

**APPLICATION OF THE SYSTEMS ENGINEERING APPROACH TO THE
CONVERSION OF OCEAN SURVEILLANCE VESSELS INTO
HYDROGRAPHIC SURVEY, BUOY TENDING, AND GENERAL
OCEANOGRAPHY MISSIONS FOR THE NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION**

by

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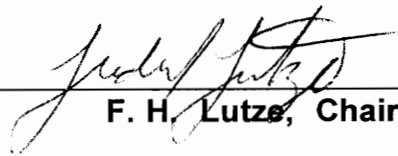
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in

Systems Engineering

APPROVED:



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Dedication:

To Pipin, Yorkie with attitude

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List of Abbreviations

ABS	American Bureau of Shipping
CFR	Code of Federal Regulations
CTD	Conductivity, Temperature, Depth
DOLPHIN	Deep Ocean Logging Platform for Hydrographic and Instrumentation Navigation
EEZ	Exclusive Economic Zone
GFM	Government Furnished Material
GM	Transverse Metacentric Height
HM&E	Hull, Mechanical & Electrical
HSHR	High Speed High Resolution
HSL	Hydrographic Survey Launch
KG	Distance from the Keel to the Center of Gravity
MSC	Military Sealift Command <u>or</u> U.S. Coast Guard Marine Safety Center
MVI	Marine Vessel Inspection
NAVSEA	Naval Sea Systems Command
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
OAR	Oceanic and Atmospheric Research
ONCO	Office of NOAA Corps
PNA	Project Naval Architect
ROM	Rough Order of Magnitude
ROV	Remotely Operated Vehicle
SAMM	Shipboard Automated Maintenance Management
SOC	SURTASS Operations Center
SPO	NOAA Systems Program Office
SURTASS	Surveillance Underwater Towed Array Sensor System
T-AGOS	Oceanographic Surveillance Ship, Operated by the Military Sealift Command
TAO	Tropical, Atmospheric, and Oceanic
USCG	United States Coast Guard

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1.0 Introduction

1.1 Purpose

The intent of this report is to demonstrate how the systems engineering approach is applied to ship conversion feasibility studies. Feasibility study designs for two T-AGOS 13 class conversions are described. The two missions under study are 1) Low to Medium Endurance Charting and 2) Tropical, Atmospheric and Oceanic (TAO) Program Support; these missions are described at the end of the introduction section. The National Oceanic and Atmospheric Administration (NOAA) may eventually acquire up to five vessels of the T-AGOS 13 class; four will likely be converted to the charting mission and one to the TAO support mission.

This report will focus on requirements definition and trade-off studies performed during the feasibility and preliminary design phases. During these phases, requirements were defined and various options were explored and presented to the customers in areas such as General Arrangements, Weights and Stability, Machinery, and Distributive Systems.

1.2 Design History

In October 1984, NAVSEA completed the contract design for the Navy's T-AGOS 13 class. The T-AGOS 13 class is a 224 ft length overall, diesel electric powered ocean surveillance ship, built by Halter Marine of New Orleans, LA. The final ship of the class, T-AGOS 18, was delivered to the Navy's Military Sealift Command (MSC) in 1988. The T-AGOS 13 Class accommodates 33 Officers, crew, and technicians. Her sole mission is to deploy, monitor, and transmit data obtained from the SURTASS (Surveillance Towed Array Sensor System) array.

With the end of the Cold War, the shrinking operations and manpower budget for the Navy, and the award and construction of the Navy's new T-AGOS 19 class and later the T-AGOS 23 class of SWATH (Small Waterplane Area Twin Hull) ocean surveillance ships, the requirement for the earlier monohull T-AGOS vessels was greatly diminished. Since the Navy no longer needed the vessels, but they were still quite early in their service life, several of the hulls had their SURTASS equipment removed and they were given to NOAA. The National Ocean Service (NOS) and the Office of Oceanic and Atmospheric Research (OAR) were the two branches of NOAA which expressed interest in obtaining one or more of the T-AGOS vessels.

In february of 1991, NAVSEA formed a small design team in order to perform Rough Order of Magnitude (ROM) Studies to evaluate NOAA's mission needs as stated in ref (f), "5,000 Days at Sea". These studies were used solely for the purposes of cost estimating, in order for NOAA to present their case to congress for funding. Two of the dozen or so studies performed were for T-AGOS 13 class conversions into the two missions described above.

In June of 1992 shortly after the first T-AGOS 13 class hull was delivered to NOAA, the NAVSEA design team inspected the T-AGOS 13 and work began on the preparation of ref (a), the feasibility study for the Mapping and Charting Conversion. In December of 1992, I became the Project Naval Architect (PNA) for the conversions and completed ref (a) in March of 1993. That summer, M. Rosenblatt and Son (MR&S) was awarded a contract for the preliminary design and specification development of the Charting Conversion, while John J. McMullen and Assos. (JJMA) was awarded a similar contract for the TAO Support Mission Conversion. The following sections of this report document several of the more significant design decisions and trade-off studies performed by myself, a few co-workers during the feasibility design phase, and by contractors under my direction during the preliminary design. Figures prepared by one of the above contractors are so noted.

1.3 Trade-Off Studies

Trade-off studies are necessary when evaluating any complex system in order to optimize the baseline design and to verify the feasibility of requirements. Utilizing a systems methodology, the designers' goals were to provide NOAA with the most cost effective solutions to meet their mission requirements. If, however, the total ship impacts due to implementing these requirements were judged infeasible, it was the designers' responsibility to demonstrate this to the customers with all feasible alternatives. The requirements document could then be revised to alleviate the infeasible requirement while still meeting the mission needs as best as possible.

With the conclusion of all necessary trade-off studies, the baseline configuration comprising the total ship system was "frozen" in order to work out the design details, or subsystems. These subsystems will provide the basis for preparation of the shipbuilder solicitation packages, which contain the contract, specifications, and drawings detailing

the government's requirements for the conversion work. The solicitation packages are structured such that shipyard cost estimators can easily bid on the conversion work and support services necessary. After the government answers any questions from the shipbuilders, they will return their closed bids and proposals to the government and the source selection process will end when the contract is awarded.

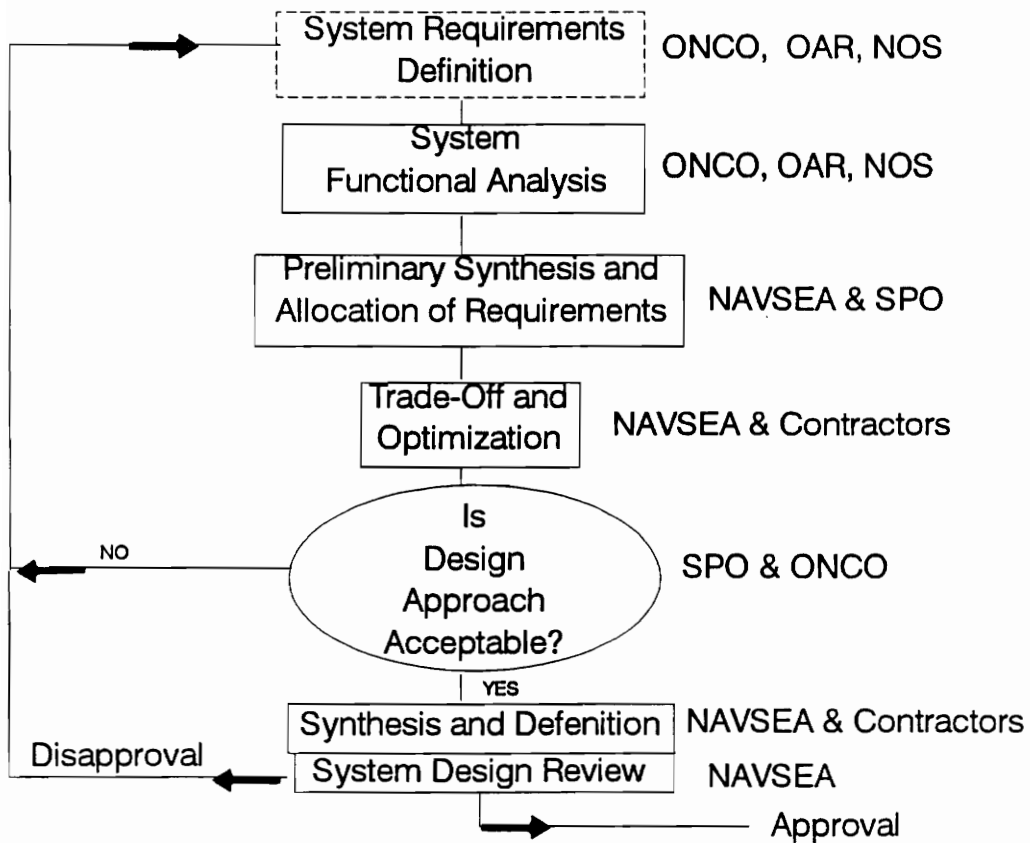
1.4 Design Management

Figure (1) is a generic diagram modified from ref (e) to depict the work & decision making flow generally used on the conversion design process. Those organizations responsible for action are noted next to each step in the process.

It is important to note that figure (1) shows an idealized process which often was not the case in practical terms. Design decisions were not always evaluated as the designers, i.e., NAVSEA and the contractors would have liked. In the end, when cost, schedule, and inter-NOAA politics became more important than the technical adequacy of the conversions, the design teams did as the customer wished; which is difficult when customer/supplier relationships are not well defined. In any case, the requirements often were not revised to reflect design decisions, as long as the project office felt that the spirit of the document was met.

FIGURE (1) - Preliminary System Design:

T-AGOS 13 Conversion Design Process



1.5 Overview of Sections

Section (1) contains a detailed description of trade-offs made within the area of General Arrangements. The general arrangements are among the most critical elements of a successful design. General arrangements encompass the overall layout of the ship, both internal and external. On a new design, a required area/volume estimate would be performed, along with the initial placement of subdivisions and location of major subsystems such as the placement of machinery, living, and ship control spaces. As a starting point, broad requirements such as manning estimates and propulsion system type, derived from a mission profile would be needed. Topside arrangements can also drive the total ship size necessary to meet mission needs.

In the case of the T-AGOS conversions, the large majority of the usable volume is already fixed. The major challenges were to provide mission space layouts and arrangements of deck systems to fully meet mission needs at a minimum amount of change to the pre-conversion configuration. With this as the goal, NOAA required that several arrangement studies be performed in order to determine the number and size of launches, the size and configuration of laboratory spaces, and the maximum number of accommodations which could be provided.

The 34' notional launches discussed in section (1) for the charting conversion are being considered as replacements for the existing 29' launches by ONCO (Office of NOAA Corps). Similarly, the Deep Ocean Logging Platform for Hydrographic and Instrumentation Navigation (DOLPHIN) Remotely Operated Vehicles (ROV's) are being considered as either replacements or additions to the current method of obtaining hydrographic survey information, i.e., the manned launches. The size of the labs was studied in order to trade-off the amount of equipment in that could be carried aboard versus the extent of modification necessary to the ship; much of the mission equipment desired by NOAA is redundant.

Section (2) compares the ship characteristics of both conversions for reference purposes. Weight estimates for both conversions are also provided. These estimates were necessary for determination of the stability status of the conversions as analyzed in section (4). Additions, removals, loads, and margins are all accounted for. These weights when examined with their associated moments further determine the amount of fixed or solid ballast necessary to

assure that all operating points, from the full load condition to light ship, will meet the stability, as well as static heel and trim limits imposed by the USCG and the original ship's specifications.

Section 2.3 contains the speed/power curves for the T-AGOS 1 and 13 classes; the hull forms were identical. The curves were obtained from model tests performed by the Navy during the T-AGOS 13 class design. They are included because an older version of the requirements document required that the charting conversion's minimum sustained speed be equal to that of the Fairweather Class (the existing medium endurance charting platform). The Fairweather class has a sustained speed of 12.8 knots in calm water. The existing T-AGOS 13 class is driven by two 800 HP motors and can reach 11.7 knots in calm water. The two points marked on the 14.91' draft speed/power curve indicate the existing full power operating point and the point which could theoretically be reached if the motors could be upgraded to deliver 960 HP each. This is the maximum power available for propulsion assuming that no new generating capability would be added. Section 10 further details this study.

Section (3) provides an overview of the mission arrangement requirements and layout of spaces. The required and actual areas are provided along with preliminary arrangements of the two most important mission spaces on the charting conversion, the Data Acquisition and Data Processing Rooms. These space arrangements are critical to the utility of the vessel, and are therefore included for reference.

Section 3 also contains a discussion of the habitability spaces. With the increase in crew size of the charting conversion from 33 to 42, the level of habitability is a critical issue. The Navy has found that reenlistment rates and crew performance increase as the level of habitability increases. Human factors engineering is a part of any well designed system with a man/machine interface, and comfortable berthing, recreation, and messing spaces should increase the overall mission effectiveness of the crew.

Section 3 further discusses tankage changes to meet the new endurance requirements on both conversions and the DOLPHIN ROV system. The reduced tankage allows for the optimum placement of fixed ballast in the charting conversion; low KG with the proper centers to correct for list and trim, and for the similar use of saltwater ballast in the TAO conversion.

Section (4) contains a summation of the changes necessary to meet USCG damage stability requirements for oceanographic research vessels. NOAA requested that the designers investigate every feasible alternative for meeting Subchapter U requirements as called out in both conversions' requirements documents. NOAA requested the stability trade-offs in order to determine the most cost effective alternatives to modifying the bulkhead between the Propulsion Motor Room and the Machinery Control Station into a watertight subdivision. Tables 13 and 14 are the final matrices prepared to compare the actual and allowable damaged KG (vertical center of gravity) for the 10 options investigated, taken separately and in combination. The accompanying figures plot the allowable KG with and without the recommended design modifications.

Section (5) contains a breakdown of NAVSEA's recommended approach to weight and KG margins. A summary of the total impact of the margins is also included, as well as the designers' approach to obtaining a baseline weight and KG estimate.

The weight estimate is a critical tool for meeting the requirements. The estimate is used along with hydrostatic calculations to assure the customer that stability requirements can be met while retaining a satisfactory weight and KG allowance for all contingencies, e.g., contract modifications and government furnished material.

Section (6) addresses the impacts of increasing the accommodations on the Charting Conversion from 33 to 42. This trade-off study was originally performed in the course of the feasibility study, ref (a). It was necessary in order to validate that support services such as distilling capability, sanitary treatment capability, and power and HVAC would be adequate for the increase in the hotel services load. The findings indicate that the hotel services were designed with adequate redundancy and margin to accommodate the increase in personnel.

Section (7) provides an overview of the deck systems equipment and arrangement. The deck systems on both conversions are intrinsic to mission performance. The primary mission of the TAO Conversion is to retrieve and deploy buoys, this section provides a description of how the mission is performed and why equipment such as cranes, frames and winches are arranged as they are.

Similarly, the deck equipment on the Charting Conversion is in the critical path to mission performance. The primary mission of the charting conversion is to serve as a mother ship for the Hydrographic Survey Launches (HSLs). The design of the HSL davits, and the method of loading and offloading equipment and personnel is the single most important aspect of the conversion design to the customer. Secondary missions, such as the provision of an A-Frame for the towed sonars are also addressed. This section demonstrates how all of the requirements are fully met.

Section (8) describes some of the early stage machinery analyses performed to assure the adequacy of the T-AGOS 13 class systems to meet the new mission needs of the converted vessels. An electric load summary and its method of calculation is provided. The summary was required to assure the designers and customers that adequate power would be available to carry out each mission scenario.

The bow thruster options examined in section 8.2 were required by the customer because of their concern over sonar performance. ONCO was concerned that placement of the charting ship's hull mounted sonar may result in inadequate performance due to aerated water flowing in way of the transducers; the bow thruster was thought to be a possible cause of this. The options discussed in section 8.2 were presented to ONCO in the hopes of removing section 9 of the Charting Mission Requirements Document pertaining to bow thruster modifications. This section was never removed, however, the design team was given verbal assurance that bow thruster modifications would not be necessary with the baseline transducer location described at the end of section (8).

Section (8) further examines new machinery requirements for both conversions. New requirements for Hydraulic Power Units (HPU's) and fan rooms are described. These support systems are necessary to provide hydraulic for the new deck machinery and the additional cooling requirements for the new air conditioned volume and heating loads being added. A final discussion of new regulatory body impacts to the conversions is presented. Both HALON (used as an extinguishing agent) and R-12 (used as a refrigerant) will no longer be in production during the service life of the converted vessels. Section (8.5) discusses alternatives investigated during the feasibility design phase.

Section (9) provides an overview of NOAA's maintenance concept for the conversions. It is important to note that the design teams were not involved in any logistical or RMA analyses, so some of the information presented is assumed; as pointed out in the body of the text. Ref (f) does contain a section on general logistics requirements for the new NOAA fleet, so much of the general information contained in this section was taken from this reference.

