGNED			0.0
	TOTAL	76761.4	13447.8	100.0

ASSET/MONOSC VERSION 3.2 - RESISTANCE MODULE - REFDD

PRINTED REPORT NO. 1 - SUMMARY

RESID RESIST IND	REGR	BILGE KEEL IND	NONE
FRICTION LINE IND	ITTC	SHAFT SUPPORT TYPE IND	OPEN STRUT
ENDUR DISP IND	FULL LOAD	PRPLN SYS RESIST IND	CALC
ENDUR CONFIG IND	NO TS	PROP TYPE IND	CP
SONAR DRAG IND	APPENDAGE	SONAR DOME IND	PRESENT
SKEG IND	PRESENT	RUDDER TYPE IND	SPADE
FULL LOAD WT, LTON	8173.9	CORR ALW	0.00050
AVG ENDUR DISP, LTON	8173.9	DRAG MARGIN FAC	0.110
USABLE FUEL WT, LTON	1733.6	TRAILSHAFT PWR FAC	
NO FIN PAIRS	0.	PRPLN SYS RESIST FRAC	
PROP TIP CLEAR RATIO	0.27	MAX SPEED	0.206
NO PROP SHAFTS	2.	SUSTN SPEED	0.229
PROP DIA, FT	17.00	ENDUR SPEED	0.390

CONDITION SPEED	-----EFFECTIVE HORSEPOWER, HP-----							DRAG
	KT	FRIC	RESID	APPDG	WIND	MARGIN	TOTAL	LBF
MAX	31.46	16073.	22245.	9601.	547.	5331.	53797.	557246.
SUSTN	30.00	13996.	15974.	8412.	474.	4274.	43131.	468500.
ENDUR	20.00	4300.	1644.	3599.	140.	1065.	10749.	175138.

ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE - REFDD

PRINTED REPORT NO. 1 - SUMMARY

HULL SUBDIV IND-GIVEN		INNER BOT IND-PRESENT	
SHAFT SUPPORT TYPE IND-OPEN STRUT			
LBP, FT	529.00	HULL AVG DECK HT, FT	10.01
DEPTH STA 10, FT	42.00		
HULL VOLUME, FT3	817721.	NO INTERNAL DECKS	3
MR VOLUME, FT3	180765.	NO TRANS BEDS	13
TANKAGE VOL REQ, FT3	83792.	NO LONG BEDS	0
EXCESS TANKAGE, FT3	13266.	NO MACHY RMS	5
		NO PROP SHAFTS	2
ARR AREA LOST TANKS, FT2	61.0		
HULL ARR AREA AVAIL, FT2	55528.9		

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - REFDD

PRINTED REPORT NO. 1 - SUMMARY

TRANS TYPE IND	MECH	MAX SPEED, KT	31.46
ELECT PRPLN TYPE IND		SUSTN SPEED IND	GIVEN
SHAFT SUPPORT TYPE IND	OPEN STRUT	SUSTN SPEED, KT	30.00
NO PROP SHAFTS	2.	ENDUR SPEED IND	GIVEN
ENDUR CONFIG IND	NO TS	ENDUR SPEED, KT	20.00
SEC ENG USAGE IND		DESIGN MODE IND	ENDURANCE
MAX MARG ELECT LOAD, KW	3696.	ENDURANCE, MM	6000.
AVG 24 HR ELECT LOAD, KW	1858.	USABLE FUEL WT, LTON	1733.6
SWBS 200 GROUP WT, LTON	763.4		
SWBS 300 GROUP WT, LTON	255.6		

ARRANGEMENT OR SS GEN	TYPE	NO INSTALLED	NO ONLINE MAX+SUSTN	NO ONLINE ENDURANCE
MECH PORT ARR IND	M2-LTDR	1	1	1
MECH STBD ARR IND	M2-LTDR/F	1	1	1
SEP SS GEN	2000. KW	3	2	2
VSCF SS CYCLO	KW	0	0	0

	MAIN ENG	SEC ENG	SS ENG
ENG SELECT IND	GIVEN		GIVEN
ENG MODEL IND	GE-LM2500-21		DDA-501-K17
ENG TYPE IND	GT		GT
ENG SIZE IND	GIVEN		GIVEN
NO INSTALLED	4	0	3
ENG PWR AVAIL, HP	21500.		3800.
ENG RPM	3600.0		13820.0
ENG SFC, LBM/HP-HR	0.410		.545
ENG LOAD FRAC	0.950		.743

PRINTED REPORT NO. 12 - POWERING - REFDD

SUSTN SPEED IND-GIVEN
 ENDUR SPEED IND-GIVEN
 TRANS EFF IND-CALC

100 PCT POWER TRANS EFF 0.9781*
 25 PCT POWER TRANS EFF 0.9643*

* VALUES DO NOT INCLUDE CP PROP TRANSMISSION EFFICIENCY MULTIPLIER

	MAX SPEED	SUSTN SPEED	ENDUR SPEED
SHIP SPEED, KT	31.46	30.00	20.00
PROP RPM	165.1	155.0	100.0
NO OP PROP SHAFTS	2	2	2
EHP (/SHAFT), HP	26898.	21566.	5375.
PROPULSIVE COEF	0.675	0.678	0.682
ENDUR PWR ALW	1.0	1.0	1.1
SHP (/SHAFT), HP	39828.	31789.	8666.
TRANS EFFY	0.978	0.976	0.964
CP PROP TRANS EFFY MULT	0.997	0.997	0.997
PROPUL PWR (/SHAFT), HP	40842.	32674.	9013.
PD GEN PWR (/SHAFT), HP	0.	0.	0.
BHP (/SHAFT), HP	40842.	32674.	9013.

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	100.4	391.52	10.19
162	STACKS AND MASTS	10.6	258.50	68.84
180	FOUNDATIONS			
182	PROPULSION PLANT FOUNDATIONS	172.3	263.61	10.56
183	ELECTRIC PLANT FOUNDATIONS	37.8	295.42	22.00

PRINTED REPORT NO. 14 - PROPULSION PLANT WEIGHT - REFDD

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
200	PROPULSION PLANT	763.4	311.29	20.57
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	84.7	258.28	19.53
233	PROPULSION INTERNAL COMBUSTION ENGINES	0.0	0.00	0.00
234	PROPULSION GAS TURBINES	84.7	258.28	19.53
235	ELECTRIC PROPULSION	0.0	0.00	0.00
240	TRANSMISSION AND PROPULSOR SYSTEMS	391.6	353.62	8.84
241	PROPULSION REDUCTION GEARS	124.8	258.02	14.52
242	PROPULSION CLUTCHES AND COUPLINGS	0.0	0.00	0.00
243	PROPULSION SHAFTING	153.6	395.08	6.39
244	PROPULSION SHAFT BEARINGS	46.4	349.11	8.73
245	PROPULSORS	66.8	440.02	3.95
250	PROPULSION SUPPORT SYS (EXCEPT FUEL+LUBE OIL)	195.7	262.24	48.76
251	COMBUSTION AIR SYSTEM	48.6	258.87	44.18
252	PROPULSION CONTROL SYSTEM	21.9	258.28	27.30
256	CIRCULATING AND COOLING SEA WATER SYSTEM	9.8	333.27	15.12
259	UPTAKES (INNER CASING)	115.4	258.38	57.62
260	PROPULSION SUPPORT SYS (FUEL+LUBE OIL)	42.4	251.52	13.23
261	FUEL SERVICE SYSTEM	9.4	231.83	13.53
262	MAIN PROPULSION LUBE OIL SYSTEM	23.5	258.28	12.00
264	LUBE OIL FILL, TRANSFER, AND PURIF	9.4	254.28	16.00
290	SPECIAL PURPOSE SYSTEMS	49.1	312.12	9.95
298	OPERATING FLUIDS	40.9	317.40	8.00
299	REPAIR PARTS AND SPECIAL TOOLS	8.2	285.66	19.74

PRINTED REPORT NO. 15 - ELECTRIC PLANT WEIGHT - REFDD

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
300	ELECTRIC PLANT	255.6	291.98	26.68
310	ELECTRIC POWER GENERATION	76.4	309.02	19.91
311	SHIP SERVICE POWER GENERATION	66.3	319.88	17.13
313	BATTERIES AND SERVICE FACILITIES	0.0	0.00	0.00
314	POWER CONVERSION EQUIPMENT	10.1	238.05	38.13
320	POWER DISTRIBUTION SYSTEMS	117.4	283.35	27.77
321	SHIP SERVICE POWER CABLE	84.3	280.37	27.00
324	SWITCHGEAR AND PANELS	33.1	290.95	29.73
330	LIGHTING SYSTEM	32.4	278.00	38.18
331	LIGHTING DISTRIBUTION	17.9	280.37	37.80
332	LIGHTING FIXTURES	14.5	275.08	38.64
340	POWER GENERATION SUPPORT SYSTEMS	24.7	280.21	28.64
342	DIESEL SUPPORT SYSTEMS	0.0	0.00	0.00
343	TURBINE SUPPORT SYSTEMS	24.7	280.21	28.64
350	SPECIAL PURPOSE SYSTEMS	4.6	389.90	19.89
398	OPERATING FLUIDS	1.3	319.88	17.13
399	REPAIR PARTS AND SPECIAL TOOLS	3.3	417.91	21.00

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

PRINTED REPORT NO. 18 - MACHINERY SPACE REQUIREMENTS - REFDD

MACHINERY ROOM VOLUME REQUIREMENTS

VOLUME CATEGORY	VOLUME FT3
SWBS GROUP 200	129372
PROPULSION POWER GENERATION	54744.
PROPULSION ENGINES	42232.
PROPULSION REDUCTION GEARS AND GENERATORS	12512.
DRIVELINE MACHINERY	0.
REDUCTION AND BEVEL GEARS WITH Z-DRIVE	0.
ELECTRIC PROPULSION MOTORS AND GEARS	0.
REMOVELY-LOCATED THRUST BEARINGS	0.
PROPELLER SHAFT	10693.
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	63936.
PROPULSION LOCAL CONTROL CONSOLES	3525.
CP PROP HYDRAULIC OIL POWER MODULES	4181.
FUEL OIL PUMPS	32749.
LUBE OIL PUMPS	4108.
LUBE OIL PURIFIERS	15125.
ENGINE LUBE OIL CONDITIONERS	1187.
SEAWATER COOLING PUMPS	1060.
SWBS GROUP 300	39125.
ELECTRIC PLANT POWER GENERATION	20921.
ELECTRIC PLANT ENGINES	14520.
ELECTRIC PLANT GENERATORS AND GEARS	6400.
SHIP SERVICE SWITCHBOARDS	18204.
CYCLOCONVERTERS	0.
SWBS GROUP 500	47258.
AUXILIARY MACHINERY	47258.
AIR CONDITIONING PLANTS	8596.
AUXILIARY BOILERS	6340.
FIRE PUMPS	5106.
DISTILLING PLANTS	15193.
AIR COMPRESSORS	9726.
ROLL FIN PAIRS	0.
SEWAGE PLANTS	2297.

ARRANGEABLE AREA REQUIREMENTS

SSCS	GROUP NAME	-----FT2-----	
		HULL/DRHS	DRHS ONLY
3.4X	AUXILIARY MACHINERY DELTA	3493.8	0.0
3.511	SHIP SERVICE POWER GENERATION	2037.9	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	522.6	987.5
4.143	GAS TURBINE ENG EXHAUST	754.5	1395.6

NOTE: * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

ASSET/MONOSC VERSION 3.2 - WEIGHT MODULE - REFDD

PRINTED REPORT NO. 1 - SUMMARY

SWBS	G R O U P	W E I G H T		LCG	VCG	RESULTANT ADJ	
		LTON	PER CENT	FT	FT	WT-LTON	VCG-FT
100	HULL STRUCTURE	2795.3	34.2	259.52	27.16	42.2	.17
200	PROP PLANT	763.4	9.3	311.29	20.57		
300	ELECT PLANT	255.6	3.1	291.98	26.68		
400	COMM + SURVEIL	388.5	4.8	201.02	28.16	134.6	.81
500	AUX SYSTEMS	775.9	9.5	290.95	28.44	25.0	.11
600	OUTFIT + FURN	508.4	6.2	264.50	30.79		
700	ARMAMENT	399.8	4.9	238.05	35.21	397.6	1.71
M11	D*B WT MARGIN		0.0	266.90			

D*B KG MARGIN

L I G H T S H I P							
		5887.0	72.0	266.90	27.38	599.4	2.81

F00	FULL LOADS	2286.9	28.0	286.69	8.33	328.6	.97
F10	CREW + EFFECTS	30.2		248.63	31.31		
F20	MISS REL EXPEN	263.6		232.76	27.54		
F30	SHIPS STORES	42.5		285.66	23.48		
F40	FUELS + LUBRIC	1906.3		295.84	5.03		
F50	FRESH WATER	44.3			5.90		
F60	CARGO						
M24	FUTURE GROWTH						

	FULL LOAD WT	8174.0	100.0	272.44	22.05	928.0	3.77

ASSET/MONOSC VERSION 3.2 - SEAKEEPING ANALYSIS - REFDD

PRINTED REPORT NO. 1 - SUMMARY

APPENDAGE IND-WITH

FULL LOAD WT, LTON 8174.0

FULL LOAD

BALES RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL DISP)	15.468
RANK OF THE SYNTHESIZED SHIP (NORMALIZED)	3.452
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)	13.837
RANK OF THE CLOSEST DATA BASE HULL	13.856
ID NO OF CLOSEST DATA BASE SHIP	33

ASSET/MONOSC VERSION 3.2 - COST ANALYSIS - REFDD

PRINTED REPORT NO. 1 - SUMMARY

YEAR \$	1992.	NO OF SHIPS ACQUIRED	50.
INFLATION ESCALATION FAC	2.149	SERVICE LIFE, YR	30.0
LEARNING RATE	0.970	ANNUAL OPERATING HRS	2500.0
FUEL COST, \$/GAL	2.579	MILITARY P/L, LTON	1182.7
PAYLOAD FUEL RATE, LTON/HR	0.33	LIGHTSHIP WT, LTON	5887.0
SHIP FUEL RATE, LTON/HR	5.78	FULL LOAD WT, LTON	8173.9

COST ITEM	COSTS (MILLIONS OF DOLLARS)		
	TOT SHIP	+ PAYLOAD	= TOTAL
LEAD SHIP	1156.3	807.0*	1963.3
FOLLOW SHIP	534.3	710.4*	1244.7
AVG ACQUISITION COST/SHIP(50 SHIPS)	478.7	712.3*	1191.0
LIFE CYCLE COST/SHIP(30 YEARS)			3571.3
TOTAL LIFE CYCLE COST(30 YEARS)			178564.7
DISCOUNTED LIFE CYCLE COST/SHIP			448.4**
DISCOUNTED TOTAL LIFE CYCLE COST			22417.8**

*ESTIMATED VALUE
**DISCOUNTED AT 10 PERCENT

PRINTED REPORT NO. 2 - UNIT ACQUISITION COSTS - REFDD

SWBS GROUP	UNITS	INPUTS	KN FACTORS	LEAD SHIP	FOLLOW SHIP	
				COSTS \$K	COSTS \$K	
100	HULL STRUCTURE	LTON	2795.3	1.00	33401.	31397.
200	PROPULSION PLANT	HP	81684.0	2.35	87284.	82047.
300	ELECTRIC PLANT	LTON	255.6	1.00	25034.	23532.
400	COMMAND+SURVEILLANCE	LTON	388.5	3.15	29132.	27384.
500	AUX SYSTEMS	LTON	775.9	1.53	56671.	53270.
600	OUTFIT+FURNISHINGS	LTON	508.4	1.00	28041.	26358.
700	ARMAMENT	LTON	399.8	1.00	6661.	6262.
	MARGIN	LTON	0.0		0.	0.
800	DESIGN+ENGINEERING		26.06		420964.	46515.
900	CONSTRUCTION SERVICES		4.25		65999.	62039.
TOTAL CONSTRUCTION COST					753186.	358804.
CONSTRUCTION COST					753186.	358804.
PROFIT(15.0 PERCENT OF CONSTRUCTION COST)					112978.	53821.
PRICE					866164.	412625.
CHANGE ORDERS(12/8 PERCENT OF PRICE)					103940.	33010.
NAVSEA SUPPORT(2.5 PERCENT OF PRICE)					21654.	10316.
POST DELIVERY CHARGES(5 PERCENT OF PRICE)					43308.	20631.
OUTFITTING(4 PERCENT OF PRICE)					34647.	16505.
H/M/E + GROWTH(10 PERCENT OF PRICE)					86616.	41262.
TOTAL SHIP COST					1156329.	534349.
ESTIMATED PAYLOAD COST					806991.	710373.
SHIP PLUS PAYLOAD COST					1963320.	1244722.
ADJUSTED FIRST UNIT SHIP COST, \$K		568456.3				
COMBAT SYSTEM WEIGHT, LTON		1182.7				
PROPULSION SYSTEM WEIGHT, LTON		763.4				
ADJUSTED FIRST UNIT SHIP COST EQUALS						
FOLLOW SHIP TOTAL COST DIVIDED BY		0.940				

PDSS: 4-LM2500 Gas Turbine Propulsion Engines (20797 hp)
2-Locked Train Double Reduction Gears
2-Controllable-Reversible Pitch Propellers (17', .73EAR)
2-Strut-Supported Open Shafts
2-Spade Rudders
 Transom Stern
 6000 N.Mile Range
1-501K17 Separate SSTG Set (3000 kw)
2-VSCF Propulsion Derived Ship Service Systems (2000 kw)

This machinery option is available in the ASSET Machinery Module and is a modification to "REFDD". Two of the separate ship service turbine-generator sets are removed. They are replaced by two variable-speed, constant-frequency, propulsion-derive ship service systems. Each system consists of a pair of 12-pole, variable frequency, liquid-cooled alternators gear driven by the propulsion reduction gear and a cycloconverter providing high-quality 60 Hz power. These PDSS alternators operate over a 3:1 speed range and two per system are required. The remaining ship service turbine-generator set is uprated to 3000 kw in order to handle the anchor load.

This propulsion machinery is directly specified in ASSET identically to "REFDD".

This electric plant machinery is specified by modifying the "REFDD" as follows:

SS SYS TYPE IND =	PD
SEP SS GEN KW =	3000.
VSCF SS CYCLO KW =	2000.
SS ARR NO ARRAY =	0,0,0,0,1

I) ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 3/22/93 14.59.05.
GRAPHIC DISPLAY NO. 1 - SHIP MACHINERY LAYOUT

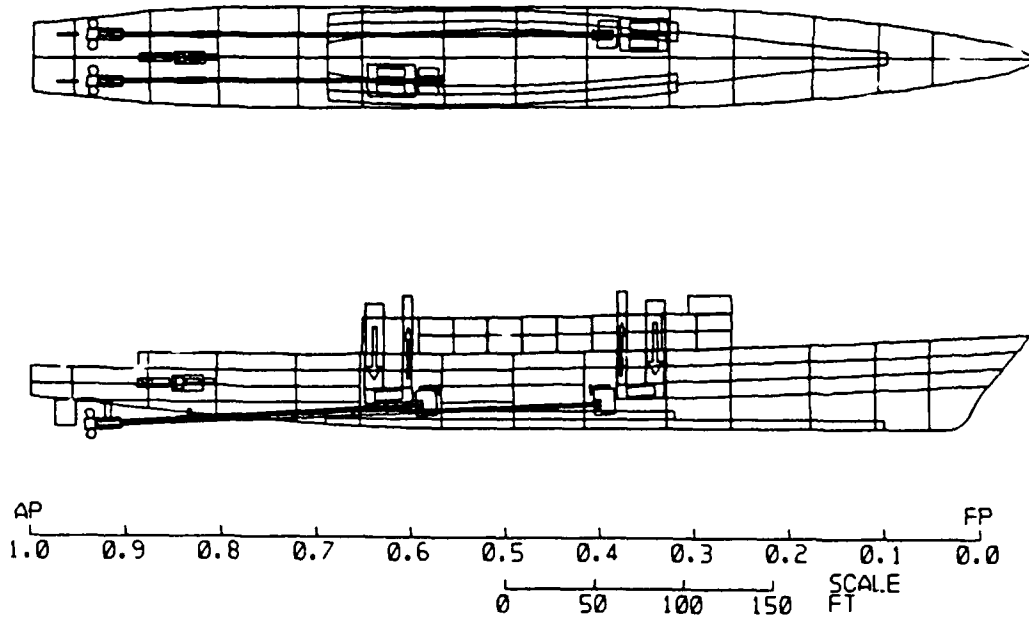


Fig. B.6. "PDSS" Machinery Arrangement

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I>

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 3/22/93 14.59.05.
GRAPHIC DISPLAY NO. 2 - MACHINERY BOX

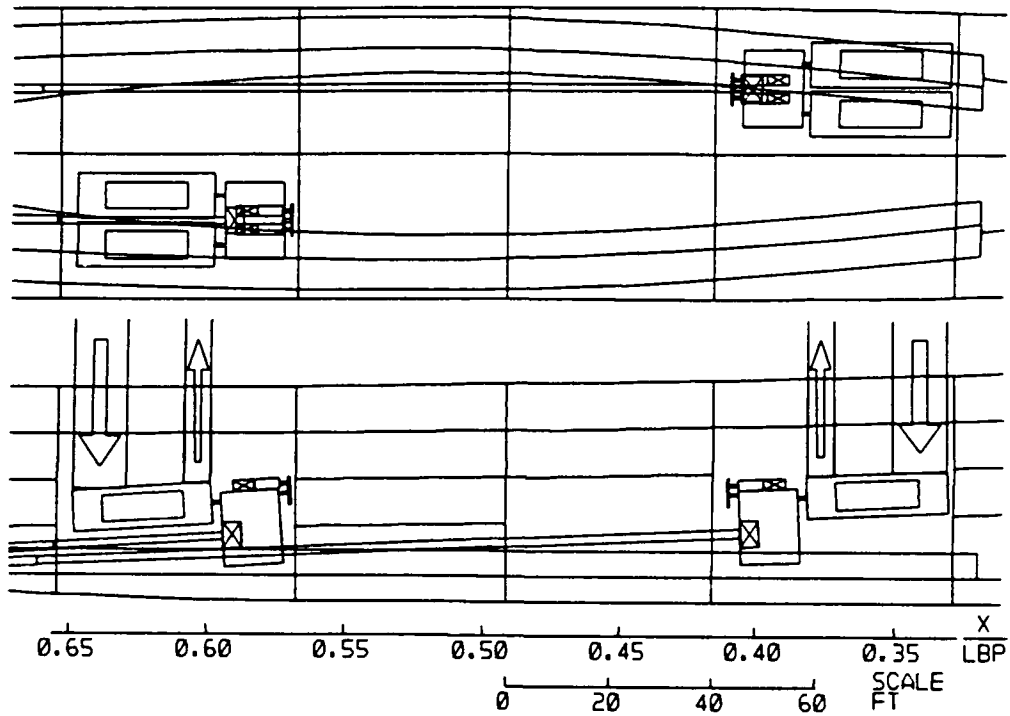


Fig. B.7. "PDSS" Machinery Box

D) ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 3/22/93 14.59.05.
 GRAPHIC DISPLAY NO. 3 - MR PLAN VIEWS (MMR1)
 PAGE 1 OF 5

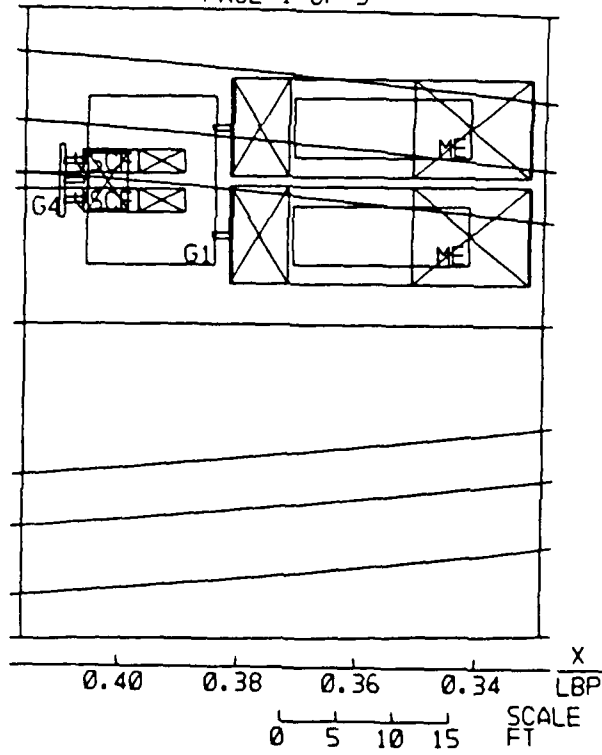


Fig. B.8. "PDSS" Main Machinery Room Plan View

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ASSET/MONOSC VERSION 3.2 - DESIGN SUMMARY - PDSS

PRINTED REPORT NO. 1 - SUMMARY **

PRINCIPAL CHARACTERISTICS - FT				WEIGHT SUMMARY - LTON	
LBP			529.0	GROUP 1 - HULL STRUCTURE	2748.4
LOA			556.3	GROUP 2 - PROP PLANT	762.8
BEAM, DWL			55.8	GROUP 3 - ELECT PLANT	233.9
BEAM, WEATHER DECK			55.8	GROUP 4 - COMM + SURVEIL	388.6
DEPTH @ STA 10			42.0	GROUP 5 - AUX SYSTEMS	764.8
DRAFT TO KEEL DWL			18.8	GROUP 6 - OUTFIT + FURN	502.6
DRAFT TO KEEL LWL			18.8	GROUP 7 - ARMAMENT	399.8
FREEBOARD @ STA 3			32.8	-----	
GMT			4.2	SUM GROUPS 1-7	5800.9
CP			0.576	DESIGN MARGIN	0.0
CX			0.836	-----	
SPEED(KT): MAX= 31.5 SUST= 30.0				LIGHTSHIP WEIGHT	5800.9
ENDURANCE: 6000.0 NM AT 20.0 KTS				LOADS	2061.3
TRANSMISSION TYPE: MECH				-----	
MAIN ENG: 4 GT @ 20797.0 HP				FULL LOAD DISPLACEMENT	7862.3
SHAFT POWER/SHAFT: 38233.2 HP				FULL LOAD KG: FT	22.3
PROPELLERS: 2 - CP - 17.0 FT DIA				MILITARY PAYLOAD WT - LTON	1182.7
SEP GEN: 1 GT @ 3000.0 KW				USABLE FUEL WT - LTON	1519.1
PD GEN: 2 VSCF @ 2000.0 KW				-----	
24 HR LOAD 1830.6				AREA SUMMARY - FT ²	
MAX MARG ELECT LOAD 3637.6				HULL AREA -	56229.1
				SUPERSTRUCTURE AREA -	18335.5

				TOTAL AREA	74564.6

				VOLUME SUMMARY - FT ³	
				HULL VOLUME -	828995.2
				SUPERSTRUCTURE VOLUME -	188784.6

				TOTAL VOLUME	1017779.8

** MAIN ENG REQUIRED POWER IS REPORTED

ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - PDSS

PRINTED REPORT NO. 1 - HULL GEOMETRY SUMMARY

HULL OFFSETS IND-GENERATE	MIN BEAM, FT	30.00
HULL DIM IND-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-CONV DD		

HULL PRINCIPAL DIMENSIONS (ON DWL)

LBP, FT	529.00	PRISMATIC COEF	0.576
LOA, FT	556.27	MAX SECTION COEF	0.836
BEAM, FT	55.76	WATERPLANE COEF	0.734
BEAM @ WEATHER DECK, FT	55.76	LCB/LCP	0.515
DRAFT, FT	18.76	HALF SIDING WIDTH, FT	1.00
DEPTH STA 0, FT	51.59	BOT RAKE, FT	0.00
DEPTH STA 3, FT	47.58	RAISED DECK HT, FT	9.00
DEPTH STA 10, FT	42.00	RAISED DECK FWD LIM, STA	
DEPTH STA 20, FT	34.06	RAISED DECK AFT LIM, STA	17.77
FREEBOARD @ STA 3, FT	32.82	BARE HULL DISPL, LTON	7615.07
STABILITY BEAM, FT	55.74	AREA BEAM, FT	51.41

BARE HULL DATA ON LWL

LGTH ON WL, FT	529.00
BEAM, FT	55.76
DRAFT, FT	18.76
FREEBOARD @ STA 3, FT	32.83
PRISMATIC COEF	0.576
MAX SECTION COEF	0.836
WATERPLANE COEF	0.737
WATERPLANE AREA, FT2	21751.14
WETTED SURFACE, FT2	30898.96
BARE HULL DISPL, LTON	7619.41
APPENDAGE DISPL, LTON	242.84
FULL LOAD WT, LTON	7862.25

STABILITY DATA ON LWL

KB, FT	11.13
BMT, FT	15.44
KG, FT	22.28
FREE SURF COR, FT	0.10
SERV LIFE KG ALW, FT	0.00
GMT, FT	4.19
GML, FT	1231.46
GMT/B AVAIL	0.075
GMT/B REQ	0.075

ASSET/MONOSC VERSION 3.2 - SPACE MODULE - PDSS

PRINTED REPORT NO. 1 - SUMMARY

COLL PROTECT SYS-NONE	SONAR DOME-PRESENT	UNIT COMMANDER-NONE	
FULL LOAD WT, LTON	7862.3	HAB STANDARD FAC	0.260
TOTAL CREW ACC	298.	PASSWAY MARGIN FAC	0.000
HULL AVG DECK HT, FT	9.99	AC MARGIN FAC	0.000
MR VOLUME, FT3	182708.	SPACE MARGIN FAC	0.000

	PAYLOAD REQUIRED	AREA FT2		VOL FT3
		TOTAL REQUIRED	TOTAL AVAILABLE	TOTAL ACTUAL
DKHS ONLY	5874.0	12783.2	18335.5	188785.
HULL OR DKHS	15757.0	61781.7	56229.1	828995.
TOTAL	21631.0	74564.9	74564.6	1017780.

SSCS	GROUP	TOTAL	DKHS	PERCENT
		AREA FT2	AREA FT2	TOTAL AREA
1.	MISSION SUPPORT	23303.5	6577.5	31.3
2.	HUMAN SUPPORT	18836.7	886.0	25.3
3.	SHIP SUPPORT	28326.2	3278.9	38.0
4.	SHIP MOBILITY SYSTEM	4098.4	2040.8	5.5
5.	UNASSIGNED			0.0
	TOTAL	74564.9	12783.2	100.0

ASSET/MONOSC VERSION 3.2 - RESISTANCE MODULE - PDSS

PRINTED REPORT NO. 1 - SUMMARY

RESID RESIST IND	REGR	BILGE KEEL IND	NONE
FRICTION LINE IND	ITTC	SHAFT SUPPORT TYPE IND	OPEN STRUT
ENDUR DISP IND	FULL LOAD	PRPLN SYS RESIST IND	CALC
ENDUR CONFIG IND	NO TS	PROP TYPE IND	CP
SONAR DRAG IND	APPENDAGE	SONAR DOME IND	PRESENT
SKEG IND	PRESENT	RUDDER TYPE IND	SPADE
FULL LOAD WT, LTON	7862.3	CORR ALW	0.00050
AVG ENDUR DISP, LTON	7862.3	DRAG MARGIN FAC	0.110
USABLE FUEL WT, LTON	1519.1	TRAILSHAFT PWR FAC	
NO FIN PAIRS	0.	PRPLN SYS RESIST FRAC	
PROP TIP CLEAR RATIO	0.23	MAX SPEED	0.205
NO PROP SHAFTS	2.	SUSTN SPEED	0.228
PROP DIA, FT	17.00	ENDUR SPEED	0.384

CONDITION	SPEED	-----EFFECTIVE HORSEPOWER, HP-----						DRAG
	KT	FRIC	RESID	APPDG	WIND	MARGIN	TOTAL	LBF
MAX	31.50	15886.	20922.	9269.	563.	5130.	51771.	535634.
SUSTN	30.0	13786.	14989.	8104.	487.	4110.	41476.	450522.
ENDUR	20.00	4235.	1550.	3501.	144.	1037.	10468.	170557.

ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE - PDSS

PRINTED REPORT NO. 1 - SUMMARY

HULL SUBDIV IND-GIVEN	INNER BOT IND-PRESENT		
SHAFT SUPPORT TYPE IND-OPEN STRUT			
LBP, FT	529.00	HULL AVG DECK HT, FT	9.99
DEPTH STA 10, FT	42.00		
		NO INTERNAL DECKS	3
HULL VOLUME, FT3	828989.	NO TRANS BHDS	13
MR VOLUME, FT3	182707.	NO LONG BHDS	0
TANKAGE VOL REQ, FT3	74051.	NO MACHY RMS	5
EXCESS TANKAGE, FT3	26410.	NO PROP SHAFTS	2
ARR AREA LOST TANKS, FT2	61.0		
HULL ARR AREA AVAIL, FT2	56228.8		

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - PDSS

PRINTED REPORT NO. 1 - SUMMARY

TRANS TYPE IND	MECH	MAX SPEED, KT	31.50
ELECT PRPLN TYPE IND		SUSTN SPEED IND	GIVEN
SHAFT SUPPORT TYPE IND OPEN STRUT		SUSTN SPEED, KT	30.00
NO PROP SHAFTS	2.	ENDUR SPEED IND	GIVEN
ENDUR CONFIG IND	NO TS	ENDUR SPEED, KT	20.00
SEC ENG USAGE IND		DESIGN MODE IND	ENDURANCE
MAX MARG ELECT LOAD, KW	3638.	ENDURANCE, NM	6000.
AVG 24 HR ELECT LOAD, KW	1831.	USABLE FUEL WT, LTON	1519.1
SWBS 200 GROUP WT, LTON	762.7		
SWBS 300 GROUP WT, LTON	233.9		

ARRANGEMENT OR SS GEN	TYPE	NO INSTALLED	NO ONLINE MAX+SUSTN	NO ONLINE ENDURANCE
MECH PORT ARR IND	M2-LTDR	1	1	1
MECH STB ⁿ ARR IND	M2-LTDR/F	1	1	1
SEP SS GEN	3000. KW	1	0	0
VSCF SS CYCLO	2000. KW	2	2	2

	MAIN ENG	SEC ENG	SS ENG
ENG SELECT IND	GIVEN		GIVEN
ENG MODEL IND	GE-LM2500-21		DDA-501-K17
ENG TYPE IND	GT		GT
ENG SIZE IND	GIVEN		GIVEN
NO INSTALLED	4	0	1
ENG PWR AVAIL, HP	21500.		3800.
ENG RPM	3600.0		13820.0
ENG SFC, LBM/HP-HR	0.410		.545
ENG LOAD FRAC	0.967		1.114

PRINTED REPORT NO. 12 - POWERING - PDSS

SUSTN SPEED IND-GIVEN
 ENDUR SPEED IND-GIVEN
 TRANS EFF IND-CALC

100 PCT POWER TRANS EFF 0.9781*
 25 PCT POWER TRANS EFF 0.9643*

* VALUES DO NOT INCLUDE CP PROP TRANSMISSION EFFICIENCY MULTIPLIER

	MAX SPEED	SUSTN SPEED	ENDUR SPEED
SHIP SPEED, KT	31.50	30.00	20.00
PROP RPM	163.9	153.8	99.5
NO OP PROP SHAFTS	2	2	2
EHP (/SHAFT), HP	25886.	20738.	5234.
PROPULSIVE COEF	0.677	0.680	0.682
ENDUR PWR ALW	1.0	1.0	1.1
SHP (/SHAFT), HP	38232.	30515.	8436.
TRANS EFFY	0.978	0.976	0.964
CP PROP TRANS EFFY MULT	0.997	0.997	0.997
PROPUL PWR (/SHAFT), HP	39204.	31363.	8774.
PD GEN PWR (/SHAFT), HP	2390.	2378.	1321.
BHP (/SHAFT), HP	41594.	33741.	10096.

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - PDSS

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	96.5	391.07	1.93
162	STACKS AND MASTS	10.6	259.24	60.29
180	FOUNDATIONS			
182	PROPULSION PLANT FOUNDATIONS	176.2	264.11	10.52
183	ELECTRIC PLANT FOUNDATIONS	37.5	310.91	24.52

PRINTED REPORT NO. 14 - PROPULSION PLANT WEIGHT - PDSS

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
200	PROPULSION PLANT	762.7	311.17	20.61
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	84.7	259.02	19.53
233	PROPULSION INTERNAL COMBUSTION ENGINES	0.0	0.00	0.00
234	PROPULSION GAS TURBINES	84.7	259.02	19.53
235	ELECTRIC PROPULSION	0.0	0.00	0.00
240	TRANSMISSION AND PROPULSOR SYSTEMS	391.3	352.79	8.89
241	PROPULSION REDUCTION GEARS	130.3	258.76	14.49
242	PROPULSION CLUTCHES AND COUPLINGS	0.0	0.00	0.00
243	PROPULSION SHAFTING	150.2	395.60	6.34
244	PROPULSION SHAFT BEARINGS	44.8	351.36	8.59
245	PROPULSORS	66.1	441.83	3.87
250	PRPLN SUPPORT SYS (EXCEPT FUEL+LUBE OIL)	194.6	262.79	48.99
251	COMBUSTION AIR SYSTEM	48.6	259.57	44.24
252	PROPULSION CONTROL SYSTEM	21.0	259.02	27.30
256	CIRCULATING AND COOLING SEA WATER SYSTEM	9.4	333.27	15.12
259	UPTAKES (INNER CASING)	115.5	259.09	57.69
260	PRPLN SUPPORT SYS (FUEL+LUBE OIL)	42.6	252.29	13.23
261	FUEL SERVICE SYSTEM	9.4	232.57	13.53
262	MAIN PROPULSION LUBE OIL SYSTEM	23.7	259.02	12.00
264	LUBE OIL FILL, TRANSFER, AND PURIF	9.5	255.02	16.00
290	SPECIAL PURPOSE SYSTEMS	49.6	312.07	9.97
298	OPERATING FLUIDS	41.3	317.40	8.00
299	REPAIR PARTS AND SPECIAL TOOLS	8.3	285.66	19.74

PRINTED REPORT NO. 15 - ELECTRIC PLANT WEIGHT - PDSS

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
300	ELECTRIC PLANT	233.9	301.11	29.65
310	ELECTRIC POWER GENERATION	74.4	322.71	26.50
311	SHIP SERVICE POWER GENERATION	64.3	336.08	23.64
313	BATTERIES AND SERVICE FACILITIES	0.0	0.00	0.00
314	POWER CONVERSION EQUIPMENT	10.1	238.05	44.64
320	POWER DISTRIBUTION SYSTEMS	116.6	283.32	29.58
321	SHIP SERVICE POWER CABLE	84.1	280.37	27.00
324	SWITCHGEAR AND PANELS	32.5	290.95	36.24
330	LIGHTING SYSTEM	32.2	278.03	38.17
331	LIGHTING DISTRIBUTION	18.0	280.37	37.80
332	LIGHTING FIXTURES	14.2	275.08	38.64
340	POWER GENERATION SUPPORT SYSTEMS	6.2	429.86	30.26
342	DIESEL SUPPORT SYSTEMS	0.0	0.00	0.00
343	TURBINE SUPPORT SYSTEMS	6.2	429.86	30.26
390	SPECIAL PURPOSE SYSTEMS	4.5	394.53	21.75
398	OPERATING FLUIDS	1.3	336.08	23.64
399	REPAIR PARTS AND SPECIAL TOOLS	3.2	417.91	21.00

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

PRINTED REPORT NO. 18 - MACHINERY SPACE REQUIREMENTS - PDSS

MACHINERY ROOM VOLUME REQUIREMENTS

VOLUME CATEGORY	VOLUME, FT3
SWBS GROUP 200	132015.
PROPULSION POWER GENERATION	57633.
PROPULSION ENGINES	42231.
PROPULSION REDUCTION GEARS AND GENERATORS	15402.
DRIVELINE MACHINERY	0.
REDUCTION AND BEVEL GEARS WITH Z-DRIVE	0.
ELECTRIC PROPULSION MOTORS AND GEARS	0.
REMOTELY-LOCATED THRUST BEARINGS	0.
PROPELLER SHAFT	10732.
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	63649.
PROPULSION LOCAL CONTROL CONSOLES	3518.
CP PROP HYDRAULIC OIL POWER MODULES	4073.
FUEL OIL PUMPS	32681.
LUBE OIL PUMPS	4113.
LUBE OIL PURIFIERS	15093.
ENGINE LUBE OIL CONDITIONERS	1185.
SEAWATER COOLING PUMPS	2986.
SWBS GROUP 100	19316.
ELECTRIC PLANT POWER GENERATION	0.
ELECTRIC PLANT ENGINES	0.
ELECTRIC PLANT GENERATORS AND GEARS	0.
SHIP SERVICE SWITCHBOARDS	18023.
CYCLOCONVERTERS	1292.
SWBS GROUP 500	46946.
AUXILIARY MACHINERY	46946.
AIR CONDITIONING PLANTS	8487.
AUXILIARY BOILERS	6327.
FIRE PUMPS	5044.
DISTILLING PLANTS	15161.
AIR COMPRESSORS	9636.
ROLL FIN PAIRS	0.
SEWAGE PLANTS	2292.

ARRANGEABLE AREA REQUIREMENTS

SSCS	GROUP NAME	FT2	
		HULL/DKHS	DKHS ONLY
3.4X	AUXILIARY MACHINERY DELTA	1558.7	0.0
3.511	SHIP SERVICE POWER GENERATION	2593.1	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	469.0	872.1
4.143	GAS TURBINE ENG EXHAUST	648.6	1168.7

NOTE: * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

ASSET/MONOSC VERSION 3.2 - WEIGHT MODULE - PDSS

PRINTED REPORT NO. 1 - SUMMARY

SWBS	GROUP	WEIGHT		LCG	VCG	RESULTANT ADJ	
		LTON	PER CENT	FT	FT	WT-LTON	VCG-FT
100	HULL STRUCTURE	2748.4	35.0	257.81	26.62	42.2	.18
200	PROP PLANT	762.7	9.7	311.17	20.61		
300	ELECT PLANT	233.9	3.0	301.11	29.65		
400	COMM + SURVEIL	388.6	4.9	201.02	28.06	134.6	.85
500	AUX SYSTEMS	764.8	9.7	290.95	28.09	25.0	.12
600	OUTFIT + FURN	502.6	6.4	264.50	29.72		
700	ARMAMENT	399.8	5.1	238.05	35.21	397.6	1.78
M11	D+B WT MARGIN		0.0	266.36			
D+B KG MARGIN							
L I G H T S F I P		5800.9	73.8	266.36	27.10	599.4	2.92
F00	FULL LOADS	2061.3	26.2	289.55	8.71	328.6	1.01
F10	CREW + EFFECTS	30.2		248.63	31.31		
F20	MISS REL EXPEN	263.6		232.76	27.54		
F30	SHIPS STORES	42.5		285.66	23.48		
F40	FUELS + LUBRIC	1680.6		300.57	5.05		
F50	FRESH WATER	44.3			5.90		
F60	CARGO						
M24	FUTURE GROWTH						
FULL LOAD WT		7862.2	100.0	272.44	22.28	928.0	3.92

ASSET/MONOSC VERSION 3.2 - SEAKEEPING ANALYSIS - PDSS

PRINTED REPORT NO. 1 - SUMMARY

APPENDAGE IND-WITH

FULL LOAD WT, LTON 7862.2

		FULL LOAD

BALES RANK		
RANK OF THE SYNTHESIZED SHIP (ACTUAL DISP)		15.117
RANK OF THE SYNTHESIZED SHIP (NORMALIZED)		4.052
RANK OF THE CLOSEST DATA BASE HULL (NORMALIZED)		3.960
ID NO OF CLOSEST DATA BASE SHIP		20
MCCREIGHT RANK		
RANK OF THE SYNTHESIZED SHIP (ACTUAL SHIP)		14.406
RANK OF THE CLOSEST DATA BASE HULL		14.107
ID NO OF CLOSEST DATA BASE SHIP		12

ASSET/MONOSC VERSION 3.2 - COST ANALYSIS - PDSS

PRINTED REPORT NO. 1 - SUMMARY

YEAR \$	1992.	NO OF SHIPS ACQUIRED	50.
INFLATION ESCALATION FAC	2.149	SERVICE LIFE, YR	30.0
LEARNING RATE	0.970	ANNUAL OPERATING HRS	2500.0
FUEL COST, \$/GAL	2.579	MILITARY P/L, LTON	1182.7
PAYLOAD FUEL RATE, LTON/HR	0.33	LIGHTSHIP WT, LTON	5800.9
SHIP FUEL RATE, LTON/HR	5.06	FULL LOAD WT, LTON	7862.3

COST ITEM	COSTS(MILLIONS OF DOLLARS)		
	TOT SHIP	+ PAYLOAD	= TOTAL
LEAD SHIP	1128.8	807.0*	1935.8
FOLLOW SHIP	522.3	710.4*	1232.7
AVG ACQUISITION COST/SHIP(50 SHIPS)	467.9	712.3*	1180.2
LIFE CYCLE COST/SHIP(30 YEARS)			3508.1
TOTAL LIFE CYCLE COST(30 YEARS)			175402.7
DISCOUNTED LIFE CYCLE COST/SHIP			443.0**
DISCOUNTED TOTAL LIFE CYCLE COST			22152.4**

*ESTIMATED VALUE
 **DISCOUNTED AT 10 PERCENT

PRINTED REPORT NO. 2 - UNIT ACQUISITION COSTS PDSS

SWBS GROUP	UNITS	INPUTS	KN FACTORS	LEAD SHIP COSTS \$K	FOLLOW SHIP COSTS \$K	
100	HULL STRUCTURE	LTON	2748.4	1.00	32967.	30989.
200	PROPULSION PLANT	HP	78408.0	2.35	84445.	79378.
300	ELECTRIC PLANT	LTON	233.9	1.00	23094.	21709.
400	COMMAND+SURVEILLANCE	LTON	388.6	3.15	29134.	27386.
500	AUX SYSTEMS	LTON	764.8	1.53	56038.	52675.
600	OUTFIT+FURNISHINGS	LTON	502.6	1.00	27789.	26121.
700	ARMAMENT	LTON	399.8	1.00	6661.	652.
	MARGIN	LTON	0.0		0.	0.
800	DESIGN+ENGINEERING		26.06	410384.	45346.	
900	CONSTRUCTION SERVICES		4.25	64729.	60845.	
TOTAL CONSTRUCTION COST					735241.	350712.
CONSTRUCTION COST					735241.	350712.
PROFIT(15.0 PERCENT OF CONSTRUCTION COST)					110286.	52607.
PRICE					845527.	403318.
CHANGE ORDERS(12/8 PERCENT OF PRICE)					101463.	32265.
NAVSEA SUPPORT(2.5 PERCENT OF PRICE)					21138.	10083.
POST DELIVERY CHARGES(5 PERCENT OF PRICE)					42276.	20166.
OUTFITTING(4 PERCENT OF PRICE)					33821.	16133.
H/M/E + GROWTH(10 PERCENT OF PRICE)					84553.	40332.
TOTAL SHIP COST					1128778.	522297.
ESTIMATED PAYLOAD COST					806991.	710373.
SHIP PLUS PAYLOAD COST					1935769.	1232670.
ADJUSTED FIRST UNIT SHIP COST, \$Y		555635.3				
COMBAT SYSTEM WEIGHT, LTON		1182.7				
PROPULSION SYSTEM WEIGHT, LTON		762.8				
ADJUSTED FIRST UNIT SHIP COST EQUALS						
FOLLOW SHIP TOTAL COST DIVIDED BY		0.940				

ICR: 4-WR-21 ICR Gas Turbine Propulsion Engines (19894 hp)
 2-Locked Train Double Reduction Gears
 2-Controllable-Reversible Pitch Propellers (17', .73EAR)
 2-Strut-Supported Open Shafts
 2-Spade Rudders
 Transom Stern
 6000 N.Mile Range
 1-501K17 Separate SSTG Set (3000 kw)
 2-VSCF Propulsion Derived Ship Service Systems (2000 kw)

This machinery option is available in the ASSET Machinery Module and is a modification to "PDSS". The LM2500 simple-cycle propulsion gas turbines are replaced by intercooled recuperated gas turbines in the preceding ship. The PDSS system remains.

