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SUBMARINE RESCUE SHIP (ASR/T-ASR) FEASIBILITY STUDY REPORT.(U)

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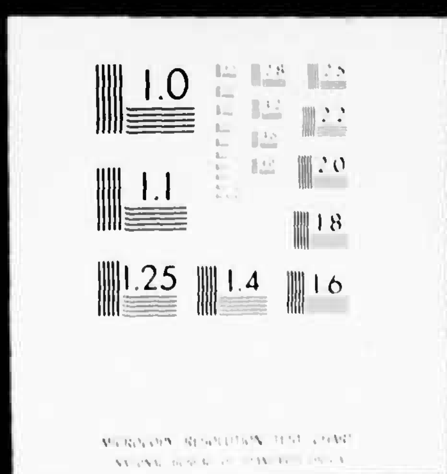

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Submarine Rescue Ship (ASR/T-ASR)
Feasibility Study Report

NAVSEC Report No. 6114-019-77

Prepared by Granville W. Broome, Jr.
and Everett A. Young

October 1977

NAVAL SHIP ENGINEERING CENTER
WASHINGTON, D.C.

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This report documents the feasibility study of a new Auxiliary Submarine Rescue (ASR) ship Class. The study resulted in descriptions of feasible ship alternatives that can be compared to demonstrate the effects of capability, manning type, and construction standards on ship characteristics. Two basic levels of capability were investigated: (1) a small ship capable of escorting submarines during test and trials and 2) a larger ship capable of escort operations plus Submarine Rescue Chamber (SRC) operations. Military and civilian manning as well as Military and commercial construction standards were considered

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ABSTRACT

This report documents the feasibility study of a new Auxiliary Submarine Rescue (ASR) ship Class. The study resulted in descriptions of feasible ship alternatives that can be compared to demonstrate the effects of capability, manning type, and construction standards on ship characteristics. Two basic levels of capability were investigated: 1) a small ship capable of escorting submarines during test and trials and 2) a larger ship capable of escort operations plus Submarine Rescue Chamber (SRC) operations or other operations typical of the ASR 7 Class. Military manning and civilian manning were considered along with military standards and commercial standards for construction. Special studies were also conducted to investigate SRC center well handling, deep-water Remote Unmanned Work System (RUWS) handling, 120,000 lb. bollard pull, ship noise effect on underwater communication (and submarine tracking), and alternative hull forms. Alternatives are described in enough detail to permit Class "F" cost estimates to be made.

ADMINISTRATIVE INFORMATION

The feasibility studies documented in this report were authorized by reference (1). The work was completed under NAVSEC Job Order Number 837KP01 between December 1976 and October 1977. This report is the final deliverable under this task.

ACKNOWLEDGEMENT

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SECTION I. INTRODUCTION

1.1 Background

The U.S. Navy's primary submarine rescue capability is provided by the Deep Submergence Rescue Vehicles (DSRV's), carried either by ASR 21 Class ships or by mother submarines. The secondary capability is provided by ASR 7 Class ships, which employ submarine rescue chambers (SRC's) rather than the DSRV's. These ships serve collaterally as escort ships for submarines undergoing sea trials, providing continuous tracking of and communicating with the submarine, serving as a test target for the submarine, and retrieving test torpedoes. Four ASR 7 Class ships are programmed for retirement from service in FY 84. In view of the current austere budgetary environment, and the priority which auxiliary support ships receive, construction and operation cost impacts on ship design were critical factors which governed the scope and approach for these studies.

NAVSEA tasked NAVSEC, reference (1), to do feasibility studies for a new submarine rescue ship to replace the ASR 7 Class. The major tasks are listed below:

a. Evaluate alternative capabilities; i.e., submarine escort, submarine rescue, salvage, towing, etc.

b. Evaluate military vs civilian manning.

c. Evaluate military vs commercial construction standards.

d. Evaluate alternative positioning systems.

1.2 Objectives

These studies are intended to form the engineering basis for decision making on the following major ASR issues:

a. Capability

b. Manning type

c. Construction standards

The engineering basis needed, is a description of feasible alternatives that can be compared to demonstrate the effect these issues have on ship characteristics and cost. Therefore, the specific objective of this feasibility study is to provide descriptions of the alternative ships to a sufficient level of detail to support class "F" cost estimates.

SECTION II. REQUIREMENTS

2.1 General

The general requirement is to develop feasible ship alternatives that demonstrate the effects of capability, manning type, and construction standards on ship characteristics and cost. There are numerous alternative capabilities that could be investigated, however, the study has been limited to two basic levels of capability; 1) a small ship capable of escorting submarines during test and trials and 2) a larger ship capable of escort operations plus Submarine Rescue Chamber (SRC) operations or other operations typical of the ASR 7 Class. The requirements for these two alternatives are discussed in more detail in Section 2.2. Manning type and construction standards are discussed in Sections 2.3 and 2.4. Section 2.5 defines special studies required and Section 2.6 summarizes the requirements and defines the ship alternatives that were investigated, including special studies.

2.2 Alternative Capabilities

As previously mentioned, the requirement to investigate alternative capabilities has been limited to two basic levels of capability. The intent behind the investigation of a simple, small submarine escort and a larger "fully capable" ASR was to allow an evaluation of a mix of the two. In other words, instead of a fixed number of fully capable ASR's, perhaps a fewer number of these and several small submarine escorts would be more attractive.

2.2.1 Submarine Escort Requirements

Escorting submarines during trials and test is one of the primary functions of the existing ASR 7 Class. A ship or boat to do this should be capable of:

a. communicating with and tracking a submarine during test and trials at ranges up to 10,000 yards;

b. retrieving test torpedoes;

c. acting as a target for submarine tests;

d. supporting limited air diving using portable equipment;

In addition to these requirements, the submarine escort ship is required to maneuver with the submarine. A sustained speed greater than previous ASR's is thus desirable (approximately 15 knots) for a small ship dedicated to submarine escort. Therefore, for comparison the following sustained speed alternatives have been required to be investigated:

a. Normal speed submarine escort; sustained speed equal to 15 knots, with endurance fuel provided for 2000 nautical miles at 13 knots.

b. High speed submarine escort; sustained speed equal to 30 knots, with endurance fuel provided for 2000 nautical miles at 15 knots.

2.2.2. Fully Capable ASR Requirements

A fully capable ASR, in addition to escorting submarines, should also be capable of:

a. Handling and support for rescue operations with new increased depth SRC.

b. Handling and support for remote underwater vehicles (RUV's), such as CURV III, to support SRC operations.

c. Surface salvage support.

d. Air diving support.

e. Towing submarines.

f. Deep Submergence Vehicles (DSV) handling and support (i.e. SEA CLIFF and TURTLE and other submersibles of opportunity).

Portable equipment should be considered to the greatest extent possible to satisfy the above required capabilities, because all capabilities will not be required simultaneously. For example, the ship will not be required to carry equipment for surface salvage and SRC operations simultaneously. Only the handling and support of the SRC and a Remote Underwater Vehicles (RUV) such as Cable-Controlled Underwater Recovery Vehicle (CURV) will be required simultaneously.

2.3 Manning

Two alternatives are required to be considered for manning, military manning and civilian manning by Military Sealift Command (MSC).

Military manning implies the normal Navy maintenance philosophy, which requires spare parts, workshops, manuals, test equipment, etc. for a substantial amount of onboard maintenance and repair by the crew. The FY 77 ATF manpower study, reference (2), serves as a baseline for determining the minimum manpower requirement for an ASR manned by Navy officers and crew.

The manning requirements for civilians will be provided by MSC and these ships are designated as T-ASR's. On the fully capable T-ASR's, a Navy detachment of ten men will be permanently assigned for communications (four men) and sonar operations (six men). Accommodations similar to those for the MSC personnel shall be provided for these men.

Troop type accommodations must be provided on the fully capable ASR's and T-ASR's for transient Navy detachments for specific missions. Since simultaneous SRC and RUV is a requirement, 6 officer and 23 enlisted accommodations must be provided for:

a. SRC detachment - 3 officers and 18 enlisted

b. CURV III detachment - 8 civilians (3 officers and 5 enlisted equivalent quarters)

2.4 Construction Standards

Two alternatives are required to be considered for construction standards:

a. Military standards with Navy design practices for Navy auxiliary ships.

b. Commercial standards with U.S. Coast Guard, ABS and MSC design practices for the type and size ships addressed.

Construction standards affect test and evaluation, tolerances, stability, structure, machinery, habitability, logistic support, margins, quality assurance, etc. which are reflected in the ship space and weight and the cost factors used for estimating costs.

2.5 Special Study Requirements

In addition to the requirements above the following special studies are required:

a. Investigation of center well handling of the SRC.

b. An investigation of the feasibility of back fitting the deep-water RUWS.

c. Investigation of a 120,000 pound bollard pull capability.

d. Investigation of ship noise to evaluate effect on underwater communications and submarine tracking.

e. An evaluation of alternative positioning systems including dynamic positioning.

f. An evaluation of alternative hull forms to determine applicability to the ASR.

2.6 Requirements Summary

Based on the requirements discussed above, eight basic ship alternatives, defined in Table 2-1, were chosen for consideration in the feasibility studies. A comparison of these alternative ships should adequately demonstrate the effects of capabilty, manning type, and construction standards on ship characteristics and cost. Whenever ship size impact was required in a special study, Alternative 8 was used as the baseline ASR.

	Manning	Civilian	Military	Military
	Construction Standards	Commercial	Commercial	Military
Submarine Escort	15 knot sustained speed 2000 n.mi. @ 13 knots	1	2	3
Submarine Escort	30 knot sustained speed 2000 n.mi. @ 15 knots	4		5
Fully Capable ASR	15 knot sustained speed 10,000 n.mi. @ 13 knots	6	7	8*

* This alternative was used as the baseline ASR for special studies

Table 2-1 Ship Alternatives Matrix

SECTION III SMALL SUBMARINE ESCORT

3.1 Design Approach

The submarine escort ship alternatives in Table 2-1 (Alternatives 1 through 5) do not require large vessels. For example the existing 100-foot Navy Torpedo Weapon Retriever (TWR) is equipped for submarine escort duty during submarine sea trials. The 100-foot TWR is a logical candidate for Alternative 3 and will be discussed in more detail in Section 3.2.

The design approach for submarine escorts was to evaluate existing designs, both commercial and Navy, to determine the approximate size to best satisfy the requirements. The selection of the 100-foot TWR to satisfy the requirements for a 15 knot, Navy manned, military standards, submarine escort demonstrates this approach.

3.2 15-Knot Submarine Escorts

The first three alternatives (Alternatives 1, 2, and 3) listed in Table 2-1, are ships that are to be designed exclusively for submarine escort at speeds attainable by the existing ASR 7 Class, i.e. 15 knots. The only differences between these alternatives are the manning type and the construction standards. Each will be discussed separately in this section.

3.2.1 15-Knot Civilian Manned and Commercial Standards Submarine Escort - Alternative 1

The civilian manned, commercial standards ship has not been selected. Data requested for existing commercial vessels of approximately the required size have not been obtained to date. Final selection could not be made without adequate data to allow an evaluation of arrangeable volume, weights, stability, etc. If the ASR/T-ASR is continued in the future a renewed effort to obtain this data should be made, enabling final selection of Alternative 1, which should be documented in an Addendum to this report.

3.2.2 15-Knot Military Manned and Commercial Standards Submarine Escort - Alternative 2

Final selection could not be made without additional data as discussed in Section 3.2.1.

3.2.3 15-Knot Military Manned and Military Standards Submarine Escort - Alternative 3

The boat described by Figure 3-3 and Table 3-3 has been selected for the 15 knot, military manned and military standards design. Note that this is basically the existing 100-foot TWR with some equipment changes, primarily communication, navigation, and sonar equipment. This equipment is discussed in some detail in Appendix C. Note that the speed and endurance estimates indicated in Table 3-3 are predicated on the assumption that appendage drag due to sonar equipment will be relatively small. It is anticipated that the tracking function will be accomplished using a "pinger" on the submarine and triangulation equipment on the submarine escort. However this system will require development in later design stages. As a fallback; weight, space, and power have been provided for the AN/SQS 51 active sonar. Dome drag for this sonar would cause a significant reduction in speed and endurance.

3.3 30-Knot Submarine Escorts

Alternatives 4 and 5 in Table 2-1 are ships that are to be designed exclusively for submarine escort at high speeds, i.e., 30-knots. The only differences between these alternatives are the manning type and the construction standards. Each will be discussed separately in this section.

3.3.1 30-Knot Civilian Manned/Commercial Standards Submarine Escort - Alternative 4

Final selection could not be made without additional data on existing Offshore Supply Boats (OSB) and Offshore Crew Boats (OCB), as discussed in Section 3.2.1.

3.3.2 30-Knot Military Manned/Military Standards Submarine Escort - Alternative 5

The design approach for sumarine escorts was to evaluate existing designs to determine the approximate size to best satisfy the requirements. The CPIC (Coastal Patrol Interdiction Craft) was selected as a candidate for the high speed escort ship. If the major mission for this ship is to communicate with and track a submarine during testing, and the torpedo retrival requirement is eliminated, the CPIC can be easily modified (not redesigned) to perform the mission.

Pertinent items of description are listed below:

a. The welded aluminum hull structure was designed to be as light as the state-of-the-art would allow.

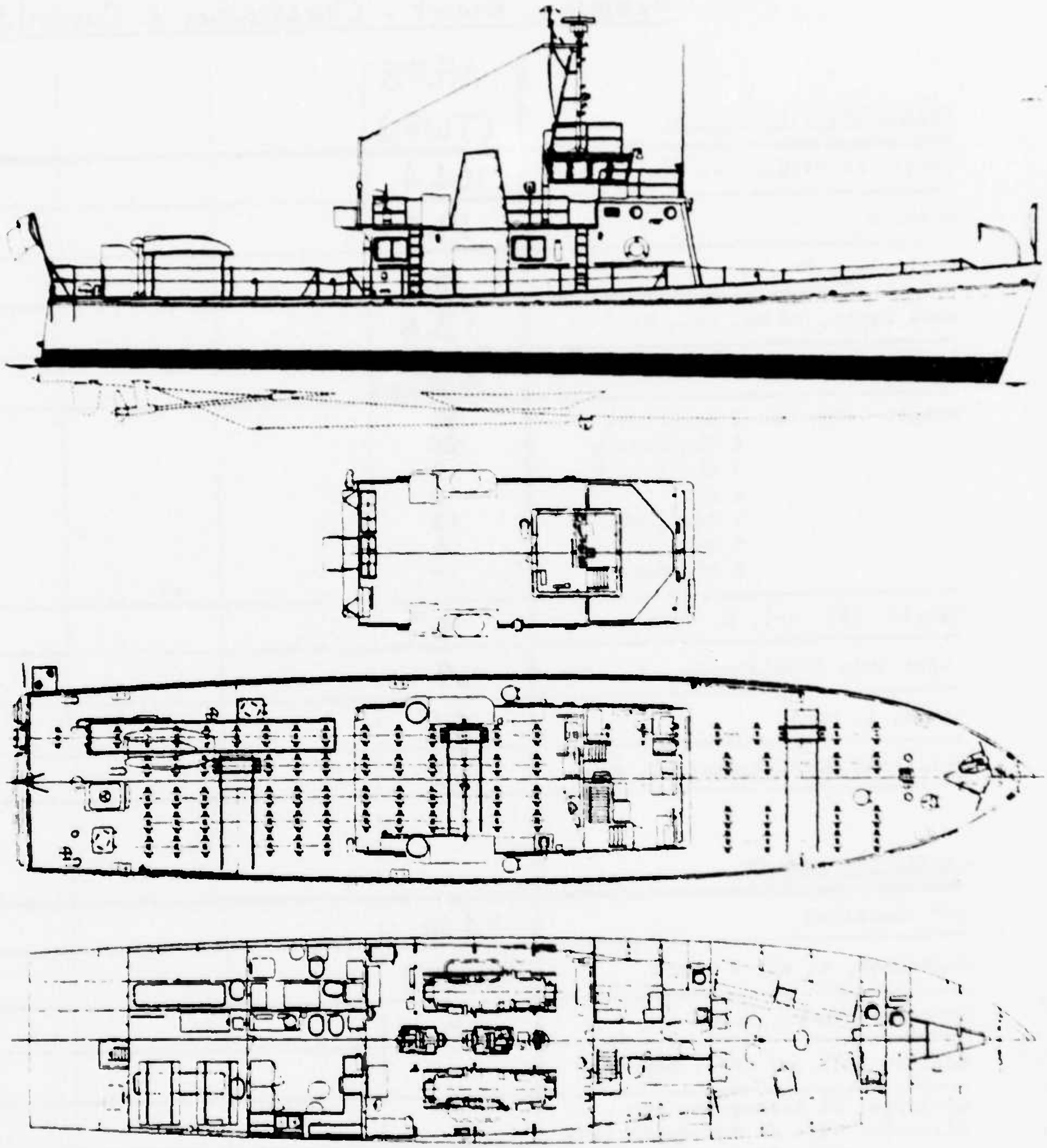


Figure 3-3 15-Knot Military Manned/Military Standards Submarine Escort

Table 3-3 15-Knot Military Manned/Military Standards Submarine Escort - Characteristics & Capabilities

CHARACTERISTICS SUMMARY	Alt. #3 (TWR)			
Length on Waterline, LWL, ft.	104.4			
Beam, B_x, ft.	19.7			
Draft, T_x, ft.	5.7			
Hull Depth, to Mn. Dk., ft.	13.6			
$C_p/C_x/C_{wp}$	0.586/0.737/0.814			
Weight Group No. 1 Structure 2 Propulsion 3 Electric P. 4 C&C 5 Aux. Sys. 6 O&F 7 Armament	53 20 3 8 13 8 —			
Margin, 10% 1-7, L. tons	4 *			
Light Ship Displacement, L. tons	109			
Loads, L. tons	54			
Full Load Displacement, L. tons	163			
CAPABILITY SUMMARY				
SHP Installed	2400			
Endurance, n. mi. @ knots	1900 @ 10			
Sustained Speed, knots	18			
Bollard Pull (w/ CRP), pounds	—			
Civilian: SR Accommodations Military: Off. SR Accommodations Off. BR Accommodations Crew BR, CPO/other enl.	— — — 3/12			
Manning Type	military			
Construction Standards	military			

* 4% based on TWR

b. The criteria for the auxiliary systems were that they should be comprised of reliable, off-the-shelf commercially available components of lightest weight.

c. The weapons, ammunition, and gunfire control equipment were removed. Equipment for submarine communication and tracking were added. As discussed in Section 3.2.3, sonar appendage drag has been assumed to be small in the speed and endurance estimates.

d. The electric generator need not be changed.

e. It is expected that the manning need not be changed.

f. It is assumed that the volume required for the guns and ammunition removed, is at least that required for the sonar equipment which was added.

g. Minor modifications would be required to the general arrangements.

The ship is described by Table 3-4, and Figures 3-5 and 3-6. Note that this total weight of the ship was reduced by 6 tons but then 5.3 tons (10% of weight groups 1 through 7) was added as a margin.

3.4 Submarine Escort Designs Summary

Due to the lack of adequate data on existing commercial vessels in the size range of interest for small submarine escorts, none of the commercial standards alternatives (Alternative 1, 2, and 4 in Table 2-1) could be selected. If the ASR/T-ASR design effort is continued in the future, a renewed effort should be made to obtain data, enabling final selection of commercial alternatives which should be documented as an Addendum to this report.

Military standards alternatives were selected for 15 knots and 30 knots, Alternatives 3 and 5, respectively. Baselines used for these alternatives were existing Navy designs, the 100-foot TWR and the CPIC-X. The characteristics and capabilities of Alternatives 3 and 5 are summarized in Table 3-5.

