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SHIP DESIGN, ENGINEERING, CONSTRUCTION TECHNOLOGY AND CLASSIFICATION REQUIREMENTS

by

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ABSTRACT

This paper discusses the present U.S. trends in the areas of ship design, engineering, construction technology and classification requirements.

The topic of ship design is presented from the point of view of the naval architecture community who is trying to apply the results of millions of dollars in research, primarily funded by the U.S. Navy and the Maritime Administration, to the cost effective design of naval and commercial vessels. Computer-aided ship design and analysis software and hardware have had a significant impact on the ability of naval architecture firms to produce total ship designs quicker and less costly than ever before. An example of an actual ship design developed using computer-aided design techniques is presented along with the total design cost.

Ship construction technology in the U.S. has come up with recent innovative approaches which provide alternatives that have resulted in maintaining some U.S. shipyard activity in spite of the depressed U.S. shipbuilding market. One such approach is the construction of 30,000 DWT tankers by building bow and stern units in one yard, midbody units in another yard and transporting all units to a third yard for final assembly of the tankers. The cost effectiveness of this approach is illustrated.

A third topic of interest to ship designers, builders and owners is the development of new ship design concepts which are more responsive to the needs of the owner throughout the life of the ship. This involves the consideration of key factors from the very beginning of the design process. These factors include ship convertibility from one trade to another at any time during the life of the vessel; proper selection of materials, coatings, maintenance/repair systems and the selection of cost effective propulsion systems. The application of these concepts to the National Economic Emergency Defense Ship is discussed for illustrative purposes.

The final topic covered by this paper deals with the role of the regulatory and classification bodies in the design, construction and operation of ships.

INTRODUCTION

This paper is a general overview of conceptual, preliminary and contract design as viewed from our own perspective. We will use recent examples to indicate our approach to engineering problems. The general thesis of this paper is that the design and construction process, like everything else, is becoming expensive. For the customer to obtain full value from his investment he should:

1. Define the problem as well as he can.
2. Prioritize all requirements.
3. Be willing to explore options.

and the engineering firm should:

1. Work toward the final product required.
2. Eliminate unnecessary work.
3. Maintain close liaison with the customer.

1.0 SHIP DESIGN/ENGINEERING

Ship design is not unlike any other engineering/design discipline and requires the integration of the mission requirements of the potential owner with good engineering practice, appropriate regulations and the economics of construction and operation.

The design spiral shown in Figure 1 is a graphical representation of the traditional design sequence with refinement as the spiral winds down toward the center. You will note that this particular spiral contains no reference to seakeeping or the ability of the ship to perform in various seas. In a current project for the State of Alaska, we are designing a seagoing passenger/car ferry to replace an existing ferry. The seakeeping qualities of the existing ferry are so poor that passenger traffic drops to near zero in winter months in favor of considerably more expensive air travel.

Thus, the State of Alaska is quite concerned about seakeeping. Since we were designing a replacement ship, the characteristics of the existing ship, the route, weather, sea state encountered, ship speed were all known. The new design, while greater in size and speed, is certainly not unlike other U.S. and foreign passenger/car ferries.

Our proposal was then to estimate the size of the ship without detailed arrangements and to develop an immediate set of lines for seakeeping testing. We also proposed to work with a model tank experienced in seakeeping model tests of similar type ferries to define those characteristics which would provide the best seakeeping qualities given the sea spectra to be encountered.

In this particular case, we found that the model tank could generate a set of lines at less expense than we could and thus had the base lines drawn by the model tank. Before creating a model and committing to any testing, we then ran a parametric study of the existing ship, the model tank lines and three variants of those lines on an in-house seakeeping computer program. That program showed one set of lines superior and those lines were tested in the tank for confirmation and visual aspects such as deck wetness.

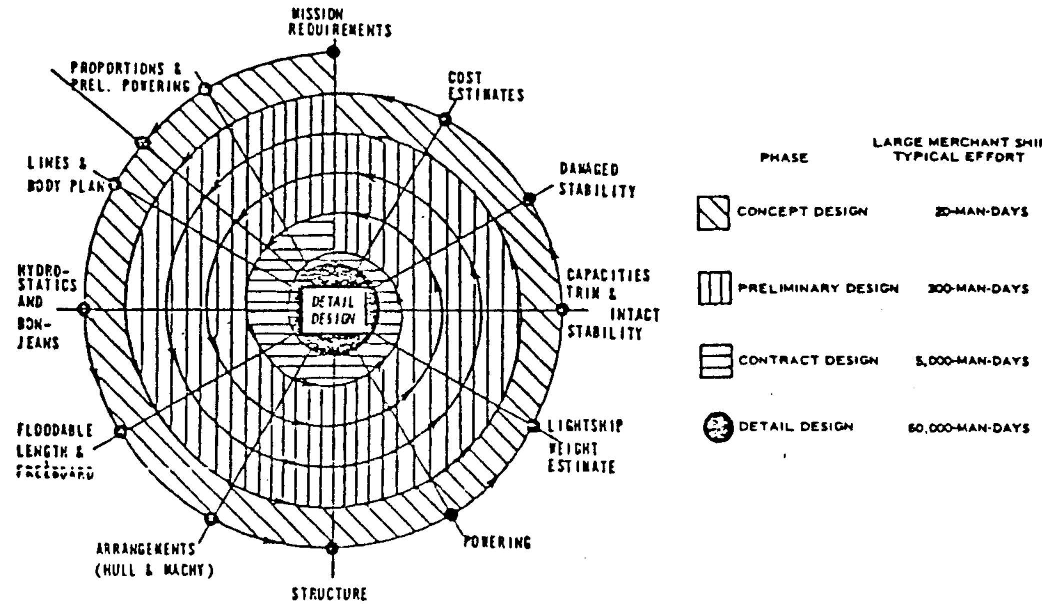


Figure 1

Traditional Design Spiral

All through this process the options available to the owner were reviewed with him with regard to cost and acceptability of output.

Returning to Figure 1, under the traditional design method, seakeeping may not have been analyzed until the design was so constrained by arrangement and powering considerations that there would be virtually no hull form latitude left. Under those circumstances, a 5% (or any) improvement in seakeeping may have been considered the best that could be attained. Under our system, the best seakeeping possible was presented initially. While not the case here, it is possible that the owner had the best ship already and that no significant improvement could be found, within all the design constraints. It is better and certainly less costly to find out at that point than 3/4 of the way through contract design. We believe it is most important for the designer to ascertain, before the design process starts, the owner's priorities. This may require at the outset a study of the owner's requirements and prioritizing by the design agent and owner.

Another ferry service has sought quotations for an entire study of the cost of continued operationl and refurbishment of their existing fleet against a planned modernization of the fleet using new technology craft such as surface effect ships, small waterplane craft and hydrofoils. The designer will design and cost as many as twelve very preliminary designs which will be evaluated by the ferry owners on their own computer using their own evaluation program. The owner will then return to the designer with as many as six candidate designs to be finalized and more accurately priced. We feel this is a particularly good arrangement as the owner is involved in the decision process at the right point. While the normal process is to provide a concept design approved by the owner, then a preliminary contract and design for bidding by shipyards, the design process is an integration process and may be accomplished in many ways

We feel there are two extremes in the design process today that impede design/cost effectiveness as follows:

A. The all knowning naval architecture firm who tells the owner from the outset what ship he needs. In today's legalistic business world where the decision process has been replaced with legal opinion, the owner may very well agree with the all knowing naval architect as the burden of responsibility is thought to be the naval architects. When the final ship is not what the owner now realizes he wanted, it is usually the shipyard who receives the brunt of the owners wrath as the naval architect claims the yard did not build the ship he designed.

Litigation in this area, historically, has not been very satisfying to any of the parties. The owner may recover some token sum which in no way will compensate him for the losses he must now face for the life of the ship. The shipyard, and possibly the architect, who will both tell you that no profit was made on the design and/or construction, may have to further their losses by making some token payment to an owner who should have told them what he wanted in the first place.

It is our opinion that modern U.S. ship design does not share the caliber of design evident in U.S. aircraft, automotive and other design fields. The technology is there, but the way we design and build ships often forces incomplete designs on a shipyard or the owner/shipyard/design agent interaction produces compromises which satisfy the politics, but not the real world. Consequently, many new ships have some major problem on delivery such as vibration, lack of speed or higher fuel consumption than estimated. Some shipowners, thus bitten, become much more insistent the second time around bringing us to the other end of the spectrum which we call the owner with T-2 mentality.

B. The T-2 was a World War II tanker work horse of relatively simple design that provided the backbone of many U.S. tanker fleets up into the 1960's. While the T-2 had its problems, everyone understood them and was comfortable with them. Similarly, our T-2 mentality owner has a ship design he is relatively happy with having either fixed it or gotten used to it and he doesn't want to change. This owner impedes progress by clinging to outmoded designs. Many naval architecture firms are at fault here also by either promoting the same design to the owner or readily agreeing to hold to the old design.

It is much more lucrative for the naval architecture firm to xerox the old design (and a lot less risky) than to embark on a new design. Considering today's costs it is almost humorous to hold to an old design to save 200,000 to 300,000 dollars on a flight of five 80 million dollar ships where a percent difference in fuel rate or speed would wipe out the engineering cost differential in the first few months of operation.

It is in this second area where we believe if it were not for the Maritime Administration promoting research and modern design that the U.S. would be technologically further behind than it presently finds itself.

We feel the industry would be better off if owners, once they have made up their minds to build a ship:

(1) Stepped up to contract design with complete engineering reviewwed by an in-house or competing naval architecture firm or;

(2) Allowed shipyards to prepare the contract design with a rigorous review by an in-house staff or naval architecture firm. The quality of commercial and naval engineering is poor and both military and commercial owners should be made aware of the additional operating costs involved. Engineering based cost overruns should be tallied and should be a factor in the decision process for selection of engineering firms for subsequent ships.