In ASSET the user can select one of two intercooled recuperated gas turbine engines in the engine library. As an alternative the user can create an engine based on "OTHER" data.

The "OTHER" option is used to describe the WR-21 ICR engine being developed. The data used are the best available from NSWC Code 808. The specific fuel consumption (SFC) data used describe operation of the engine along a cubic load line. An algorithm, of the ASSET "POLY X" type, is developed based on the data.

This algorithm is used directly with electrical transmissions allowing engine speed optimization through frequency control. It is modified (by adjusting the design point SFC) to correctly model the split-plant operation of this mechanical transmission.

This propulsion machinery is specified by modifying the "REFDD" as follows:

MAIN ENG MODEL IND	= OTHER	
MAIN ENG TYPE IND	= RGT	
MAIN ENG PWR AVAIL	= 26400.0	HP
MAIN ENG RPM	= 3600.00	RPM
MAIN ENG MASS FL	= 131.600	LBM/SEC
MAIN ENG EXH TEMP	= 655.000	DEGF
MAIN ENG BARE WT	= 5.57000	LTON
MAIN ENG DIM ARRAY	= (3X 1)	FT
	1 15.65	
	2 5.200	
	3 5.200	
MAIN ENG SFC EQN IND	= POLY X	
MAIN ENG SFC	= 0.396000	LBM/HP-HR
MAIN ENG SFC FAC ARRAY	= (11X 1)	
	1 -.2133E-02	
	2 0.3693	
	3 2.580	
	4 0.6332	
	5 1.840	
	6-11 0.0000E+00	

The electric plant is specified identically to "PDSS".

I) ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 3/22/93 15.05.45.
GRAPHIC DISPLAY NO. 1 - SHIP MACHINERY LAYOUT

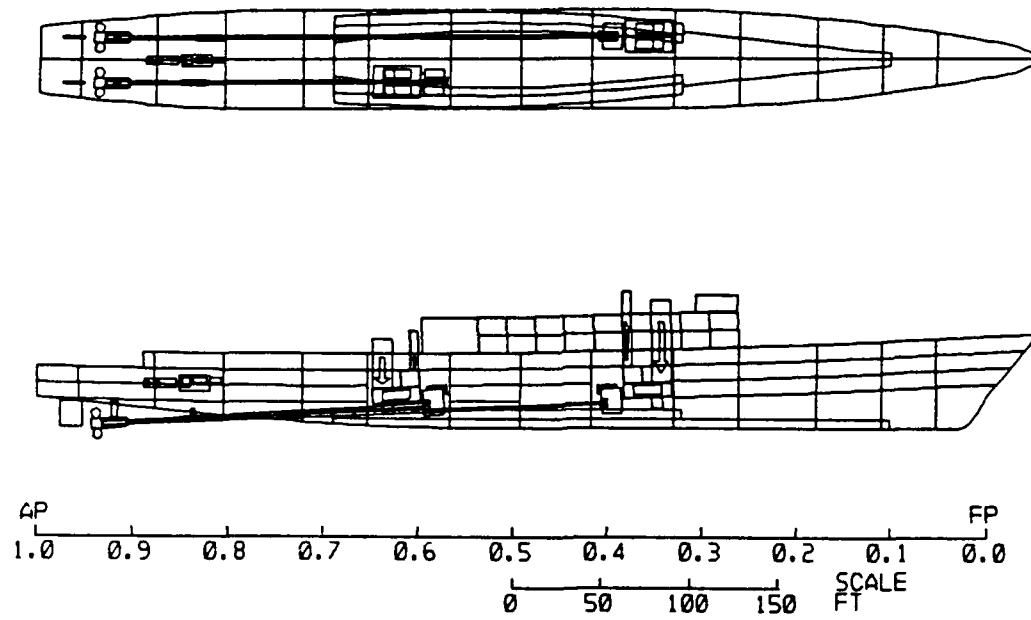


Fig. B.9. "ICR" Machinery Arrangement

B-44

I) ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 3/22/93 15.05.45.
GRAPHIC DISPLAY NO. 2 - MACHINERY BOX

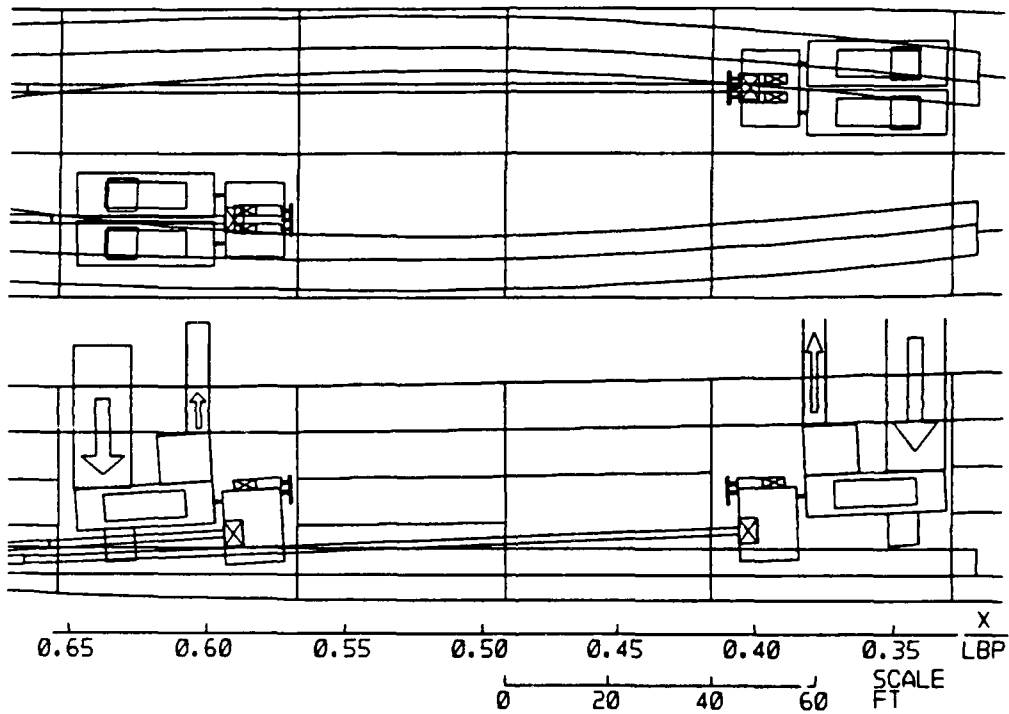


Fig. B.10. "ICR" Machinery Box

B-45

I)

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 3/22/93 15.05.45.
GRAPHIC DISPLAY NO. 3 - MR PLAN VIEWS (MMR1)
PAGE 1 OF 5

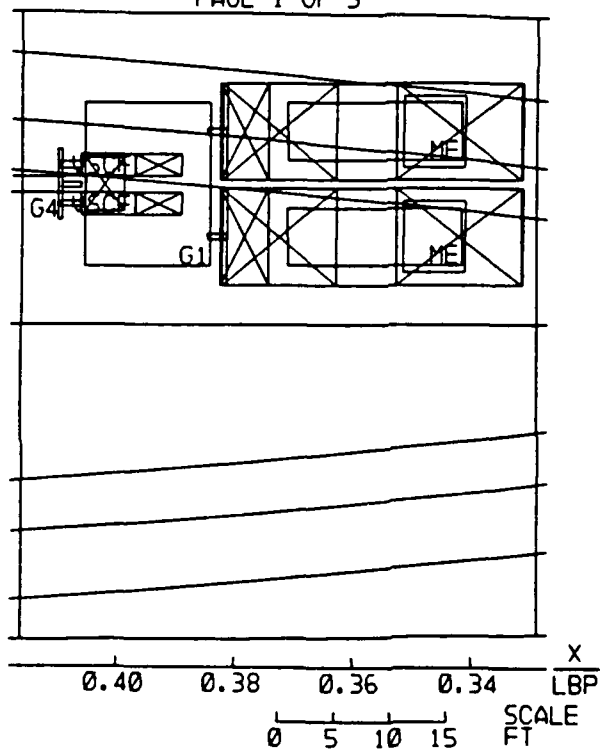


Fig. B.11. "ICR" Main Machinery Room Plan View

ASSET/MONOSC VERSION 3.2 - DESIGN SUMMARY - ICR

PRINTED REPORT NO. 1 - SUMMARY **

PRINCIPAL CHARACTERISTICS - FT				WEIGHT SUMMARY - LTON	
LBP			529.0	GROUP 1 - HULL STRUCTURE	2793.5
LOA			557.1	GROUP 2 - PROP PLANT	828.6
BEAM, DWL			56.0	GROUP 3 - ELECT PLANT	234.1
BEAM, WEATHER DECK			56.0	GROUP 4 - COMM + SURVEIL	388.7
DEPTH @ STA 10			42.0	GROUP 5 - AUX SYSTEMS	754.3
DRAFT TO KEEL DWL			17.8	GROUP 6 - OUTFIT + FURN	499.2
DRAFT TO KEEL LWL			17.8	GROUP 7 - ARMAMENT	399.8
FREEBOARD @ STA 3			33.8	-----	
GMT			4.2	SUM GROUPS 1-7	5898.3
CP			0.576	DESIGN MARGIN	0.0
CK			0.836	-----	
SPEED(KT): MAX= 31.5 SUST= 30.0				LIGHTSHIP WEIGHT	5898.3
ENDURANCE: 6000.0 NM AT 20.0 KTS				LOADS	1608.5
TRANSMISSION TYPE: MECH				-----	
MAIN ENG: 4 RGT @ 19894.0 HP				FULL LOAD DISPLACEMENT	7506.9
SHAFT POWER/SHAFT: 36497.8 HP				FULL LOAD KG: FT	22.6
PROPELLERS: 2 - CP - 17.0 FT DIA				-----	
SEP GEN: 1 GT @ 3000.0 KW				MILITARY PAYLOAD WT - LTON	1182.7
PD GEN: 2 VSCF @ 2000.0 KW				USABLE FUEL WT - LTON	1087.9
24 HR LOAD 1812.5				-----	
MAX MARG ELECT LOAD 3606.2				AREA SUMMARY - FT2	
MANNING				HULL AREA	57180.5
OFF	CPO	ENL	TOTAL	SUPERSTRUCTURE AREA	15816.2
22	19	229	270	-----	
ACCOM	25	21	252	TOTAL AREA	72996.8
			298	-----	
				VOLUME SUMMARY - FT3	
				HULL VOLUME	842304.4
				SUPERSTRUCTURE VOLUME	162796.4

				TOTAL VOLUME	1005100.9

** MAIN ENG REQUIRED POWER IS REPORTED

ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - ICR

PRINTED REPORT NO. 1 - HULL GEOMETRY SUMMARY

HULL OFFSETS IND-GENERATE	MIN BEAM, FT	30.00
HULL DIM IND 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-CONV DD		

HULL PRINCIPAL DIMENSIONS (ON DWL)

LBP, FT	529.00	PRISMATIC COEF	0.576
LOA, FT	557.06	MAX SECTION COEF	0.836
BEAM, FT	56.00	WATERPLANE COEF	0.734
BEAM @ WEATHER DECK, FT	56.00	LCB/LCP	0.515
DRAFT, FT	17.81	HALF SIDING WIDTH, FT	1.00
DEPTH STA 0, FT	51.59	BOT RAKE, FT	0.00
DEPTH STA 3, FT	47.58	RAISED DECK HT, FT	9.00
DEPTH STA 10, FT	42.00	RAISED DECK FWD LIM, STA	
DEPTH STA 20, FT	34.06	RAISED DECK AFT LIM, STA	17.77
FREEBOARD @ STA 3, FT	33.77	BARE HULL DISPL, LTON	7260.98
STABILITY BEAM, FT	56.02	AREA BEAM, FT	49.59

BARE HULL DATA ON LWL

STABILITY DATA ON LWL

LGTH ON WL, FT	529.00	KB, FT	10.55
BEAM, FT	56.00	BMT, FT	16.38
DRAFT, FT	17.81	KG, FT	22.65
FREEBOARD @ STA 3, FT	33.77	FREE SURF COR, FT	0.10
PRISMATIC COEF	0.576	SERV LIFE KG ALW, FT	0.00
MAX SECTION COEF	0.836		
WATERPLANE COEF	0.737	GMT, FT	4.19
WATERPLANE AREA, FT2	21844.76	GML, FT	1294.95
WETTED SURFACE, FT2	30376.07	GMT/B AVAIL	0.075
		GMT/B REQ	0.075
BARE HULL DISPL, LTON	7265.12		
APPENDAGE DISPL, LTON	241.74		
FULL LOAD WT, LTON	7506.87		

ASSET/MONOSC VERSION 3.2 - SPACE MODULE - ICR

PRINTED REPORT NO. 1 - SUMMARY

COLL PROTECT SYS-NONE	SONAR DOME-PRESENT	UNIT COMMANDER-NONE	
FULL LOAD WT, LTON	7506.9	HAB STANDARD FAC	0.260
TOTAL CREW ACC	298.	PASSWAY MARGIN FAC	0.000
HULL AVG DECK HT, FT	9.94	AC MARGIN FAC	0.000
MR VOLUME, FT3	184938.	SPACE MARGIN FAC	0.000

	AREA FT2		VOL FT3	
	PAYLOAD REQUIRED	TOTAL REQUIRED	TOTAL AVAILABLE	TOTAL ACTUAL
DKHS ONLY	5874.0	11445.8	15816.2	162796.
HULL OR DKHS	15757.0	61550.9	57180.5	842304.
TOTAL	21631.0	72996.7	72996.8	1005101.

SSCS	GROUP	TOTAL AREA FT2	DKHS AREA FT2	PERCENT TOTAL AREA
1.	MISSION SUPPORT	23297.1	6581.1	31.9
2.	HUMAN SUPPORT	18836.7	886.0	25.8
3.	SHIP SUPPORT	27860.3	2996.0	38.2
4.	SHIP MOBILITY SYSTEM	3002.6	982.7	4.1
5.	UNASSIGNED			0.0
	TOTAL	72996.7	11445.8	100.0

ASSET/MONOSC VERSION 3.2 - RESISTANCE MODULE - ICR

PRINTED REPORT NO. 1 - SUMMARY

RESID RESIST IND	REGR	BILGE KEEL IND	NONE
FRICTION LINE IND	ITTC	SHAFT SUPPORT TYPE IND	OPEN STRUT
ENDUR DISP IND	FULL LOAD	PRPLN SYS RESIST IND	CALC
ENDUR CONFIG IND	NO TS	PROP TYPE IND	CP
SONAR DRAG IND	APPENDAGE	SONAR DOME IND	PRESENT
SKEG IND	PRESENT	RUDDER TYPE IND	SPADE
FULL LOAD WT, LTON	7506.9	CORR ALW	0.00050
AVG ENDUR DISP, LTON	7506.9	DRAG MARGIN FAC	0.110
USABLE FUEL WT, LTON	1087.9	TRAILSHAFT PWR FAC	
NO FIN PAIRS	0.	PRPLN SYS RESIST FRAC	
PROP TIP CLEAR RATIO	0.19	MAX SPEED	0.204
NO PROP SHAFTS	2.	SUSTN SPEED	0.227
PROP DIA, FT	17.00	ENDUR SPEED	0.376
CONDITION SPEED-----	EFFECTIVE HORSEPOWER, HP-----		
KT	FRIC	RESID	APPDG WIND MARGIN TOTAL DRAG
			LBF
MAX	31.54	15680.	19457. 8913. 582. 4910. 49543. 511871.
SUSTN	30.00	13553.	13902. 7771. 501. 3930. 39658. 430775.
ENDUR	20.00	4163.	1448. 3394. 148. 1007. 10161. 165561.

ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE - ICR

PRINTED REPORT NO. 1 - SUMMARY

HULL SUBDIV IND-GIVEN	INNER BOT IND-PRESENT		
SHAFT SUPPORT TYPE IND-OPEN STRUT			
LBP, FT	529.00	HULL AVG DECK HT, FT	9.94
DEPTH STA 10, FT	42.00		
		NO INTERNAL DECKS	3
HULL VOLUME, FT3	842301.	NO TRANS BHDS	13
MR VOLUME, FT3	184938.	NO LONG BHDS	0
TANKAGE VOL REQ, FT3	54469.	NO MACHY RMS	5
EXCESS TANKAGE, FT3	50789.	NO PROP SHAFTS	2
ARR AREA LOST TANKS, FT2	61.0		
HULL ARR AREA AVAIL, FT2	57180.7		

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - ICR

PRINTED REPORT NO. 1 - SUMMARY

TRANS TYPE IND	MECH	MAX SPEED, KT	31.54
ELECT PRPLN TYPE IND		SUSTN SPEED IND	GIVEN
SHAFT SUPPORT TYPE IND OPEN STRUT		SUSTN SPEED, KT	30.00
NO PROP SHAFTS	2.	ENDUR SPEED IND	GIVEN
ENDUR CONFIG IND	NO TS	ENDUR SPEED, KT	20.00
SEC ENG USAGE IND		DESIGN MODE IND	ENDURANCE
MAX MARG ELECT LOAD, KW	3606.	ENDURANCE, NM	6000.
AVG 24 HR ELECT LOAD, KW	1812.	USABLE FUEL WT, LTON	1087.9
SWBS 200 GROUP WT, LTON	828.6		
SWBS 300 GROUP WT, LTON	234.1		

ARRANGEMENT OR SS GEN	TYPE	NO INSTALLED	NO ONLINE MAX*SUSTN	NO ONLINE ENDURANCE
MECH PORT ARR IND	M2-LTDR	1	1	1
MECH STBD ARR IND	M2-LTDR/F	1	1	1
SEP SS GEN	3000. KW	1	0	0
VSCF SS CYCLO	2000. KW	2	2	2

	MAIN ENG	SEC ENG	SS ENG
ENG SELECT IND	GIVEN		GIVEN
ENG MODEL IND	OTHER		DDA-501-K17
ENG TYPE IND	RGT		GT
ENG SIZE IND	GIVEN		GIVEN
NO INSTALLED	4	0	1
ENG PWR AVAIL, HP	26400.		3800.
ENG RPM	3600.0		13820.0
ENG SFC, LBM/HP-HR	0.396		.545
ENG LOAD FRAC	0.754		1.114

PRINTED REPORT NO. 12 - POWERING - ICR

SUSTN SPEED IND-GIVEN
 ENDUR SPEED IND-GIVEN
 TRANS EFF IND-CALC

100 PCT POWER TRANS EFF 0.9781*
 25 PCT POWER TRANS EFF 0.9643*

* VALUES DO NOT INCLUDE CP PROP TRANSMISSION EFFICIENCY MULTIPLIER

	MAX SPEED	SUSTN SPEED	ENDUR SPEED
SHIP SPEED, KT	31.54	30.00	20.00
PROP RPM	162.6	152.5	99 0
NO OP PROP SHAFTS	2	2	2
EHP (/SHAFT), HP	24771.	19829.	5081.
PROPULSIVE COEF	0.679	0.681	0.683
ENDUR PWR ALW	1.0	1.0	1.1
SHP (/SHAFT), HP	36494.	29128.	8187.
TRANS EFFY	0.978	0.976	0.964
CP PROP TRANS EFFY MULT	0.997	0.997	0.997
PROPUL PWR (/SHAFT), HP	37423.	29938.	8516.
PD GEN PWR (/SHAFT), HP	2365.	2353.	1308.
BHP (/SHAFT), HP	39788.	32292.	9824.

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - ICR

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	92.2	390.97	9.64
162	STACKS AND MASTS	7.4	259.66	58.80
180	FOUNDATIONS			
182	PROPULSION PLANT FOUNDATIONS	258.9	263.59	12.50
183	ELECTRIC PLANT FOUNDATIONS	37.5	310.89	24.52

PRINTED REPORT NO. 14 - PROPULSION PLANT WEIGHT - ICR

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
-----	-----	-----	-----	-----
200	PROPULSION PLANT	828.6	305.79	18.08
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	216.9	259.09	22.29
233	PROPULSION INTERNAL COMBUSTION ENGINES	0.0	0.00	0.00
234	PROPULSION GAS TURBINES	216.9	259.09	22.29
235	ELECTRIC PROPULSION	0.0	0.00	0.00
240	TRANSMISSION AND PROPULSOR SYSTEMS	380.4	353.98	8.90
241	PROPULSION REDUCTION GEARS	125.8	258.69	14.60
242	PROPULSION CLUTCHES AND COUPLINGS	0.0	0.00	0.00
243	PROPULSION SHAFTING	146.3	396.03	6.37
244	PROPULSION SHAFT BEARINGS	43.1	353.41	8.56
245	PROPULSORS	65.3	443.64	3.81
250	PRPLN SUPPORT SYS (EXCEPT FUEL+LUBE OIL)	138.3	260.94	41.00
251	COMBUSTION AIR SYSTEM	48.3	253.55	41.07
252	PROPULSION CONTROL SYSTEM	20.1	259.09	27.30
256	CIRCULATING AND COOLING SEA WATER SYSTEM	12.3	333.27	15.12
259	UPTAKES (INNER CASING)	57.7	252.42	51.20
260	PRPLN SUPPORT SYS (FUEL+LUBE OIL)	43.6	252.50	13.82
261	FUEL SERVICE SYSTEM	9.4	232.64	16.29
262	MAIN PROPULSION LUBE OIL SYSTEM	24.5	259.09	12.00
264	LUBE OIL FILL, TRANSFER, AND PURIF	9.8	255.09	16.00
290	SPECIAL PURPOSE SYSTEMS	49.3	312.28	9.89
298	OPERATING FLUIDS	41.3	317.40	8.00
299	REPAIR PARTS AND SPECIAL TOOLS	8.0	285.66	19.74

PRINTED REPORT NO. 15 - ELECTRIC PLANT WEIGHT - ICR

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
-----	-----	-----	-----	-----
300	ELECTRIC PLANT	234.1	301.07	29.64
310	ELECTRIC POWER GENERATION	74.4	322.67	26.51
311	SHIP SERVICE POWER GENERATION	64.3	336.03	23.65
313	BATTERIES AND SERVICE FACILITIES	0.0	0.00	0.00
314	POWER CONVERSION EQUIPMENT	10.1	238.05	44.65
320	POWER DISTRIBUTION SYSTEMS	116.9	283.29	29.55
321	SHIP SERVICE POWER CABLE	84.7	280.37	27.00
324	SWITCHGEAR AND PANELS	32.3	290.95	36.25
330	LIGHTING SYSTEM	32.1	278.05	38.17
331	LIGHTING DISTRIBUTION	18.1	280.37	37.80
332	LIGHTING FIXTURES	14.1	275.08	38.64
340	POWER GENERATION SUPPORT SYSTEMS	6.2	429.86	30.26
342	DIESEL SUPPORT SYSTEMS	0.0	0.00	0.00
343	TURBINE SUPPORT SYSTEMS	6.2	429.86	30.26
390	SPECIAL PURPOSE SYSTEMS	4.5	394.52	21.76
398	OPERATING FLUIDS	1.3	336.03	23.65
399	REPAIR PARTS AND SPECIAL TOOLS	3.2	417.91	21.00

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

PRINTED REPORT NO. 18 - MACHINERY SPACE REQUIREMENTS - ICR

MACHINERY ROOM VOLUME REQUIREMENTS

VOLUME CATEGORY	VOLUME, FT3
SWBS GROUP 200	132186.
PROPULSION POWER GENERATION	57464.
PROPULSION ENGINES	42236.
PROPULSION REDUCTION GEARS AND GENERATORS	15228.
DRIVELINE MACHINERY	0.
REDUCTION AND BEVEL GEARS WITH Z-DRIVE	0.
ELECTRIC PROPULSION MOTORS AND GEARS	0.
REMOTELY-LOCATED THRUST BEARINGS	0.
PROPELLER SHAFT	10969.
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	63753.
PROPULSION LOCAL CONTROL CONSOLES	3500.
CP PROP HYDRAULIC OIL POWER MODULES	3943.
FUEL OIL PUMPS	32515.
LUBE OIL PUMPS	4168.
LUBE OIL PURIFIERS	15017.
ENGINE LUBE OIL CONDITIONERS	1179.
SEAWATER COOLING PUMPS	3432.
SWBS GROUP 300	19140.
ELECTRIC PLANT POWER GENERATION	0.
ELECTRIC PLANT ENGINES	0.
ELECTRIC PLANT GENERATORS AND GEARS	0.
SHIP SERVICE SWITCHBOARDS	17854.
CYCLOCONVERTERS	1286.
SWBS GROUP 500	46563.
AUXILIARY MACHINERY	46563.
AIR CONDITIONING PLANTS	8381.
AUXILIARY BOILERS	6295.
FIRE PUMPS	4984.
DISTILLING PLANTS	15084.
AIR COMPRESSORS	9539.
ROLL FIN PAIRS	0.
SEWAGE PLANTS	2281.

ARRANGEABLE AREA REQUIREMENTS

SSCS	GROUP NAME	-----FT2-----	
		HULL/DKHS	DKHS ONLY
3.4X	AUXILIARY MACHINERY DELTA	1303.1	0.0
3.511	SHIP SERVICE POWER GENERATION	2593.1	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	498.5	465.6
4.143	GAS TURBINE ENG EXHAUST	581.4	517.1

NOTE: * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

ASSET/MONOSC VERSION 3.2 - WEIGHT MODULE - ICR

PRINTED REPORT NO. 1 - SUMMARY

SWBS	GROUP	WEIGHT		LCG	VCG	RESULTANT ADJ	
		LTON	PER CENT	FT	FT	WT-LTON	VCG-FT
100	HULL STRUCTURE	2793.5	37.2	257.08	25.77	42.2	.18
200	PROP PLANT	828.6	11.0	305.79	18.08		
300	ELECT PLANT	234.1	3.1	301.07	29.64		
400	COMM + SURVEIL	388.7	5.2	201.02	27.99	134.6	.89
500	AUX SYSTEMS	754.3	10.0	290.95	27.81	25.0	.12
600	OUTFIT + FURN	499.2	6.6	264.50	28.82		
700	ARMAMENT	399.8	5.3	238.05	35.21	397.6	1.86
M11	D*B WT MARGIN		0.0	265.64			

D*B KG MARGIN

L I G H T S H I P							
		5898.3	78.6	265.64	26.15	599.4	3.06
F00	FULL LOADS	1608.5	21.4	297.34	9.81	328.6	1.05
F10	CREW + EFFECTS	30.2		248.63	31.31		
F20	MISS REL EXPEN	263.6		232.76	27.54		
F30	SHIPS STORES	42.5		285.66	23.48		
F40	FUELS + LUBRIC	1227.8		314.85	5.14		
F50	FRESH WATER	44.3			5.90		
F60	CARGO						
M24	FUTURE GROWTH						
FULL LOAD WT		7506.8	100.0	272.44	22.65	928.0	4.11

ASSET/MONOSC VERSION 3.2 - SEAKEEPING ANALYSIS - ICR

PRINTED REPORT NO. 1 - SUMMARY

APPENDAGE IND-WITH

FULL LOAD WT, LTON 7506.8

FULL LOAD

BALES RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL DISP)	14.712
RANK OF THE SYNTHESIZED SHIP (NORMALIZED)	4.731
RANK OF THE CLOSEST DATA BASE HULL (NORMALIZED)	4.580
ID NO OF CLOSEST DATA BASE SHIP	9
MCCREIGHT RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL SHIP)	14.982
RANK OF THE CLOSEST DATA BASE HULL	14.688
ID NO OF CLOSEST DATA BASE SHIP	23
SHIP FUEL RATE	

ASSET/MONOSC VERSION 3.2 - COST ANALYSIS - ICR

PRINTED REPORT NO. 1 - SUMMARY

YEAR \$	1992.	NO OF SHIPS ACQUIRED	50.
INFLATION ESCALATION FAC	2.149	SERVICE LIFE, YR	30.0
LEARNING RATE	0.970	ANNUAL OPERATING HRS	2500.0
FUEL COST, \$/GAL	2.579	MILITARY P/L, LTON	1182.7
PAYLOAD FUEL RATE, LTON/HR	0.33	LIGHTSHIP WT, LTON	5898.3
SHIP FUEL RATE, LTON/HR	3.63	FULL LOAD WT, LTON	7506.9

COST ITEM	COSTS(MILLIONS OF DOLLARS)		
	TOT SHIP + PAYLOAD		TOTAL
LEAD SHIP	1113.3	807.0*	1920.3
FOLLOW SHIP	515.5	710.4*	1225.9
AVG ACQUISITION COST/SHIP(50 SHIPS)	461.8	712.3*	1174.1
LIFE CYCLE COST/SHIP(30 YEARS)			3403.5
TOTAL LIFE CYCLE COST(30 YEARS)			170176.4
DISCOUNTED LIFE CYCLE COST/SHIP			436.7**
DISCOUNTED TOTAL LIFE CYCLE COST			21835.9**

*ESTIMATED VALUE
 **DISCOUNTED AT 10 PERCENT

PRINTED REPORT NO. 2 - UNIT ACQUISITION COSTS - ICR

SWBS GROUP	UNITS	INPUTS	KN FACTORS	LEAD SHIP	FOLLOW SHIP	
				COSTS \$K	COSTS \$K	
100	HULL STRUCTURE	LTON	2793.5	1.00	33384.	31381.
200	PROPULSION PLANT	HP	74846.0	2.35	81331.	76451.
300	ELECTRIC PLANT	LTON	234.1	1.00	23113.	21726.
400	COMMAND*SURVEILLANCE	LTON	388.7	3.15	29142.	27394.
500	AUX SYSTEMS	LTON	754.3	1.53	55434.	52108.
600	OUTFIT*FURNISHINGS	LTON	499.2	1.00	27639.	25981.
700	ARMAMENT	LTON	399.8	1.00	6661.	6261.
	MARGIN	LTON	0.0		0.	0.
800	DESIGN*ENGINEERING			26.06	404452.	44691.
900	CONSTRUCTION SERVICES			4.25	64013.	60172.
TOTAL CONSTRUCTION COST					725170.	346166.
CONSTRUCTION COST					725170.	346166.
PROFIT(15.0 PERCENT OF CONSTRUCTION COST)					108776.	51925.
PRICE					833946.	398091.
CHANGE ORDERS(12/8 PERCENT OF PRICE)					100073.	31847.
NAVSEA SUPPORT(2.5 PERCENT OF PRICE)					20849.	9952.
POST DELIVERY CHARGES(5 PERCENT OF PRICE)					41697.	19905.
OUTFITTING(4 PERCENT OF PRICE)					33358.	15924.
H/M/E + GROWTH(10 PERCENT OF PRICE)					83395.	39809.
TOTAL SHIP COST					1113318.	515527.
ESTIMATED PAYLOAD COST					806991.	710373.
SHIP PLUS PAYLOAD COST					1920309.	1225900.
ADJUSTED FIRST UNIT SHIP COST, \$K				548433.2		
COMBAT SYSTEM WEIGHT, LTON				1182.7		
PROPULSION SYSTEM WEIGHT, LTON				828.6		
ADJUSTED FIRST UNIT SHIP COST EQUALS						
FOLLOW SHIP TOTAL COST DIVIDED BY				0.940		

DIREL: 3-WR-21 ICR Gas Turbine Propulsion Engines (26048 hp)
3-AC Air-cooled Propulsion Generators (28 mw)
2-Direct Drive Air-cooled AC Propulsion Motors (27.2 mw)
2-Fixed Pitch Propellers (17', .73EAR)
2-Strut-Supported Open Shafts
2-Spade Rudders
Transom Stern
6000 N.Mile Range
1-501K17 Separate SSTG Set (3000 kw)
2-VSCF Propulsion Derived Ship Service Systems (4000 kw)

This machinery option is available in the ASSET Machinery Module and is a significant modification of "ICR". The mechanical transmission is replaced by an electrical transmission. Fixed-pitch propellers are directly driven by solid-state controlled, reversible, air-cooled AC motors. The motors are located similarly to the reduction gears and as low as possible to minimize shaft angle. A maximum shaft angle of 3.0 degrees (starboard shaft) results.

The solid-state controls permit the engine to operate along the "cubic load line" and the design point SFC is unmodified. Electrical cross-connect of the two shafts permits three heavily loaded engines to replace the four lighter loaded engines of the preceding ship. Each engine drives an air-cooled propulsion alternator. The propulsion engine-generator sets are rotated 90 degrees so bulkhead spacings are not changed. Two of the engines supply ship service power by driving PDSS alternators through a step-up gear. The solid-state controls permit these PDSS alternators to operate over a 1.5:1 speed range and only one per system is required. The VCSF system rating is increased to 4000 kw so that a single engine provides all propulsion and ship service power at all summer and winter cruise operating conditions.

This propulsion machinery is specified by modifying the "ICR" as follows:

```
PROP TYPE IND           = FP

MAIN ENG SFC            = .3239

TRANS TYPE IND         = ELECT
ELECT PRPLN TYPE IND   = ACC-AC
ELECT PRPLN RATING IND = CALC
AC SYNC ROTOR COOLING IND = AIR
TRANS LINE NODE PT IND = CALC
SWITCHGEAR TYPE IND   = ADV
ELECT PG ARR 1 IND     = M-CG-PG
ELECT PG ARR 2 IND     = M-PG

ELECT DL ARR IND       = MTR
  ELECT PG ARR NO ARRAY = ( 10X 2)
  1 1.000 1.000
  2 0.0000E+00 0.0000E+00
  3 0.0000E+00 0.0000E+00
  4 1.000 0.0000E+00
  5 0.0000E+00 0.0000E+00
  ELECT DL ARR NO ARRAY = ( 10X 2)
  1 0.0000E+00 0.0000E+00
  2 1.000 0.0000E+00
  3 0.0000E+00 1.000
  4 0.0000E+00 0.0000E+00
  5 0.0000E+00 0.0000E+00
  ARR ROT ANGLE ARRAY   = ( 10X 1) DEG
  1 90.00
  2 0.0000E+00
  3 0.0000E+00
  4 90.00
  5 0.0000E+00
  PRPPL MOTOR KG ARRAY = ( 2X 1 )
  1 0.3300
  2 0.3300
```

The electric plant is specified by the following "PDSS" change:

```
VSCF SS CYCLO KW      = 4000.
```

I> ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 3/22/93 15.20.33.
GRAPHIC DISPLAY NO. 1 - SHIP MACHINERY LAYOUT

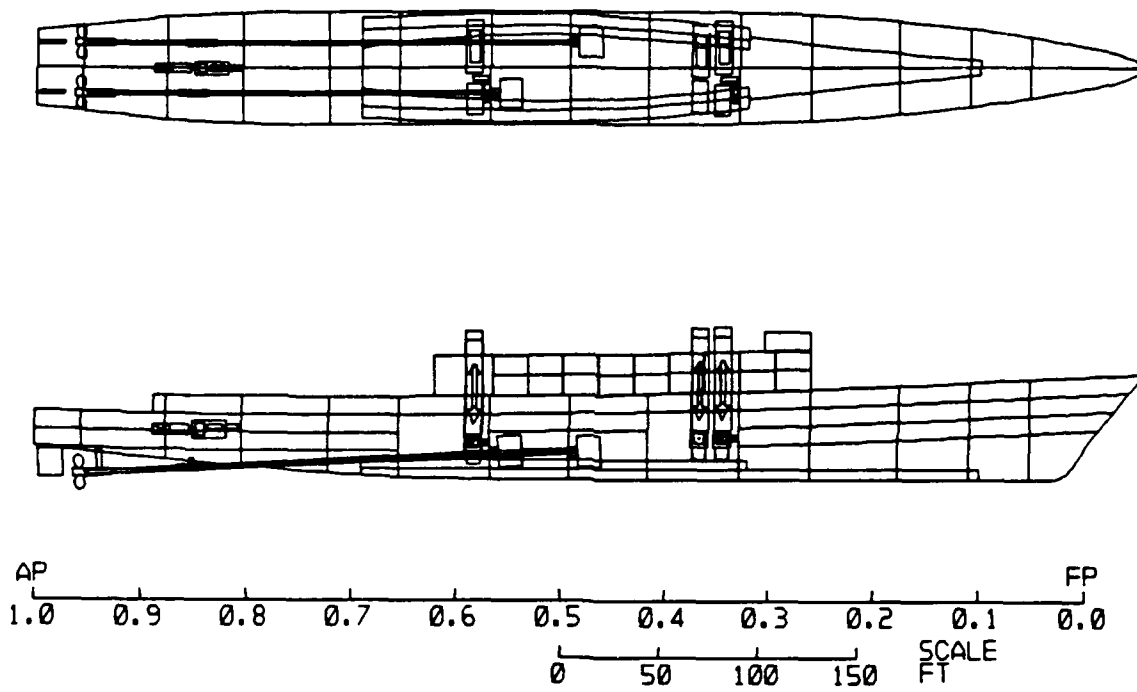


Fig. B.12. "DIREL" Machinery Arrangement

I)
 ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 3/22/93 15.20.33.
 GRAPHIC DISPLAY NO. 2 - MACHINERY BOX

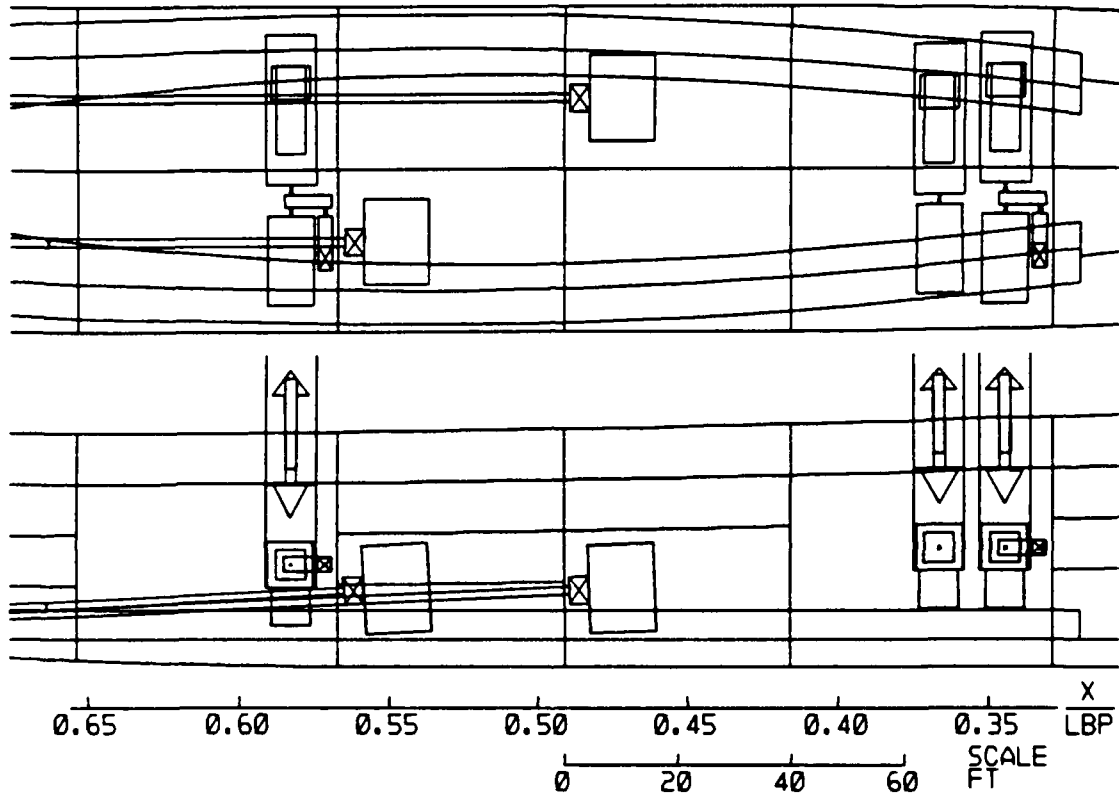


Fig. B.13. "DIREL" Machinery Box

I)

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 3/22/93 15.20.33.
GRAPHIC DISPLAY NO. 3 - MR PLAN VIEWS (MMR1)
PAGE 1 OF 5

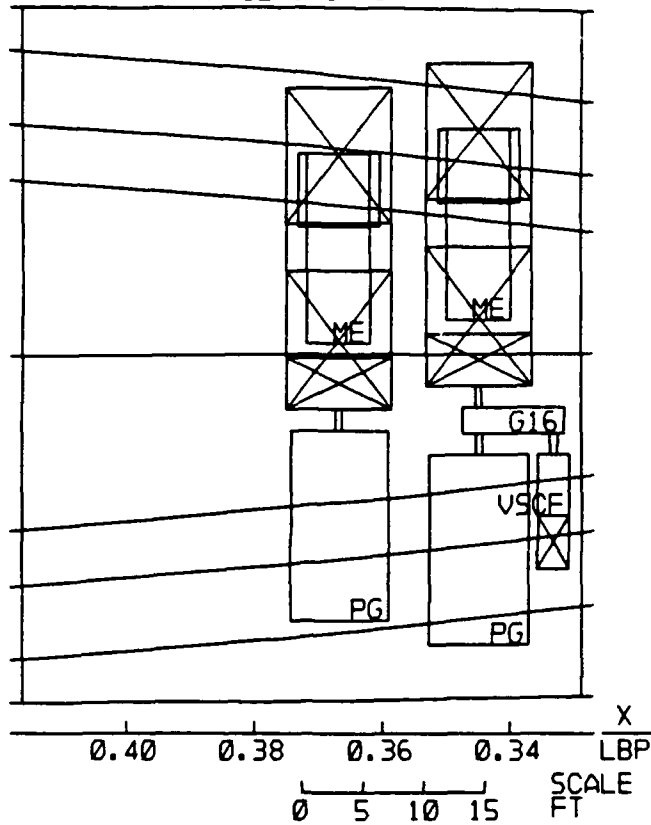


Fig. B.14. "DIREL" Main Machinery Room Plan View

B-59

ASSET/MONOSC VERSION 3.2 - DESIGN SUMMARY - DIREL

PRINTED REPORT NO. 1 - SUMMARY **

PRINCIPAL CHARACTERISTICS - FT
 LBP 529.0
 LOA 557.4
 BEAM, DWL 57.2
 BEAM, WEATHER DECK 57.2
 DEPTH @ STA 10 42.0
 DRAFT TO KEEL DWL 17.4
 DRAFT TO KEEL LWL 17.4
 FREEBOARD @ STA 3 34.2
 GMT 4.3
 CP 0.576
 CX 0.836

SPEED(KT): MAX= 31.5 SUST= 30.0
 ENDURANCE: 6000.0 NM AT 20.0 KTS

TRANSMISSION TYPE: ELECT
 MAIN ENG: 3 RGT @ 26048.0 HP

SHAFT POWER/SHAFT: 34172.4 HP
 PROPELLERS: 2 - FP - 17.0 FT DIA

SEP GEN: 1 GT @ 3000.0 KW
 PD GEN: 2 VSCF @ 4000.0 KW

24 HR LOAD 1839.6
 MAX MARG ELECT LOAD 3679.6

	OFF	CPO	ENL	TOTAL
MANNING	22	19	229	270
ACCOM	25	21	252	298

WEIGHT SUMMARY - LTON
 GROUP 1 - HULL STRUCTURE 2871.4
 GROUP 2 - PROP PLANT 846.9
 GROUP 3 - ELECT PLANT 253.3
 GROUP 4 - COMM + SURVEIL 390.8
 GROUP 5 - AUX SYSTEMS 771.4
 GROUP 6 - OUTFIT + FURN 511.2
 GROUP 7 - ARMAMENT 399.8

 SUM GROUPS 1-7 6044.8
 DESIGN MARGIN 0.0

LIGHTSHIP WEIGHT 6044.8
 LOADS 1422.8

FULL LOAD DISPLACEMENT 7467.6
 FULL LOAD KG: FT 23.4

MILITARY PAYLOAD WT - LTON 1182.7
 USABLE FUEL WT - LTON 921.6

AREA SUMMARY - FT2
 HULL AREA - 58703.8
 SUPERSTRUCTURE AREA - 17534.1

 TOTAL AREA 76237.8

VOLUME SUMMARY - FT3
 HULL VOLUME - 863621.3
 SUPERSTRUCTURE VOLUME - 180507.9

 TOTAL VOLUME 1044129.1

** MAIN ENG REQUIRED POWER IS REPORTED

ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - DIREL

PRINTED REPORT NO. 1 - HULL GEOMETRY SUMMARY

HULL OFFSETS IND-GENERATE	MIN BEAM, FT	30.00
HULL DIM IND-T	M/X 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-CONV DD		

HULL PRINCIPAL DIMENSIONS (ON DWL)

LBP, FT	529.00	PRISMATIC COEF	0.576
LOA, FT	557.42	MAX SECTION COEF	0.836
BEAM, FT	57.15	WATERPLANE COEF	0.754
BEAM @ WEATHER DECK, FT	57.15	LCB/LCP	0.515
DRAFT, FT	17.39	HALF SIDING WIDTH, FT	1.00
DEPTH STA 0, FT	51.59	BOT RAKE, FT	0.00
DEPTH STA 3, FT	47.58	RAISED DECK HT, FT	9.00
DEPTH STA 10, FT	42.00	RAISED DECK FWD LIM, STA	
DEPTH STA 20, FT	34.06	RAISED DECK AFT LIM, STA	17.77
FREEBOARD @ STA 3, FT	34.20	BARE HULL DISPL, LTON	7232.18
STABILITY BEAM, FT	57.10	AREA BEAM, FT	51.65

BARE HULL DATA ON LWL

LGTH ON WL, FT	529.00
BEAM, FT	57.15
DRAFT, FT	17.38
FREEBOARD @ STA 3, FT	34.20
PRISMATIC COEF	0.576
MAX SECTION COEF	0.836
WATERPLANE COEF	0.737
WATERPLANE AREA, FT2	22293.38
WETTED SURFACE, FT2	30497.10
BARE HULL DISPL, LTON	7236.32
APPENDAGE DISPL, LTON	231.27
FULL LOAD WT, LTON	7467.58

STABILITY DATA ON LWL

KB, FT	10.32
BMT, FT	17.50
KG, FT	23.42
FREE SURF COR, FT	0.10
SERV LIFE KG ALW, FT	0.00
GMT, FT	4.31
GML, FT	1327.81
GMT/B AVAIL	0.075
GMT/B REQ	0.075

ASSET/MONOSC VERSION 3.2 - SPACE MODULE - DIREL

PRINTED REPORT NO. 1 - SUMMARY

COLL PROTECT SYS-NONE	SONAR DOME-PRESENT	UNIT COMMANDER-NONE	
FULL LOAD WT, LTON	7467.6	HAB STANDARD FAC	0.260
TOTAL CREW ACC	298	PASSWAY MARGIN FAC	0.000
HULL AVG DECK HT, FT	9.90	AC MARGIN FAC	0.000
MR VOLUME, FT3	189585.	SPACE MARGIN FAC	0.000

	PAYLOAD	AREA FT2	TOTAL	VOL FT3
	REQUIRED	REQUIRED	AVAILABLE	TOTAL
				ACTUAL
DKHS ONLY	5874.0	12171.3	17534.1	180508.
HULL OR DKHS	15757.0	64067.1	58703.8	863621.
TOTAL	21631.0	76238.4	76237.8	1044129.