Table 3-4 30-kt. Military Manned/Military Standards

CHARACTERISTICS SUMMARY	AH. #5 (CPIC - X)			
Length on Waterline, LWL, ft.	90			
Beam, B_x, ft.	17.98			
Draft, T_x, ft.	3.75			
Hull Depth, to Mn. Dk., ft.	10.0			
$C_p/C_x/C_{wp}$	0.744/0.66/0.707			
Weight Group No. 1 Structure	20.7			
2 Propulsion	10.0			
3 Electric P.	5.3			
4 C&C	8.7			
5 Aux. Sys.	4.4			
6 O&F	4.1			
7 Armament	—			
Margin, 10% 1-7, L. tons	5.3			
Light Ship Displacement, L. tons	58.5			
Loads, L. tons	19.7			
Full Load Displacement, L. tons	78.2			
CAPABILITY SUMMARY				
SHP Installed, GT/Diesel	4000/370			
Endurance, n. mi. @ knots	2490 @ 8.5 313 @ 30+			
Sustained Speed, knots	30+			
Bollard Pull (w/ CRP), pounds	—			
Civilian: SR Accommodations	—			
Military: Off. SR Accommodations	1			
Off. BR Accommodations	—			
Crew BR, CPO/other enl.	2/8			
Manning Type	military			
Construction Standards	military			

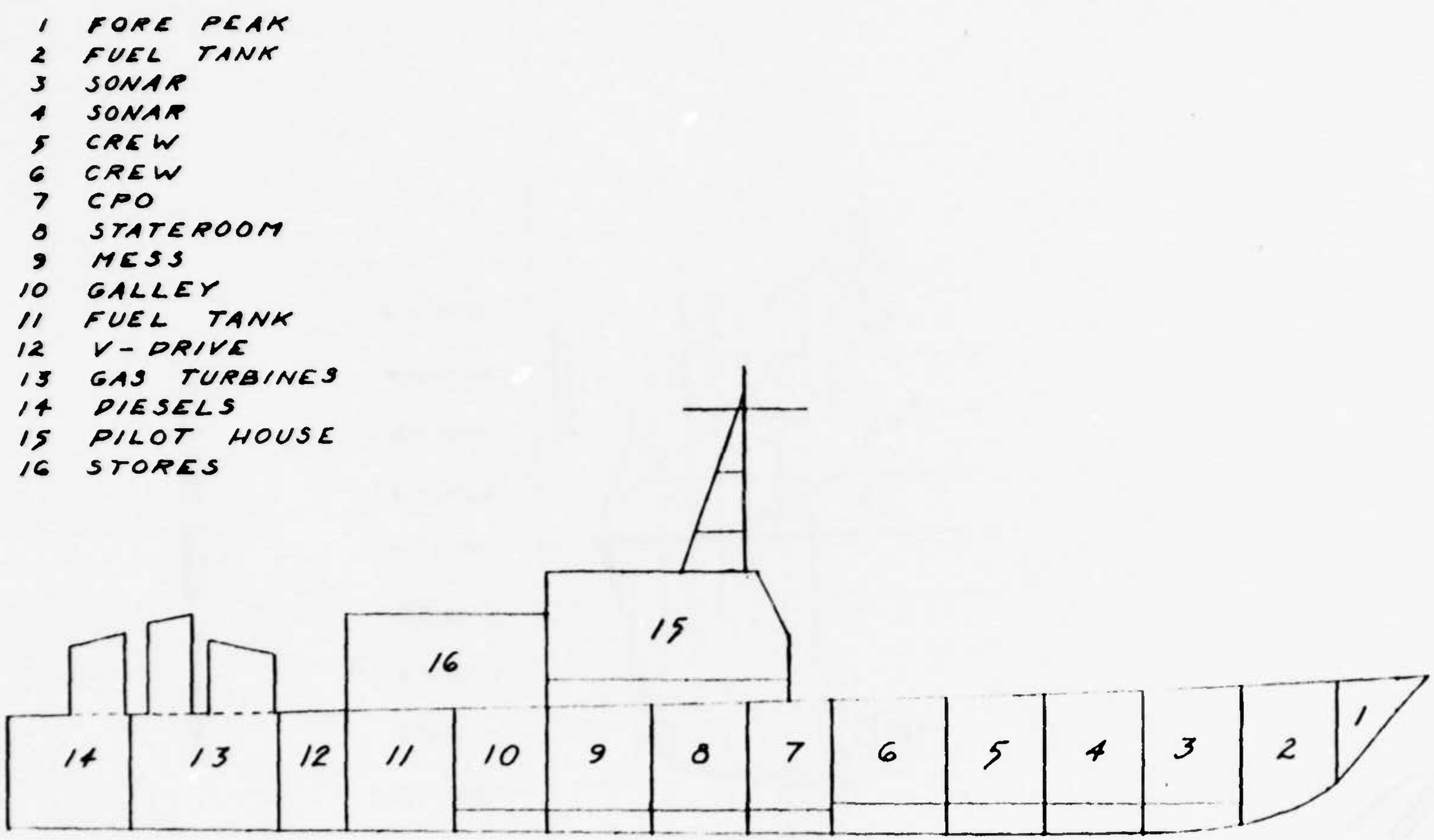


Figure 3-5 <u>CPIC-X Inboard Profile</u>

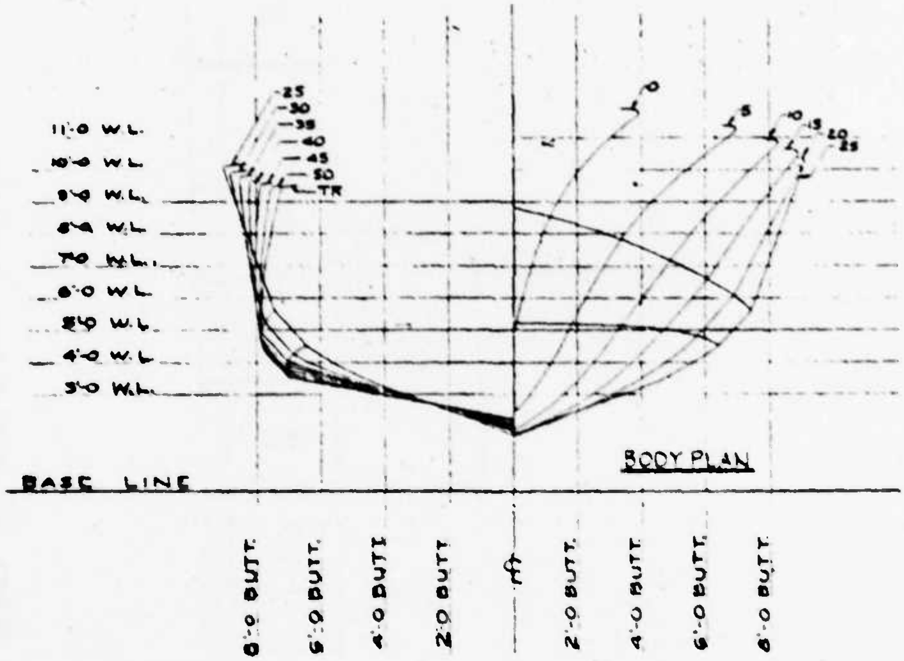


Figure 3-6 CPIC-X Body Plan

CHARACTERISTICS SUMMARY	Alt. #3 (TWR)		Alt. #5 (CPIC-X)	
Length on Waterline, LWL, ft.	104.4		90.0	
Beam, B_x, ft.	19.7		18.0	
Draft, T_x, ft.	5.7		3.75	
Hull Depth, to Mn. Dk., ft.	13.6			
$C_p/C_x/C_{wp}$	0.586/0.739/0.814		0.744/0.66/0.789	
Weight Group No. 1 Structure	53		20.7	
2 Propulsion	20		10.0	
3 Electric P.	3		5.3	
4 C&C	8		8.7	
5 Aux. Sys.	13		4.4	
6 O&F	8		4.1	
7 Armament	0		—	
Margin, 10% 1-7, L. tons	4 *		5.3	
Light Ship Displacement, L. tons	109		58.5	
Loads, L. tons	54		19.5	
Full Load Displacement, L. tons	163		78.2	
CAPABILITY SUMMARY				
SHP Installed	2400		4000 GT 370 Diesel	
Endurance, n. mi. @ knots	1900 @ 10		2490 @ 8.5	
Sustained Speed, knots	18		30 +	
Total Accommodations	15		10	
* 4% margin				

Table 3-5 Summary of Small Submarine Escorts

SECTION IV FULLY CAPABLE ASR

4.1 Design Approach

The design approach taken for determining ship size and characteristics for the fully capable ASR alternatives depended on whether commercial standards or military standards were assumed. The same procedure used for the smaller submarine escort types was used for commercial standards ASR, i.e. existing ships were selected to best fit the requirements. The military standards ASR's sizing was based on volume, weight, and stability requirements, using previous Navy designs as a data base for weights and volumes.

4.2 15-Knot ASR/T-ASR

The last three alternatives (Alternatives 6, 7, and 8) listed in Table 2-1, are ships that are to be designed with full submarine rescue and escort capability. The only differences between them are manning type and construction standards. Each will be discussed separately in this section; however, some features are common to all three alternatives. These common features are listed below with a brief discussion of each:

a. Configuration - each alternative must have a virtually clear deck aft to allow space for portable equipment associated with the SRC, submersibles, torpedoes, surface salvage, and air diving equipment. Wood decking will cover this area as required to prevent deck plating damage by movement of portable equipment, anchors, anchor chain, etc. The location of deck mounted tracks and tie-downs for SRC, other submersibles, and other gear will be determined in later design stages. Deck equipment arrangement will be as shown for the T-ASR in Figure 4-1 and Appendix D.

b. Traction winch - a traction winch located at the aft end of the superstructure will provide a towing capability for each alternative. Detail towing analysis has not been done, however submarine towing with the ASR/T-ASR should be no problem with installed shaft horsepower 4500 or greater. Drag on a TRIDENT submarine at 6 knots is estimated to be about 50,000 pounds which corresponds to approximately 2800 shaft horsepower. The traction winch will also be used in conjunction with the stern A-frame.

c. A-frame lift system - a stern mounted A-frame will be used to launch and retrieve the SRC and other submersibles and for torpedo retrieval. Hydraulic rams will raise and lower the A-frame which is hinged at the deck. The traction winch will be used to hoist items on the A-frame.

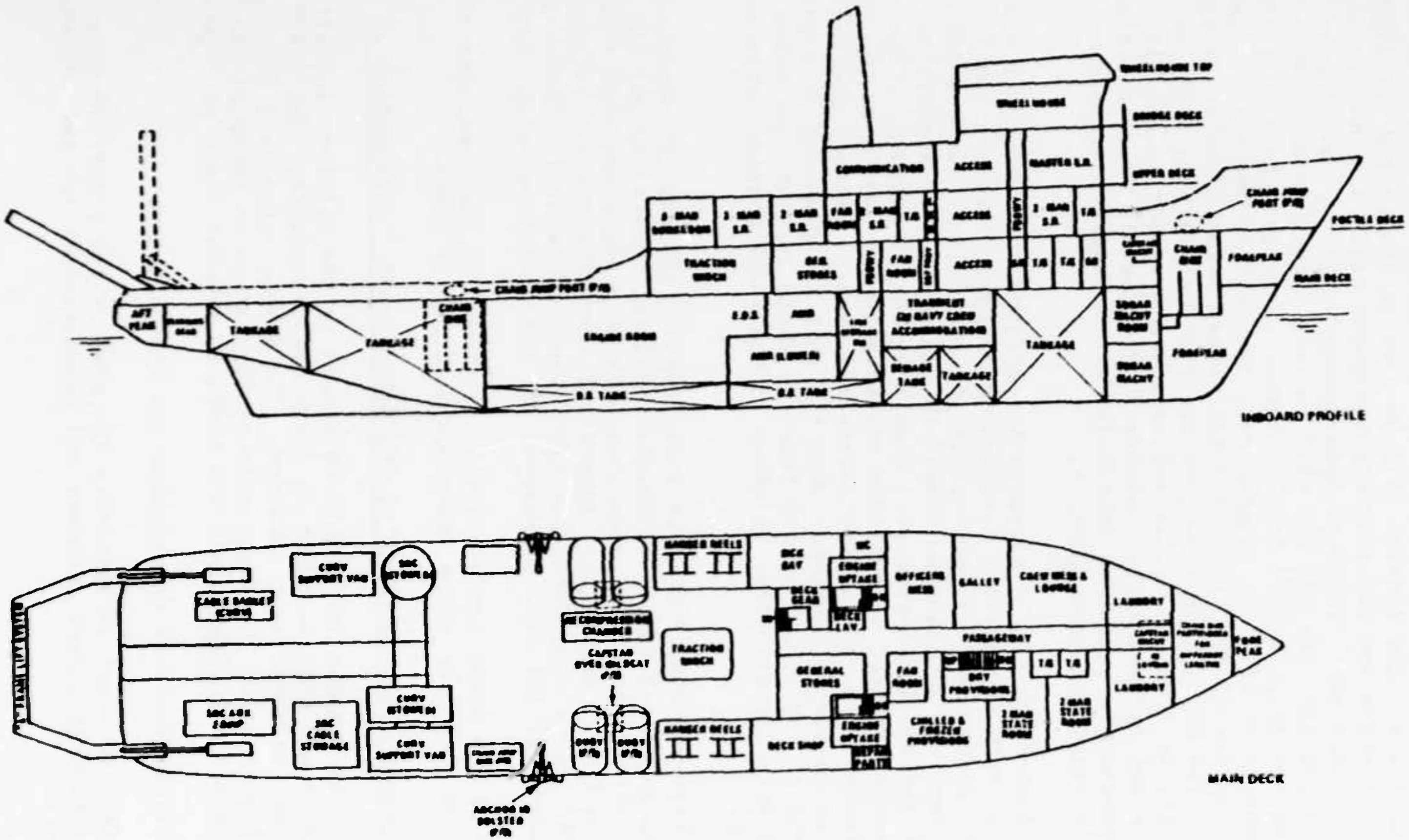


Figure 4-1 Civilian Manned/Commercial Standards (T-ASR)

d. Fly-away SRC - a new increased depth submarine rescue chamber fly-away kit is currently being developed, reference (3), for deployment by "ships of opportunity" in the vicinity of a submarine disaster. The fully capable ASR must be designed to accommodate this kit. As previously mentioned, the A-frame will be used to launch and retrieve the SRC over the stern and SRC portable equipment will be stowed on the open deck aft. Since most "ships of opportunity" will not have the required mooring capability, the SRC kit will include a four-point moor capable of mooring the ship in 2000 feet of water. This must be a very light weight moor to be air lift capable and, although it has not yet been designed, is envisioned to require additional ships to help lay and retrieve. The new ASR will be used for routine training with the SRC kit and will be required to lay and retrieve the moor relatively frequently and independently; therefore, the new ASR will be designed with a permanently installed four-point moor. Additional information on the SRC is contained in Appendix B.

e. Four-Point Moor - Appendix A describes the four-point moor and compares it with alternative positioning systems (also see Section 5.5). The fully capable ASR will be capable of independently laying and retrieving the four legs and positioning itself in the moor. The anchors and chains of the mooring system will double as ship's anchors. Capstans over wildcats are used to position the ship in the moor with the spring lines attached to buoys. The wildcats are used to recover the chain and anchors, or to lower the anchor when the ship is anchoring in a harbor. A schematic of the chain jumping from the chain lockers, and being recovered with the wildcats, is shown on the T-ASR drawing contained in Appendix D.

f. Fly-away *CURV III* - the fully capable ASR must be designed to handle and support a remote underwater vehicle (RUV) to attach the SRC downhaul cable to stricken submarines without or with non functional, damaged, or fouled downhauls. Appendix B describes the alternative RUV's; CURV III is considered the most likely to be used. Therefore, the fly-away CURV III will be assumed for the full load weight estimate.

Each of the fully capable ASR's, discussed in the remainder of this Section, have the above described features in common.

4.2.1 Civilian Manned/Commercial Standards T-ASR - Alternative 6

The fully capable T-ASR will be manned by the Military Sealift Command (MSC) and will be built to commercial standards. The T-ATF 166 Class was selected as a baseline. The double chine hull form is shown in Figure 4-2. The basic ship configuration is shown on the T-ASR drawing contained in Appendix D and shown at reduced scale in Figure 4-1.

Additional items of description are listed below:

a. The structure is virtually the same as the T-ATF 166 Class except for superstructure geometry and reinforcement for the A-frame foundation.

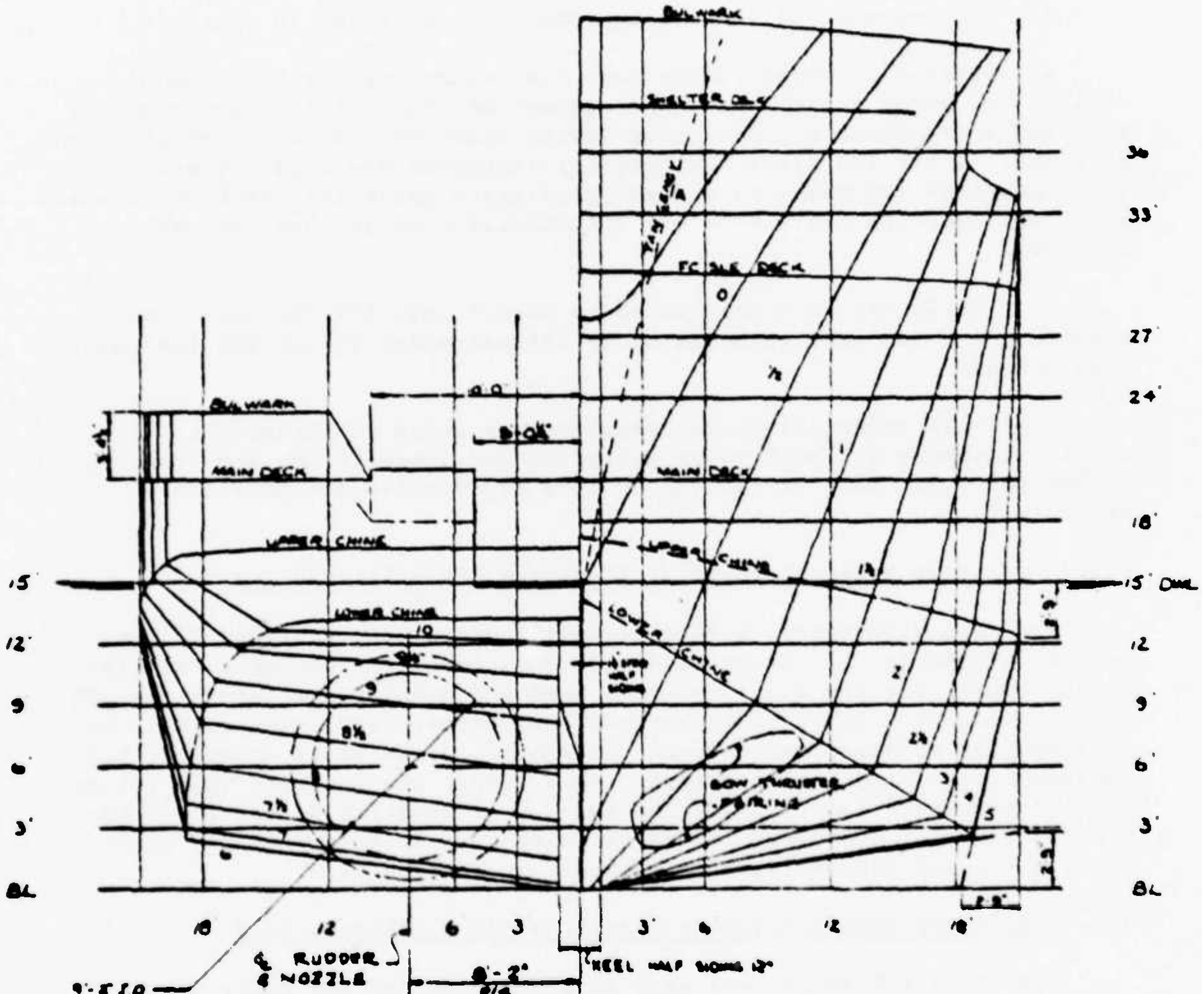


Figure 4-2 Typical Body Plan For T-ASR Based On OSB

b. Based on the speed-power curve in Figure 4.3 the propulsion plant has a total installed shaft horsepower of 6300 provided by two diesels each driving a separate shaft and CRP propeller. A schematic of the machinery arrangement is shown in Figure 4-4.

c. Electric power is provided by three 400 Kw diesel generators.

d. The command and control equipment is described in Appendix C.

e. Sixteen civilian staterooms, ten staterooms for the communications and sonar detachments, a transient military officer bunkroom for six, and a transient military crew living space for twenty-three will be provided. T-ATF 166 Class habitability standards are used. These accommodations are based on a manning estimate using the T-ATF 166 Class as a baseline, see Table 4-3. An accommodation margin has not been provided.

f. The GM has been calculated to be 4.1 feet for the full load condition and 3.5 feet with sea water ballast after 90% of the fuel has been burned.

The T-ASR principal characteristics are shown in Figure 4-1. A complete summary of T-ASR characteristics and capabilities are provided in Section 4.3. Some variations on this alternative are provided in Appendix E.

4.2.2 Military Manned/Commercial Standards ASR - Alternative 7

For this alternative a Navy crew will man a ship designed to commercial standards. It is assumed that structure and equipment, similar to the T-ASR (Section 4.2.1) will be used and manning similar to the ASR (Section 4.2.3). Since it is assumed that normal Navy practice will be followed for on-board maintenance; workshops, spare parts, manuals, test equipment, etc., must be provided. As a result the required ship volume for Alternative 7 is virtually the same as Alternative 8, therefore the profiles and basic configurations are similar. A summary of the characteristics and capabilities is provided in Section 4.3.

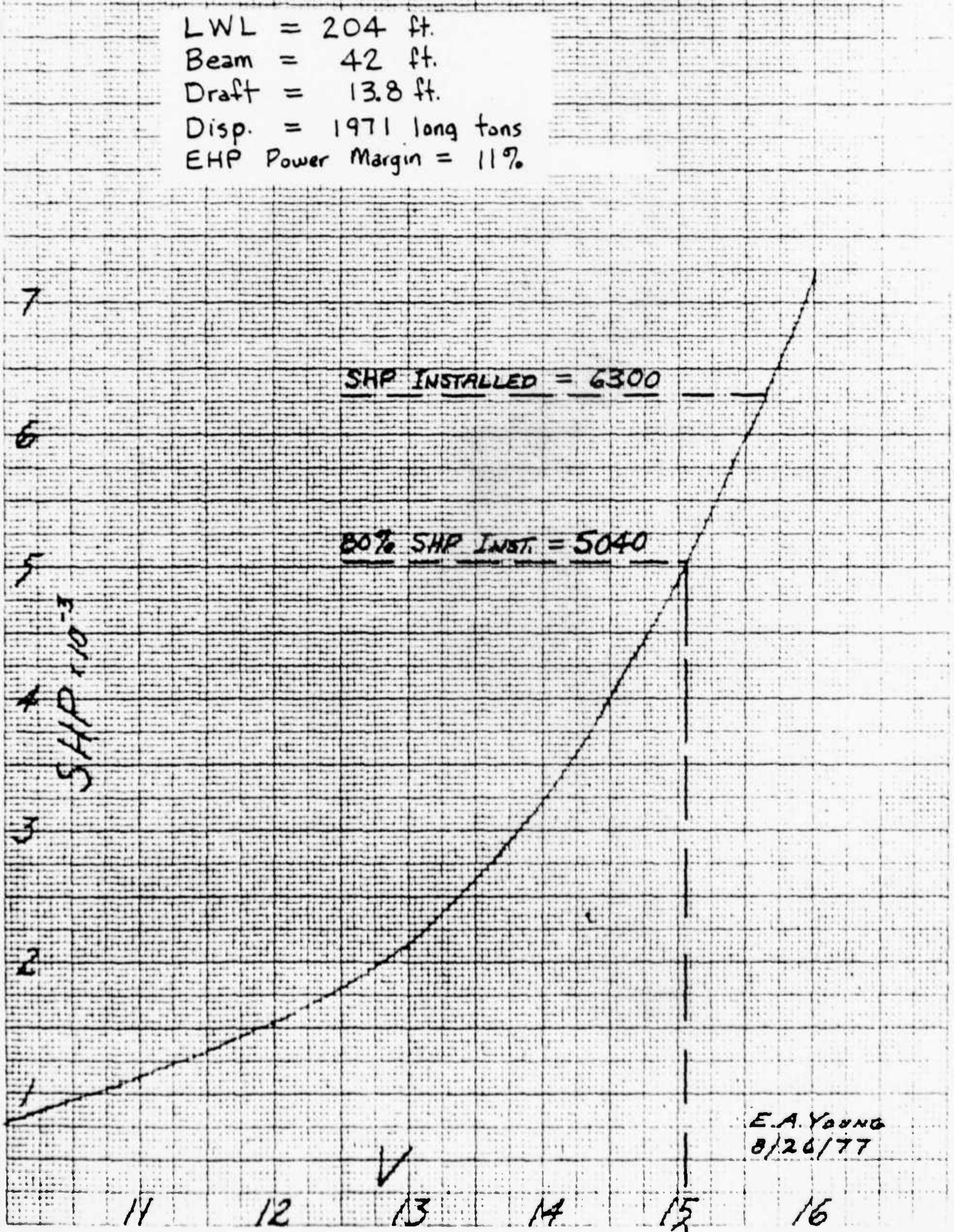
4.2.3 Military Manned/Military Standards ASR - Alternative 8

The FY 75 ATF design was used as a baseline for the fully capable ASR designed for military manning and military standards. The inboard profile and rounded bilge hull form are shown in Figures 4-5 and 4-6 respectively.