Computers are slowly finding their way into the design process as compared to other design fields. Again, MARAD has helped progress immmensely. As an indication of the value of the computer I would like to conclude the topic of design with the following example: In the 1970's owners would frequently contract with design agents for contract design packages that would cost between 300,000 and 600,000 dollars, occupy about 30 people and occupy a period of six to twelve months. Our firm, with the aid of computers recently finished contract plans and specifications for an original design in a 30 day period, utilizing 3 senior engineers, 3 junior engineers, 2 draftsmen, and one word processor operator for a total cost of just over $50,000.

2.0 CONSTRUCTION TECHNOLOGY

While the naval architecture community does not seem, to us, to be taken to task for not keeping up with technology, the U.S. shipbuilding industry certainly is, constantly. Japanese and Korean shipyard practices and production rates for building are compared to U.S yards where union work rules and regulations dictate production rates. The contracts and government support these foreign yards receive allow an investment in modern equipment not possible in the U.S. While some argue that shipbuilding subsidies in the past should have allowed modernization and some argue that subsidies have fostered inefficient shipyard practices, it seems to us that in a competitive atmosphere, with or without subsidy, shipyard modernization is merely dictated by simple economics.

However, while our shipyard system, for whatever reason, is not the most modern overall, certain segments building barges, drill rigs, crew and fishing boats and high performance craft do export technology and/or the hardware itself.

In offshore ship construction the most recent major advance is the concept of pre-outfitting or zone-outfitting. In this process, the ship is divided into blocks which are completed as units with piping, outfit and wiring, to the extent possible, installed before assembly. In this manner the relatively accessible subassembly is more efficiently outfitted than would be the completed ship. Zone outfitting requires considerably more "up front" engineering and planning which should reduce cost and error. Detailed pre-engineering and planning, even with the aid of computers, is costly in time and money and is most effective in series production where many similar ships are produced.

Returning to our existing shipyard base, we feel that even though American Shipyards cannnot compete with Far East yards, American ingenuity will provide innovative alternatives that will maintain some activity within the current shipyard base.

As an example, last year a request for proposals was sent out by Military Sealift Command for a replacement tanker. A group of three yards under the same corporate management approached us to investigate how they could compete in this program.

Figure 2 shows the location of the 3 shipyards involved, one in Lorain, Ohio on the Great Lakes, one, a barge building yard, in Nashville, Tennessee and one, a repair yard, in Tampa, Florida.

American Shipbuilding in Lorain, Ohio has built large Great Lakes carriers and is well experienced in large diesel engine installation. As the replacement tanker was to be diesel powered, American Shipbuilding was the most qualified of the three yards to produce the stern and engine room. The barge building yard lacked large engine experience and the repair yard also had less experience than American Shipbuilding. On the other hand, American Shipbuilding at Lorain had one major constraint which was the Welland Canal through which the ship would have to pass. The canal is 78 feet wide. The optimum ship beam was 85 to 90 feet.

NABRICO, the barge yard, on the other hand, had the lowest labor cost of the three yards and coincidently the highest steel production rates for relatively straight sections.

Tampa Ship had excellent drydock and crane facilities as well as good fitting out docks. They did not have major platten areas and subassembly shops.

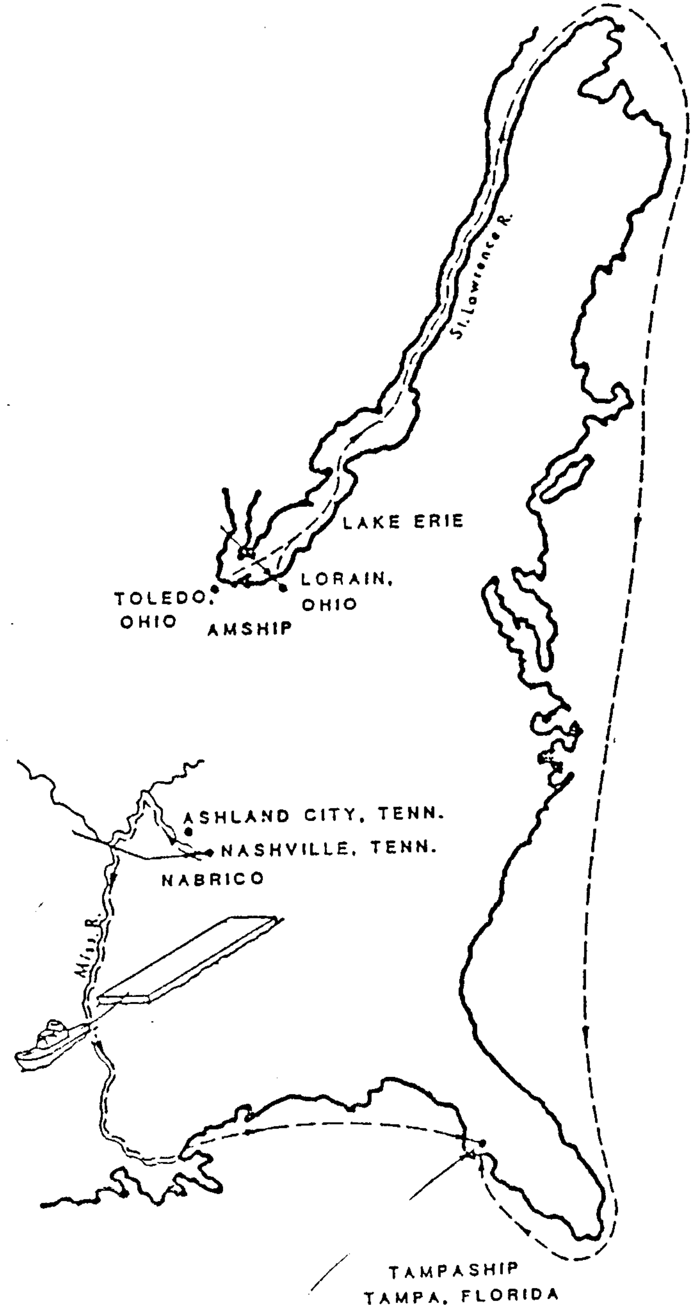


Figure 2
American Shipbuilding Company Shipyards

Figure 3 shows the scheme envolved with the three shipyards. The bow and stern units would be built in Lorain as a stub ship. The ship was designed as a double skinned ship (Figure 4) to provide required segregated ballast and to permit the stub (Figure 5) to transit the Welland Canal with the outer section of the wing tank removed. NABRICO would build the midbody in floatable sections as each double bottom tank, wing tank and the inverted trunk deck could all be made to float with temporary closures.

The stub ship would be sailed and the midbody sections would be towed to Tampa Ship where the entire ship would be erected in a graving dock using existing crane capacity.

Figure 6 shows how the stub would enter the drydock, be cut apart and joined to the midbody which would be assembled in an adjacent graving dock.

A ridiculous concept? To costly to be competitive? In stiff competition, the contract was awarded to these three shipyards earlier this year.

Some interesting advantages came out of the interaction of these three yards and the naval architect.

1. By utilizing three yards with some overlapping capabilities the ship could be completed by any two. As most of the components were designed to float, a labor disruption at any one yard would not materially delay the project.

2. The Great Lakes yard was used to using AH36 Steel to provide the lightest ship possible as Great Lakes ships are restrained in dimension by lock dimensions. AH36 was found to be no more difficult to fabricate than mild steel. As the final award was based largely on a required deadweight and speed at a minimum horsepower, the saving from using AH36 steel was a distinct advantage.

3. Politically, three economically depressed areas of the U.S. benefited from this method which was a definitive plus for a government contract.

3.0 TRENDS IN SHIP DESIGN FOR LINER VESSELS, DRY BULKERS AND TANKERS

As the cost of ships, fuel, crew and all of the components of ship operating cost escalate, the only way to hold down freight rates is to build larger ships where the cargo unit cost of fuel, ship and crew is reduced.

The two constraints to this process are materials technology to build the larger structures and geographical constraints. Historically, it is geographical constraints that have forced the design, not material constraints.

The U.S. is in a particularly poor position in that most U.S. ports are shallow water ports in terms of today's bulk tonnage. If subsidy or government assistance is to be allocated to improve the overall position of the U.S. in ocean commerce, we would then recommend that the funds be placed in port improvement more than in ships or shipyards. The funds should strictly be earmarked for dredging and widening of major existing ports where railroad and inland waterway ties exist.

We are currently involved in a study where a Southern exporter of coal is being forced to reduce his business because only small bulkers of about 40 feet of draft and 70,000 DWT tons can leave his terminal fully loaded. Other coal