A well designed system is not only concerned with minimizing acquisition cost while meeting mission needs, but support during service life is also critical. For a design to be operationally feasible, reliability, maintainability, and supportability are critical areas of concern. The conversions will be supported by NOAA's Marine Centers under the same procedures as other newly acquired vessels. The basic NOAA philosophy regarding RMA is to provide redundancy where ever possible. This is evident when examining the list of mission electronics contained in appendix (a). All of the antennas called out are provided with both installed and back-up spares. Spare electronics are also carried within the Electronic Technician's (ET) Shops and mission storerooms on both conversions. Again, the equipment carried aboard is required by NOAA, and no RMA analysis was carried out by the design teams. Section (9) further contains ILS guidelines for the shipbuilder which could be incorporated into the contract and specifications. These guidelines should facilitate supportability for the Marine Centers through commonality of contractor furnished equipment. A generic guide describing maintenance levels is also included; it is meant as an example of how subsystems might be supported.

Finally, a maintenance flow diagram for pre-mission readiness tests was provided. This diagram was derived primarily from the existing Engineer's Operating Manual for the T-AGOS 15 through 18, Ref (i). The diagram represents a possible flow of pre-mission tests which may be conducted prior to a deployment by the ship's force.

Section (10) is the results of a NAVSEA trade-off study performed at NOAA's request during the Charting Conversion Feasibility Study. As discussed in the introduction to section (2) above, NOAA was interested in determining the maximum sustained speed attainable without adding additional generating capability. This section contains a matrix of six options examined which would utilize all of the remaining power of the existing generators running at 90% capacity.

1.6 Mission Backgrounds

1.6.1 Charting Mission - The T-AGOS 13 Class Charting Conversion was originally intended as a replacement of the Fairweather class, a NOAA Class II (Medium Endurance) Mapping and Charting Ship. After completion of the NAVSEA feasibility study, ref (a), however, certain branches of NOAA representing those responsible for data collection (NOS), ship operation (ONCO), and the acquisition program office (SPO) agreed that the T-AGOS 13 class was not a suitable platform to fully meet the mission requirements of a NOAA class II charting vessel. The primary shortfalls were the number of accommodations that could be provided and the sustained speed. As a result, the charting conversion is currently referred to as a "low/medium" endurance vessel.

The charting conversion will replace the Davidson class, a NOAA Class I (Low Endurance) Mapping and Charting Ship. The first of the converted vessels will operate off the east and gulf coasts. The Davidson class operates two 29' survey launches and accommodates 42 personnel. The T-AGOS 13 class conversion will operate two additional launches, have a larger endurance, much larger laboratory facilities, and a higher sustained speed than the Davidson Class, which can only make 10 knots.

The design presented within the body of this report has been modified from the feasibility study of ref (a) to suit the new lower endurance mission. The feasibility study requirements document stated that the Charting Conversion would potentially operate in any waters of the U.S. Exclusive Economic Zone (EEZ), including Alaska and Hawaii. The current document calls out an area of operation consisting of near shore waters off the east coast and gulf of Mexico. In relation to this, the sonar requirements have been changed from intermediate depth missions of 150 - 600 meters to shallow depth missions of 10 - 150 meters. Endurance and speed requirements were also reduced. The single most important shortfall of the T-AGOS vessels, however, is in the area of manning. The Fairweather class can accommodate 70 personnel while T-AGOS 13 class was designed to accommodate 33. Sections (3) and (6) describe the impacts of increasing the accommodations to 42, however, approaching 70 accommodations is clearly infeasible.

Information gained during the course of three separate inspections (Ship Checks) of USNS Relentless, T-AGOS 18, by the charting conversion design team has also been

incorporated into this report as contained in ref (d), the feasibility validation study report.

The primary mission of the Charting Conversion is to perform seafloor mapping and surveying missions in the nearshore waters of the east and gulf coasts. The seafloor maps are used for fishing and resource assessment, identification of submerged hazards, and management of the marine environment. A tabular list of requirements is contained in section (1). The anticipated home port of the first converted vessel, the former T-AGOS 18 is the Atlantic Marine Center in Norfolk, Virginia.

Deck operations are described in section (7), they are to include the following:

- 1) Boat launching and retrieval
- 2) Side scan sonar operations
- 3) Velocimeter/CTD/rosette casts
- 4) Bottom sampling
- 5) Small ROV deployment and retrieval (unspecified)
- 6) Crane operations
- 7) Vessel line-handling activities
- 8) DOLPHIN (ROV) handling operations
(future capability)

Acoustic survey operations include:

- 1) Shallow depth multibeam surveys at cruising speed using hull-mounted transducers
- 2) Side-scan sonar operations at speeds of 3 knots through cruising, with transducer towed astern
- 3) Single-beam* (24 Khz) using hull mounted system
- 4) Launch hydrography using 4 launches equipped with High Speed High Resolution (HSHR) side scan sonar and single beam echo sounder
- 5) Shallow/intermediate depth surveys using 2 DOLPHIN ROV's as a possible future addition
- 6) Conduct resource assessments as a possible secondary mission concurrent with primary missions

* A single beam transducer can be used for checking data points from the multi-beam sonar, but it cannot produce maps of the ocean bottom with 100% coverage without severely limiting the speed of the vessel. The speed of advance for 100% bottom coverage is also dependent on the depth.

Shallow depth multi-beam surveys will be performed using the new transducers added to the bow just forward of the bow

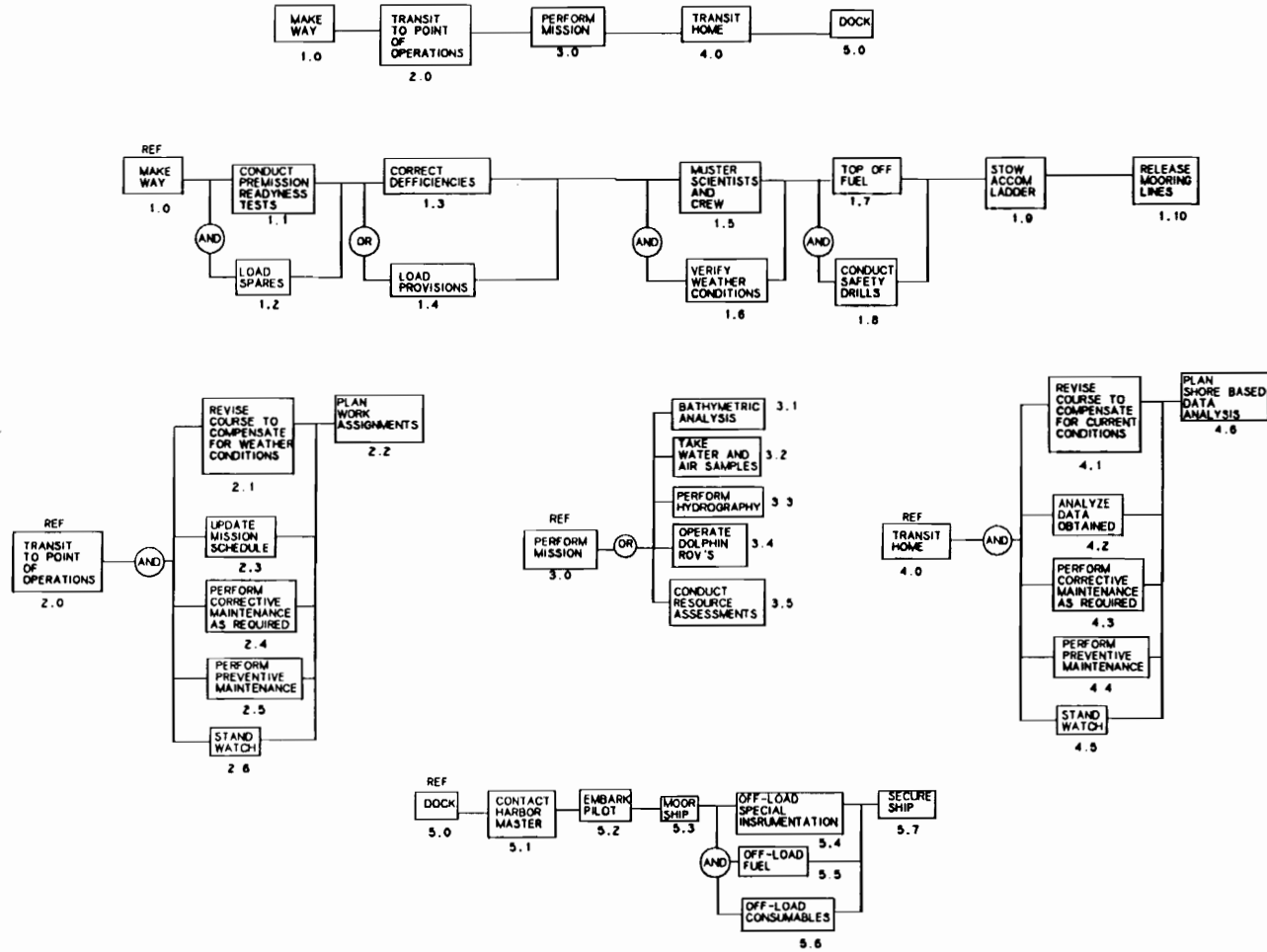
thruster tunnels, section (8.2.3) discusses this installation. Both sidescan sonar, and HSHR sonar operations are performed using the winches added to the 01 level at frame 86. These can be controlled either locally or remotely from the Aft Control Station. The sonars will be towed from the new A-Frame installation on the Poop Deck. The installations are depicted on the general arrangements sketches in section (3).

Section (7), Figure 19 is a plan view depicting the location of the 4 hydrographic survey launches and the DOLPHIN ROV system. The DOLPHINS are further discussed in section (3).

No specific design features were necessary to incorporate the conducting of resource assessments, which involves mission personnel counting wildlife species in order to ascertain population shifts.

Figure (2) is a simplified functional analysis for the charting conversion. Ship operations are detailed to the second level while mission operations are carried out to the third level in order to give some idea of what the charting mission entails.

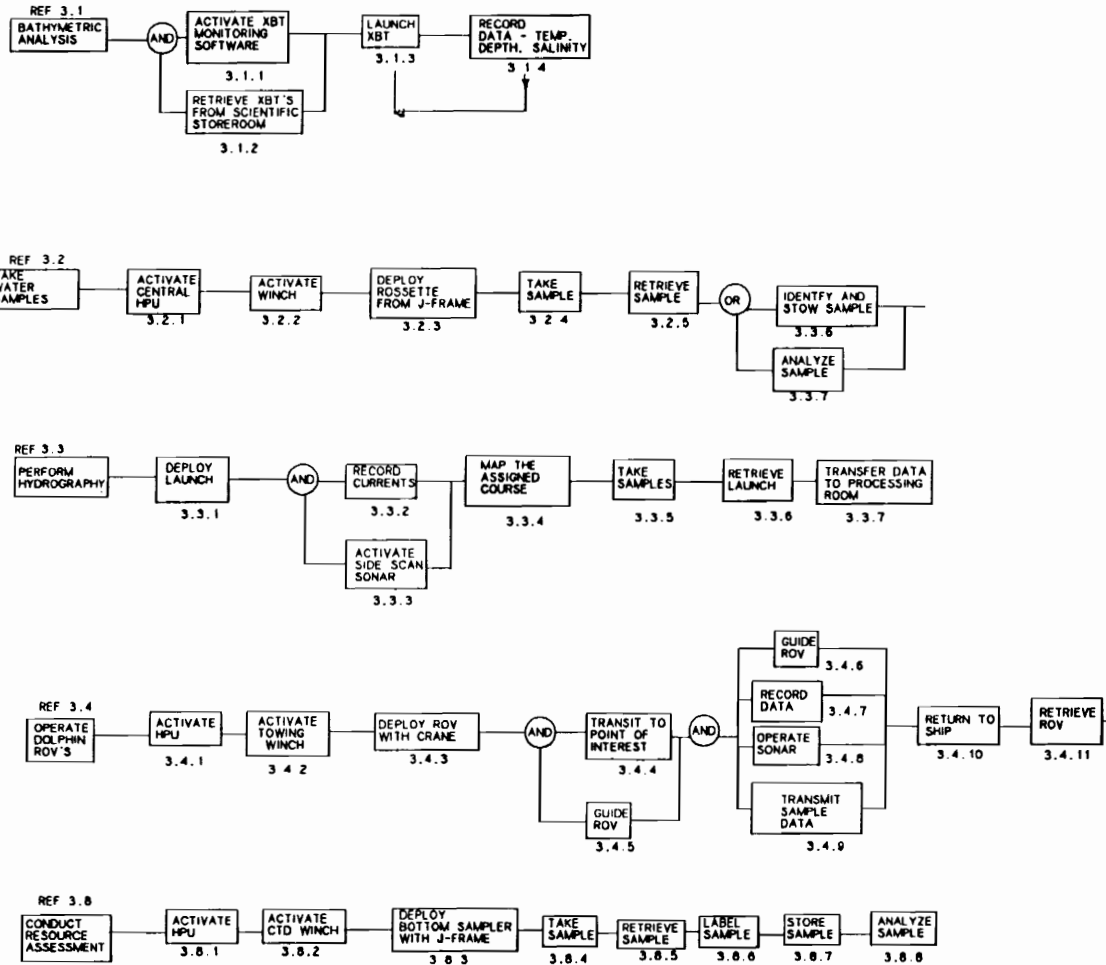
FIGURE (2)
 CHARTING CONVERSION
 FUNCTIONAL FLOW DIAGRAM
 (TO THE SECOND LEVEL)



13

CHARTING CONVERSION
FUNCTIONAL FLOW DIAGRAM
(THIRD LEVEL - MISSION)

FIGURE (2) CONT.



14

1.6.2 TAO Support Mission - The TAO Support mission can be summarized as that of an open ocean buoy tender. A tabular list of requirements is contained in section (1). The mission is currently carried out by a number of ships of opportunity. The TAO Support ship will be the first ship specifically designed or converted to carry out its mission, which consists of the deployment and recovery of deep ocean moorings and associated oceanographic observations, and the collection of upper air boundary atmospheric data.

The configuration of the TAO Conversion was designed with many features which will make it the most suitable mission platform for maintaining TAO buoys that NOAA has had at its disposal. Major design features include a raised fantail, a customized A-Frame, 2 buoy assembly areas, and a stowage system specifically designed for buoy components. Section (3) contains the general arrangements of the vessel which depict these design features.

The raised fantail will facilitate working deck operations by allowing the top of the bulwark to retain its current distance of 13 feet above the waterline, keeping water on deck to a minimum, while reducing the height of the freestanding bulwark to the standard 4 feet. This will provide good visibility over the side for the crane operators.

The customized A-frame will be specified with the preferred dimensions for passing fully assembled TAO array buoys through its throat. The current TAO support ships do not have an A-frame large enough to use the A-frame for buoy handling.

The buoy assembly areas will allow the bridles and anchors to be attached simultaneously. They will also allow two buoys to be pre-assembled and properly secured in place prior to arrival at the buoy sites.

The mission stowage system consists of recessed padeyes in the deck which provide a tie-down method for buoy components. There is also a scientific storeroom with a hatch providing access to the fantail for stowage of items which should be kept out of the weather. The storeroom is provided with a grid pattern for portable battens, providing a flexible stowage area.

The TAO Conversion will operate year round in waters of the Equatorial Pacific from Central and South America to the

international dateline. The data collected is used for numerical modeling of thermal and current structure, including the tracking of El Nino events. The vessel designated for conversion to the TAO support mission is the former USNS TITAN (T-AGOS 15). The anticipated home port of the vessel is Honolulu, Hawaii; but the ship will operate from several ports including Guam.

The TAO array consists of 70 moored buoys which span the basin from 95 Degrees West in the Eastern Pacific to 135 Degrees East in the Western Pacific. The buoys provide monitoring of wind and upper ocean thermal current structure used for development of numerical models and diagnostic studies. The TAO support ship will replace these buoys where necessary on an annual basis. If replacement is not necessary, the workboat will be utilized to change batteries and collect data not transmitted via satellite.

Deck operations to be conducted will include:

- 1) Boat launching and retrieval
- 2) Velocimeter/CTD/rosette casts
- 3) Bottom sampling
- 4) Crane operations
- 5) Vessel line-handling activities
- 6) Buoy retrieval, maintenance, and replacement
- 7) Data checking and calibration of buoy instrumentation
- 8) Launching of weather balloons for upper air sounding

1.6.3 Oceanography Mission:

Both conversions will be outfitted with wet labs and handling equipment for obtaining Conductivity, Temperature, and Depth (CTD) readings, and shallow core samples. This oceanographic requirement is related to the primary missions described above; since calibration of the charting sonars depends on accurate CTD information, while the TAO Support mission can benefit from a data check of buoy readings. The CTD information can be used for thermal boundary layer mapping as well as for checking ocean salinity at various depths. Sampling rosettes can also be deployed from the J-frames for obtaining samples at different depths. These will be analyzed and stowed in the wet lab on both conversions.

2.0 REQUIREMENTS

The proceeding three tables list the conversion requirements in an abbreviated form. The information was distilled from the requirements documents contained in appendix (a). Meeting these respective minimum requirements was the primary goal of the two design teams.