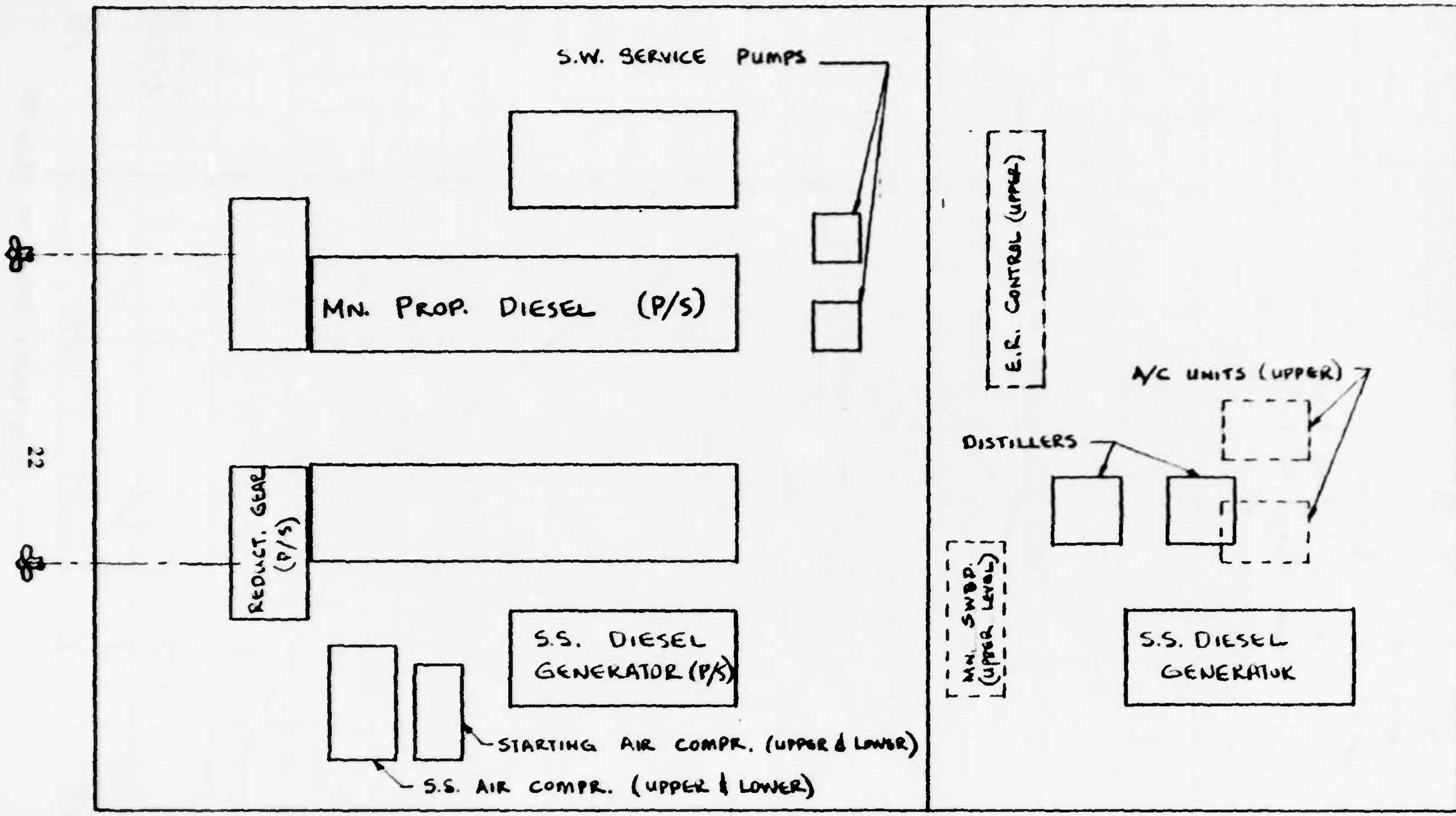
Additional items of description are listed below:

a. The structure will be similar to the FY 75 ATF.

FIGURE 4-3 T-ASR SPEED-POWER CURVE



SUSTAINED SPEED = 15.06 kts.



MAIN MACHINERY ROOM

AUXILIARY MACH'Y ROOM

FIGURE 4-4 T-ASR MACHINERY ARRANGEMENT

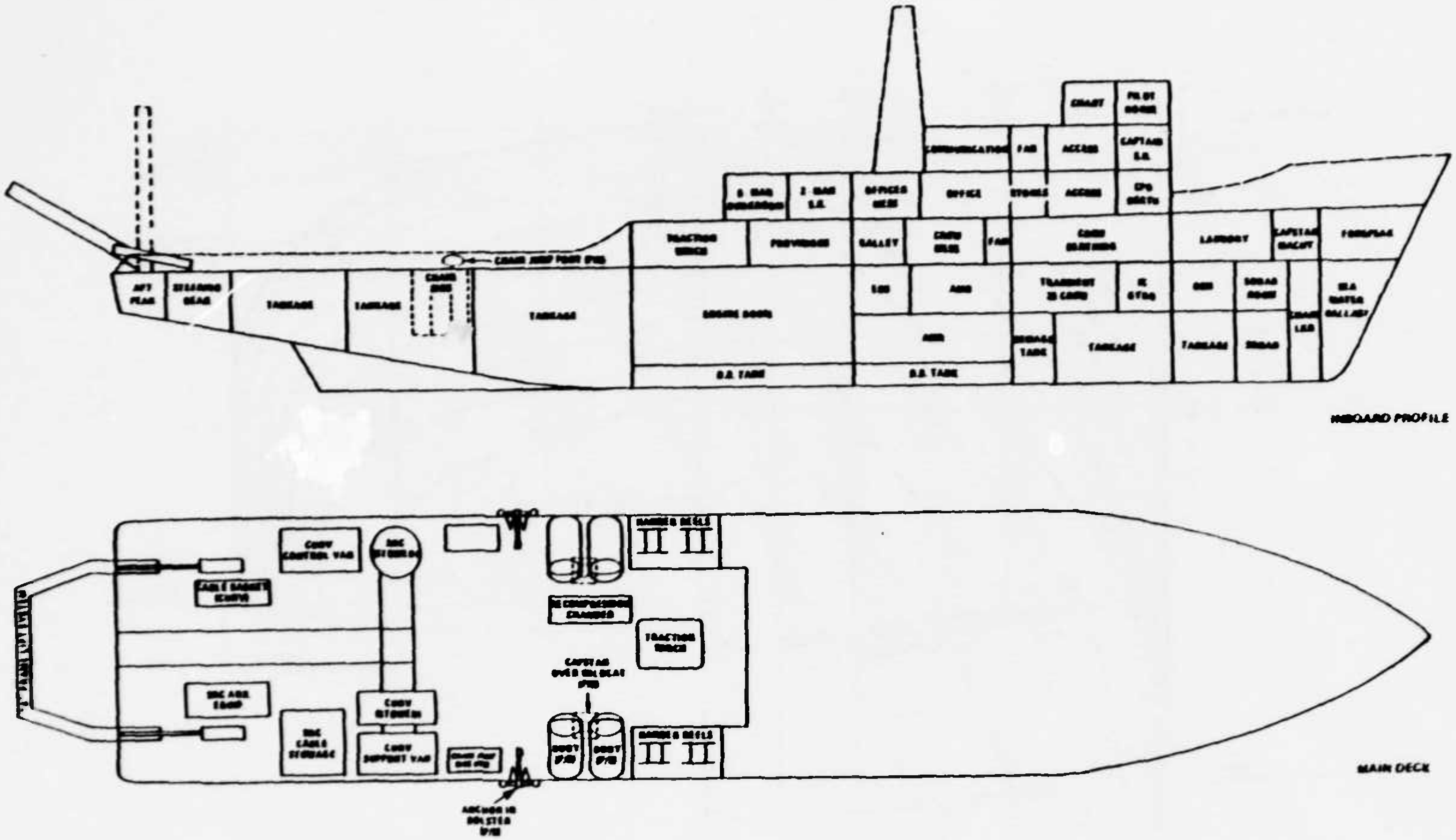


Figure 4-5 Military Manned/Military Standards (ASR)

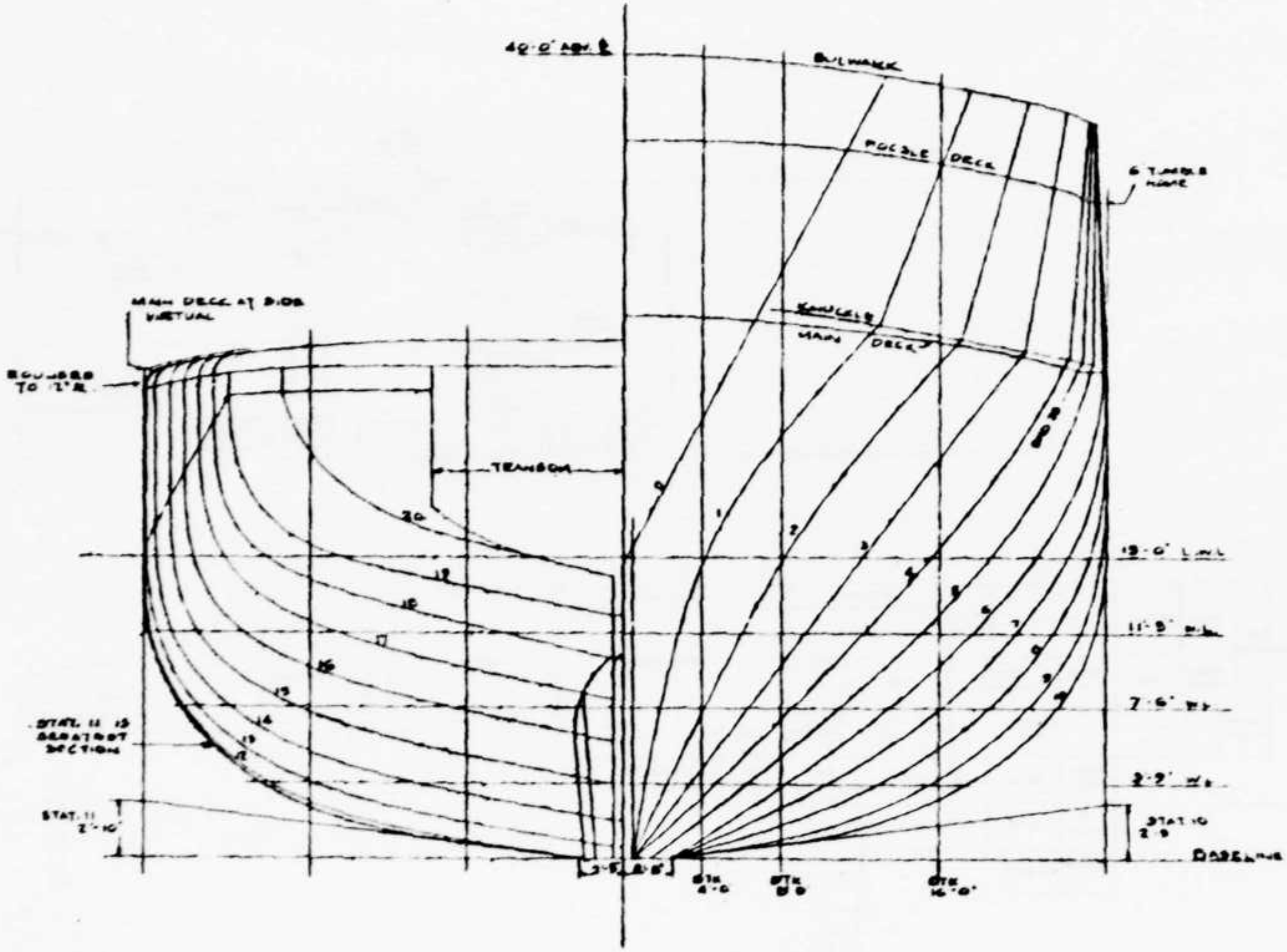


Figure 4-6 Typical Body Plan For ASR

b. Based on the speed-power curve in Figure 4-7 the propulsion plant has a total installed horsepower of 4500 provided by twin shaft and CRP propellers, driven by geared diesels. Figure 4-8 shows the machinery arrangement schematic. (The power difference between the T-ASR and the ASR is attributable to the different hull forms and dimensions; i.e., hard chine vs molded and high displacement/length ratio for the T-ASR).

c. Three 400 Kw diesel generators will provide ship service electric power.

d. The command and control equipments i.e., communications, navigation, etc., are discussed in Appendix C.

e. Accommodations for 12 officers, 3 CPO's and 70 other enlisted men will be provided assuming FY 75 ATF habitability standards. These accommodations are based on a manning estimate using the FY 75. ATF as a baseline, see Table 4-3. An accommodation margin has not been provided.

f. Although a stability analysis could not be performed at the feasibility study level of detail, the ship was proportioned from the FY 75 ATF, which meets the Navy two compartment standard. Clean ballast requirements for pollution abatement and its affect on stability must be considered in detail in Concept Design if this Alternative is selected.

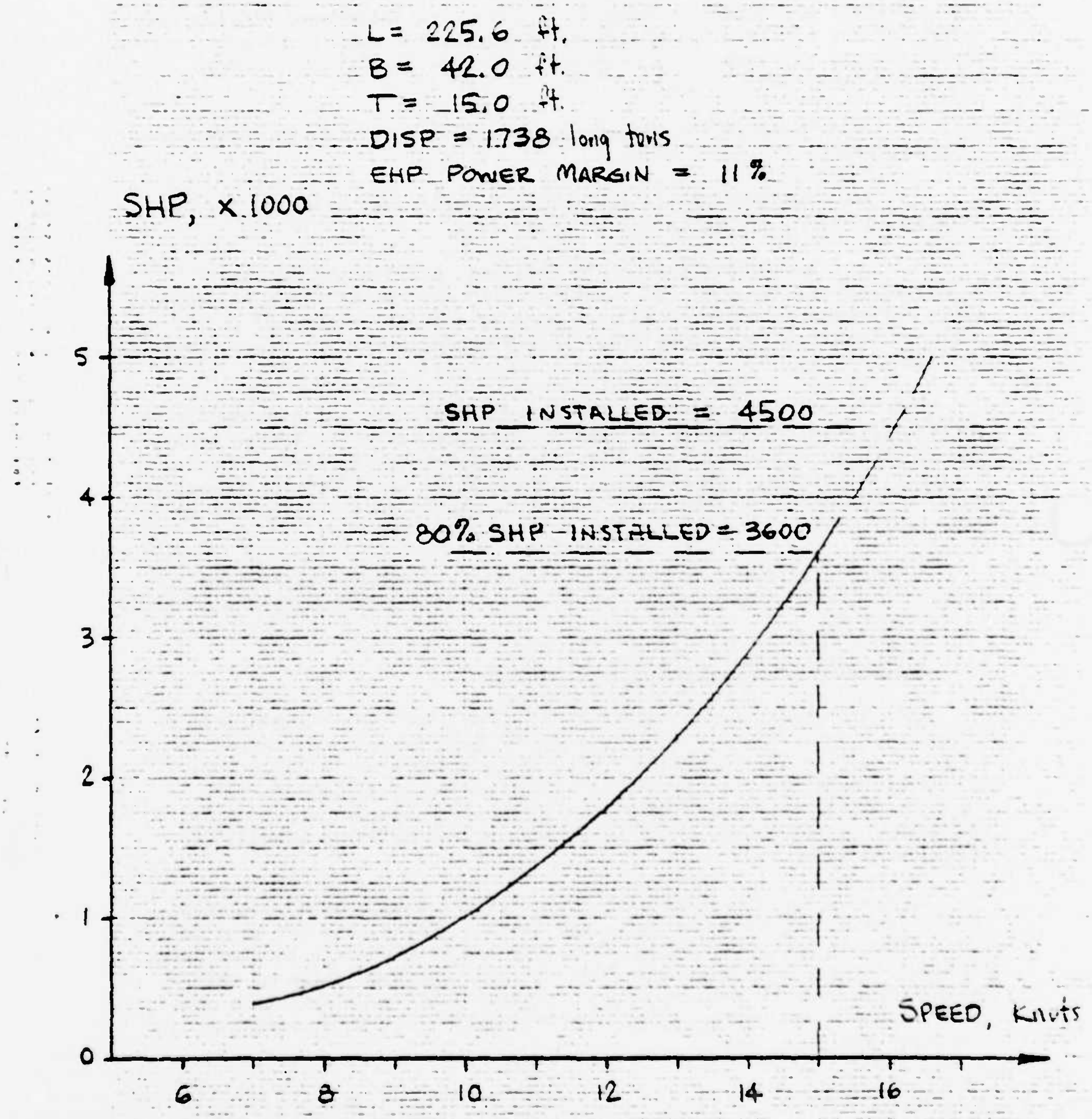
A complete summary of the ASR characteristics and capabilities are provided in Section 4.3. Some variations on this alternative are provided in Appendix E.

4.3 Fully Capable ASR/T-ASR Design Summary

The three alternatives considered in Section 4.2 are summarized in Table 4-1. Each of these alternatives has been selected as nearly as possible for the same payload. The loads are compared in Table 4-2. All have common features described at the beginning of Section 4.2. The only significant differences are in manning type and contruction standards. A comparison of civilian manning and military manning is provided in Table 4-3.

It should be emphasized that these designs have been accomplished to the feasibility study design stage level of detail and are good for Class "F" cost estimates only. Ship size and weights were ratioed from previous designs and it is anticipated that a Concept Design of the selected alternative will be done to confirm ship characteristics and capabilities based on more detail arrangements, hull form, weights, stability analysis, etc.

FIGURE 4-7 ASR SPEED-POWER CURVE



Granville Broome
9/28/77

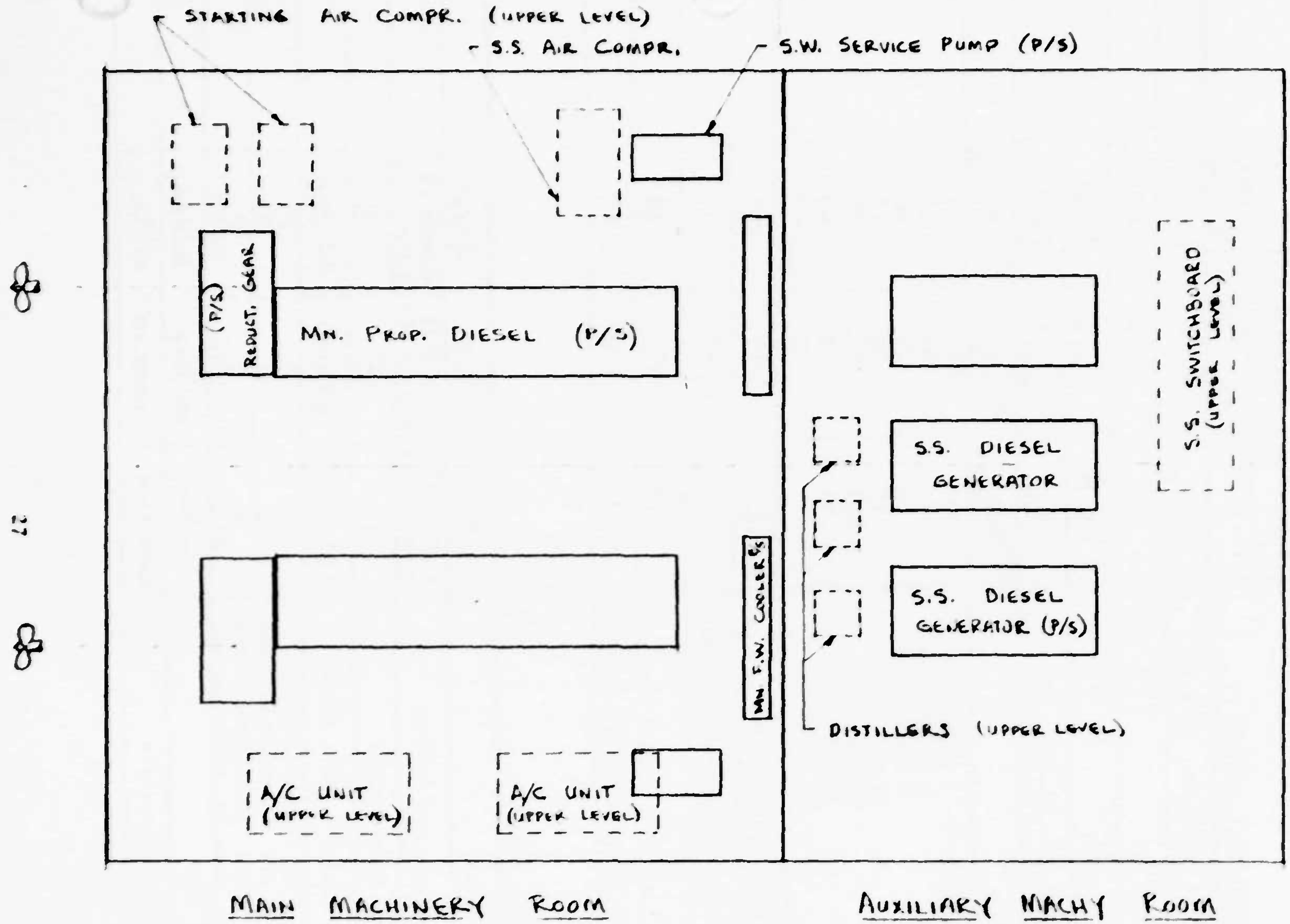


FIGURE 4-8 ASR MACHINERY ARRANGEMENT

Table 4-1 Summary of Fully Capable ASR/T-ASR

CHARACTERISTICS SUMMARY	Alt. #6 (T-ASR)	Alt. #7 (commercial std. ASR)	Alt. #8 (military std. ASR)
Length on Waterline, LWL, ft.	204	228	225.6
Beam, B_x, ft.	42	43	48
Draft, T_x, ft.	13.8	15.0	15.0
Hull Depth, to Mn. Dk., ft.	20	20.2	24.4
$C_p/C_x/C_{wp}$	0.687/[illegible]/0.869	0.54/0.85/0.85	0.54/0.86/0.85
Weight Group No. 1 Structure	777	799	761
2 Propulsion	131	91	153
3 Electric P.	32	28	60
4 C&C	11	12	13
5 Aux. Sys.	229	242	280
6 O&F	91	98	107
7 Armament	—	—	—
Margin, 10% 1-7, L. tons	127	127	137
Light Ship Displacement, L. tons	1398	1397	1511
Loads, L. tons	573	553	638
Full Load Displacement, L. tons	1971	1950	2149
CAPABILITY SUMMARY			
SHP Installed	6300	4200	4500
Endurance, n. mi. @ knots	10,000 @ 13 (5,350 @ 15)	10,000 @ 13 (8,260 @ 15)	10,000 @ 13 (8,470 @ 15)
Sustained Speed, knots	15	15	15
Bollard Pull (w/ CRP), pounds	114,000	87,000	99,000
Civilian: SR Accommodations	16	0	0
Military: Off. SR Accommodations	10	12	12
Off. BR Accommodations	6	0	0
Crew BR, CPO/other enl.	0/23	3/70	3/70
Manning Type	civilian	military	military
Construction Standards	commercial	commercial	military