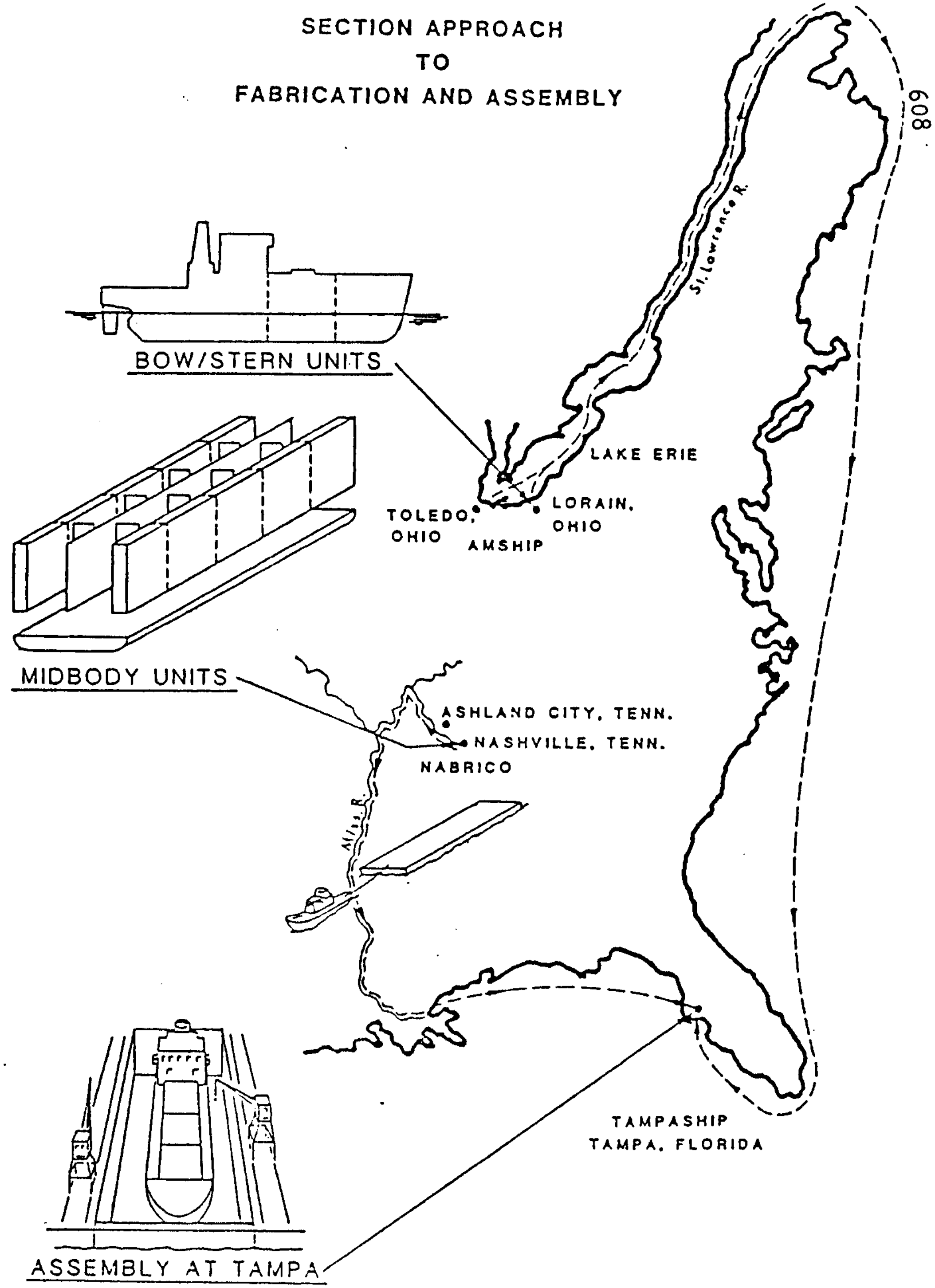


Figure 3

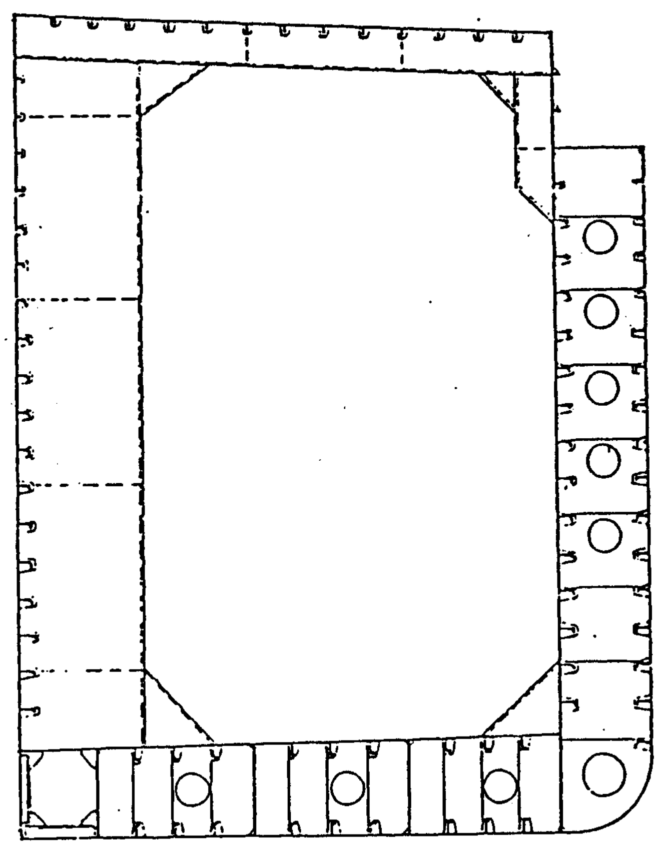


Figure 4

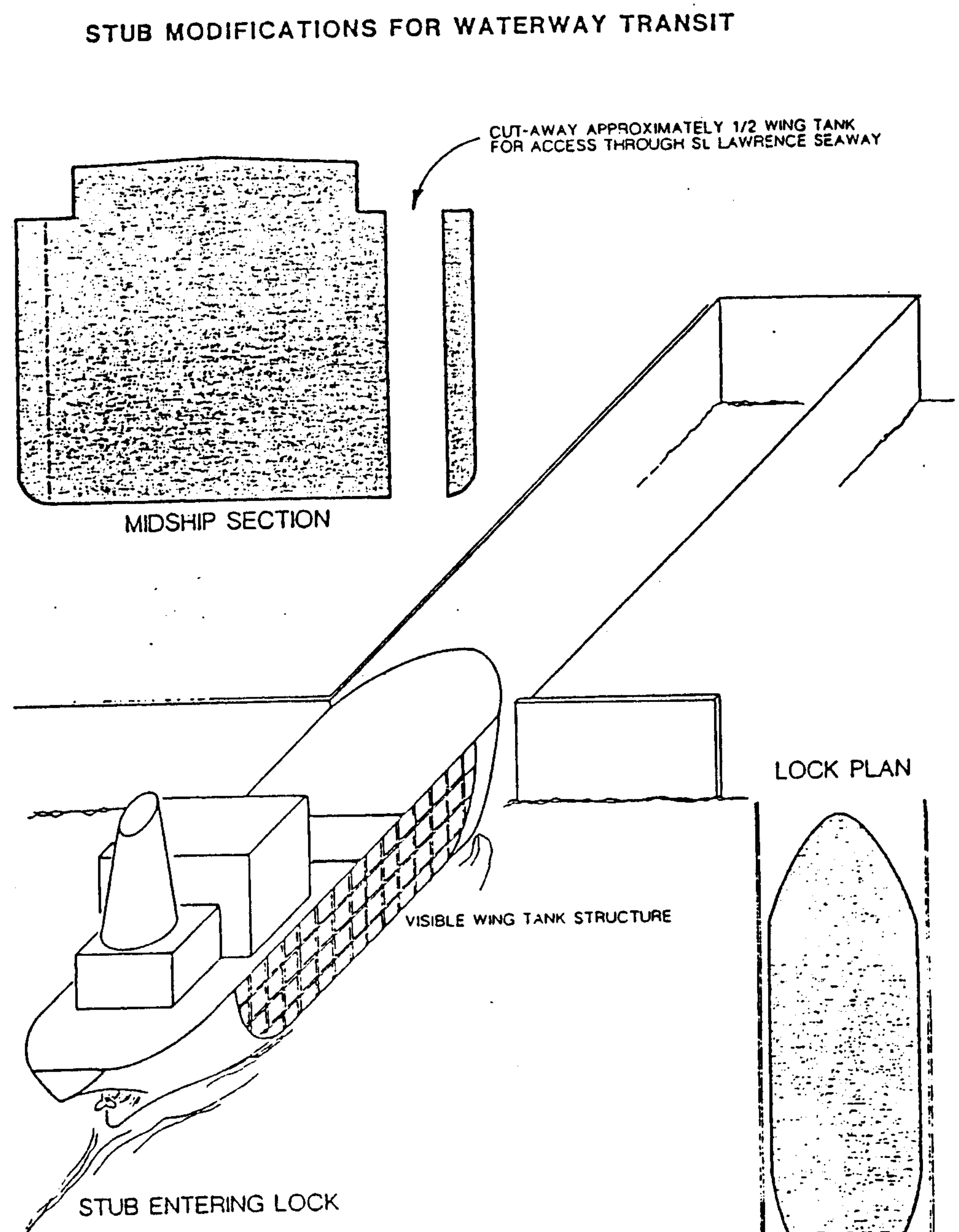


Figure 5

TANKER ASSEMBLY

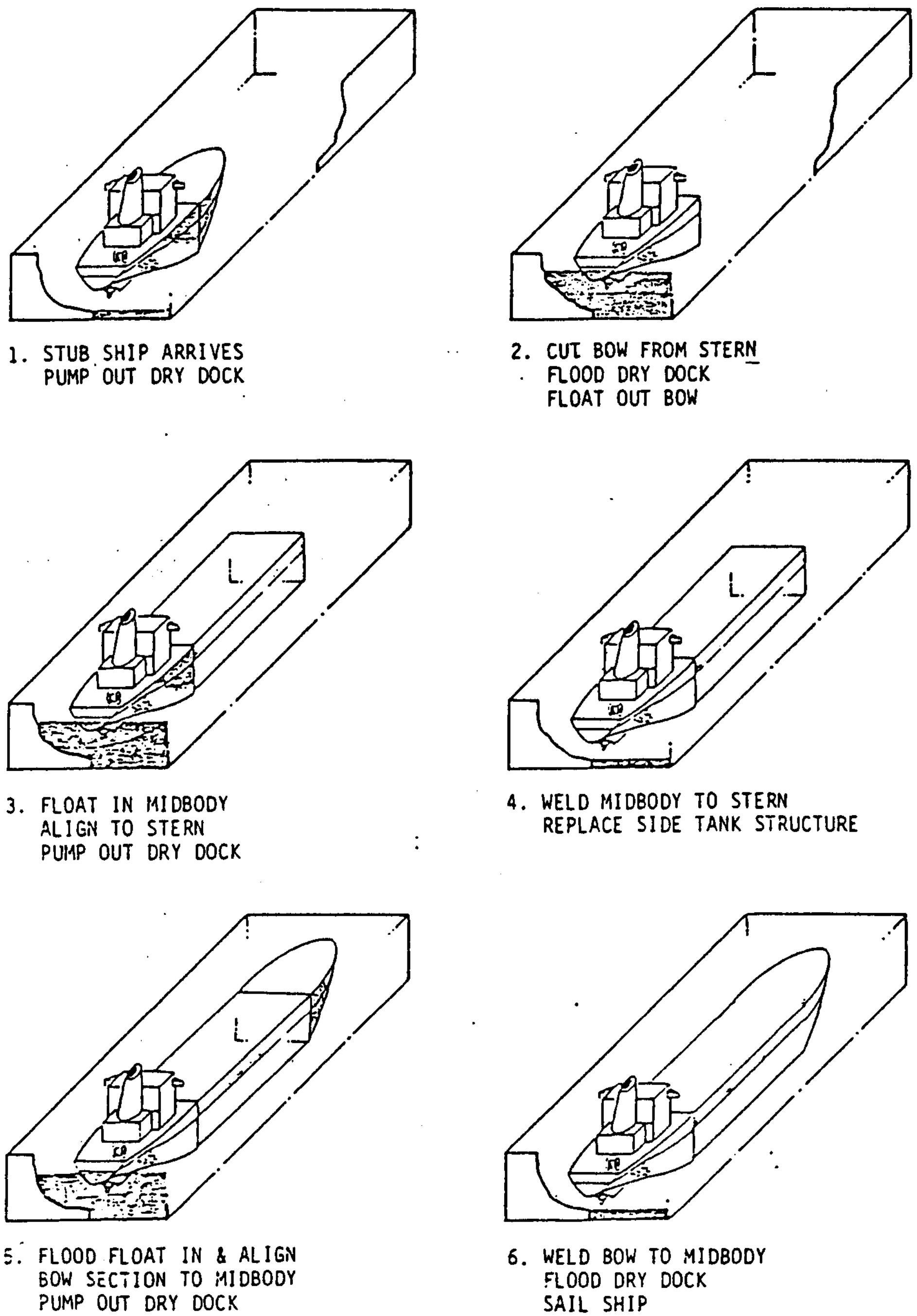


Figure 6

exporting countries can handle 150,000 DWT (and larger) vessels as can the receiving country to which he ships. His rate for coal ex the U.S. is very competitive to the extent that he can afford \$3 to \$4/ton for some sort of top off system to load larger ships than can be fully loaded at his facility. The economics of this study show already that top off or other schemes can only be economical on the basis of the differential rate with 100% utilization of the top off facility. On the other hand, if the shallow portion of the channel (in this case the last 20 miles of a 100 mile channel) were deepened it is certain that his trade and that of the entire port area would incrase measurably.

As the U.S. offshore commercial shipbuilding industry declines and U.S. owners are allowed to build foreign ships, we feel regardless of understandings with the U.S. owners, treaties with other nations, etc. that the reliance of the Navy for support commercial craft in time of need falls to an aging and dwindling fleet. Our reserve fleets are full of World War II vessels for which there are no spares and an insufficient supply of operating personnel. The number of personnel required to operate these small inefficient ships is such that we feel they cannot realistically be considered reserve ships.

In another related area, commercial ship owners face an extremely expensive new ship market. The present and future capital costs of new ship construction should cause the shipowner, in our opinion, to consider the possibility of future mission conversion during initial design so that the impact of conversion from both the standpoint of capital cost and time out of service is minimized.

And in a third related area, series production has not been prevalent in the U.S. commercial shipbuilding due to the total number of ships constructed, and the individual needs of owners for particular types of ships. With the rise in fuel costs, the design speed of vessels should now tend toward a more narrow band. If one parent ship could be configured to suit many different cargo modes, perhaps the economics of pre-engineering and series production can be applied to a base ship even though only a few of any one type are built.

We would therefore propose a program whereby some standard, modern, simple ship be designed and built as a modern reserve fleet or commercial vessel.

The cost of a ship today is such that the following should be considered in any new design:

A. The ship should be designed to be convertible from inception so that the owner is not stuck with an uneconomic vessel for reasons of a particular trade change midway in the vessels life.