2.1 Tabular List

**REQUIREMENTS FOR NOAA LOW/MEDIUM ENDURANCE CHARTING SHIP
T-AGOS 13 CLASS CONVERSION**

Table 1 - Charting Conversion Requirements

Total Accommodations	42
Sustained Speed (knots, calm water)	11 (existing T-AGOS 13 class capability)
Range (nautical miles)	8,000 at sustained speed
Endurance (days)	30
Charting Lab Area (sqft)	1,350 (Acquisition & Processing)
Wet Lab (sqft)	175
Working Deck Area	No specific requirement
Scientific Stores (cuft)	2,500 at 6.5 feet high
Itinerant Load (long tons)	13*
Vans	2**
Helicopter/ROV	None/DOLPHIN System***
Cranes	Service A-Frame (1,500 lb at sea rating) Service J-Frame (1,500 lb at sea rating) Service CTD Winch Drum (3,000 lb pier side rating) Service Survey Launches (1,000 lb at sea rating) Service Working Deck Hatches (1,000 lb at sea and 3,000 lb pier side rating) Service Stores Hatches (up to 14' over either side of vessel)

**REQUIREMENTS FOR NOAA LOW/MEDIUM ENDURANCE CHARTING SHIP
T-AGOS 13 CLASS CONVERSION - Cont.**

Table (1) - Cont.

Frames	One Stern A-Frame One Side J-Frame
One High Speed High Resolution (HSHR) Sonar Winch	Capable of deploying 1,310 feet of .72" diameter electro-mechanical wire
One Side Scan Sonar Winch	Capable of deploying 984 feet of .442" diameter electro-mechanical wire
One Conductivity, Temperature, Depth (CTD) Winch	Capable of deploying 9,842 feet of .322" diameter of electro-mechanical wire
Capstans	18" diameter barrel, 10,000# line pull @25 ft/min
Station Keeping	Sea state 5 at 9.7 second wave period with wind speed of 27 knots without rudder input (existing T-AGOS 13 class capability)
Precision Trackline	Sea state 5 with 2 knot surface current with 27 knot winds acting at right angles to track (existing T-AGOS 13 class capability)
Boats	Four 29' Hydrographic Survey Launches One 17' to 19' workboat One 20' Rescue Boat

- * To be placed at Frame 72 (144' aft of the forward perpendicular), 4 feet above the main deck
- ** It is acceptable to remove 2 survey launches for their installation
- *** To replace port side survey launches at NOAA's discretion - See section 3.2.4

**REQUIREMENTS FOR NOAA TAO SUPPORT SHIP
T-AGOS 13 CLASS CONVERSION**

Table 2 - TAO Conversion Requirements

Total Accommodations	33 (Existing T-AGOS 13 class capability)
Cruising Speed (knots, calm water)	11 (Existing T-AGOS 13 class capability)*
Range (nautical miles)	5,040 at cruising speed plus 230 hours on station at two knots**
Endurance (days)	35
Lab area (sqft)	200 - Instrument Repair Rm 350 - Computer room 175 - Wet Lab
Working Deck Requirement	No specific requirement
Scientific Stores (cuft)	2,500 @6.5 feet high
Itinerant Load (long tons)	60 minus buoy loadout***
Vans	2****
Helicopter/ROV	None
Cranes	Service A-Frame (8,000 lb at sea rating) Service J-Frame (1,500 lb at sea rating) Service top of former SURTASS Operations Center (1,500 lb at sea rating) Service Working Deck Hatches (1,000 lb at sea rating) Service Stores Hatches (up to 14' over either side of vessel @7,000#)
Frames	One stern A-Frame One Side J-Frame
One CTD Winch	Electric, with a capacity of 33,000 ft of .322" electro-mechanical wire
Capstans	18" dia barrel, 10,000# line pull @25 ft/min

**REQUIREMENTS FOR NOAA TAO SUPPORT SHIP
T-AGOS 13 CLASS CONVERSION - Cont.**

Table (2) - Cont.

Boats	One 15' to 17' workboat One 20' rescue boat
Station Keeping	Existing T-AGOS 13 class capability (see charting requirements table for details)
Precision Trackline	Not required

- * Additional speed is desired if found feasible
- ** Double the required range is desired if feasible
- *** Itinerant load is distributed evenly over working deck
- **** Vans can be placed in way of buoy assemblies

**COMMON REQUIREMENTS FOR NOAA CHARTING & TAO SUPPORT SHIPS
T-AGOS 13 CLASS CONVERSION (CONTINUED)**

Table 3 - Common Conversion Requirements

Ice strengthening	Existing T-AGOS 13 ABS class C is acceptable
Panama Canal Transit	Required
Noise Levels	Not to exceed T-AGOS 13 class noise levels for working deck & converted spaces
Load Line	Preconversion load line shall remain in effect
Dimensional Constraints	Existing length, beam and draft are acceptable

2.2 Previous Studies (Requirements Definition)

The design approach was similar for both conversions; meet all NOAA imposed requirements with a minimum of modifications, while giving the operators as many desirable features as the program office would support. Where a requirement seemed difficult or unnecessary, it was brought to the attention of the program office to consider its removal. Throughout this report, conclusions drawn at the end of each section will summarize what action was taken based on the results of the design trade-offs detailed. Changes to the existing configurations were to be minimized given the limitations on NOAA's budget.

2.2 Previous Studies (Requirements Definition)

This section will describe the major changes to the requirements document which were made during the feasibility and early preliminary design phases. Certain changes were based on findings of the NAVSEA design team as described in the introduction, while others were imposed by the customers as they solidified their mission needs.

Charting Ship - The original requirements called for two survey launches, of the existing 29' size. In the course of the feasibility design phase, documented in ref (a), this requirement was changed to four survey launches, with two of the launches removable for possible installation of the DOLPHIN ROV system. The requirements were then changed to provide for four 34' notional survey launches and possible DOLPHIN ROV installation. Finally, NOAA settled on four 29' survey launches with nothing to preclude the later removal of the port side launches and replacement with two DOLPHINS.

Similarly, requirements for the Charting Lab gross area were increased from 1,000 sqft required on the ROM study to 1,400 sqft in the first version of feasibility study requirements. This requirement was relaxed unofficially midway through the design, and studies providing between 600 and 800 sq ft labs were performed. The requirement was later increased to 900 sqft in the 11 Sept 92 requirements, and then to 1,500 sq ft. 1,350 sqft was the final requirement as the list of mission equipment was firmed up.

Additional changes were made to the configuration based on ongoing comments from the National Ocean Service (NOS). Initial arrangement studies placed the survey launches

outboard of the former SURTASS Operations Center (SOC) on the 01 level; this configuration was unacceptable to NOS since the launches were thought to be excessively high above the water line. This drove the survey launch location to the main deck; but when NOS further required that the boats be located as far forward of the propellers as possible, the boats were again raised to the 01 level. Figure (20), section 7.2 was prepared comparing the relative locations of the survey launches aboard the Fairweather Class with those of the T-AGOS conversion. As can be seen, even with the survey launches located on the 01 level, they are still closer to the water line than those of the Fairweather.

The number of accommodations was increased in the closing weeks of the study. The initial number was 33, which is the preconversion level. This was incrementally raised to 35, 38, 38 + 4 surge, and finally to 42. Section 6.0 details the ship impacts of raising the accommodations to this level.

Other changes made during the course of the study include the relocation of the J-frame, and the requirement for ISO container van stowage. The J-frame was initially located on the fantail, but NOS requested that it be relocated to amidships to avoid fouling the line during station keeping maneuvers. When the size of the survey launches increased to 34', the J-frame requirement was changed such that it was only required to be in place when the forward starboard launch was removed. NOS then backed away from this position allowing the survey launches to be relocated aft in order to keep the J-frame in place with all four launches aboard.

The ISO van requirement was relaxed from 4 vans initially, down to none required with the possibility of displacing a survey launch to accommodate one van; and then finally to 2 vans in way of survey launches.

TAO Support - The TAO Support requirements changed little from those in place during the ROM study. Because of the relative simplicity of the TAO conversion, few arrangements trade-off studies were conducted. The final configuration is quite similar to that of the ROM study, ref (b).

Most of the changes made during the course of the design stemmed from two design reviews held with Capt. Otto Stephin, NOAA OAR (Oceanic and Atmospheric Research). Capt Stephin is the current commanding officer of the TAO support vessels, these have included the NOAA ships OCEANOGRAPHER and DISCOVERER. At Capt. Stephin's request, the ISO van

requirement was revised as a space reservation with distributive systems connections. He further requested a Scientific Storeroom adjacent to the Instrument Repair Room and a new hull mounted sonar used for acoustic buoy release. These changes were easily accommodated

3.0 Ship Characteristics

3.1 Tabular List of major Characteristics

The following table is presented for the general information of the reader. Note that the only major differences in the ship characteristics of the two conversion designs are the weight and number of accommodations.

Table 4 - Ship Characteristics

Characteristic	Charting Conversion	TAO Conversion
Length Overall	224'-0"	Same
LBP	194'-2"	194'-6"
Beam	43'-0"	Same
Depth, Hull to Main Deck	20'-0"	Same
Draft, Design	14'-3"	14'-7"
Displacement, Full Load, Tons	2082	2173
Installed SHP	1600	Same
Sustained Speed	11 knots	Same
Propeller Dia	8'	Same
Electric Plant	(4) 600 KW/VAC Diesel Generators with common bus	Same
Stores - Scientific Engineering	2984 Gross 1495 Cuft	2607 Gross 1495 Cuft
Accommodations	42	33

3.2 Weight Summaries and Comparisons

The following tables are summations of weight estimates from ref's (c) and (d). They are included to inform the reader of what major subsystems are being modified, and to what degree. Note that very little modification has been made to the Propulsion, Electric, and Armament weight groups on both conversions. As can be seen, the major modification to the Charting Conversion is in the area of structural and auxiliary systems. The TAO Conversion is similar, however, the structural and auxiliary systems additions are much smaller. The primary reasons for this is the greater weights of boats, cranes, and frames needed on the charting mission, and the need for solid ballast as well. The TAO also has a much higher weight for loads, due to around 200 tons of additional fuel required over the Charting Conversion. Section (5) and the appendix include a more detailed description of the weights and endurance fuel requirements. Note that the weights in appendix (c) were rough estimates made on support of ref's (a) and (b), the current estimates were too lengthy for incorporation in this report.

Table 5 - Charting Conversion (Long Tons)

<u>Weight Group</u>	<u>Additions</u>	<u>Removals</u>	<u>Weight</u>
Structure *	132.0	71.75	877.96
Propulsion	0.0	.16	64.13
Electric Plant	0.0	1.32	124.46
Command & Surveillance	4.82	36.04	15.11
Auxiliary Systems	108.69	85.69	256.03
Outfit & Furnishings	13.64	25.95	159.07
<u>Armament</u>	0.0	0.0	.12
Lightship (w/o margins)	259.14	220.91	1496.89
Margins			43.29
Itinerant load			13.0
Total Lightship			1553.18
Loads (incl anti-roll tank)			542.55
Full Load			2096

* Charting conversion carries 72.23 tons of fixed ballast (considered structural weight above); T-AGOS 13 class carry 117 tons of salt water ballast (load item)

Table 6 - TAO Conversion (Long Tons)

<u>Weight Group</u>	<u>Additions</u>	<u>Removals</u>	<u>Weight</u>
Structure	20.34	16.58	818.13
Propulsion	0.0	0.0	64.09
Electric Plant	0.0	1.4	127.38
Command & Surveillance	4.5	37.4	12.13
Auxiliary Systems	60.7	73.89	210.09
Outfit & Furnishings	7.95	20.34	158.61
<u>Armament</u>	0.0	0.0	.13
Lightship (no margins)	93.49	149.61	1390.55
Margins			37.38
Total Lightship			1427.93
Loads			745.32
Full Load			2173

Table 7 - Weight Comparison, Charting Conv. vs. T-AGOS 13 Class

	<u>As Converted</u>	<u>T-AGOS 13</u>
T-AGOS 13 Lightship (inclining)	1459	1459
Weight of Conversion Package w/o blst	-34	-
Weight Margin	43	-
Ballast	72	117
Itinerant load	13	-
Converted Lightship	1553	-
Mission and Ship loads	506	670
<u>Roll Tank Fluid</u>	<u>36</u>	<u>36</u>
Full Load	2096	2282

Table 8 - Weight Comparison, TAO Conv. vs. T-AGOS 13 Class

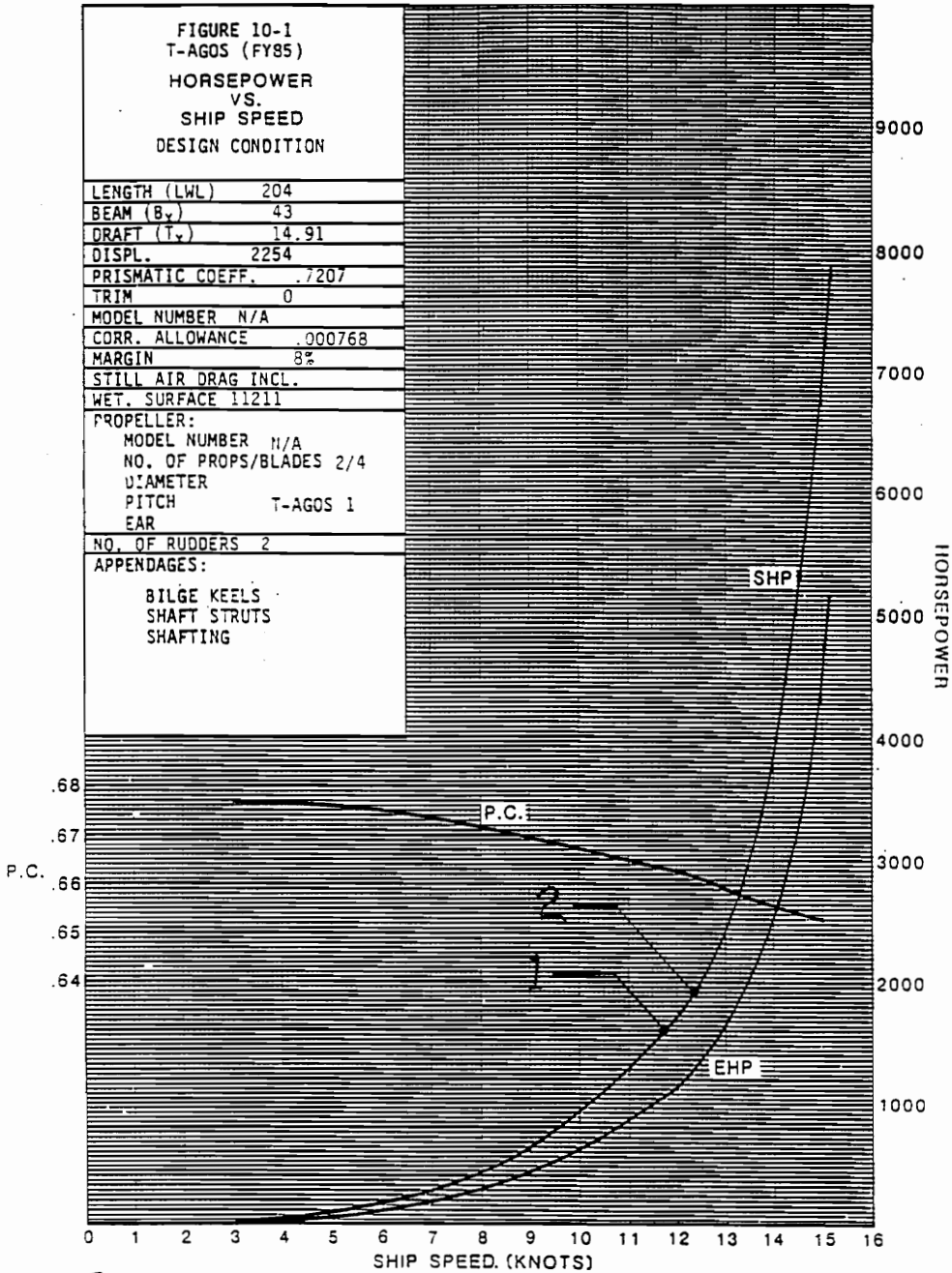
	<u>As Converted,</u> <u>Full Load</u>	<u>T-AGOS 13</u> <u>Full Load</u>
T-AGOS 13 Lightship (inclining)	1459	1459
Weight of Conversion Package	-56	-
Weight Margin	37	-
Ballast (Salt Water)	128	117
Converted Lightship	1428	-
Loads	709	670
<u>Roll Tank Fluid</u>	<u>36</u>	<u>36</u>
Converted Full Load	2173	2282

3.3 Speed/Power Curves

A Speed/Power curves from the T-AGOS 1 Class which is applicable to the T-AGOS 13 conversion is provided for reference, figure (3). The curve was obtained from ref (n). A draft of 14.91 feet, which is the closest draft to both of the conversion designs available is presented. The difficulty of increasing the sustained speed as requested in the requirements document of the TAO conversion (and previously in the Charting Conversion) is apparent, for more details see the repowering study, section 9.2.