Table 4-2 Comparison of Loads

ACCT. NO.	DESCRIPTION	WEIGHT (Tons)	Alt. #6 (T-ASR)	Alt. #7 (commercial std. ASR)	Alt. #8 (military std. ASR)
10	Ships Force, Amphibious Force, Troops and Passengers		8.4	9.1	9.1
11	Ships Officers			1.1	1.1
12	Ships Noncommissioned Officers			0.5	0.5
13	Ships Enlisted Men			4.8	4.8
14	Marines				
15	Troops				
16	Other Personnel			2.7	2.7
20	Ordnance & Ordnance Delivery Systems		—	—	—
21	Ship Ammunition *(For use by ship on which stowed)*				
22	Ordnance Delivery Systems Ammunition				
23	Ordnance Delivery Systems				
24	Ordnance Repair Parts *(Ship Ammo)*				
25	Ordnance Repair Parts *(Ordnance Delivery Systems Ammo)*				
26	Ordnance Delivery Systems Support Equipment				
27	Miscellaneous Ordnance and Pyrotechnics				
30	Stores				
31	Provisions & Personnel Stores		19.2	10.7	10.7
32	General Stores		14.4	14.5	16.6
33	Marines Stores *(For ship's complement)*				
34	Special Stores				1.0
40	Liquids, Petroleum Base				
41	Diesel Oil		478.0	450.0	549.0
42	JP-5				
43	Gasoline				
44	Distillate Fuel				
45	Navy Standard Fuel Oil (NSFO)				
46	Lubricating Oil		10.0	24.5	7.2
47	Fog Oil				
50	Liquids, Non Petroleum Base				
51	Sea Water				
52	Fresh Water		16.8	18.9	18.9
53	Reserve Feed Water				
54	Hydraulic Fluid				
55	Sanitary Tank Liquid				
59	Miscellaneous Liquids, Non Petroleum Base				
60	Cargo		25.8	25.8	25.8
61	Cargo, Ordnance				
62	Cargo, Stores				
63	Cargo, Liquid *(Petroleum Base)*				
64	Cargo, Liquid *(Non Petroleum Base)*				
65	Cargo, Cryogenic				
66	Cargo, Amphibious Assault Systems				
69	Cargo, Miscellaneous				
	TOTAL, LOADS, tons		572.6	553.5	638.3

Shipboard Function	Number of People						
	T-ASR				ASR		
	Single state-room	Double state-room	Officer bunk-room	Crew bunk-room	Officers	CPO	Other Enlisted
Ship Operators, civilian*	4	12					
Ship Operators, military**					6	3	37
Navy Comm. Team, permanent		4					4
Navy Sonar Team, permanent		6					6
SRC Team, transient			3	18	3		18
CURV Team, transient			3	5	3		5
Total	4	22	6	23	12	3	70
	55				85		

* from T-ATF 166 Class manning estimate

** from FY 75 ATF manning estimate

Table 4-3 Civilian and Military Manning Comparison

SECTION V SPECIAL STUDIES

5.1 SRC Centerwell Impact

Centerwell operations of the SRC have been evaluated and reported in reference (5). Substantial modifications to the SRC would be required: 1) A rapid ballast/deballast system capable of making the SRC negatively bouyant; 2) a protective framework must be attached to the SRC to allow it to mate with, and lift a well-guide carriage.

The proposed operating procedure would be as follows:

a. The SRC operating normally would have the backhaul cable slack and be positively bouyant as it approaches the surface/ship.

b. When the SRC is within 200 feet of the surface/ship, ballast is taken on until the SRC becomes negatively bouyant, thus slacking the downhaul cable and plumbing itself on the backhaul cable directly beneath the ship centerwell.

c. The backhaul cable is used to haul in the SRC as the downhaul cable is kept slack.

d. As the protective framework on the SRC mates with the ship centerwell guide carriage, carriage locks are mechanically disengaged, allowing the carriage to be lifted with the SRC, as sea water ballast is blown.

e. The guide carriage keeps the SRC centered in the well as it is raised through the well and into the well house above the well.

f. The well door(s) are closed and the SRC/carriage lowered onto the door(s). The procedure is reversed for launching the SRC through the centerwell.

The dimensions recommended in reference (5) for SRC centerwell handling spaces are shown in Figure 5-1. They have been superimposed simply to show the size of the recommended centerwell and wellhouse relative to the ASR described in Section 4.2.3, which was sized assuming SRC launch and recovery over the stern.

The addition of a 15' x 15' centerwell, a 30' x 30' well house, and SRC handling machinery would require enlargement of the ASR hull and superstructure shown in Figure 4-5. This could be accomplished by an eight to twelve foot increase in length and a one to two foot increase in beam. The volume increase would be accompanied by a full load displacement increase of approximately 400 tons. Additional work is required to accurately quantify the obviously significant impact on ship volume, weight, and arrangements.

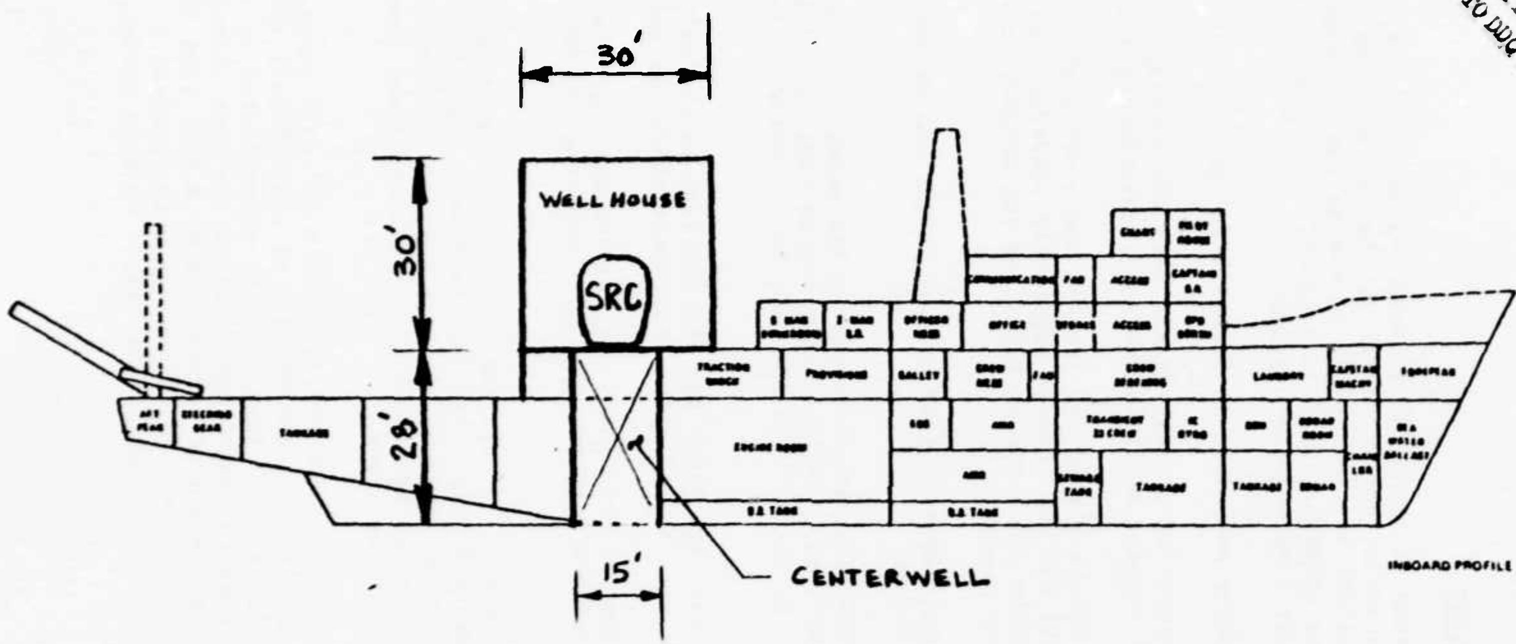


Figure 5-1 Military Manned/Military Standards ASR with SRC Centerwell and Wellhouse Superimposed

Most ships of opportunity will launch and recover the SRC over the side and will not have specially designed SRC centerwells. Training exercises for the SRC detachment will typically be conducted on the ASR and should be over-the-side. Therefore even if the ASR had SRC centerwell handling, over-the-side and/or over-the-stern handling would also be needed for taining.

In summary, SRC centerwell handling, although feasible, requires substantial modifications to the SRC and would result in a significantly larger ship than one having over-the-stern handling.

5.2 Deep-Water RUWS Impact

The impact of back fitting the deep water Remote Unmanned Work System (RUWS) has been investigated, refer to Appendices B and E. It was assumed that the Baseline ASR, described in Section 4.2.3, would be converted to support the deep-water RUWS. This would involve removing all portable equipment associated with SRC and CURV plus the stern mounted A-frame and perhaps the four-point moor components and traction winch. The two configurations considered are summarized in Table 5-1. Note that for each configuration items were removed from the baseline ASR and the special deep-water RUWS crane and portable equipment were installed. The configuration with minimum removals is depicted in Figure 5-2.

Back fitting the deep-water RUWS on the baseline ASR appears to be feasible with minimal impact on the ship, however, stationkeeping may be a problem. The baseline ship does not have a bow thruster, since it is not absolutely necessitated by the stated requirements. The Test and Evaluation Master Plan for RUWS, reference (6), states that the support ship must be capable of remaining within a circle diameter of approximately 1000 feet. The associated wind, sea state, and current were not specified. Stationkeeping requirements and capabilities should be considered in more detail in later design stages.

5.3 Bollard Pull Impact

The impact of bollard pull, specifically 120,000 pounds, has been investigated. The ASR described in Section 4.2.3 was used as a baseline for studying the effects on bollard pull of various propellers and changes in installed shaft horsepower (SHPI).

Bollard estimates for this study are summarized in Table 5-1. Any of the first five variations would not invalidate feasibility of the ASR described in Section 4.2.3. A cost difference due to different equipment cost would result from fixed pitch vs controllable reversing pitch (CRP) propellers and single-speed vs two-speed gear boxes (note that the Navy does not have any first hand information on the reliablity, controls, weights, and size of two-speed gear boxes). Variations with nozzles (nos. 6 and 7) have not been evaluated in detail and may result in

Configuration	Removals	Full Load Displacement Change	Full Load Draft Change	Sustained Speed Change
		Long tons	feet	knots
Minimun removals	SRC CURV A-frame	+22	+0.08	less than 0.1 decrease
Maximum removals	SRC CURV A-frame 4-point moor Traction winch	-48	-0.18	approximately 0.1 increase

Table 5-1 Summary of Deep-Water RUWS Impact on the Baseline ASR

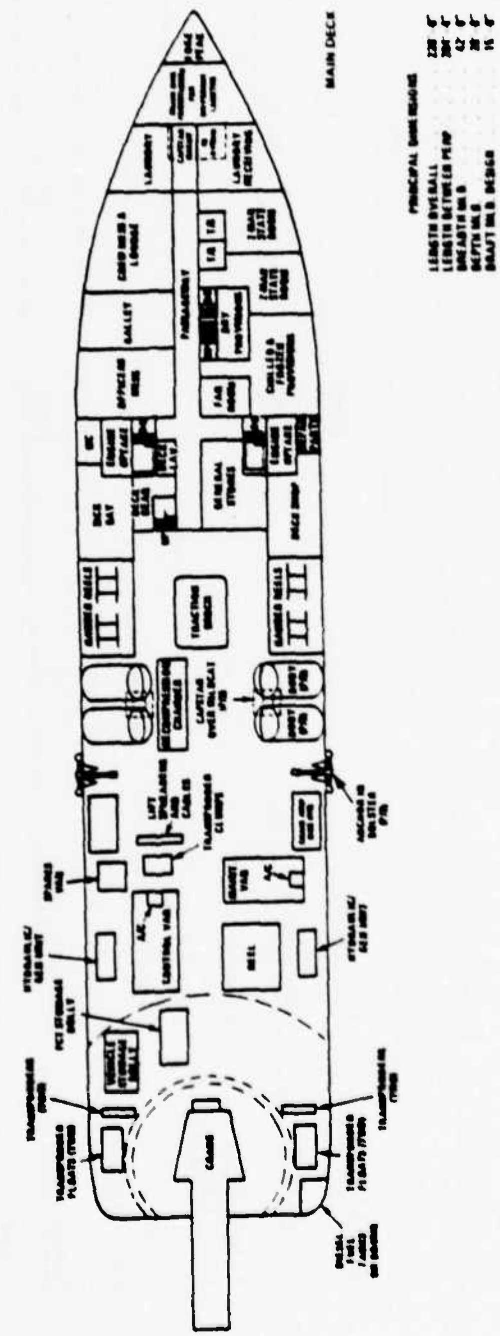


Figure 5-2 ASR Converted for Deep-Water RUWS Support

No.	Propeller	Gearbox	Propeller * Design Speed (knots)	Installed SHP	Sustained Speed (knots)	Bollard (pounds)
1	Controllable Reversing Pitch (CRP)	single speed	all speeds	4500	15.7	99,000
2	Fixed Pitch	single speed	15	4500	15.8	69,000
3	Fixed Pitch	single speed	0	4500	15.2	74,000
4	Fixed Pitch	two speed	15	4500	15.8	88,000
5	Fixed Pitch	two speed	0	4500	15.2	99,000
6	Fixed Pitch with nozzle	single speed	0	4500	-	105,000**
7	CRP with nozzle	single speed	all speeds	4500	-	135,000**
8	Fixed Pitch	single speed	0	7425	15 +	120,000
9	CRP	single speed	all speeds	6075	16.5	120,000

* this is the speed at which the propeller is designed to be most efficient.
** rough estimate.

Table 5-2 Summary of Bollard Estimates

decreased sustained speed and endurance due to added drag. The last two variations (nos. 8 and 9) may also be infeasible within the bounds of ship size and weight of the ASR described in Section 4.2.3. These last two are presented to demonstrate the increase in SHPI (for the ASR described in Section 4.2.3.) required to provide 120,000 pounds of bollard with fixed pitch and CRP, both without nozzles (nos. 8 and 9 respectively). For example, the machinery box sized for 4500 SHPI probably is not large enough for a 7425 SHPI plant.

In summary, the ASR described in Section 4.2.3 (assumed CRP) provides 99,000 pounds bollard inherently. The towing capability is adequate since the shaft horsepower required to tow TRIDENT at 6 knots (towline pull of approximately 50,000 pounds) is estimated to be approximately 2800 and should be no problem for the 4500 SHPI plant.

Nozzles or increased SHPI will be required to attain 120,000 pounds bollard and will result in an increase in ship size. This appears unwarranted unless surface salvage is an overriding consideration.

5.4 Ship Noise Evaluation

Submarine trial escort is envisioned as the primary mission for these ASR's. Because of this and because of ships' own radiated noise interference with underwater communication and tracking system (WQC-2) experienced on other ASR's, it was considered essential to examine the compatibility of existing underwater communication and tracking equipment with these conceptual ASR's. These preliminary studies have been completed, (reference (4)). In essence the findings indicate that assuming a T-ASR design derived from an offshore supply boat, with no special noise control treatments other than a well designed propeller, the maximum range of acceptable communication will be less than 10,000 yards at speeds above 8 knots.

It is recommended that the WQC-2 system and tracking system, and ship self-noise be investigated on a cost and performance basis including:

a. Conventional noise control such as machinery isolation and a Prairie-Masker system;

b. WQC-2 system treatments such as baffling, decoupling coatings, and beam forming.

Reductions in self-noise on a conventional geared diesel propulsion offshore supply boat of 15 to 25 dB will be required to achieve the desired WQC-2 performance.

It is recommanded that a ship comparable to the ship type selected for ASR/T-ASR be used as a test platform to demonstrate WQC-2 performance required, including development of required hydrophone installation details. This effort should be initiated during the concept design stage.

5.5 Alternative Positioning Systems Evaluation

Alternative positioning systems have been evaluated for the Baseline ASR and are discussed in detail in Appendix A. Based on this evaluation the selection of the positioning system for the ASR reduces to a choice between a four-point moor or a dynamic positioning system. The ship sizes for these alternatives, as previously mentioned are not significantly different; therefore, the choice should be made based on a comparison of capability, cost, reliability, and other considerations.

Dynamic positioning is virtually independent of water depth and can be used for other missions where DSV's are being used in deep water. There are disadvantages, such as thruster wash interference with submersible launch/retrieval and tethered cables; and propeller noise interference with underwater communications during operations. There will probably be some small excursions of the ship with dynamic positioning, however these are difficult to estimate, but should not exceed approximately 10 percent of the water depth.

The following recommendations are made concerning the ASR positioning system:

(1) Equipment costs of a four-point moor and dynamic positioning systems should be estimated based on Appendix A.

(2) Trade-off studies considering capability, cost, reliability, etc., should be done to select between a four-point moor and dynamic positioning.

(3) If dynamic positioning is selected, a trade-off study should be done to determine the best dynamic positioning system.

(4) Pending action on the above recommendations, a permanently installed four-point moor (as described in Appendix A) should be assumed for the ASR/T-ASR (the ship should be capable of independently laying and retrieving the moor).

5.6 Alternative Hull forms Evaluation

Many advanced hull concepts could be considered for this mission. SWATH (small waterplane area twin hull) and hydrofoil offer some potential. Schedule and cost constraints precluded considerations of these alternatives at this time.

SECTION VI FEASIBILITY STUDY SUMMARY

The intent of this study was to provide a description of feasible ship alternatives that can be compared to demonstrate the effects that capability, manning type, and construction standards have on ship characteristics and cost. Alternatives that were considered are defined by Table 2-1 and a summary of the characteristics and capabilities of these alternatives are contained in Tables 6-1, 6-2, and 6-3.

Table 6-1 Summary of 15-knot Submarine Escorts

CHARACTERISTICS SUMMARY	Alt. #1	Alt. #2	Alt. #3 (TWR)	
Length on Waterline, LWL, ft.	(commercial data required was not available)	(commercial data required was not available)	104.4	
Beam, B_x, ft.			19.7	
Draft, T_x, ft.			5.7	
Hull Depth, to Mn. Dk., ft.			13.6	
$C_p/C_x/C_{wp}$			0.586/0.737/0.814	
Weight Group No. 1 Structure			53	
2 Propulsion			20	
3 Electric P.			3	
4 C&C			8	
5 Aux. Sys.			13	
6 O&F			8	
7 Armament			—	
Margin, 10% 1-7, L. tons			4 *	
Light Ship Displacement, L. tons			109	
Loads, L. tons			54	
Full Load Displacement, L. tons			163	
CAPABILITY SUMMARY				
SHP Installed			2400	
Endurance, n. mi. @ knots			1900@10	
Sustained Speed, knots			18	
Bollard Pull (w/ CRP), pounds			—	
Civilian: SR Accommodations			—	
Military: Off. SR Accommodations			—	
Off. BR Accommodations			—	
Crew BR, CPO/other enl.			3/12	
Manning Type	civilian	military	military	
Construction Standards	commercial	commercial	military	

* 4% margin based on TWR

Table 6-2 Summary of 30-knot Submarine Escorts

CHARACTERISTICS SUMMARY	Alt. #4	Alt. #5 (CPIC - X)		
Length on Waterline, LWL, ft.		90.0		
Beam, B_x, ft.	(commercial data required was not available)	17.98		
Draft, T_x, ft.		3.75		
Hull Depth, to Mn. Dk., ft.		10.0		
$C_p/C_x/C_{wp}$		0.744/0.66/0.787		
Weight Group No. 1 Structure		20.7		
2 Propulsion		10.0		
3 Electric P.		5.3		
4 C&C		8.7		
5 Aux. Sys.		4.4		
6 O&F		4.1		
7 Armament		—		
Margin, 10% 1-7, L. tons		5.3		
Light Ship Displacement, L. tons		58.5		
Loads, L. tons		19.7		
Full Load Displacement, L. tons		78.2		
CAPABILITY SUMMARY				
SHP Installed		4000		
Endurance, n. mi. @ knots		2490 @ 8.5 313 @ 30+		
Sustained Speed, knots		30+		
Bollard Pull (w/ CRP), pounds		—		
Civilian: SR Accommodations		—		
Military: Off. SR Accommodations		1		
Off. BR Accommodations		—		
Crew BR, CPO/other enl.		2/8		
Manning Type	civilian	military		
Construction Standards	commercial	military		

Table 6-3 Summary of Fully Capable ASR/T-AS[illegible]

CHARACTERISTICS SUMMARY	Alt. #6 (T-ASR)	Alt. #7 (commercial std. ASR)	Alt. #8 (military std. ASR)
Length on Waterline, LWL, ft.	204	228	225.6
Beam, B_x, ft.	42	43	48
Draft, T_x, ft.	13.8	15.0	15.0
Hull Depth, to Mn. Dk., ft.	20	20.2	24.4
$C_p/C_x/C_{wp}$	0.687/0.88/0.869	0.54/0.85/0.85	0.54/0.85/0.85
Weight Group No. 1 Structure	777	799	761
2 Propulsion	131	91	153
3 Electric P.	32	28	60
4 C&C	11	12	13
5 Aux. Sys.	229	242	280
6 O&F	91	98	107
7 Armament	—	—	—
Margin, 10% 1-7, L. tons	127	127	137
Light Ship Displacement, L. tons	1398	1397	1511
Loads, L. tons	573	553	638
Full Load Displacement, L. tons	1971	1950	2149

CAPABILITY SUMMARY			
SHP Installed	6300	4200	4500
Endurance, n. mi. @ knots	10,000 @ 13 (5,350 @ 15)	10,000 @ 13 (8,260 @ 15)	10,000 @ 13 (8,470 @ 15)
Sustained Speed, knots	15	15	15
Bollard Pull (w/ CRP), pounds	114,000	87,000	99,000
Civilian: SR Accommodations	16	0	0
Military: Off. SR Accommodations	10	12	12
Off. BR Accommodations	6	0	0
Crew BR, CPO/other enl.	0/23	3/70	3/70
Manning Type	civilian	military	military
Construction Standards	commercial	commercial	military

VII CONCLUSIONS AND RECOMMENTATIONS

Listed below are the major conclusions reached from this study and the associated recommendations:

a. The alternatives that are provided in this report demonstrate the effects of capability, manning type, and construction standards. Recommendation: When costs estimates for the alternatives are obtained they should be provided to NAVSEC so that they can be made an Addendum to this report.

b. Due to the lack of adequate data on some existing commercial vessels, commercial versus military construction standards could not be compared directly for small submarine escorts. Recommendation: If the small submarine escort concept is selected, adequate data for commercial vessels of appropriate size should be obtained such that commercial and military standards can be compared for this specific size vessel.

c. SRC centerwell handling, although feasible, requires significant modifications to the SRC and would result in a significantly larger ship than one having over-the-stern handling. The merits of the centerwell for a "ship of opportunity" for the "fly-away SRC" are questionable. Recommendation: SRC over-the-stern handling is recommended instead of centerwell handling.

d. Back fitting the deep-water RUWS on the baseline ASR appears to be feasible. Recommendation: If this alternative is selected, stationkeeping requirements and capabilities should be considered in more detail in later design stages.

e. The baseline ASR with controllable pitch propellers inherently has approximately 99,000 pounds bollard pull. Propellers with nozzles or increased installed shaft horsepower will be required to achieve 120,000 pounds bollard pull. Recommendation: It is recommended that the installed shaft horsepower and the propeller design be based on the sustained speed requirement instead of a bollard pull requirement.

f. A reduction in self noise of 15 to 25 dB will be required to achieve the desired underwater communication and tracking performance with the WQC-2 on a conventional geared diesel off shore supply boat (like the one selected for T-ASR). Recommendation: It is recommended that the following be initiated during the Concept Design stage to determine that the degree of self noise reduction cited above can be achieved:

(1) An investigation of conventional noise control such as machinery isolation and Prairie Masker.