SSCS	GROUP	TOTAL	DKHS	PERCENT	TOTAL AREA
			AREA FT2	AREA FT2	
1.	MISSION SUPPORT	23347.6	6600.2	30.6	
2.	HUMAN SUPPORT	18836.7	886.0	24.7	
3.	SHIP SUPPORT	30563.0	3211.1	40.1	
4.	SHIP MOBILITY SYSTEM	3491.1	1474.0	4.6	
5.	UNASSIGNED			0.0	
	TOTAL	76238.4	12171.3	100.0	

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ASSET/MONOSC VERSION 3.2 - RESISTANCE MODULE - DIREL

PRINTED REPORT NO. 1 - SUMMARY

RESID RESIST IND	REGR	BILGE KEEL IND	NONE
FRICTION LINE IND	ITTC	SHAFT SUPPORT TYPE IND	OPEN STRUT
ENDUR DISP IND	FULL LOAD	PRPLN SYS RESIST IND	CALC
ENDUR CONFIG IND	NO TS	PROP TYPE IND	FP
SONAR DRAG IND	APPENDAGE	SONAR DOME IND	PRESENT
SKEG IND	PRESENT	RUDDER TYPE IND	SPADE
FULL LOAD WT, LTON	7467.6	CORR ALW	0.00050
AVG ENDUR DISP, LTON	7467.6	DRAG MARGIN FAC	0.110
USABLE FUEL WT, LTON	921.6	TRAILSHAFT PWR FAC	
NO FIN PAIRS	0.	PRPLN SYS RESIST FRAC	
PROP TIP CLEAR RATIO	0.17	MAX SPEED	0.128
NO PROP SHAFTS	2.	SUSTN SPEED	0.142
PROP DIA, FT	17.00	ENDUR SPEED	0.236

CONDITION	SPEED	-----EFFECTIVE HORSEPOWER, HP-----					DRAG	
	KT	FRIC	RESID	APPDG	WIND	MARGIN	TOTAL	LBF
MAX	31.54	15743.	19318.	6247.	602.	4610.	46520.	480639.
SUSTN	30.00	13607.	13826.	5455.	518.	3675.	37081.	402777.
ENDUR	20.00	4180.	1432.	2609.	153.	921.	9296.	151456.

ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE - DIREL

PRINTED REPORT NO. 1 - SUMMARY

HULL SUBDIV IND-GIVEN		INNER BOT IND-PRESENT	
SHAFT SUPPORT TYPE IND-OPEN STRUT			
LBP, FT	529.00	HULL AVG DECK HT, FT	9.90
DEPTH STA 10, FT	42.00		
		NO INTERNAL DECKS	3
HULL VOLUME, FT3	863617.	NO TRANS BEDS	13
MR VOLUME, FT3	189584.	NO LONG BHDS	0
TANKAGE VOL REQ, FT3	46914.	NO MACHY RMS	5
EXCESS TANKAGE, FT3	62346.	NO PROP SHAFTS	2
ARR AREA LOST TANKS, FT2	61.0		
HULL ARR AREA AVAIL, FT2	58703.2		

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - DIREL

PRINTED REPORT NO. 1 - SUMMARY

TRANS TYPE IND	ELECT	MAX SPEED, KT	31.54
ELECT PRPLN TYPE IND	ACC-AC	SUSTN SPEED IND	GIVEN
SHAFT SUPPORT TYPE IND	OPEN STRUT	SUSTN SPEED, KT	30.00
NO PROP SHAFTS	2.	ENDUR SPEED IND	GIVEN
ENDUR CONFIG IND	NO TS	ENDUR SPEED, KT	20.00
SEC ENG USAGE IND		DESIGN MODE IND	ENDURANCE
MAX MARG ELECT LOAD, KW	3680.	ENDURANCE, NM	6000.
AVG 24 HR ELECT LOAD, KW	1840.	USABLE FUEL WT, LTON	921.8
SWBS 200 GROUP WT, LTON	847.2		
SWBS 300 GROUP WT, LTON	253.3		

ARRANGEMENT OR SS GEN	TYPE	NO INSTALLED	NO ONLINE MAX+SUSTN	NO ONLINE ENDURANCE
ELECT PG ARR 1 IND	M-CG-PG	2	2	1
ELECT PG ARR 2 IND	M-PG	1	1	0
ELECT DL ARR IND	MTR	2	2	2
SEP SS GEN	3000. KW	1	0	0
VSCF SS CYCLO	4000. KW	2	2	1

	MAIN ENG	SEC ENG	SS ENG
ENG SELECT IND	GIVEN		GIVEN
ENG MODEL IND	OTHER		DDA-501-K17
ENG TYPE IND	RGT		GT
ENG SIZE IND	GIVEN		GIVEN
NO INSTALLED	3	0	1
ENG PWR AVAIL, HP	26400.		3800.
ENG RPM	3600.0		13820.0
ENG SFC, LBM/HP-HR	0.324		.545
ENG LOAD FRAC	0.987		1.114

PRINTED REPORT NO. 12 - POWERING - DIREL

SUSTN SPEED IND-GIVEN
 ENDUR SPEED IND-GIVEN
 TRANS EFF IND-CALC

100 PCT POWER TRANS EFF	0.9295
25 PCT POWER TRANS EFF	0.8976

	MAX SPEED	SUSTN SPEED	ENDUR SPEED
SHIP SPEED, KT	31.54	30.00	20.00
PROP RPM	160.6	150.6	97.5
NO OP PROP SHAFTS	2	2	2
EHP (/SHAFT), HP	23260.	18540.	4648.
PROPULSIVE COEF	0.681	0.682	0.682
ENDUR PWR ALW	1.0	1.0	1.1
SHP (/SHAFT), HP	34179.	27186.	7493.
TRANS EFFY	0.930	0.924	0.898
CP PROP TRANS EFFY MULT	1.000	1.000	1.000
PROPUL PWR (/SHAFT), HP	36771.	29417.	8348.
PD GEN PWR (/SHAFT), HP	2301.	2304.	1316.
BHP (/SHAFT), HP	39072.	31721.	9664.

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - DIREL

PRINTED REPORT NO. 13 - BULL STRUCTURE AND MISCELLANEOUS WEIGHT

SWBS	COMPONENT	WT, LTON	LCG, FT	VCG, FT
160	SPECIAL STRUCTURES			
161	CASTINGS, FORGINGS, AND WELDMENTS	63.4	355.86	13.25
162	STACKS AND MASTS	5.5	228.20	69.37
180	FOUNDATIONS			
182	PROPULSION PLANT FOUNDATIONS	272.3	248.33	12.71
183	ELECTRIC PLANT FOUNDATIONS	26.1	326.59	24.16

PRINTED REPORT NO. 14 - PROPULSION PLANT WEIGHT - DIREL

SWBS	COMPONENT	WT, LTON	LCG, FT	VCG, FT
200	PROPULSION PLANT	847.2	287.02	18.71
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	461.9	244.63	18.62
233	PROPULSION INTERNAL COMBUSTION ENGINES	0.0	0.00	0.00
234	PROPULSION GAS TURBINES	165.5	228.20	22.74
235	ELECTRIC PROPULSION	296.4	253.81	16.32
240	TRANSMISSION AND PROPULSOR SYSTEMS	214.0	413.85	6.91
241	PROPULSION REDUCTION GEARS	4.2	242.48	19.53
242	PROPULSION CLUTCHES AND COUPLINGS	0.0	0.00	0.00
243	PROPULSION SHAFTING	132.4	406.11	7.19
244	PROPULSION SHAFT BEARINGS	38.5	365.01	9.19
245	PROPULSORS	38.9	506.95	2.29
250	PRPLN SUPPORT SYS (EXCEPT FUEL+LUBE OIL)	114.8	234.88	43.83
251	COMBUSTION AIR SYSTEM	39.0	228.31	44.97
252	PROPULSION CONTROL SYSTEM	20.5	228.20	27.30
256	CIRCULATING AND COOLING SEA WATER SYSTEM	7.2	333.27	15.12
259	UPTAKES (INNER CASING)	48.2	228.37	54.22
260	PRPLN SUPPORT SYS (FUEL+LUBE OIL)	31.1	219.41	14.23
261	FUEL SERVICE SYSTEM	9.4	201.75	16.74
262	MAIN PROPULSION LUBE OIL SYSTEM	15.5	228.20	12.00
264	LUBE OIL FILL, TRANSFER, AND PURIF	6.2	224.20	16.00
290	SPECIAL PURPOSE SYSTEMS	25.4	307.62	11.62
298	OPERATING FLUIDS	17.5	317.40	8.00
299	REPAIR PARTS AND SPECIAL TOOLS	7.8	285.66	19.74

PRINTED REPORT NO. 15 - ELECTRIC PLANT WEIGHT - DIREL

SWBS	COMPONENT	WT, LTON	LCG, FT	VCG, FT
300	ELECTRIC PLANT	253.3	310.19	26.94
310	ELECTRIC POWER GENERATION	89.4	347.26	19.61
311	SHIP SERVICE POWER GENERATION	44.8	361.23	22.75
313	BATTERIES AND SERVICE FACILITIES	34.4	361.23	8.40
314	POWER CONVERSION EQUIPMENT	10.1	238.05	43.75
320	POWER DISTRIBUTION SYSTEMS	121.5	283.24	29.26
321	SHIP SERVICE POWER CABLE	88.6	280.37	27.00
324	SWITCHGEAR AND PANELS	32.9	290.95	35.35
330	LIGHTING SYSTEM	33.1	278.03	38.17
331	LIGHTING DISTRIBUTION	18.4	280.37	37.80
332	LIGHTING FIXTURES	14.6	275.08	38.64
340	POWER GENERATION SUPPORT SYSTEMS	6.2	429.86	30.26
342	DIESEL SUPPORT SYSTEMS	0.0	0.00	0.00
343	TURBINE SUPPORT SYSTEMS	6.2	429.86	30.26
390	SPECIAL PURPOSE SYSTEMS	3.1	401.72	21.50
398	OPERATING FLUIDS	0.9	361.23	22.75
399	REPAIR PARTS AND SPECIAL TOOLS	2.2	417.91	21.00

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

PRINTED REPORT NO. 18 - MACHINERY SPACE REQUIREMENTS - DIREL

MACHINERY ROOM VOLUME REQUIREMENTS

VOLUME CATEGORY	VOLUME, FT3
SWBS GROUP 200	156621.
PROPULSION POWER GENERATION	61663.
PROPULSION ENGINES	38322.
PROPULSION REDUCTION GEARS AND GENERATORS	23340.
DRIVELINE MACHINERY	16500.
REDUCTION AND BEVEL GEARS WITH Z-DRIVE	0.
ELECTRIC PROPULSION MOTORS AND GEARS	16500.
REMOTELY-LOCATED THRUST BEARINGS	0.
PROPELLER SHAFT	10375.
ELECTRIC PROPULSION MISCELLANEOUS EQUIPMENT	14549.
CONTROLS	1861.
BRAKING RESISTORS	1616.
MOTOR AND GENERATOR EXCITERS	3075.
SWITCHGEAR	1725.
POWER CONVERTERS	3241.
DEIONIZED COOLING WATER SYSTEMS	3032.
RECTIFIERS	0.
HELIUM REFRIGERATION SYSTEMS	0.
PROPULSION AUXILIARIES	53533.
PROPULSION LOCAL CONTROL CONSOLES	3488.
CP PROP HYDRAULIC OIL POWER MODULES	0.
FUEL OIL PUMPS	28432.
LUBE OIL PUMPS	3213.
LUBE OIL PURIFIERS	14964.
ENGINE LUBE OIL CONDITIONERS	881.
SEAWATER COOLING PUMPS	2556.
SWBS GROUP 300	19382.
ELECTRIC PLANT POWER GENERATION	0.
ELECTRIC PLANT ENGINES	0.
ELECTRIC PLANT GENERATORS AND GEARS	0.
SHIP SERVICE SWITCHBOARDS	17966.
CYCLOCONVERTERS	1416.
SWBS GROUP 500	46844.
AUXILIARY MACHINERY	46844.
AIR CONDITIONING PLANTS	8543.
AUXILIARY BOILERS	6273.
FIRE PUMPS	5072.
DISTILLING PLANTS	15031.
AIR COMPRESSORS	9652.
ROLL FIN PAIRS	0.
SEWAGE PLANTS	2273.

ARRANGEABLE AREA REQUIREMENTS

SSCS	GROUP NAME	FT2	
		HULL/DKHS	DKHS ONLY
3.4X	AUXILIARY MACHINERY DELTA	3358.9	0.0
3.511	SHIP SERVICE POWER GENERATION	2593.1	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	382.1	698.4
4.143	GAS TURBINE ENG EXHAUST	695.0	775.7

NOTE: * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

ASSET/MONOSC VERSION 3.2 - WEIGHT MODULE - DIREL

PRINTED REPORT NO. 1 - SUMMARY

SWBS	GROUP	WEIGHT		LCG FT	VCG FT	RESULTANT ADJ	
		LTON	PER CENT			WT-LTON	VCG-FT
100	HULL STRUCTURE	2871.4	38.4	254.56	26.37	42.2	.18
200	PROP PLANT	847.2	11.3	287.02	18.71		
300	ELECT PLANT	253.3	3.4	310.19	26.94		
400	COMM + SURVEIL	390.8	5.2	201.02	28.06	134.6	.89
500	AUX SYSTEMS	771.4	10.3	290.95	28.05	25.0	.12
600	OUTFIT + FURN	511.2	6.8	264.50	29.32		
700	ARMAMENT	399.8	5.4	238.05	35.21	397.6	1.87
M11	D+B WT MARGIN		0.0	262.37			
D+B KG MARGIN							
L I G H T S H I P		6045.1	80.9	262.37	26.48	599.4	3.07
F00	FULL LOADS	1423.0	19.1	315.19	10.41	328.6	1.06
F10	CREW + EFFECTS	30.2		248.63	31.31		
F20	MISS REL EXPEN	263.6		232.76	27.54		
F30	SHIPS STORES	42.5		285.66	23.48		
F40	FUELS + LUBRIC	1042.4		342.32	5.13		
F50	FRESH WATER	44.3			5.90		
F60	CARGO						
M24	FUTURE GROWTH						
FULL LOAD WT		7468.1	100.0	272.44	23.41	928.0	4.13

ASSET/MONOSC VERSION 3.2 - SEAKEEPING ANALYSIS - DIREL

PRINTED REPORT NO. 1 - SUMMARY

APPENDAGE IND-WITH

FULL LOAD WT, LTON 7468.1

	FULL LOAD
BALES RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL DISP)	14.899
RANK OF THE SYNTHESIZED SHIP (NORMALIZED)	5.036
RANK OF THE CLOSEST DATA BASE HULL (NORMALIZED)	5.080
ID NO OF CLOSEST DATA BASE SHIP	11
MCCREIGHT RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL SHIP)	15.434
RANK OF THE CLOSEST DATA BASE HULL	15.715
ID NO OF CLOSEST DATA BASE SHIP	14

ASSET/MONOSC VERSION 3.2 - COST ANALYSIS - DIREL

PRINTED REPORT NO. 1 - SUMMARY

YEAR \$	1992.	NO OF SHIPS ACQUIRED	50.
INFLATION ESCALATION FAC	2.149	SERVICE LIFE, YR	30.0
LEARNING RATE	0.970	ANNUAL OPERATING HRS	2500.0
FUEL COST, \$/GAL	2.579	MILITARY P/L, LTON	1182.7
PAYLOAD FUEL RATE, LTON/HR	0.33	LIGHTSHIP WT, LTON	6044.8
SHIP FUEL RATE, LTON/HR	3.07	FULL LOAD WT, LTON	7467.6

COST ITEM	COSTS(MILLIONS OF DOLLARS)		
	TOT SHIP	+ PAYLOAD	= TOTAL
LEAD SHIP	1126.3	807.0*	1933.3
FOLLOW SHIP	521.2	710.4*	1231.6
AVG ACQUISITION COST/SHIP(50 SHIPS)	466.9	712.3*	1179.2
LIFE CYCLE COST/SHIP(30 YEARS)			3373.9
TOTAL LIFE CYCLE COST(30 YEARS)			168697.2
DISCOUNTED LIFE CYCLE COST/SHIP			436.3**
DISCOUNTED TOTAL LIFE CYCLE COST			21817.1**

*ESTIMATED VALUE
 **DISCOUNTED AT 10 PERCENT

PRINTED REPORT NO. 2 - UNIT ACQUISITION COSTS - DIREL

SWBS GROUP	UNITS	INPUTS	KN FACTORS	LEAD SHIP COSTS \$K	FOLLOW SHIP COSTS \$K	
100	HULL STRUCTURE	LTON	2871.4	1.00	34100.	32054.
200	PROPULSION PLANT	HP	73542.0	2.35	80104.	75373.
300	ELECTRIC PLANT	LTON	253.3	1.00	24824.	23334.
400	COMMAND+SURVEILLANCE	LTON	390.8	3.15	29236.	27481.
500	AUX SYSTEMS	LTON	771.4	1.53	56410.	53025.
600	OUTFIT+FURNISHINGS	LTON	511.2	1.00	28162.	26473.
700	ARMAMENT	LTON	399.8	1.00	6662.	6262.
	MARGIN	LTON	0.0		0.	0.
800	DESIGN+ENGINEERING			26.06	409430.	45241.
900	CONSTRUCTION SERVICES			4.25	64614.	60737.

TOTAL CONSTRUCTION COST					733621.	349981.

CONSTRUCTION COST					733621.	349981.
PROFIT(15.0 PERCENT OF CONSTRUCTION COST)					110043.	52497.
PRICE					843664.	402478.

CHANGE ORDERS(12/8 PERCENT OF PRICE)					101240.	32198.
NAVSEA SUPPORT(2.5 PERCENT OF PRICE)					21092.	10062.
POST DELIVERY CHARGES(5 PERCENT OF PRICE)					42183.	20124.
OUTFITTING(4 PERCENT OF PRICE)					33747.	16099.
H/M/E + GROWTH(10 PERCENT OF PRICE)					84366.	40248.
TOTAL SHIP COST					1126291.	521209.

ESTIMATED PAYLOAD COST					806991.	710373.

SHIP PLUS PAYLOAD COST					1933282.	1231581.
ADJUSTED FIRST UNIT SHIP COST, \$K				554477.2		
COMBAT SYSTEM WEIGHT, LTON				1182.7		
PROPULSION SYSTEM WEIGHT, LTON				846.9		
ADJUSTED FIRST UNIT SHIP COST EQUALS						
FOLLOW SHIP TOTAL COST DIVIDED BY				0.940		

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GRELEC: 3-WR-21 ICR Gas Turbine Propulsion Engines (22125 hp)
 3-AC Liquid-cooled Propulsion Generators (28 mw)
 2-Geared AC Liquid-cooled Propulsion Motors (27.2 mw)
 2-Contrarotating Bi-coupled Epicyclic Reduction Gears
 2-Contrarotating Propellers (17', .80EAR)
 2-Strut-Supported Open Contrarotating Shafts
 2-Spade Rudders
 Transom Stern
 6000 N.Mile Range
 1-501K17 Separate SSTG Set (3000 kw)
 2-VSCF Propulsion Derived Ship Service Systems (4000 kw)

The direct drive motors of the preceding ship ("DIREL") are replaced by high-speed liquid-cooled geared motors. Contrarotating propellers are driven through a contrarotating driveline including contrarotating shafting, thrust bearings and contrarotating bicoupled epicyclic reduction gears. The propeller expanded area ratio is increased to .80 (from .73). The air-cooled propulsion generators are replaced by liquid-cooled ones.

The motors are moved lower and a maximum shaft angle of 2.0 degrees (starboard shaft) results.

The machinery is specified by modifying the previous "DIREL" as follows:

	ELECT DL ARR IND	= MTR-BCE
	AC SYNC ROTOR COOLING IND	= LIQUID
	PRPLN MOTOR KG ARRAY	= (2X 1)
1	0.2000	
2	0.2000	
	REL ROTATE EFF	= 1.00000
	PROP TYPE IND	= CR
	PROP SERIES IND	= ANALYTIC2
	EXPAND AREA RATIO	= 0.800000
	BLADE NUMBER ARRAY	= (2X 1)
1	7.000	
2	5.000	
	PROP LOC IND	= CALC
	PROP TIP CLEAR RATIO	= 0.250000
	ANALYTIC2 ADJ FAC ARRAY	= (5X 1)
1	1.000	
2	1.000	
3	1.000	
4	1.000	
5	1.000	
	PITCH RATIO IND	= CALC
	PROP HUB SOLIDITY FAC	= 0.328000

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I>

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 3/22/93 15.32.13.
GRAPHIC DISPLAY NO. 1 - SHIP MACHINERY LAYOUT

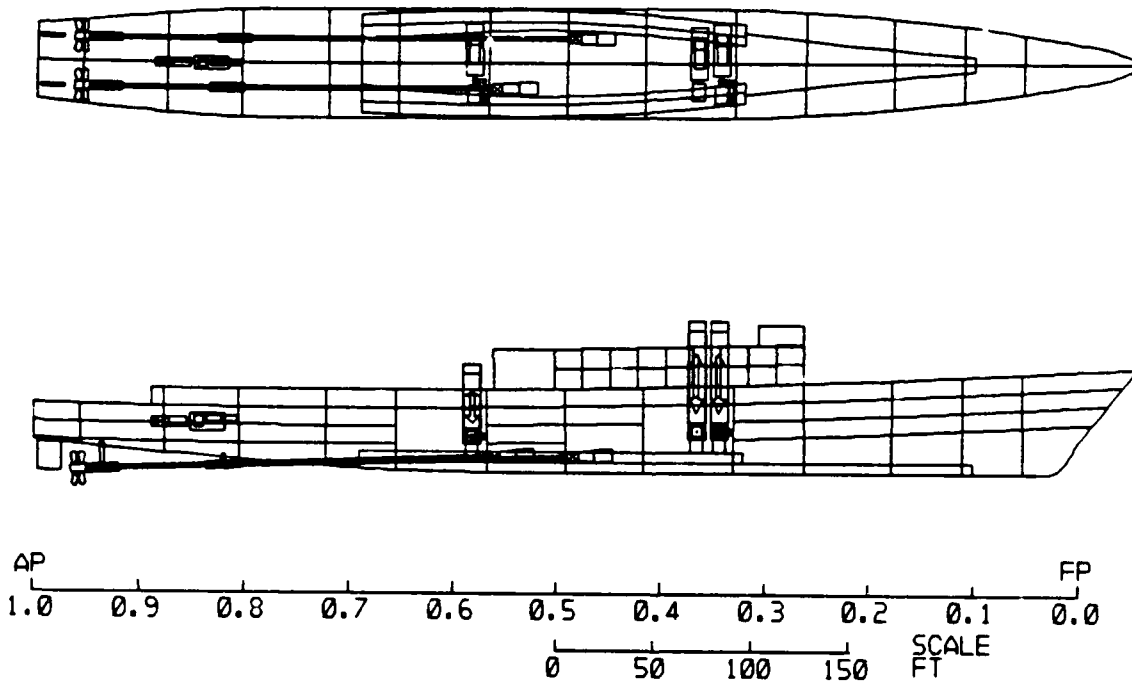


Fig. B.15. "GRELEC" Machinery Arrangement

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I)

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 3/22/93 15.32.13.
GRAPHIC DISPLAY NO. 2 - MACHINERY BOX

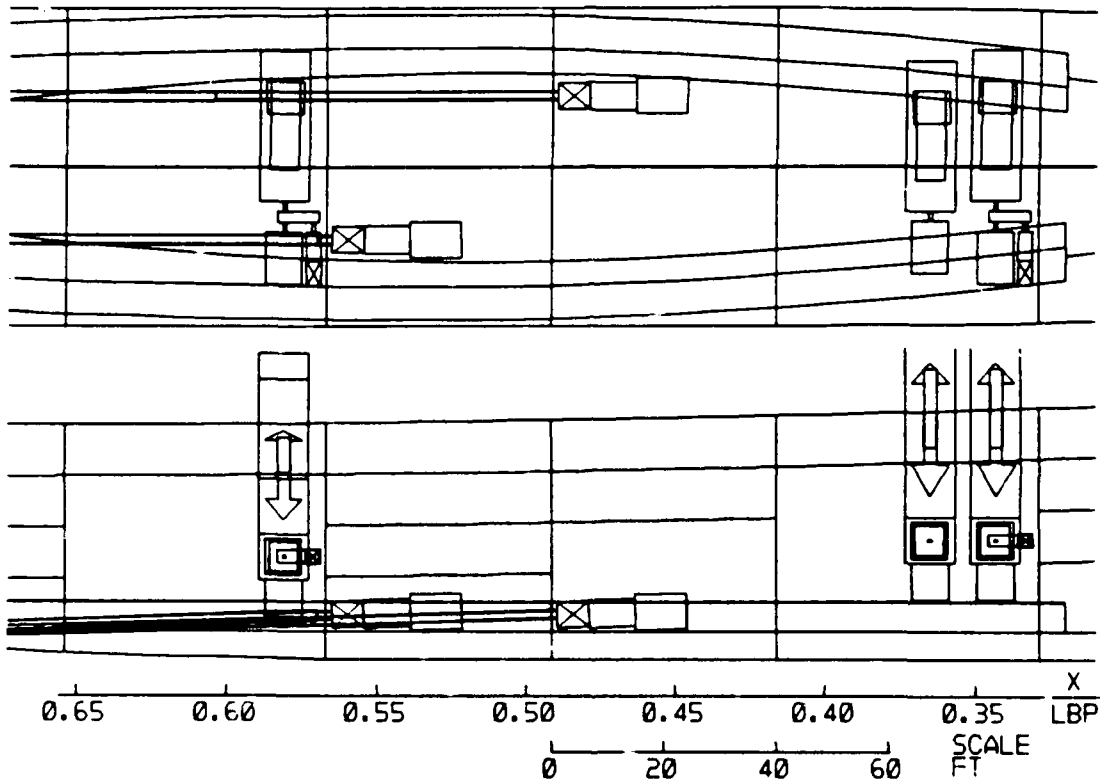


Fig. B.16. "GRELEC" Machinery Box

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I) ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 3/22/93 16.19.10.
 GRAPHIC DISPLAY NO. 3 - MR PLAN VIEWS (MMR1)
 PAGE 1 OF 5

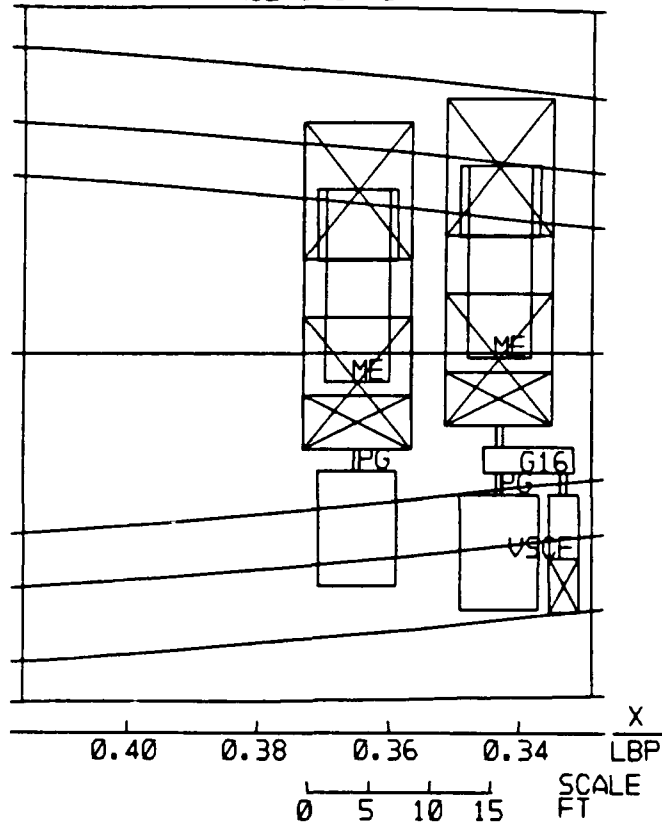


Fig. B.17. "GRELEC" Main Machinery Room Plan View

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ASSET/MONOSC VERSION 3.2 - DESIGN SUMMARY - GRELEC

PRINTED REPORT NO. 1 - SUMMARY **

PRINCIPAL CHARACTERISTICS - FT
 LBP 529.0
 LOA 558.1
 BEAM, DWL 56.2
 BEAM, WEATHER DECK 56.2
 DEPTH @ STA 10 42.0
 DRAFT TO KEEL DWL 16.6
 DRAFT TO KEEL LWL 16.6
 FREEBOARD @ STA 3 35.0
 GMT 4.2
 CP 0.576
 CX 0.836

SPEED(KT): MAX= 31.6 SUST= 30.0
 ENDURANCE: 6000.0 NM AT 20.0 KTS

TRANSMISSION TYPE: ELECT
 MAIN ENG: 3 RGT @ 22125.0 HP

SHAFT POWER/SHAFT: 28676.2 HP
 PROPELLERS: 2 - CR - 17.0 FT DIA

SEP GEN: 1 GT @ 3000.0 KW
 PD GEN: 2 VSCF @ 4000.0 KW

24 HR LOAD 1769.2
 MAX MARG ELECT LOAD 3535.1

	OFF	CPO	ENL	TOTAL
MANNING	22	19	229	270
ACCOM	25	21	252	298

WEIGHT SUMMARY - LTON
 GROUP 1 - HULL STRUCTURE 2689.6
 GROUP 2 - PROP PLANT 708.4
 GROUP 3 - ELECT PLANT 244.9
 GROUP 4 - COMM + SURVEIL 388.9
 GROUP 5 - AUX SYSTEMS 751.0
 GROUP 6 - OUTFIT + FURN 498.1
 GROUP 7 - ARMAMENT 399.8

 SUM GROUPS 1-7 5680.7
 DESIGN MARGIN 0.0

LIGHTSHIP WEIGHT 5680.7
 LOADS 1327.4

FULL LOAD DISPLACEMENT 7008.1
 FULL LOAD KG: FT 23.2

MILITARY PAYLOAD WT - LTON 1182.7
 USABLE FUEL WT - LTON 828.4

AREA SUMMARY - FT²
 HULL AREA - 58442.7
 SUPERSTRUCTURE AREA - 14292.4

 TOTAL AREA 72735.1

VOLUME SUMMARY - FT³
 HULL VOLUME - 856616.2
 SUPERSTRUCTURE VOLUME - 147078.1

 TOTAL VOLUME 1003694.3

** MAIN ENG REQUIRED POWER IS REPORTED

ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - GRELEC

PRINTED REPORT NO. 1 - HULL GEOMETRY SUMMARY

HULL OFFSETS IND-GENERATE	MIN BEAM, FT	30.00
HULL DIM IND-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-CONV DD		

HULL PRINCIPAL DIMENSIONS (ON DWL)

LBP, FT	529.00	PRISMATIC COEF	0.576
LOA, FT	558.09	MAX SECTION COEF	0.836
BEAM, FT	56.15	WATERPLANE COEF	0.734
BEAM @ WEATHER DECK, FT	56.15	LCB/LCP	0.515
DRAFT, FT	16.57	HALF SIDING WIDTH, FT	1.00
DEPTH STA 0, FT	51.59	BOT RAKE, FT	0.00
DEPTH STA 3, FT	47.58	RAISED DECK HT, FT	9.00
DEPTH STA 10, FT	42.00	RAISED DECK FWD LIM, STA	
DEPTH STA 20, FT	34.06	RAISED DECK AFT LIM, STA	17.77
FREEBOARD @ STA 3, FT	35.01	BARE HULL DISPL, LTON	6773.61
STABILITY BEAM, FT	56.14	AREA BEAM, FT	48.50

BARE HULL DATA ON LWL

STABILITY DATA ON LWL

LGTH ON WL, FT	529.00	KB, FT	9.81
BEAM, FT	56.15	BMT, FT	17.69
DRAFT, FT	16.57	KG, FT	23.19
FREEBOARD @ STA 3, FT	35.01	FREE SURF COR, FT	0.10
PRISMATIC COEF	0.576	SERV LIFE KG ALW, FT	0.00
MAX SECTION COEF	0.836		
WATERPLANE COEF	0.737	GMT, FT	4.21
WATERPLANE AREA, FT2	21903.31	GML, FT	1390.45
WETTED SURFACE, FT2	29651.91	GMT/B AVAIL	0.075
		GMT/B REQ	0.075
BARE HULL DISPL, LTON	6777.48		
APPENDAGE DISPL, LTON	230.60		
FULL LOAD WT, LTON	7008.07		

ASSET/MONOSC VERSION 3.2 - SPACE MODULE - GRELEC

PRINTED REPORT NO. 1 - SUMMARY

COLL PROTECT SYS-NONE	SONAR DOME-PRESENT	UNIT COMMANDER-NONE	
FULL LOAD WT, LTON	7008.1	HAB STANDARD FAC	0.260
TOTAL CREW ACC	298.	PASSWAY MARGIN FAC	0.000
HULL AVG DECK HT, FT	9.82	AC MARGIN FAC	0.000
MR VOLUME, FT3	187119.	SPACE MARGIN FAC	0.000

	PAYLOAD REQUIRED	AREA FT2		VOL FT3
		TOTAL REQUIRED	TOTAL AVAILABLE	TOTAL ACTUAL
DKHS ONLY	5874.0	11279.6	14292.4	147078.
HULL OR DKHS	15757.0	61455.4	58442.7	856616.
TOTAL	21631.0	72735.0	72735.1	1003694.

SSCS	GROUP	TOTAL AREA FT2	DKHS AREA FT2	PERCENT TOTAL AREA
1.	MISSION SUPPORT	23298.7	6583.5	32.0
2.	HUMAN SUPPORT	18836.7	886.0	25.9
3.	SHIP SUPPORT	27734.2	2827.4	38.1
4.	SHIP MOBILITY SYSTEM	2865.3	982.7	3.9
5.	UNASSIGNED			0.0
	TOTAL	72735.0	11279.6	100.0

ASSET/MONOSC VERSION 3.2 - RESISTANCE MODULE - GRELEC

PRINTED REPORT NO. 1 - SUMMARY

RESID RESIST IND	REGR	BILGE KEEL IND	NONE
FRICTION LINE IND	ITTC	SHAFT SUPPORT TYPE IND	OPEN STRUT
ENDUR DISP IND	FULL LOAD	PRPLN SYS RESIST IND	CALC
ENDUR CONFIG IND	NO TS	PROP TYPE IND	CR
SONAR DRAG IND	APPENDAGE	SONAR DOME IND	PRESENT
SKEG IND	PRESENT	RUDDER TYPE IND	SPADE
FULL LOAD WT, LTON	7008.1	CORR ALW	0.00050
AVG ENDUR DISP, LTON	7008.1	DRAG MARGIN FAC	0.110
USABLE FUEL WT, LTON	828.4	TRAILSHAFT PWR FAC	
NO FIN PAIRS	0.	PRPLN SYS RESIST FRAC	
PROP TIP CLEAR RATIO	0.25	MAX SPEED	0.140
NO PROP SHAFTS	2.	SUSTN SPEED	0.156
PROP DIA, FT	17.00	ENDUR SPEED	0.254

CONDITION	SPEED	-----EFFECTIVE HORSEPOWER, HP-----						DRAG
	KT	FRIC	RESID	APPDG	WIND	MARGIN	TOTAL	LBF
MAX	31.64	15441.	17677.	6305.	603.	4403.	44429.	457659.
SUSTN	30.00	13230.	12485.	5467.	514.	3487.	35182.	382159.
ENDUR	20.00	4064.	1317.	2621.	152.	897.	9051.	147472.

ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE - GRELEC

PRINTED REPORT NO. 1 - SUMMARY

HULL SUBDIV IND-GIVEN		INNER BOT IND-PRESENT	
SHAFT SUPPORT TYPE IND-OPEN STRUT			
LBP, FT	529.00	HULL AVG DECK HT, FT	9.82
DEPTH STA 10, FT	42.00	NO INTERNAL DECKS	3
HULL VOLUME, FT3	856617.	NO TRANS BHDS	13
MR VOLUME, FT3	187119.	NO LONG BHDS	0
TANKAGE VOL REQ, FT3	42684.	NO MACHY RMS	5
EXCESS TANKAGE, FT3	69665.	NO PROP SHAFTS	2
ARR AREA LOST TANKS, FT2	61.0		
HULL ARR AREA AVAIL, FT2	58442.9		

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - GRELEC

PRINTED REPORT NO. 1 - SUMMARY

TRANS TYPE IND	ELECT	MAX SPEED, KT	31.64
ELECT PRPLN TYPE IND	ACC-AC	SUSTN SPEED IND	GIVEN
SHAFT SUPPORT TYPE IND	OPEN STRUT	SUSTN SPEED, KT	30.00
NO PROP SHAFTS	2.	ENDUR SPEED IND	GIVEN
ENDUR CONFIG IND	NO TS	ENDUR SPEED, KT	20.00
SEC ENG USAGE IND		DESIGN MODE IND	ENDURANCE
MAX MARG ELECT LOAD, KW	3535.	ENDURANCE, NM	6000.
AVG 24 HR ELECT LOAD, KW	1769.	USABLE FUEL WT, LTON	828.4
SWBS 200 GROUP WT, LTON	708.4		
SWBS 300 GROUP WT, LTON	244.9		

ARRANGEMENT OR SS GEN	TYPE	NO INSTALLED	NO ONLINE MAX+SUSTN	NO ONLINE ENDURANCE
ELECT PG ARR 1 IND	M-CG-PG	2	2	1
ELECT PG ARR 2 IND	M-PG	1	1	0
ELECT DL ARR IND	MTR-BCE	2	2	2
SEP SS GEN	3000. KW	1	0	0
VSCF SS CYCLO	4000. KW	2	2	1

	MAIN ENG	SEC ENG	SS ENG
ENG SELECT IND	GIVEN		GIVEN
ENG MODEL IND	OTHER		DDA-501-K17
ENG TYPE IND	RGT		GT
ENG SIZE IND	GIVEN		GIVEN
NO INSTALLED	3	0	1
ENG PWR AVAIL, HP	26400.		3800.
ENG RPM	3600.0		13820.0
ENG SFC, LBM/HP-HR	0.324		.545
ENG LOAD FRAC	0.838		1.114

PRINTED REPORT NO. 12 - POWERING - GRELEC

SUSTN SPEED IND-GIVEN
ENDUR SPEED IND-GIVEN
TRANS EFF IND-CALC

100 PCT POWER TRANS EFF 0.9257
25 PCT POWER TRANS EFF 0.8841

	MAX SPEED	SUSTN SPEED	ENDUR SPEED
SHIP SPEED, KT	31.64	30.00	20.00
PROP RPM	128.9	120.9	79.0
NO OP PROP SHAFTS	2	2	2
EHP (/SHAFT), HP	22215.	17591.	4526.
PROPULSIVE COEF	0.775	0.773	0.767
ENDUR PWR ALW	1.0	1.0	1.1
SHP (/SHAFT), HP	28676.	22766.	6495.
TRANS EFFY	0.926	0.919	0.884
CP PROP TRANS EFFY MULT	1.000	1.000	1.000
PROPUL PWR (/SHAFT), HP	30978.	24783.	7346.
PD GEN PWR (/SHAFT), HP	2209.	2212.	1265.
BHP (/SHAFT), HP	33187.	26995.	8611.

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ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - GRELEC

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	60.8	351.92	10.69
162	STACKS AND MASTS	5.5	227.30	62.71
180	FOUNDATIONS			
182	PROPULSION PLANT FOUNDATIONS	190.7	247.21	11.70
183	ELECTRIC PLANT FOUNDATIONS	26.1	326.59	24.16

PRINTED REPORT NO. 14 - PROPULSION PLANT WEIGHT - GRELEC

SWBS	COMPONENT	WT, LTON	LCG, FT	VCG, FT
200	PROPULSION PLANT	708.4	291.48	16.83
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	292.2	236.52	18.70
233	PROPULSION INTERNAL COMBUSTION ENGINES	0.0	0.00	0.00
234	PROPULSION GAS TURBINES	164.5	227.30	22.74
235	ELECTRIC PROPULSION	127.7	248.40	13.49
240	TRANSMISSION AND PROPULSOR SYSTEMS	243.8	391.53	4.35
241	PROPULSION REDUCTION GEARS	19.7	264.84	9.95
242	PROPULSION CLUTCHES AND COUPLINGS	0.0	0.00	0.00
243	PROPULSION SHAFTING	146.9	399.31	3.97
244	PROPULSION SHAFT BEARINGS	54.3	368.16	4.95
245	PROPULSORS	22.8	506.95	0.54
250	PRPLN SUPPORT SYS (EXCEPT FUEL+LUBE OIL)	112.4	235.70	41.18
251	COMBUSTION AIR SYSTEM	37.1	223.41	42.81
252	PROPULSION CONTROL SYSTEM	17.5	227.30	27.30
256	CIRCULATING AND COOLING SEA WATER SYSTEM	12.8	333.27	15.12
259	UPTAKES (INNER CASING)	45.0	221.39	52.63
260	PRPLN SUPPORT SYS (FUEL+LUBE OIL)	34.7	219.30	14.12
261	FUEL SERVICE SYSTEM	9.4	200.85	16.74
262	MAIN PROPULSION LUBE OIL SYSTEM	18.1	227.30	12.00
264	LUBE OIL FILL, TRANSFER, AND PURIF	7.2	223.30	16.00
290	SPECIAL PURPOSE SYSTEMS	25.3	309.09	11.07
298	OPERATING FLUIDS	18.7	317.40	8.00
299	REPAIR PARTS AND SPECIAL TOOLS	6.6	285.66	19.74

PRINTED REPORT NO. 15 - ELECTRIC PLANT WEIGHT - GRELEC

SWBS	COMPONENT	WT, LTON	LCG, FT	VCG, FT
300	ELECTRIC PLANT	244.9	310.53	27.00
310	ELECTRIC POWER GENERATION	87.5	346.95	19.86
311	SHIP SERVICE POWER GENERATION	44.8	361.23	22.75
313	BATTERIES AND SERVICE FACILITIES	32.5	361.23	8.40
314	POWER CONVERSION EQUIPMENT	10.1	238.05	43.75
320	POWER DISTRIBUTION SYSTEMS	116.0	283.25	29.28
321	SHIP SERVICE POWER CABLE	84.4	280.37	27.00
324	SWITCHGEAR AND PANELS	31.6	290.95	35.35
330	LIGHTING SYSTEM	32.2	278.06	38.17
331	LIGHTING DISTRIBUTION	18.1	280.37	37.80
332	LIGHTING FIXTURES	14.1	275.08	38.64
340	POWER GENERATION SUPPORT SYSTEMS	6.2	429.86	30.26
342	DIESEL SUPPORT SYSTEMS	0.0	0.00	0.00
343	TURBINE SUPPORT SYSTEMS	6.2	429.86	30.26
390	SPECIAL PURPOSE SYSTEMS	3.1	401.72	21.50
398	OPERATING FLUIDS	0.9	361.23	22.75
399	REPAIR PARTS AND SPECIAL TOOLS	2.2	417.91	21.00

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

PRINTED REPORT NO. 18 - MACHINERY SPACE REQUIREMENTS - GRELEC

MACHINERY ROOM VOLUME REQUIREMENTS

VOLUME CATEGORY	VOLUME, FT3
SWBS GROUP 200	134204.
PROPULSION POWER GENERATION	52241.
PROPULSION ENGINES	38322.
PROPULSION REDUCTION GEARS AND GENERATORS	13919.
DRIVELINE MACHINERY	6163.
REDUCTION AND BEVEL GEARS WITH Z-DRIVE	0.
ELECTRIC PROPULSION MOTORS AND GEARS	6163.
REMOTELY-LOCATED THRUST BEARINGS	0.
PROPELLER SHAFT	7332.
ELECTRIC PROPULSION MISCELLANEOUS EQUIPMENT	14163.
CONTROLS	1845.
BRAKING RESISTORS	1432.
MOTOR AND GENERATOR EXCITERS	3049.
SWITCHGEAR	1710.
POWER CONVERTERS	3120.
DEIONIZED COOLING WATER SYSTEMS	3006.
RECTIFIERS	0.
HELIUM REFRIGERATION SYSTEMS	0.
PROPULSION AUXILIARIES	54305.
PROPULSION LOCAL CONTROL CONSOLES	3458.
CP PROP HYDRAULIC OIL POWER MODULES	0.
FUEL OIL PUMPS	28192.
LUBE OIL PUMPS	3472.
LUBE OIL PURIFIERS	14838.
ENGINE LUBE OIL CONDITIONERS	874.
SEAWATER COOLING PUMPS	3471.
SWBS GROUP 300	18867.
ELECTRIC PLANT POWER GENERATION	0.
ELECTRIC PLANT ENGINES	0.
ELECTRIC PLANT GENERATORS AND GEARS	0.
SHIP SERVICE SWITCHBOARDS	17463.
CYCLOCONVERTERS	1404.
SWBS GROUP 500	45993.
AUXILIARY MACHINERY	45993.
AIR CONDITIONING PLANTS	8274.
AUXILIARY BOILERS	6220.
FIRE PUMPS	4921.
DISTILLING PLANTS	14905.
AIR COMPRESSORS	9420.
ROLL FIN PAIRS	0.
SEWAGE PLANTS	2254.