Based on the rating of the propulsion motors and the speed/power curves, the maximum calm water speed is about 11.7 kts. This is in good agreement actual performance data obtained from operating T-AGOS 13 class vessels. With repowering, it may be possible to increase this speed to 12.5 kts. The current operating point and the estimated speed with repowering are marked on figure (3).

Figure (3) - Speed-Power Curve, 14.91' Draft



- ① T-AGOS 13 CLASS FULL POWER SPEED
- ② CONVERSION WITH REPOWERING

4.0 General Arrangements

4.1 Introduction

The baseline general arrangement drawings were developed with the intent of providing for the optimum mission configurations. During the course of the feasibility design study, elements of NOS began a serious effort to scrap the T-AGOS Charting Conversion in favor of a completely new design. At this point, the direction from the project office changed from minimizing the cost of the conversions to providing for the best possible mission platform. This is the same point at which NOAA decided that the Charting Conversion would serve more as a low endurance platform than a medium endurance vessel.

Along with this change in philosophy, many of the requirements for the charting conversion, such as accommodations, laboratory space, and the number of survey launches were increased in the final weeks of the feasibility study. The increase in mission requirements, combined with the user's desire for the general arrangements to resemble the existing medium endurance charting platform, drove extensive configuration changes late in the feasibility design phase of the charting conversion. Few changes to the requirements document for the TAO Support conversion were made since the completion of the ROM studies.

4.2 Charting Conversion Configuration

The most important considerations in the overall configuration of the vessel were the locations of the survey launches, the size and location of the Data Acquisition and Data Processing Labs, the requirement for handling the DOLPHIN (Deep Ocean Logging Platform for Hydrographic and Instrumentation Navigation) ROV, and the configuration of the working deck.

In order to make the converted T-AGOS ships resemble the existing NOAA medium endurance vessels, weather passages were added outboard of the hydrographic survey launch (HSL) stowage locations. These passages enable the HSL's to be boarded from the main deck instead of the 01 level. ONCO insisted on adding these passages, even though they meant a major configuration change, causing an increase in structural weight, and slightly degraded longitudinal strength. ONCO was concerned over the safety of crewmen

riding down the davits. This concern arises from the possibility of wave slap knocking crewmen out the HSL's during a recovery in heavy seas.

The increase in lab size requirements and the need for new weather passages described above, drove the baseline design to incorporate split lab spaces; the data processing function was separated from the data acquisition function. Total ship impacts caused by the split labs included the detrimental effects of adding structural weight abaft the Pilot House to incorporate the data acquisition function, as well as the additional cost of running HVAC ducting and power to the new space.

The addition of the DOLPHIN ROV system as a space and weight reservation drove the amidships crane to a much larger model than would have otherwise been necessary. It further degraded the ships stability by adding approximately 16 tons of weight to the 02 level, including supporting structure.

The working deck was raised primarily for the same reason as on the TAO conversion, i.e., in order to provide an additional measure of safety to crewmen working on deck by raising the distance from the waterline. An additional synergistic effect was the creation of usable volume beneath.

The enclosed general arrangement sketches at the end of this section depict the configurations discussed above.

4.3 TAO Conversion Configuration

The major configuration drivers for the TAO conversion were the provision of adequate stowage for the buoy toroids, anchor stacks, bridles and cable reels, while optimizing the deck equipment and layout for launching and retrieving TAO buoys. The ability to optimize these requirements while limiting the scope of changes to the TAO conversion lead to a less costly and time consuming conversion.

Optimization was achieved through limiting the conversion impacts to the rearrangement of existing lab spaces aboard the T-AGOS 13 class, and the conversion of fuel tanks into seawater ballast and scientific stores. The enclosed TAO profile at the end of this section shows modified portions of the ship as cross hatched. The enclosed sketches obtained from ref (c), and were based on the configuration presented in ref (b).

4.4 Living and Working Spaces

Charting Conversion - With the increase in accommodations from the preconversion level of 33 to the final level of 42, all of the single staterooms were converted to doubles with the exception of the Master's and the Chief Engineer's. New and reconfigured staterooms were sized at a minimum of 100 sqft in accordance with the NOAA new design standards. Most of the stateroom boundaries have not changed, instead, the single berths were removed and replaced with doubles, or "bunk beds". 02 level staterooms are provided with 1 bath per each double, the senior ONCO officers will be berthed at this level. The remaining staterooms located on the 01 level and the Main Deck are all doubles, either new, modified, or existing, with every two staterooms sharing a single toilet/shower space at a minimum.

TAO Conversion - No stateroom changes were made. Modification to living spaces were not necessary and no single staterooms were converted since the total number of accommodations remained unchanged.

4.4.1 Crew Welfare Spaces (Charting and TAO Conversions)

The Exercise Rooms and Recreation Rooms were retained from the T-AGOS mission. Additional lounge areas are located within the Officer's and Crew's Messrooms. Television and VCR bulkhead mounted foundations with connections to the ship's entertainment system are retained in all staterooms.

4.4.2 Mission Related Spaces, Workshops and Work Spaces

All SURTASS (Surveillance Towed Array Sensor System) related spaces specific to the T-AGOS mission, including the SOC (SURTASS Operations Center) spaces, Winch Ship Control Station, Array Winch Shop, and the Array Fluid Leakage Tank have been removed.

4.4.2.1 Charting Conversion Mission Spaces

Spaces specific to the charting mission include the Data Processing and Acquisition Rooms, Survey Store Room, Boat Repair Shop, Battery Storeroom, and Diver's Change Room and Locker.

The Data Acquisition Room contains two work stations and plotters used for recording data from the ship's own shallow

depth sonar. It also can be used for processing data obtained from the survey launches. It contains a space and weight reservation for the DOLPHIN ROV electronics. The Data Processing Room is the space normally used for processing hydrographic information obtained on disc by the survey launches. It contains four work stations and plotters. Secure storage is provided for classified information. Space arrangement of these two labs are depicted in figures (4) and (5); they were obtained from ref (d).

Table 9 denotes the actual and required space allowances for the charting mission.

Table 9 - Required Areas and Volumes for Charting Conversion Mission Spaces:

<u>Compartment</u>	<u>Required Area</u>	<u>Actual Area</u>
Data Acquisition Room	450 sqft	456 sqft
Data Processing Room	900 sqft	911 sqft
Scientific Storeroom	2,500 cuft	2984 cuft
Wet Lab	175 sqft	210 sqft
Dive Locker	70 sqft	88 sqft
Diver's Change Room	(not required)	80 sqft
Trash Compactor Room	40 sqft	126 sqft
Boat Repair Shop	(not required)	120 sqft
Btty Storage & Maint	(not required)	72 sqft
Electronic Technicians Shop (size not specified)		98 sqft

Figure (4) - Data Acquisition Room Arrangement, Charting Conversion, 03 Level

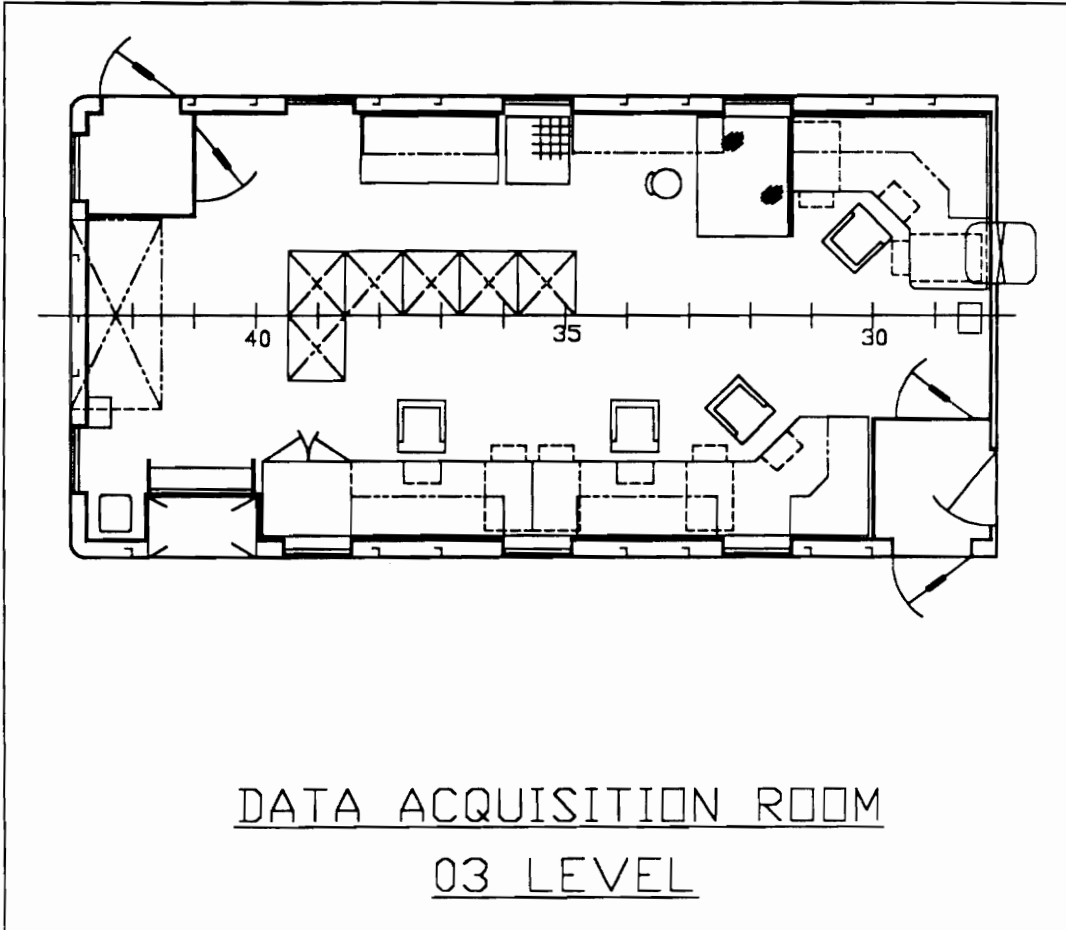


Figure (5) - Data Processing Room Arrangement, Charting Conversion, Main Deck

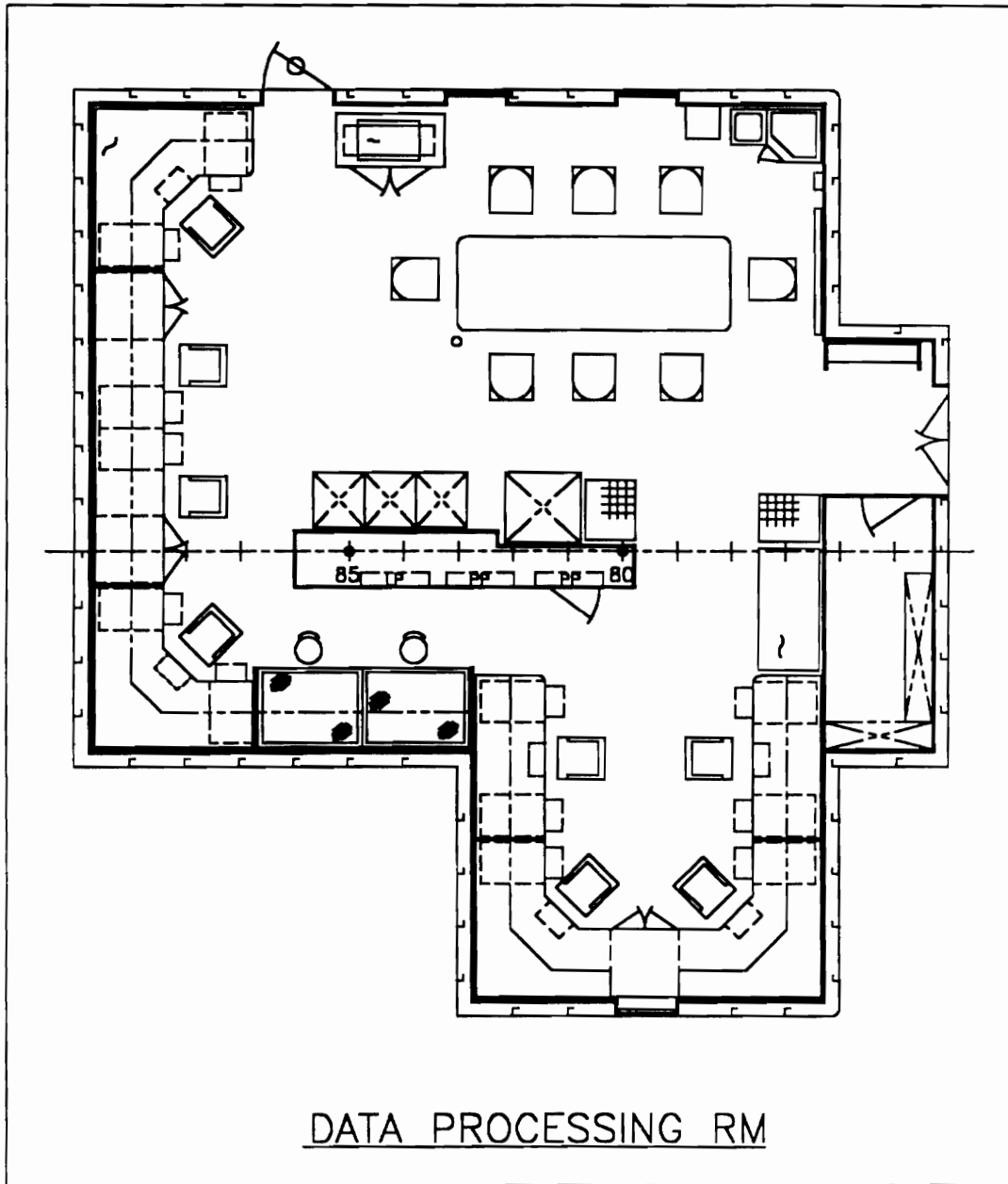
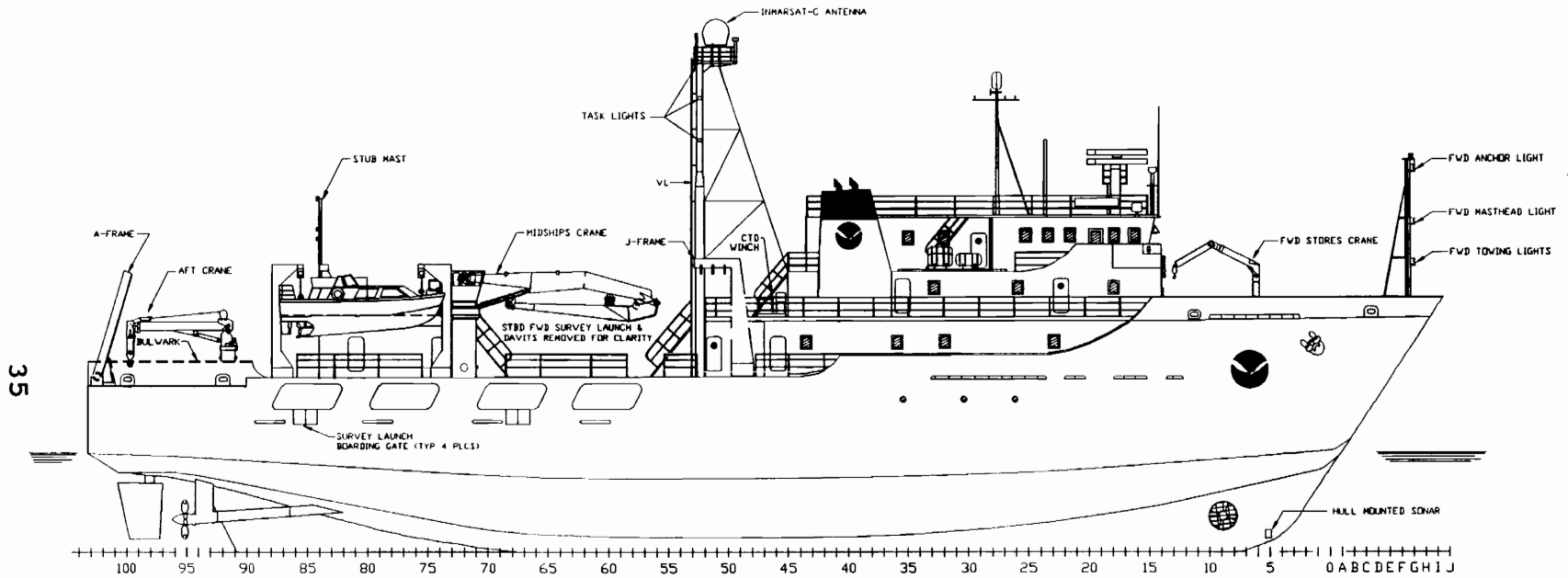