(2) An investigation of possible WQC-2 system treatments such as baffling, decoupling coatings, and beam forming.

(3) A test program to evaluate possible noise abatement treatments i.e., install the WQC-2 on a ship comparable to the type selected for ASR/T-ASR.

g. The positioning system for the ASR/T-ASR should be a choice between the conventional four-point moor designed for a water depth of 2000 feet or a dynamic positioning system requiring development. Recommendations: The following recommendations are made concerning the ASR positioning system:

(1) Equipment costs of a four-point moor and dynamic positioning systems should be estimated based on Appendix A.

(2) Trade-off studies considering capability, cost, reliability, etc., should be done to select between a four-point moor and dynamic positioning.

(3) If dynamic positioning is selected, a trade-off study should be done to determine the best dynamic positioning system.

(4) Pending action on the above recommendations, weights and space for a permanently installed four-point moor (as described in Appendix A) have been included in the feasibility studies reported herein.

APPENDIX A

Positioning System Study

Contents

Positioning System Study

A.1 Introduction

The purpose of this study is to evaluate alternative methods of positioning the ASR/T-ASR over a stricken submarine on the bottom. Mooring system alternatives assumed a water depth of 2000 feet. Requirements have not been specified for sea conditions or allowable excursions of the ship; however, rough estimates of the capabilities of each alternative were made.

The mooring system alternatives are based on the results of the "Flyaway Four-Point Mooring Study" documented by Naval Ship Engineering Center Technical Report #6162-77-3 of March 1977. Based on this report OP-23 selected a reduction in holding power to decrease mooring weight thereby improving the airlift capability required. The holding power of each leg was reduced from the existing Navy standard of 40,000 lbs to 20,000 lbs, on the assumption that the ship would be capable of heading into the resultant wind, wave, and current force, equivalent to a 2-knot bow current plus a 38-knot bow wind.

A 2,000 pound anchor with marker bouy, 4100 feet of 3/4 inch chain, a 4000 pound buoy, and 1000 feet of 8-inch spring line make up one leg which has 20,000 pounds holding power. The same leg was used for comparison of each alternative and is described in Figure A-1 and Table A-1.

The following alternatives were considered:

1. One-point moor

2. Two-point moor

3. Three-point moor

4. Four-point moor

5. Moor laid by another ship

6. Dynamic positioning system

Each alternative is discussed separately, with a comparison based on weight, holding power, excursion, etc.

A.2 One-Point Moor

Referring to Figure A-1: as the resultant wind/current forces on the ship increase from zero (the self equilibrating position for the ship without any wind or current) to the maximum holding power of the leg, the ship moves 1300 feet, which is obviously unacceptable.

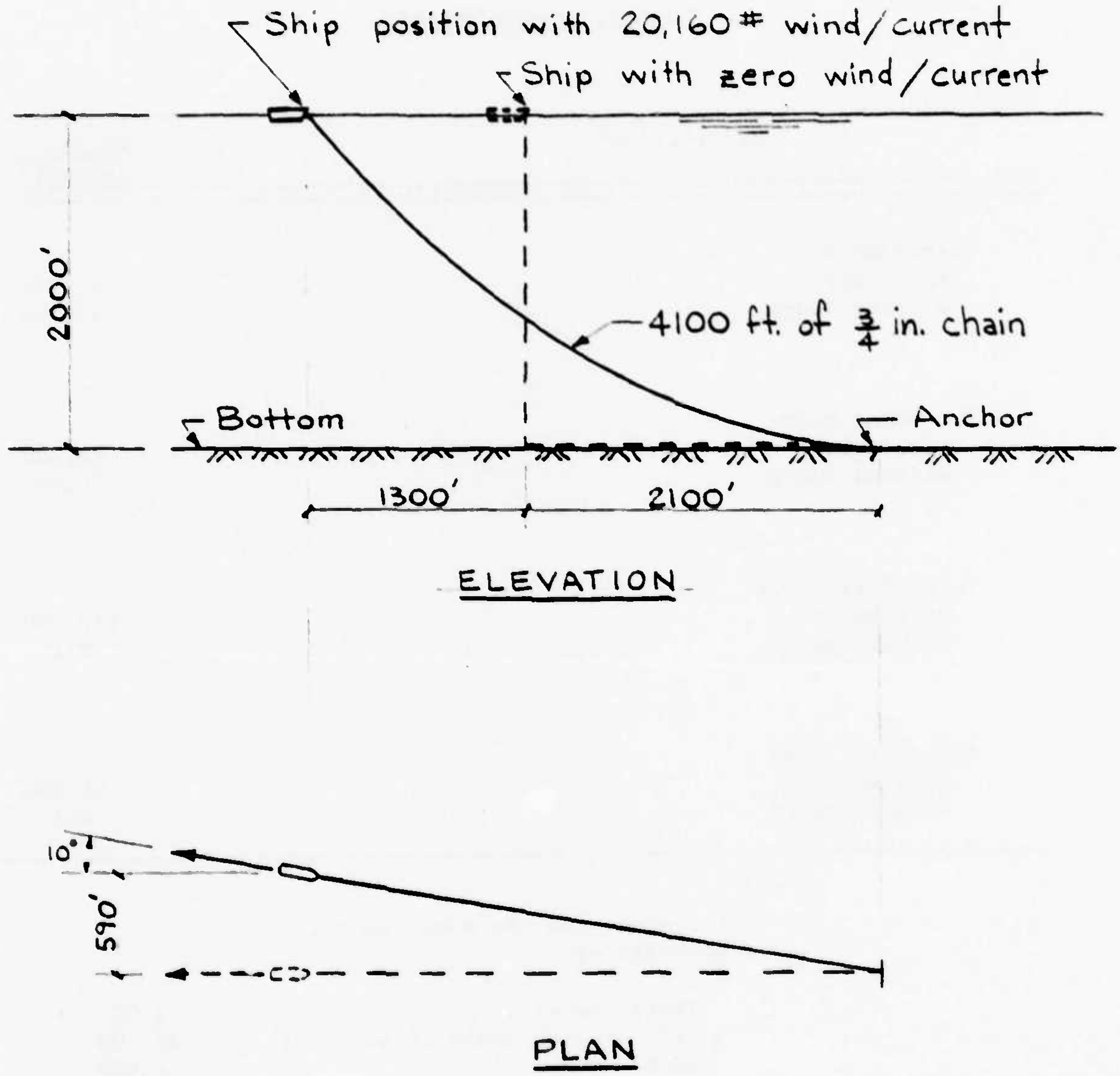


Figure A-1 Excursions of a Single Point Moor Without Buoy

TABLE A-1

Mooring System Weights

Description*	Weight (pounds)
One-Point Moor	
with buoys	41,250
without buoys	35,100
Two-Point Moor	
with buoys	82,500
without buoys	70,200
Three-Point Moor	
with buoys	123,750
without buoys	N/A
Four-Point Moor	
with buoys	165,000
without buoys	N/A

*All systems use the same leg with components of:

stato anchor	2,000 lb.
4100' - 3/4" chain (6.11 #/ft)	25,100
Buoy	4,000
1000' - 8" spring line	2,150
capstan/wildcat	8,000
Total weight =	41,250 lb.

Note that the addition of a buoy and spring line would permit a reduction in the excursion in line with the leg as illustrated in Figure A-2. Even if the magnitude of the wind and current were constant and the ship "weather vaned" in the resultant force direction, a 10° shift in direction would cause an excursion of 590 feet as shown in the plan view in Figure A-1. Obviously ship position control is inherently poor with a one-point moor.

A.3 Two-Point Moor

Although a two-point moor is an improvement on the one-point moor, it does not provide adequate position maintaining. Assuming the configuration shown in Figure A-3, a rough estimate is 1000 to 1300 feet of excursion from the equilibrium position. The numbered positions of the apex are defined below:

Position 1: This is an equilibrium position to which the apex would always return from the other positions if a frictionless bottom is assumed.

Position 2: Since there is friction and other resistance to the chain on the bottom, this is an estimate of where the apex might return if released at position 4.

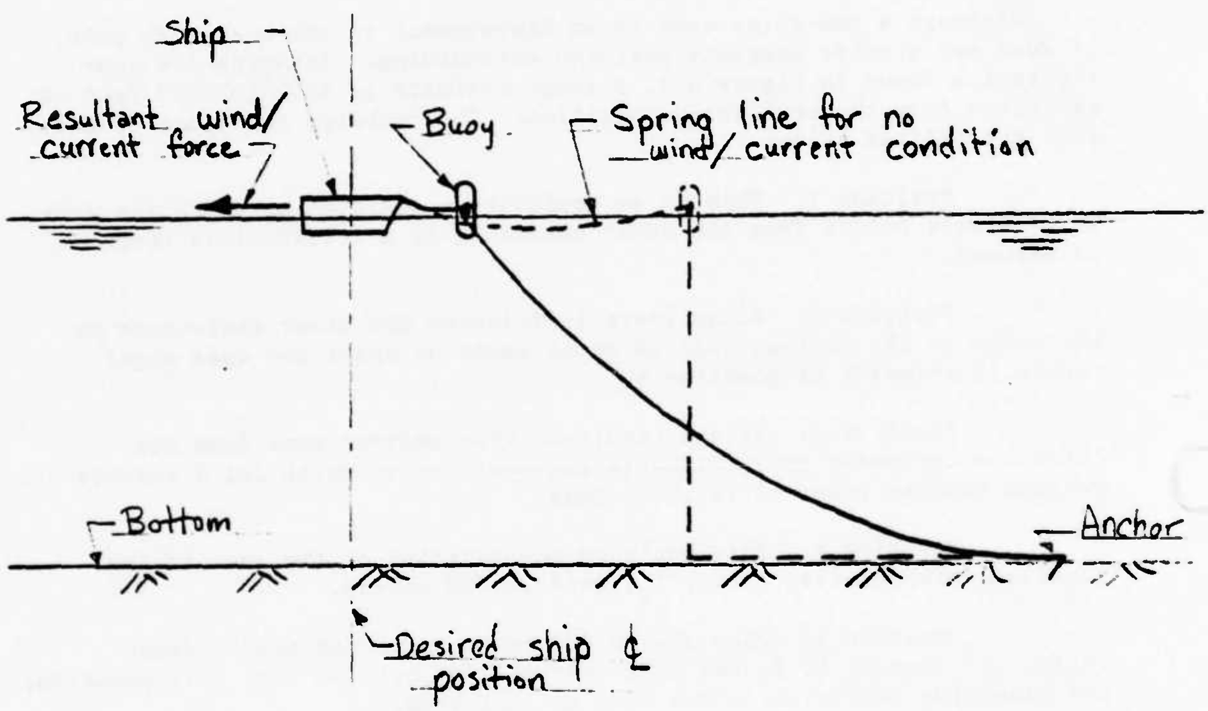
Position 3: If the resultant wind/current were from the direction indicated by F_3, this is the position at which leg A reaches maximum holding power of 20,160 pounds.

Position 4: This would be the position of the apex if the resultant wind/current force, F_4, were 20,000 pounds.

Position 5: When the 20,000 pound resultant wind/current shifts 10° from F_4 to F_5 the apex shifts from position 4 to this position; the resulting excursion is 200 feet as indicated.

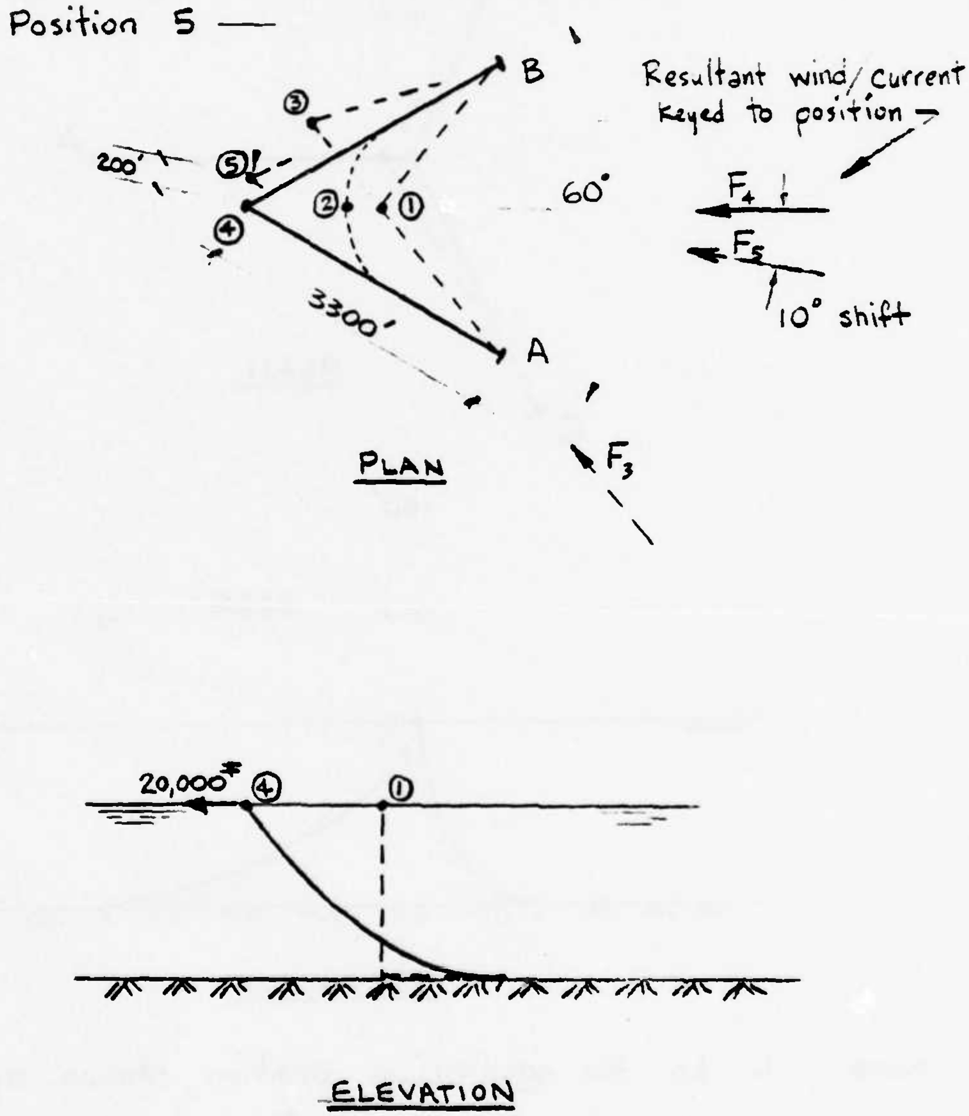
A.4 Three-Point Moor

A three-point moor can be pretensioned to eliminate the large excursion from the equilibrium position experienced in both one and two-point moors. Figure A-4 shows an idealized three-point moor without buoys and spring lines. Assuming a pretension of 10,000 pounds in each leg, a 180 foot excursion in line with a leg causes a 20,160 pounds horizontal force in that leg. This would be caused by the ship exerting 12,220 pounds of force on the apex of the moor, in line with a leg. This corresponds to a 34.6-knot bow wind and 2-knot bow current acting on the ship.



Note: The spring line can be taken in and paid out to help maintain the desired ship position.

Figure A-2 One-Point Moor with Buoy



Note: Shown without spring lines and buoys for the sake of simplicity

Figure A-3 Two-Point Moor Excursions

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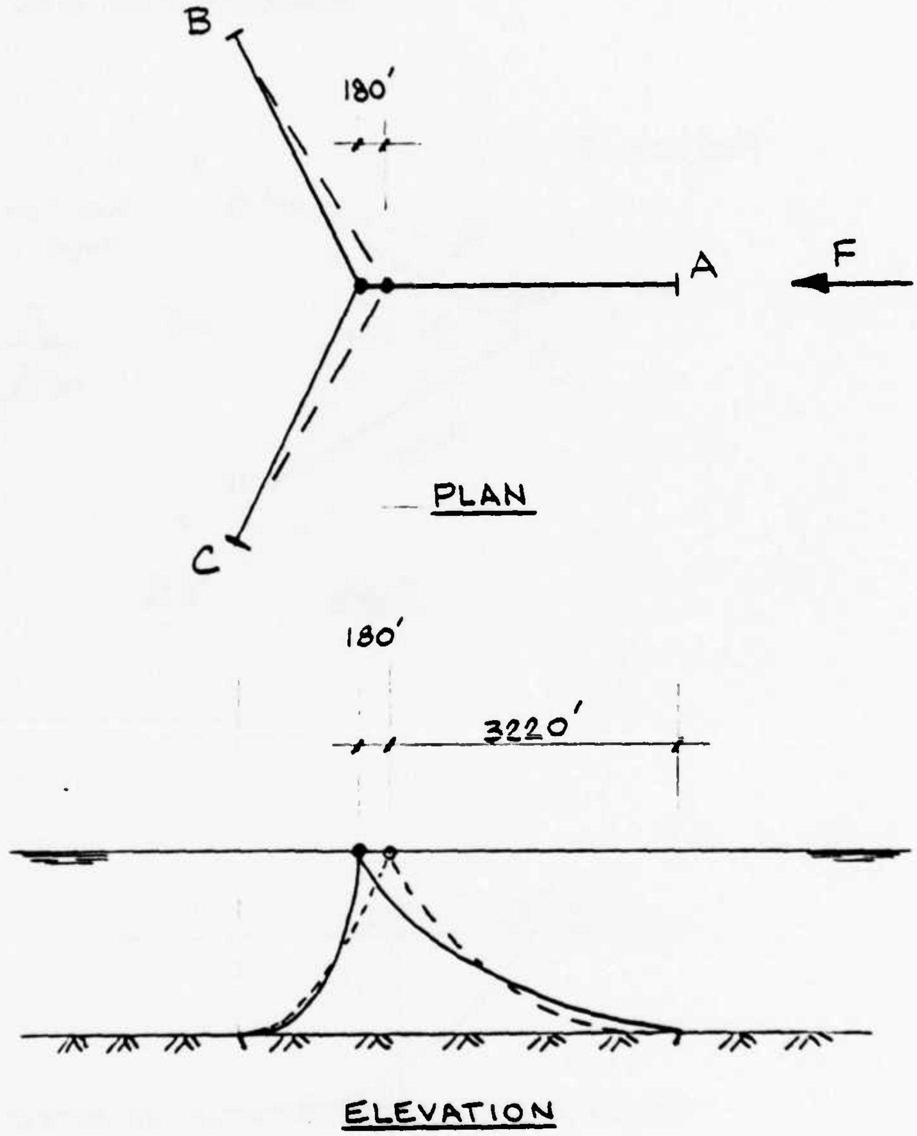


NOTE: 1. In the equilibrium position, shown dashed, each leg has 10,000# pretension.

2. For the 180 foot excursion shown, leg A has a 20,160# tension (max. allowable).

3. For the sake of simplicity, spring lines and buoys are not shown.

Figure A-4 Three-Point Moor Excursion

The problem with a three-point moor is that the ship cannot be rotated in the moor, to keep the ship bow into the resultant wind and current force. The holding power of the moor (12,220 pounds) corresponds to only one knot of current on the beam.