ARRANGEABLE AREA REQUIREMENTS

SSCS	GROUP NAME	-----FT2-----	
		HULL//DKHS	DKHS ONLY
3.4X	AUXILIARY MACHINERY DELTA	1216.4	0.0
3.511	SHIP SERVICE POWER GENERATION	2593.1	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	382.1	465.6
4.143	GAS TURBINE ENG EXHAUST	560.5	517.1

NOTE: * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

ASSET/MONOSC VERSION 3.2 - WEIGHT MODULE - GRELEC

PRINTED REPORT NO. 1 - SUMMARY

SWBS	GROUP	WEIGHT		LCG	VCG	RESULTANT ADJ	
		LTON	PER CENT	FT	FT	WT-LTON	VCG-FT
100	HULL STRUCTURE	2689.6	38.4	255.30	25.97	42.2	.20
200	PROP PLANT	708.4	10.1	291.48	16.83		
300	ELECT PLANT	244.9	3.5	310.53	27.00		
400	COMM + SURVEIL	388.9	5.5	201.02	27.95	134.6	.95
500	AUX SYSTEMS	751.0	10.7	290.95	27.68	25.0	.13
600	OUTFIT + FURN	498.1	7.1	264.50	28.31		
700	ARMAMENT	399.8	5.7	238.05	35.21	397.6	2.00
M11	D-B WT MARGIN		0.0	262.78			
D-B KG MARGIN							
L I G H T S H I P							
		5680.7	81.1	262.78	26.09	599.4	3.27
F00	FULL LOADS	1327.4	18.9	313.75	10.76	328.6	1.13
F10	CREW + EFFECTS	30.2		248.63	31.31		
F20	MISS REL EXPEN	263.6		232.76	27.54		
F30	SHIPS STORES	42.5		285.66	23.48		
F40	FUELS + LUBRIC	946.7		343.05	5.09		
F50	FRESH WATER	44.3			5.90		
F60	CARGO						
M24	FUTURE GROWTH						
FULL LOAD WT		7008.1	100.0	272.44	23.19	928.0	4.40

ASSET/MONOSC VERSION 3.2 - SEAKEEPING ANALYSIS - GRELEC

PRINTED REPORT NO. 1 - SUMMARY

APPENDAGE IND-WITH

FULL LOAD WT, LTON 7008.1

	FULL LOAD
BALES RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL DISP)	14.079
RANK OF THE SYNTHESIZED SHIP (NORMALIZED)	5.617
RANK OF THE CLOSEST DATA BASE HULL (NORMALIZED)	5.080
ID NO OF CLOSEST DATA BASE SHIP	11
MCCREIGHT RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL SHIP)	15.488
RANK OF THE CLOSEST DATA BASE HULL	15.468
ID NO OF CLOSEST DATA BASE SHIP	1

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ASSET/MONOSC VERSION 3.2 - COST ANALYSIS - GRELEC

PRINTED REPORT NO. 1 - SUMMARY

YEAR \$	1992.	NO OF SHIPS ACQUIRED	50.
INFLATION ESCALATION FAC	2.149	SERVICE LIFE, YR	30.0
LEARNING RATE	0.970	ANNUAL OPERATING HRS	2500.0
FUEL COST, \$/GAL	2.579	MILITARY P/L, LTON	1182.7
PAYLOAD FUEL RATE, LTON/HR	0.33	LIGHTSHIP WT, LTON	5680.7
SHIP FUEL RATE, LTON/HR	2.76	FULL LOAD WT, LTON	7008.1

COST ITEM	COSTS (MILLIONS OF DOLLARS)		
	TOT SHIP	+ PAYLOAD	= TOTAL
LEAD SHIP	1060.3	807.0*	1867.3
FOLLOW SHIP	492.3	710.4*	1202.7
AVG ACQUISITION COST/SHIP(50 SHIPS)	441.0	712.3*	1153.3
LIFE CYCLE COST/SHIP(30 YEARS)			3315.8
TOTAL LIFE CYCLE COST(30 YEARS)			165790.2
DISCOUNTED LIFE CYCLE COST/SHIP			428.1**
DISCOUNTED TOTAL LIFE CYCLE COST			21407.0**

*ESTIMATED VALUE
 **DISCOUNTED AT 10 PERCENT

PRINTED REPORT NO. 2 - UNIT ACQUISITION COSTS - GRELEC

SWBS GROUP	UNITS	INPUTS	KN FACTORS	LEAD SHIP COSTS \$K	FOLLOW SHIP COSTS \$K	
100	HULL STRUCTURE	LTON	2689.6	1.00	32421.	30476.
200	PROPULSION PLANT	HP	61956.0	2.35	69812.	65624.
300	ELECTRIC PLANT	LTON	244.9	1.00	24077.	22633.
400	COMMAND+SURVEILLANCE	LTON	388.9	3.15	29151.	27402.
500	AUX SYSTEMS	LTON	751.0	1.53	55241.	51927.
600	OUTFIT+FURNISHINGS	LTON	498.1	1.00	27593.	25937.
700	ARMAMENT	LTON	399.8	1.00	6661.	6261.
	MARGIN	LTON	0.0		0.	0.
800	DESIGN+ENGINEERING		26.06		384157.	42448.
900	CONSTRUCTION SERVICES		4.25		61546.	57853.
TOTAL CONSTRUCTION COST					690660.	330561.
CONSTRUCTION COST					690660.	330561.
PROFIT(15.0 PERCENT OF CONSTRUCTION COST)					103599.	49584.
PRICE					794259.	380145.
CHANGE ORDERS(12/8 PERCENT OF PRICE)					95311.	30412.
NAVSEA SUPPORT(2.5 PERCENT OF PRICE)					19856.	9504.
POST DELIVERY CHARGES(5 PERCENT OF PRICE)					39713.	19007.
OUTFITTING(4 PERCENT OF PRICE)					31770.	15206.
H/M/E + GROWTH(10 PERCENT OF PRICE)					79426.	38015.
TOTAL SHIP COST					1060336.	492288.
ESTIMATED PAYLOAD COST					806991.	710373.
SHIP PLUS PAYLOAD COST					1867327.	1202661.
ADJUSTED FIRST UNIT SHIP COST, \$K				523710.6		
COMBAT SYSTEM WEIGHT, LTON				1182.7		
PROPULSION SYSTEM WEIGHT, LTON				708.4		
ADJUSTED FIRST UNIT SHIP COST EQUALS						
FOLLOW SHIP TOTAL COST DIVIDED BY				0.940		

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TUMBLE HOME MONOHULLS

The next five machinery options are installed in an unconventional tumble home monohull and are unconventionally arranged. They represent a significant change in design philosophy when compared to the first five options. All main machinery is moved out of the conventional machinery box. The propulsion and ship service power generation modules are located in the helicopter hanger and have a side exhaust. This arrangement eliminates the space occupied by intake and exhaust ducts. The propulsion driveline is completely outside the hull and is housed in a steerable pod. This eliminates the rudder and the space occupied by the long shafting runs associated with conventional arrangements. The 10 degree tumble home hull allows the designer to take advantage of the space savings. The machinery/fuel weight savings and reduced draft allow further installed power reduction, lower decks and improved seakeeping.

This tumble home hull and some aspects of the five machinery options are not handled straightforwardly in ASSET. Special techniques are required to model the hull/deckhouse geometry and the elevated machinery foundations/ducts. Calculations external to ASSET and appropriate adjustments are needed.

ASSET Synthesis.....

The following ASSET synthesis procedure meets the groundrules:

The constant range, payload and sustained speed aspects of the tumble home ships are handled identically to the conventional ships.

Initially a tumble home ship is designed identically to the conventional ship. The ship is designed to be stable at full load. The beam necessary to meet the stability requirement is guessed. This is accomplished by:

```
ENDUR DISP IND = FULL LOAD
HULL OFFSETS IND = GENERATE
HULL BC IND = GIVEN (CONV DD with tumble home's waterplane)
HULL DIM IND = T
OFFSETS DEF ARRAY = 13,2,1,1 (puts 2 points above waterline)
BEAM = "guess"
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Then offsets above the waterline are manually adjusted to provide the 10 degree inwardly sloping "tumble home" hull from bow to stern. This is accomplished by:

HULL OFFSET IND = GIVEN
HALF BEAM ARRAY =
 (columns 14 & 15 adjusted relative to column 13)
HBA(14) = HBA(13) - Tan(10) [Z(14) - T]
HBA(15) = HBA(13) - Tan(10) [Z(15) - T]
 T = Draft
 Z = Vertical coordinate of WATERLINE ARRAY

Synthesis is run and the deckhouse is adjusted until there is no excess area. Synthesis is rerun and the ship's stability is compared to the requirement. A new beam is guessed and the procedure repeated until.....GMT/B AVAIL = .075.

ASSET Adjustments.....

Each of the five machinery options installed in the tumble home hull contained aspects which are not directly accounted for in ASSET (version 3.2). Special techniques are used to account for:

- Elevated Engines
- Elevated Composite Engine/Generator Foundations
- Machinery Space Requirements
- Intake/Exhaust System
- Spade Rudder Removal
- Side Hull Plating

Elevated Engines

Since engines cannot be located in the deckhouse, the helicopter hanger is simulated with a raised deck as follows:

RAISED DECK HGT = 13.5
RAISED DECK LIMITS ARRAY = .330 ; .717
MAIN ENG KG ARRAY = .8432 ; .8432
SS ENG KG ARRAY = .8620

This positions the engines in the desired location but triggers warnings in ASSET since the engines are outside the main machinery rooms. Furthermore, excessive foundation weights and machinery box space requirements result from this "illegal" placement.

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Elevated Composite Engine/Generator Foundations

ASSET version 3.2 automatically puts a steel bedplate foundation under both the propulsion and ship service engine/generator sets with steel pedestals running down to the hull's bottom structure. The bedplate and pedestal weights are proportional to the supported weight. The pedestal weight is also proportional to the height of the bedplate above the baseline.

The foundation concept for all tumble home hull machinery options involves a composite bedplate attached to the local deck. This composite bedplate is assumed to weigh half that of a steel bedplate. No pedestals exist.

The composite foundation concept is modeled by removing the pedestal weight and halving the bedplate weight within the PAYLOAD AND ADJUSTMENTS.

The pedestal weight is estimated by temporarily positioning the engines as low as possible in the ship and observing the reduced foundation weights (SWBS 182 & 183). The reduced weights are bedplates only. The difference is pedestals only.

The net effect is an approximate 2/3 reduction in foundation weights. Specifically the following adjustments are made to correct the weight and locate the composite bedplates under the engine/generator sets:

P+A WT KEY TBL	P+A WT FAC ARRAY	P+A VCG FAC ARRAY
W182	-.69	.50
W183	-.65	.965

Machinery Space Requirements

ASSET version 3.2 automatically calculates the volume under the footprint of the propulsion engine/generator sets and includes it as machinery box volume required in PRINTED REPORT NO. 18.

The machinery box volume required is zero for propulsion engine/generator sets for all the tumble home hull machinery options. However, these sets do occupy hull area which is not accounted for by ASSET.

The appropriate correction is made by converting the calculated machinery box volume required into area, comparing it to the area being occupied in the helicopter hanger and entering the difference into the P+A AREA ADD ARRAY.

The machinery box volume required for two propulsion engine/generator sets is divided by the HULL AVG DECK HT to yield approximately 3300 square feet. These sets are assumed to occupy approximately twice their footprint area in the helicopter hanger or about 2000 square feet. The footprint area is doubled to allow space for the air inlet, intake silencer, exhaust elbow (to side exhaust) and intercooler. The recuperator remains atop and within the engine module's footprint.

The following adjustments are made to correct the space occupied by the propulsion engines and generators respectively:

P+A WT KEY TBL	P+A AREA KEY TBL	P+A VCG FAC ARRAY
W234	A34X	30.
W235	A34X	-1315.

It can be noted that this space problem does not exist in regard to the ship service engine/generator sets which are located in "OTHER" machinery rooms. ASSET directly accounts for their space requirements. ASSET version 3.4 will allow propulsion plant engine/generator sets to exist in "OTHER" machinery rooms thus eliminating the need to do space corrections for units located outside the machinery box.

Intake/Exhaust System

The intake/exhaust system model in ASSET assumes that engines are located in the machinery box and that ducting exists there, in the hull above the top of the box and in the deckhouse and that an exhaust stack sits atop the deckhouse. Inlets can be either atop the deckhouse ("HIGH HAT") or built into it with inlet louvers to the side ("PLENUM").

The size and weight of the ducting and all ducting components (silencers, stack, bleed air system etc.) are calculated as functions of the required engine mass flow.

The intake/exhaust system concept for all tumble home machinery options involves the elimination of many components and all of the ducting and trunks. Exhaust stacks do not exist with side exhaust. It is assumed that exhaust silencers are unnecessary due to the recuperator's presence and the side exhaust. The ducting system is assumed to occupy no space in the ship except for that already accounted for by doubling the propulsion engine/generator footprint. The spray ring and eductor are replaced by a passive, shielded side exhaust elbow.

This intake/exhaust system concept is approximated in ASSET by first setting the main engine mass flow to approximately zero which eliminates the entire system. The following components are then added back within PAYLOAD AND ADJUSTMENTS and placed with the main engines:

Recuperators
Inlets
Intake Silencers
Engine Cooling Air Supply
Engine Bleed Air System

This is specifically accomplished in ASSET by:

MAIN ENG MASS FL = .001

P+A WT KEY TBL	P+A WT ADD ARRAY	P+A VCG ADD ARRAY
W251	18.0	46.8
W259	32.0	46.8

Spade Rudder Removal

A steerable propulsion pod (with contra-rotating tractor propellers facing directly into the undisturbed flow stream outside the hull boundary layer) is a common feature of the five machinery options installed in the tumble home hull. This feature eliminates the need for the spade rudder.

The spade rudder is "removed" by setting the dimensions of the rudder to approximately zero. This effectively eliminates the rudder weight and resistance while maintaining the steering gear. It is assumed that the steering gear is now associated with the propulsion pod. This is accomplished by:

RUDDER SIZE IND = GIVEN

RUDDER SIZE ARRAY = (3X 1) FT
1 0.1000E-03
2 0.1000E-03
3 0.1000E-03

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Side Hull Plating

It is observed that ASSET incorrectly calculates the weight and center-of-gravity of the inward sloping hull plating. An estimate of the hull plating can be obtained from the "GENERATED" hull before the tumble home is manually input to the "GIVEN" hull.

The hull plating calculation is corrected through PAYLOAD AND ADJUSTMENTS as follows:

WT KEY TBL	WT ADD ARRAY	WT FAC ARRAY	VCG ADD ARRAY
W111	0.0	-1.000	0.0
W115	458.9	0.0	24.7

Machinery Options.....

The following machinery options are installed in the unconventional 10 degree tumble home hull:

- POD - Relative to the last option installed in the conventional monohull, this option has similiar machinery components but a vastly different arrangement of those components. One of the propulsion engine/generator sets is removed. The remaining two and the single ship service engine/generator set are relocated to the helicopter hanger and have side exhausts. The geared motors are also moved out of the hull and into steerable propulsion pods. The tractor driven contrarotating propellers face directly into the flow stream. The expanded area ratio of the propeller is increased (to 1.0). The spade rudders are removed.
- NOSSTG - The single ship service engine/generator set of the preceding option is removed.
- EAR.8 - The expanded area ratio of the contrarotating propeller is reduced to .8 (from 1.0 in the preceding option).
- FLAP - A retractable flap is added to the transom of the preceding option.
- 2XR - The range of the preceding ship is doubled.

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Ship/Machinery Graphics and Data.....

An ASSET hull body plan and isometric view of the unconventional tumble home ship is shown on succeeding pages followed by information on each machinery option installed including ASSET modeling details, machinery arrangements and representative ASSET printed reports. These ships are available to all ASSET users on:

MSSF2 USERDISK:[SHANK.ASSET]JACK1V32.BNK

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I) ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - 8/19/93 07.59.47.
GRAPHIC DISPLAY NO. 1 - BODY PLAN

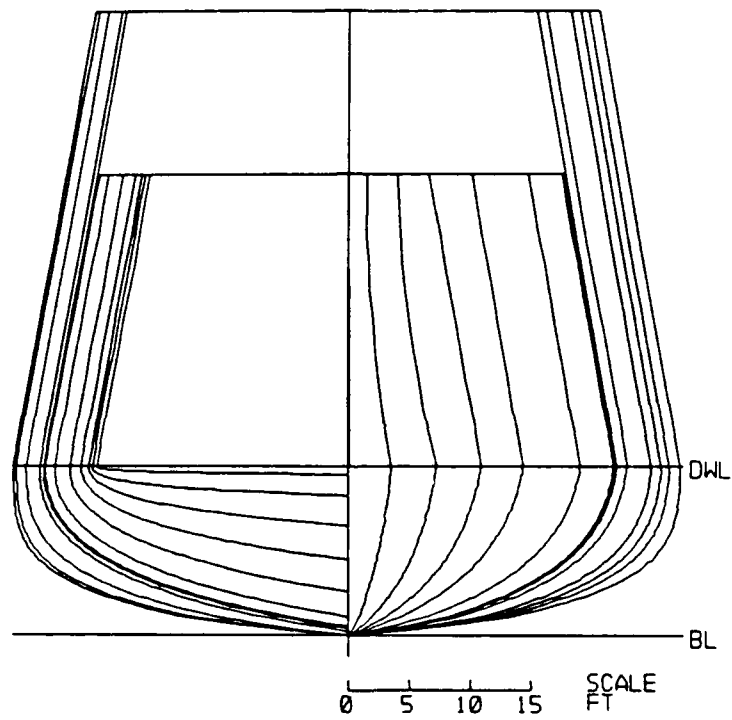


Fig. B.18. Unconventional 10 degree Tumble Home Hull Body Plan

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I) ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - 8/19/93 07.59.47.
GRAPHIC DISPLAY NO. 2 - HULL ISOMETRIC VIEW

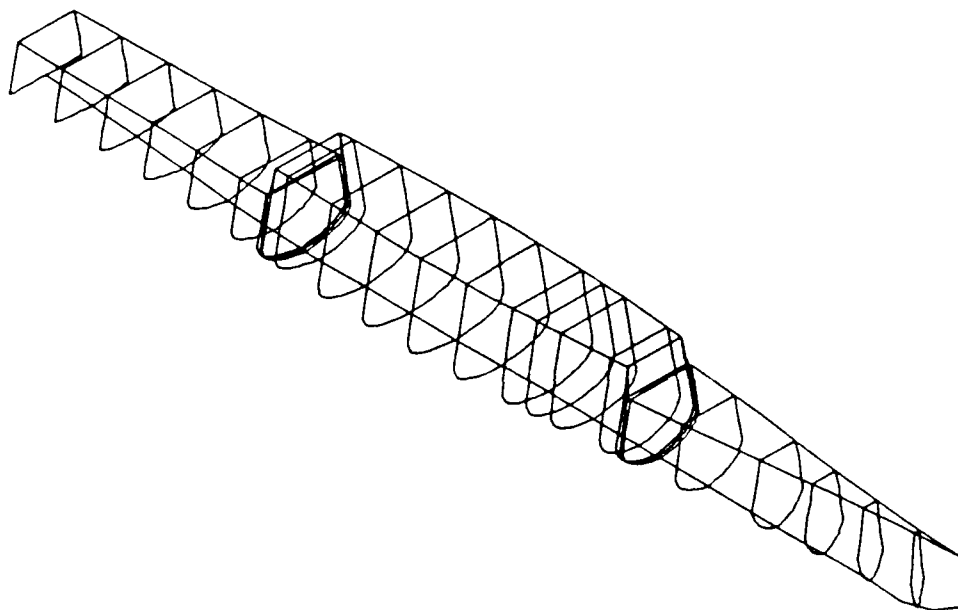


Fig. B.19. Unconventional 10 degree Tumble Home Hull Isometric View

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POD: 2-WR-21 ICR Gas Turbine Propulsion Engines (25580 hp)
2-AC Liquid-cooled Propulsion Generators (28 mw)
2-Geared AC Liquid-cooled Propulsion Motors (27.2 mw)
2-Contrarotating Bi-coupled Epicyclic Reduction Gears
2-Contrarotating Propellers (17', 1.0EAR)
2-POD-Supported Contrarotating Shafts
2-Steerable PODs
 Transom Stern
 6000 N.Mile Range
1-DDA-571K Separate SSTG Set (3000 kw)
2-VSCF Propulsion Derived Ship Service Systems (4000 kw)

This option has similiar machinery components to the preceding one ("GRELEC") but a vastly different component arrangement. All main machinery is located outside the hull.

One propulsion engine/generator sets is removed. The two remaining propulsion engine/generator sets and the single ship service engine/generator set are located in the helicopter hanger. All engines have side exhausts and flush plenum type inlets.

A DDA-571K gas turbine is used in place of the 501K17 engines driving the separate ship service generators.

The propulsion-derived ship service generators are directly driven rather than driven by combining gears.

The motors and contrarotating gears, thrust bearings and shafting are moved into steerable propulsion pods.

The tractor driven contrarotating propellers are faced down into the flow stream at shaft angles of -3 degrees. The expanded area ratio of the propeller is increased (to 1.0).

The spade rudders are removed.

In addition to the special ASSET inputs previously described concerning elevated engines, intake/exhaust systems and spade rudder removal, the machinery is specified by modifying the previous ship "GRELEC" as follows:

```
MACHINERY ROOMS
MR TYPE TBL                = ( 10X 1)*10
1 OMR
2 AMR
3 MMR
4 MMR
5 AMR

MR FWD BHD ID ARRAY       = ( 10X 1)
1 5.000
2 6.000
3 7.000
4 8.000
5 9.000

MR UPR DECK ID ARRAY     = ( 10X 1)
1 1.000
2 3.000
3 4.000
4 3.000
5 4.000

ELECT PG ARR 1 IND       = M-PG

ARRANGEMENT NUMBER
MECH ARR NO ARRAY        = ( 10X 2)
1 0.0000E+00 0.0000E+00
2 0.0000E+00 0.0000E+00
3 0.0000E+00 0.0000E+00
4 0.0000E+00 0.0000E+00
5 0.0000E+00 0.0000E+00
6 0.0000E+00 0.0000E+00
7 0.0000E+00 0.0000E+00

ELECT PG ARR NO ARRAY    = ( 10X 2)
1 0.0000E+00 0.0000E+00
2 0.0000E+00 0.0000E+00
3 1.000      0.0000E+00
4 1.000      0.0000E+00
5 0.0000E+00 0.0000E+00
6 0.0000E+00 0.0000E+00
7 0.0000E+00 0.0000E+00