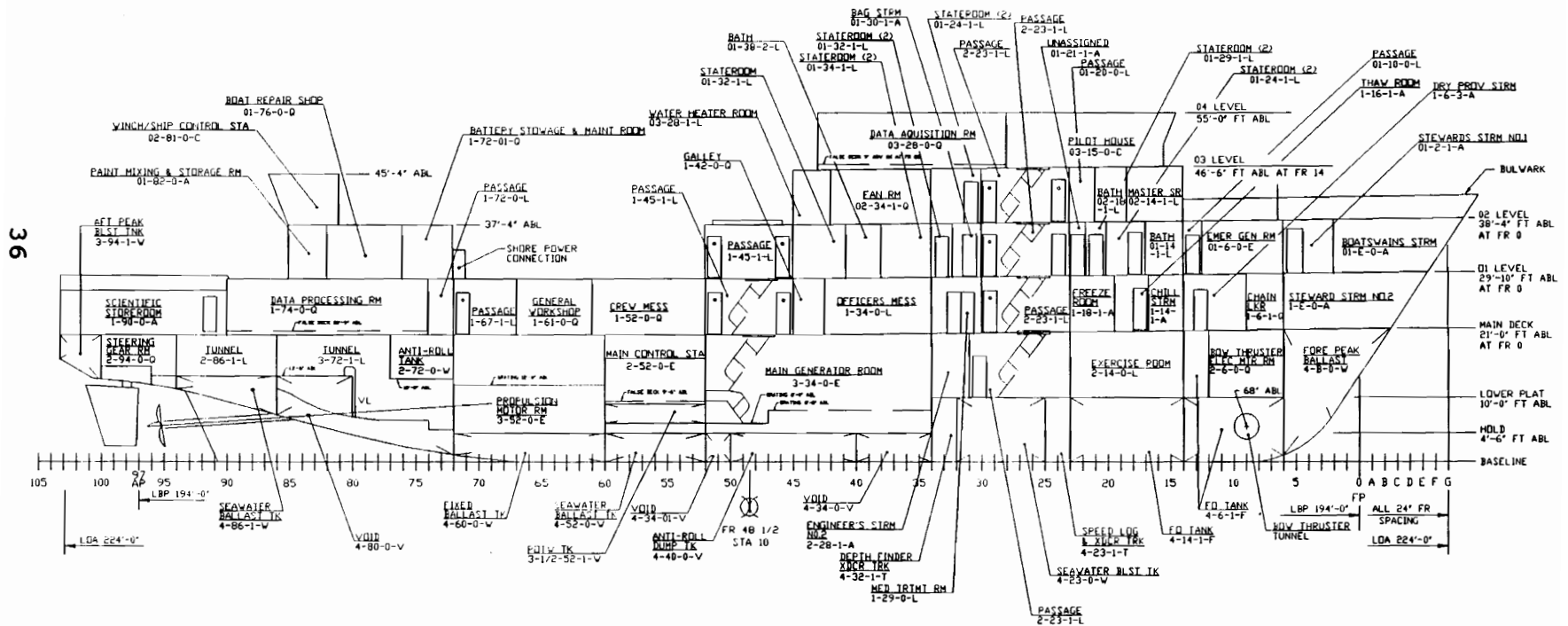
Figure (6) - Charting Conversion Arrangements, Sheet 1 of 5



OUTBOARD PROFILE CONFIGURATION BASELINE

12/07/93

Figure (6) - Charting Conversion Arrangements, Sheet 2 of 5



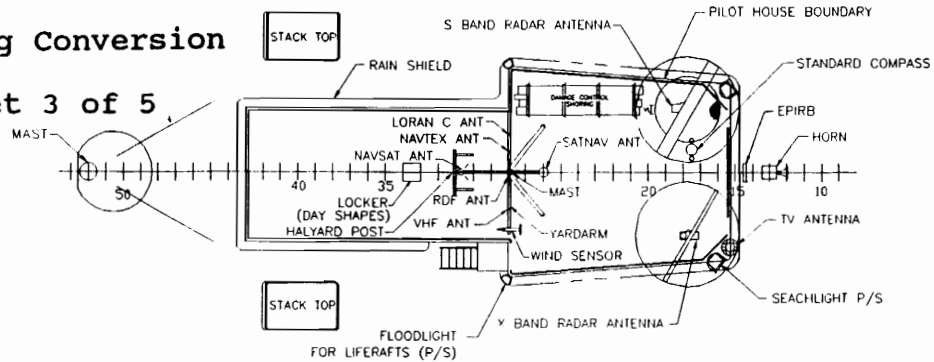
36

INBOARD PROFILE CONFIGURATION BASELINE

12/13/93

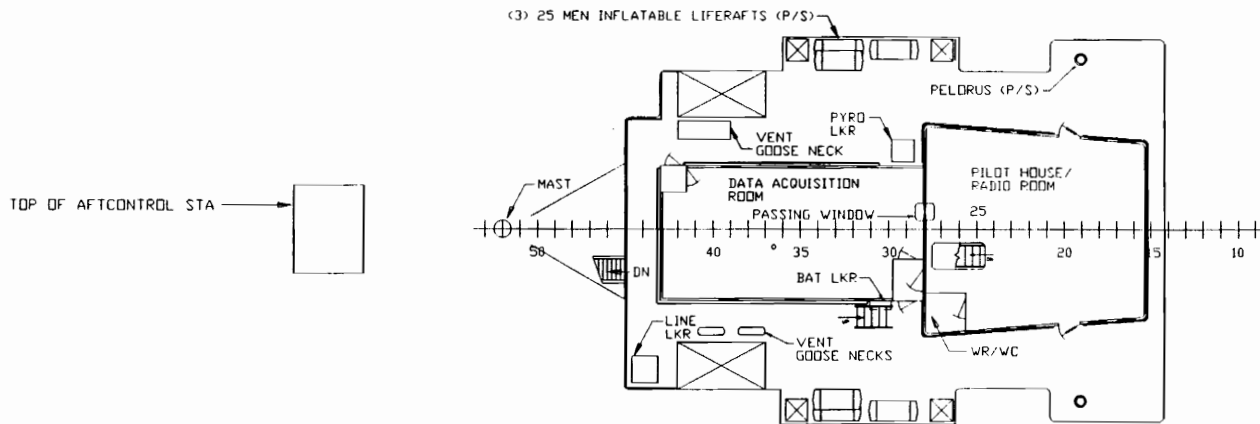
Figure (6) - Charting Conversion

Arrangements, Sheet 3 of 5



04 LEVEL CONFIGURATION BASELINE 12/0793

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03 LEVEL CONFIGURATION BASELINE 12/07/93

4.4.2.2 TAO Conversion Mission Spaces

Spaces specific to the TAO Support Mission include the Instrument Repair Area, Scientific Storerooms, Computer Lab, Autosalinometer Room, and Mission Office.

Buoys are repaired within the Instrument Repair Room. Mission electronics and the ship's local area network server are located within the Computer Lab. The Autosalinometer Room houses equipment which can take continuous salinity and temperature readings from uncontaminated seawater intakes.

Table 10 denotes the actual and required space allowances for the TAO Support Mission.

Table 10 - Required Areas and Volumes for TAO Conversion Mission Spaces:

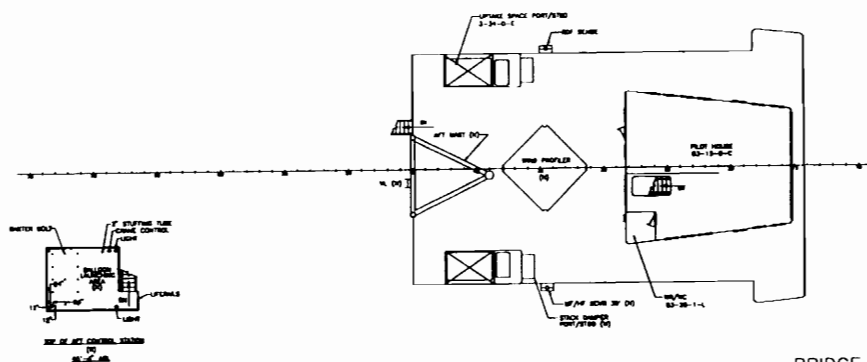
<u>Compartment</u>	<u>Required Area</u>	<u>Actual Area</u>
Mission/Operations Office	100 sqft	102 sqft
Autosalinometer Room	60 sqft	71 sqft
Scientific Storeroom #1	(not required)	728 cuft
Scientific Storeroom #2	1,196 cuft	1,567 cuft
Wet Lab	100 sqft	106 sqft
Dive Locker	100 sqft	91 sqft
Computer Lab	350 sqft	380 sqft
Trash Compactor Room	40 sqft	130 sqft
Instrument Repair Area	200 sqft	222 sqft
Electronic Technicians Shop	80 sqft	82 sqft

4.4.2.3 Common Work Spaces

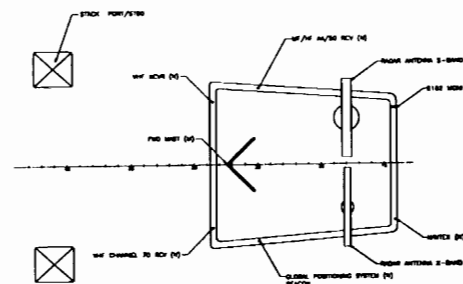
The ET Shop, HPU Room, General Workshop, Dive Locker and Wet Lab are common to both Charting and TAO Support Missions. The General Workshop and ET Shop support both ship and mission functions. The General Workshop is located near lab spaces and the machinery room access trunks, while the ET Shop is between the Pilot House and the mission Labs on both conversions. These locations will maximize the functionality of the spaces for both ship and mission support. Administrative and supply functions are performed out of the existing Ship's Office.

Figure (7) - TAO Conversion Arrangements, Sheet 3 of 8

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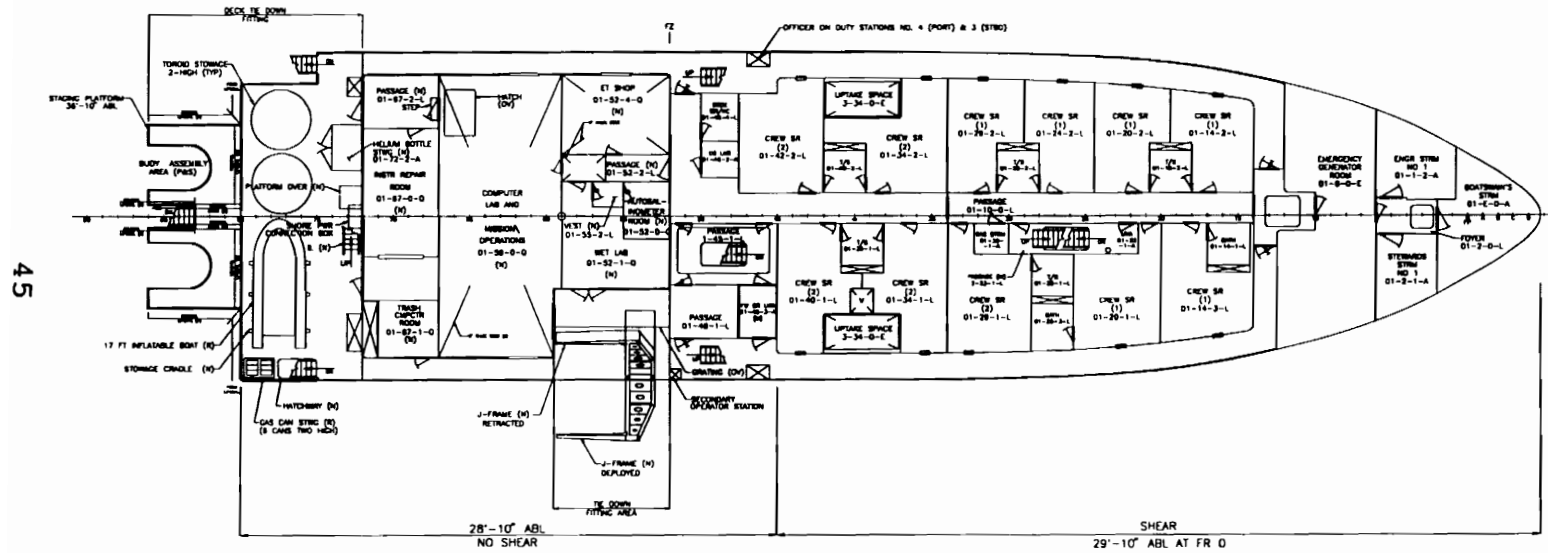


BRIDGE DECK
46'-6" ABL AT FR 14



PILOT HOUSE TOP
55'-0" ABL

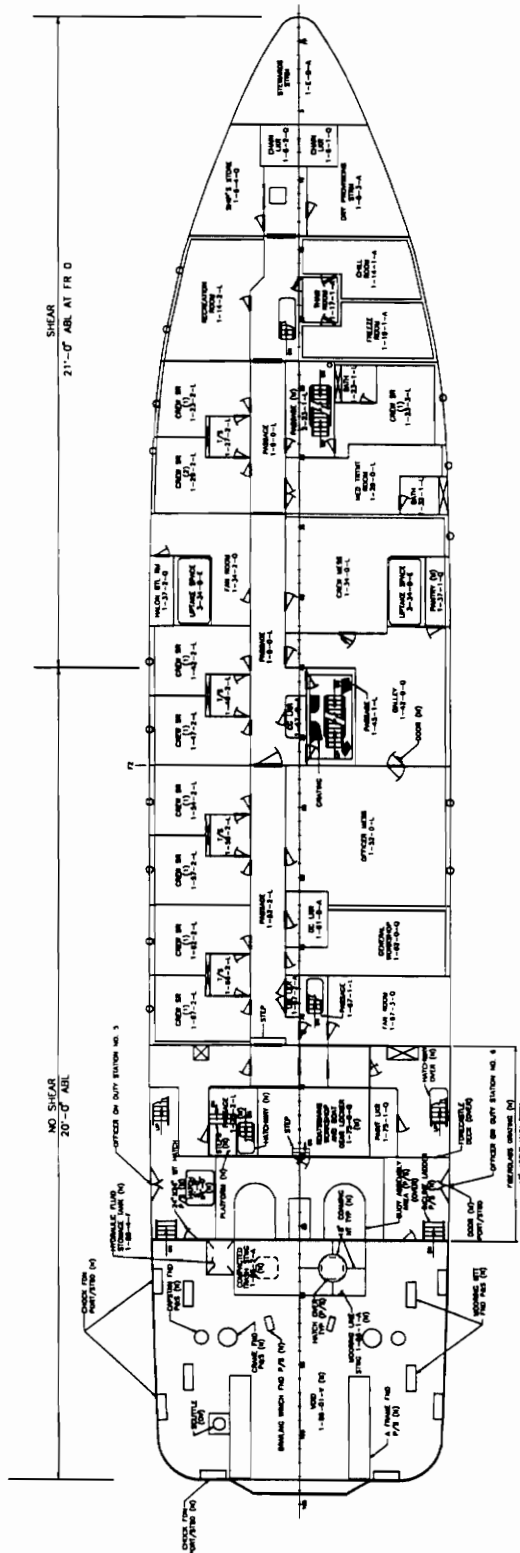
Figure (7) - TAO Conversion Arrangements, Sheet 5 of 8



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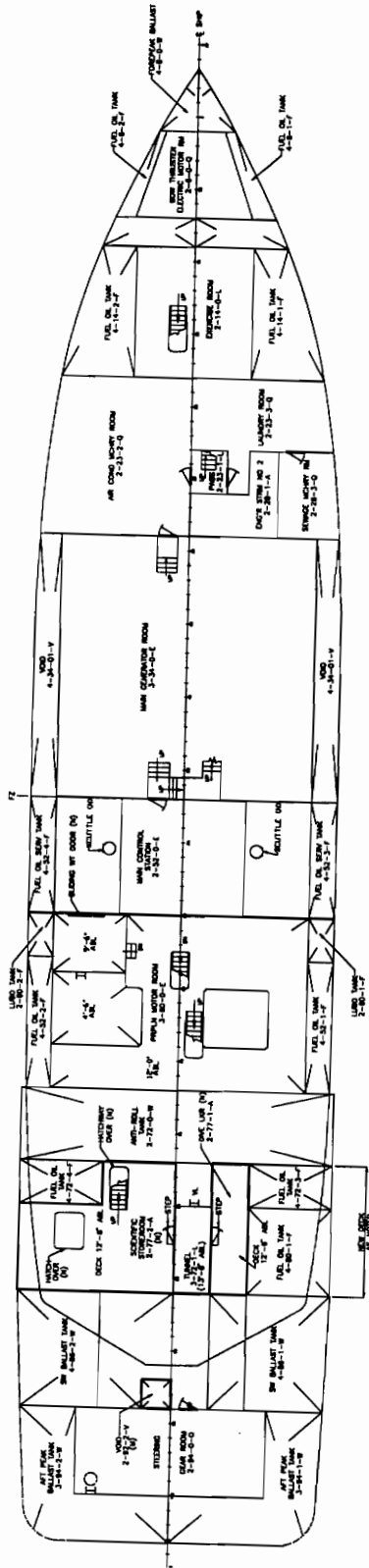
FORECASTLE DECK

Figure (7) - TAO Conversion Arrangements, Sheet 6 of 8



MAIN DECK

Figure (7) - TAO Conversion Arrangements, Sheet 7 of 8



4.5 Stowage & Tankage

The existing T-AGOS 13 storerooms were utilized to the maximum extent practicable. Given the 90 day mission of the T-AGOS 13 class, all of the provisions, engineering, stewards and medical stores are more than adequate to meet the 30 & 35 day durances of the conversions, even with the increase in accommodations on the Charting Conversion.