B. Economic ship life should be extended to 30 years. Materials, coatings, M & R systems and other operating practices allow such a life today for the prudent operator.

C. Slow speed diesel propulsion has clearly established itself for the forseeable future and provides a ship that can be laid up and reactivated at a relatively small investment in time and money.

To illustrate this concept we offer the concept of the National Economic Emergency Defense Ship (NEEDS ship).

NEEDS Ship

The midship section might be configured as shown in Figure 7. As can be seen, the main hull structure is of double skin construction with longitudinal and transverse girders installed at predetermined heights and lengths. Only the longitudinal structure shown in Figure 7 would be considered effective in providing the required section modulus. It is possible the ship could be built as shown in Figure 7 with the deck plated over with lapped plate structure and kept in reserve in that configuration. Using the pre-stocked material, the final configuration could (in the same period of time necessary to activate existing NDRF ships) be determined and installed. Various possible configurations are:

- o Tanker
- o Bulker
- o Container
- o RO/RO.

In each case the engine room, auxiliary spaces, quarters and other spaces would be outfitted to some basic standard. This standard would be such that the balance of outfitting in these areas could take place in the same time frame as the various configuration modifications described in the following sections. The main power plant and auxiliaries would be diesel not only for fuel economy, but also for the ease in lay-up and reactivation.

Tanker

To configure the NEEDS ship as a tanker, corregated or flat plate bulkheads are installed between the longitudinal and transverse girders to form longitudinal and transverse bulkheads as shown in Figure 8. The lapped plate deck closure over each future tank would be removed for tank structure installation and outfitting and then reinstalled by welding once the tanks were completed. Brackets at the intersection of the wing tank and double bottom are installed to meet tanker structure requirements.

Cargo piping could be minimized by fitting tanks with deep well pumps in each tank. Deck piping could be replaced by hoses made up to the discharge flange of the pump on deck.

Bulker

The bulker (Figure 9) is configured similar to the tanker with a sloped plate added to the brackets at the double bottom/wing tank junction. In this case, however, the removed lapped plate deck closures are taken ashore as units and are fitted out as hatch covers. Hatch coamings are added together with deck cranes or other outfitting as required.

Container

In this configuration structure is fitted to the transverse girders only to form transverse bulkheads (Figure 10). In a similar fashion to the bulker, hatch covers and coamings are provided. Cell guides are installed below deck and container fittings are installed on top of the hatch covers.