ELECT DL ARR NO ARRAY    = ( 10X 2)
1 0.0000E+00 0.0000E+00
2 0.0000E+00 0.0000E+00
3 0.0000E+00 0.0000E+00
4 0.0000E+00 0.0000E+00
5 0.0000E+00 0.0000E+00
6 0.0000E+00 0.0000E+00
7 0.0000E+00 0.0000E+00
```

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SS ARR NO ARRAY = (10X 1)
 1 1.000
 2 0.0000E+00
 3 0.0000E+00
 4 0.0000E+00
 5 0.0000E+00
 6 0.0000E+00
 7 0.0000E+00

ARR ROT ANGLE ARRAY = (10X 1) DEG
 1 0.0000E+00
 2 0.0000E+00
 3 0.0000E+00
 4 0.0000E+00
 5 0.0000E+00
 6 0.0000E+00
 7 0.0000E+00

ARRANGEMENT OPERATION
 PRPLN GEN OP ARRAY = (2X 2)
 1 2.000 0.0000E+00
 2 1.000 0.0000E+00

SEP SS GEN OP ARRAY = (2X 1)
 1 1.000
 2 0.0000E+00

VSCF SS CYCLO OP ARRAY = (2X 1)
 1 2.000
 2 1.000

MACHY CLR ARRAY = (7X 1) FT
 1 3.000
 2 1.200
 3 0.0000E+00
 4 6.000
 5 3.300
 6 0.0000E+00
 7 0.0000E+00

HULL CLR ARRAY = (4X 1) FT
 1 1.000
 2 1.000
 3 0.0000E+00
 4 0.2500

EXPAND AREA RATIO = 1.0000
 SHAFT SUPPORT TYPE IND = POD
 CR SHAFT CLEAR RATIO = 1.38000
 POD DES BEND STRESS = 3.00000 KSI
 POD MIDBODY FRAC = 0.500000

SS ENGINES
 SS ENG MODEL IND = DDA-571K

I> ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 8/19/93 08.02.23.
GRAPHIC DISPLAY NO. 1 - SHIP MACHINERY LAYOUT

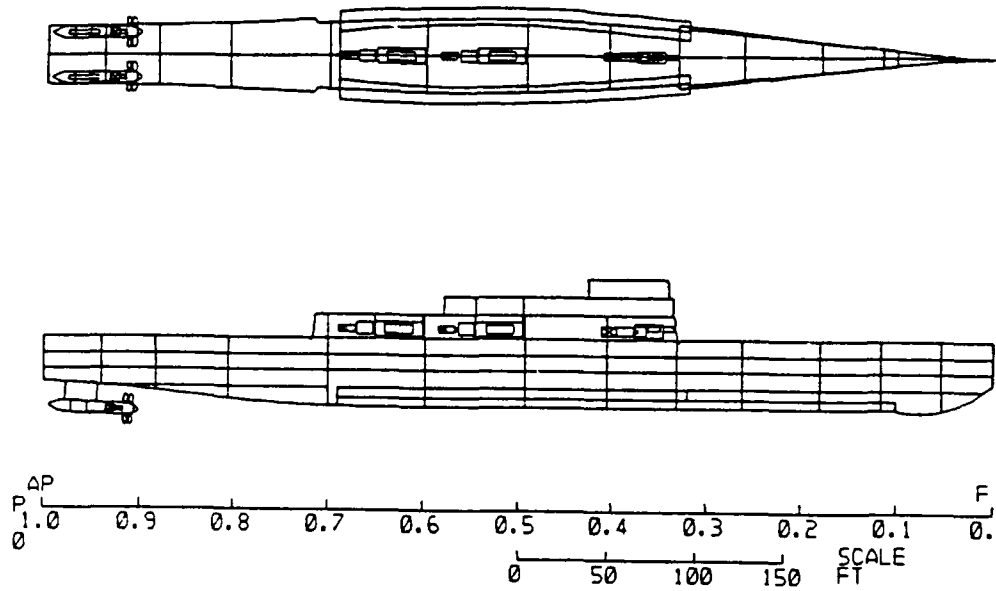


Fig. B.20. "POD" Machinery Arrangement

I> ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 8/19/93 08.04.20.
GRAPHIC DISPLAY NO. 3 - MR PLAN VIEWS (MMR1)
PAGE 3 OF 5

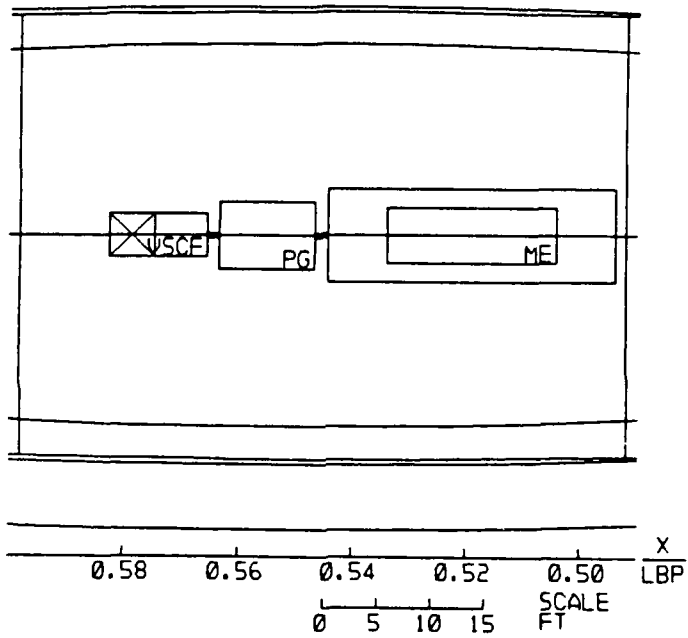


Fig. B.21. "POD" Main Machinery Room Plan View

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I) ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 8/19/93 08.04.20.
GRAPHIC DISPLAY NO. 5 - PROPULSION APPENDAGES PROFILE VIEW

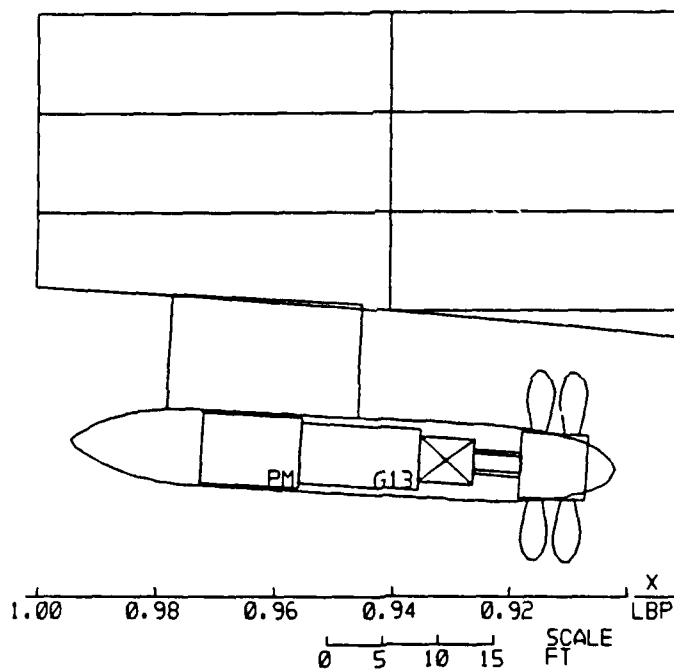


Fig. B.22. "POD" Drive Line Machinery

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ASSET/MONOSC VERSION 3.2 - DESIGN SUMMARY - POD

PRINTED REPORT NO. 1 - SUMMARY **

PRINCIPAL CHARACTERISTICS - FT				WEIGHT SUMMARY - LTON	
LBP			529.0	GROUP 1 - HULL STRUCTURE	2160.0
LOA			529.0	GROUP 2 - PROP PLANT	377.3
BEAM, DWL			55.0	GROUP 3 - ELECT PLANT	232.6
BEAM, WEATHER DECK			55.0	GROUP 4 - COMM + SURVEIL	385.7
DEPTH @ STA 10			51.5	GROUP 5 - AUX SYSTEMS	592.6
DRAFT TO KEEL DWL			13.8	GROUP 6 - OUTFIT + FURN	441.4
DRAFT TO KEEL LWL			13.8	GROUP 7 - ARMAMENT	399.6
FREEBORD @ STA 3			24.2	-----	
GMT			4.3	SUM GROUPS 1-7	4589.3
CP			0.578	DESIGN MARGIN	0.0
CX			0.830	-----	
SPEED(KT): MAX= 31.8 SUST= 30.0				LIGHTSHIP WEIGHT	4589.3
ENDURANCE: 6000.0 NM AT 20.0 KTS				LOADS	1219.2
TRANSMISSION TYPE: ELECT				-----	
MAIN ENG: 2 RGT @ 25580.0 HP				FULL LOAD DISPLACEMENT	5808.5
SHAFT POWER/SHAFT: 22392.5 HP				FULL LOAD KG: FT	22.7
PROPELLERS: 2 - CR - 17.0 FT DIA				MILITARY PAYLOAD WT - LTON	1182.7
SEP GEN: 1 GT @ 3000.0 KW				USABLE FUEL WT - LTON	727.5
PD GEN: 2 VSCF @ 4000.0 KW				AREA SUMMARY - FT2	
24 HR LOAD 1622.9				HULL AREA	65712.4
MAX MARG ELECT LOAD 3229.6				SUPERSTRUCTURE AREA	5652.3
MANNING				-----	
OFF	CPO	ENL	TOTAL	TOTAL AREA	71364.7
22	19	229	270	VOLUME SUMMARY - FT3	
ACCOM	25	21	298	HULL VOLUME	770214.6
				SUPERSTRUCTURE VOLUME	57653.4

				TOTAL VOLUME	827868.0

** MAIN ENG REQUIRED POWER IS REPORTED

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ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - POD

PRINTED REPORT NO. 1 - HULL GEOMETRY SUMMARY

HULL OFFSETS IND-GIVEN	MIN BEAM, FT	30.00
HULL DIM IND-NONE	MAX BEAM, FT	110.00
MARGIN LINE IND-GIVEN	HULL FLARE ANGLE, DEG	
HULL STA IND-GIVEN	FORWARD BULWARK, FT	0.00
HULL BC IND-GIVEN		

HULL PRINCIPAL DIMENSIONS (ON DWL)

LBP, FT	529.00	PRISMATIC COEF	0.578
LOA, FT	529.00	MAX SECTION COEF	0.830
BEAM, FT	55.05	WATERPLANE COEF	0.734
BEAM @ WEATHER DECK, FT	55.05	LCB/LCP	0.515
DRAFT, FT	13.80	HALF SIDING WIDTH, FT	0.00
DEPTH STA 0, FT	38.00	BOT RAKE, FT	0.00
DEPTH STA 3, FT	38.00	RAISED DECK HT, FT	13.50
DEPTH STA 10, FT	51.50	RAISED DECK FWD LIM, STA	6.60
DEPTH STA 20, FT	38.00	RAISED DECK AFT LIM, STA	14.34
FREEBOARD @ STA 3, FT	24.20	BARE HULL DISPL, LTON	5506.59
STABILITY BEAM, FT	54.83	AREA BEAM, FT	88.12

BARE HULL DATA ON LWL

STABILITY DATA ON LWL

LGTH ON WL, FT	529.00	KB, FT	7.93
BEAM, FT	55.05	BMT, FT	19.15
DRAFT, FT	13.80	KG, FT	22.71
FREEBOARD @ STA 3, FT	24.20	FREE SURF COR, FT	0.10
PRISMATIC COEF	0.578	SERV LIFE KG ALW, FT	0.00
MAX SECTION COEF	0.830		
WATERPLANE COEF	0.734	GMT, FT	4.27
WATERPLANE AREA, FT2	21385.32	GML, FT	1716.94
WETTED SURFACE, FT2	27372.76	GMT/B AVAIL	0.078
		GMT/B REQ	0.075
BARE HULL DISPL, LTON	5507.75		
APPENDAGE DISPL, LTON	300.72		
FULL LOAD WT, LTON	5808.47		

ASSET/MONOSC VERSION 3.2 - SPACE MODULE - POD

PRINTED REPORT NO. 1 - SUMMARY

COLL PROTECT SYS-NONE	SONAR DOME-PRESENT	UNIT COMMANDER-NONE	
FULL LOAD WT, LTON	5808.5	HAB STANDARD FAC	0.260
TOTAL CREW ACC	298.	PASSWAY MARGIN FAC	0.000
HULL AVG DECK HT, FT	9.45	AC MARGIN FAC	0.000
MR VOLUME, FT3	101797.	SPACE MARGIN FAC	0.000

	AREA FT2		VOL FT3	
	PAYLOAD REQUIRED	TOTAL REQUIRED	TOTAL AVAILABLE	TOTAL ACTUAL
DKHS ONLY	5874.0	9394.7	5652.3	57653.
HULL OR DKHS	14472.0	61975.6	65712.4	770215.
TOTAL	20346.0	71370.3	71364.7	827868.

SSCS GROUP	TOTAL	DKHS	PERCENT
	AREA FT2	AREA FT2	TOTAL AREA
1. MISSION SUPPORT	23138.2	6562.5	32.4
2. HUMAN SUPPORT	18836.7	886.0	26.4
3. SHIP SUPPORT	28143.7	1740.0	39.4
4. SHIP MOBILITY SYSTEM	1251.7	206.2	1.8
5. UNASSIGNED			0.0
TOTAL	71370.3	9394.7	100.0

ASSET/MONOSC VERSION 3.2 - RESISTANCE MODULE - POD

PRINTED REPORT NO. 1 - SUMMARY

RESID RESIST IND	REGR	BILGE KEEL IND	NONE
FRICTION LINE IND	ITTC	SHAFT SUPPORT TYPE IND	POD
ENDUR DISP IND	FULL LOAD	PRPLN SYS RESIST IND	CALC
ENDUR CONFIG IND	NO TS	PROP TYPE IND	CR
SONAR DRAG IND	APPENDAGE	SONAR DOME IND	PRESENT
SKEG IND	PRESENT	RUDDER TYPE IND	SPADE
FULL LOAD WT, LTON	5808.5	CORR ALW	0.00050
AVG ENDUR DISP, LTON	5808.5	DRAG MARGIN FAC	0.110
USABLE FUEL WT, LTON	727.5	TRAILSHAFT PWR FAC	
NO FIN PAIRS	0.	PRPLN SYS RESIST FRAC	
PROP TIP CLEAR RATIO	0.25	MAX SPEED	0.132
NO PROP SHAFTS	2.	SUSTN SPEED	0.147
PROP DIA, FT	17.00	ENDUR SPEED	0.233

CONDITION	SPEED	EFFECTIVE HORSEPOWER, HP						DRAG
	KT	FRIC	RESID	APPDG	WIND	MARGIN	TOTAL	LBF
MAX	31.76	14416.	12171.	3916.	520.	3412.	34435.	353339.
SUSTN	30.00	12213.	8466.	3419.	438.	2699.	27235.	295832.
ENDUR	20.00	3752.	1227.	2083.	130.	791.	7982.	130055.

ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE - POD

PRINTED REPORT NO. 1 - SUMMARY

HULL SUBDIV IND-GIVEN		INNER BOT IND-PRESENT	
SHAFT SUPPORT TYPE IND-POD			
LBP, FT	529.00	HULL AVG DECK HT, FT	9.45
DEPTH STA 10, FT	51.50		
HULL VOLUME, FT3	770215.	NO INTERNAL DECKS	4
MR VOLUME, FT3	101797.	NO TRANS BHDS	12
TANKAGE VOL REQ, FT3	38098.	NO LONG BHDS	0
EXCESS TANKAGE, FT3	45988.	NO MACHY RMS	5
		NO PROP SHAFTS	2
ARR AREA LOST TANKS, FT2	101.6		
HULL ARR AREA AVAIL, FT2	65712.4		

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - POD

PRINTED REPORT NO. 1 - SUMMARY

TRANS TYPE IND	ELECT	MAX SPEED, KT	31.76
ELECT PRPLN TYPE IND	ACC-AC	SUSTN SPEED IND	GIVEN
SHAFT SUPPORT TYPE IND	POD	SUSTN SPEED, KT	30.00
NO PROP SHAFTS	2.	ENDUR SPEED IND	GIVEN
ENDUR CONFIG IND	NO TS	ENDUR SPEED, KT	20.00
SEC ENG USAGE IND		DESIGN MODE IND	ENDURANCE
MAX MARG ELECT LOAD, KW	3230.	ENDURANCE, NM	6000.
AVG 24 HR ELECT LOAD, KW	1623.	USABLE FUEL WT, LTON	727.5
SWBS 200 GROUP WT, LTON	377.3		
SWBS 300 GROUP WT, LTON	232.6		

ARRANGEMENT OR SS GEN	TYPE	NO INSTALLED	NO ONLINE MAX+SUSTN	NO ONLINE ENDURANCE
ELECT PG ARR 1 IND	M-PG	2	2	1
ELECT PG ARR 2 IND	M-CG-PG	0	0	0
ELECT DL ARR IND	MTR-BCE	2	2	2
SEP SS GEN	3000. KW	1	1	0
VSCF SS CYCLO	4000. KW	2	2	1

	MAIN ENG	SEC ENG	SS ENG
ENG SELECT IND	GIVEN		GIVEN
ENG MODEL IND	OTHER		DDA-571K
ENG TYPE IND	RGT		GT
ENG SIZE IND	GIVEN		GIVEN
NO INSTALLED	2	0	1
ENG PWR AVAIL, HP	26400.		6365.
ENG RPM	3600.0		11500.0
ENG SFC, LBM/HP-HR	0.324		.455
ENG LOAD FRAC	0.959		.665

PRINTED REPORT NO. 12 - POWERING - POD

SUSTN SPEED IND-GIVEN
 ENDUR SPEED IND-GIVEN
 TRANS EFF IND-CALC

100 PCT POWER TRANS EFF	0.9282
25 PCT POWER TRANS EFF	0.8865

	MAX SPEED	SUSTN SPEED	ENDUR SPEED
SHIP SPEED, KT	31.76	30.00	20.00
PROP RPM	106.9	100.1	66.6
NO OP PROP SHAFTS	2	2	2
EHP (/SHAFT), HP	17218.	13617.	3991.
PROPULSIVE COEF	0.769	0.766	0.765
ENDUR PWR ALW	1.0	1.0	1.1
SHP (/SHAFT), HP	22393.	17778.	5736.
TRANS EFFY	0.928	0.921	0.887
CP PROP TRANS EFFY MULT	1.000	1.000	1.000
PROPUL PWR (/SHAFT), HP	24126.	19301.	6465.
PD GEN PWR (/SHAFT), HP	1454.	1454.	1139.
BHP (/SHAFT), HP	25580.	20755.	7604.

PRINTED REPORT NO. 13 - HULL STRUCTURE AND MISCELLANEOUS WEIGHT - POD

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
160	SPECIAL STRUCTURES			
161	CASTINGS, FORGINGS, AND WELDMENTS	100.8	443.77	3.18
162	STACKS AND MASTS	0.0	315.87	62.80
180	FOUNDATIONS			
* 182	PROPULSION PLANT FOUNDATIONS	39.7	403.90	31.54
* 183	ELECTRIC PLANT FOUNDATIONS	14.1	253.64	38.86

PRINTED REPORT NO. 14 - PROPULSION PLANT WEIGHT - POD

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
200	PROPULSION PLANT	377.3	385.24	21.28
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	167.3	393.98	26.11
233	PROPULSION INTERNAL COMBUSTION ENGINES	0.0	0.00	0.00
* 234	PROPULSION GAS TURBINES	62.9	302.59	43.43
* 235	ELECTRIC PROPULSION	104.4	449.08	15.68
240	TRANSMISSION AND PROPULSOR SYSTEMS	83.9	491.51	-2.63
241	PROPULSION REDUCTION GEARS	33.2	500.10	-2.16
242	PROPULSION CLUTCHES AND COUPLINGS	0.0	0.00	0.00
243	PROPULSION SHAFTING	5.7	487.70	-2.84
244	PROPULSION SHAFT BEARINGS	15.3	491.62	-2.62
245	PROPULSORS	29.7	482.61	-3.12
250	PRPLN SUPPORT SYS (EXCEPT FUEL+LUBE OIL)	73.2	305.00	40.73
* 251	COMBUSTION AIR SYSTEM	18.0	274.09	46.80
252	PROPULSION CONTROL SYSTEM	13.8	302.59	33.47
256	CIRCULATING AND COOLING SEA WATER SYSTEM	9.3	333.27	18.54
* 259	UPTAKES (INNER CASING)	32.2	315.17	46.83
260	PRPLN SUPPORT SYS (FUEL+LUBE OIL)	32.1	294.05	20.24
261	FUEL SERVICE SYSTEM	9.4	276.14	37.43
262	MAIN PROPULSION LUBE OIL SYSTEM	16.2	302.59	12.00
264	LUBE OIL FILL, TRANSFER, AND PURIF	6.5	298.59	16.00
290	SPECIAL PURPOSE SYSTEMS	20.8	309.58	11.99
298	OPERATING FLUIDS	15.6	317.40	8.00
299	REPAIR PARTS AND SPECIAL TOOLS	5.1	285.66	24.20

PRINTED REPORT NO. 15 - ELECTRIC PLANT WEIGHT - POD

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
300	ELECTRIC PLANT	732.6	267.54	37.83
310	ELECTRIC POWER GENERATION	94.9	249.50	36.03
311	SHIP SERVICE POWER GENERATION	55.6	250.88	43.48
313	BATTERIES AND SERVICE FACILITIES	29.2	250.88	10.30
314	POWER CONVERSION EQUIPMENT	10.1	238.05	69.23
320	POWER DISTRIBUTION SYSTEMS	98.1	283.48	36.39
321	SHIP SERVICE POWER CABLE	69.2	280.37	27.00
324	SWITCHGEAR AND PANELS	28.8	290.95	58.93
330	LIGHTING SYSTEM	29.4	278.28	46.76
331	LIGHTING DISTRIBUTION	17.8	280.37	46.35
332	LIGHTING FIXTURES	11.6	275.08	47.38
340	POWER GENERATION SUPPORT SYSTEMS	6.4	178.62	52.06
342	DIESEL SUPPORT SYSTEMS	0.0	0.00	0.00
343	TURBINE SUPPORT SYSTEMS	6.4	178.62	52.06
390	SPECIAL PURPOSE SYSTEMS	3.9	370.19	27.42
398	OPERATING FLUIDS	1.1	250.88	43.48
399	REPAIR PARTS AND SPECIAL TOOLS	2.8	417.91	21.00

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

PRINTED REPORT NO. 18 - MACHINERY SPACE REQUIREMENTS - POD

MACHINERY ROOM VOLUME REQUIREMENTS

VOLUME CATEGORY	VOLUME, FT3
SWBS GROUP 200	91937.
PROPULSION POWER GENERATION	28867.
PROPULSION ENGINES	11112.
PROPULSION REDUCTION GEARS AND GENERATORS	17755.
DRIVELINE MACHINERY	0.
REDUCTION AND BEVEL GEARS WITH Z-DRIVE	0.
ELECTRIC PROPULSION MOTORS AND GEARS	0.
REMOTELY-LOCATED THRUST BEARINGS	0.
PROPELLER SHAFT	0.
ELECTRIC PROPULSION MISCELLANEOUS EQUIPMENT	13383.
CONTROLS	1770.
BRAKING RESISTORS	1481.
MOTOR AND GENERATOR EXCITERS	2621.
SWITCHGEAR	1741.
POWER CONVERTERS	3321.
DEIONIZED COOLING WATER SYSTEMS	2448.
RECTIFIERS	0.
HELIUM REFRIGERATION SYSTEMS	0.
PROPULSION AUXILIARIES	49687.
PROPULSION LOCAL CONTROL CONSOLES	3510.
CP PROP HYDRAULIC OIL POWER MODULES	0.
FUEL OIL PUMPS	23938.
LUBE OIL PUMPS	3327.
LUBE OIL PURIFIERS	15329.
ENGINE LUBE OIL CONDITIONERS	602.
SEAWATER COOLING PUMPS	2982.
SWBS GROUP 300	18837.
ELECTRIC PLANT POWER GENERATION	0.
ELECTRIC PLANT ENGINES	0.
ELECTRIC PLANT GENERATORS AND GEARS	0.
SHIP SERVICE SWITCHBOARDS	17318.
CYCLOCONVERTERS	1519.
SWBS GROUP 500	44466.
AUXILIARY MACHINERY	44466.
AIR CONDITIONING PLANTS	7387.
AUXILIARY BOILERS	6360.
FIRE PUMPS	4523.
DISTILLING PLANTS	15054.
AIR COMPRESSORS	8827.
ROLL FIN PAIRS	0.
SEWAGE PLANTS	2314.

ARRANGEABLE AREA REQUIREMENTS

SSCS	GROUP NAME	-----FT2-----	
		HULL/DKHS	DKHS ONLY
3.4X	AUXILIARY MACHINERY DELTA	4372.5*	0.0
3.511	SHIP SERVICE POWER GENERATION	2568.3	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	36.7	72.6
4.143	GAS TURBINE ENG EXHAUST	68.8	133.6

NOTE: * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

ASSET/MONOSC VERSION 3.2 - WEIGHT MODULE - POD

PRINTED REPORT NO. 1 - SUMMARY

SWBS	GROUP	WEIGHT		LCG	VCG	RESULTANT ADJ	
		LTON	PER CENT	FT	FT	WT-LTON	VCG-FT
100	HULL STRUCTURE	2160.0	37.2	272.82	22.81	42.2	.20
200	PROP PLANT	377.3	6.5	385.24	21.28		
300	ELECT PLANT	232.6	4.0	267.54	37.83		
400	COMM + SURVEIL	385.7	6.6	201.02	30.96	134.6	1.36
500	AUX SYSTEMS	592.6	10.2	290.95	29.14	25.0	.18
600	OUTFIT + FURN	441.4	7.6	264.50	25.65		
700	ARMAMENT	399.6	6.9	238.05	31.38	397.6	2.14
M11	D+B WT MARGIN		0.0	274.27			

D+B KG MARGIN							

L I G H T S H I P		4589.3	79.0	274.27	25.97	599.4	3.89

F00	FULL LOADS	1219.2	21.0	265.98	10.43	328.6	1.26
F10	CREW + EFFECTS	30.2		248.63	31.64		
F20	MISS REL EXPEN	263.6		232.76	25.20		
F30	SHIPS STORES	42.5		285.66	23.73		
F40	FUELS + LUBRIC	838.6		277.38	4.58		
F50	FRESH WATER	44.3			.96		
F60	CARGO						
M24	FUTURE GROWTH						

FULL LOAD WT		5808.5	100.0	272.53	22.71	928.0	5.15

ASSET/MONOSC VERSION 3.2 - SEAKEEPING ANALYSIS - POD

PRINTED REPORT NO. 1 - SUMMARY

APPENDAGE IND-WITH

FULL LOAD WT, LTON 5808.5

	FULL LOAD

BALES RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL DISP)	12.961
RANK OF THE SYNTHESIZED SHIP (NORMALIZED)	8.155
RANK OF THE CLOSEST DATA BASE HULL (NORMALIZED)	7.930
ID NO OF CLOSEST DATA BASE SHIP	2
MCCREIGHT RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL SHIP)	17.995
RANK OF THE CLOSEST DATA BASE HULL	17.616
ID NO OF CLOSEST DATA BASE SHIP	43

ASSET/MONOSC VERSION 3.2 - COST ANALYSIS - POD

PRINTED REPORT NO. 1 - SUMMARY

YEAR \$	1992.	NO OF SHIPS ACQUIRED	50.
INFLATION ESCALATION FAC	2.149	SERVICE LIFE, YR	30.0
LEARNING RATE	0.970	ANNUAL OPERATING HRS	2500.0
FUEL COST, \$/GAL	2.579	MILITARY P/L, LTON	1182.7
PAYLOAD FUEL RATE, LTON/HR	0.33	LIGHTSHIP WT, LTON	4589.3
SHIP FUEL RATE, LTON/HR	2.42	FULL LOAD WT, LTON	5808.5

COST ITEM	COSTS(MILLIONS OF DOLLARS)		
	TOT SHIP	* PAYLOAD	= TOTAL
LEAD SHIP	921.5	807.0*	1728.5
FOLLOW SHIP	431.1	710.4*	1141.5
Avg ACQUISITION COST/SHIP(50 SHIPS)	386.2	712.3*	1098.5
LIFE CYCLE COST/SHIP(30 YEARS)			3214.1
TOTAL LIFE CYCLE COST(30 YEARS)			160706.1
DISCOUNTED LIFE CYCLE COST/SHIP			411.0**
DISCOUNTED TOTAL LIFE CYCLE COST			20591.0**

*ESTIMATED VALUE

**DISCOUNTED AT 10 PERCENT

PRINTED REPORT NO. 2 - UNIT ACQUISITION COSTS - POD

SWBS GROUP	UNITS	INPUTS	KN FACTORS	LEAD	FOLLOW	
				SHIP COSTS \$K	SHIP COSTS \$K	
100	HULL STRUCTURE	LTON	2160.0	1.00	27372.	25730.
200	PROPULSION PLANT	HP	48252.0	2.35	57044.	53621.
300	ELECTRIC PLANT	LTON	232.6	1.00	22973.	21595.
400	COMMAND+SURVEILLANCE	LTON	385.7	3.15	29003.	27262.
500	AUX SYSTEMS	LTON	592.6	1.53	45899.	43145.
600	OUTFIT+FURNISHINGS	LTON	441.4	1.00	25100.	23594.
700	ARMAMENT	LTON	399.6	1.00	6658.	6259.
	MARGIN	LTON	0.0		0.	0.
800	DESIGN+ENGINEERING		26.06		331233.	36600.
900	CONSTRUCTION SERVICES		4.25		54961.	51663.
TOTAL CONSTRUCTION COST					600243.	289470.
CONSTRUCTION COST					600243.	289470.
PROFIT(15.0 PERCENT OF CONSTRUCTION COST)					90036.	43420.
PRICE					690279.	332890.
CHANGE ORDERS(12/8 PERCENT OF PRICE)					82834.	26631.
NAVSEA SUPPORT(2.5 PERCENT OF PRICE)					17257.	8322.
POST DELIVERY CHARGES(5 PERCENT OF PRICE)					34514.	16645.
OUTFITTING(4 PERCENT OF PRICE)					27611.	13316.
H/M/E + GROWTH(10 PERCENT OF PRICE)					69028.	33289.
TOTAL SHIP COST					921523.	431093.
ESTIMATED PAYLOAD COST					806991.	710373.
SHIP PLUS PAYLOAD COST					1728514.	1141465.
ADJUSTED FIRST UNIT SHIP COST, \$K				458609.2		
COMBAT SYSTEM WEIGHT, LTON				1182.7		
PROPULSION SYSTEM WEIGHT, LTON				377.3		
ADJUSTED FIRST UNIT SHIP COST EQUALS						
FOLLOW SHIP TOTAL COST DIVIDED BY				0.940		

NOSSTG: 2-WR-21 ICR Gas Turbine Propulsion Engines (25557 hp)
2-AC Liquid-cooled Propulsion Generators (28 mw)
2-Geared AC Liquid-cooled Propulsion Motors (27.2 mw)
2-Contrarotating Bi-coupled Epicyclic Reduction Gears
2-Contrarotating Propellers (17', 1.0EAR)
2-POD-Supported Contrarotating Shafts
2-Steerable PODs
Transom Stern
6000 N.Mile Range
2-VSCF Propulsion Derived Ship Service Systems (4000 kw)

This option is similiar to the preceding one ("POD") except the DDA-571K separate ship service engine/generator set is removed. This is accomplished as follows:

	SS ARR NO ARRAY	= (10X 1)
1	0.0000E+00	
2	0.0000E+00	
3	0.0000E+00	
4	0.0000E+00	
5	0.0000E+00	
6	0.0000E+00	
7	0.0000E+00	

The previous adjustment for pedestal weight (W183) reduction is no longer necessary and is deleted.

I) ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 8/19/93 08.09.03.
GRAPHIC DISPLAY NO. 1 - SHIP MACHINERY LAYOUT

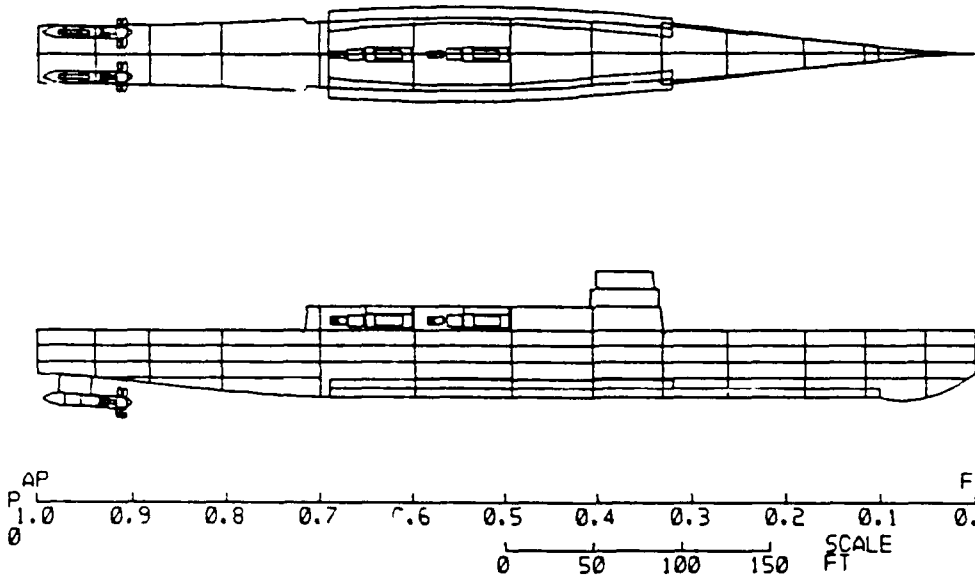


Fig. B.23. "NOSSTG" Machinery Arrangement

B-104

ASSET/MONOSC VERSION 3.2 - DESIGN SUMMARY - NOSSTG

PRINTED REPORT NO. 1 - SUMMARY **

PRINCIPAL CHARACTERISTICS - FT		WEIGHT SUMMARY - LTON	
LBP	529.0	GROUP 1 - HULL STRUCTURE	2081.3
LOA	529.0	GROUP 2 - PROP PLANT	377.0
BEAM, DWL	55.0	GROUP 3 - ELECT PLANT	187.3
BEAM, WEATHER DECK	55.0	GROUP 4 - COMM + SURVEIL	385.3
DEPTH @ STA 10	51.5	GROUP 5 - AUX SYSTEMS	575.3
DRAFT TO KEEL DWL	13.8	GROUP 6 - OUTFIT + FURN	429.9
DRAFT TO KEEL LWL	13.5	GROUP 7 - ARMAMENT	399.6
FREEBOARD @ STA 3	24.5	-----	-----
GMT	5.3	SUM GROUPS 1-7	4435.7
CP	0.578	DESIGN MARGIN	0.0
CX	0.830	-----	-----
SPEED(KT): MAX= 31.7 SUST= 30.0		LIGHTSHIP WEIGHT	4435.7
ENDURANCE: 6000.0 NM AT 20.0 KTS		LOADS	1207.4
TRANSMISSION TYPE: ELECT		-----	-----
MAIN ENG: 2 RGT @ 25557.0 HP		FULL LOAD DISPLACEMENT	5643.1
SHAFT POWER/SHAFT: 21908.3 HP		FULL LOAD KG: FT	22.0
PROPELLERS: 2 - CR - 17.0 FT DIA		MILITARY PAYLOAD WT - LTON	1182.7
PD GEN: 2 VSCF @ 4000.0 KW		USABLE FUEL WT - LTON	716.2
24 HR LOAD 1586.4		AREA SUMMARY - FT2	
MAX MARG ELECT LOAD 3139.2		HULL AREA -	65712.4
		SUPERSTRUCTURE AREA -	2096.6
		-----	-----
		TOTAL AREA	67809.0
		VOLUME SUMMARY - FT3	
OFF	CPO	ENL	TOTAL
MANNING 22	19	229	270
ACCOM 25	21	252	298
		-----	-----
		TOTAL VOLUME	791599.9

** MAIN ENG REQUIRED POWER IS REPORTED

ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - NOSSTG

PRINTED REPORT NO. 1 - HULL GEOMETRY SUMMARY

HULL OFFSETS IND-GIVEN	MIN BEAM, FT	30.00
HULL DIM IND-NONE	MAX BEAM, FT	110.00
MARGIN LINE IND-GIVEN	HULL FLARE ANGLE, DEG	
HULL STA IND-GIVEN	FORWARD BULWARK, FT	0.00
HULL BC IND-GIVEN		

HULL PRINCIPAL DIMENSIONS (ON DWL)

LBP, FT	529.00	PRISMATIC COEF	0.578
LOA, FT	529.00	MAX SECTION COEF	0.830
BEAM, FT	55.05	WATERPLANE COEF	0.734
BEAM @ WEATHER DECK, FT	55.05	LCB/LCP	0.515
DRAFT, FT	13.80	HALF SIDING WIDTH, FT	0.00
DEPTH STA 0, FT	38.00	BOT RAKE, FT	0.00
DEPTH STA 3, FT	38.00	RAISED DECK HT, FT	13.50
DEPTH STA 10, FT	51.50	RAISED DECK FWD LIM, STA	6.60
DEPTH STA 20, FT	38.00	RAISED DECK AFT LIM, STA	14.34
FREEBOARD @ STA 3, FT	24.20	BARE HULL DISPL, LTON	5506.59
STABILITY BEAM, FT	53.74	AREA BEAM, FT	209.45

BARE HULL DATA ON LWL

STABILITY DATA ON LWL

LGTH ON WL, FT	528.65	KB, FT	7.76
BEAM, FT	55.05	BMT, FT	19.66
DRAFT, FT	13.53	KG, FT	22.01
FREEBOARD @ STA 3, FT	24.47	FREE SURF COR, FT	0.10
PRISMATIC COEF	0.574	SERV LIFE KG ALW, FT	0.00
MAX SECTION COEF	0.827		
WATERPLANE COEF	0.734	GMT, FT	5.30
WATERPLANE AREA, FT2	21350.63	GML, FT	1760.22
WETTED SURFACE, FT2	27072.99	GMT/B AVAIL	0.096
		GMT/B REQ	0.075
BARE HULL DISPL, LTON	5342.40		
APPENDAGE DISPL, LTON	300.68		
FULL LOAD WT, LTON	5643.08		

ASSET/MONOSC VERSION 3.2 - SPACE MODULE - NOSSTG

PRINTED REPORT NO. 1 - SUMMARY

COLL PROTECT SYS-NONE	SONAR DOME-PRESENT	UNIT COMMANDER-NONE	
FULL LOAD WT, LTON	5643.1	HAB STANDARD FAC	0.260
TOTAL CREW ACC	298.	PASSWAY MARGIN FAC	0.000
HULL AVG DECK HT, FT	9.45	AC MARGIN FAC	0.000
MR VOLUME, FT3	101797.	SPACE MARGIN FAC	0.000

	AREA FT2		VOL FT3
	PAYLOAD	TOTAL	TOTAL
	REQUIRED	REQUIRED	ACTUAL
		AVAILABLE	
DKHS ONLY	5874.0	8753.2	21385.
HULL OR DKHS	14472.0	59051.8	770215.
TOTAL	20346.0	67805.0	791600.

SSCS	GROUP	TOTAL AREA FT2	DKHS AREA FT2	PERCENT TOTAL AREA
1.	MISSION SUPPORT	23108.5	6561.8	34.1
2.	HUMAN SUPPORT	18836.7	886.0	27.8
3.	SHIP SUPPORT	24917.3	1305.4	36.7
4.	SHIP MOBILITY SYSTEM	942.5	0.0	1.4
5.	UNASSIGNED			0.0
	TOTAL	67805.0	8753.2	100.0

ASSET/MONOSC VERSION 3.2 - RESISTANCE MODULE - NOSSTG

PRINTED REPORT NO. 1 - SUMMARY

RESID RESIST IND	REGR	BILGE KEEL IND	NONE
FRICTION LINE IND	ITTC	SHAFT SUPPORT TYPE IND	POD
ENDUR DISP IND	FULL LOAD	PRPLN SYS RESIST IND	CALC
ENDUR CONFIG IND	NO TS	PROP TYPE IND	CR
SONAR DRAG IND	APPENDAGE	SONAR DOME IND	PRESENT
SKEG IND	PRESENT	RUDDER TYPE IND	SPADE
FULL LOAD WT, LTON	5643.1	CORR ALW	0.00050
AVG ENDUR DISP, LTON	5643.1	DRAG MARGIN FAC	0.110
USABLE FUEL WT, LTON	716.2	TRAILSHAFT PWR FAC	
NO FIN PAIRS	0.	PRPLN SYS RESIST FRAC	
PROP TIP CLEAR RATIO	0.25	MAX SPEED	0.135
NO PROP SHAFTS	2.	SUSTN SPEED	0.150
PROP DIA, FT	17.00	ENDUR SPEED	0.239
CONDITION SPEED-----	EFFECTIVE HORSEPOWER, HP-----		
KT	FRIC	RESID	APPDG
WIND	MARGIN	TOTAL	DRAG
MAX	31.75	14245.	11731.
SUSTN	30.00	12080.	8111.
ENDUR	20.00	3711.	1113.

ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE - NOSSTG

PRINTED REPORT NO. 1 - SUMMARY

HULL SUBDIV IND-GIVEN		INNER BOT IND-PRESENT	
SHAFT SUPPORT TYPE IND-POD			
LBP, FT	529.00	HULL AVG DECK HT, FT	9.45
DEPTH STA 10, FT	51.50		
HULL VOLUME, FT3	770215.	NO INTERNAL DECKS	4
MR VOLUME, FT3	101797.	NO TRANS BHDS	12
TANKAGE VOL REQ, FT3	37588.	NO LONG BHDS	0
		NO MACHY RMS	5
		NO PROP SHAFTS	2
ARR AREA LOST TANKS, FT2	101.6		
HULL ARR AREA AVAIL, FT2	65712.4		

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - NOSSTG

PRINTED REPORT NO. 1 - SUMMARY

TRANS TYPE IND	ELECT	MAX SPEED, KT	31.75
ELECT PRPLN TYPE IND	ACC-AC	SUSTN SPEED IND	GIVEN
SHAFT SUPPORT TYPE IND	POD	SUSTN SPEED, KT	30.00
NO PROP SHAFTS	2.	ENDUR SPEED IND	GIVEN
ENDUR CONFIG IND	NO TS	ENDUR SPEED, KT	20.00
SEC ENG USAGE IND		DESIGN MODE IND	ENDURANCE
MAX MARG ELECT LOAD, KW	3139.	ENDURANCE, MM	6000.
AVG 24 HR ELECT LOAD, KW	1586.	USABLE FUEL WT, LTON	716.2
SWBS 200 GROUP WT, LTON	377.0		
SWBS 300 GROUP WT, LTON	187.3		

ARRANGEMENT OR SS GEN	TYPE	NO INSTALLED	NO ONLINE MAX+SUSTN	NO ONLINE ENDURANCE
ELECT PG ARR 1 IND	M-PG	2	2	1
ELECT PG ARR 2 IND	M-CG-PG	0	0	0
ELECT DL ARR IND	MTR-BCE	2	2	2
SEP SS GEN	3000. KW	0	0	0
VSCF SS CYCLO	4000. KW	2	2	1

	MAIN ENG	SEC ENG	SS ENG
ENG SELECT IND	GIVEN		GIVEN
ENG MODEL IND	OTHER		DDA-571K
ENG TYPE IND	RCT		GT
ENG SIZE IND	GIVEN		GIVEN
NO INSTALLED	2	0	0
ENG PWR AVAIL, HP	26400.		6365.
ENG RPM	3600.0		11500.0
ENG SFC, LBM/HP-HR	0.324		.455
ENG LOAD FRAC	0.968		

PRINTED REPORT NO. 12 - POWERING - NOSSTG

SUSTN SPEED IND-GIVEN
 ENDUR SPEED IND-GIVEN
 TRANS EFF IND-CALC

100 PCT POWER TRANS EFF	0.9282
25 PCT POWER TRANS EFF	0.8865

	MAX SPEED	SUSTN SPEED	ENDUR SPEED
SHIP SPEED, KT	31.75	30.00	20.00
PROP RPM	105.4	98.7	65.7
NO OP PROP SHAFTS	2	2	2
EHP (/SHAFT), HP	16868.	13339.	3902.
PROPULSIVE COEF	0.770	0.767	0.766
ENDUR PWR ALW	1.0	1.0	1.1
SHP (/SHAFT), HP	21908.	17393.	5601.
TRANS EFFY	0.928	0.921	0.887
CP PROP TRANS EFFY MULT	1.000	1.000	1.000
PROPUL PWR (/SHAFT), HP	23604.	18883.	6314.
PD GEN PWR (/SHAFT), HP	1953.	1953.	1114.
BHP (/SHAFT), HP	25557.	20836.	7427.

PRINTED REPORT NO. 13 - HULL STRUCTURE AND MISCELLANEOUS WEIGHT - NOSSTG

SWBS	COMPONENT	WT, LTON	LCC, FT	VCG, FT
160	SPECIAL STRUCTURES			
161	CASTINGS, FORGINGS, AND WELDMENTS	99.4	444.64	3.14
162	STACKS AND MASTS	0.0	315.87	57.80
180	FOUNDATIONS			
* 182	PROPULSION PLANT FOUNDATIONS	39.7	404.13	31.46
* 183	ELECTRIC PLANT FOUNDATIONS	11.4	329.51	34.07

PRINTED REPORT NO. 14 - PROPULSION PLANT WEIGHT - NOSSTG

SWBS	COMPONENT	WT, LTON	LCC, FT	VCG, FT
200	PROPULSION PLANT	377.0	386.19	21.26
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	167.3	393.98	26.12
233	PROPULSION INTERNAL COMBUSTION ENGINES	0.0	0.00	0.00
* 234	PROPULSION GAS TURBINES	62.9	302.59	43.43
* 235	ELECTRIC PROPULSION	104.4	449.08	15.68
240	TRANSMISSION AND PROPULSOR SYSTEMS	84.1	491.57	-2.62
241	PROPULSION REDUCTION GEARS	33.8	500.08	-2.15
242	PROPULSION CLUTCHES AND COUPLINGS	0.0	0.00	0.00
243	PROPULSION SHAFTING	5.7	487.73	-2.83
244	PROPULSION SHAFT BEARINGS	14.9	491.60	-2.62
245	PROPULSORS	29.7	482.63	-3.12
250	PRPLN SUPPORT SYS (EXCEPT FUEL-LUBE OIL)	72.7	309.01	40.81
* 251	COMBUSTION AIR SYSTEM	18.0	289.31	46.80
252	PROPULSION CONTROL SYSTEM	13.5	302.59	33.47
256	CIRCULATING AND COOLING SEA WATER SYSTEM	9.1	333.27	18.54
* 259	UPTAKES (INNER CASING)	32.2	315.87	46.81
260	PRPLN SUPPORT SYS (FUEL-LUBE OIL)	32.2	294.05	20.24
261	FUEL SERVICE SYSTEM	9.4	276.14	37.43
262	MAIN PROPULSION LUBE OIL SYSTEM	16.3	302.59	12.00
264	LUBE OIL FILL, TRANSFER, AND PURIF	6.5	298.59	16.00
290	SPECIAL PURPOSE SYSTEMS	20.7	309.57	12.00
298	OPERATING FLUIDS	15.6	317.40	8.00
299	REPAIR PARTS AND SPECIAL TOOLS	5.1	285.66	24.20

PRINTED REPORT NO. 15 - ELECTRIC PLANT WEIGHT - NOSSTG

SWBS	COMPONENT	WT, LTON	LCC, FT	VCG, FT
300	ELECTRIC PLANT	187.3	293.79	36.56
310	ELECTRIC POWER GENERATION	61.9	314.53	32.40
311	SHIP SERVICE POWER GENERATION	23.3	329.51	43.43
313	BATTERIES AND SERVICE FACILITIES	28.5	329.51	10.30
314	POWER CONVERSION EQUIPMENT	10.1	238.05	69.18
320	POWER DISTRIBUTION SYSTEMS	95.3	283.48	36.37
321	SHIP SERVICE POWER CABLE	67.3	280.37	27.00
324	SWITCHGEAR AND PANELS	28.0	290.95	58.88
330	LIGHTING SYSTEM	28.8	278.34	46.75
331	LIGHTING DISTRIBUTION	17.8	280.37	46.35
332	LIGHTING FIXTURES	11.1	275.08	47.38
340	POWER GENERATION SUPPORT SYSTEMS	0.0	0.00	0.00
342	DIESEL SUPPORT SYSTEMS	0.0	0.00	0.00
343	TURBINE SUPPORT SYSTEMS	0.0	0.00	0.00
390	SPECIAL PURPOSE SYSTEMS	1.2	417.91	21.00
398	OPERATING FLUIDS	0.0	0.00	0.00
399	REPAIR PARTS AND SPECIAL TOOLS	1.2	417.91	21.00

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

PRINTED REPORT NO. 18 - MACHINERY SPACE REQUIREMENTS - NOSSTG

MACHINERY ROOM VOLUME REQUIREMENTS

VOLUME CATEGORY	VOLUME, FT3
SWBS GROUP 200	91903.
PROPULSION POWER GENERATION	28867.
PROPULSION ENGINES	11112.
PROPULSION REDUCTION GEARS AND GENERATORS	17755.
DRIVELINE MACHINERY	0.
REDUCTION AND BEVEL GEARS WITH Z-DRIVE	0.
ELECTRIC PROPULSION MOTORS AND GEARS	0.
REMOTELY-LOCATED THRUST BEARINGS	0.
PROPELLER SHAFT	0.
ELECTRIC PROPULSION MISCELLANEOUS EQUIPMENT	13383.
CONTROLS	1770.
BRAKING RESISTORS	1481.
MOTOR AND GENERATOR EXCITERS	2621.
SWITCHGEAR	1741.
POWER CONVERTERS	3321.
DEIONIZED COOLING WATER SYSTEMS	2448.
RECTIFIERS	0.
HELIUM REFRIGERATION SYSTEMS	0.
PROPULSION AUXILIARIES	49653.
PROPULSION LOCAL CONTROL CONSOLES	3510.
CP PROP HYDRAULIC OIL POWER MODULES	0.
FUEL OIL PUMPS	23938.
LUBE OIL PUMPS	3327.
LUBE OIL PURIFIERS	15329.
ENGINE LUBE OIL CONDITIONERS	602.
SEAWATER COOLING PUMPS	2948.
SWBS GROUP 300	18600.
ELECTRIC PLANT POWER GENERATION	0.
ELECTRIC PLANT ENGINES	0.
ELECTRIC PLANT GENERATORS AND GEARS	0.
SHIP SERVICE SWITCHBOARDS	17081.
CYCLOCONVERTERS	1519.
SWBS GROUP 500	44027.
AUXILIARY MACHINERY	44027.
AIR CONDITIONING PLANTS	7197.
AUXILIARY BOILERS	6360.
FIRE PUMPS	4416.
DISTILLING PLANTS	15054.
AIR COMPRESSORS	8685.
ROLL FIN PAIRS	0.
SEWAGE PLANTS	2314.

ARRANGEABLE AREA REQUIREMENTS

SSCS	GROUP NAME	-----FT2-----	
		HULL/DKHS	DKHS ONLY
3.4X	AUXILIARY MACHINERY DELTA	4297.3*	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	0.4	0.0
4.143	GAS TURBINE ENG EXHAUST	2.1	0.0

NOTE: * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

ASSET/MONOSC VERSION 3.2 - WEIGHT MODULE - NOSSTG

PRINTED REPORT NO. 1 - SUMMARY

SWBS	GROUP	WEIGHT		LCG	VCG	RESULTANT ADJ	
		LTON	PER CENT	FT	FT	WT-LTON	VCG-FT
100	HULL STRUCTURE	2081.3	36.9	274.34	11.58	42.2	.21
200	PROP PLANT	377.0	6.7	386.19	21.26		
300	ELECT PLANT	187.3	3.3	293.79	36.56		
400	COMM + SURVEIL	385.3	6.8	201.02	30.89	134.6	1.40
500	AUX SYSTEMS	575.3	10.2	290.95	28.94	25.0	.19
600	OUTFIT + FURN	429.9	7.6	264.50	24.85		
700	ARMAMENT	399.6	7.1	238.05	31.38	397.6	2.21
M11	D+B WT MARGIN		0.0	276.23			

D+B KG MARGIN

L I G H T S H I P	4435.7	78.6	276.23	25.1*	599.4	4.01	

F00	FULL LOADS	1207.4	21.4	258.95	10.49	328.6	1.29
F10	CREW + EFFECTS	30.2		248.63	31.64		
F20	MISS REL EXPEN	263.6		232.76	25.20		
F30	CHIPS STORES	42.5		285.66	23.73		
F40	FUELS + LUBRIC	826.7		267.27	4.59		
F50	FRESH WATER	44.3			5.96		
F60	CARGO						
M24	FUTURE GROWTH						

FULL LOAD WT	5643.1	100.0	272.53	22.01	928.0	5.30	

ASSET/MONOSC VERSION 3.2 - SEAKEEPING ANALYSIS - NOSSTG

PRINTED REPORT NO. 1 - SUMMARY

APPENDAGE IND-WITH

FULL LOAD WT, LTON 5643.1

FULL LOAD

BALES RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL DISP)	12.822
RANK OF THE SYNTHESIZED SHIP (NORMALIZED)	8.521
RANK OF THE CLOSEST DATA BASE HULL (NORMALIZED)	8.440
ID NO OF CLOSEST DATA BASE SHIP	1
MCCREIGHT RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL SHIP)	17.858
RANK OF THE CLOSEST DATA BASE HULL	18.464
ID NO OF CLOSEST DATA BASE SHIP	21

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ASSET/MONOSC VERSION 3.2 - COST ANALYSIS - NOSSTG

PRINTED REPORT NO. 1 - SUMMARY

YEAR \$	1992.	NO OF SHIPS ACQUIRED	50.
INFLATION ESCALATION FAC	2.149	SERVICE LIFE, YR	30.0
LEARNING RATE	0.970	ANNUAL OPERATING HRS	2500.0
FUEL COST, \$/GAL	2.579	MILITARY P/L, LTON	1182.7
PAYLOAD FUEL RATE, LTON/HR	0.33	LIGHTSHIP WT, LTON	4430.7
SHIP FUEL RATE, LTON/HR	2.39	FULL LOAD WT, LTON	5643.1

COST ITEM	COSTS(MILLIONS OF DOLLARS)		
	TOT SHIP	+ PAYLOAD	= TOTAL
LEAD SHIP	888.1	807.0*	1695.1
FOLLOW SHIP	416.3	710.4*	1126.7
AVG ACQUISITION COST/SHIP(50 SHIPS)	372.9	712.3*	1085.2
LIFE CYCLE COST/SHIP(30 YEARS)			3192.5
TOTAL LIFE CYCLE COST(30 YEARS)			159622.7
DISCOUNTED LIFE CYCLE COST/SHIP			408.0**
DISCOUNTED TOTAL LIFE CYCLE COST			20400.8**

*ESTIMATED VALUE
 **DISCOUNTED AT 10 PERCENT

PRINTED REPORT NO. 2 - UNIT ACQUISITION COSTS - NOSSTG

SWBS GROUP	UNITS	INPUTS	KN FACTORS	LEAD SHIP	FOLLOW SHIP	
				COSTS \$K	COSTS \$K	
100	HULL STRUCTURE	LTON	2081.3	1.00	26599.	25003.
200	PROPULSION PLANT	HP	47208.0	2.35	56044.	52682.
300	ELECTRIC PLANT	LTON	187.3	1.00	18861.	17730.
400	COMMAND+SURVEILLANCE	LTON	385.3	3.15	28992.	27243.
500	AUX SYSTEMS	LTON	575.3	1.53	44847.	42157.
600	OUTFIT+FURNISHINGS	LTON	429.9	1.00	24586.	23110.
700	ARMAMENT	LTON	399.6	1.00	6658.	6258.
	MARGIN	LTON	0.0		0.	0.
800	DESIGN+ENGINEERING			26.06	318550.	35199.
900	CONSTRUCTION SERVICES			4.25	53347.	50146.
TOTAL CONSTRUCTION COST					578476.	279529.
CONSTRUCTION COST					578476.	279529.
PROFIT(15.0 PERCENT OF CONSTRUCTION COST)					86771.	41929.
PRICE					665247.	321458.
CHANGE ORDERS(12/8 PERCENT OF PRICE)					79830.	25717.
NAVSEA SUPPORT(2.5 PERCENT OF PRICE)					16631.	8036.
POST DELIVERY CHARGES(5 PERCENT OF PRICE)					33262.	16073.
OUTFITTING(4 PERCENT OF PRICE)					26610.	12858.
H/M/E + GROWTH(10 PERCENT OF PRICE)					66525.	32146.
TOTAL SHIP COST					888105.	416288.
ESTIMATED PAYLOAD COST					806991.	710373.
SHIP PLUS PAYLOAD COST					1695096.	1126661.
ADJUSTED FIRST UNIT SHIP COST, \$K				442859.9		
COMBAT SYSTEM WEIGHT, LTON				1182.7		
PROPULSION SYSTEM WEIGHT, LTON				377.0		
ADJUSTED FIRST UNIT SHIP COST EQUALS						
FOLLOW SHIP TOTAL COST DIVIDED BY				0.940		

EAR.8: 2-WR-21 ICR Gas Turbine Propulsion Engines (24767 hp)
2-AC Liquid-cooled Propulsion Generators (28 mw)
2-Geared AC Liquid-cooled Propulsion Motors (27.2 mw)
2-Contrarotating Bi-coupled Epicyclic Reduction Gears
2-Contrarotating Propellers (17', 0.8EAR)
2-POD-Supported Contrarotating Shafts
2-Steerable PODs
 Transom Stern
 6000 N.Mile Range
2-VSCF Propulsion Derived Ship Service Systems (4000 kw)

This option is similiar to the preceding one ("NOSSTG") except the expanded area ratio of the propeller is reduced. This is accomplished by:

EXPAND AREA RATIO = .8000

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I) ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 8/19/93 08.09.03.
GRAPHIC DISPLAY NO. 1 - SHIP MACHINERY LAYOUT

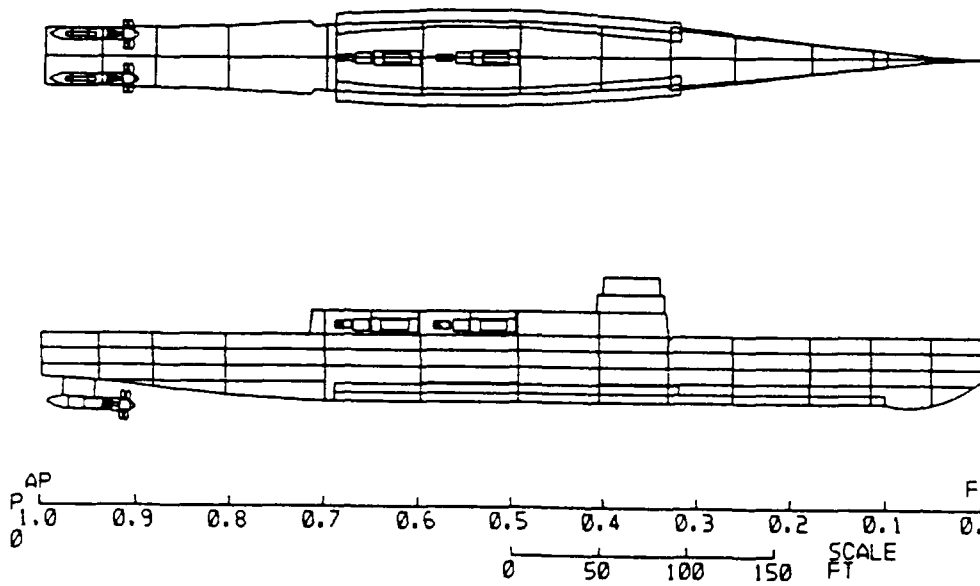


Fig. B.24. "EAR.8" Machinery Arrangement

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ASSET/MONOSC VERSION 3.2 - DESIGN SUMMARY - EAR.8

PRINTED REPORT NO. 1 - SUMMARY **

PRINCIPAL CHARACTERISTICS - FT				WEIGHT SUMMARY - LTON	
LBP			529.0	GROUP 1 - HULL STRUCTURE	2079.5
LOA			529.0	GROUP 2 - PROP PLANT	366.6
BEAM, DWL			55.0	GROUP 3 - ELECT PLANT	186.8
BEAM, WEATHER DECK			55.0	GROUP 4 - COMM + SURVEIL	385.3
DEPTH @ STA 10			51.5	GROUP 5 - AUX SYSTEMS	575.0
DRAFT TO KEEL DWL			13.8	GROUP 6 - OUTFIT + FURN	429.9
DRAFT TO KEEL LWL			13.5	GROUP 7 - ARMAMENT	399.6
FREEBOARD @ STA 3			24.5	-----	
GMT			5.2	SUM GROUPS 1-7	4422.7
CP			0.578	DESIGN MARGIN	0.0
CX			0.830	-----	
SPEED(KT): MAX= 31.7 SUST= 30.0				LIGHTSHIP WEIGHT	4422.7
ENDURANCE: 6000.0 NM AT 20.0 KTS				LOADS	1192.1
TRANSMISSION TYPE: ELECT				-----	
MAIN ENG: 2 RGT @ 24767.0 HP				FULL LOAD DISPLACEMENT	5614.8
SHAFT POWER/SHAFT: 21180.3 HP				FULL LOAD KG: FT	22.1
PROPELLERS: 2 - CR - 17.0 FT DIA				MILITARY PAYLOAD WT - LTON	1182.7
PD GEN: 2 VSCF @ 4000.0 KW				USABLE FUEL WT - LTON	701.8
24 HR LOAD 1581.5				-----	
MAX MARG ELECT LOAD 3131.0				AREA SUMMARY - FT2	
				HULL AREA	65712.4
				SUPERSTRUCTURE AREA	2078.7

				TOTAL AREA	67791.1

				VOLUME SUMMARY - FT3	
				HULL VOLUME	770214.6
				SUPERSTRUCTURE VOLUME	21202.2

				TOTAL VOLUME	791416.9

** MAIN ENG REQUIRED POWER IS REPORTED

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ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - EAR.8

PRINTED REPORT NO. 1 - HULL GEOMETRY SUMMARY

HULL OFFSETS IND-GIVEN	MIN BEAM, FT	30.00
HULL DIM IND-NONE	MAX BEAM, FT	110.00
MARGIN LINE IND-GIVEN	HULL FLARE ANGLE, DEG	
HULL STA IND-GIVEN	FORWARD BULWARK, FT	0.00
HULL BC IND-GIVEN		

HULL PRINCIPAL DIMENSIONS (ON DWL)

LBP, FT	529.00	PRISMATIC COEF	0.578
LOA, FT	529.00	MAX SECTION COEF	0.830
BEAM, FT	55.05	WATERPLANE COEF	0.734
BEAM @ WEATHER DECK, FT	55.05	LCB/LCP	0.515
DRAFT, FT	13.80	HALF SIDING WIDTH, FT	0.00
DEPTH STA 0, FT	38.00	BOT RAKE, FT	0.00
DEPTH STA 3, FT	38.00	RAISED DECK HT, FT	13.50
DEPTH STA 10, FT	51.50	RAISED DECK FWD LIM, STA	6.60