The Ship's Store, a required function of Military Sealift Command (MSC) operated vessels is not a NOAA requirement and is used for general and trash storage on the TAO and charting conversions respectively. MSC uses the space to sell incidental items, such as toiletries and snack food.

4.5.1 Charting Conversion

New mission related stores are located beneath the raised fantail. The T-AGOS 13 class carries 626 tons of fuel, the charting conversion requires only 350 tons. Because of the difference in required fuel, salt water ballast tanks 4-86-1/2 are no longer needed to control trim; they are converted to voids. They were eliminated since they are the pair with the highest free surface.

4.5.2 TAO Conversion

Mission related stores are located within the Scientific Storeroom and Dive Locker. These spaces were former fuel tanks located on the lower platform between frames 77 and 86. This volume is no longer required for fuel since the total fuel requirements dropped from 626 tons (T-AGOS 13 Class) to 544 tons required for 2 TAO support mission legs. The gross area of the converted tankage is 332 sqft. The molded height of the scientific stowage area is eight feet, fuel is retained in the volume between the new spaces and the hull. Combined with Scientific Storeroom No 1 the total scientific storage capacity is 2,295 cuft, exceeding the 1,200 cuft required.

4.5.3 Fuel Requirements

Endurance fuel calculations for the Charting and TAO Conversions are contained in appendix (e).

4.6 DOLPHIN System

The Charting Mission requires that two DOLPHIN (Deep Ocean Logging Platform for Hydrographic and Instrumentation Navigation) remotely operated vehicles (ROV's) be used in place of two survey launches at the operator's discretion. The DOLPHIN system can be outfitted with the SIMRAD EM 950 Side Scan Sonar, performing similar bottom mapping surveys as the HSL's.

The DOLPHIN Handling System (DHS) was developed by Brooke Ocean Technology (BOT) for deploying and retrieving the DOLPHIN. The BOT DHS utilizes a specially adapted crane, towing boom, and deck cradle for this purpose. The charting conversion will be fitted with a crane suitable for DOLPHIN handling. The towing boom is a space and weight reservation, it will be added at the time of DOLPHIN installation. The DOLPHINS and their cradles will be fitted to ISO flat racks, so that they can be easily transported by ground or air.

The DOLPHIN will be deployed using a single lifting cable; a bow line rigged from a constant tension winch through the towing boom is used to prevent sway during hoisting and lowering. The general arrangements of the DOLPHIN handling crane, the towing boom and associated winches, and the DOLPHIN cradle locations on the port side in way of two survey launches are all located in accordance with BOT's general arrangement criteria, ref (h). Figure (8) was obtained from ref (h) and shows the launching and retrieval concept. Figure (9) was obtained from ref (d) and shows how this generic concept will be applied to the Charting Conversion.

FIGURE (8)
GENERIC DOLPHIN
HANDLING ARRANGEMENT

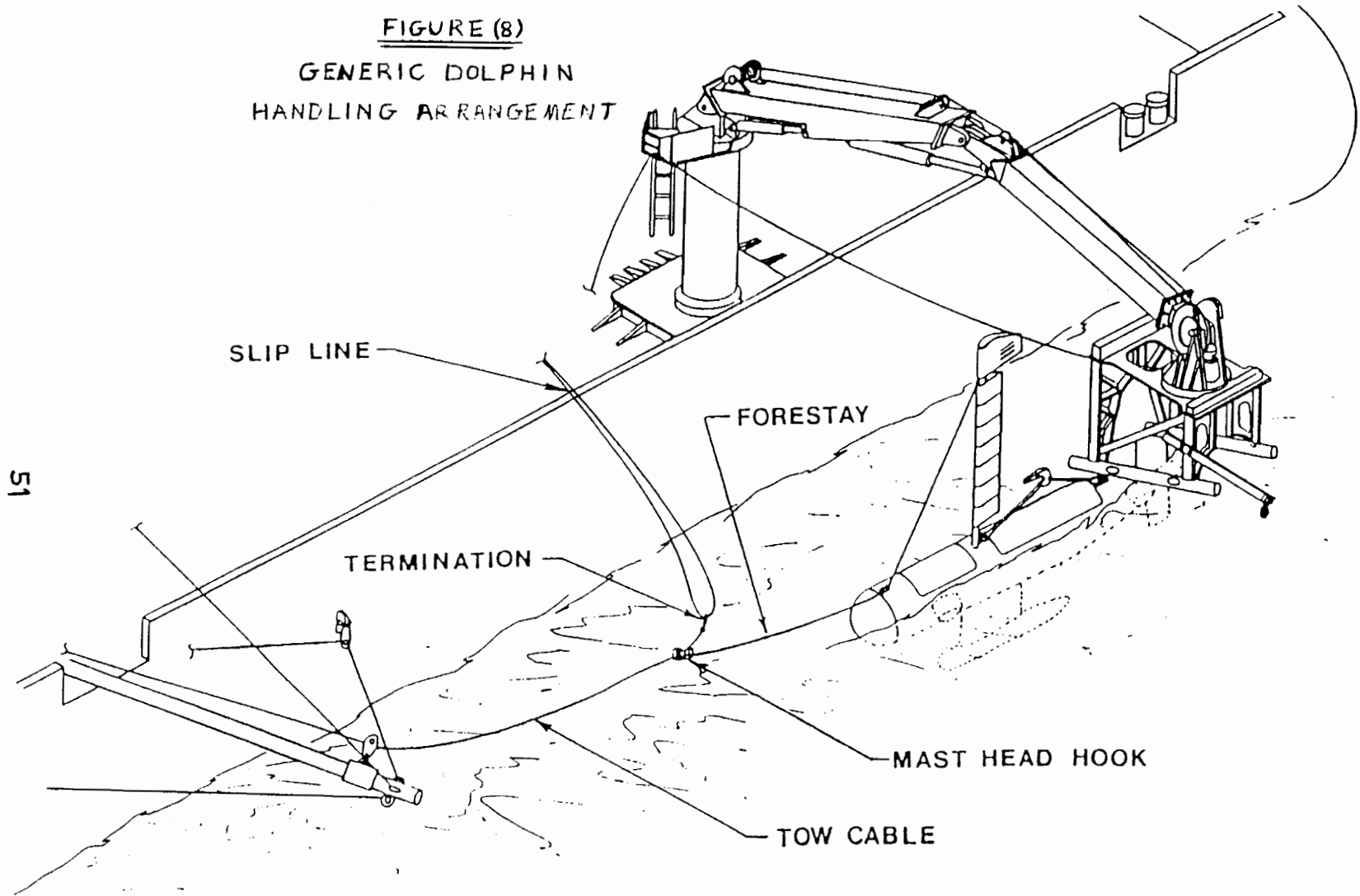
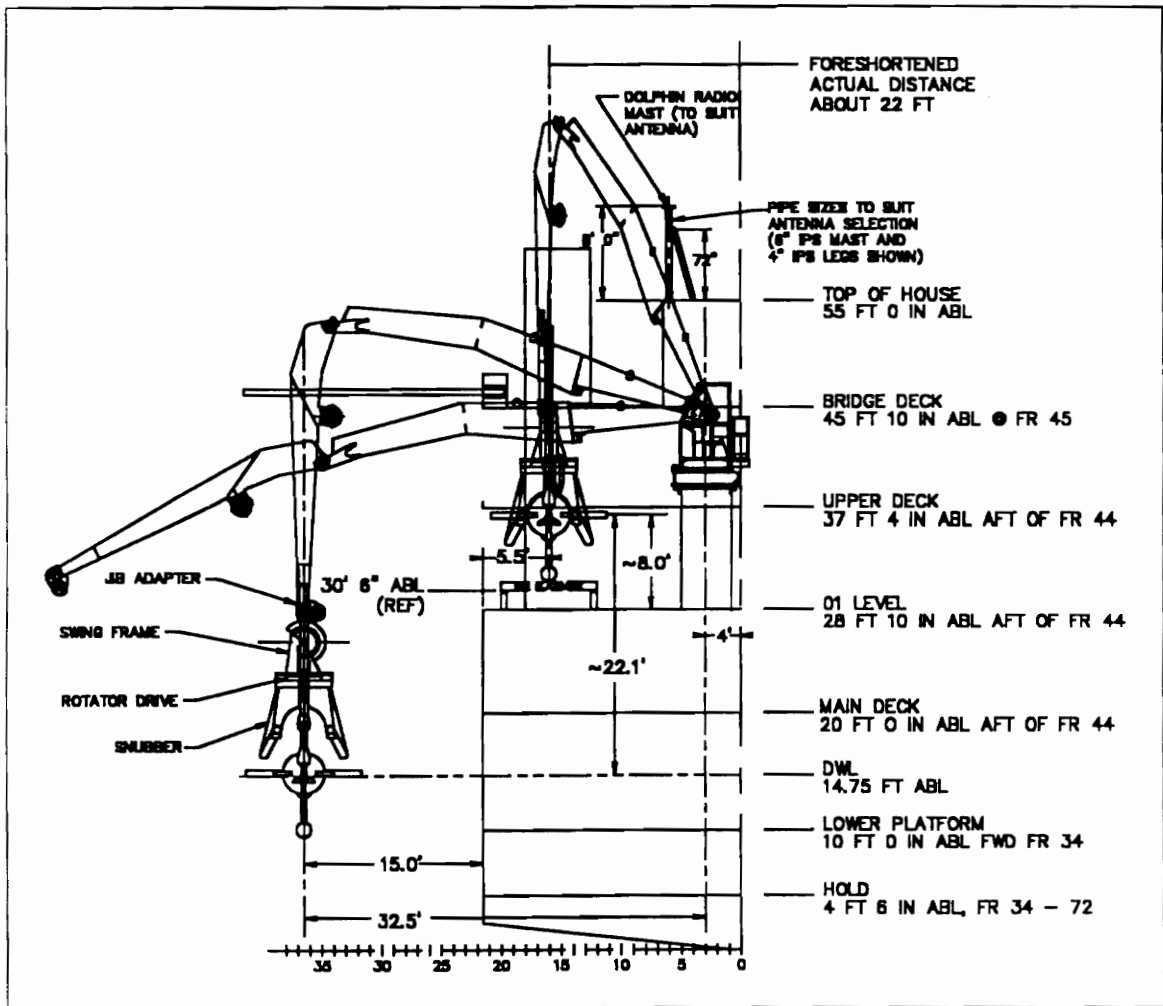


Figure (9) - Actual DOLPHIN Handling Geometry



5.0 Stability

5.1 Preconversion Stability Status/New Requirements

The T-AGOS 13 class vessels were originally certified by the United States Coast Guard (USCG) under Subchapter I, Cargo and Miscellaneous Vessels. Under subchapter I, a vessel of the T-AGOS 13 class would not be required to survive any damage to the watertight subdivisions. The requirements documents for both conversions call out adherence to 46CFR Subchapter U, this subchapter is applicable to oceanographic research vessels. Invoking subchapter U means that the converted vessels must meet USCG requirements for surviving damage which would flood any one watertight subdivision.

The T-AGOS 13 class is currently certified to meet the requirements of 46CFR, parts 170.11 & 42.15-1 as called out in subchapter I; these parts contain requirements for freeboard and intact stability. The conversions would still need to meet these requirements, along with USCG one compartment damage criteria.

Calculations have demonstrated that damaged criteria govern the maximum allowable KG (distance from the keel to the center of gravity) in lieu of intact criteria such as wind heel and vessels of unusual form. Since icing is not a requirement on either of the conversions (NOAA vessels return to port in such conditions), the analysis centered on surviving one compartment flooding.

5.2 Approach

To assure that the converted vessels would meet Subchapter U stability requirements, NAVSEA and the design teams performed several damage stability analyses. Regulations governing ships constructed to both pre- and post December, 1992 ("old" and "new") regulations were examined. Both criteria were examined since rules applicability is the responsibility of USCG-MVI (Office of Marine Vessel Inspection), who would not give us a timely ruling as to whether the T-AGOS conversions were considered "major" or not. A major conversion would need to meet the new rules; a minor conversion could meet the older rules in effect when the ships were originally constructed, i.e., 1984.

The post December 1992 regulations allow for submergence of the margin line in the transient condition, i.e., prior to tank equalization via cross connections and anti-roll tank dumping. However, they evoke pre- and post equalization requirements which are much more rigorous than those of the older rules. Figure (10) compares the old and new Subchapter U damage stability rules.

From previously performed studies, the worst case one compartment damage under the old rules occurs when the subdivision containing the Propulsion Motor Room (Compartment 3-52-01-E) is flooded; this is referred to as group 5 damage, i.e., 5th subdivision from the bow, in the stability analyses. Group 5 and 6 are governing under the new rules at the drafts of interest. Figure (11) shows the location of damaged compartment groups.

NAVSEA and both design teams performed damage stability analyses using SHCP (Ship's Hull Characteristics Program) to analyze damaged and intact stability. From these analyses, maximum allowable KG curves were developed.

5.3 Findings

Figures (12) through (17) show the maximum KG for both conversions at various drafts. Operating points denoting full load, mid-voyage, and 15% consumables, both with and without the anti-roll tank dumped, are denoted. Free surface effects were taken into account by adjusting the operating points.

5.3.1 Pre December 1992 Rules

Under the old rules, both the T-AGOS conversions would need little modification to comply with subchapter U. Although the ships were only certified as zero compartment vessels, they were designed to sustain damage within 1 subdivision given time to equalize asymmetrical flooding and dump the anti-roll tank.

5.3.1.1 Charting Conversion

The operating points with all margins and free surface correction fall below the maximum allowable KG after equalization assuming cross flooding and the anti-roll tank intact. Under the old rules there are no specific limitations on the transient condition except that at no point is the margin line to be submerged. Heel angle cannot

exceed 7 degrees and at least 2" of transverse metacentric height (GM) is required after equalization (GM is the distance from the center of gravity to the center of an arc described by locations of a vessel's center of buoyancy as the ship is inclined to small angles). The rules allow 15 minutes for equalization. Under these rules no design changes are required for the vessel to meet the post equalization rules. Since the vessel will submerge its margin line in the pre-equalization condition, however, calculations must be reviewed by USCG for approval. See figure (15).

5.3.1.2 TAO Conversion

The operating points with all margins and free surface correction are above the maximum allowable KG, post equalization. Allowing for cross connections and the dumping of the anti-roll tank, however, the old rules regarding the final stage of flooding can be met. Under these rules the only change necessary would be the addition a motorized valve with push button dumping from the Pilot House in order to drain the anti-roll tank within the required 15 minutes. The TAO Conversion would, however, submerge its margin line with group 5 damage prior to equalization. Again, approval from USCG-MCS is required. See figure (12).

5.3.2 Post December 1992 rules

Figures (16) and (13) show the Charting and TAO conversions allowable KG with cross connections added to group 6 (includes the anti-roll tank and tunnel, just aft of the motor room) and the upgrade of the bulkhead at FR 60 to watertight up to the Main Deck. With these two modifications both conversions can meet the new and old damaged stability criteria.

5.3.2.1 Modification of Bulkhead 60 into a Watertight Subdivision

The following systems would be effected by the modification of bulkhead 60 as required to meet new subchapter U requirements:

<u>System</u>	<u>Action</u>
WSC-6 Dry Air System	Remove
Propulsion Motor Lube Oil System	Relocate
SW Cooling System Valve	Relocate
Bilge System	Relocate Drain
Motor Connections	Remove, Reconnect, Splice
Control Room Door	Replace with Sliding WT
Door	
Misc. Mods (Switches, Gauges and indicators)	Relocate

Preparation for work would include system isolation, draining, containment, gas-freeing and prestaging. The actual structural modifications would be minor since the bulkhead is stiffened similarly to the existing subdivision bulkheads. Completion tests of all welds and penetrations would be required.

5.4 Conclusion

Under the old rules, little modification to the designs are necessary to meet post equalization requirements. Both conversions, however, will submerge the margin line prior to equalization; this is in violation of the old rules. In the past, the USCG has allowed margin line submergence if there is no downflooding and they were satisfied with the range of stability and maximum righting arm.

Applying the new pre-equalization requirements which allow for margin line submergence, both vessels would not pass the righting arm requirements as is. Since it is very likely

the USCG would require that the vessels meet these criteria, regardless of whether or not they are considered "major" conversions, one of the options necessary to meet the new rules, from tables (13) and (14) would have to be pursued.

At the time of this writing, NOAA is uncertain as to whether or not any of the options presented in tables (13) and (14) will be accomplished. The design teams have estimated the cost of upgrading bulkhead 60 at \$500,000. If NOAA wishes, they may disregard subchapter U requirements since public vessels are not subject USCG regulations.