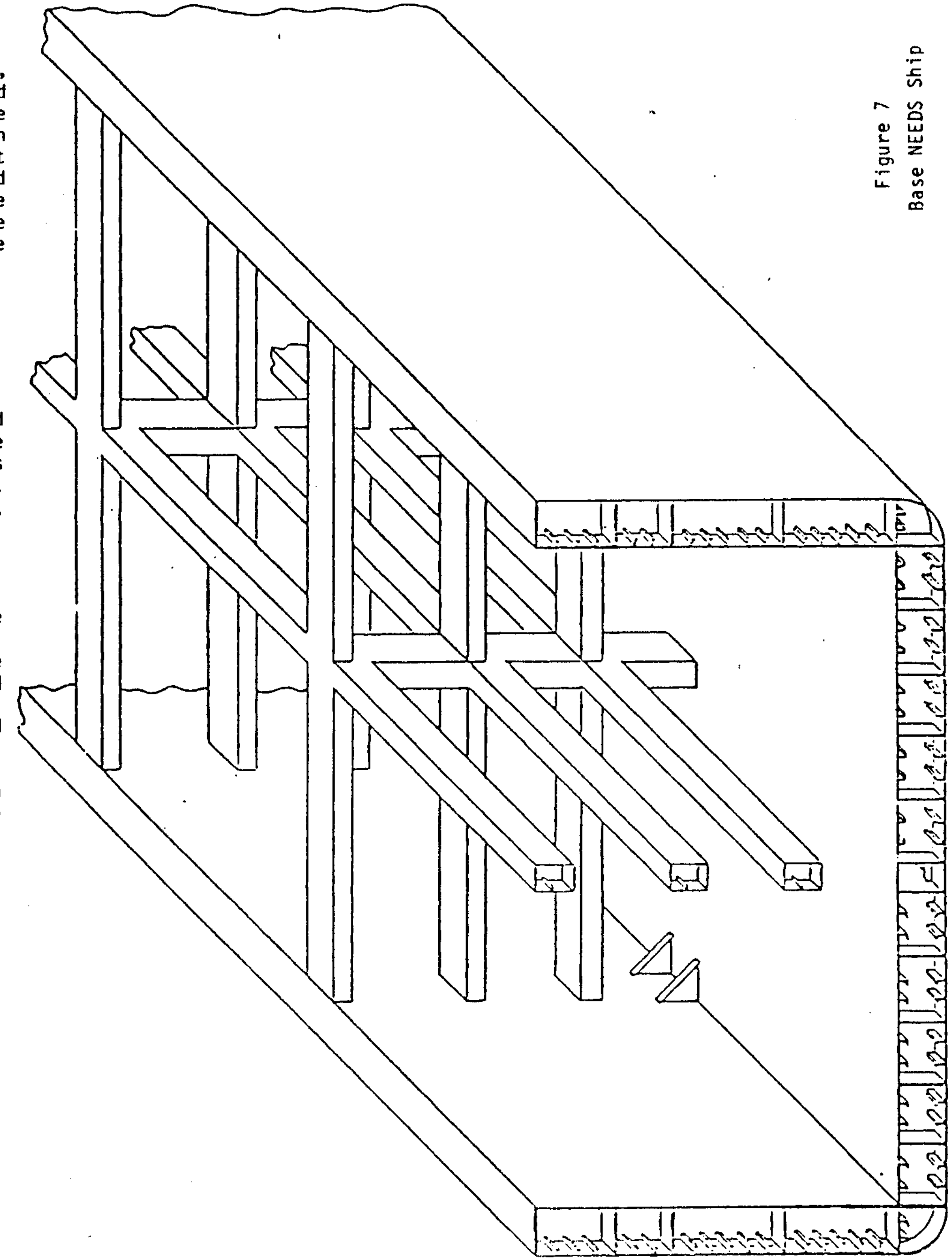


Figure 7
Base NEEDS Ship

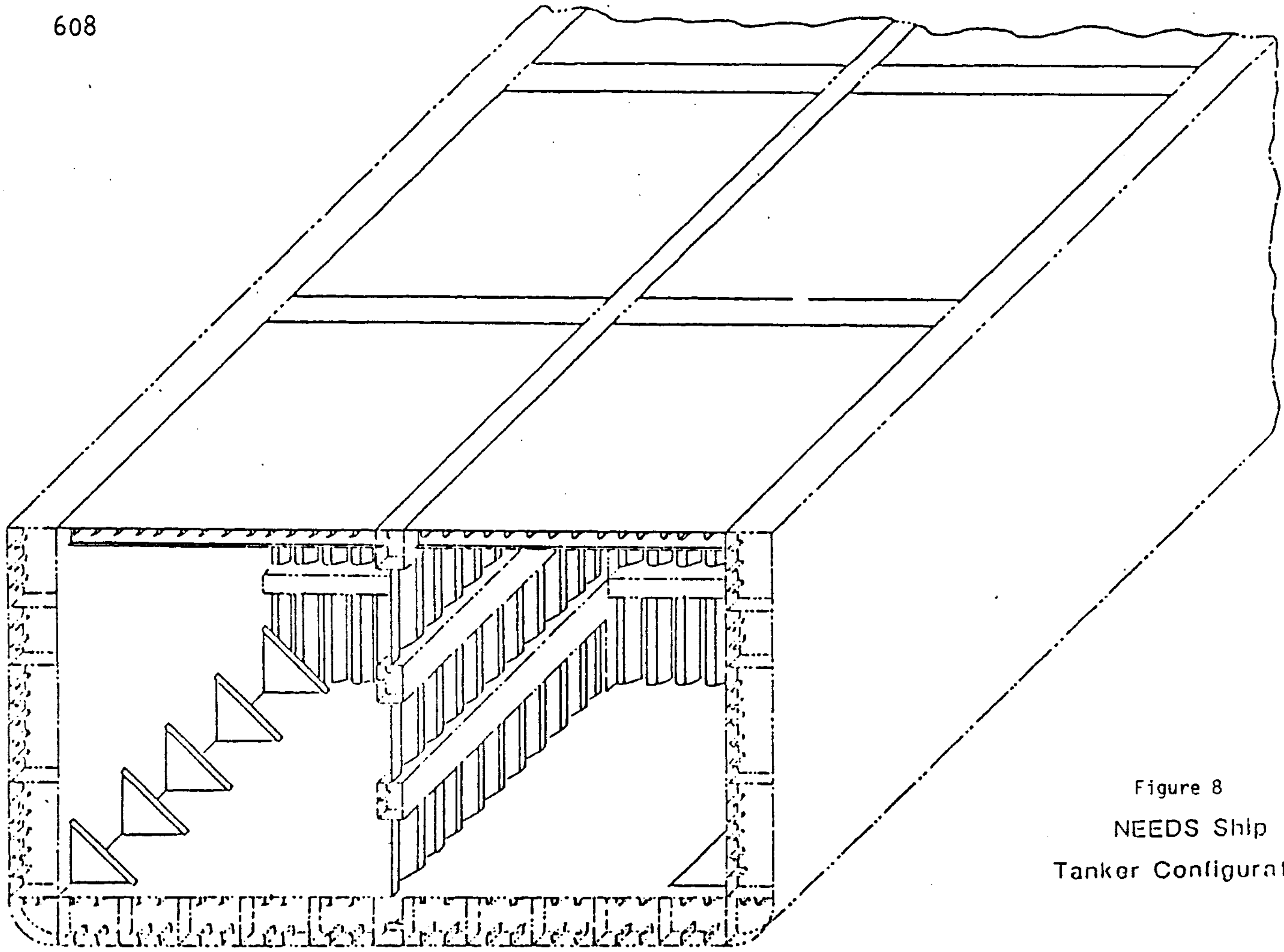


Figure 8

NEEDS Ship

Tanker Configuration

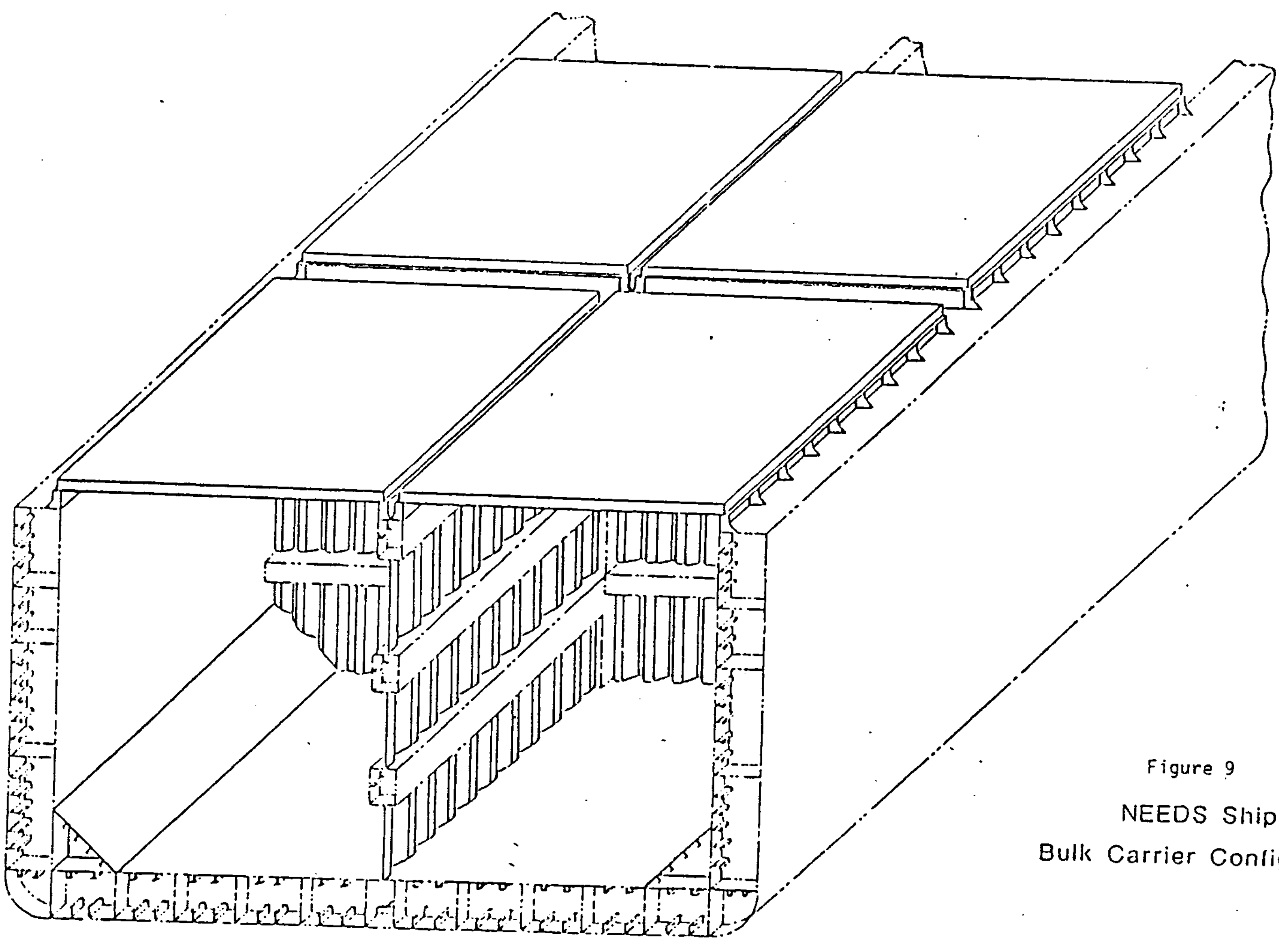


Figure 9

NEEDS Ship

Bulk Carrier Configuration

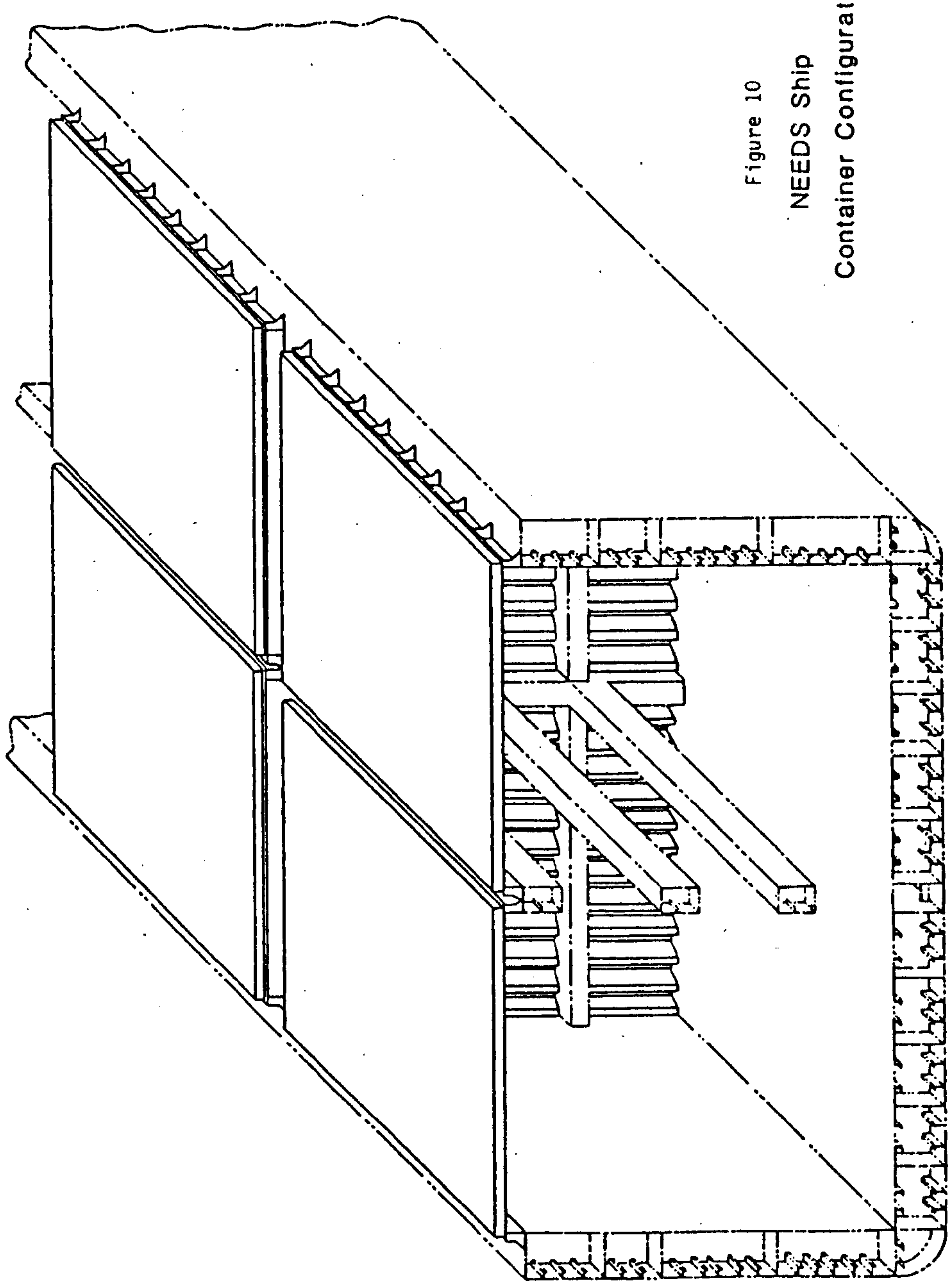


Figure 10
NEEDS Ship
Container Configuration

RO/RO

To form a RO/RO configuration the longitudinal girders are so spaced vertically that by placing horizontal structure on these girders RO/RO decks are formed with proper height for military vehicles (See Figure 11). The uppermost (weather) deck would be left flush once internal structure had been installed.

The aft house would be narrow to allow passage outboard and would be combined with a stern mounted ramp to provide access to the forward RO/RO area. Access to the weather deck could be on one side of the house while the other side could be fitted with a down ramp to the first deck below the weather deck which would probably be the freeboard deck. Either the wing tank space outboard of the engine room to one side or area forward of the engine room could be used for this down ramp.

General Features

Note in all these configurations the following:

o Conversion or reconfiguration for any cargo mode does not require drydocking or broaching of the main hull. Work sites can, therefore, be pierside providing many more sites.

o Tankage is available, piped up, in the base ship for fuel oil and ballast. Sufficient tankage would exist to provide sufficient fuel and/or ballast capacity for all configurations.

o The standard configuration would allow series shipyard production along with its inherent economics.

Capacities

To show the versatility in capacity we have calculated the capacities of a proposed base NEEDS ship and integer lengthenings for various cargo modes. Figure 12 shows the various lengths assumed.

Table 1 shows for the tanker or bulker the possible deadweight as a function of length and allowable draft.

Table 1
Available Cargo DWT for Bulker or Tanker

Length (LBP) / Draft	600	648	696	744
36	36000	40000	44000	51000
40	42000	46000	51000	59000
45	-----	54000	59000	69000

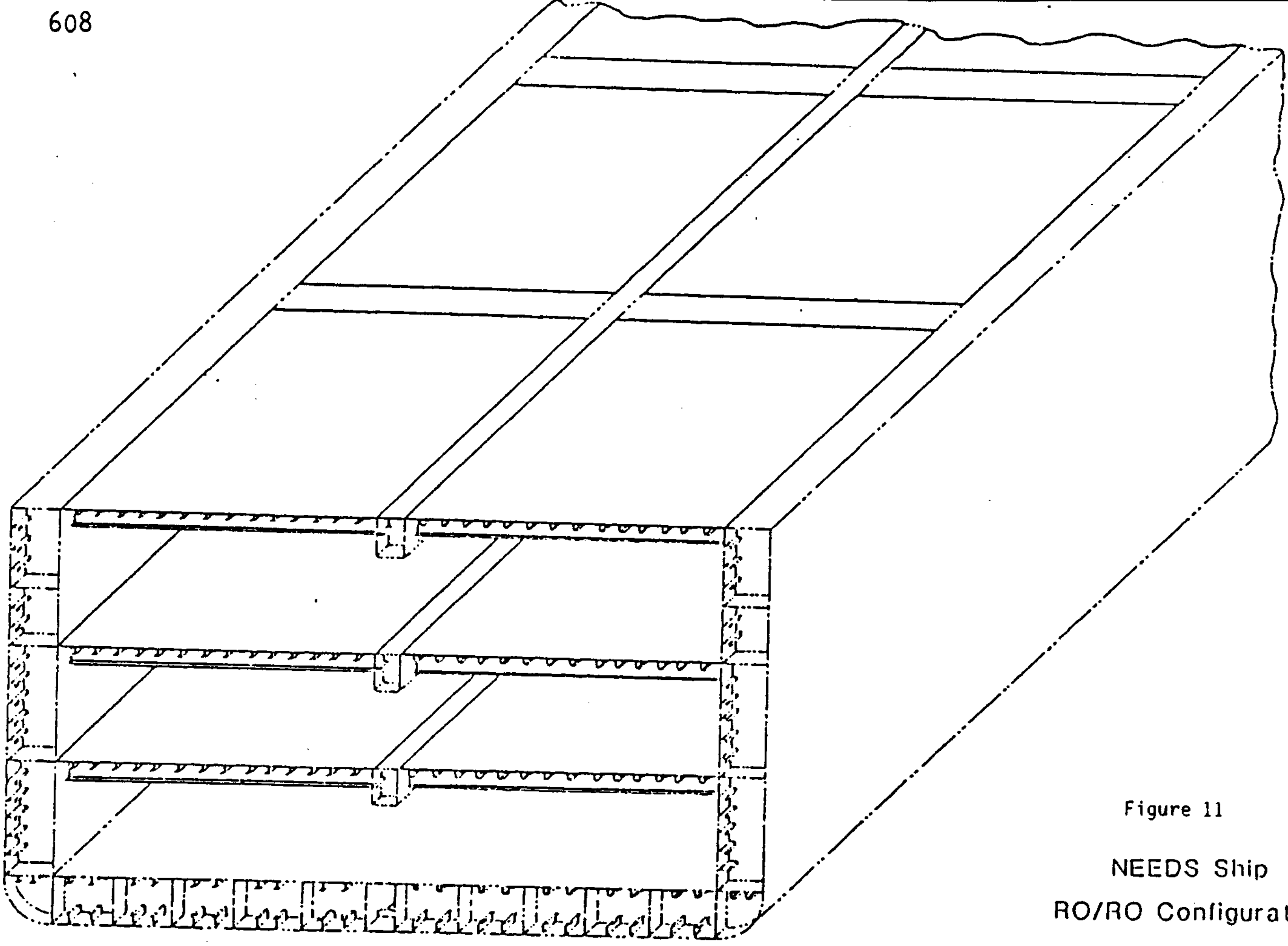


Figure 11

NEEDS Ship

RO/RO Configuration

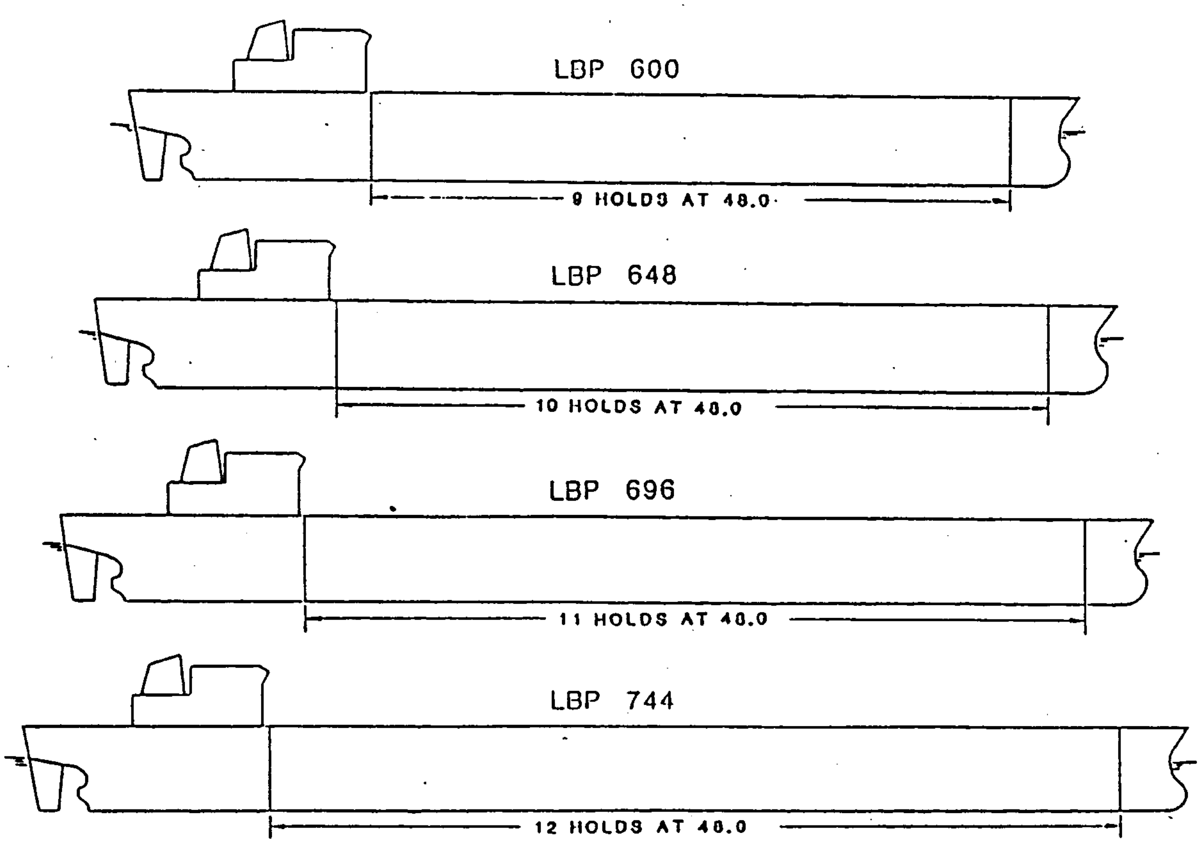


Figure 12

Table 2 shows the estimated 40 and 20 foot container capacity as a function of length. Container deck loadings are based on the proportion of deck containers to under deck containers for container ships of similar form.