DEPTH STA 20, FT	38.00	RAISED DECK AFT LIM, STA	14.34
FREEBOARD @ STA 3, FT	24.20	BARE HULL DISPL, LTON	5506.59
STABILITY BEAM, FT	53.89	AREA BEAM, FT	211.08

BARE HULL DATA ON LWL

LGTH ON WL, FT	528.59
BEAM, FT	55.04
DRAFT, FT	13.48
FREEBOARD @ STA 3, FT	24.52
PRISMATIC COEF	0.574
MAX SECTION COEF	0.826
WATERPLANE COEF	0.733
WATERPLANE AREA, FT2	21334.22
WETTED SURFACE, FT2	27014.37
BARE HULL DISPL, LTON	5314.77
APPENDAGE DISPL, LTON	299.99
FULL LOAD WT, LTON	5614.76

STABILITY DATA ON LWL

KB, FT	7.73
BMT, FT	19.72
KG, FT	22.11
FREE SURF COR, FT	0.10
SERV LIFE KC ALW, FT	0.00
GMT, FT	5.25
GML, FT	1765.13
GMT/B AVAIL	0.095
GMT/B REQ	0.075

ASSET/MONOSC VERSION 3.2 - SPACE MODULE - EAR.8

PRINTED REPORT NO. 1 - SUMMARY

COLL PROTECT SYS-NONE	SONAR DOME-PRESENT	UNIT COMMANDER-NONE	
FULL LOAD WT, LTON	5614.8	HAB STANDARD FAC	0.260
TOTAL CREW ACC	298.	PASSWAY MARGIN FAC	0.000
HULL AVG DECK HT, FT	9.45	AC MARGIN FAC	0.000
MR VOLUME, FT3	101797.	SPACE MARGIN FAC	0.000

	AREA FT2		VOL FT3	
	PAYLOAD REQUIRED	TOTAL REQUIRED	TOTAL AVAILABLE	TOTAL ACTUAL
DKHS ONLY	5874.0	8751.0	2078.7	21202.
HULL OR DKHS	14472.0	59040.4	65712.4	770215.
TOTAL	20346.0	67791.4	67791.1	791417.

SSCS GROUP	TOTAL	DKHS	PERCENT
	AREA FT2	AREA FT2	TOTAL AREA
1. MISSION SUPPORT	23108.4	6561.8	34.1
2. HUMAN SUPPORT	18836.7	886.0	27.8
3. SHIP SUPPORT	24903.9	1303.2	36.7
4. SHIP MOBILITY SYSTEM	942.5	0.0	1.4
5. UNASSIGNED			0.0
TOTAL	67791.4	8751.0	100.0

ASSET/MONOSC VERSION 3.2 - RESISTANCE MODULE - EAR.8

PRINTED REPORT NO. 1 - SUMMARY

RESID RESIST IND	REGR	BILGE KEEL IND	NONE
FRICTION LINE IND	ITTC	SHAFT SUPPORT TYPE IND	POD
ENDUR DISP IND	FULL LOAD	PRPLN SYS RESIST IND	CALC
ENDUR CONFIG IND	NO TS	PPOP TYPE IND	CR
SONAR DRAG IND	APPENDAGE	SONAR DOME IND	PRESENT
SKEG IND	PRESENT	RUDDER TYPE IND	SPADE
FULL LOAD WT, LTON	5614.8	CORR ALW	0.00050
AVG ENDUR DISP, LTON	5614.8	DRAG MARGIN FAC	0.110
USABLE FUEL WT, LTON	701.8	TRAILSHAFT PWR FAC	
NO FIN PAIRS	0.	PRPLN SYS RESIST FRAC	
PROP TIP CLEAR RATIO	0.25	MAX SPEED	0.135
NO PROP SHAFTS	2.	SUSTN SPEED	0.150
PROP DIA, FT	17.00	ENDUR SPEED	0.241
CONDITION SPEED-----	EFFECTIVE HORSEPOWER, HP-----		
KT	FRIC	RESID	APPDG WIND MARGIN TOTAL
MAX	31.73	14198.	11624. 3888. 516. 3325. 33553.
SUSTN	30.00	12054.	8065. 3400. 438. 2635. 26592.
ENDUR	20.00	3703.	1075. 2073. 130. 768. 7749. 126259.
			DRAG LBF

ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE - EAR.8

PRINTED REPORT NO. 1 - SUMMARY

HULL SUBDIV IND-GIVEN	INNER BOT IND-PRESENT		
SHAFT SUPPORT TYPE IND-POD			
LBP, FT	529.00	HULL AVG DECK HT, FT	9.45
DEPTH STA 10, FT	51.50	NO INTERNAL DECKS	4
HULL VOLUME, FT3	770215.	NO TRANS BHDS	12
MR VOLUME, FT	101797.	NO LONG BHDS	0
TANKAGE VOL REQ, FT3	36932.	NO MACHY RMS	5
EXCESS TANKAGE, FT3	47154.	NO PROP SHAFTS	2
ARR AREA LOST TANKS, FT2	101.6		
HULL ARR AREA AVAIL, FT2	65712.4		

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - EAR.8

PRINTED REPORT NO. 1 - SUMMARY

TRANS TYPE IND	ELECT	MAX SPEED, KT	31.73
ELECT PRPLN T:PF IND	ACC-AC	SUSTN SPEED IND	GIVEN
SHAFT SUPPORT TYPE IND	POD	SUSTN SPEED, KT	30.00
NO PROP SHAFTS	2.	ENDUR SPEED IND	GIVEN
ENDUR CONFIG IND	NO TS	ENDUR SPEED, KT	20.00
SEC ENG USAGE IND		DESIGN MODE IND	ENDURANCE
MAX MARG ELECT LOAD, KW	3131.	ENDURANCE, NM	6000.
AVG 24 HR ELECT LOAD, KW	1581.	USABLE FUEL WT, LTON	701.8
SWBS 200 GROUP WT, LTON	366.6		
SWBS 300 GROUP WT, LTON	186.8		

ARRANGEMENT OR SS GEN	TYPE	NO INSTALLED	NO ONLINE MAX+SUSTN	NO ONLINE ENDURANCE
ELECT PG ARR 1 IND	M-PG	2	2	1
ELECT PG ARR 2 IND	M-CG-PG	0	0	0
ELECT DL ARR IND	MTR-BCE	2	2	2
SEP SS GEN	3000. KW	0	0	0
VSCF SS CYCLO	4000. KW	2	2	1

	MAIN ENG	SEC ENG	SS ENG
ENG SELECT IND	GIVEN		GIVEN
ENG MODEL IND	OTHER		DDA-571K
ENG TYPE IND	RGT		GT
ENG SIZE IND	GIVEN		GIVEN
NO INSTALLED	2	0	0
ENG PWR AVAIL, HP	26400.		6365.
ENG RPM	3600.0		11500.0
ENG SFC, LBM/HP-HR	0.324		.455
ENG LOAD FRAC	0.938		

PRINTED REPORT NO. 12 - POWERING - EAR.8

SUSTN SPEED IND-GIVEN
 ENDUR SPEED IND-GIVEN
 TRANS EFF IND-CALC

100 PCT POWER TRANS EFF 0.9282
 25 PCT POWER TRANS EFF 0.8865

	MAX SPEED	SUSTN SPEED	ENDUR SPEED
SHIP SPEED, KT	31.73	30.00	20.00
PROP RPM	105.0	98.3	65.4
NO OP PROP SHAFTS	2	2	2
EHP (/SHAFT), HP	16777.	13296.	3875.
PROPULSIVE COEF	0.792	0.791	0.790
ENDUR PWR ALW	1.0	1.0	1.1
SHP (/SHAFT), HP	21180.	16815.	5393.
TRANS EFFY	0.928	0.921	0.887
CP PROP TRANS EFFY MULT	1.000	1.000	1.000
PROPUL PWR (/SHAFT), HP	22820.	18256.	6080.
PD GEN PWR (/SHAFT), HP	1947.	1947.	1110.
BHP (/SHAFT), HP	24767.	20203.	7190.

PRINTED REPORT NO. 13 - HULL STRUCTURE AND MISCELLANEOUS WEIGHT -EAR.8

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
160	SPECIAL STRUCTURES			
161	CASTINGS, FORGINGS, AND WELDMENTS	98.0	444.27	3.27
162	STACKS AND MASTS	0.0	315.87	57.80
180	FOUNDATIONS			
* 182	PROPULSION PLANT FOUNDATIONS	39.6	403.83	31.72
* 183	ELECTRIC PLANT FOUNDATIONS	11.4	329.51	34.07

PRINTED REPORT NO. 14 - PROPULSION PLANT WEIGHT - EAR.8

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
200	PROPULSION PLANT	366.6	383.99	21.90
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	167.3	393.98	26.17
233	PROPULSION INTERNAL COMBUSTION ENGINES	0.0	0.00	0.00
* 234	PROPULSION GAS TURBINES	62.9	302.59	43.43
* 235	ELECTRIC PROPULSION	104.4	449.07	15.76
240	TRANSMISSION AND PROPULSOR SYSTEMS	74.9	492.47	-2.53
241	PROPULSION REDUCTION GEARS	32.9	500.14	-2.07
242	PROPULSION CLUTCHES AND COUPLINGS	0.0	0.00	0.00
243	PROPULSION SHAFTING	4.8	487.85	-2.80
244	PROPULSION SHAFT BEARINGS	14.5	491.82	-2.56
245	PROPULSORS	22.8	482.76	-3.10
250	PRPLN SUPPORT SYS (EXCEPT FUEL+LUBE OIL)	72.0	308.94	40.94
* 251	COMBUSTION AIR SYSTEM	18.0	289.31	46.80
252	PROPULSION CONTROL SYSTEM	13.1	302.59	33.47
256	CIRCULATING AND COOLING SEA WATER SYSTEM	8.8	333.27	18.54
* 259	UPTAKES (INNER CASING)	32.2	315.87	46.81
260	PRPLN SUPPORT SYS (FUEL+LUBE OIL)	32.0	294.02	20.27
261	FUEL SERVICE SYSTEM	9.4	276.14	37.43
262	MAIN PROPULSION LUBE OIL SYSTEM	16.2	302.59	12.00
264	LUBE OIL FILL, TRANSFER, AND PURIF	6.5	298.59	16.00
290	SPECIAL PURPOSE SYSTEMS	20.3	309.66	11.95
298	OPERATING FLUIDS	15.4	317.40	8.00
299	REPAIR PARTS AND SPECIAL TOOLS	5.0	285.66	24.20

PRINTED REPORT NO. 15 - ELECTRIC PLANT WEIGHT - EAR.8

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
300	ELECTRIC PLANT	186.8	293.77	36.59
310	ELECTRIC POWER GENERATION	61.7	314.48	32.46
311	SHIP SERVICE POWER GENERATION	23.3	329.51	43.43
313	BATTERIES AND SERVICE FACILITIES	28.3	329.51	10.30
314	POWER CONVERSION EQUIPMENT	10.1	238.05	69.18
320	POWER DISTRIBUTION SYSTEMS	95.1	283.48	36.37
321	SHIP SERVICE POWER CABLE	67.1	280.37	27.00
324	SWITCHGEAR AND PANELS	28.0	290.95	58.88
330	LIGHTING SYSTEM	28.8	278.34	46.75
331	LIGHTING DISTRIBUTION	17.8	280.37	46.35
332	LIGHTING FIXTURES	11.1	275.08	47.38
340	POWER GENERATION SUPPORT SYSTEMS	0.0	0.00	0.00
342	DIESEL SUPPORT SYSTEMS	0.0	0.00	0.00
343	TURBINE SUPPORT SYSTEMS	0.0	0.00	0.00
390	SPECIAL PURPOSE SYSTEMS	1.2	417.91	21.00
398	OPERATING FLUIDS	0.0	0.00	0.00
399	REPAIR PARTS AND SPECIAL TOOLS	1.2	417.91	21.00

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

PRINTED REPORT NO. 18 - MACHINERY SPACE REQUIREMENTS - EAR.8

MACHINERY ROOM VOLUME REQUIREMENTS

VOLUME CATEGORY	VOLUME, FT3
SWBS GROUP 200	91839.
PROPULSION POWER GENERATION	28867.
PROPULSION ENGINES	11112.
PROPULSION REDUCTION GEARS AND GENERATORS	17755.
DRIVELINE MACHINERY	0.
REDUCTION AND BEVEL GEARS WITH Z-DRIVE	0.
ELECTRIC PROPULSION MOTORS AND GEARS	0.
REMOTELY-LOCATED THRUST BEARINGS	0.
PROPELLER SHAFT	0.
ELECTRIC PROPULSION MISCELLANEOUS EQUIPMENT	13383.
CONTROLS	1770.
BRAKING RESISTORS	1481.
MOTOR AND GENERATOR EXCITERS	2621.
SWITCHGEAR	1741.
POWER CONVERTERS	3321.
DEIONIZED COOLING WATER SYSTEMS	2448.
RECTIFIERS	0.
MEDIC. REFRIGERATION SYSTEMS	0.
PROPULSION AUXILIARIES	49590.
PROPULSION LOCAL CONTROL CONSOLES	3510.
CP PROP HYDRAULIC OIL POWER MODULES	0.
FUEL OIL PUMPS	23938.
LUBE OIL PUMPS	3316.
LUBE OIL PURIFIERS	15329.
ENGINE LUBE OIL CONDITIONERS	602.
SEAWATER COOLING PUMPS	2895.
SWBS GROUP 300	18577.
ELECTRIC PLANT POWER GENERATION	0.
ELECTRIC PLANT ENGINES	0.
ELECTRIC PLANT GENERATORS AND GEARS	0.
SHIP SERVICE SWITCHBOARDS	17058.
CYCLOCONVERTERS	1519.
SWBS GROUP 500	44025.
AUXILIARY MACHINERY	44025.
AIR CONDITIONING PLANTS	7197.
AUXILIARY BOILERS	6360.
FIRE PUMPS	4415.
DISTILLING PLANTS	15054.
AIR COMPRESSORS	8685.
ROLL FIN PAIRS	0.
SEWAGE PLANTS	2314.

ARRANGEABLE AREA REQUIREMENTS

SSCS	GROUP NAME	-----FT2-----	
		HULL/DRHS	DRHS ONLY
3.4X	AUXILIARY MACHINERY DELTA	4288.0*	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	0.4	0.0
4.143	GAS TURBINE ENG EXHAUST	2.1	0.0

NOTE: * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

ASSET/MONOSC VERSION 3.2 - WEIGHT MODULE - EAR.8

PRINTED REPORT NO. 1 - SUMMARY

SWBS	GROUP	WEIGHT		LCG	VCG	RESULTANT ADJ	
		LTON	PER CENT	FT	FT	WT-LTON	VCG-FT
100	HULL STRUCTURE	2079.5	37.0	274.19	21.60	42.2	.21
200	PROP PLANT	366.6	6.5	383.99	21.90		
300	ELECT PLANT	186.8	3.3	293.77	36.59		
400	COMM + SURVEIL	385.3	6.9	201.02	30.89	134.6	1.41
500	AUX SYSTEMS	575.0	10.2	290.95	28.94	25.0	.19
600	OUTFIT + FURN	429.9	7.7	264.50	24.85		
700	ARMAMENT	399.6	7.1	238.05	31.38	397.6	2.22
M11	D+B WT MARGIN		0.0	275.72			

D+B KG MARGIN							

	L I G H T S H I P	4422.7	78.8	275.72	25.22	599.4	4.03

F00	FULL LOADS	1192.1	21.2	260.73	10.57	328.6	1.30
F10	CREW + EFFECTS	30.2		248.63	31.64		
F20	MISS REL EXPEN	263.6		232.76	25.20		
F30	SHIPS STORES	42.5		285.66	23.73		
F40	FUELS + LUBRIC	811.5		270.04	4.60		
F50	FRESH WATER	44.3			5.96		
F60	CARGO						
M24	FUTURE GROWTH						

	FULL LOAD WT	5614.8	100.0	272.53	22.11	928.0	5.33

ASSET/MONOSC VERSION 3.2 - SEAKEEPING ANALYSIS - EAR.8

PRINTED REPORT NO. 1 - SUMMARY

APPENDAGE IND-WITH

FULL LOAD WT, LTON 5614.8

	FULL LOAD

BALES RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL DISP)	12.783
RANK OF THE SYNTHESIZED SHIP (NORMALIZED)	8.568
RANK OF THE CLOSEST DATA BASE HULL (NORMALIZED)	8.440
ID NO OF CLOSEST DATA BASE SHIP	1
MCCREIGHT RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL SHIP)	17.793
RANK OF THE CLOSEST DATA BASE HULL	18.356
ID NO OF CLOSEST DATA BASE SHIP	21

ASSET/MONOSC VERSION 3.2 - COST ANALYSIS - EAR.8

PRINTED REPORT NO. 1 - SUMMARY

YEAR \$	1992.	NO OF SHIPS ACQUIRED	50.
INFLATION ESCALATION FAC	2.149	SERVICE LIFE, YR	30.0
LEARNING RATE	0.970	ANNUAL OPERATING HRS	2500.0
FUEL COST, \$/GAL	2.579	MILITARY P/L, LTON	1182.7
PAYLOAD FUEL RATE, LTON/HR	0.33	LIGHTSHIP WT, LTON	4422.7
SHIP FUEL RATE, LTON/HR	2.34	FULL LOAD WT, LTON	5614.8

COST ITEM	COSTS(MILLIONS OF DOLLARS)		
	TOT SHIP	+ PAYLOAD	= TOTAL
LEAD SHIP	881.0	807.0*	1688.0
FOLLOW SHIP	413.1	710.4*	1123.5
AVG ACQUISITION COST/SHIP(50 SHIPS)	370.1	712.3*	1082.4
LIFE CYCLE CGST/SHIP(30 YEARS)			3185.2
TOTAL LIFE CYCLE COST(30 YEARS)			159259.0
DISCOUNTED LIFE CYCLE COST/SHIP			407.1**
DISCOUNTED TOTAL LIFE CYCLE COST			20353.9**

*ESTIMATED VALUE
 **DISCOUNTED AT 10 PERCENT

PRINTED REPORT NO. 2 - UNIT ACQUISITION COSTS - EAR.8

SWBS GROUP	UNITS	INPUTS	KN FACTORS	LEAD	FOLLOW	
				SHIP COSTS \$K	SHIP COSTS \$K	
100	HULL STRUCTURE	LTON	2079.5	1.00	26581.	24986.
200	PROPULSION PLANT	HP	45640.0	2.35	54536.	51263.
300	ELECTRIC PLANT	LTON	186.8	1.00	18821.	17692.
400	COMMAND+SURVEILLANCE	LTON	385.3	3.15	28982.	27243.
500	AUX SYSTEMS	LTON	575.0	1.53	44833.	42143.
600	OUTFIT+FURNISHINGS	LTON	429.9	1.00	24583.	23108.
700	ARMAMENT	LTON	399.6	1.00	6658.	6258.
	MARGIN	LTON	0.0		0.	0.
800	DESIGN+ENGINEERING			26.06	315866.	34902.
900	CONSTRUCTION SERVICES			4.25	53003.	49823.
TOTAL CONSTRUCTION COST					573863.	277420.
CONSTRUCTION COST					573863.	277420.
PROFIT(15.0 PERCENT OF CONSTRUCTION COST)					86079.	41613.
PRICE					659942.	319032.
CHANGE ORDERS(12/8 PERCENT OF PRICE)					79193.	23523.
NAVSEA SUPPORT(2.5 PERCENT OF PRICE)					16499.	7976.
POST DELIVERY CHARGES(5 PERCENT OF PRICE)					32997.	15952.
OUTFITTING(4 PERCENT OF PRICE)					26398.	12761.
H/M/E + GROWTH(10 PERCENT OF PRICE)					65994.	31903.
TOTAL SHIP COST					881023.	413147.
ESTIMATED PAYLOAD COST					806991.	710373.
SHIP PLUS PAYLOAD COST					1688014.	1123520.
ADJUSTED FIRST UNIT SHIP COST, \$K				439518.1		
COMBAT SYSTEM WEIGHT, LTON				1182.7		
PROPULSION SYSTEM WEIGHT, LTON				366.6		
ADJUSTED FIRST UNIT SHIP COST EQUALS						
FOLLOW SHIP TOTAL COST DIVIDED BY				0.940		

FLAP: 2-WR-21 ICR Gas Turbine Propulsion Engines (21879 hp)
 2-AC Liquid-cooled Propulsion Generators (28 mw)
 2-Geared AC Liquid-cooled Propulsion Motors (27.2 mw)
 2-Contrarotating Bi-coupled Epicyclic Reduction Gears
 2-Contrarotating Propellers (17', 0.8EAR)
 2-POD-Supported Contrarotating Shafts
 2-Steerable PODs
 Retractable Flap on Transom Stern
 6000 N.Mile Range
 2-VSCF Propulsion Derived Ship Service Systems (4000 kw)

A retractable flap is added to the transom stern of the preceding option ("EAR.8"). The flap is deployed at high speed to reduce resistance by increasing the effective length of the ship and reducing the Froude number. At endurance speed the flap is retracted to reduce wetted surface.

The retractable flap is assumed to weigh 50 L. tons and to reduce the total ship resistance by 15 % at high speed. The weight is handled in PAYLOAD AND ADJUSTMENTS and the resistance reduction is simulated by eliminating the propulsion system resistance at maximum and sustained speeds as follows:

WT KEY TBL	WT ADD ARRAY	VCG ADD ARRAY
W565	50.0	14.0
PRPLN SYS RESIST IND	=	GIVEN
PRPLN SYS RESIST ARRAY	=	(3 X 1)
1 0.0000E+00		
2 0.0000E+00		
3 0.2410		

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I) ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 8/19/93 08.09.03.
GRAPHIC DISPLAY NO. 1 - SHIP MACHINERY LAYOUT

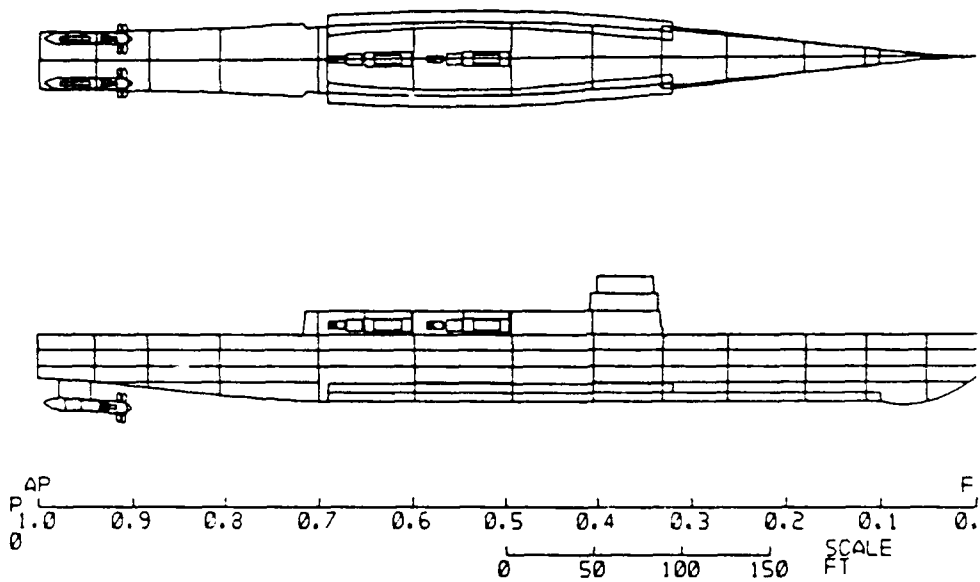


Fig. B.25. "FLAP" Machinery Arrangement (Flap Not Shown)

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ASSET/MONOSC VERSION 3.2 - DESIGN SUMMARY - FLAP

PRINTED REPORT NO. 1 - SUMMARY **

PRINCIPAL CHARACTERISTICS - FT				WEIGHT SUMMARY - LTON	
LBP			529.0	GROUP 1 - HULL STRUCTURE	2077.5
LOA			529.0	GROUP 2 - PROP PLANT	360.0
BEAM, DWL			55.0	GROUP 3 - ELECT PLANT	185.3
BEAM, WEATHER DECK			55.0	GROUP 4 - COMM + SURVEIL	385.3
DEPTH @ STA 10			51.5	GROUP 5 - AUX SYSTEMS	629.8
DRAFT TO KEEL DWL			13.8	GROUP 6 - OUTFIT + FURN	429.7
DRAFT TO KEEL LWL			13.6	GROUP 7 - ARMAMENT	399.6
FREEBOARD @ STA 3			24.4	-----	
GMT			5.2	SUM GROUPS 1-7	4467.3
CP			0.578	DESIGN MARGIN	0.0
CX			0.830	-----	
SPEED(KT): MAX= 31.6	SUST= 30.0			LIGHTSHIP WEIGHT	4467.3
ENDURANCE: 6000.0 NM	AT 20.0 KTS			LOADS	1190.7

TRANSMISSION TYPE:			ELECT	FULL LOAD DISPLACEMENT	5658.0
MAIN ENG: 2 RGT			@ 21879.0 HP	FULL LOAD KG: FT	22.1
SHAFT POWER/SHAFT:			18521.9 HP	MILITARY PAYLOAD WT - LTON	1182.7
PROPELLERS: 2 - CR			- 17.0 FT DIA	USABLE FUEL WT - LTON	700.7
				AREA SUMMARY - FT2	
PD GEN: 2 VSCF			@ 4000.0 KW	HULL AREA	- 65712.4
				SUPERSTRUCTURE AREA	- 2042.8

24 HR LOAD			1563.8	TOTAL AREA	67755.3
MAX MARG ELECT LOAD			3102.1		
				VOLUME SUMMARY - FT3	
	OFF	CPO	ENL	TOTAL	
MANNING	22	19	229	270	HULL VOLUME - 770214.6
ACCOM	25	21	252	298	SUPERSTRUCTURE VOLUME - 20837.0

					TOTAL VOLUME 791051.6

** MAIN ENG REQUIRED POWER IS REPORTED

ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - FLAP

PRINTED REPORT NO. 1 - HULL GEOMETRY SUMMARY

HULL OFFSETS IND-GIVEN	MIN BEAM, FT	30.00
HULL DIM IND-NONE	MAX BEAM, FT	110.00
MARGIN LINE IND-GIVEN	HULL FLARE ANGLE, DEG	
HULL STA IND-GIVEN	FORWARD BULWARK, FT	0.00
HULL BC IND-GIVEN		

HULL PRINCIPAL DIMENSIONS (ON DWL)

LBP, FT	529.00	PRISMATIC COEF	0.578
LOA, FT	529.00	MAX SECTION COEF	0.830
BEAM, FT	55.05	WATERPLANE COEF	0.734
BEAM @ WEATHER DECK, FT	55.05	LCB/LCP	0.515
DRAFT, FT	13.80	HALF SIDING WIDTH, FT	0.00
DEPTH STA 0, FT	38.00	BOT RAKE, FT	0.00
DEPTH STA 3, FT	38.00	RAISED DECK HT, FT	13.50
DEPTH STA 10, FT	51.50	RAISED DECK FWD LIM, STA	6.60
DEPTH STA 20, FT	38.00	RAISED DECK AFT LIM, STA	14.34
FREEBOARD @ STA 3, FT	24.20	BARE HULL DISPL, LTON	5506.59
STABILITY BEAM, FT	53.80	AREA BEAM, FT	214.41

BARE HULL DATA ON LWL

STABILITY DATA ON LWL

LGTH ON WL, FT	528.68	KB, FT	7.78
BEAM, FT	55.05	BMT, FT	19.62
DRAFT, FT	13.55	KG, FT	22.06
FREEBOARD @ STA 3, FT	24.45	FREE SURF COR, FT	0.10
PRISMATIC COEF	0.575	SERV LIFE KG ALW, FT	0.00
MAX SECTION COEF	0.827		
WATERPLANE COEF	0.734	GMT, FT	5.24
WATERPLANE AREA, FT2	21358.40	GML, FT	1757.34
WETTED SURFACE, FT2	27106.41	GMT/B AVAIL	0.095
BARE HULL DISPL, LTON	5359.03	GMT/B REQ	0.075
APPENDAGE DISPL, LTON	298.96		
FULL LOAD WT, LTON	5657.99		

ASSET/MONOSC VERSION 3.2 - SPACE MODULE - FLAP

PRINTED REPORT NO. 1 - SUMMARY

LOLL PROTECT SYS-NONE	SONAR DOME-PRESENT	UNIT COMMANDER-NONE	
FULL LOAD WT, LTON	5658.0	HAB STANDARD FAC	0.260
TOTAL CREW ACC	298.	PASSWAY MARGIN FAC	0.000
HULL AVG DECK HT, FT	9.45	AC MARGIN FAC	0.000
MR VOLUME, FT3	101797.	SPACE MARGIN FAC	0.000

	AREA FT2		VOL FT3
	PAYLOAD REQUIRED	TOTAL AVAILABLE	TOTAL ACTUAL
DKHS ONLY	5874.0	8746.6	20837.
HULL OR DKHS	14472.0	59008.4	770215.
TOTAL	20346.0	67755.0	791052.

SSCS	GROUP	TOTAL AREA FT2	DKHS AREA FT2	PERCENT TOTAL AREA
1.	MISSION SUPPORT	23108.1	6561.8	28.4
2.	HUMAN SUPPORT	18836.7	886.0	4.7
3.	SHIP SUPPORT	24867.8	1298.7	5.2
4.	SHIP MOBILITY SYSTEM	942.4	0.0	0.0
5.	UNASSIGNED			0.0
	TOTAL	67755.0	8746.6	12.9

ASSET/MONOSC VERSION 3.2 - RESISTANCE MODULE - FLAP

PRINTED REPORT NO. 1 - SUMMARY

RESID RESIST IND	REGR	BILGE KEEL IND	NONE					
FRICTION LINE IND	ITTC	SHAFT SUPPORT TYPE IND	POD					
ENDUR DISP IND	FULL LOAD	PRPLN SYS RESIST IND	GIVEN					
ENDUR CONFIG IND	NO TS	PROP TYPE IND	CR					
SONAR DRAG IND	APPENDAGE	SONAR DOME IND	PRESENT					
SKEG IND	PRESENT	RUDDER TYPE IND	SPADE					
FULL LOAD WT, LTON	5658.0	CORR ALW	0.00050					
AVG ENDUR DISP, LTON	5658.0	DRAG MARGIN FAC	0.110					
USABLE FUEL WT, LTON	700.7	TRAILSHAFT PWR FAC						
NO FIN PAIRS	0.	PRPLN SYS RESIST FRAC						
PROP TIP CLEAR RATIO		MAX SPEED	0.000					
NO PROP SHAFTS	2.	SUSTN SPEED	0.000					
PROP DIA, FT	17.00	ENDUR SPEED	0.241					
CONDITION SPEED-----	EFFECTIVE HORSEPOWER, HP-----		DRAG					
KT	FRIC	RESID	APPDG	WIND	MARGIN	TOTAL	LBF	
MAX	31.64	14128.	11541.	399.	513.	2924.	29506.	303849.
SUSTN	10.00	12095.	8143.	377.	437.	2316.	23369.	253835.
ENDUR	20.00	3715.	1133.	2091.	130.	778.	7846.	127836.

ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE - FLAP

PRINTED REPORT NO. 1 - SUMMARY

HULL SUBDIV IND-GIVEN	INNER BOT IND-PRESENT		
SHAFT SUPPORT TYPE IND-POD			
LBP, FT	529.00	HULL AVG DECK HT, FT	9.45
DEPTH STA 10, FT	51.50		
		NO INTERNAL DECKS	4
HULL VOLUME, FT3	770215.	NO TRANS BHDS	12
MR VOLUME, FT3	101797.	NO LONG BHDS	0
TANKAGE VOL REQ, FT3	36881.	NO MACHY RMS	5
EXCESS TANKAGE, FT3	47205.	NO PROP SHAFTS	2
ARR AREA LOST TANKS, FT2	101.6		
HULL ARR AREA AVAIL, FT2	65712.4		

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - FLAP

PRINTED REPORT NO. 1 - SUMMARY

TRANS TYPE IND	ELECT	MAX SPEED, KT	31.64
ELECT PRPLN TYPE IND	ACC-AC	SUSTN SPEED IND	GIVEN
SHAFT SUPPORT TYPE IND	POD	SUSTN SPEED, KT	30.00
NO PROP SHAFTS	2.	ENDUR SPEED IND	GIVEN
ENDUR CONFIG IND	NO TS	ENDUR SPEED, KT	20.00
SEC ENG USAGE IND		DESIGN MODE IND	ENDURANCE
MAX MARG ELECT LOAD, KW	3102.	ENDURANCE, NM	6000.
AVG 24 HR ELECT LOAD, KW	1564.	USABLE FUEL WT, LTON	700.7
SWBS 200 GROUP WT, LTON	360.0		
SWBS 300 GROUP WT, LTON	185.3		

ARRANGEMENT OR SS GEN	TYPE	NO INSTALLED	NO ONLINE MAX+SUSTN	NO ONLINE ENDURANCE
ELECT PG ARR 1 IND	M-PG	2	2	1
ELECT PG ARR 2 IND	M-CG-PG	0	0	0
ELECT DL ARR IND	MTR-BCE	2	2	2
SEP SS GEN	3000. KW	0	0	0
VSCF SS CYCLO	4000. KW	2	2	1

	MAIN ENG	SEC ENG	SS ENG
ENG SELECT IND	GIVEN		GIVEN
ENG MODEL IND	OTHER		DDA-571K
ENG TYPE IND	RGT		GT
ENG SIZE IND	GIVEN		GIVEN
NO INSTALLED	2	0	0
ENG PWR AVAIL, HP	26400.		6365.
ENG RPM	3600.0		11500.0
ENG SFC, LBM/HP-HR	0.324		.455
ENG LOAD FRAC	0.829		

PRINTED REPORT NO. 12 - POWERING - FLAP

SUSTN SPEED IND-GIVEN
ENDUR SPEED IND-GIVEN
TRANS EFF IND-CALC

100 PCT POWER TRANS EFF	0.9282
25 PCT POWER TRANS EFF	0.8865

	MAX SPEED	SUSTN SPEED	ENDUR SPEED
SHIP SPEED, KT	31.64	30.00	20.00
PROP RPM	96.0	90.1	61.2
NO OP PROP SHAFTS	2	2	2
EHP (/SHAFT), HP	14753.	11684.	3923.
PROPULSIVE COEF	0.797	0.795	0.797
ENDUR PWR ALW	1.0	1.0	1.1
SHP (/SHAFT), HP	18522.	14705.	5412.
TRANS EFFY	0.928	0.921	0.891
CP PROP TRANS EFFY MULT	1.000	1.000	1.000
PROPUL PWR (/SHAFT), HP	19956.	15964.	6073.
PD GEN PWR (/SHAFT), HP	1923.	1923.	1098.
BHP (/SHAFT), HP	21879.	17888.	7171.

PRINTED REPORT NO. 13 - HULL STRUCTURE AND MISCELLANEOUS WEIGHT - FLAP

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
-----	-----	-----	-----	-----
160	SPECIAL STRUCTURES			
161	CASTINGS, FORGINGS, AND WELDMENTS	91.4	439.82	3.32
162	STACKS AND MASTS	0.0	315.88	57.80
180	FOUNDATIONS			
*	182 PROPULSION PLANT FOUNDATIONS	39.4	403.79	31.88
*	183 ELECTRIC PLANT FOUNDATIONS	11.4	329.51	34.07

PRINTED REPORT NO. 14 - PROPULSION PLANT WEIGHT - FLAP

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
-----	-----	-----	-----	-----
200	PROPULSION PLANT	360.0	384.21	22.07
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	167.3	393.98	26.17
233	PROPULSION INTERNAL COMBUSTION ENGINES	0.0	0.00	0.00
*	234 PROPULSION GAS TURBINES	62.9	302.59	43.43
*	235 ELECTRIC PROPULSION	104.4	449.07	15.77
240	TRANSMISSION AND PROPULSOR SYSTEMS	72.6	492.78	-2.49
241	PROPULSION REDUCTION GEARS	32.8	500.26	-2.04
242	PROPULSION CLUTCHES AND COUPLINGS	0.0	0.00	0.00
243	PROPULSION SHAFTING	4.8	488.38	-2.75
244	PROPULSION SHAFT BEARINGS	12.3	492.10	-2.53
245	PROPULSORS	22.8	483.29	-3.06
250	PROPULSION SUPPORT SYS (EXCEPT FUEL+LUBE OIL)	69.5	308.69	41.46
*	251 COMBUSTION AIR SYSTEM	18.0	289.31	46.80
252	PROPULSION CONTROL SYSTEM	11.6	302.59	33.47
256	CIRCULATING AND COOLING SEA WATER SYSTEM	7.7	333.27	18.54
*	259 UPTAKES (INNER CASING)	32.2	315.87	46.81
260	PROPULSION SUPPORT SYS (FUEL+LUBE OIL)	31.8	293.96	20.33
261	FUEL SERVICE SYSTEM	9.4	276.14	37.43
262	MAIN PROPULSION LUBE OIL SYSTEM	16.0	302.59	12.00
264	LUBE OIL FILL, TRANSFER, AND PURIFY	6.4	298.59	16.00
290	SPECIAL PURPOSE SYSTEMS	18.9	310.05	11.75
298	OPERATING FLUIDS	14.5	317.40	8.00
299	REPAIR PARTS AND SPECIAL TOOLS	4.4	285.66	24.20

PRINTED REPORT NO. 15 - ELECTRIC PLANT WEIGHT - FLAP

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
-----	-----	-----	-----	-----
300	ELECTRIC PLANT	185.3	293.69	36.68
310	ELECTRIC POWER GENERATION	61.1	314.32	32.70
311	SHIP SERVICE POWER GENERATION	23.3	329.51	43.43
313	BATTERIES AND SERVICE FACILITIES	27.7	329.51	10.30
314	POWER CONVERSION EQUIPMENT	10.1	238.05	69.18
320	POWER DISTRIBUTION SYSTEMS	94.2	283.48	36.37
321	SHIP SERVICE POWER CABLE	66.5	280.37	27.00
324	SWITCHGEAR AND PANELS	27.7	290.95	58.88
330	LIGHTING SYSTEM	28.8	278.34	46.75
331	LIGHTING DISTRIBUTION	17.8	280.37	46.35
332	LIGHTING FIXTURES	11.1	275.08	47.38
340	POWER GENERATION SUPPORT SYSTEMS	0.0	0.00	0.00
342	DIESEL SUPPORT SYSTEMS	0.0	0.00	0.00
343	TURBINE SUPPORT SYSTEMS	0.0	0.00	0.00
390	SPECIAL PURPOSE SYSTEMS	1.2	417.91	21.00
398	OPERATING FLUIDS	0.0	0.00	0.00
399	REPAIR PARTS AND SPECIAL TOOLS	1.2	417.91	21.00

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

PRINTED REPORT NO. 18 - MACHINERY SPACE REQUIREMENTS - FLAP

MACHINERY ROOM VOLUME REQUIREMENTS

VOLUME CATEGORY	VOLUME, FT3
SWBS GROUP 200	91621.
PROPULSION POWER GENERATION	28867.
PROPULSION ENGINES	11112.
PROPULSION REDUCTION GEARS AND GENERATORS	17755.
DRIVELINE MACHINERY	0.
REDUCTION AND BEVEL GEARS WITH Z-DRIVE	0.
ELECTRIC PROPULSION MOTORS AND GEARS	0.
REMOTELY-LOCATED THRUST BEARINGS	0.
PROPELLER SHAFT	0.
ELECTRIC PROPULSION MISCELLANEOUS EQUIPMENT	13383.
CONTROLS	1770.
BRAKING RESISTORS	1481.
MOTOR AND GENERATOR EXCITERS	2621.
SWITCHGEAR	1741.
POWER CONVERTERS	3321.
DEIONIZED COOLING WATER SYSTEMS	2448.
RECTIFIERS	0.
HELIUM REFRIGERATION SYSTEMS	0.
PROPULSION AUXILIARIES	49372.
PROPULSION LOCAL CONTROL CONSOLES	3510.
CP PROP HYDRAULIC OIL POWER MODULES	0.
FUEL OIL PUMPS	23938.
LUBE OIL PUMPS	3296.
LUBE OIL PURIFIERS	15329.
ENGINE LUBE OIL CONDITIONERS	602.
SEAWATER COOLING PUMPS	2697.
SWBS GROUP 300	18497.
ELECTRIC PLANT POWER GENERATION	0.
ELECTRIC PLANT ENGINES	0.
ELECTRIC PLANT GENERATORS AND GEARS	0.
SHIP SERVICE SWITCHBOARDS	16978.
CYCLOCONVERTERS	1519.
SWBS GROUP 500	44020.
AUXILIARY MACHINERY	44020.
AIR CONDITIONING PLANTS	7195.
AUXILIARY BOILERS	6360.
FIRE PUMPS	4414.
DISTILLING PLANTS	15054.
AIR COMPRESSORS	8683.
ROLL FIN PAIRS	0.
SEWAGE PLANTS	2314.

ARRANGEABLE AREA REQUIREMENTS

SSCS	GROUP NAME	-----FT2-----	
		HULL/DKHS	DKHS ONLY
3.4X	AUXILIARY MACHINERY DELTA	4255.9*	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	0.4	0.0
4.143	GAS TURBINE LNG EXHAUST	2.1	0.0

NOTE: * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

ASSET/MONOSC VERSION 3.2 - WEIGHT MODULE - FLAP

PRINTED REPORT NO. 1 - SUMMARY

SWBS	GROUP	WEIGHT		LCG	VCG	RESULTANT ADJ	
		LTON	PER CENT	FT	FT	WT-LTON	VCG-FT
100	HULL STRUCTURE	2077.5	36.7	273.35	21.61	42.2	.21
200	PROP PLANT	360.0	6.4	384.21	22.07		
300	ELECT PLANT	185.3	3.3	293.69	36.68		
400	COMM + SURVEIL	385.3	6.8	201.02	30.89	134.6	1.40
500	AUX SYSTEMS	629.8	11.1	290.95	27.69	25.0	.19
600	OUTFIT + FURN	429.7	7.6	264.50	24.84		
700	ARMAMENT	399.6	7.1	238.05	31.38	397.6	2.20
M11	D+B WT MARGIN		0.0	275.36			
D+B KG MARGIN							

L I G H T S H I P		4467.3	79.0	275.36	25.12	599.4	4.00

F00	FULL LOADS	1190.7	21.0	261.92	10.58	328.6	1.29
F10	CREW + EFFECTS	30.2		248.63	31.64		
F20	MISS REL EXPEN	263.6		232.76	25.20		
F30	SHIPS STORES	42.5		285.66	23.73		
F40	FUELS + LUBRIC	810.1		271.81	4.60		
F50	FRESH WATER	44.3			5.96		
F60	CARGO						
M24	FUTURE GROWTH						

FULL LOAD WT		5658.0	100.0	272.53	22.06	928.0	5.29

ASSET/MONOSC VERSION 3.2 - SEAKEEPING ANALYSIS - FLAP

PRINTED REPORT NO. 1 - SUMMARY

APPENDAGE IND-WITH

FULL LOAD WT, LTON 5658.0

	FULL LOAD

BALES RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL DISP)	12.837
RANK OF THE SYNTHESIZED SHIP (NORMALIZED)	8.490
RANK OF THE CLOSEST DATA BASE HULL (NORMALIZED)	8.440
ID NO OF CLOSEST DATA BASE SHIP	1
MCCREIGHT RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL SHIP)	17.869
RANK OF THE CLOSEST DATA BASE HULL	18.530
ID NO OF CLOSEST DATA BASE SHIP	21

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ASSET/MONOSC VERSION 3.2 - COST ANALYSIS - FLAP

PRINTED REPORT NO. 1 - SUMMARY

YEAR \$	1992.	NO OF SHIPS ACQUIRED	50.
INFLATION ESCALATION FAC	2.149	SERVICE LIFE, YR	30.0
LEARNING RATE	0.970	ANNUAL OPERATING HRS	2500.0
FUEL COST, \$/GAL	2.579	MILITARY P/L, LTON	1182.7
PAYLOAD FUEL RATE, LTON/HR	0.33	LIGHTSHIP WT, LTON	4467.3
SHIP FUEL RATE, LTON/HR	2.34	FULL LOAD WT, LTON	5658.0

COST ITEM	COSTS(MILLIONS OF DOLLARS)		
	TOT SHIP	+ PAYLOAD	= TOTAL
LEAD SHIP	870.0	807.0*	1677.0
FOLLOW SHIP	408.3	710.4*	1118.6
AVG ACQUISITION COST/SHIP(50 SHIPS)	365.7	712.3*	1078.0
LIFE CYCLE COST/SHIP(30 YEARS)			3178.6
TOTAL LIFE CYCLE COST(30 YEARS)			158930.0
DISCOUNTED LIFE CYCLE COST/SHIP			405.8**
DISCOUNTED TOTAL LIFE CYCLE COST			20292.5**

*ESTIMATED VALUE
 **DISCOUNTED AT 10 PERCENT

PRINTED REPORT NO. 2 - UNIT ACQUISITION COSTS - FLAP

SWBS GROUP	UNITS	INPUTS	KN FACTORS	LEAD SHIP COSTS \$K	FOLLOW SHIP COSTS \$K
100 HULL STRUCTURE	LTON	2077.5	1.00	26562.	24968.
200 PROPULSION PLANT	HP	7001.0	2.35	48935.	45999.
300 ELECTRIC PLANT	LTON	185.3	1.00	18677.	17556.
400 COMMAND SURVEILLANCE	LTON	385.3	3.15	28982.	27243.
500 AUX SYSTEMS	LTON	629.8	1.53	48138.	45250.
600 OUTFIT FURNISHINGS	LTON	429.7	1.00	24578.	23103.
700 ARMAMENT	LTON	399.6	1.00	6658.	6258.
MARGIN	LTON	0.0		0.	0.
800 DESIGN ENGINEERING			26.06	311695.	34441.
900 CONSTRUCTION SERVICES			4.25	52468.	49320.
TOTAL CONSTRUCTION COST				566693.	274139.
CONSTRUCTION COST				566693.	274139.
PROFIT(15.0 PERCENT OF CONSTRUCTION COST)				85004.	41121.
PRICE				651697.	315260.
CHANGE ORDERS(12/8 PERCENT OF PRICE)				78204.	25221.
NAVSEA SUPPORT(2.5 PERCENT OF PRICE)				16292.	7882.
POST DELIVERY CHARGES(5 PERCENT OF PRICE)				32585.	15763.
OUTFITTING(4 PERCENT OF PRICE)				26068.	12610.
H/M/E + GROWTH(10 PERCENT OF PRICE)				65170.	31526.
TOTAL SHIP COST				870015.	408262.
ESTIMATED PAYLOAD COST				806991.	710373.
SHIP PLUS PAYLOAD COST				1677006.	1118635.
ADJUSTED FIRST UNIT SHIP COST, \$K				434321.2	
COMBAT SYSTEM WEIGHT, LTON				1182.7	
PROPULSION SYSTEM WEIGHT, LTON				360.0	
ADJUSTED FIRST UNIT SHIP COST EQUALS					
FOLLOW SHIP TOTAL COST DIVIDED BY				0.940	

2XR: 2-WR-21 ICR Gas Turbine Propulsion Engines(24789 hp)
2-AC Liquid-cooled Propulsion Generators (28 mw)
2-Geared AC Liquid-cooled Propulsion Motors (27.2 mw)
2-Contrarotating Bi-coupled Epicyclic Reduction Gears
2-Contrarotating Propellers (17', 0.8EAR)
2-POD-Supported Contrarotating Shafts
2-Steerable PODs
Retractable Flap on Transom Stern
12000 N.Mile Range
2-VSCF Propulsion Derived Ship Service Systems (4000 kw)

This ship is similiar to the preceding one ("FLAP") except the range of the ship is doubled. The consequence of this is that "dirty" ballast is again required to maintain stability.

The increased range is specified by:

ENDURANCE = 12000.

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I)
ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 8/19/93 08.09.03.
GRAPHIC DISPLAY NO. 1 - SHIP MACHINERY LAYOUT

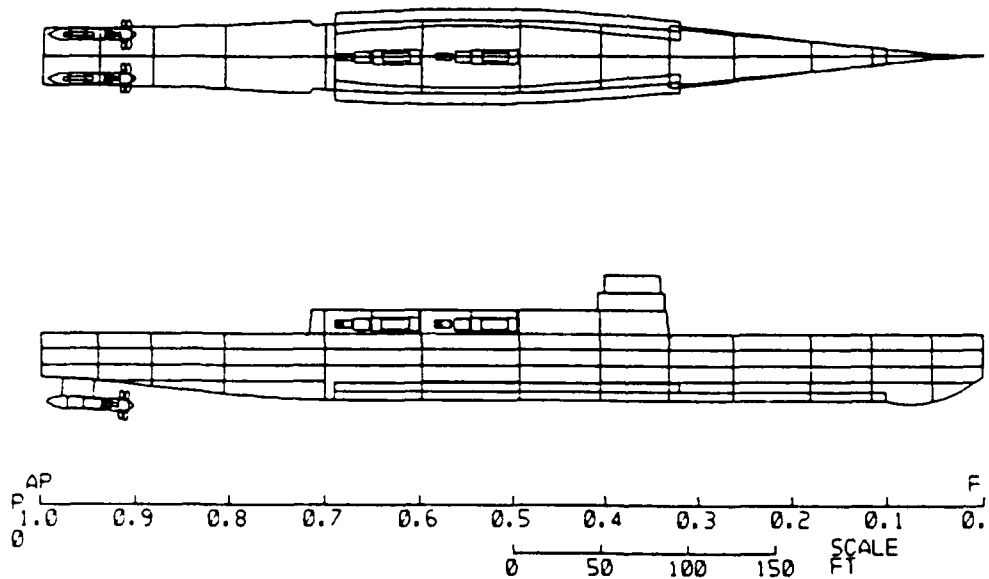


Fig. B.26. "2XR" Machinery Arrangement

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ASSET/MONOSC VERSION 3.2 - DESIGN SUMMARY - 2XR

PRINTED REPORT NO. 1 - SUMMARY **

PRINCIPAL CHARACTERISTICS - FT
 LBP 529.0
 LOA 529.0
 BEAM, DWL 55.0
 BEAM, WEATHER DECK 55.0
 DEPTH @ STA 10 51.5
 DRAFT TO KEEL DWL 13.8
 DRAFT TO KEEL LWL 15.0
 FREEBOARD @ STA 3 23.0
 GMT 5.4
 CP 0.578
 CX 0.830

SPEED(KT): MAX= 31.8 SUST= 30.0
 ENDURANCE: 12000.0 NM AT 20.0 KTS

TRANSMISSION TYPE: ELECT
 MAIN ENG: 2 RGT @ 24789.0 HP

SHAFT POWER/SHAFT: 21200.7 HP
 PROPELLERS: 2 - CR - 17.0 FT DIA

PD GEN: 2 VSCF @ 4000.0 KW

24 HR LOAD 1582.1
 MAX MARG ELECT LOAD 3132.4

	OFF	CPO	ENL	TOTAL
MANNING	22	19	229	270
ACCOM	25	21	252	298

WEIGHT SUMMARY - LTON
 GROUP 1 - HULL STRUCTURE 2088.7
 GROUP 2 - PROP PLANT 366.7
 GROUP 3 - ELECT PLANT 186.9
 GROUP 4 - COMM + SURVEIL 385.3
 GROUP 5 - AUX SYSTEMS 638.5
 GROUP 6 - OUTFIT + FURN 430.0
 GROUP 7 - ARMAMENT 399.6

 SUM GROUPS 1-7 4495.6
 DESIGN MARGIN 0.0

LIGHTSHIP WEIGHT 4495.6
 LOADS 2029.8

FULL LOAD DISPLACEMENT 6525.4
 FULL LOAD KG: FT 19.7

MILITARY PAYLOAD WT - LTON 1182.7
 USABLE FUEL WT - LTON 1497.6

AREA SUMMARY - FT2
 HULL AREA - 65712.4
 SUPERSTRUCTURE AREA - 2123.1

 TOTAL AREA 67835.5

VOLUME SUMMARY - FT3
 HULL VOLUME - 770214.6
 SUPERSTRUCTURE VOLUME - 21655.1

 TOTAL VOLUME 791869.8

** MAIN ENG POWER REQUIRED IS REPORTED

ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - 2XR

PRINTED REPORT NO. 1 - HULL GEOMETRY SUMMARY

HULL OFFSETS IND-GIVEN	MIN BEAM, FT	30.00
HULL DIM IND-NONE	MAX BEAM, FT	110.00
MARGIN LINE IND-GIVEN	HULL FLARE ANGLE, DEG	
HULL STA IND-GIVEN	FORWARD BULWARK, FT	0.00
HULL BC IND-GIVEN		

HULL PRINCIPAL DIMENSIONS (ON DWL)

LBP, FT	529.00	PRISMATIC COEF	0.578
LOA, FT	529.00	MAX SECTION COEF	0.830
BEAM, FT	55.05	WATERPLANE COEF	0.734
BEAM @ WEATHER DECK, FT	55.05	LCB/LCP	0.515
DRAFT, FT	13.80	HALF SIDING WIDTH, FT	0.00
DEPTH STA 0, FT	38.00	BOT RAKE, FT	0.00
DEPTH STA 3, FT	38.00	RAISED DECK HT, FT	13.50
DEPTH STA 10, FT	51.50	RAISED DECK FWD LIM, STA	6.60
DEPTH STA 20, FT	38.00	RAISED DECK AFT LIM, STA	14.34
FREEBOARD @ STA 3, FT	24.20	BARE HULL DISPL, LTON	5506.59
STABILITY BEAM, FT	49.98	AREA BEAM, FT	206.48

BARE HULL DATA ON LWL

STABILITY DATA ON LWL

LGTH ON WL, FT	529.00	KB, FT	8.64
BEAM, FT	54.63	BMT, FT	16.61
DRAFT, FT	14.98	KG, FT	19.73
FREEBOARD @ STA 3, FT	23.02	FREE SURF COR, FT	0.10
PRISMATIC COEF	0.592	SERV LIFE KG ALW, FT	0.00
MAX SECTION COEF	0.850		
WATERPLANE COEF	0.732	GMT, FT	5.41
WATERPLANE AREA, FT2	21166.48	GML, FT	1507.48
WETTED SURFACE, FT2	28569.88	GMT/B AVAIL	0.099
		GMT/B REQ	0.075
BARE HULL DISPL, LTON	6225.49		
APPENDAGE DISPL, LTON	300.00		
FULL LOAD WT, LTON	6525.45		

ASSET/MONOSC VERSION 3.2 - SPACE MODULE - 2XR

PRINTED REPORT NO. 1 - SUMMARY

COLL PROTECT SYS-NONE	SONAR DOME-PRESENT	UNIT COMMANDER-NONE	
FULL LOAD WT, LTON	6525.4	HAB STANDARD FAC	0.260
TOTAL CREW ACC	298	PASSWAY MARGIN FAC	0.000
HULL AVG DECK HT, FT	9.45	AC MARGIN FAC	0.000
MR VOLUME, FT3	101797	SPACE MARGIN FAC	0.000

	AREA FT2		VOL FT3
	PAYLOAD REQUIRED	TOTAL AVAILABLE	
DKHS ONLY	5874.0	8756.5	2123.1
HULL OR DKHS	14472.0	59080.6	65712.4
TOTAL	20346.0	67837.0	67835.5

SSCS GROUP	TOTAL	DKHS	PERCENT
	AREA FT2	AREA FT2	TOTAL AREA
1. MISSION SUPPORT	23108.7	6561.8	34.1
2. HUMAN SUPPORT	18836.7	886.0	27.8
3. SHIP SUPPORT	24949.1	1308.6	36.8
4. SHIP MOBILITY SYSTEM	942.5	0.0	1.4
5. UNASSIGNED			0.0
TOTAL	67837.0	8756.5	100.0

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ASSET/MONOSC VERSION 3.2 - RESISTANCE MODULE - 2XR

PRINTED REPORT NO. 1 - SUMMARY

RESID RESIST IND	REGR	BILGE KEEL IND	NONE
FRICTION LINE IND	ITTC	SHAFT SUPPORT TYPE IND	POD
ENDUR DISP IND	FULL LOAD	PRPLN SYS RESIST IND	GIVEN
ENDUR CONFIG IND	NO TS	PROP TYPE IND	CR
SONAR DRAG IND	APPENDAGE	SONAR DOME IND	PRESENT
SKEG IND	PRESENT	RUDDER TYPE IND	SPADE

FULL LOAD WT, LTON	6525.4	CORR ALW	0.00050
AVG ENDUR DISP, LTON	6525.4	DRAG MARGIN FAC	0.110
USABLE FUEL WT, LTON	1497.6	TRAILSHAFT PWR FAC	
NO FIN PAIRS	0.	PRPLN SYS RESIST FRAC	
PROP TIP CLEAR RATIO		MAX SPEED	0.000
NO PROP SHAFTS	2.	SUSTN SPEED	0.000
PROP DIA, FT	17.00	ENDUR SPEED	0.241

CONDITION SPEED	-----EFFECTIVE HORSEPOWER, HP-----						DRAG	
KT	FRIC	RESID	APPDC	WIND	MARGIN	TOTAL	LBF	
MAX	31.75	15042.	14317.	398.	503.	3328.	33587.	344678.
SUSTN	30.00	12747.	10436.	375.	424.	2638.	26620.	289156.
ENDUR	20.00	3916.	1586.	2249.	126.	866.	8743.	142450.

ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE - 2XR

PRINTED REPORT NO. 1 - SUMMARY

HULL SUBDIV IND-GIVEN		INNER BOT IND-PRESENT	
SHAFT SUPPORT TYPE IND-POD			
LBP, FT	529.00	HULL AVG DECK HT, FT	9.45
DEPTH STA 10, FT	51.50		
HULL VOLUME, FT3	770215.	NO INTERNAL DECKS	4
MR VOLUME, FT3	101797.	NO TRANS BHDS	12
TANKAGE VOL REQ, FT3	73077.	NO LONG BHDS	0
EXCESS TANKAGE, FT3	11009.	NO MACHY RMS	5
		NO PROT SHAFTS	2
ARR AREA LOST TANKS, FT2	101.6		
HULL ARR AREA AVAIL, FT2	65712.4		

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 2XR

PRINTED REPORT NO. 1 - SUMMARY

TRANS TYPE IND	ELECT	MAX SPEED, KT	31.75
ELECT PRPLN TYPE IND	ACC-AC	SUSTN SPEED IND	GIVEN
SHAFT SUPPORT TYPE IND	POD	SUSTN SPEED, KT	30.00
NO PROP SHAFTS	2.	ENDUR SPEED IND	GIVEN