COMPARISON OF POST DECEMBER 1992 SUBCHAPTER S RULES WITH "AS BUILT" SUBCHAPTER S RULES

FIGURE (10) TAO AND CHARTING CONVERSION

"AS BUILT" SUBCHAPTER S (AS APPLICABLE TO SUBCHPT U)

- 1) THE FINAL ANGLE OF EQUILIBRIUM MUST NOT EXCEED 7 DEGREES
- 2) THE MARGIN LINE MUST NOT BE SUBMERGED AT ANY POINT
- 3) A MINIMUM OF 2 INCHES OF GM IS REQUIRED

RULES GOVERNING EQUALIZATION

EQUALIZATION MUST BE APPROVED BY THE USCG MARINE SAFETY CENTER IF NOT AUTOMATIC

EQUALIZATION MUST BE ACCOMPLISHED WITHIN 15 MINUTES

PER VERBAL DIRECTION FROM THE USCG, THE MARGIN LINE MAY NOT BE SUBMERGED PRIOR TO EQUALIZATION UNDER THE OLD RULES

POST DEC 1992 SUBCHAPTER S (AS APPLICABLE TO SUBCHT U)

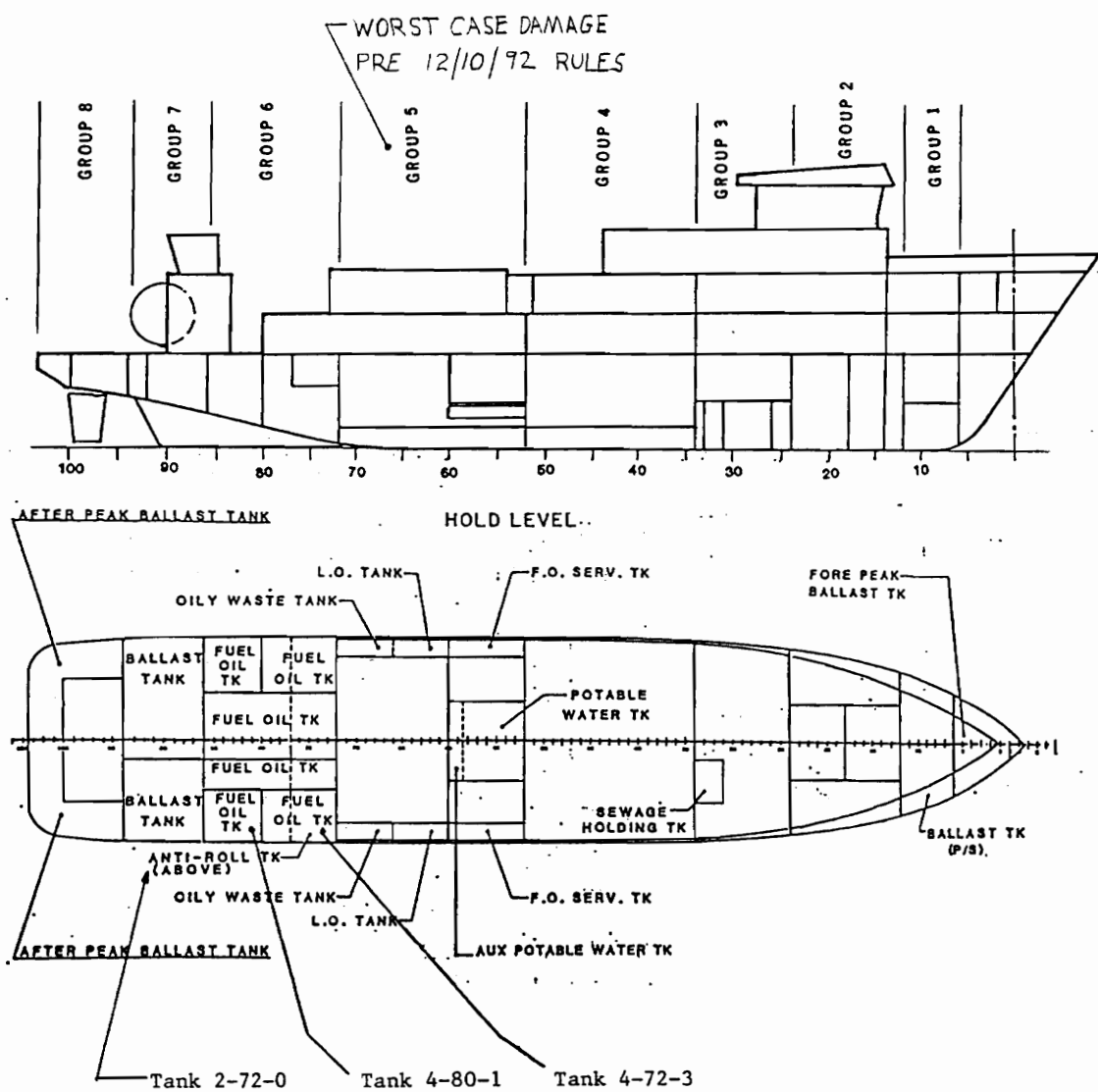
- o TWO STAGES OF FLOODING; PRE AND POST EQUALIZATION

PRE EQUALIZATION REQUIREMENTS:

- 1) 15 DEGREE MAXIMUM ANGLE OF EQUILIBRIUM
- 2) MAXIMUM RIGHTING ARM - .16' MINIMUM
- 3) POSITIVE RIGHTING ARMS THROUGH 7 DEGREES ASSUMING ONLY 1 BREACH IN HULL AND 1 WORST CASE FREE SURFACE EFFECT

POST EQUALIZATION REQUIREMENTS:

- 1) POSITIVE RIGHTING ARMS EXTENDING 15 DEG BEYOND EQUILIBRIUM
- 2) NO DOWNFLOODING WITHIN 15 DEGREES
- 3) MINIMUM RIGHTING ARM AREA OF 2.82 FT-DEG TO THE LESSER OF EITHER THE DOWNFLOODING ANGLE OR 22 DEGREES FROM UPRIGHT
- 4) MAX RIGHTING ARM WITHIN 15 DEGS OF EQUILIBRIUM OF A MINIMUM OF .13 FT ABOVE MAX HEEL ARM; IN NO CASE SHALL THE RIGHTING ARM BE LESS THAN .33'
- 5) THE ANGLE OF EQUILIBRIUM SHALL NOT EXCEED 7 DEGS
- 6) THE MARGIN LINE MAY NOT BE SUBMERGED



FIGURE(11)

LOCATION OF DAMAGED COMPARTMENT GROUPS

Table (11) - Allowable KG Matrix - TAO Conversion

Allowable KG Matrix - T-AGOS TAO Conversion

	Full Load Departure				Mid Voyage				15% Arrival				Governing DG (see note #4)	Estimated Cost	Comments	
	Draft	Actual KG	Allowable KG	(+)(-)	Draft	Actual KG	Allowable KG	(+)(-)	Draft	Actual KG	Allowable KG	(+)(-)				
BASELINE																
Lightship=13911LT, Ibin=43LT, Margin=36.9LT	14.62	18.80	17.11	1.69	13.31	19.93	18.88	1.05	13.75	19.49	18.42	1.07	5B,5B,5B	none	Fails Old Grp. 5 Before Eq	
OPTIONS																
(1) Install Fr. 60 BHD	14.62	17.73	17.69	0.04	13.31	18.71	18.21	0.50	13.75	18.32	18.00	0.32	6,6,6	\$500,000	Fails Old Grp. 6 After Eq	
(2) Reduce Fuel Load	13.42	20.01	18.77	1.24	13.26	19.37	18.93	0.44	13.14	19.90	19.03	0.87	5B,5B,5B	none	Fails Old Grp. 5 Before Eq	
(3) Add Solid Ballast	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
(4) Eliminate Anti-Roll Tank	14.47	17.99	17.33	0.66	13.21	19.02	18.97	0.05	13.65	18.61	18.55	0.06	5B,5B,5B	\$3,000	Fails Old Grp. 5 Before Eq	
(5) Cross Connect 4-72-3/4-F	14.62	18.80	17.11	1.69	13.31	19.93	18.88	1.05	13.75	19.49	18.42	1.07	5B,5B,5B	\$3,000	Fails Old Grp. 5 Before Eq	
(6) Eliminate Margins	14.45	18.37	17.37	1.00	13.14	19.46	19.03	0.43	13.58	19.03	18.60	0.43	5B,5B,5B	none	Fails Old Grp. 5 Before Eq	
(7) Reduce Margin by 50%	14.54	18.59	17.22	1.37	13.23	19.70	18.96	0.74	13.67	19.26	18.52	0.74	5B,5B,5B	none	Fails Old Grp. 5 Before Eq	
(8) Reduce Linerant Load by 50%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
(9) Reduce Margin by 25%	14.58	18.69	17.17	1.52	13.27	19.81	18.92	0.89	13.71	19.37	18.47	0.90	5B,5B,5B	none	Fails all three cases	
COMBINATIONS																
(4)+(5)	14.47	17.99	17.33	0.66	13.21	19.02	18.97	0.05	13.65	18.61	18.55	0.06	5B,5B,5B	\$6,000	Fails Old Grp. 5 Before Eq	
(4)+(6)	14.24	17.53	17.68	-0.15	12.98	18.52	18.38	0.14	13.42	18.13	18.14	-0.01	5B,6,6	\$3,000	Fails mid-voyage	
(5)+(6)	14.45	18.37	17.37	1.00	13.14	19.46	19.03	0.43	13.58	19.03	18.60	0.43	5B,5B,5B	\$3,000	Fails Old Grp. 5 Before Eq	
(4)+(5)+(6)	14.24	17.53	17.68	-0.15	12.98	18.52	19.20	-0.68	13.42	18.13	18.74	-0.61	5B,5B,5B	\$6,000	Passes all three cases	
(1)+(5)	14.62	18.80	19.24	-0.44	13.31	19.93	20.36	-0.43	13.75	19.49	20.00	-0.51	6B,6B,6B	\$503,000	Passes all three cases	
(4)+(7)	14.33	17.76	17.55	0.21	13.07	18.77	18.33	0.44	13.51	18.37	18.10	0.27	5B,6,6	\$3,000	Fails all three cases	
(4)+(5)+(7)	14.33	17.76	17.55	0.21	13.07	18.77	19.10	-0.33	13.51	18.37	18.70	-0.33	5B,5B,5B	\$6,000	Fails full load	
(1)+(5)+(9)	14.62	18.80	19.24	-0.44	13.31	19.93	20.36	-0.43	13.75	19.49	20.00	-0.51	6B,6B,6B	\$503,000	Passes all three cases	
(1)+(5)+(10)	14.58	18.69	19.27	-0.58	13.27	19.81	20.38	-0.57	13.71	19.37	20.03	-0.66	6B,6B,6B	\$503,000	Passes all three cases	
(4)+(5)+(10)	14.41	17.88	17.42	0.46	13.10	18.90	19.07	-0.17	13.54	18.49	18.65	-0.16	5B,5B,5B	\$3,000	Fails full load	

NOTES:

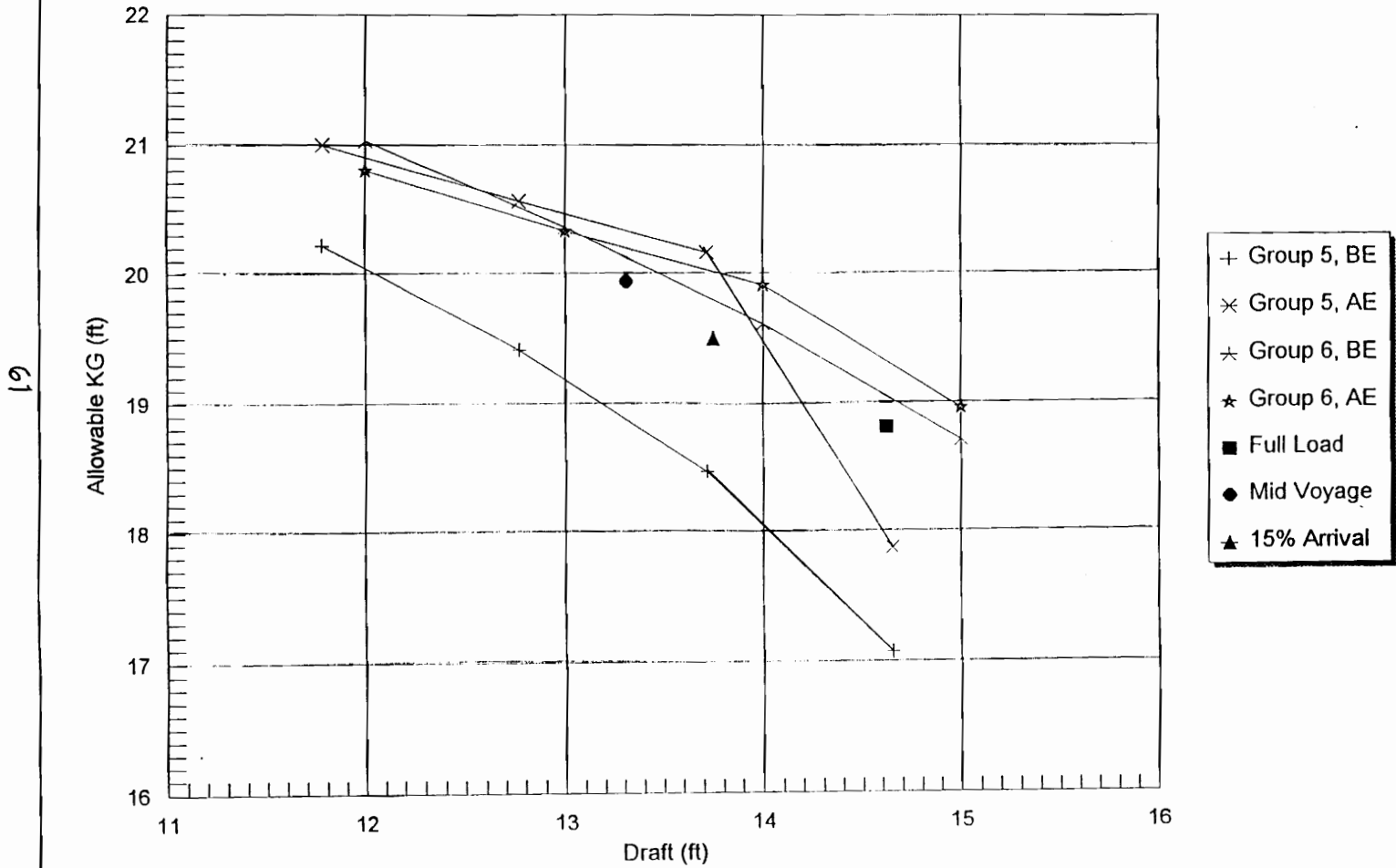
- The BASELINE condition includes a Weight Margin of 36.86LT and an Linerant Load of 43LT.
- Allowable KG values are developed by meeting all 8 criteria set forth in 46 CFR 171.080c (for ships built after 12 December 1992).
- A negative (-) value in the (+)(-) column means that Actual KG is less than Allowable KG (which is good...).
- Under Governing DG: 6 indicates Group 6 (as is); 5B indicates Group 5 Before Equalization (by cross-connection of 4-52-1/2-F); 6B indicates Group 6 Before Equalization (by cross-connection of 4-72-3/4-F); 6A indicates Group 6 After Equalization (by cross-connection of 4-72-3/4-F).
- Group 6A and 6B damage includes modification to 4-80-1/2-F and 4-72-1/2-F.