A.5 Four-Point Moor

Like the three-point moor the four-point moor can be pretensioned to reduce excursion. Figure A-5 illustrates a 10,000 pound pretension idealized moor without buoys and spring lines. The maximum moor holding power of 14,300 pounds (equivalent to a 38.6-knot bow wind in conjunction with a 2-knot bow current) results in a 180 foot excursion. Buoys and spring lines allow compensation for this excursion plus they allow the ship to rotate in the moor keeping the bow headed into the resultant wind, current, and wave force. Note that the moor holding power and excursion is dependent on water depth, pretension, and maximum leg holding power. A 20 percent decrease in water depth results in a holding power of 19,600 pounds (47.1 knot bow wind and 2 knot bow current) for the 4-point moor described above when pretensioned to 13,900 pounds to restrict maximum excursion to 180 feet.

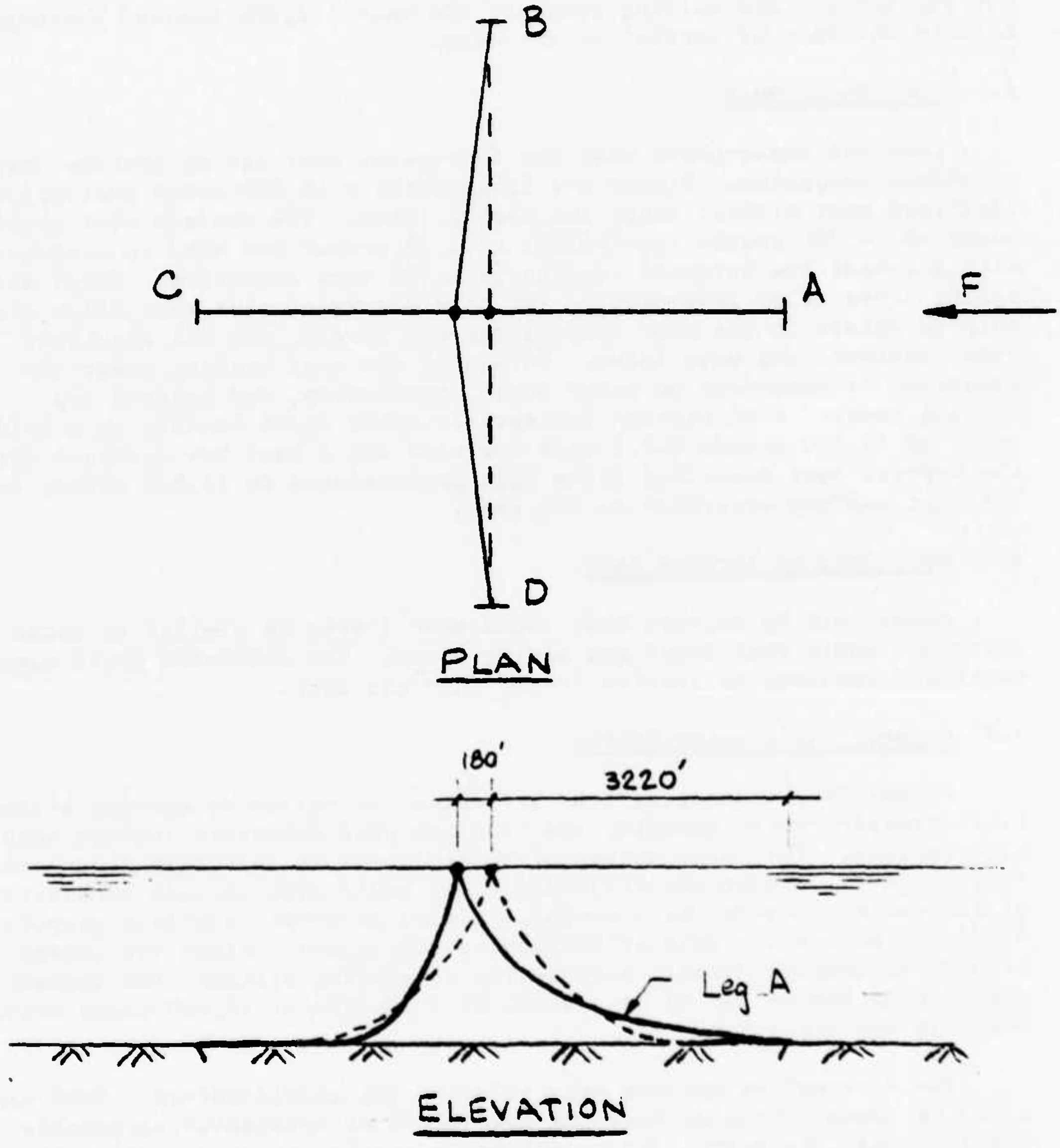
A.6 Moor Laid by Another Ship

Moors laid by another ship would most likely be similar to those described above with buoys and spring lines. The ASR/T-ASR would need machinery required to tension itself into the moor.

A.7 Dynamic Positioning System

Dynamic positioning systems are almost as varied as mooring systems, i.e. thruster types, numbers, and location plus automatic station keeping alternatives. The large number of alternatives is partially demonstrated by Table A-2. A complete trade-off study would also include consideration of integrated thruster/main propulsion such as diesel-electric propulsion with d.c. motors for main propulsion and thrusters. Since the intent here is to compare dynamic positioning to mooring systems, the dynamic positioning system had to be capable of a minimum of 20,000 pound holding power in any direction.

Two alternative systems were selected for consideration. Both use a 500 hp tunnel thruster near the bow, a 450 hp rotatable/retractable thruster near the stern, and an automatic station keeping system which uses transponders placed on the bottom near the sunken submarine to determine position. One system uses electric motor driven thrusters and the other uses hydraulic motors. The two alternative are further described below:



NOTE: 1. Each leg pretensioned 10,000# at equilibrium, shown dashed.
2. Leg A developes 20,160# tension (max. allow.) for the 180 foot excursion shown.
3. For the sake of simplicity, spring lines and buoys are not shown.

Figure A-5 Four-Point Moor Excursion

TABLE A-2

Alternative Thrusters

Item	Alternatives
Thruster Type	Tunnel, rotatable/retractable, water jet
Propeller	Fixed pitch, controllable pitch
Drive	a.c. Motor, d.c. Motor, diesel direct drive, hydraulic motor
Automatic Station Keeping	Satellite navigation, bottom transponders for local position fixing

a. Electric motor drive - the tunnel thruster will have a 5.5 foot diameter controllable (with hydraulics) pitch propeller driven by a 500 hp a.c. motor using power supplied by a dedicated 400 Kw diesel generator. The rotatable/retractable thruster will have a 4-foot diameter, fixed pitch propeller driven by a 450 hp d.c. motor, using power supplied from a Silcon Controlled Rectifier (SCR) and a dedicated 400 Kw diesel generator.

b. Hydraulic motor drive - the thrusters, with fixed pitch propellers the same size as the electric drive alternate, will be driven by constant displacement hydraulic motors. Hydraulic fluid would be supplied by variable displacement pumps driven off the forward end of the main diesel. Thruster rpm would be controlled by varying pump output.

These alternatives were selected to demonstrate a range of ship design impacts, with the hydraulic motor drive representing an anticipated minimum. Ship impact is addressed in Appendix E which shows full load displacement increases of 66 tons and 52 tons for electric drive and hydraulic drive respectively. The ASR with permanently installed four-point moor was used as a baseline for this evaluation. Since the ship impact is relatively small (less than 3% of full load displacement) only the equipment weight is compared to the mooring system equipment. The weight for the electric drive equipment (thrusters, motors, diesel generators, SCR, and automatic station keeping equipment) is approximately 39 tons. The weight for the comparable hydraulic drive system equipment is approximately 33 tons. These weights are summarized in Table A-3 and are provided in Table A-4 for comparison with the mooring system alternatives. Included are 2 tons for automatic station keeping equipment consisting of control console, computer, printer, wind sensor, remote display, transceiver (to be mounted in the ship bottom), and disposable transponders (to be dropped to the ocean floor around the sunken submarine).

A.8 Comparison of Alternatives

Estimates of weight, holding power, excursion, and time to establish position are compared in Table A-4 for the alternative positioning systems considered.

The four-point moor has one overriding advantage over the other mooring alternatives. It allows the ship to rotate in the moor to keep her bow into the wind, current, and waves. The importance of this is obvious from a comparison of the current forces alone, which is the dominant force. A two-knot bow current exerts approximately 3600 pounds on the ship, whereas a two-knot beam current exerts approximately 50,000 pounds. This demonstrates that the ship must be capable of rotating in the moor if a reduced holding power is expected to hold the ship against any appreciable combined wind, waves, and current force. Therefore the four-point moor is the only viable mooring alternative.

Table A-3

Weight Summary For Dynamic Positioning

<u>Electric Drive</u>

Thruster, bow - 500 hp tunnel w/motor	8.5 tons
stern - 450 hp retractable w/motor	18.8
Diesel Generators, 2-400 Kw	8.5
Silicon control rectifier - 400 Kw	1.4
Automatic station keeping equipment	2.0
	39.2 tons

<u>Hydraulic Drive</u>

Thrusters, bow - 500 hp tunnel (pumps & motors)	10.3 tons
stern - 450 hp retractable (pumps & motors)	18.8
Hydraulic piping	2.0
Automatic station keeping equipment	2.0
	33.1 tons

Table A-4

Comparison of Alternative Positioning Systems

Alternative	Weight	Holding* Power	Excursion from Equilibrium	Time Required to Establish Position
One-point moor	35,100 lb.	20,160 lb. (48.0 knots)	1300 ft	1 hr.
Two-point moor	70,200	20,160 (48.0)**	1000-1300	2 hrs.
Three-point moor (pretension 10,000#)	123,750	12,220 (34.6)**	180	3 hrs.
Four-point moor (pretension 10,000#)	165,000	14,300 (38.6)	180	4 hrs.
Moor laid by another ship	8000/leg	-	-	1-2 hrs.
Dynamic Positioning				
Electric drive	87,800	20,000 (48.0)	approx. 10% of water depth	less than 1 hr.
Hydraulic drive	74,100			

* This is the maximum force that the ship can exert on the mooring, in the mooring's weakest direction, before the force in any leg reaches 20,160 pounds. Shown in parentheses is the wind velocity that the ASR could take bow-on in conjunction with a 2-knot bow current.

** This is somewhat misleading since the ship cannot be rotated to reduce wind or current loads.

Since the ASR will support SRC training and operations as well as surface supported diving and salvage operations, and since all of these operations require positioning; permantently installed, vice portable fly-away, mooring and dynamic positioning systems were considered in developing ship weights and volumes for these studies.

Based on the above discussion the selection of the positioning system for the ASR reduces to a choice between a four-point moor or a dynamic positioning system. The ship sizes for these alternatives, as previously mentioned are not significantly different; therefore the choice should be made based on a comparison of capability, cost, reliability, and other considerations. Tables A-1 and A-3 can be used to determine cost, however, this is beyond the scope of this study.

Dynamic positioning is independent of water depth and can be used for other missions where DSV's are being used in deep water. There are disadvantages, such as thruster wash interference with submersible launch/retrieval and tethered cables; and propeller noise interference with underwater communications during operations. There will probably be some small excursions of the ship with dynamic positioning, however these are difficult to estimate, but should not exceed approximately 10 percent of the water depth.

When comparing excursions of dynamic positioning with those of a four-point moor, it should be noted that the moor excursions can be further reduced from the 180 feet listed in Table A-4 by taking in and paying out spring lines as required, however, this is not automated and thus less responsive than dynamic positioning with automatic station keeping.

A.9 Recommendations

The following recommendations are made concerning the ASR positioning system:

1. Equipment costs of a four-point moor and dynamic positioning systems should be estimated based on Tables A-1 and A-3.

2. Trade-off studies considering capability, cost, reliability, etc., should be done to select between a four-point moor and dynamic positioning.

3. If dynamic positioning is selected, a trade-off study should be done to determine the best dynamic positioning system.

4. Pending action on the above recommendations, a permanently installed four-point moor (as described in Table A-1) should be assumed for the ASR/T-ASR (the ship should be capable of independently laying and retrieving the moor).

APPPENDIX B

CHARACTERISTICS AND USE OF SUBMERSIBLES

CONTENTS

Characteristics and Use of Submersibles

B.1 Introduction

The intent of this appendix is to describe submersibles that may be operated from the fully capable ASR/T-ASR described in Section 4 of the Submarine Resuce Ship (ASR/T-ASR) Feasibility Study Report, NAVSEC Report No. 6114-019-77, October 1977. In addition to the submersible's description, the assumed shipboard handling and support will also be described. The characteristics of the submersibles of interest are summarized in Table B-1.

	SRC (New Increased Depth)	CURV III	RUWS** DEEP		RUWS SHALLOW	DSV-3 DSV-4	ALVIN
			PCT	RUV			
Long Tons	11.2	1.5	2.4	2.3	2.3	22.3	15
Length Ft.	Dia. 9.5	15	9.6	11.0	11.0	26	25
Width	Dia. 9.5	6	4.8	4.7	4.7	12	8
Height	15	6	9.4	4.8	4.8	12	13
Draft	--------	--	---	---	---	7.5	7.5
Passengers	25	--	---	---	---	1	1
Crew	2	0	---	---	---	2	2
Operating Depth	---	7,000	20,000		3,000	6,500*	12,000
Knots	---	---	---	---	---	1	1
Hours	---		(surface supported)			8	8
Endurance		unlimited	unlimited		unlimited		
Payload	Dry Wt. (25 men)	<200	?	?	?	300	1,000

*DSV 3 with modifications will go to 10,000 ft. and DSV 4, planned for the mid 80's, will go to 20,000 ft.

**Deep-water RUWS has two submerged elements; the Primary Cable Termination (PCT) and the Remote Underwater Vehicle (RUV).

Table B-1 Characteristics of Submersibles

B2. Submarine Rescue Chamber (SRC)

The new increased depth SRC, Table B-1 and Figures B2-1 and B2-2, will be part of a fly-away kit including a four-point moor, portable air compressor, high pressure air bank, spare downhaul cable, SCUBA equipment, hoses, cables, etc., required to support SRC operations. The kit will be designed to be transported by two C-141 aircraft, which have a cargo load capacity of 68,000 pounds each. Three kits are planned; one on the east coast, one on the west coast, and one for standby and training. In case of a submarine disaster the SRC kit will be flown to the nearest port where it would be taken aboard a ship of opportunity for the rescue operation. When the ASR/T-ASR is used, the portable moor will be unnecessary since this ship will have a permanently installed four-point moor (needed for this and other missions). Assuming the portable equipment arrangement in Figure B2-3, SRC operations will be as described below.

The SRC will be transferred on deck tracks from its stowed position to the stern mounted A-frame. The A-frame is used to hoist the SRC from its dolly and launch it over the stern. The positively buoyant SRC is attached to the cable on the submarine messenger buoy and uses its air motor winches to haul itself to the mating seal of the escape hatch on the submarine. Any pressure difference between the SRC and the submarine is equalized to allow the hatches to be opened. Up to 25 people can enter the SRC and lead pigs are manually transferred to the submarine to compensate for their weight. This operation keeps the amount of positive buoyancy of the SRC constant, thus not over stressing the downhaul cable. The hatches are closed and the down haul cable is paid out allowing positive buoyancy to carry the SRC to the surface. The backhaul cable which has remained slack since launch is used to pull the SRC to the ships stern for recovery. Once on deck the rescued personnel leave the SRC and the lead ballast is replenished.

The process is repeated until all personnel are removed from the submarine.

B.3 CURV III - (CABLE-CONTROLLED UNDERWATER RECOVERY VEHICLE)

CURV III is an unmanned remotely operated tethered vehicle capable of operating at depths to 7000 ft. Originally conceived for use in search and recovery operations CURV has evolved into a multipurpose work tool with expanded capabilities for research, search, recovery, test, and limited underwater "work horse" operations. The basic system consists of a open aluminum rectangular frame to which various support systems can be readily adapted for each particular task. The major components of the system include the frame comprising the body of the vehicle, control cable, control console (in a portable van), power supply and conversion equipment, and surface handling equipment. Systems may be mounted on the frame including active and passive sonar, TV systems, 35mm camera, optics, propulsion, hydraulics, compass, and work systems package. See Figure B3-1 and Table B-1.