ENDUR CONFIG IND	NO TS	ENDUR SPEED, KT	20.00
SEC ENG USAGE IND		DESIGN MODE IND	ENDURANCE
MAX MARG ELECT LOAD, KW	3132.	ENDURANCE, NM	12000.
AVG 24 HR ELECT LOAD, KW	1582.	USABLE FUEL WT, LTON	1497.6
SWBS 200 GROUP WT, LTON	366.7		
SWBS 300 GROUP WT, LTON	186.9		

ARRANGEMENT OR SS GEN	TYPE	NO INSTALLED	NO ONLINE MAX+SUSTN	NO ONLINE ENDURANCE
ELECT PG ARR 1 IND	M-PG	2	2	1
ELECT PG ARR 2 IND	M-CG-PG	0	0	0
ELECT DL ARR IND	MTR-BCE	2	2	2
SEP SS GEN	3000. KW	0	0	0
VSCF SS CYCLO	4000. KW	2	2	1

	MAIN ENG	SEC ENG	SS ENG
ENG SELECT IND	GIVEN		GIVEN
ENG MODEL IND	OTHER		DDA-571K
ENG TYPE IND	RGT		GT
ENG SIZE IND	GIVEN		GIVEN
NO INSTALLED	2	0	0
ENG PWR AVAIL, HP	26400.		6365.
ENG RPM	3600.0		11500.0
ENG SFC, LBM/HP-HR	0.324		.455
ENG LOAD FRAC	0.939		

PRINTED REPORT NO. 12 - POWERING

SUSTN SPEED IND-GIVEN
 ENDUR SPEED IND-GIVEN
 TRANS EFF IND-CALC

100 PCT POWER TRANS EFF	0.9282
25 PCT POWER TRANS EFF	0.8865

	MAX SPEED	SUSTN SPEED	ENDUR SPEED
SHIP SPEED, KT	31.75	30.00	20.00
PROP RPM	105.0	98.3	66.5
NO OP PROP SHAFTS	2	2	2
EHP (/SHAFT), HP	16794.	13310.	4371.
PROPULSIVE COEF	0.792	0.791	0.793
ENDUR PWR ALW	1.0	1.0	1.1
SHP (/SHAFT), HP	21201.	16831.	6066.
TRANS EFFY	0.928	0.921	0.890
CP PROP TRANS EFFY MULT	1.000	1.000	1.000
PROPUL PWR (/SHAFT), HP	22842.	18273.	6812.
PD GEN PWR (/SHAFT), HP	1947.	1947.	1711.
BHP (/SHAFT), HP	24789.	20221.	7943.

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PRINTED REPORT NO. 13 - HULL STRUCTURE AND MISCELLANEOUS WEIGHT - 2XR

SWBS	COMPONENT	WT, LTON	LCG, FT	VCG, FT
160	SPECIAL STRUCTURES			
161	CASTINGS, FORGINGS, AND WELDMENTS	99.9	436.11	3.53
162	STACKS AND MASTS	0.0	315.87	57.80
180	FOUNDATIONS			
* 182	PROPULSION PLANT FOUNDATIONS	39.6	403.84	31.71
* 183	ELECTRIC PLANT FOUNDATIONS	11.4	329.51	34.07

PRINTED REPORT NO. 14 - PROPULSION PLANT WEIGHT - 2XR

SWBS	COMPONENT	WT, LTON	LCG, FT	VCG, FT
200	PROPULSION PLANT	366.7	384.00	21.90
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	167.3	393.98	26.17
233	PROPULSION INTERNAL COMBUSTION ENGINES	0.0	0.00	0.00
* 234	PROPULSION GAS TURBINES	62.9	302.59	43.43
* 235	ELECTRIC PROPULSION	104.4	449.07	15.76
240	TRANSMISSION AND PROPULSOR SYSTEMS	75.0	492.00	-2.53
241	PROPULSION REDUCTION GEARS	32.9	500.14	-2.07
242	PROPULSION CLUTCHES AND COUPLINGS	0.0	0.00	0.00
243	PROPULSION SHAFTING	4.8	487.85	-2.80
244	PROPULSION SHAFT BEARINGS	14.5	491.81	-2.56
245	PROPULSORS	22.8	482.76	-3.10
250	PRPLN SUPPORT SYS (EXCEPT FUEL+LUBE OIL)	72.1	308.94	40.94
* 251	COMBUSTION AIR SYSTEM	18.0	289.31	46.80
252	PROPULSION CONTROL SYSTEM	13.1	302.59	33.47
256	CIRCULATING AND COOLING SEA WATER SYSTEM	8.8	333.27	18.54
* 259	UPTAKES (INNER CASING)	32.2	315.87	46.81
260	PRPLN SUPPORT SYS (FUEL+LUBE OIL)	32.0	294.02	20.27
261	FUEL SERVICE SYSTEM	9.4	276.14	37.43
262	MAIN PROPULSION LUBE OIL SYSTEM	16.2	302.59	12.00
264	LUBE OIL FILL, TRANSFER, AND PURIF	6.5	298.59	16.00
290	SPECIAL PURPOSE SYSTEMS	20.3	309.66	11.95
298	OPERATING FLUIDS	15.4	317.40	8.00
299	REPAIR PARTS AND SPECIAL TOOLS	5.0	285.66	24.20

PRINTED REPORT NO. 15 - ELECTRIC PLANT WEIGHT - 2XR

SWBS	COMPONENT	WT, LTON	LCG, FT	VCG, FT
300	ELECTRIC PLANT	186.9	293.77	36.59
310	ELECTRIC POWER GENERATION	61.7	314.49	32.46
311	SHIP SERVICE POWER GENERATION	23.3	329.51	43.43
313	BATTERIES AND SERVICE FACILITIES	28.3	329.51	10.30
314	POWER CONVERSION EQUIPMENT	10.1	238.05	69.18
320	POWER DISTRIBUTION SYSTEMS	95.1	283.48	36.37
321	SHIP SERVICE POWER CABLE	67.2	280.37	27.00
324	SWITCHGEAR AND PANELS	28.0	290.95	58.88
330	LIGHTING SYSTEM	28.9	278.34	46.75
331	LIGHTING DISTRIBUTION	17.8	280.37	46.35
332	LIGHTING FIXTURES	11.1	275.08	47.38
340	POWER GENERATION SUPPORT SYSTEMS	0.0	0.00	0.00
342	DIESEL SUPPORT SYSTEMS	0.0	0.00	0.00
343	TURBINE SUPPORT SYSTEMS	0.0	0.00	0.00
390	SPECIAL PURPOSE SYSTEMS	1.2	417.91	21.00
398	OPERATING FLUIDS	0.0	0.00	0.00
399	REPAIR PARTS AND SPECIAL TOOLS	1.2	417.91	21.00

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

PRINTED REPORT NO. 18 - MACHINERY SPACE REQUIREMENTS - 2XR

MACHINERY ROOM VOLUME REQUIREMENTS

VOLUME CATEGORY	VOLUME, FT3
SWBS GROUP 200	91841.
PROPULSION POWER GENERATION	28867.
PROPULSION ENGINES	11112.
PROPULSION REDUCTION GEARS AND GENERATORS	17755.
DRIVELINE MACHINERY	0.
REDUCTION AND BEVEL GEARS WITH Z-DRIVE	0.
ELECTRIC PROPULSION MOTORS AND GEARS	0.
REMOTELY-LOCATED THRUST BEARINGS	0.
PROPELLER SHAFT	0.
ELECTRIC PROPULSION MISCELLANEOUS EQUIPMENT	13383.
CONTROLS	1770.
BRAKING RESISTORS	1481.
MOTOR AND GENERATOR EXCITERS	2621.
SWITCHGEAR	1741.
POWER CONVERTERS	3321.
DEIONIZED COOLING WATER SYSTEMS	2448.
RECTIFIERS	0.
HELIUM REFRIGERATION SYSTEMS	0.
PROPULSION AUXILIARIES	49592.
PROPULSION LOCAL CONTROL CONSOLES	3510.
CP PROP HYDRAULIC OIL POWER MODULES	0.
FUEL OIL PUMPS	23938.
LUBE OIL PUMPS	3317.
LUBE OIL PURIFIERS	15329.
ENGINE LUBE OIL CONDITIONERS	602.
SEAWATER COOLING PUMPS	2897.
SWBS GROUP 300	18581.
ELECTRIC PLANT POWER GENERATION	0.
ELECTRIC PLANT ENGINES	0.
ELECTRIC PLANT GENERATORS AND GEARS	0.
SHIP SERVICE SWITCHBOARDS	17062.
CYCLOCONVERTERS	1519.
SWBS GROUP 500	44030.
AUXILIARY MACHINERY	44030.
AIR CONDITIONING PLANTS	7199.
AUXILIARY BOILERS	6360.
FIRE PUMPS	4417.
DISTILLING PLANTS	15054.
AIR COMPRESSORS	8686.
ROLL FIN PAIRS	0.
SEWAGE PLANTS	2314.

ARRANGEABLE AREA REQUIREMENTS

SSCS	GROUP NAME	-----FT2-----	
		HULL/DKHS	DKHS ONLY
3.4X	AUXILIARY MACHINERY DELTA	4289.1*	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	0.4	0.0
4.143	GAS TURBINE ENG EXHAUST	2.1	0.0

NOTE: * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

ASSET/MONOSC VERSION 3.2 - WEIGHT MODULE - 2XR

PRINTED REPORT NO. 1 - SUMMARY

SWBS	GROUP	WEIGHT		LCG	VCG	RESULTANT ADJ	
		LTON	PER CENT	FT	FT	WT-LTON	VCG-FT
100	HULL STRUCTURE	2088.7	32.0	273.87	21.58	42.2	.18
200	PROP PLANT	366.7	5.6	384.00	21.90		
300	ELECT PLANT	186.9	2.9	293.77	36.59		
400	COMM + SURVEIL	385.3	5.9	201.02	30.89	134.6	1.21
500	AUX SYSTEMS	638.5	9.8	290.95	27.56	25.0	.16
600	OUTFIT + FURN	430.0	6.6	264.50	24.86		
700	ARMAMENT	399.6	6.1	238.05	31.38	397.6	1.91
M11	D+B WT MARGIN		0.0	275.78			

D+B KG MARGIN

L I G H T S H I P							
		4495.6	68.9	275.78	25.06	599.4	3.46
F00	FULL LOADS	2029.8	31.1	265.34	7.94	328.6	1.12
F10	CREW + EFFECTS	30.2		248.63	31.64		
F20	MISS REL EXPEN	263.6		232.76	25.20		
F30	SHIPS STORES	42.5		285.66	23.73		
F40	FUELS + LUBRIC	1649.2		270.98	4.39		
F50	FRESH WATER	44.3			5.96		
F60	CARGO						
M24	FUTURE GROWTH						
FULL LOAD WT		6525.4	100.0	272.53	19.73	928.0	4.58

ASSET/MONOSC VERSION 3.2 - SEAKEEPING ANALYSIS - 2XR

PRINTED REPORT NO. 1 - SUMMARY

APPENDAGE IND-WITH

FULL LOAD WT, LTON 6525.4

FULL LOAD

BALES RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL DISP)	12.883
RANK OF THE SYNTHESIZED SHIP (NORMALIZED)	5.893
RANK OF THE CLOSEST DATA BASE HULL (NORMALIZED)	6.530
ID NO OF CLOSEST DATA BASE SHIP	14
MCCREIGHT RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL SHIP)	17.073
RANK OF THE CLOSEST DATA BASE HULL	17.103
ID NO OF CLOSEST DATA BASE SHIP	35

ASSET/MONOSC VERSION 3.2 - COST ANALYSIS - 2XR

PRINTED REPORT NO. 1 - SUMMARY

YEAR \$	1992.	NO OF SHIPS ACQUIRED	50.
INFLATION ESCALATION FAC	2.149	SERVICE LIFE, YR	30.0
LEARNING RATE	0.970	ANNUAL OPERATING HRS	2500.0
FUEL COST, \$/GAL	2.579	MILITARY P/L, LTON	1182.7
PAYLOAD FUEL RATE, LTON/HR	0.33	LIGHTSHIP WT, LTON	4495.6
SHIP FUEL RATE, LTON/HR	2.50	FULL LOAD WT, LTON	6525.4

COST ITEM	COSTS(MILLIONS OF DOLLARS)		
	TOT SHIP	PAYLOAD	TOTAL
LEAD SHIP	898.8	807.0*	1705.8
FOLLOW SHIP	421.0	710.4*	1131.4
AVG ACQUISITION COST/SHIP(50 SHIPS)	377.1	712.3*	1089.5
LIFE CYCLE COST/SHIP(30 YEARS)			3205.8
TOTAL LIFE CYCLE COST(30 YEARS)			160290.6
DISCOUNTED LIFE CYCLE COST/SHIP			409.5**
DISCOUNTED TOTAL LIFE CYCLE COST			20477.1**

*ESTIMATED VALUE
 **DISCOUNTED AT 10 PERCENT

PRINTED REPORT NO. 2 - UNIT ACQUISITION COSTS - 2XR

SWBS GROUP	UNITS	INPUTS	KN FACTORS	LEAD SHIP	FOLLOW SHIP	
				COSTS \$K	COSTS \$K	
100	HULL STRUCTURE	LTON	2088.7	1.00	26672.	25072.
200	PROPULSION PLANT	HP	45684.0	2.35	54578.	51303.
300	ELECTRIC PLANT	LTON	186.9	1.00	18827.	17697.
400	COMMAND*SURVEILLANCE	LTON	385.3	3.15	28982.	27243.
500	AUX SYSTEMS	LTON	638.5	1.53	48657.	45737.
600	OUTFIT*FURNISHINGS	LTON	430.0	1.00	24589.	23114.
700	ARMAMENT	LTON	399.6	1.00	6658.	6258.
	MARGIN	LTON	0.0		0.	0.
800	DESIGN*ENGINEERING		26.06		322594.	35646.
900	CONSTRUCTION SERVICES		4.25		53863.	50631.
TOTAL CONSTRUCTION COST					585420.	282702.
CONSTRUCTION COST					585420.	282702.
PROFIT(15.0 PERCENT OF CONSTRUCTION COST)					87813.	42405.
PRICE					673233.	325108.
CHANGE ORDERS(12/8 PERCENT OF PRICE)					80788.	26009.
NAVSEA SUPPORT(2.5 PERCENT OF PRICE)					16831.	8128.
POST DELIVERY CHARGES(5 PERCENT OF PRICE)					33662.	16255.
OUTFITTING(4 PERCENT OF PRICE)					26929.	13004.
H/M/E + GROWTH(10 PERCENT OF PRICE)					67323.	32511.
TOTAL SHIP COST					898766.	421015.
ESTIMATED PAYLOAD COST					806991.	710373.
SHIP PLUS PAYLOAD COST					1705757.	1131387.
ADJUSTED FIRST UNIT SHIP COST, \$K				447887.8		
COMBAT SYSTEM WEIGHT, LTON				1182.7		
PROPULSION SYSTEM WEIGHT, LTON				366.7		
ADJUSTED FIRST UNIT SHIP COST EQUALS						
FOLLOW SHIP TOTAL COST DIVIDED BY				0.940		

21st CENTURY BASELINE

The results obtained, from the preceding series of 10 machinery options, in two markedly different hullforms, are the basis for a new ship design ("DD21A").

This new ship design is expected to be useful as a baseline for evaluating ship designs for the 21st century. This 21st CENTURY BASELINE "DD21A" has the following important new features when compared to the TUMBLE HOME "2XR" ship:

- * Ship LBP increased to 553', no flap
- * Tumble home increased to 12 degrees
- * Ship stable to fuel burn out, no ballast
- * Full synchronous operation, no solid state controls

In addition to the above, the following minor changes are included in "DD21A":

- * Maximum section coefficient of .785 (vs .830)
- * Updated SFC characteristic of WR-21 engine
- * Stem angle of approximately 25 degrees (vs 90)

Alternate Name.....

When compared to the reference ship ("REFDD"), the 21st CENTURY BASELINE ("DD21A") is expected to be:

Small, Efficient and Affordable with

Main Machinery Outside her Tumble Home Hull and Extended Range

The acronym SEA MOTHER is provided as an alternate name to help the reader remember the attributes of "DD21A". SEA MOTHER is an environmentally friendly ship as she requires no seawater ballast for stability.

ASSET Synthesis.....

The ASSET synthesis procedure for SEA MOTHER is identical to that described for the TUMBLE HOME MONOHULL. The design criteria of stable at fuel burnout is met by establishing the design waterline at the maximum beam with no usable fuel in the ship. As fuel is added to SEA MOTHER the beam at the waterline decreases, because of tumble home, while the cg is reduced and the GMT/B increases slightly. This is accomplished in the first phase of synthesis, when a conventional monohull is designed and before tumble home is introduced, by:

DESIGN MODE IND = FUEL WT
USABLE FUEL WT = .01

Machinery Options.....

The following machinery options are installed in the 553 foot, unconventional, 12 degree tumble home hull:

- DD21A - Relative to the last option installed in the unconventional tumble home hull ("2XR"), this option has similiar machinery with some exceptions. The solid state propulsion motor controls have been removed and the propulsion motors/generators now operate synchronously over the entire operating range. The stern flaps no longer exist. The ship has excess stability in the full load condition.
- DD21ABO - This is identical to DD21A except the usable fuel is removed to simulate the fuel burn out condition and check the stability.

Ship/Machinery Graphics and Data.....

An ASSET hull body plan and isometric view of the SEA MOTHER is shown on succeeding pages followed by information on the machinery options installed including ASSET modeling details, machinery arrangements and representative ASSET printed reports. These ships are available to all ASSET users on:

MSSF2 USERDISK:[SHANK.ASSET]JNEWREF.BNK

B-144

I) ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - 7/30/93 09.56.49.
GRAPHIC DISPLAY NO. 1 - BODY PLAN

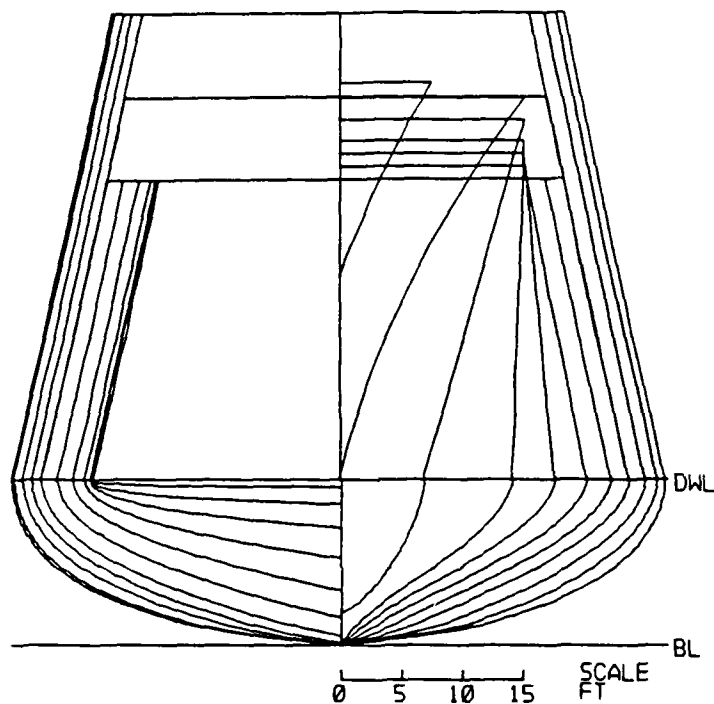


Fig. B.27. "DD21A" (SEA MOTHER) 12 degree Tumble Home Hull Body Plan

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I) ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - 7/30/93 09.56.49.
GRAPHIC DISPLAY NO. 2 - HULL ISOMETRIC VIEW

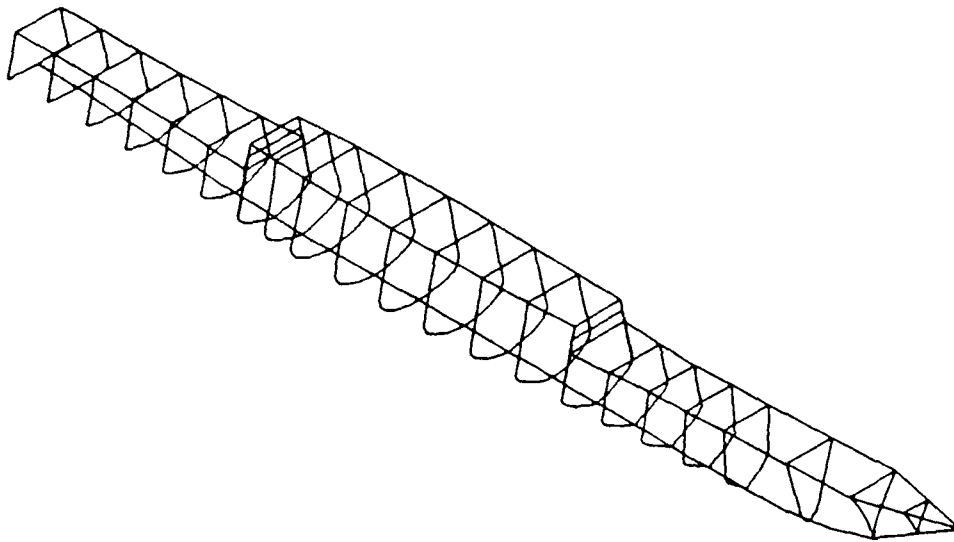


Fig. B.28. "DD21A" (SEA MOTHER) 12 degree Tumble Home Hull
Isometric View

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DD21A: 2-WR-21 ICR Gas Turbine Propulsion Engines(25872 hp)
 2-AC Liquid-cooled Propulsion Generators (28 mw)
 2-Geared AC Liquid-cooled Propulsion Motors (27.2 mw)
 2-Contrarotating Bi-coupled Epicyclic Reduction Gears
 2-Contrarotating Propellers (17', 0.8EAR)
 2-POD-Supported Contrarotating Shafts
 2-Steerable PODs
 Transom Stern
 12000 N.Mile Range
 2-VSCF Propulsion Derived Ship Service Systems (4000 kw)

This option has similiar machinery to the preceding one (2XR) except the propulsion motors/generators operate synchronously over the entire operating range without benefit of the solid state propulsion motor controls . The solid state controls did allow engine SFC optimization but with ICR engines that benefit is small.The stern flaps no longer exist and their benefit has been obtained by increasing the ship length.

These are specified in ASSET by eliminating the stern flap weight adjustment and by specifying the following:

ELECT PRPLN TYPE IND = AC-AC
 LBP = 553.
 PRPLN SYS RESIST IND = CALC

The ICR engine update is specified by:

MAIN ENG EXH TEMP	=	654.000	DEGF
MAIN ENG BARE WT	=	4.35400	LTON
MAIN ENG DIM ARRAY	=	(3X 1)	FT
1 15.41			
2 5.160			
3 5.860			
MAIN ENG SFC EQN IND	=	POLY QN	
MAIN ENG SFC	=	0.327300	LBM/HP-HR
MAIN ENG SFC FAC ARRAY	=	(11X 1)	
1 -.5369			
2 0.6204			
3 -.3983E-01			
4 0.5255			
5 0.4816			
6 2.010			
7 1.715			
8 0.1742			
9 -.1964			
10 0.2654			
11 0.6210			

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I) ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - 7/30/93 09.58.23.
GRAPHIC DISPLAY NO. 1 - SHIP MACHINERY LAYOUT

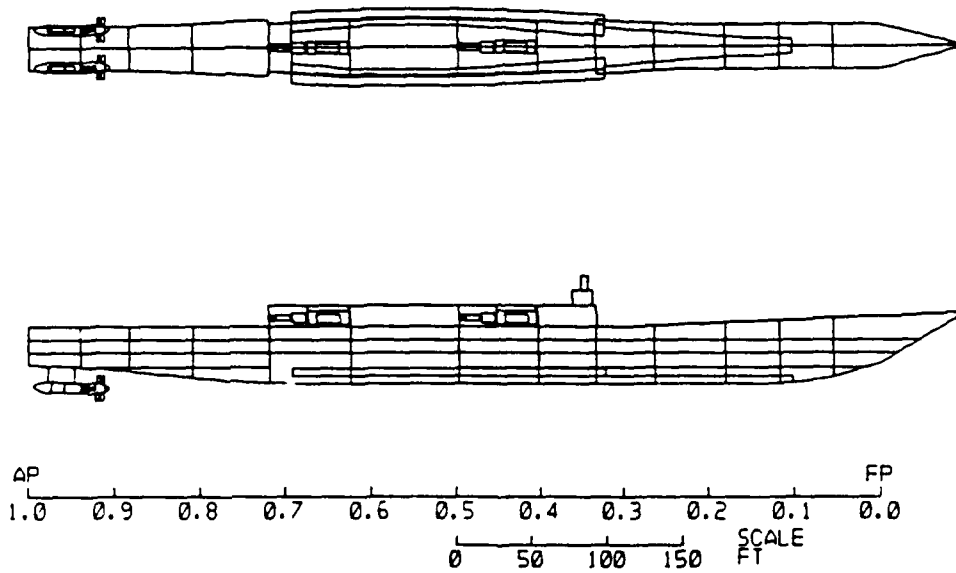


Fig. B.29. "DD21A" (SEA MOTHER) Machinery Arrangement

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ASSET/MONOSC VERSION 3.2 - DESIGN SUMMARY - DD21A (SEA MOTHER)

PRINTED REPORT NO. 1 - SUMMARY **

PRINCIPAL CHARACTERISTICS - FT

LBP	553.0
LOA	609.3
BEAM, DWL	53.0
BEAM, WEATHER DECK	53.0
DEPTH @ STA 10	51.5
DRAFT TO KEEL DWL	13.4
DRAFT TO KEEL LWL	15.3
FREEBOARD @ STA 3	25.8
GMT	5.1
CP	0.578
CX	0.784

SPEED(KT): MAX= 31.8 SUST= 30.0
 ENDURANCE: 12000.0 NM AT 20.0 KTS

TRANSMISSION TYPE: ELECT
 MAIN ENG: 2 RGT @ 25872.0 HP

SHAFT POWER/SHAFT: 22080.0 HP
 PROPELLERS: 2 - CP - 17.0 FT DIA

PD GEN: 2 VSCF @ 4000.0 KW

24 HR LOAD	1619.4
MAX MARG ELECT LOAD	3224.4

	OFF	CPO	ENL	TOTAL
MANNING	22	19	229	270
ACCOM	25	21	252	298

WEIGHT SUMMARY - LTON

GROUP 1 - HULL STRUCTURE	2208.7
GROUP 2 - PROP PLANT	344.7
GROUP 3 - ELECT PLANT	220.0
GROUP 4 - COMM + SURVEIL	386.9
GROUP 5 - AUX SYSTEMS	601.2
GROUP 6 - OUTFIT + FURN	441.7
GROUP 7 - ARMAMENT	399.6

 SUM GROUPS 1-7 4602.9
 DESIGN MARGIN 0.0

 LIGHTSHIP WEIGHT 4602.9
 LOADS 2018.6

 FULL LOAD DISPLACEMENT 6621.5
 FULL LOAD KG: FT 20.2

MILITARY PAYLOAD WT - LTON 1182.7
 USABLE FUEL WT - LTON 1486.9

AREA SUMMARY - FT2

HULL AREA	-	67867.3
SUPERSTRUCTURE AREA	-	507.8

 TOTAL AREA 68375.1

VOLUME SUMMARY - FT3

HULL VOLUME	-	821063.6
SUPERSTRUCTURE VOLUME	-	5179.1

 TOTAL VOLUME 826242.8

** MAIN ENG REQUIRED POWER IS REPORTED

ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - DD21A (SEA MOTHER)

PRINTED REPORT NO. 1 - HULL GEOMETRY SUMMARY

HULL OFFSETS IND-GIVEN	MIN BEAM, FT	30.00
HULL DIM IND-NONE	MAX BEAM, FT	110.00
MARGIN LINE IND-CALC	HULL FLARE ANGLE, DEG	
HULL STA IND-OPTIMUM	FORWARD BULWARK, FT	0.00
HULL BC IND-GIVEN		

HULL PRINCIPAL DIMENSIONS (ON DWL)

LBP, FT	553.00	PRISMATIC COEF	0.578
LOA, FT	609.27	MAX SECTION COEF	0.784
BEAM, FT	53.00	WATERPLANE COEF	0.771
BEAM @ WEATHER LECK, FT	53.00	LCB/LCP	0.506
DRAFT, FT	13.36	HALF SIDING WIDTH, FT	0.00
DEPTH STA 0, FT	44.63	BOT RAKE, FT	0.00
DEPTH STA 3, FT	41.14	RAISED DECK HT, FT	13.50
DEPTH STA 10, FT	51.50	RAISED DECK FWD LIM, STA	6.60
DEPTH STA 20, FT	38.00	RAISED DECK AFT LIM, STA	14.34
FREEBOARD @ STA 3, FT	27.78	BARE HULL DISPL, LTON	5069.20
STABILITY BEAM, FT	46.31	AREA BEAM, FT	792.37

BARE HULL DATA ON LWL

LGTH ON WL, FT	556.25
BEAM, FT	52.18
DRAFT, FT	15.30
FREEBOARD @ STA 3, FT	25.84
PRISMATIC COEF	0.604
MAX SECTION COEF	0.823
WATERPLANE COEF	0.768
WATERPLANE AREA, FT2	22299.14
WETTED SURFACE, FT2	29380.38
BARE HULL DISPL, LTON	6316.65
APPENDAGE DISPL, LTON	304.85
FULL LOAD WT, LTON	6621.49

STABILITY DATA ON LWL

KB, FT	9.14
BMT, FT	16.19
KG, FT	20.15
FREE SURF COR, FT	0.10
SERV LIFE KG ALW, FT	0.00
GMT, FT	5.07
GML, FT	1830.11
GMT/B AVAIL	0.097
GMT/B REQ	0.075

ASSET/MONOSC VERSION 3.2 - SPACE MODULE - DD21A (SEA MOTHER)

PRINTED REPORT NO. 1 - SUMMARY

COLL PROTECT SYS-NONE	SONAR DOME-PRESENT	UNIT COMMANDER-NONE	
FULL LOAD WT, LTON	6621.5	HAB STANDARD FAC	0.260
TOTAL CREW ACC	298.	PASSWAY MARGIN FAC	0.000
HULL AVG DECK HT, FT	9.85	AC MARGIN FAC	0.000
MR VOLUME, FT3	107624.	SPACE MARGIN FAC	0.000

	AREA FT2		VOL FT3	
	PAYLOAD REQUIRED	TOTAL REQUIRED	TOTAL AVAILABLE	TOTAL ACTUAL
DKHS ONLY	5874.0	8609.3	507.8	5179.
HULL OR DKHS	14472.0	59763.9	67867.3	821064.
TOTAL	20346.0	68373.1	68375.1	826243.

ESCS	GROUP	TOTAL	DKHS	PERCENT
		AREA FT2	AREA FT2	TOTAL AREA
1.	MISSION SUPPORT	23102.7	6529.7	33.8
2.	HUMAN SUPPORT	18878.1	927.3	27.6
3.	SHIP SUPPORT	25449.9	1152.2	37.2
4.	SHIP MOBILITY SYSTEM	942.5	0.0	1.4
5.	UNASSIGNED			0.0
	TOTAL	68373.1	8609.3	100.0

ASSET/MONOSC VERSION 3.2 - RESISTANCE MODULE - DD21A (SEA MOTHER)

PRINTED REPORT NO. 1 - SUMMARY

RESID RESIST IND	REGR	BILGE KEEL IND	NONE
FRICTION LINE IND	ITTC	SHAFT SUPPORT TYPE IND	POD
ENDUR DISP IND	AVG DISP	PRPLN SYS RESIST IND	CALC
ENDUR COMFIG IND	NO TS	PROP TYPE IND	CR
SONAR DRAG IND	APPENDAGE	SONAR DOME IND	PRESENT
SKEG IND	PRESENT	RUDDER TYPE IND	SPADE
FULL LOAD WT, LTON	6621.5	CORR ALW	0.00050
AVG ENDUR DISP, LTON	5878.1	DRAG MARGIN FAC	0.110
USABLE FUEL WT, LTON	1486.9	TRAILSHAFT PWR FAC	
NO FIN PAIRS	0.	PRPLN SYS RESIST FRAC	
PROP TIP CLEAR RATIO	0.25	MAX SPEED	0.131
NO PROP SHAFTS	2.	SUSTN SPEED	0.145
PROP DIA, FT	17.00	ENDUR SPEED	0.231
CONDITION SPEED-----	EFFECTIVE HORSEPOWER, HP-----		
	KT	FRIC	RESID
			APPDG
			WIND
			MARGIN
			TOTAL
			DRAG
			LBF
MAX	31.81	15486.	11510.
			3998.
			462.
			3460.
			34916.
			357675.
SUSTN	30.00	13055.	8052.
			3565.
			387.
			2757.
			27816.
			302148.
ENDUR	20.00	3827.	1201.
			2164.
			118.
			804.
			8115.
			132214.

ASSET/MONOSC VERSION 3.2 - HULL SUBDIV MODULE - DD21A (SEA MOTHER)

PRINTED REPORT NO. 1 - SUMMARY

HULL SUBDIV IND-GIVEN		INNER BOT IND-PRESENT	
SHAFT SUPPORT TYPE IND-POD			
LBP, FT	553.00	HULL AVG DECK HT, FT	9.85
DEPTH STA 10, FT	51.50		
HULL VOLUME, FT3	821064.	NO INTERNAL DECKS	4
MR VOLUME, FT3	107624.	NO TRANS BHDS	12
TANKAGE VOL REQ, FT3	72587.	NO LONG BHDS	0
EXCESS TANKAGE, FT3	4869.	NO MACHY RMS	5
		NO PROP SHAFTS	2
ARR AREA LOST TANKS, FT2	101.6		
HULL ARR AREA AVAIL, FT2	67867.3		

ASSET/MONOSC VERSION 3.2 - MACHINERY MODULE - DD21A (SEA MOTHER)

PRINTED REPORT NO. 1 - SUMMARY

TRANS TYPE IND	ELECT	MAX SPEED, KT	31.81
ELECT PRPLN TYPE IND	AC-AC	SUSTN SPEED IND	GIVEN
SHAFT SUPPORT TYPE IND	POD	SUSTN SPEED, KT	30.00
NO PROP SHAFTS	2.	ENDUR SPEED IND	GIVEN
ENDUR CONFIG IND	NO TS	ENDUR SPEED, KT	20.00
SEC ENG USAGE IND		DESIGN MODE IND	ENDURANCE
MAX MARG ELECT LOAD, KW	3224.	ENDURANCE, NM	12000.
AVG 24 HR ELECT LOAD, KW	1619.	USABLE FUEL WT, LTON	1486.9
SWBS 200 GROUP WT, LTON	344.7		
SWBS 300 GROUP WT, LTON	220.0		

ARRANGEMENT OR SS GEN	TYPE	NO INSTALLED	NO ONLINE MAX+SUSTN	NO ONLINE ENDURANCE
ELECT PG ARR 1 IND	M-PG	2	2	1
ELECT PG ARR 2 IND	M-CG-PG	0	0	0
ELECT DL ALA IND	MTR-BCE	2	2	2
SEP SS GEN	3000. KW	0	0	0
VSCF SS CYCLO	4000. KW	2	2	1

	MAIN ENG	SEC ENG	SS ENG
ENG SELECT IND	GIVEN		GIVEN
ENG MODEL IND	OTHER		DDA-571K
ENG TYPE IND	RGT		GT
ENG SIZE IND	GIVEN		GIVEN
NO INSTALLED	2	0	0
ENG PWR AVAIL, HP	26400.		6365.
ENG RPM	3600.0		11500.0
ENG SFC, LBM/HP-HR	0.327		.455
ENG LOAD FRAC	0.980		

PRINTED REPORT NO. 12 - POWERING - DD21A (SEA MOTHER)

SUSTN SPEED IND-GIVEN
 ENDUR SPEED IND-GIVEN
 TRANS EFF IND-CALC

100 PCT POWER TRANS EFF	0.9282
25 PCT POWER TRANS EFF	0.9118

	MAX SPEED	SUSTN SPEED	ENDUR SPEED
SHIP SPEED, KT	31.81	30.00	20.00
PROP RPM	107.8	100.8	67.1
NO OF PROP SHAFTS	2	2	2
EHP (/SHAFT), HP	17458.	13908.	4057.
PROPULSIVE COEF	0.791	0.790	0.789
ENDUR PWR ALW	1.0	1.0	1.1
SHP (/SHAFT), HP	22080.	17613.	5655.
TRANS EFFY	0.928	0.925	0.912
CP PROP TRANS EFFY MULT	1.000	1.000	1.000
PROPUL PWR (/SHAFT), HP	23790.	19032.	6200.
PD GEN PWR (/SHAFT), HP	2083.	2069.	1148.
BHP (/SHAFT), HP	25872.	21101.	7348.

PRINTED REPORT NO. 13 - HULL STRUCTURE AND MISCELLANEOUS WEIGHT - DD21A

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
160	SPECIAL STRUCTURES			
161	CASTINGS, FORGINGS, AND WELDMENTS	102.7	457.66	3.39
162	STACKS AND MASTS	0.0	310.11	57.80
180	FOUNDATIONS			
* 182	PROPULSION PLANT FOUNDATIONS	35.9	409.64	32.76
* 183	ELECTRIC PLANT FOUNDATIONS	24.3	326.16	34.07

PRINTED REPORT NO. 14 - PROPULSION PLANT WEIGHT - DD21A (SEA MOTHER)

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
200	PROPULSION PLANT	344.7	388.06	22.29
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	142.9	393.62	27.97
233	PROPULSION INTERNAL COMBUSTION ENGINES	0.0	0.00	0.00
* 234	PROPULSION GAS TURBINES	54.4	296.98	43.43
* 235	ELECTRIC PROPULSION	88.5	453.01	18.47
240	TRANSMISSION AND PROPULSOR SYSTEMS	76.0	516.34	-2.44
241	PROPULSION REDUCTION GEARS	33.2	524.06	-2.16
242	PROPULSION CLUTCHES AND COUPLINGS	0.0	0.00	0.00
243	PROPULSION SHAFTING	4.8	511.62	-2.61
244	PROPULSION SHAFT BEARINGS	15.3	515.66	-2.46
245	PROPULSORS	22.8	506.52	-2.80
250	PRPLN SUPPORT SYS (EXCEPT FUEL+LUBE OIL)	72.9	305.98	40.78
* 251	COMBUSTION AIR SYSTEM	18.0	283.86	46.80
252	PROPULSION CONTROL SYSTEM	13.6	296.98	33.47
256	CIRCULATING AND COOLING SEA WATER SYSTEM	9.1	348.39	18.54
* 259	UPTAKES (INNER CASING)	32.2	310.11	46.81
260	PRPLN SUPPORT SYS (FUEL+LUBE OIL)	32.1	288.08	20.25
261	FUEL SERVIC. SYSTEM	9.4	269.33	37.43
262	MAIN PROPULSION LUBE OIL SYSTEM	16.2	296.98	12.00
264	LUBE OIL FILL, TRANSFER, AND PURIF	6.5	292.98	16.00
290	SPECIAL PURPOSE SYSTEMS	20.8	323.56	12.02
298	OPERATING FLUIDS	15.7	331.80	8.00
299	REPAIR PARTS AND SPECIAL TOOLS	5.2	298.62	24.20

PRINTED REPORT NO. 15 - ELECTRIC PLANT WEIGHT - DD21A (SEA MOTHER)

SWBS	COMPONENT	WT,LTON	LCG,FT	VCG,FT
300	ELECTRIC PLANT	220.0	305.65	37.18
310	ELECTRIC POWER GENERATION	88.8	317.33	35.51
311	SHIP SERVICE POWER GENERATION	49.6	326.16	43.43
313	BATTERIES AND SERVICE FACILITIES	29.1	326.16	10.30
314	POWER CONVERSION EQUIPMENT	10.1	248.85	69.18
320	POWER DISTRIBUTION SYSTEMS	99.3	296.30	16.25
321	SHIP SERVICE POWER CABLE	70.5	293.09	27.00
324	SWITCHGEAR AND PANELS	28.8	304.13	58.88
330	LIGHTING SYSTEM	29.4	290.92	46.75
331	LIGHTING DISTRIBUTION	17.9	293.09	46.35
332	LIGHTING FIXTURE	11.6	287.56	47.38
340	POWER GENERATION SUPPORT SYSTEMS	0.0	0.00	0.00
342	DIESEL SUPPORT SYSTEMS	0.0	0.00	0.00
343	TURBINE SUPPORT SYSTEMS	0.0	0.00	0.00
390	SPECIAL PURPOSE SYSTEMS	2.5	436.87	21.00
398	OPERATING FLUIDS	0.0	0.00	0.00
399	REPAIR PARTS AND SPECIAL TOOLS	2.5	436.87	21.00

* DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

PRINTED REPORT NO. 18 - MACHINERY SPACE REQUIREMENTS - DD21A (SEA MOTHER)

MACHINERY ROOM VOLUME REQUIREMENTS

VOLUME CATEGORY	VOLUME, FT ³
SWBS GROUP 200	95642.
PROPULSION POWER GENERATION	33050.
PROPULSION ENGINES	10954.
PROPULSION REDUCTION GEARS AND GENERATORS	22096.
DRIVELINE MACHINERY	0.
REDUCTION AND BEVEL GEARS WITH Z-DRIVE	0.
ELECTRIC PROPULSION MOTORS AND GEARS	0.
REMOTELY-LOCATED THRUST BEARINGS	0.
PROPELLER SHAFT	0.
ELECTRIC PROPULSION MISCELLANEOUS EQUIPMENT	10828.
CONTROLS	1845.
BRAKING RESISTORS	1544.
MOTOR AND GENERATOR EXCITERS	2732.
SWITCHGEAR	1229.
POWER CONVERTERS	927.
DEIONIZED COOLING WATER SYSTEMS	2551.
RECTIFIERS	0.
HELIUM REFRIGERATION SYSTEMS	0.
PROPULSION AUXILIARIES	51764.
PROPULSION LOCAL CONTROL CONSOLES	3658.
CP PROP HYDRAULIC OIL POWER MODULES	0.
FUEL OIL PUMPS	24951.
LUBE OIL PUMPS	3465.
LUBE OIL PURIFIERS	15977.
ENGINE LUBE OIL CONDITIONERS	627.
SEAWATER COOLING PUMPS	3085.
SWBS GROUP 300	19620.
ELECTRIC PLANT POWER GENERATION	0.
ELECTRIC PLANT ENGINES	0.
ELECTRIC PLANT GENERATORS AND GEARS	0.
SHIP SERVICE SWITCHBOARDS	18036.
CYCLOCONVERTERS	1583.
SWBS GROUP 500	46327.
AUXILIARY MACHINERY	46327.
AIR CONDITIONING PLANTS	7691.
AUXILIARY BOILERS	6630.
FIRE PUMPS	4710.
DISTILLING PLANTS	15691.
AIR COMPRESSORS	9194.
ROLL FIN PAIRS	0.
SEWAGE PLANTS	2411.

ARRANGEABLE AREA REQUIREMENTS

SSCS	GROUP NAME	-----FT ² -----	
		HULL/DKHS	DKHS ONLY
3.4X	AUXILIARY MACHINERY DELTA	4195.9*	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	0.4	0.0
4.143	GAS TURBINE ENG EXHAUST	2.1	0.0

NOTE: * DENOTES INCLUSION OF PAYLOAD OR ADJUSTMENTS

ASSET/MONOSC VERSION 3.2 - WEIGHT MODULE - DD21A (SEA MOTHER)

PRINTED REPORT NO. 1 - SUMMARY

SWBS	GROUP	WEIGHT		LCG	VCG	RESULTANT ADJ	
		LTON	PER CENT	FT	FT	WT-LTON	VCG-FT
100	HULL STRUCTURE	2208.7	33.4	280.05	21.59	42.2	.18
200	PROP PLANT	344.7	5.2	388.06	22.29		
300	ELECT PLANT	220.0	3.3	305.65	37.18		
400	COMM + SURVEIL	386.9	5.8	210.14	31.03	134.6	1.20
500	AUX SYSTEMS	601.2	9.1	304.15	29.16	25.0	.16
600	OUTFIT + FURN	441.7	6.7	276.50	25.04		
700	ARMAMENT	399.6	6.0	248.85	31.72	397.6	1.90
M11	D+B WT MARGIN		0.0	283.58			

D+B KG MARGIN							

L I G H T S H I P		4602.9	69.5	283.58	25.38	599.4	3.43

F00	FULL LOADS	2018.6	30.5	271.11	8.24	328.6	1.10
F10	CREW + EFFECTS	30.2		259.91	32.28		
F20	MISS REL EXPEN	263.6		243.32	25.18		
F30	SHIPS STORES	42.5		298.62	24.21		
F40	FUELS + LUBRIC	1638.0		275.60	4.72		
F50	FRESH WATER	44.3			6.09		
F60	CARGO						
M24	FUTURE GROWTH						

FULL LOAD WT		6621.5	100.0	279.78	20.15	928.0	4.54

ASSET/MONOSC VERSION 3.2 - SEAKEEPING ANALYSIS - DD21A (SEA MOTHER)

PRINTED REPORT NO. 1 - SUMMARY

APPENDAGE IND-WITH

FULL LOAD WT, LTON 6621.5

	FULL LOAD

SALES RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL DISP)	19.061
RANK OF THE SYNTHESIZED SHIP (NORMALIZED)	11.778
RANK OF THE CLOSEST DATA BASE HULL (NORMALIZED)	10.000
ID NO OF CLOSEST DATA BASE SHIP	16
MCCREIGHT RANK	
RANK OF THE SYNTHESIZED SHIP (ACTUAL SHIP)	25.605
RANK OF THE CLOSEST DATA BASE HULL	25.557
ID NO OF CLOSEST DATA BASE SHIP	30

ASSET/MONOSC VERSION 3.2 - COST ANALYSIS - DD21A (SEA MOTHER)

PRINTED REPORT NO. 1 - SUMMARY

YEAR \$	1992.	NO OF SHIPS ACQUIRED	50.
INFLATION ESCALATION FAC	2.149	SERVICE LIFE, YR	30.0
LEARNING RATE	0.970	ANNUAL OPERATING HRS	2500.0
FUEL COST, \$/GAL	2.579	MILITARY P/L, LTON	1182.7
PAYLOAD FUEL RATE, LTON/HR	0.33	LIGHTSHIP WT, LTON	4602.9
SHIP FUEL RATE, LTON/HR	2.48	FULL LOAD WT, LTON	6621.5

COST ITEM	COSTS (MILLIONS OF DOLLARS)		
	TOT SHIP	+ PAYLOAD	= TOTAL
LEAD SHIP	918.3	807.0*	1725.3
FOLLOW SHIP	429.7	710.4*	1140.1
AVG ACQUISITION COST/SHIP(50 SHIPS)	384.9	712.3*	1097.2
LIFE CYCLE COST/SHIP(30 YEARS)			3215.8
TOTAL LIFE CYCLE COST(30 YEARS)			160792.4
DISCOUNTED LIFE CYCLE COST/SHIP			411.6**
DISCOUNTED TOTAL LIFE CYCLE COST			20582.2**

*ESTIMATED VALUE

**DISCOUNTED AT 10 PERCENT

PRINTED REPORT NO. 2 - UNIT ACQUISITION COSTS - DD21A (SEA MOTHER)

SWBS GROUP	UNITS	INPUTS	KN FACTORS	LEAD	FOLLOW
				SHIP COSTS \$K	SHIP COSTS \$K
100 HULL STRUCTURE	LTON	2208.7	1.00	27848.	26177.
200 PROPULSION PLANT	RP	47580.0	2.35	56401.	53017.
300 ELECTRIC PLANT	LTON	220.0	1.00	21841.	20530.
400 COMMAND+SURVEILLANCE	LTON	386.9	3.15	29060.	27316.
500 AUX SYSTEMS	LTON	601.2	1.53	46421.	43635.
600 OUTFIT+FURNISHINGS	LTON	441.7	1.00	25112.	23605.
700 ARMAMENT	LTON	399.6	1.00	6658.	6259.
MARGIN	LTON	0.0		0.	0.
800 DESIGN+ENGINEERING			26.06	330027.	36467.
900 CONSTRUCTION SERVICES			4.25	54808.	51520.
TOTAL CONSTRUCTION COST				598175.	288526.
CONSTRUCTION COST				598175.	288526.
PROFIT(15.0 PERCENT OF CONSTRUCTION COST)				89726.	43279.
PRICE				687902.	331805.
CHANGE ORDERS(12/8 PERCENT OF PRICE)				82548.	26544.
NAVSEA SUPPORT(2.5 PERCENT OF PRICE)				17198.	8295.
POST DELIVERY CHARGES(5 PERCENT OF PRICE)				34395.	16590.
OUTFITTING(4 PERCENT OF PRICE)				27516.	13272.
H/M/E + GROWTH(10 PERCENT OF PRICE)				68790.	33181.
TOTAL SHIP COST				918349.	429688.
ESTIMATED PAYLOAD COST				806991.	710373.
SHIP PLUS PAYLOAD COST				1725340.	1140061.
ADJUSTED FIRST UNIT SHIP COST, \$K				457114.8	
COMBAT SYSTEM WEIGHT, LTON				1182.7	
PROPULSION SYSTEM WEIGHT, LTON				344.7	
ADJUSTED FIRST UNIT SHIP COST EQUALS					
FOLLOW SHIP TOTAL COST DIVIDED BY				0.940	

DD21ABO: 2-WR-21 ICR Gas Turbine Propulsion Engines(25872 hp)
 2-AC Liquid-cooled Propulsion Generators (28 mw)
 2-Geared AC Liquid-cooled Propulsion Motors (27.2 mw)
 2-Contrarotating Bi-coupled Epicyclic Reduction Gears
 2-Contrarotating Propellers (17', 0.8EAR)
 2-POD-Supported Contrarotating Shafts
 2-Steerable PODs
 Transom Stern
 12000 N.Mile Range
 2-VSCF Propulsion Derived Ship Service Systems (4000 kw)

This option has identical machinery to "DD21A". The usable fuel is removed from the ship to verify the design waterline and stability at the burn out condition.

This is accomplished in ASSET by using a weight adjustment for the usable fuel and skipping the machinery module in the synthesis process as follows:

WT KEY TBL	WT ADD ARRAY	VCG ADD ARRAY
WF45	-1486.9	4.53

SKIP,MACHINERY MODULE

Stability at burn out.....

The burn out GMT/B (.087) is higher than that specified (.075) in the groundrules. Some more reduction in ship size can be obtained through another iteration.

B-157

THE FOLLOWING MODULES ARE NOT INCLUDED WITHIN THE SYNTHESIS PROCESS:
MACHINERY MODULE

ASSET/MONOSC VERSION 3.2 - DESIGN SUMMARY - DD21ABO

PRINTED REPORT NO. 1 - SUMMARY **

SHIP COMMENT TABLE

MUST USE THIS SHIP & SKIP MACH MOD TO SIMULATE BURN OUT

PRINCIPAL CHARACTERISTICS - FT				WEIGHT SUMMARY - LTON	
LBP			553.0	GROUP 1 - HULL STRUCTURE	2208.7
LOA			609.3	GROUP 2 - PROP PLANT	344.7
BEAM, DWL			53.0	GROUP 3 - ELECT PLANT	220.0
BEAM, WEATHER DECK			53.0	GROUP 4 - COMM + SURVEIL	386.9
DEPTH @ STA 10			51.5	GROUP 5 - AUX SYSTEMS	601.2
DRAFT TO KEEL DWL			13.4	GROUP 6 - OUTFIT + FURN	441.7
DRAFT TO KEEL LWL			13.0	GROUP 7 - ARMAMENT	399.6
FREEBOARD @ STA 3			28.2	-----	
GMT			4.6	SUM GROUPS 1-7	4602.9
CP			0.578	DESIGN MARGIN	0.0
CX			0.784	-----	
SPEED(KT): MAX= 31.8 SUST= 30.0				LIGHTSHIP WEIGHT	4602.9
ENDURANCE: 12000.0 NM AT 20.0 KTS				LOADS	531.7
TRANSMISSION TYPE: ELECT				-----	
MAIN ENG: 2 RGT @ 25872.0 HP				FULL LOAD DISPLACEMENT	5134.6
SHAFT POWER/SHAFT: 17413.9 HP				FULL LOAD KG: FT	24.7
PROPELLERS: 2 - CR - 17.0 FT DIA				MILITARY PAYLOAD WT - LTON	1182.7
PD GEN: 2 VSCF @ 4000.0 KW				USABLE FUEL WT - LTON	1486.9
24 HR LOAD 1619.4				-----	
MAX MARG ELECT LOAD 3224.4				AREA SUMMARY - FT2	
				HULL AREA	- 67867.3
				SUPERSTRUCTURE AREA	- 507.8

				TOTAL AREA	68375.1

				VOLUME SUMMARY - FT3	
				HULL VOLUME	- 821063.6
				SUPERSTRUCTURE VOLUME	- 5179.1

				TOTAL VOLUME	826242.8

** MAIN ENG REQUIRED POWER IS REPORTED

ASSET/MONOSC VERSION 3.2 - HULL GEOM MODULE - DD21ABO

PRINTED REPORT NO. 1 - HULL GEOMETRY SUMMARY

HULL OFFSETS IND-GIVEN	MIN BEAM, FT	30.00
HULL DIM IND-NONE	MAX BEAM, FT	110.00
MARGIN LINE IND-CALC	HULL FLARE ANGLE, DEG	
HULL STA IND-OPTIMUM	FORWARD BULWARK, FT	0.00
HULL BC IND-GIVEN		

HULL PRINCIPAL DIMENSIONS (ON DWL)

LBP, FT	553.00	PRISMATIC COEF	0.578
LOA, FT	609.27	MAX SECTION COEF	0.784
BEAM, FT	53.00	WATERPLANE COEF	0.771
BEAM @ WEATHER DECK, FT	53.00	LCB/LCP	0.506
DRAFT, FT	13.36	HALF SIDING WIDTH, FT	0.00
DEPTH STA 0, FT	44.63	BOT RAKE, FT	0.00
DEPTH STA 3, FT	41.14	RAISED DECK HT, FT	13.50
DEPTH STA 10, FT	51.50	RAISED DECK FWD LIM, STA	6.60
DEPTH STA 20, FT	38.00	RAISED DECK AFT LIM, STA	14.34
FREEBOARD @ STA 3, FT	27.78	BARE HULL DISPL, LTON	5069.20
STABILITY BEAM, FT	52.82	AREA BEAM, FT	792.37

BARE HULL DATA ON LWL

LGTH ON WL, FT	551.96
BEAM, FT	52.98
DRAFT, FT	12.99
FREEBOARD @ STA 3, FT	28.16
PRISMATIC COEF	0.572
MAX SECTION COEF	0.778
WATERPLANE COEF	0.768
WATERPLANE AREA, FT2	22457.75
WETTED SURFACE, FT2	26727.46
BARE HULL DISPL, LTON	4829.74
APPENDAGE DISPL, LTON	304.85
FULL LOAD WT, LTON	5134.59

STABILITY DATA ON LWL

KB, FT	7.69
BMT, FT	21.70
KG, FT	24.68
FREE SURF COR, FT	0.10
SERV LIFE KG ALW, FT	0.00
GMT, FT	4.60
GML, FT	2324.14
GMT/B AVAIL	0.087
GMT/B REQ	0.075

APPENDIX C
EVALUATION OF STEERING SYSTEMS

In order to compare various ship propulsion systems effects on turning performance in a feasibility-design trade-off study, A mild turn (10 ship lengths radius) and moderate speed were chosen. This was done such that linear hydrodynamic theory could be used. As turns get more severe, wave effects and the effects of inflow angles to appendages above those causing stalling are beyond the scope of preliminary design trade-off.

The hull, for the varying propulsion systems, remained constant. The rudders, struts ,propellers, shafting, and pods were modeled independently. The rudder angle required for a baseline open shaft ship to maintain a steady turn at constant speed is used for all subsequent designs. The rudder size is varied for the subsequent designs to that necessary to achieve the steady turn.

Turning

For a steady turn:

The sum of the side forces = that necessary to maintain turn of radius R = constant.

$$\sum F_y = \frac{M \times V_g^2}{R} \quad (1a)$$

M = mass of ship

V_g = velocity of center of mass of the ship

The sum of moments about the ship's center of gravity = 0 for constant turning velocity and radius.

$$\sum Moments = 0 \quad (1b)$$

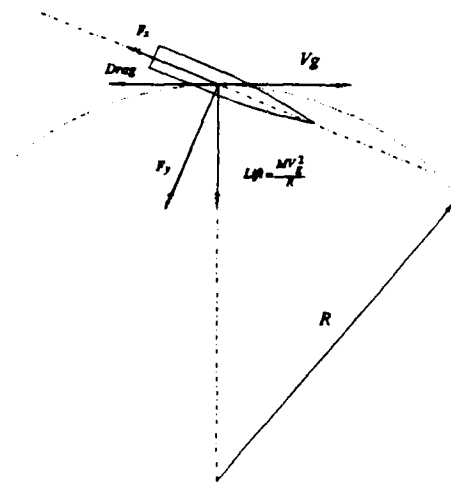


Fig. C.1. Constant radius turn.

Equations used to model turning ship

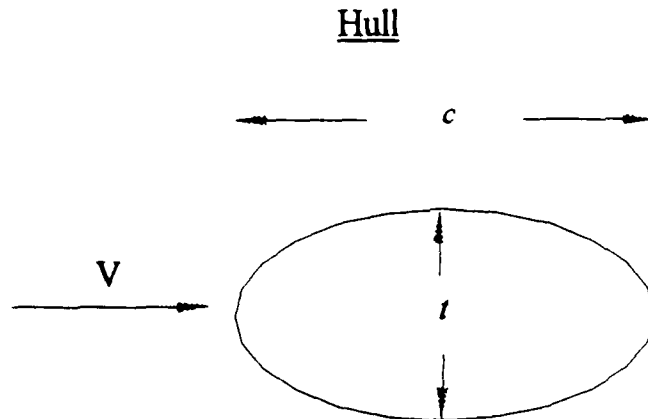


Fig. C.2. Flow past an ellipsoid.

The hull is modelled as having an ellipsoidal cross section which will have differing t/c ratios as we move from bow to stern. The equation used is¹:

$$C_{D_0} = C_{f_{\text{wet}}} (4 + 2(c/t) + 120(t/c)^2) \quad (2)$$

C_{D_0} = Drag Coefficient (based on frontal area)