Table 2
Container Capacity
55 Foot Depth

LBP	Number of 40 Foot Containers	TEU
600	540	1080
648	600	1200
696	660	1320
744	720	1440

Finally, Table 3 summarizes the total deck area available for each length of ship when configured as a RO/RO.

Table 3
RO/RO Total Deck Area Available

LBP	Total Deck Area in Square Feet
600	170,000
648	188,000
696	206,000
744	224,000

Naval Design - TAHX

Economic operation, the ability to change mission or handle multiple missions should apply to naval design where applicable. Recently, the U.S. Navy has sought hospital ship proposals (TAHX) for new construction and/or conversion. The TAHX as either new construction or conversion and in either the one, two or three ship configuration represents a sizable investment which will be on the order of $200-300 million. Coupled with this significant first cost, is the current requirement to man the ship portion of the TAHX on a continuing basis while the ship is essentially laid up on ready status. The ship and its hospital equipment are to be given operational checks every 30 days. It is our feeling that the costs of this operation will be sizable for very little direct benefit.

In addition, the true operational status of the ship and, more importantly, its delicate hospital equipment and supplies must be suspect.

An Alternate Concept

We have concluded that one way of making the TAHX more economic would be to employ the vessel as a hospital during non-critical times. This modern facility will possibly be better equipped than some older shore-based naval facilities. Recognizing that most major naval facilities are adjacent to water, a floating hospital would have the advantage of mobility both in time of need and as needs change from base to base, both in the U.S. and abroad. A floating unit would also ideally serve in any geographic area during non-emergency periods.

Still, there are two major drawbacks to a ship-type floating unit:

o Most of the propulsive plant and support ship is not used during the hospital mode.

o A ship-type unit requires about 30 feet of draft which limits the available mooring sites and access to the facility.

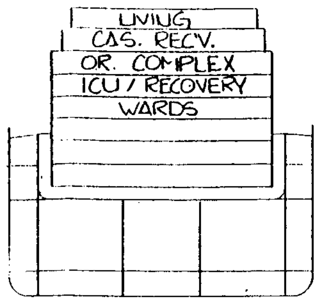
Our concept is then a barge-type floating hospital facility which is carried, when needed, by a large LSD-type vessel.

Figure 13 shows the general arrangement of the LSD/TAHX in the at-sea configuraiton. This particular sized ship would have about 230,000 square feet of available hospital space. Note that the draft of the ship in full load is 27 feet, while the draft of the floating hospital complex is estimated at 12 feet.

Figure 14 shows the method of loading the hospital facility aboard the LSD. Note that this loading would have to be accomplished in a deep harbor or channel where about 43-45 foot depth of water was available. The hospital complex could be moved into position by tugs. As an option, the hospital complex could be fitted with its own minimal propulsion plant which would run off its installed electric generating plant.

Figure 15 shows how the hospital complex, once floated free of the LSD, could be moored to shore with vehicle access ramps to provide direct shore access. With the reduced draft of the floating complex, no major pier facilities would be required, and the number of siting options will be increased.

Finally, Figure 16 shows the LSD in its dock mode drydocking, in this case, a patrol frigate. A destroyer escort or similar vessel could also be drydocked in an LSD of this size.



TYP. SECT.

DATA

Length Overall	710'-0"
Length On Waterline	680'-0"
Length Between Perpendiculars	648'-0"
Beam	106'-0"
Designed Waterline	26'-0"
Scantling Draft	27'-0"
Depth (To Main Deck)	56'-0"
Speed, Service, Knots	23
Machinery: Twin Screw Geared Turbine	
Service S.H.P. For 23 Knots	35,000
Installed S.H.P.	45,000