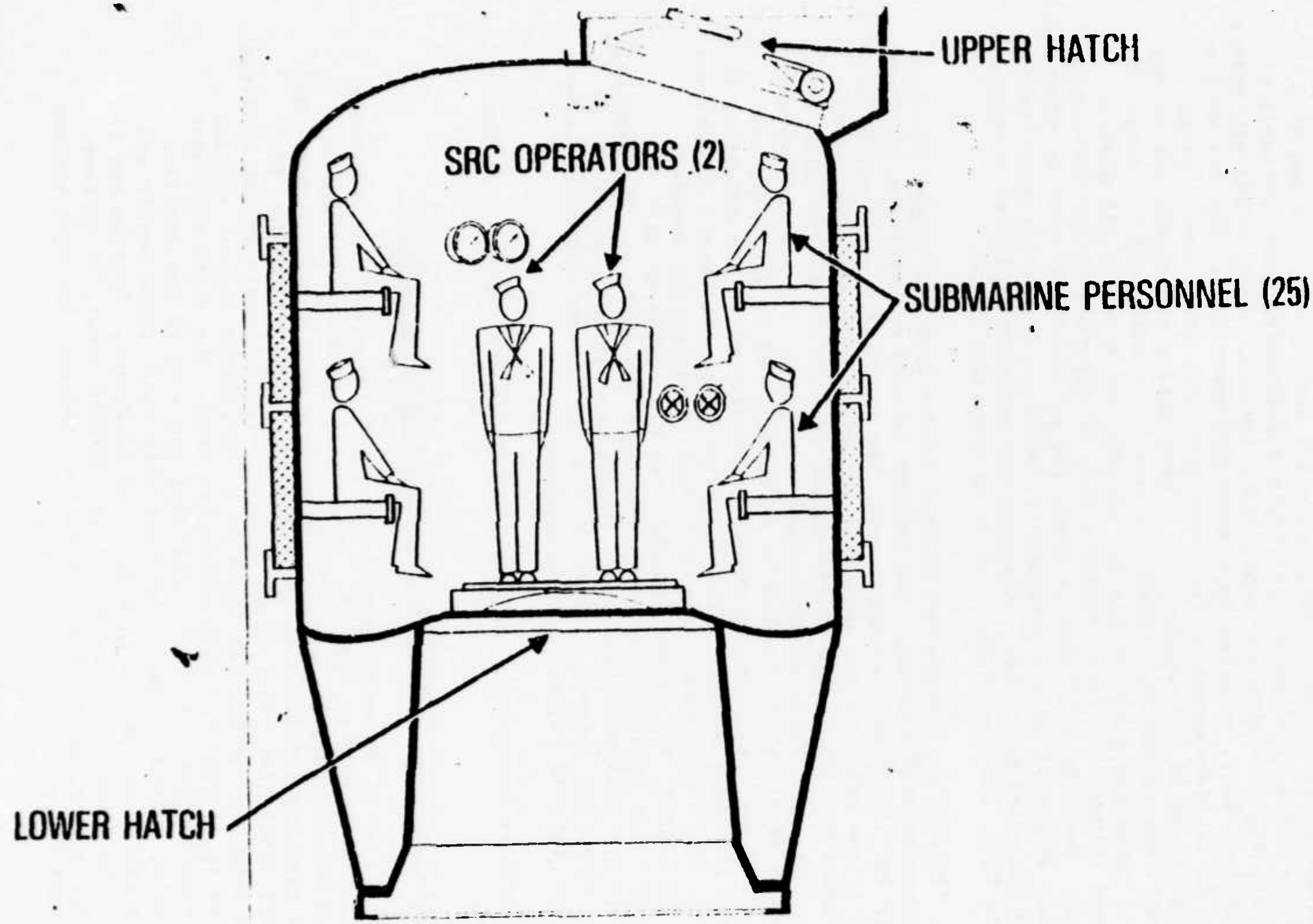


FIGURE B2_1 SRC

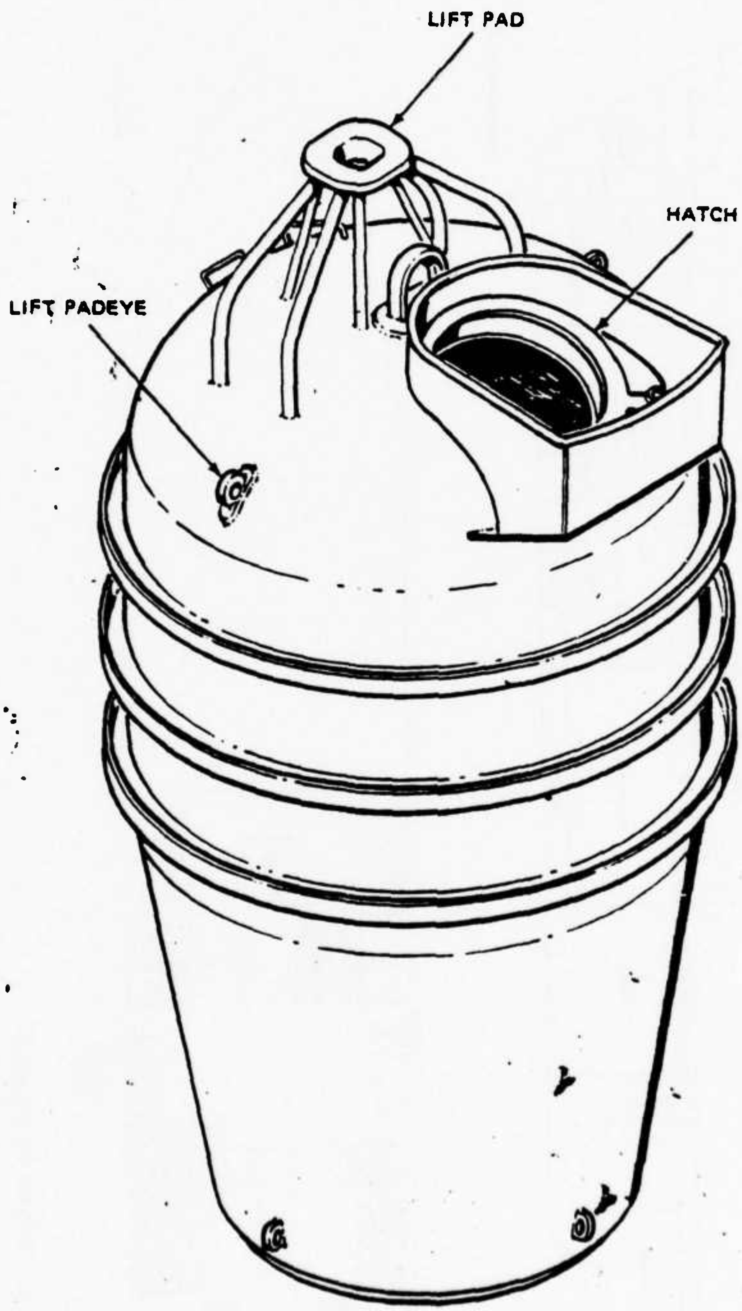


FIGURE B2-2 SRC

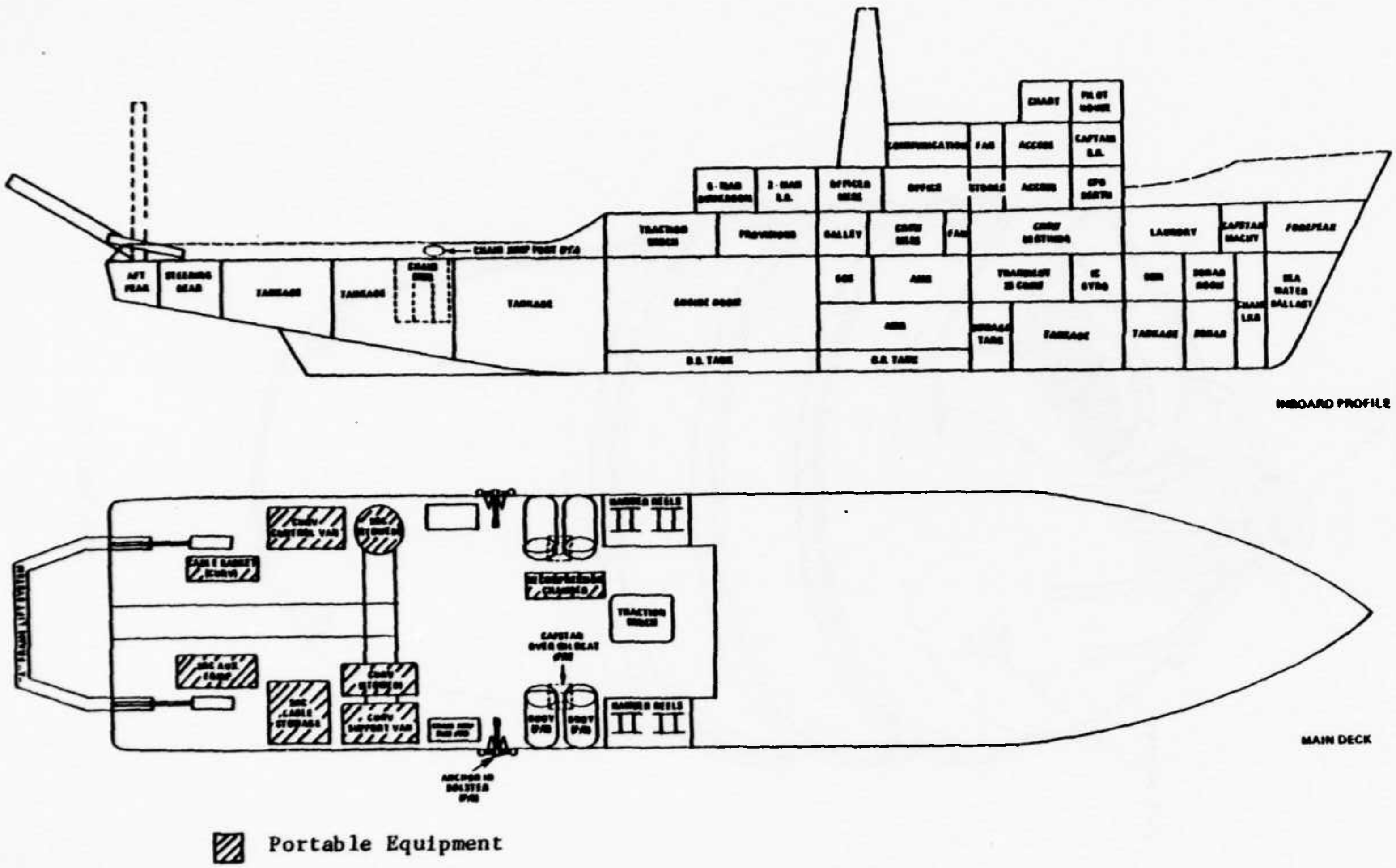


Figure B2-3 Arrangement of Portable Equipment on ASR

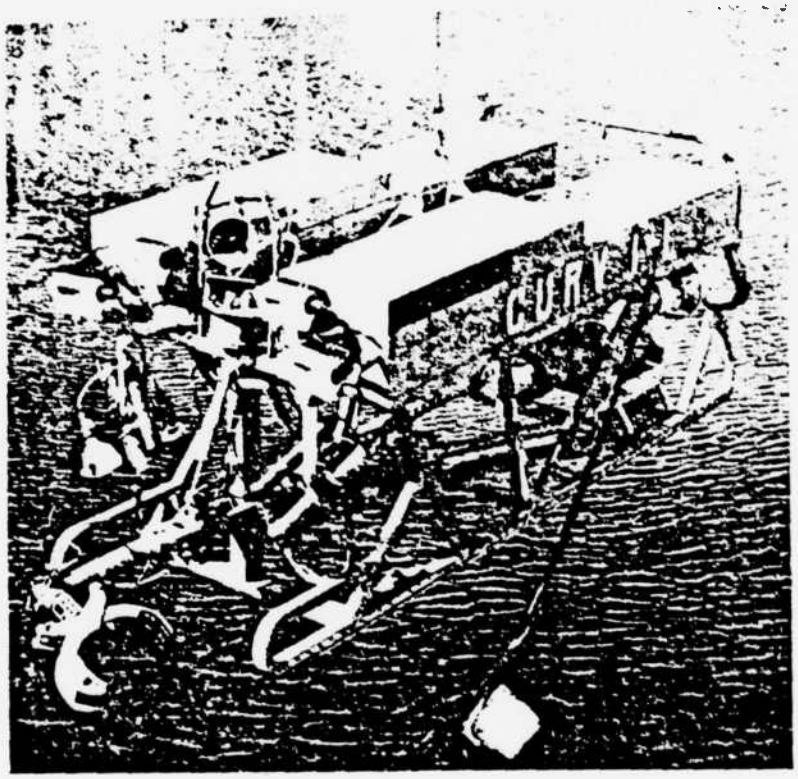


FIGURE B3.1 CURV III

The ASR must be designed to be able to carry a CURV III and an SRC, Figure B2-3. If a sunken submarine cannot send up its messenger buoy with cable to which the SCR must be attached (see B.2 SRC), the A-frame is used to launch CURV III. CURV III is then directed to the submarine to either dislodge the messeanger buoy so it can get to the surface, or to attach a cable to the submarine. Then CURV III is retrieved by the ship and operation of the SRC is begun.

B.4 RUWS (Remote Unmanned Work System)

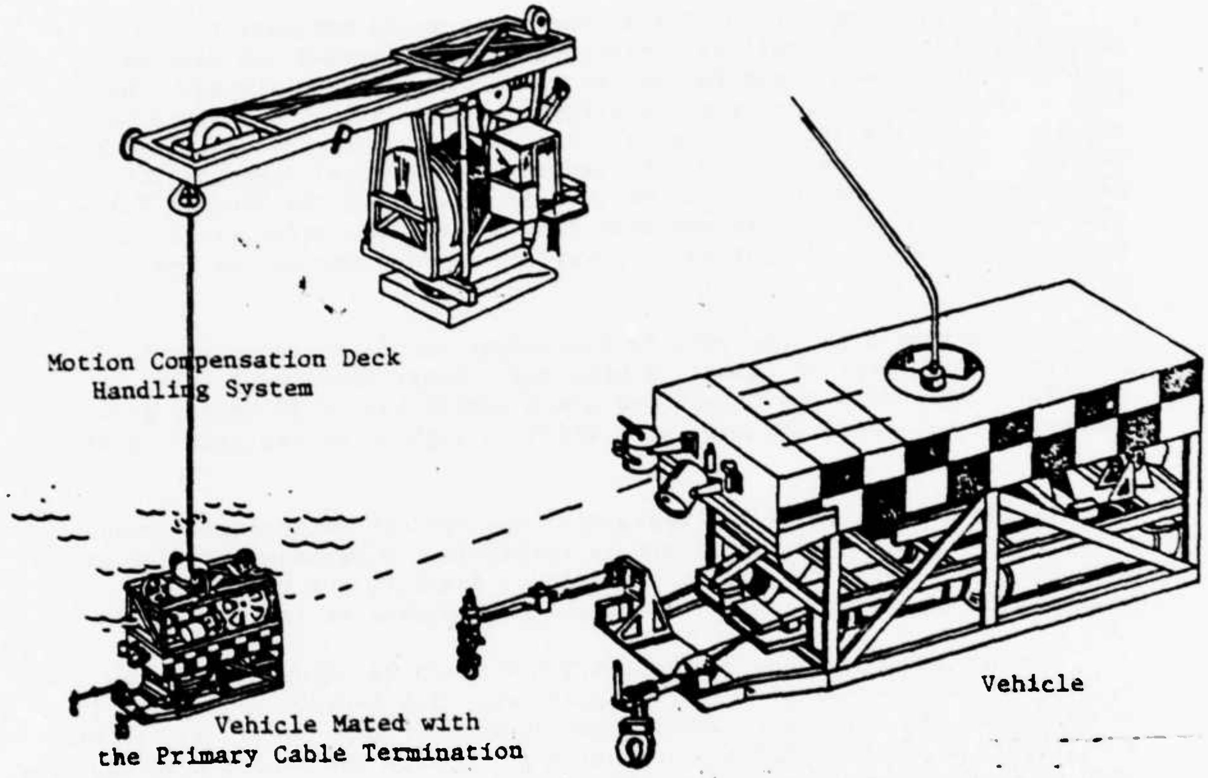
RUWS is an unmanned cable-tethered work system designed to perform a variety of engineering and scientific tasks at various ocean depths, reference (6). Missions that can be accomplished with RUWS include inspection, recovery, repair, emplantment, documentation, data gathering and limited search. The system also can be employed as a testbed for a wide variety of deep ocean experiments. Spare communication channels and power are available to facilitate expanded usage. The system is designed for air-transport and operation from specified ships of opportunity, and includes advanced capabilities for deep ocean navigation and local-area bottom search. RUWS can be used in either a shallow water (to 3000 feet) or a deep water (to 20,000 feet) configuration. Both configurations will be discussed below.

B.4.1 Deep-Water RUWS Configuration

The major components of the deep-water configuration are depicted in Figure B4-1. Equipment on the support ship consists of a Control/Navigation (CON/NAV) Center, power generation units, and Motion Compensation Deck Handling System (MCDHS). Submerged elements include the Primary Cable Termination (PCT), the remote Vehicle and Deep Ocean Transponders for navigation. A cable system consisting of the Primary Cable between the surface ship and the PCT, and a buoyant Vehicle Tether from the PCT to the Vehicle completed the major RUWS elements. All signals and power necessary to control the submersibles are multiplexed on the single coaxial core of the Primary Cable. The major system elements include:

	Size (ft)	Weight (lbs)
CON/NAV Center	8 1/2 x 18 1/2 x 8 1/2	13,500
MCDHS & PRIMARY CABLE	13 x 10 x 23 high	110,000
PCT & VEHICLE TETHER	9 1/2 x 5 x 6 high	6,000
VEHICLE	5 x 11 x 5 1/2 high	7,000
MAINTENANCE VAN	8 1/2 x 14 1/2 x 8 1/2 high	7,000
DIESEL CENERATORS (2)	8 1/2 x 3 1/2 x 5 high (ea)	11,600 (total)
MISC. EQUIPMENT		9,000
		164,100
TOTAL SYSTEM WEIGHT		74.1 long tons
APPROXIMATE DECK AREA REQUIRED		700 sq. ft.

REMOTE UNMANNED WORK SYSTEM



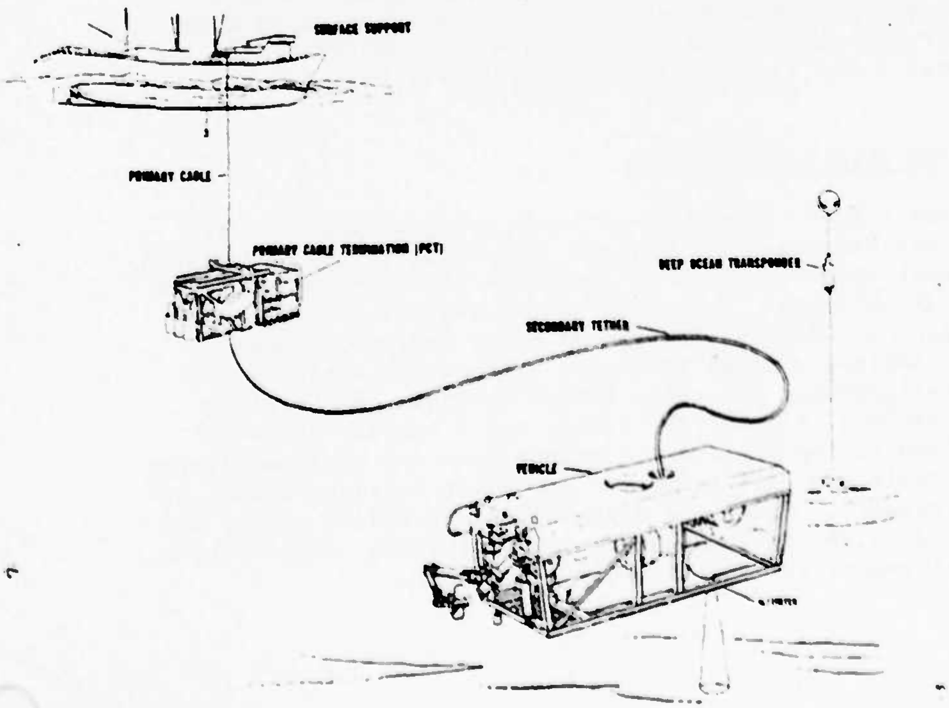


Figure B4-1 Deep-Water RUWS Configuration

In a typical operation, the surface ship would navigate to the target area using a satellite navigation system. Around the site of interest, three deep ocean navigation transponders are deployed. The RUWS Vehicle and PCT are launched piggyback fashion by the MCDHS operator and lowered to the operating depth. At 200 feet above the seafloor, the descent stops and, on command, the Vehicle is separated from the PCT which remains suspended at that depth. By paying out the Vehicle Tether, the Vehicle can thrust down and away from the PCT and maneuver to the work site. The CRT navigation displays aid in maneuvering the Vehicle and the PCT.

At the work site, the Vehicle subsystems enable the operator to perform a wide range of tasks. A wide angle sonar provides search capability to locate the target and avoid obstacles. A TV camera provides closeup inspection of the work area which is lighted by thallium-iodide lights.

At the conclusion of the operation, the Vehicle returns and docks with the PCT as the Vehicle Tether is reeled in. Piggyback recovery is then made in reverse fashion to launching. Finally, the navigation transponders are acoustically released and recovered at the surface.

Special modifications to the ASR/T-ASR would be required in order to support the deep-water RUWS configuration. The A-frame would have to be replaced with the special RUWS crane shown in Figure B4-1. A possible configuration of the ASR/T-ASR converted to support deep-water RUWS has been shown in Figure B4-2. Note that simultaneous deep-water RUWS and SRC missions do not appear feasible on the ship size shown. Also if ASR/T-ASR is intended to be a ship of opportunity for deep-water RUWS, then a bow thruster may be required for adequate stationkeeping in 20,000 feet of water. The baseline ASR/T-ASR does not have a bow thruster.

B.4.2 Shallow-Water RUWS Configuration

The shallow-water RUWS (Figure B4-3) is an optional mode of the RUWS concept that has been used for several operations to 3000-ft depths (914 meters). Deeper operations can be conducted in this configuration if a longer cable is obtained. Equipment on the support ship consists of a Control/Navigation (CON/NAV) Center and power generation unit, submerged elements include a clump and cable system, the Vehicle, and transponders for navigation. The cable system consists of the clump cable between the surface ship and the clump, and a buoyant Vehicle Tether from the clump to the Vehicle. A maintenance van accompanies the system to provide tools and test equipment and spare components that are needed for system support. Since the large MCDHS, 20,000-ft cable, and PCT are not required in the configuration, transportation, installation, and equipment requirements are considerably simplified.

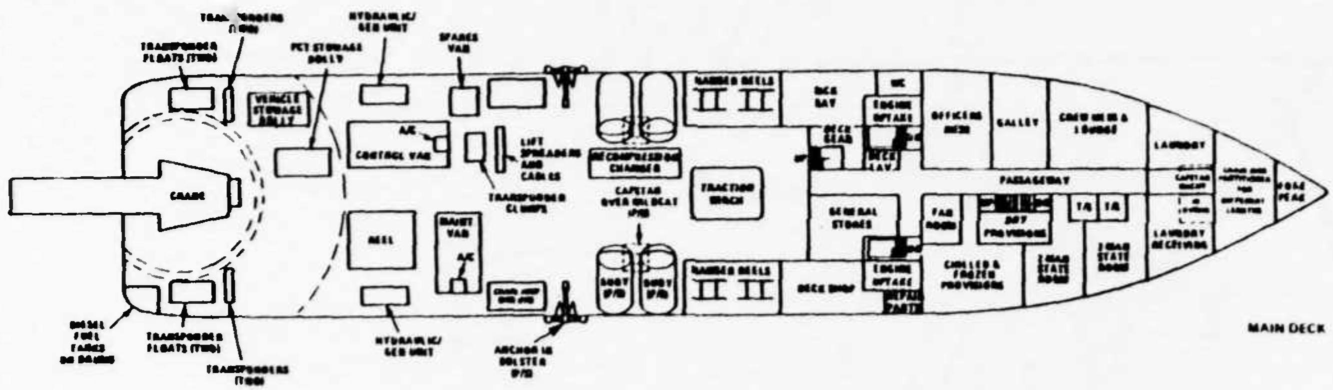


Figure B4-2 ASR/T-ASR Converted for Deep-Water RUWS Support

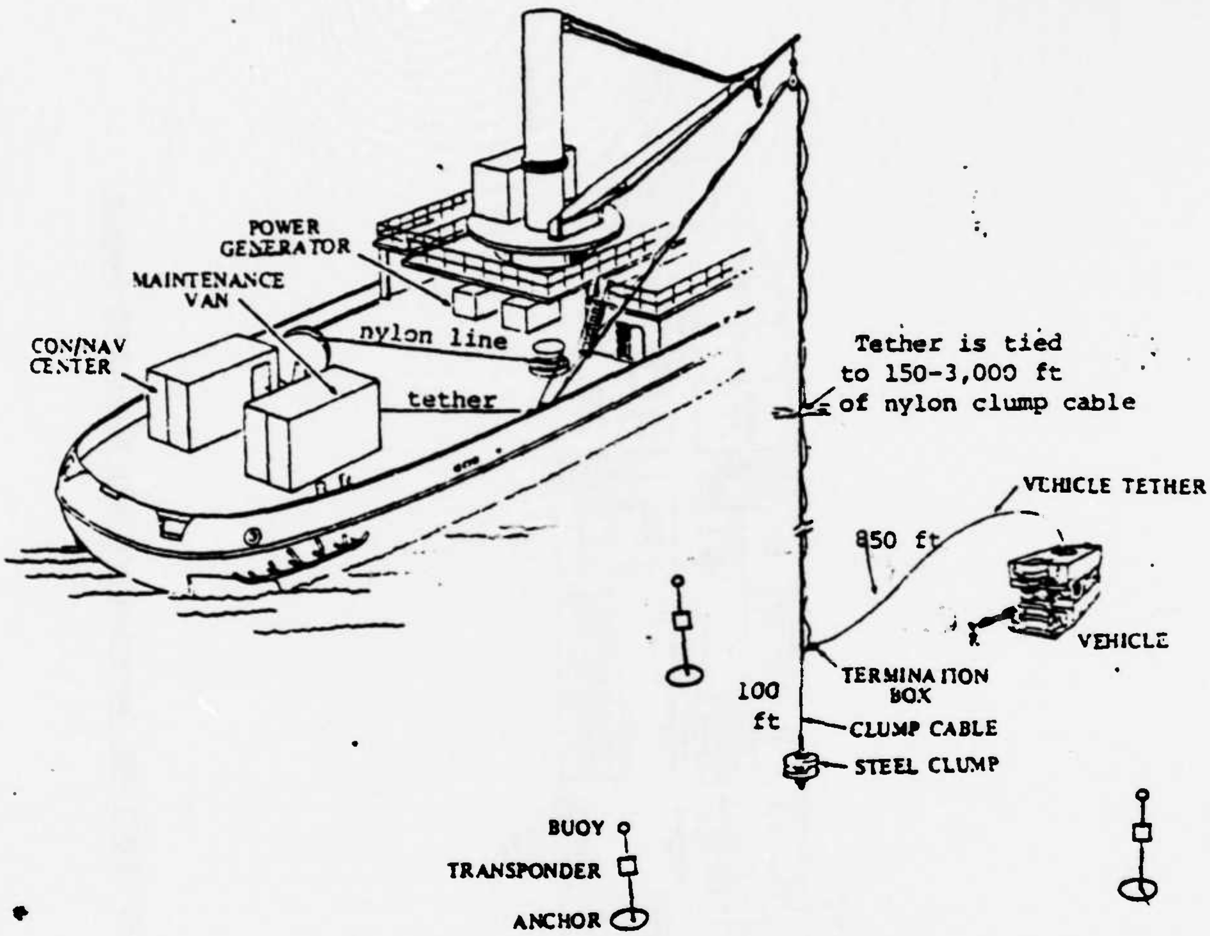


Figure B4-3 Shallow-Water RUWS Configuration

The Major system elements include:

	Size (ft)	Weight (lbs)
CON/NAV CENTER	8 1/2 x 18 1/2 x 8 1/2 high	13,500
TETHER, CABLE & CLUMP	8 x 10 1/2 x 5 high	3,100
GENERATOR	8 1/2 x 3 1/2 x 5 high	5,800
VEHICLE	5 x 11 x 5 1/2 high	7,000
MAINTENANCE VAN	8 1/2 x 14 1/2 x 8 1/2 high	7,000
MISCELLANEOUS EQUIPMENT		9,000
		45,400 TOTAL
SYSTEM WEIGHT		20.3 long tons
APPROXIMATE DECK SPACE REQUIRED		560 sq. ft.