$C_{f_{\text{wet}}}$ = Frictional Drag Coefficient (for turbulent flow)

$$= .005 + \frac{.075}{(\log(\text{Re}) - 2)^2} \quad \text{Re} = \text{Reynolds number}$$

c = chord (local ship's beam)

t = thickness (2x local ship's draft)

In this equation, The first two terms are the frictional drag and the added frictional drag due to the increased velocity around a three-dimensional object. The last term, $120(t/c)^2$, is due to the adverse pressure gradient on the rear of the section. This fluid-dynamic pressure force only corresponds to the velocity component in the direction normal to the sections axis. This cross-flow velocity will vary as we move from the bow of the ship aft and increase as we move to the rear of the ship and further from the "pivot" point (the intersection of a perpendicular from the center of the turning circle and the centerline of the ship). For equation (2), the thickness, t , is twice the draft and the C_{D_0} is based on the frontal area of the half ellipse (that is, draft multiplied by the incremental length). This is modeling the hull as a full ellipsoid and using symmetry to obtain the drag of 1/2 the full ellipsoid.

Pod & Shaft

The pod is treated as an ellipsoid with cross-flow and equation (1) is used. The shafting is treated similarly, but being circular, has a t/c ratio equal to 1.

Struts & Rudders

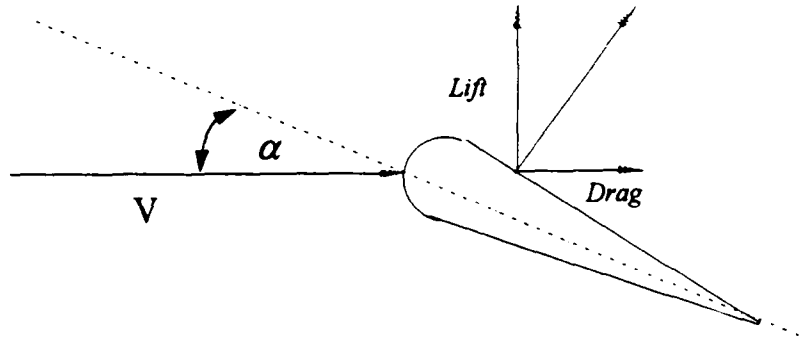


Fig. C.3. Lift of an airfoil.

The struts and rudders are treated as lifting surfaces. The inflow angle to the struts requires calculating the V_x and V_y components of the inflow at the longitudinal location on the ship of the strut (see figure 1) and resolving this vector in relation to the strut geometry to determine the angle of attack to the strut. We then calculate the lift and drag of the strut-airfoil, and resolve the lift and drag forces into F_y and F_x components to be added to the force and moment summations (equation 1a & 1b). The equations for lift² and drag³ are :

$$\frac{d\alpha^\circ}{dC_L} = 10 + \left(\frac{9}{A^2}\right) + \frac{20}{A} \quad (3)$$

α° = Angle of attack (deg)

C_L = Coefficient of lift

A = Aspect ratio (span / chord)

= 2 (span/chord) if the strut or rudder abuts the hull

$$C_{D_i} = \frac{C_L^2}{\pi A} \quad (4)$$

C_{D_i} = Coefficient of induced drag

The lift and drag are then calculated as:

$$L = C_L q S \quad (5)$$

$$D = C_D q S \quad (6)$$

$$q = \frac{1}{2} \rho v^2 = \text{dynamic head}$$

S = Surface area (span x chord)

The resistance to forward motion (hull longitudinal axis) of the struts and rudders must be calculated and added to the other propulsion appendages and the hull to determine the necessary installed power. This will determine the propulsion system sizing. The resistance is recalculated and the propulsion system is resized. This is therefore an iterative calculational procedure. The frictional and form drag of streamline airfoil shapes with 0 angle of attack is⁴:

$$C_{D_s} = 2C_f \left[1 + 2\left(\frac{t}{c}\right) + 60\left(\frac{t}{c}\right)^4 \right] \quad (7)$$

based on area = span x chord

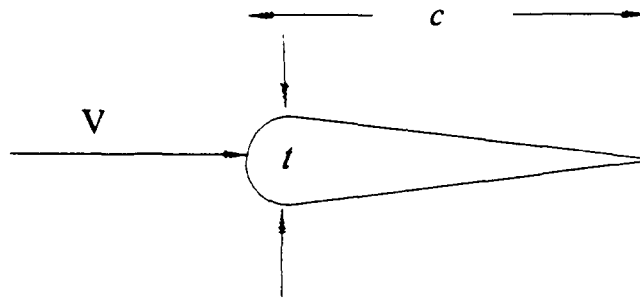


Fig. C.4. Drag is a function of the thickness to chord ratio.

Flapped Strut-Integral Rudder

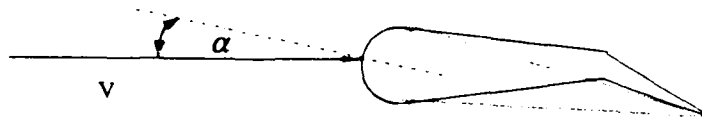


Fig. C.5. Angle of attack for integral strut-rudder.

Calculation of angle of attack

For the purposes of this study, the integrated rudder-strut was treated as an airfoil with the nose and tail determining the angle of attack of the inflow.

Propellers

The side force developed by the propellers which resists the turning of a ship is determined by treating the angled inflow to the propeller (from the side) like an angled inflow to a propeller with a shaft angle*. The torque variation on the blades as they rotate is used to calculate the force on the blade which is presumed to act at a distance of .7 times the propellers radius from the hub. The vector of propeller thrust is also resolved into F_x and F_y components.

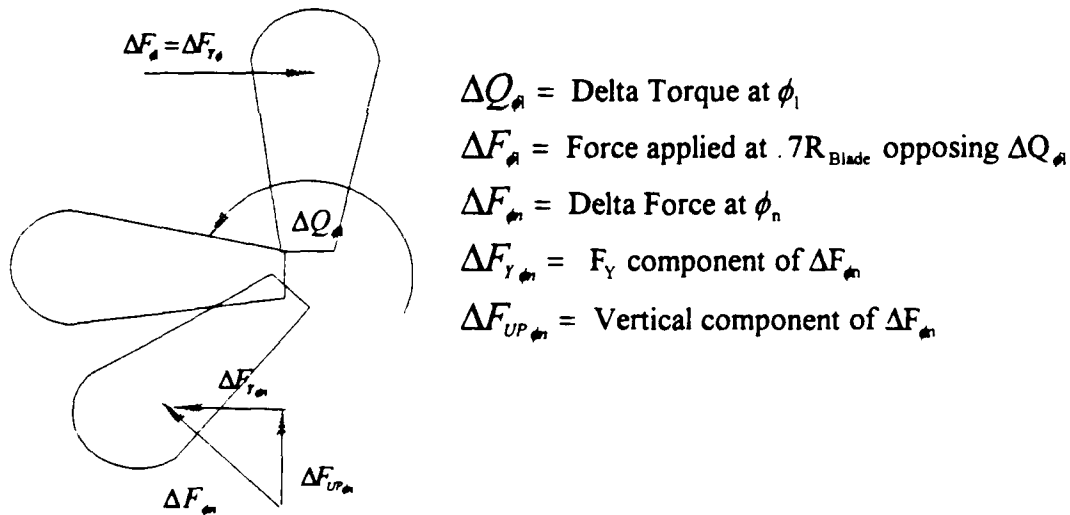


Fig. C.6. Propeller side force.

* Levedahl W., O'Reagan W. Performance, Cavitation, and Acoustic Evaluation Method for Single and Contrarotating Propulsor Systems DTNSRDC-TM-27-86-19

APPENDIX C REFERENCES

1. Hoerner, S.F., "Fluid-Dynamic Drag," Sighard Hoerner, Midland Park, N.J., p. 3-12, eq. 21 (1965).
2. Hoerner, S.F., and H.V. Borst, "Fluid-Dynamic Lift," Mrs. Liselotte A. Hoerner, Brick Town N.J., p. 3-2, eq. 6 (1975).
3. Hoerner, S.F., "Fluid-Dynamic Drag," Sighard Hoerner, Midland Park, N.J., p. 7-2, eq. 4 (1965).
4. Hoerner, S.F., "Fluid-Dynamic Drag," Sighard Hoerner, Midland Park, N.J., p. 6-6, eq. 6 (1965).

APPENDIX D
EFFECTS OF APPENDAGE TYPE ON TURNING

We find that ships can maneuver well and stay quiet only with steerable tractor pods, and even these require lift control on the pod struts. We find that use of circulation control on the strut, using the pumped effluent from the heat exchangers which cool the gear and motor, is an attractive means of achieving this lift.

Here we present a set of nine sequential podded systems, each differing from its predecessor by a single change, to illustrate the effects which brought us to the above conclusion. The nine systems include many of the concepts which have been commonly considered in recent years.

The five subsystems discussed are the propeller, the alternating-current motor (and implicitly its control philosophy), the epicyclic gear, the pod-strut system, and the steering system. The comparisons made here were with a fixed hull; no ship-impact analyses are included. The power required was calculated at maximum speed, at cruise speed, and in a standard mild turn at cruise speed.

We used a fixed displacement 620-ft hull with sonar and bilge keels, a common propeller thrust coefficient for podded drives, a common turn radius and a common rudder deflection angle.

PROPELLER

The propeller was selected to have a thrust coefficient $C_T = .2732$ at 30 knots for all podded ships. The expanded area ratio was chosen to produce incipient back cavitation at 24 knots when the ship was going straight ahead. All unrotating propellers had five blades. All contrarotating propellers had seven blades forward and five blades aft.

We then assumed one of two propeller-design philosophies:

1. The "hydrodynamically-optimum" propeller has been defined as the highest-efficiency propeller of a given thrust coefficient.
2. An alternate selection at the same thrust coefficient and incipient back-cavitation speed is the propeller which has the "best specific speed", where specific speed is defined as

$$n_s = \frac{1}{2^{.25} \pi^5 J C_T^{.75} \eta_j^5} \quad (1)$$

where J is the advance ratio, C_T is the thrust coefficient, and η_j is the ideal jet efficiency defined by

$$\eta_j = \frac{2}{1 + \sqrt{1 + C_T}} \quad (2)$$

The authors were aware that pump theorists had long known the "best" pumps of any given type tended to have the same specific speed of about 1.0. They therefore systematically investigated a series of thousands of propellers, with a computer model, to determine whether open propellers followed the trends of their ducted counterparts. Their open-water efficiencies were plotted against $C_T^{.5}/J$, the dimensionless propeller speed. The results were convincingly clear: The best propeller (the most efficient propellers at any given shaft speed or torque) were all found to have closely the following specific speeds, over a wide range of incipient cavitation speeds.

$$n_{best} \approx 1.2 \quad (3)$$

therefore,

$$J_{best} = \frac{.19763 \left[1 + (1 + C_T)^5 \right]}{C_T^{.75}} \quad (4)$$

For contrarotating propellers, the thrust coefficient per propeller is half of the total, and the ideal efficiency is correspondingly higher. The best contrarotating propeller sets have a specific speed of $n_s = 1.2$ per propeller. If we use the total thrust coefficient to calculate the specific speed, then

$$n_{bestCR} = 1.2 = \frac{1}{2^{.25} \pi^5 J(C_T/2)^{.75} \eta_j^{.25}} = \frac{2^5}{\pi^5 J(C_T)^{.75} \eta_j^{.25}} \quad (5)$$

$$J_{bestCR} = \frac{.33245 \left[1 + (1 + C_T/2)^5 \right]}{C_T^{.75}} \quad (6)$$

A pump of a given diameter usually has maximum efficiency at a dimensionless specific speed of 1.0. (For a pump with inlet and outlet pipes of the same diameter, $\eta_j = 1.0$.) An open-water propeller of fixed diameter also has its maximum efficiency near $N_s = 1.0$. This case is frequently referred to as "hydrodynamically-optimum". For the "best" case, the propeller speed at any given thrust coefficient is increased, torque is decreased, and the gear reduction ratio is smaller, so that the gears are significantly smaller, and the propeller efficiency is slightly lower. Tip cavitation appears later than for the "hydrodynamically optimum" propeller. The permitted speed of the propeller at back-cavitation onset is related to the selected open-water efficiency desired η_o , to the submergence depth h (in meters) of the upper propeller blade at .7 of its maximum radius, to the hull efficiency $\eta_H = (1-t)/(1-w)$ where t is the thrust deduction factor and w is the wake fraction, to the number of propellers N_p , and to the relationship of ship effective power P_E (in watts) to the advance velocity V_{OB} (in m/s). For unrotating propellers of back-cavitation thresholds at V_{OB} , the envelope of the results of the thousands of computer model runs gave the shaft speed at which back cavitation begins n_{OB}

$$n_{OB} \approx 1522 \left[.87 - \eta_o \right] (1 + .1h) \sqrt{\eta_H \frac{V_{OB}^{2.6} N_p}{P_{EOB}}} \quad (8)$$

Since P_{EOB} is approximately proportional to the cube of V_{OB} , we find that n_{OB} will change very slowly with the choice of back cavitation speed. Consequently the shaft speed at back-cavitation onset is nearly constant! Following through the logic, the reduction ratio is nearly proportional to back-cavitation speed, and the "best" propeller diameter is nearly proportional to back cavitation speed! **BEING QUIET DOES NOT COME FREE!**

The equivalent expression for contrarotating propellers is more complex mathematically, but shows the same trends.

$$n_{OB} \approx 1034(1+.1h)^{.543} \left[1 - \frac{.040061V_{OB}^4}{(1+.1h)^2} - \eta_O \right] \sqrt{\eta_H \frac{V_{OB}^{2.828} N_P}{P_E}} \quad (9)$$

GAS TURBINE

It was assumed that the gas turbines had a design speed of 60 rev/sec=3600 rpm and were connected directly to four-pole alternators.

ALTERNATORS

An alternator is typically limited by centrifugal stresses to a rotor tip velocity V_{tmax} in the vicinity of 145 m/s (475 fps). It must have an even number of magnetic poles. A two pole machine has its magnetic flux density limited in the inside of the rotor so that the desired magnetic field in the air gap between the rotor and stator may not be achievable. All machines with four poles or more avoid this limitation, so we shall select four poles for the alternator.

The selection of the turbine speed n_T , and the limiting rotor surface velocity V_{tmax} , determine the rotor diameter D_r .

$$D_r = \frac{V_{tmax}}{\pi n_T} \quad (10)$$

The smallest alternators for any given efficiency will come with the highest feasible turbine speed in the currently-considered turbine-power range. Thus an arbitrary choice of the turbine speed carries over into the alternators associated with it.

One of the desirable conditions for an alternator (or for an alternating current motor, for that matter), is that the fraction of the copper windings which are in the iron core, as opposed to the fraction in the end turns, be as high as possible. This condition occurs typically when the core length L_c is about 1.5 times the pole pitch of the rotor, so that on 4-pole machines the core length should be little different from the rotor diameter. For the alternators presented in ASSET, this ratio is a function of power in megawatts P_{Mw} .

$$\frac{L_c}{D_r} \approx 1.8 \frac{P}{N_p^2} = .11 P_{Mw} \quad (11)$$

and a 20 Mw, 4-pole, 120 Hz machine has an active rotor length about double the optimum.

Advanced electrically-powered weapons systems also need alternators. One possibility is to have a dedicated weapons-system alternator associated with each turbine. This alternator would be rectified and could rapidly charge capacitors. It could take its energy from both the free turbine and, via the propulsion motor and propulsion alternator, from the ship's kinetic energy. Its short-term capability could be much larger than the rated turbine power.

Another potentially attractive system incorporates a second set of windings on each propulsion alternator, thereby increasing its diameter somewhat, but greatly simplifying the turbine-alternator system. This kind

of alternator could serve many functions: not only does it provide propulsion power, and alternatively weapons power, but it can also transfer the kinetic energy of the ship into the weapons system without any switching within the propulsion system. All switching would be done within the weapons-system circuit, which basically rectifies the output of the alternator (even when it is operating as a rotating transformer) and transmits it to a chosen capacitor bank, which will be discharged at will by the weapons system. The result of firing of weapons systems will be noticed by the propulsion system as an increased load (or decreased impedance, depending on the viewpoint of the observer) which essentially parallels the propulsion-motor load.

ALTERNATING-CURRENT MOTOR

Electric motors transform electrical power into mechanical power; the motor and generator can be, to a first approximation, identical if they operate at the same speed and power level. The "best" electric machines operate at the maximum peripheral velocities allowed by centrifugal rotor stresses.

The ratio of speeds n_M/n_A of the motor and alternator is determined by the number of poles N_p on each.

$$\frac{n_M}{n_A} = \frac{N_{pA}}{N_{pM}} \quad (12)$$

Correspondingly, to maintain the rotor surface speeds at the maximum on both machines, the rotor diameters D are inversely proportional to the number of poles.

$$\frac{D_A}{D_M} = \frac{N_{pM}}{N_{pA}} \quad (13)$$

For machines which operate at the same surface speeds, the active rotor surface area, $\pi * L * D$ is proportional to power; power is proportional to the number of alternators N_A connected to each motor.

$$\frac{L_M D_M}{L_A D_A} = \frac{N_A}{N_M} \quad (14)$$

Combining (13) and (14) we obtain

$$\frac{L_M/D_M}{L_A/D_A} = \frac{N_A}{N_M} \left[\frac{N_{pA}}{N_{pM}} \right]^2 \quad (15)$$

For three alternators powering two motors, which is possible with contrarotation, the use of 6-pole motors appears attractive.

An important alternative to consider for podded drives is the small-airgap, low-slip (perhaps .1% slip) induction motor, preferably with a solid rotor, but with a laminated rotor if necessary. This machine is very rugged, has no rotating current collectors or rectifiers, and is more efficient than its synchronous counterpart. It is shorter because it requires no excitation. Its core may need to be slightly larger. The surrounding structure can be substantially thinner because it does not require solid-state pulse control and the corresponding attenuation of its vibrational excitation to provide tolerable acoustics. It also permits full-torque crash ahead and crash astern, instead of the low-torque limit of solid state controls.

The motors (and alternators) described in ASSET, whether aircooled or liquid cooled, whether synchronous or induction, have stators which are over .8 pole pitches thick, even though the flux densities

in the gap are very modest (near .7T) and the armature loadings are also modest, about 90,000-150,000 amps per meter. the result is very-large diameter motors (1.8-2m for 4-pole machines) and which require large diameter pods even at relatively low power levels. If we could achieve 1.2-1.4m diameters, as was done on the AiResearch alternating-current machine designs associated with the Superconductivity Program, much more design flexibility would exist. We analyzed systems with ASSET motors and with induction motors which had stators of thickness equal to .414 pitch.

GEAR

The reduction ratios available from a wide variety of one and two-stage epicyclic-gear configuration are given in table C1. When the motor and alternator have the same number of poles, all reduction must be in the gear; when the motor has 6 poles, the gear reduction ratio is reduced by 1/3; of equal importance, the first stage has only 2/3 as high an input speed so that centrifugal forces on the spindle bearings are greatly reduced and the frictional losses associated with maintaining 500 psi spindle-bearing pressures are greatly reduced.

Single-rotation two-stage gears must be of star-planetary configuration in order to avoid excessive first-stage spindle-bearing pressures and frictional losses. For the ratios needed here, which are always greater than 25, we must use a 4-planet second stage, and the first stage must have at most four planets. For reduction ratios of 36 or more a three-planet first stage is necessary.

Table D1. Reduction ratios available in epicyclic gears

Planets per stage		Maximum (<i>Minimum</i>) Reduction Ratios							
2nd	1st	Solar (SOL)	Star (S)	Planetary (P)	Star Planetary (SP)	Contra-Rotating (CR)	Star-Contra-Rotating (S-CR)	Carrier-Ring Bicoupled (CRB)	Ring-Ring Bicoupled (RRB)
7	0	2.0	2.4	3.4		5.8			
	7	(1.42)			8.1		13.9	15.3	22.1
	6				9.5		16.2	18.0	24.8
	5				12.2		20.9	23.5	30.3
6	4				18.7		31.9	36.4	44.2
	0	2.0	2.8	3.8		6.6			
	6	(1.36)			10.6		18.5	20.3	27.9
	5				13.6		23.8	26.4	33.9
5	4				20.9		36.3	40.8	48.4
	0	2.0	3.6	4.6		8.2			
	5	(1.28)			16.5		29.5	32.1	41.3
4	4				25.3		41.5	49.6	58.8
	0	2.0	5.5	6.5		12.0			
	4	(1.18)			35.7		66.0	70.5	83.5
3	3				72.8		134	142	157
	0	2.0	11.2	12.2		23.4			
	3	(1.09)			136		257	272	296

The ring-ring bicoupled contrarotating gear at reduction ratios comparable to those of the single-rotation gears above has one-half as much torque. It has 7, 6, or 5 planets in the second stage, and 5 or 4 planets in the first stage. One limit is that the ring-ring bicoupled gear becomes quite inefficient when the first stage must operate at an excessively-high speed which causes high centrifugal forces on the planets. The

limit on permissible spindle-bearing pressure requires large-diameter planet bearings which are turning at high relative speeds and therefore have high friction losses. The correspondingly increased size of oil coolers is non negligible. Under these circumstances an otherwise less attractive carrier-ring bicoupled gear could become preferable. Still better, however, is a multipole motor with high tip velocity and efficiency, but moderate rotational speed because it had more poles than the alternators which fed it. Wherever the ring-ring bicoupled gear can be used, its total size and weight are about one-fourth those of its single-rotation counterpart. Correspondingly, intrinsic vibration excitation can be expected to be less than that of locked-train double-reduction gears. This is partly the result of having many parallel, out-of-phase meshes, partly because the number of teeth can be selected to avoid major torsional resonances, and partly the result of low sliding velocities of the teeth.

CONTROL

Two types of control are envisioned. The first is a solid-state frequency control system, which can change the reduction ratio at part load but not at full load, providing that both generator and motor have been designed to their maximum torque capabilities at the synchronous condition. This type of control has a very high harmonic content, and cannot be used for quiet cruising. If it were designed to provide full-torque crash astern, it would be extremely large and expensive, therefore it is frequently prescribed to be built for about 25%-33% of maximum power capability. It is useful only for harbor maneuvering and peacetime transit.

The second type of control uses small-airgap induction motors of very low slip. The use of plugging (switching of any two of three three-phase leads) plus turbine fuel control, alternator field control, and braking resistors can provide full-torque crash astern. It also provides for startup, harbor maneuvering and cruise without solid-state controls and their excitation of vibration in the stator. Variable vanes in the ICR power turbine provide high efficiency at cruise.

STEERING

Three types of steering are considered.

1. The first is a standard spade rudder, with an aspect ratio of 1.5 and a tip which has a chord $2/3$ that of the root. The rudder stock is at 25% of the root chord abaft the leading edge. The rudder thickness is $1/7$ of the chord throughout its span.

2. The second is a semi-balanced horn rudder, affixed to the after end of the strut-pod combination and continuing below the pod to a radius equal to that of the propeller. The hemispheric after end of the pod is faired by a paraboloidal structure which is an integral part of the rudder. This high-aspect ratio rudder flap will produce a moment in a turn which opposes and slightly exceeds the moment caused by the pod and strut translating through the water; the net result is to greatly mitigate the bending stresses on both pod and rudder. The chord of the strut-rudder combination is quite large compared to the required thickness; the acceleration and separation factors will thus have little effect on the resistance, and the interference resistance is greatly reduced from the cases where separate rudders exist.

3. The third is a steered-pod configuration. The entire pod pivots so that the propeller faces directly into the flow during the standard turn. The total elimination of the rudder reduces resistance substantially, and the need to have a short-chord strut to limit resistance to turning is eliminated, so that the strut can be configured to give minimum resistance for the required bending moment. The bending moment is itself greatly reduced. Any net side force required to trim the turning moment with the propeller facing directly into the flow will be provided by circulation control of lift on the strut, using the Coanda effect. The effluent from the cooling pumps will be valved to provide a right or left force on the strut. In the cases considered here, the propeller would provide more turning moment than that required to keep it facing directly into the flow. Consequently, lift applied to the strut reduces the turning moment *and produces net forward thrust in the turn, reducing required propeller thrust to about that required straight ahead.*

EXPERIMENTS

A series of computational experiments was performed to learn the effects of various changes in propulsion-train subsystems. A few instructive cases will be discussed here, with the intent of illustrating the effects of one-at-a-time changes in an unambiguous way. In no case discussed here do we have an "optimum" or "ideal" configuration. We do illustrate that many of the subsystem characteristics which we or others might have thought were "optimum" or "important" are not, and that some others, not often considered, may be quite influential. To provide comparisons between the various configurations, we kept the identical bare hull associated with a 620-ft ship, and merely changed the propulsor-system and steering appendages.

All ships had the same maximum straight-ahead speed and the same radius of turn at the same rudder deflection angle. All the podded ships had the same calculated speed for incipency of surface cavitation straight ahead, and the same maximum-speed thrust coefficient. Differences in power required, power at cruise, and in incipient cavitation speed in a standard turn are reported.

The sequence of experiments was:

1. Change from twin open shafts with controllable-pitch propellers and twin spade rudders to twin pods with "optimum" fixed-pitch propellers of $C_T = 0.2732$ at 30 knots, and twin spade rudders. The propeller has a straight-ahead cavitation speed of 25 knots.
2. Reduce propeller pitch to "best specific speed".
3. Substitute "optimum" contrarotating propellers.
4. Reduce propeller pitch to "best specific speed".
5. Change from 4-pole to 6-pole motor.
6. Integrate rudder into rear of pod strut.
7. Remove rudder and make pod steerable.
8. Substitute a small-diameter induction motor for the synchronous motor and its solid-state controls.
9. Substitute three small steerable pods for two larger ones.

RESULTS

CASE 0. TWIN OPEN-SHAFT REFERENCE SHIP

A reference ship with twin open shafts, Case 0 has a length of 620 ft. and is scaled linearly from a model of the 529 ft. DD963. It has two spade rudders which provide a turning radius of 10 ship lengths when set at an angle of 8.9 degrees. The "pivot point" is nearly abeam of the forward perpendicular; the horizontal angle of inflow to the propeller in a turn is 5.2 degrees. This ship has a design speed of 15.43 m/s (30 kts). Its two controllable-reversible-pitch propellers of 6.07m (19.9 ft) diameter cavitate (either back or face) at all ship speeds by virtue of its vertical angle of inflow of 8 degrees and the automatic reduction of pitch to prevent propeller speed from ever dropping below 1/3 of its maximum-speed value.

CASE 1. TWIN-POD GEARED-ELECTRIC BASELINE WITH "OPTIMUM" UNIROTATING PROPELLER

This baseline has the "hydrodynamically-optimum" five-blade unirotating propeller with $C_T = .2732$ at 30 kts. A 3-planet, 4-planet star-planetary two-stage gear is used along with a 4-pole motor in each pod. The correspondingly large pod requires a large strut which stabilizes the hull such that a rudder 3 times as large as that for the open-shaft case is needed to provide the same turning capability at the same rudder angle. There is a 3.3% higher installed power, 9.2% higher cruise power, and 22% more power in the turn than for the open-shaft ship.

CASE 2. CASE 1 WITH REDUCED-PITCH UNIROTATING PROPELLERS

Reducing the pitch of the propeller to the "best specific speed" permits decreased diameter of the gear, and correspondingly smaller pod and rudder size. The reduction in propeller efficiency is more than compensated by smaller pods and rudders for net decreases over the podded baseline of 5.9% in installed power, 8.2% at cruise, and 9.4% in the turn.

CASE 3. CASE 2 WITH "OPTIMUM" CONTRAROTATING PROPELLERS

Contrarotating propellers of the same thrust coefficient and of "optimum" pitch provide an increase in propulsive coefficient, .7242 to .7742, over the "optimum-pitch" unirotating propeller. The gear and pod diameters are smaller. The result is a 9.7% decrease in installed power, 10.9% at cruise, and 9.5% in a turn from the values of the baseline with "optimum" uni-rotating propellers.

CASE 4. CASE 3 WITH REDUCED-PITCH CONTRAROTATING PROPELLERS

Contrarotating propellers of best specific speed have a propulsive coefficient increase, from .7131 to .7723, over that of their unirotating counterpart; the gear and pod diameters are very slightly smaller. The high-pitch contrarotating propellers, however, increase stability and the rudder must increase in size; the result is a 5.7% decrease in installed power, 5.4% at cruise, and a 3.2% decrease in the turn from the values with reduced-pitch unirotating propellers. The net improvements from the podded baseline are now 11.3% max., 13.1% cruise, and 12.3% turn. Tip cavitation speed, for the first time, is higher than the 24-kt back cavitation speed straight ahead.

CASE 5. CASE 4 WITH 6-POLE MOTOR

The 1.5:1 reduction ratio resulting from use of a 6-pole motor with 4-pole alternators permits use of 4-planet, 6-planet ring-ring bicoupled gears with a significant reduction in size, weight, and vibrational excitation. The corresponding reductions in pod and rudder size reduce resistance, for a 7.2% additional reduction in installed power, 9.4% at cruise, and 10.5% in the turn. The overall reductions are now 17.7%, 21.2%, and 21.5% from the podded baseline.

CASE 6. CASE 5 WITH RUDDER INTEGRATED INTO POD STRUT

Integration of the rudder with the pod strut substantially reduces the bending moments and stresses in each, resulting in a slender and less resistive system. The movable-rudder deflection angle is conservatively retained at the value used for separate rudders. One result is a 70% increase in the moveable rudder area; the second and more important effect is a reduced overall thickness-to-chord ratio and decreases interference resistance. A 7.9% additional reduction in installed power, 7.2% at cruise, and 15.3% in the turn result for aggregate improvements over the podded baseline of 24.2%, 26.9%, and 34%.

A peculiarity of the system exhibits itself here. Suddenly, face cavitation becomes limiting in the turn, and at a near-zero speed. This result is due to the very steep slope of the curve relating face-cavitation incipency to inflow angle, and of the increased distance between the propeller and the pivot point in the turn. This peculiarity shows the sensitivity of results to the assumptions made for the analysis. It should not be interpreted as a blanket denigration of integrated systems.

CASE 7. CASE 6 WITH STEERABLE PODS

Making the pods steerable and eliminating the rudders reduces resistance. This system provides more turning moment than needed when the propeller is faced directly into the inflow. Thus, either the propeller will have a slight inflow angle or the strut must be given some lift inward and forward. The latter can be achieved by a flap on the rear of the strut, or, our preferred solution, use circulation control on the strut. In this instance, installed power is reduced another 3.9%, cruise power by 5.7%, and power in the turn by 15.2%. The aggregate reductions from the podded baseline are now 27%, 31%, and 44%.

Importantly, the speed at which cavitation begins during a turn of 10-ship-length radius is now as high as it is straight ahead. The coefficient of lift on the strut required increases with the sharpness of the turn but is about .1, and can perhaps be achieved with only normal effluent from the cooling systems! The forward component of strut lift appears to actually reduce thrust required from the propeller below that straight ahead! Further analysis is suggested.

5.2% deflection angle on the pod produced the 10-ship-length turn; the sharpest turn radius possible is for smaller than for the preceding concepts.

CASE 8. CASE 7 WITH INDUCTION INSTEAD OF SYNCHRONOUS MOTOR

Induction motors would permit full-torque crash astern or crash ahead, as opposed to about 1/3-power maneuvering using synchronous motors with typical solid-state control. Further, the elimination of solid state controls significantly reduces the size, weight, cost and complexity of the system, and the elimination of brushes and/or rotating transformers from the pod will greatly decrease potential maintenance within the pod. Elimination of vibratory excitation caused by the solid-state devices permits much thinner stators and smaller motors.

This system results in a further 5% reduction in installed power, 7.2% at cruise, and 7.5% in the turn. It retains full cavitation speed in turns.

This system requires 30.7% less installed power, 36% less cruise power, and 48% less in the turn than the podded baseline. In the turn it can go 25 knots without cavitation compared to 7-12 kts for the fixed-pod systems.

CASE 9. THREE STEERABLE PODS

Three steerable pods instead of two reduces the gear reduction ratio, and has the advantage of providing a truly modular system, that is, one propulsor unit per gas turbine. The weight of each propulsor module in the three-pod system is lower than that of each of the pods in the two-pod system, mitigating the problems of dockside replacement. The two stages of the ring-ring bicoupled gear can now have 5 and 7 planets, making it only 1.34 meters in diameter. However, the diameter of the motor is fixed by its speed, and the 6-pole induction motor becomes the largest-diameter member of the pod. Thus the three pods have a larger total cross section than do two larger pods. The required power of the uniterated system increases 2%. Only a complete system study will show the net value of three versus two pods.

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13. ABSTRACT (Maximum 200 words) <p>Future Navy ships must be superior but inexpensive. A new philosophy and configuration provide the 21st century destroyer, the DD 21A, with global range; reduced lightship displacement and cost; superior sea-keeping; no seawater ballast; sharper turns and stops; and greatly reduced installed power, fuel consumption, and pollution. These benefits result from a new machinery-driven ship design paradigm centered on simplicity and efficiency. All main machinery is modular and outside the watertight hull, freeing midship areas for personnel. The tumble home (inward-sloped) hull is long and slender, requiring little power at maximum speed.</p> <p>Two removable, prealigned and pretested propulsor modules are attached to the stern after hull construction and are replaceable pierside. Each module includes a steerable pod aligned to the water inflow. A streamlined strut connects each pod rigidly to a vertical steerable barrel. Two removable, power-producing modules are mounted in the helicopter hangar. Each module comprises a 26,400-hp (19.7-MW) intercooled, recuperated gas turbine; a 4-MW ship service alternator; and a 20-MW propulsion alternator.</p> <p>These remarkable results are obtained by taking a reference destroyer from the advanced surface ship evaluation tool data bank and evaluating several progressive changes made to it.</p>				
14. SUBJECT TERMS ASSET, Tumble home, Pod, Electric drive, Monohull, Gas turbine, ICR, Destroyer, Ballast, Contrarotating propellers, Modules, Modular, Epicyclic gears, Marine propulsion, Naval machinery, Machinery arrangement, Surface combatant, Machinery options, Ship impact, Propulsors, Cavitation, Ship design, Machinery box, Environment			15. NUMBER OF PAGES 282	
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