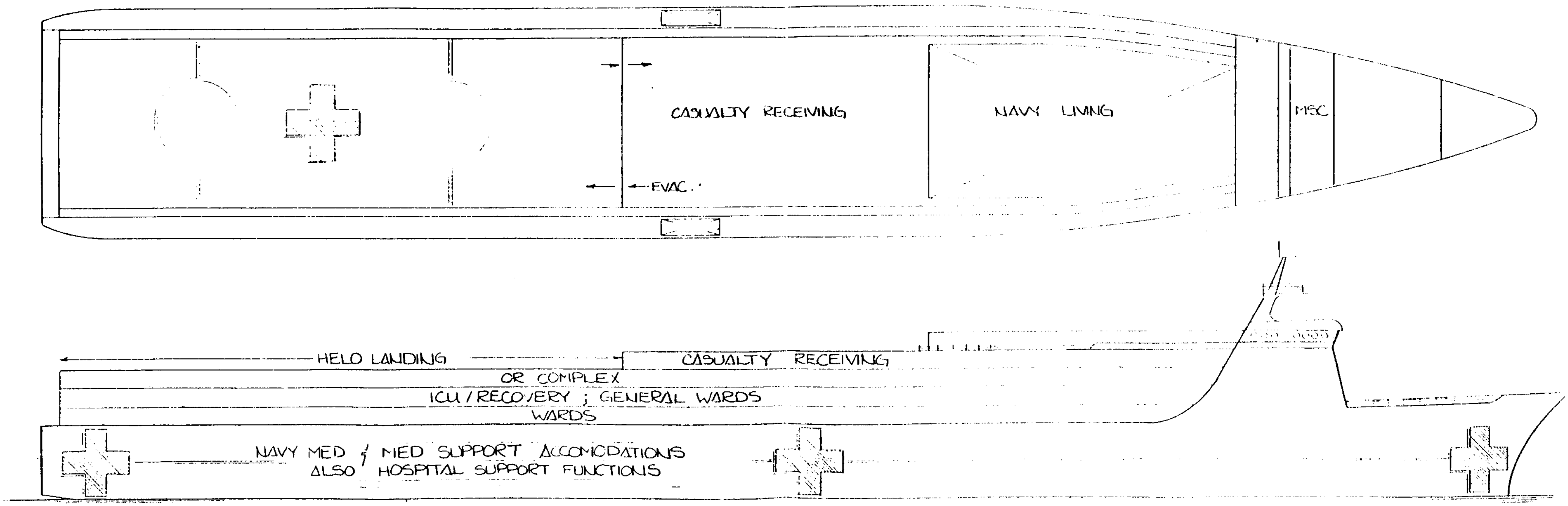


Figure 13

LSD/TAHX

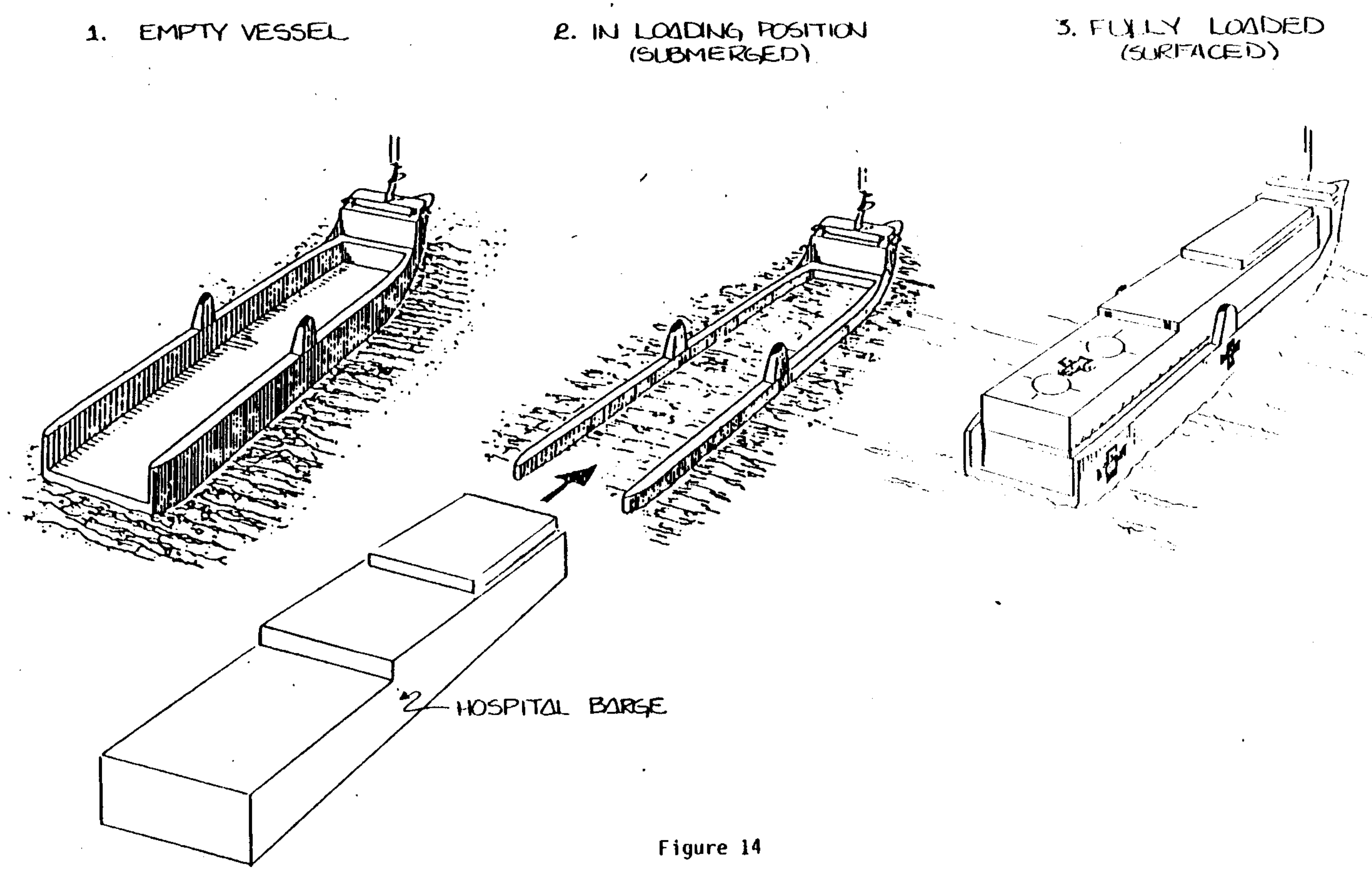

1. EMPTY VESSEL
2. IN LOADING POSITION (SUBMERGED)
3. FULLY LOADED (SURFACED)
HOSPITAL BARGE

Figure 14

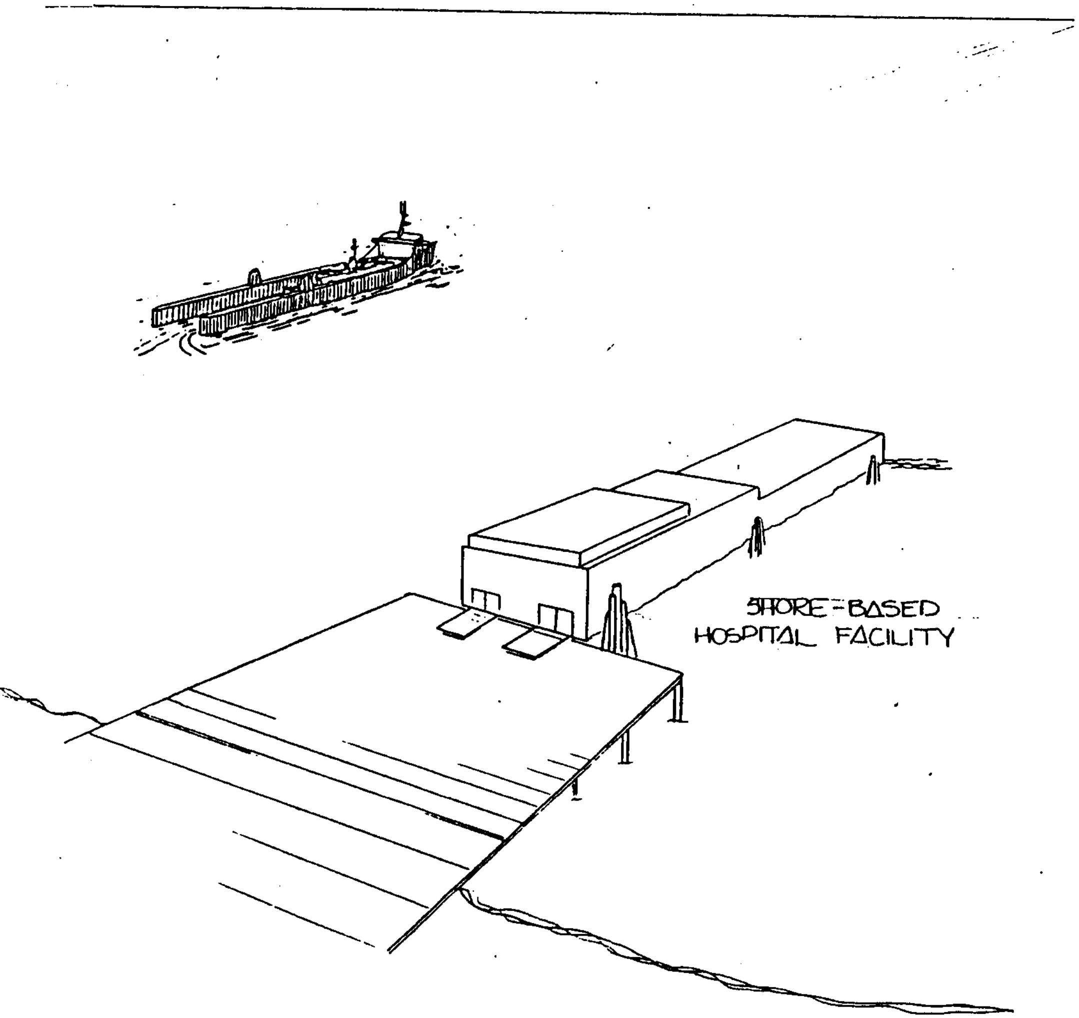
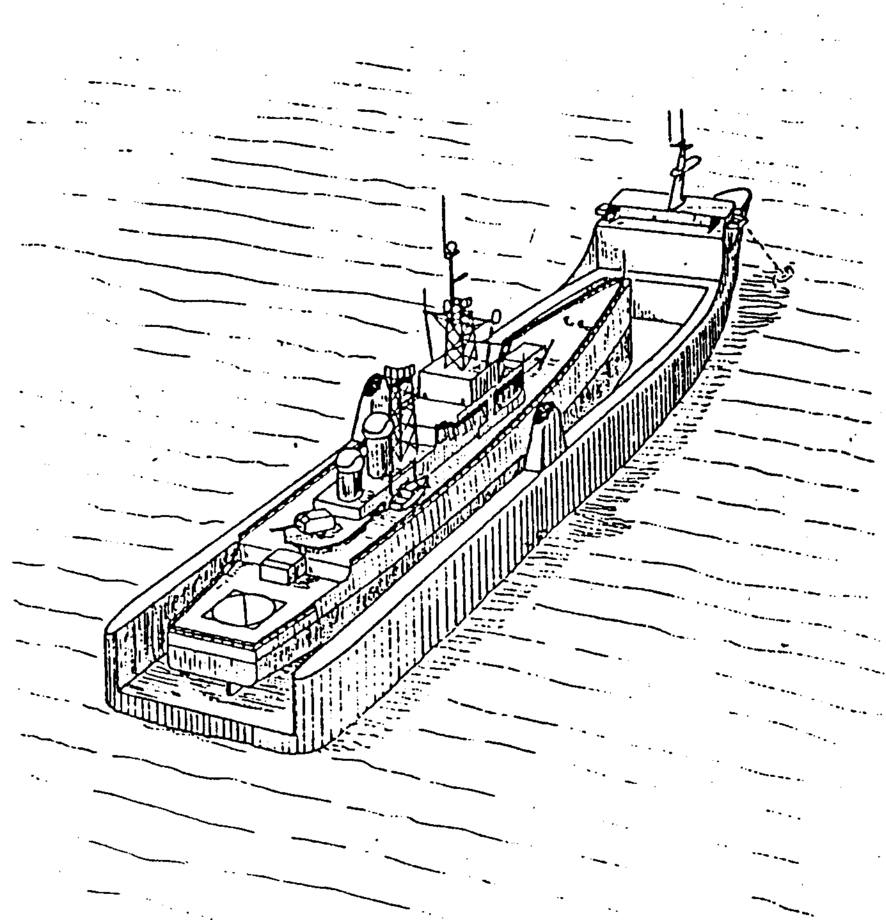


Figure 15



The LSD in it's dock mode can drydock a Patrol Frigate, Destroyer Escort, or a similar vessel.

Figure 16

We see the following major advantages to this concept as:

- Both components of the LSD/TAHX are fully usable in their nonemergency role providing a direct benefit for their cost.
- By being actively utilized, both components should be in a better state of readiness than if they were laid up in an active status.
- A much greater degree of flexibility is provided in the utilization of the combined vessel and/or either component.
- The base LSD can accept other modules and, therefore, provides a multi-mission capability.
- The hospital complex can be built at an inland barge yard which should provide a lower first cost for this unit.
- If a replacement LSD-type vessel is planned and could be configured to accept the hospital unit, the total first cost to the Navy for this proposal as opposed to a ship-type TAHX may be reduced.
- A greater degree of redundancy in electric power generation in that both the ship and floating module would have the capability of producing the electric power.

Disadvantages

- Probable higher first cost for both components as opposed to a ship-type TAHX.
- Deep water is required to off-load and load the floating module.

In summary, naval construction is also too costly to consider single mission support ships. Multiple purpose ships with proper maintenance could provide a more effective role for a longer ship life.

4.0 CLASSIFICATION REQUIREMENTS

As a general statement, it has always been interesting that although the U.S. operates one of the oldest average age vessel fleets, it also operates one of the safest fleets in the world. We believe this says something positive for U.S. regulation during construction and when ships are in operation.

Considerable progress has been made in recent years in defining the roles of and reducing the overlap of the two primary agencies, the American Bureau of Shipping and the United States Coast Guard. The Coast Guard's current economic plight is even accelerating the takeover of most construction regulating duties by ABS.

The next positive step would be to reorganize and streamline U.S.C.G. regulations so that they would be formulated similar to ABS rules where there is less discretionary interpretation. Not only would this reduce the U.S.C.G. workload, but it would also mitigate the uncertainty in final vessel cost due to interpretation during construction.

It has been our experience with foreign ships built to U.S. regulations that the anticipated problems are much greater than the actual problems. For a well built ship, the costs associated with U.S. regulation both in the U.S. and in foreign countries are small if the yards bid on U.S. standards in competition with each other.

5.0 CONCLUSION

While admittedly a brief overview, we hope some of the examples presented here will spark some thought and interest to consider a commercial and naval ship design and construction in a broader sense.