The stern A-frame will be used on the ASR/T-ASR to launch and retreive shallow-water RUWS instead of a boom crane shown in Figure B4-3. Shallow-water RUWS and the SRC could be supported by the ASR/T-ASR simultaneously, in which case for rescue operations, the SRC and RUWS would interface the same as SRC and CURV.

B.5 DSV (SEA CLIFF & TURTLE)

The DSV's are primarily research vehicles capable of performing various deep ocean tasks. Potential mission applications are listed in Table B5-1. Principal characteristics are provided in Table B-1 and Figure B5-1 shows the major features of the DSV.

If SEACLIFF and TURTLE were deployed simultaneously aboard the ASR/T-ASR the main deck arrangement might be similar to Figure B5-2. The stern A-frame would be used for launch and retreival as shown. With only one DSV the SRC could also be supported, in which case for rescue operations the SRC and DSV would interface the same as SRC and CURV.

B.6 ALVIN

The characteristics for ALVIN, which is one of the Navy's older submersibles, are listed in Table B-1 and principal features are shown in Figure B6-1. Alvin normally requires an elevator type lift system and would require special modifications for use with the ASR/T-ASR stern A-frame lift system.

TABLE B5-1 DSV POTENTIAL MISSION APPLICATIONS

Inspections

- Harbors
- Ships
- Deep sea moorings
- Underwater work platforms, arrays, manned and unmanned stations

Support

- Deep sea recovery and Salvage
- Photographic, stereo
- Directing diver work (U/W telephone available)
- Coordination of operations (diver, ship, other submersibles)
- DSRV operations, matings, SDS
- Experimental stations (Seacon, etc.)

Evaluation

- Handling systems studies
- U/W power tools
- U/W cable performance
- U/W power soruces
- Subsystems (manipulators, lift packages, lighting cameras, etc.)
- Mooring performance
- Hull-type model studies
- Buoy studies
- Diving systems
- Cavitation studies

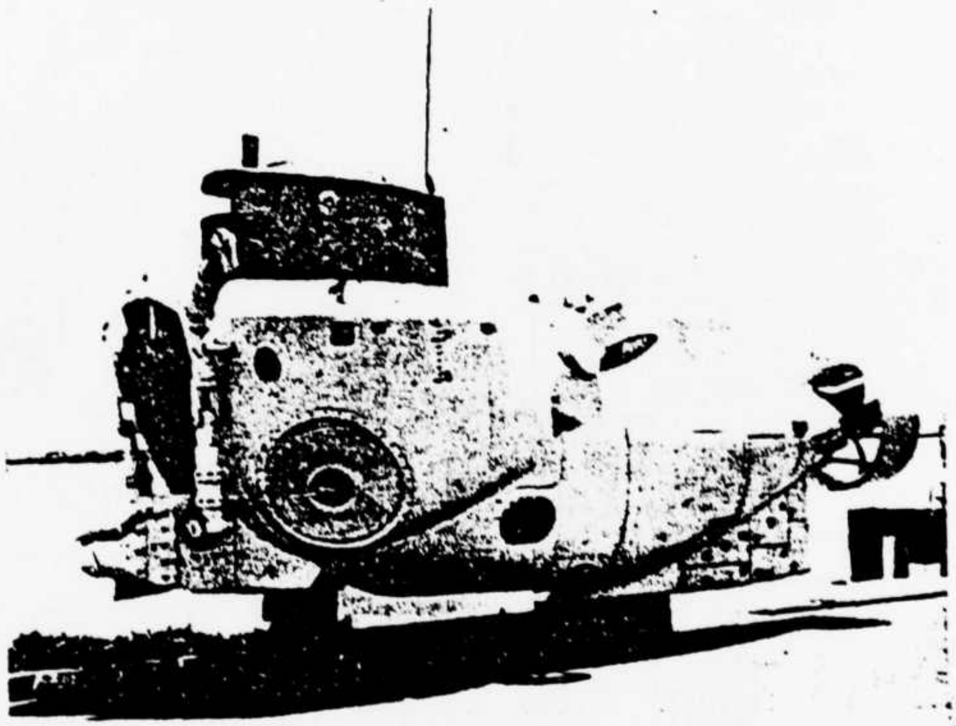
Pollution Control

- Oil leaks
- Sewage Outfall
- Radioactivity measurements
- Artificial reef studies
- Fish die-offs
- Disposal areas
- Ecology studies

Search Capabilities

Ocean Research

- Deep scattering layer
- Fish studies (recordings, anti-shark devices, black cod studies, etc.)
- Borings
- Corrosion and fouling
- Continental shelf sea floor
- Currents and turbidity-currents
- Sand movement, beach erosion, sediments
- Light transmission
- Laser studies
- Magnetic and gravitational fields
- U/W radio wave propagation
- Hydrodynamics
- U/W sound studies
- Polar applications
- Sea animals (walrus, sea lion, etc., as in Manned Undersea Science and Technology Program with Alaska Dept. of Fish and Game, NUC, NSF, NOAA)



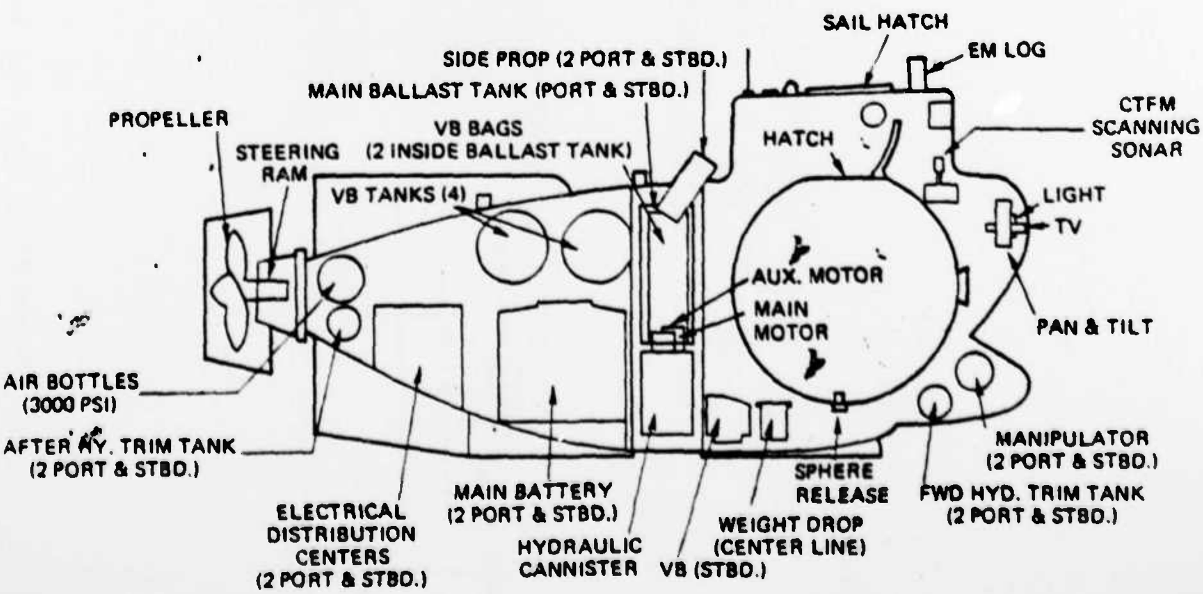


FIGURE B5-1 DSV (SEA CLIFF, TURTLE)

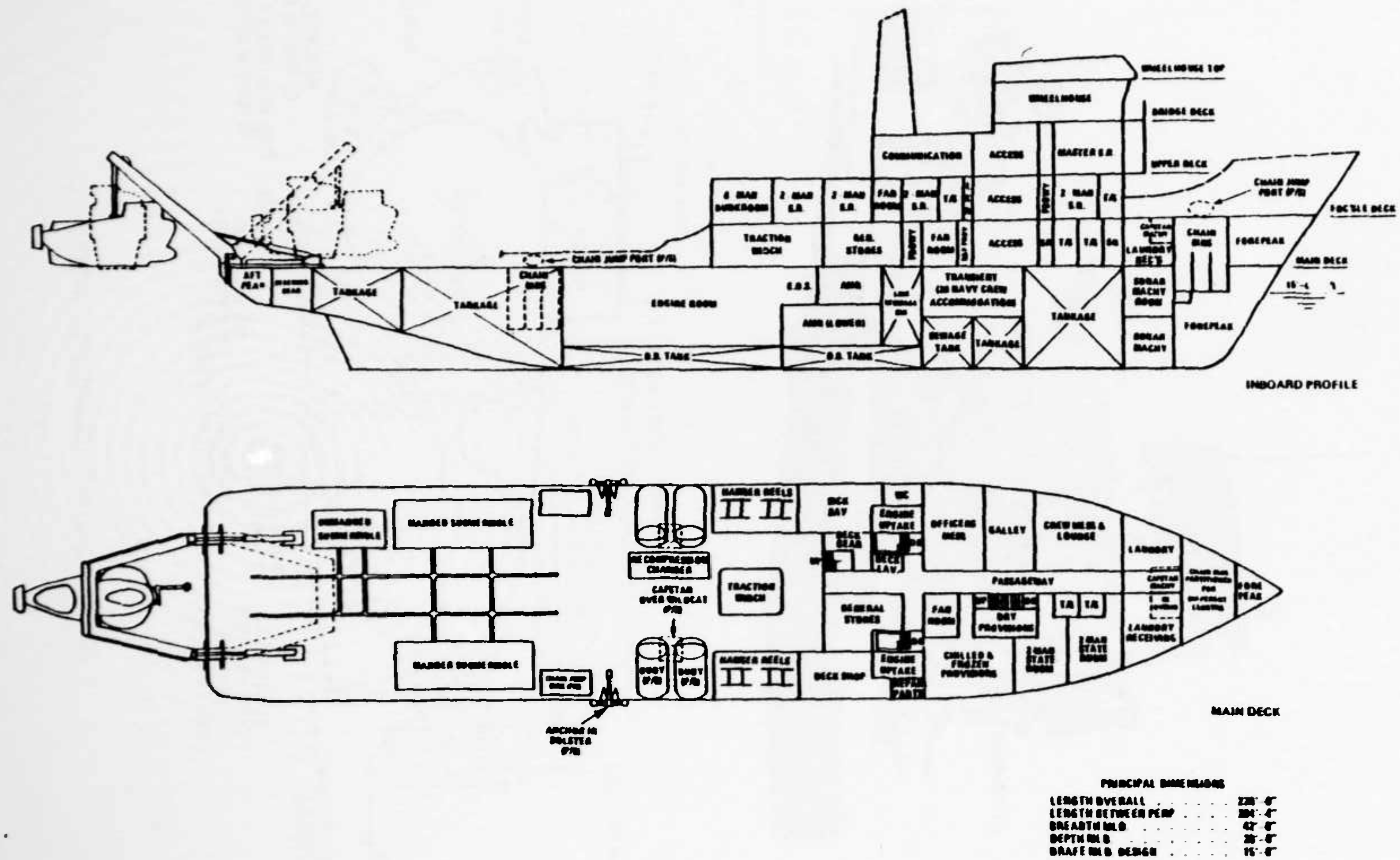


Figure B5-2 ASR/T-ASR Configured for DSY Support

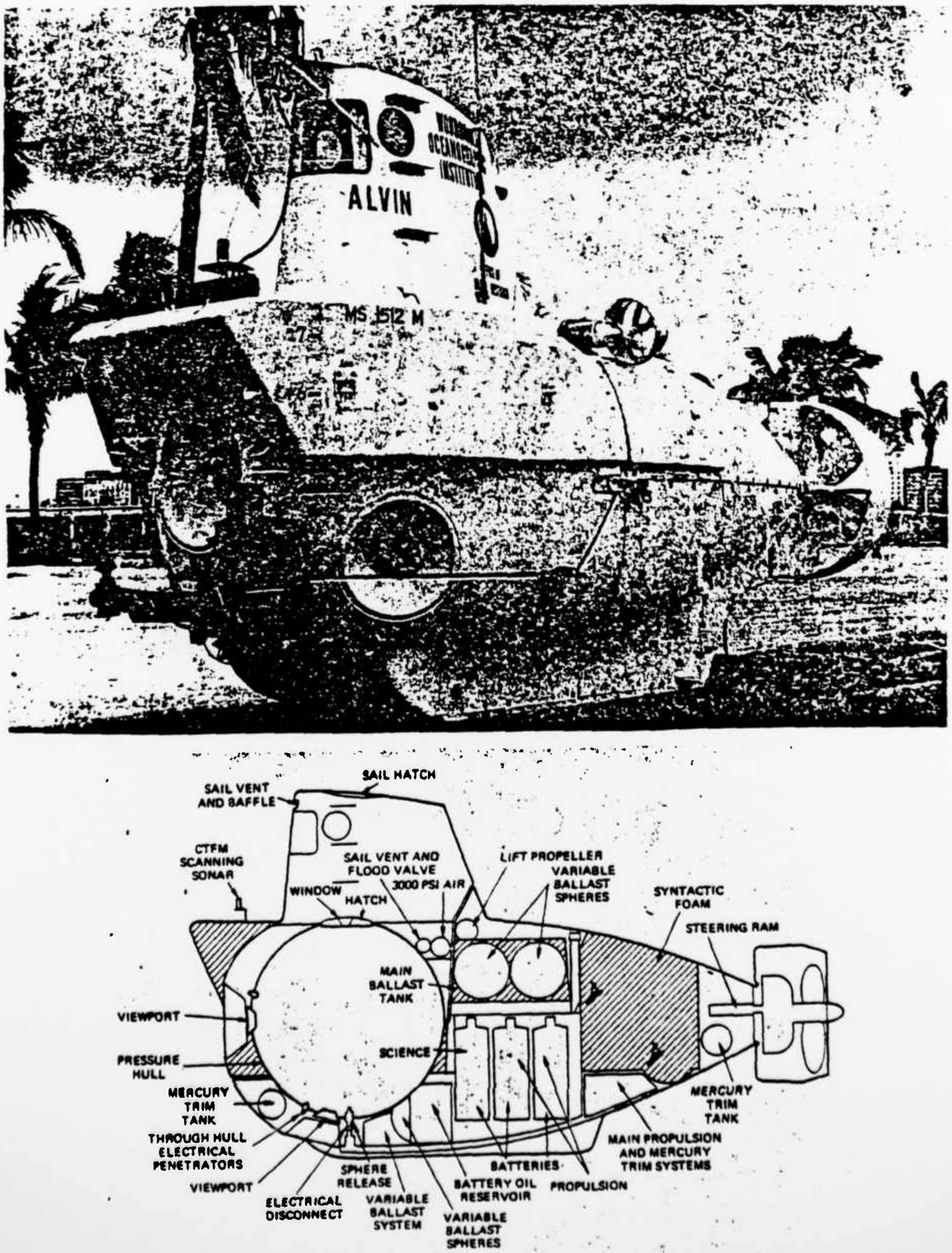


Figure B6-1 ALVIN

APPENDIX C

Command and Surveillance Equipment

Contents

Command and Surveillance Equipment

C.1 Introduction

The purpose of this Appendix is to compare military and commercial sonar equipment suitable for use on a small submarine escort ship and a fully capable ASR/T-ASR. Section C.2 compares the characteristics and capabilities of available sonar systems. Sections C.3 and C.4 describe the electronic equipment (communication, navigation, sonar, etc.,) assumed for small submarine escorts and fully capable ASR/T-ASR's respectively.

C.2 Comparison of Sonar Equipment

The characteristics and capabilities of available shipboard active sonars, fathometers, and acoustic communication sets are compared in Tables C2-1, C2-2, and C2-3 respectively. The comparison of commercial and military equipment is one of the main objectives for the ASR/T-ASR feasibility study. Certain advantages and disadvantages of commercial equipment are apparent:

a. Initial procurement costs are much less and commercial equipment usually requires less ship volume and ship services.

b. Commercial equipment frequently has less overall system capability and will not have good logistic support during the ship life.

It is the need for system documentation and logistical support that will often drive the initial apparent cost savings of commercial equipment up to a level comparable to military procurements. This "Life Cycle Cost" feature must always be stressed when comparing commercial versus military equipment. Differences in capabilities often deal with added feature flexibility rather than prime mission capabilities.

Since cost data is unavailable for the small ship sonars one general conclusion appears apparent. . . that is, they all have about the same performance capability. Although refurbishment of existing equipment is a valid option, procurement of a newer, state-of-the-art system should be stressed. This is again due to the "Life Cycle Cost" impact of supporting obsolete equipment.

C.3 Small Submarine Escort Electronics

The Small Submarine Escort must be capable of providing appropriate communication and navigation to escorted submarines during trials and test. The primary requirement is that communication with the submarine be good up to 10,000 yards separation. Tracking (range and bearing) the submarine during trials is also required, as well as the capability to act as a target.

TABLE C2-1 SHIPBOARD ACTIVE SONARS

	AN/BQS-4 AN/BQR-21	AN/SQS-51	AN/SQS-38
Frequency	6.4 KHz		11.9-14.1KHZ
Range Scale	20,000 yds	15,000 yds	20,000 yds
Weight	6212 lb	8710 lb	16,200 lb
Power Required	115v, 60Hz,1Ø 4680w 115v, 400Hz, 3Ø 2500w	115v,60H, 1Ø 3500w	440v,60Hz,3Ø 7600w 115v, 60/400Hz, 3Ø 4000/740w
Cost	——	——	——

	AN/SQS-56	AN/SQS-505	Edo 610
Frequency	7.5KHZ	4KHz	7KHz
Range Scale	20,000 yds		32,000 yds
Weight	10,556 lb	11,500 lb	12,280 lb
Power Required	440v, 60Hz, 3Ø 10.900w	440v, 60Hz, 3Ø 7200w 115v, 60/400Hz, 3Ø, 500/5500w	440, 60Hz, 3Ø 12500w 115v, 60/400Hz, 3Ø, 5000/200w
Cost	——	——	——

TABLE C2-2 SHIPBOARD FATHOMETERS

	RAYTHEON DE-735	RAYTHEON DE-731	AN/UQN-4
Frequency	125KHz	40KHz	12KHz
Depth	0-156 fathoms	0-140 fathoms	1-6000 fathoms
Weight	35 lb	61 lb	430 lb
Power Required	32 vdc, 26.5 w	115v, 60Hz, 1Ø, 40w	115v, 60Hz, 1Ø 320w
Cost	$1875	$2250	$32,000

TABLE C2-3 SHIPBOARD ACOUSTIC COMMUNICATIONS SETS

	AMT-504	AN/WQC-2
Frequency Bandwidth	8-11 KHz	8-11 KHz 1.5-3 KHz
Power Output	100 w	400-550 w
Weight	75 lb	900 lb
Power Required	28vdc, 490 w	115v, 60Hz, 1Ø 2000 w
Cost	$8,000	$35,000

Table C3-1 contains a list of the required functions and indicates the equipment selected depending upon whether commercial standards or military standards were assumed. Note that it is anticipated that the tracking function will be accomplished using a "pinger" on the submarine and triangulation equipment on the escort ship. Such a system requires development in later design stages although this concept has been used on the ASR 21 Class. As a fallback, weight, space, and power have been provided for the AN/SQS-51 active sonar. Commercial equipment has not been selected for all functions, since weight, space and power required for these are assumed relatively small compared to the sonar equipment.

C.4 Fully Capable ASR/T-ASR Electronics

The fully capable ASR/T-ASR has basically the same requirements (to communicate, navigate, track, and act as a target) as the small submarine escort. Table C4-1 contains a list of required functions and indicates equipment selected depending upon whether commercial standards or military standards are assumed. Due to the larger size vessel, some additional electronic equipment will be installed. A comparison of Table C3-1 and Table C4-1 indicates the additional equipment.

TABLE C3-1 Small Submarine Escort Electronics

Function	Commercial Standards	Military Standards
Exterior Communications		
HF/VHF XCVR	——*	AN/URC-94
UHF XCVR	——	AN/ARC-159
HF Voice Security Equipment	——	TSEC/KY-65
UHF Voice Security Equipment	——	TSEC/KY-8
Interior Communications	——	Standard sound powered telephone
Navigation		
OMEGA Receiver	MACKAY 4005A	AN/SRN-17
Sonar		
Underwater telephone	STRAZA ATM-504	AN/WQC-2
Fathometer	Raytheon DE-736	AN/UQN-4
Sonar for Submarine Tracking	**	**
(active sonar fallback)	Edo 610	AN/SQS-51 (or AN/SQS-56)
Sonar Acoustic Target Simulator	——	SATS III (AN/WQM-6)
Other		
Bathothermograph	——	AN/SSQ-61
Gyro	——	MK-27 Mod 1
Surface search radar	LN-66	——

*Items left blank because specific equipment selection is either impossible or inappropriate at this stage of design. Also, the equipment selections shown are only tentative and for feasibility study purposes.

**This system must be developed in later design stages; a triangulation system utilizing a "pinger" on the submarine.

TABLE C4-1 Fully Capable ASR/T-ASR Electronics

Function	Commerical Standards	Military Standards
Exterior Communications		
HF/VHF XCVR	——— *	AN/URC-94
UHF XCVR	———	AN/ARC-159
HF Voice Security Equipment	———	TSEC/KY-65
UHF Voice Security Equipment	———	TSEC/KY-8
Lifeboat radio	———	———
Interior Communications		
Sound powered telephone	———	———
Amplified voice communication	———	———
Electric alarm	———	———
Navigation		
Automatic Radio Direction Finder (OMEGA or LORAN)	——— ———	AN/SRN-17 AN/SPN-38
Collision avoidance & alarm	———	———
Underwater Log	———	———
Sonar		
Underwater telephone	STRAZA ATM-504	AN/WQC-2
Fathometer	Raytheon DE-736	AN/UQN-4
Sonar for Submarine Tracking	**	**
(active sonar fallback)	Edo 610	AN/SQS-51 (or AN/SQS-56)
Sonar Acoustic Target Simulator	———	SATS III (AN/WQM-6)
Other		
Bathothermograph	———	AN/SSQ-61
Gyro	———	MK 23
Surface Search Radar	LN66	AN/SPS-55 (or AN/SPS-10F)

*Items are left blank because specific equipment selection is either impossible or inappropriate at this stage of design. Also, the equipment selections shown are only tentative and for feasibility study purposes.

**This system must be developed in later design stages; a triangulation system is anticipated utilizing a "pinger" on the submarine.

APPENDIX D

DRAWINGS