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TAO Conversion - Allowable KG vs. Draft

Pre 12/92 Rules - Groups 5 (current) and 6 (current) - With Design Conditions

FIGURE(12)

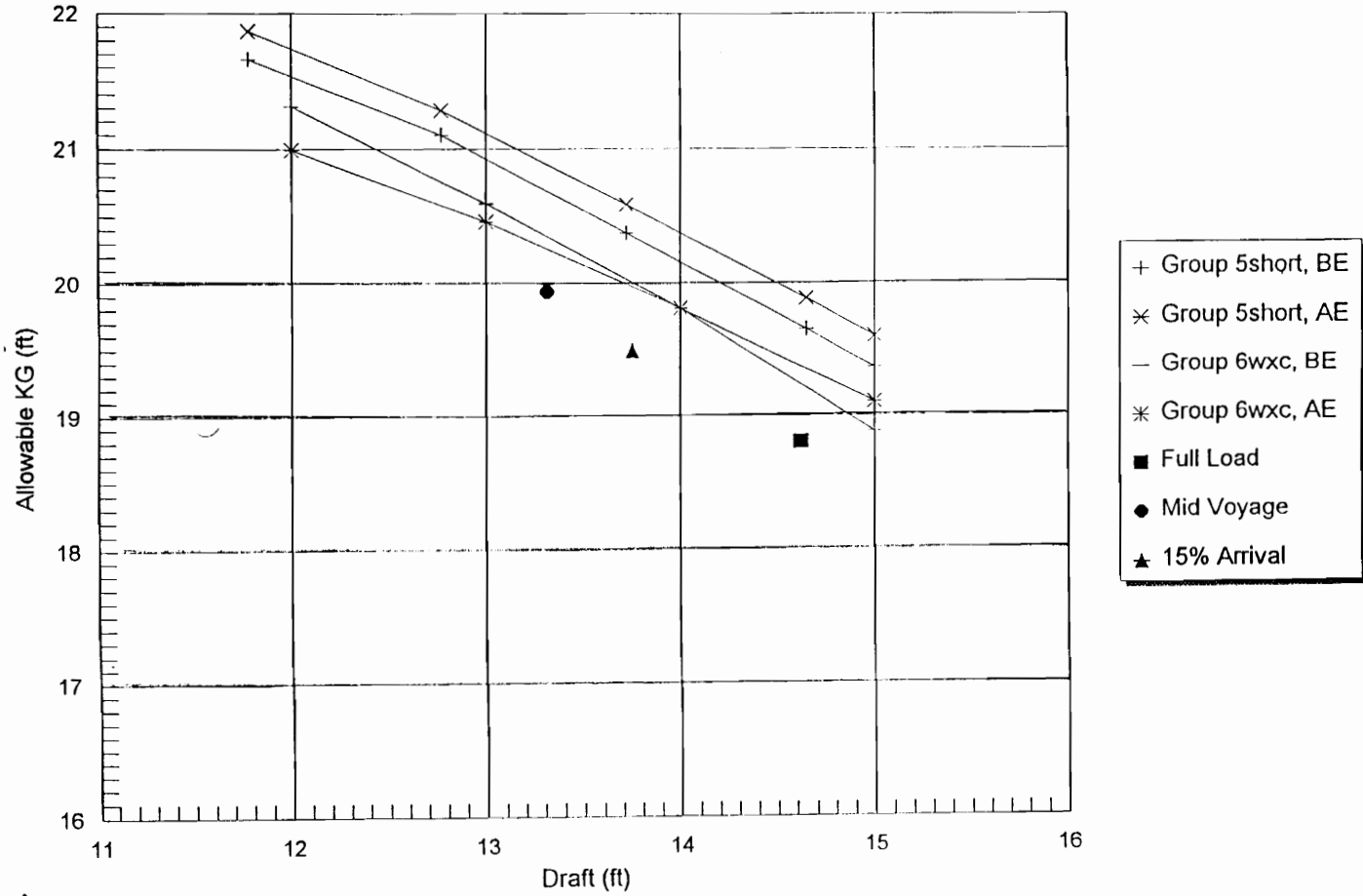


TAO Conversion - Allowable KG vs. Draft

Post 12/92 Rules - Groups 5 (with Bhd. @ Fr. 60) and 6 (with 4-72-3/4 x-connect) - With Design Conditions

FIGURE(13)

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TAO Conversion - Allowable KG vs. Draft

Post 12/92 Rules - Groups 5 (current) and 6 (current) - With Design Conditions

FIGURE (14)

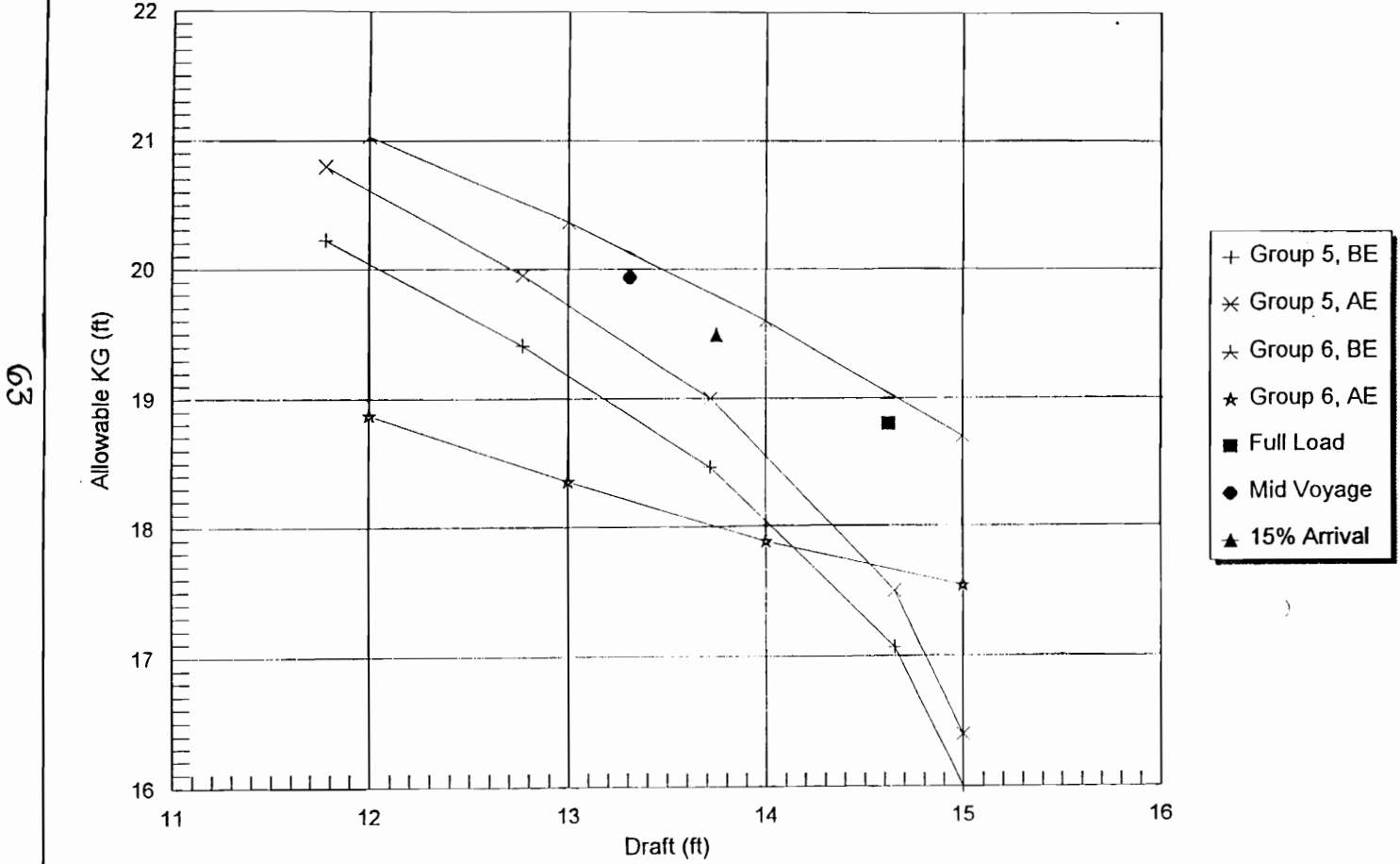


Table (12) - Allowable KG Matrix - Charting Conversion

	Full Load Departure (FLD)				Mid Voyage (MV)				15% Arrival				15% ¹⁾				Governing DG (see note #4)	Estimated Cost	Comments
	Draft	Actual KG	Allowable KG	(+)(-)	Draft	Actual KG	Allowable KG	(+)(-)	Draft	Actual KG	Allowable KG	(+)(-)	Draft	Actual KG	Allowable KG	(+)(-)			
BASELINE																			
Lightship=1493LT, Itm=13LT, Margin=43.29LT	14.22	19.12	17.72	1.40	13.39	19.72	18.06	1.66	13.64	19.64	17.95	1.69	6A,6A,6A	none	Includes change of 4-86-1/2-F SWB to VOID5				
OPTIONS																			
(1) Install Fr. 60 BHD	14.22	19.12	17.72	1.40	13.39	19.72	18.06	1.66	13.64	19.64	17.95	1.69	6A,6A,6A	\$500,000	Fails all three cases				
(2) Reduce Fuel Load	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Not applicable for Charting Conversion				
(4) Eliminate Anti-Roll Tank	14.05	18.25	17.77	0.48	13.22	18.79	18.15	0.64	13.47	18.74	18.02	0.72	6A,6A,6A	\$3,000	Fails all three cases				
(5) Cross Connect 4-72-3/4-F	14.22	19.12	17.84	1.28	13.39	19.72	18.91	0.81	13.64	19.64	18.64	1.00	5B,5B,5B	\$3,000	Fails all three cases				
(6) Eliminate Margins	14.02	18.54	17.78	0.76	13.19	19.10	18.17	0.93	13.44	19.05	18.04	1.01	6A,6A,6A	none	Fails all three cases				
(7) Reduce Margin by 50%	14.12	18.83	17.75	1.08	13.29	19.43	18.11	1.32	13.54	19.34	17.99	1.35	6A,6A,6A	none	Fails all three cases				
(8) Dump AR Tank to AR Dump Tank	14.22	17.98	17.72	0.26	13.39	18.48	18.06	0.42	13.64	18.43	17.95	0.48	6A,6A,6A	\$3,000	Fails all three cases				
(9) Reduce Itinerant Load by 50%	14.19	19.09	17.73	1.36	13.36	19.71	18.08	1.63	13.61	19.63	17.96	1.67	6A,6A,6A	none	Fails all three cases				
(10) Reduce Margin by 25%	14.17	18.98	17.74	1.24	13.34	19.58	18.09	1.49	13.59	19.49	17.97	1.52	6A,6A,6A	none	Fails all three cases				
COMBINATIONS																			
(4)+(3)	14.05	18.25	18.12	0.13	13.22	18.79	19.06	-0.27	13.47	18.74	18.84	-0.10	5B,5B,5B	\$6,000	Fails FLD case				
(4)+(6)	13.85	17.64	17.86	-0.22	13.02	18.13	18.25	-0.12	13.27	18.10	18.12	-0.02	6A,6A,6A	\$3,000	Passes all three cases				
(5)+(6)	14.02	18.54	18.16	0.38	13.19	19.10	19.08	0.02	13.44	19.05	18.86	0.19	5B,5B,5B	\$3,000	Fails all three cases				
(4)+(5)+(6)	13.85	17.64	18.38	-0.74	13.02	18.13	19.23	-1.10	13.27	18.10	19.01	-0.91	5B,5B,5B	\$6,000	Passes all three cases				
(1)+(5)	14.22	19.12	19.34	-0.22	13.39	19.72	19.89	-0.17	13.64	19.64	19.71	-0.07	x6A,x6A,x6A	\$503,000	Passes all three cases				
(4)+(7)	13.95	17.95	17.81	0.14	13.12	18.47	18.20	0.27	13.37	18.41	18.07	0.34	6A,6A,6A	\$3,000	Fails all three cases				
(4)+(5)+(7)	13.95	17.95	18.26	-0.31	13.12	18.47	19.14	-0.67	13.37	18.41	18.92	-0.51	5B,5B,5B	\$6,000	Passes all three cases				
(1)+(5)+(9)	14.19	19.09	19.36	-0.27	13.36	19.71	19.90	-0.19	13.61	19.63	19.74	-0.11	x6A,x6A,x6A	\$503,000	Fails MV and 15% cases				
(1)+(5)+(10)	14.17	18.98	19.36	-0.38	13.34	19.58	19.92	-0.34	13.59	19.49	19.75	-0.26	x6A,x6A,x6A	\$503,000	Passes all three cases				
(4)+(5)+(10)	14.00	18.34	18.20	0.14	13.17	18.63	19.10	-0.47	13.42	18.57	18.88	-0.31	5B,5B,5B	\$6,000	Fails FLD case				
(6)+(8)	14.02	17.37	17.78	-0.41	13.19	17.83	18.17	-0.34	13.44	17.80	18.04	-0.24	6A,6A,6A	\$6,000	Fails all three cases (see Note #6)				
(5)+(7)+(8)	14.12	17.68	18.00	-0.32	13.29	18.17	18.99	-0.82	13.54	18.13	18.76	-0.63	5B,5B,5B	\$3,000	Fails all three cases (see Note #6)				
(5)+(8)+(10)	14.17	18.07	17.92	0.15	13.34	18.33	18.95	-0.62	13.59	18.28	18.70	-0.42	5B,5B,5B	\$6,000	Fails all three cases (see Note #6)				

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NOTES:

- 1) The BASELINE condition includes a Weight Margin of 43.29LT and an Itinerant Load of 13LT. Percentage changes to these weights are made adjusting these values while keeping their centers fixed.
- 2) Allowable KG values are developed by meeting all 8 criteria set forth in 46 CFR 171.080a (for ships built after 12 December 1992).
- 3) A negative (-) value in the (+)(-) column means that Actual KG is less than Allowable KG (which is good).
- 4) Under Governing DG: 6A indicates "as is" Group 6 After Equalization, 5B indicates "as is" Group 5 Before Equalization by cross-connection of 4-52-1/2-F. x6A indicates modified Group 6 After Equalization by cross-connection of 4-72-3/4-F.
- 5) Raising the Margin Line aft was investigated, but not included. Since Margin Line submergence is not the governing criteria over the range of operating drafts we are investigating, it has no bearing on the results.
- 6) The values shown are for "post-equalization" (i.e. after AR Tank is completely empty). As such, this option does not satisfy the pre-equalization requirement.

Figure 15

Charting Conversion - Allowable KG vs. Draft

Pre 12/92 Rules - Groups 5 (current) and 6 (current) - With Design Conditions

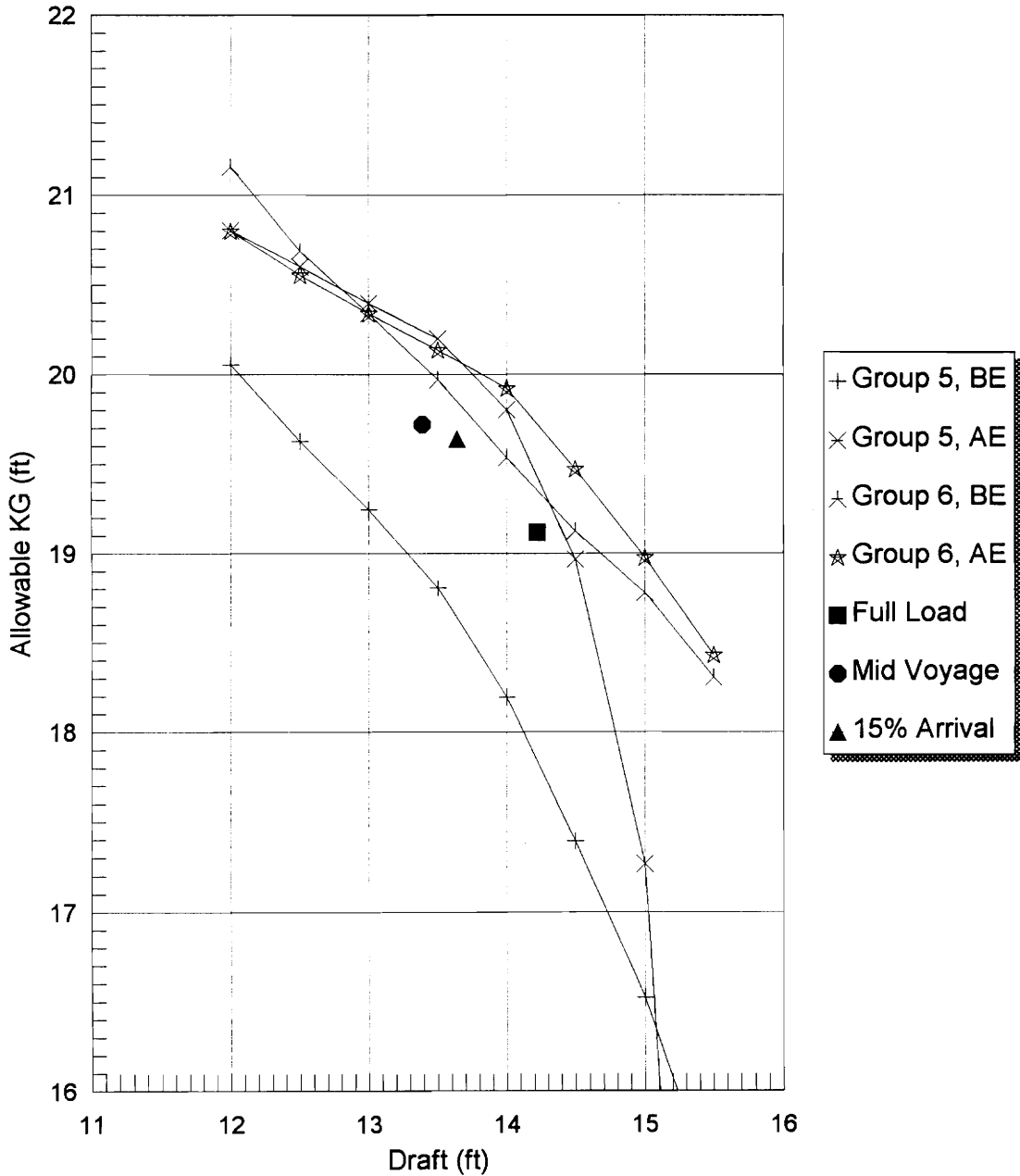


Figure 16

Charting Conversion - Allowable KG vs. Draft

Post 12/92 Rules - Groups 5 (current) and 6 (current) - With Design Conditions

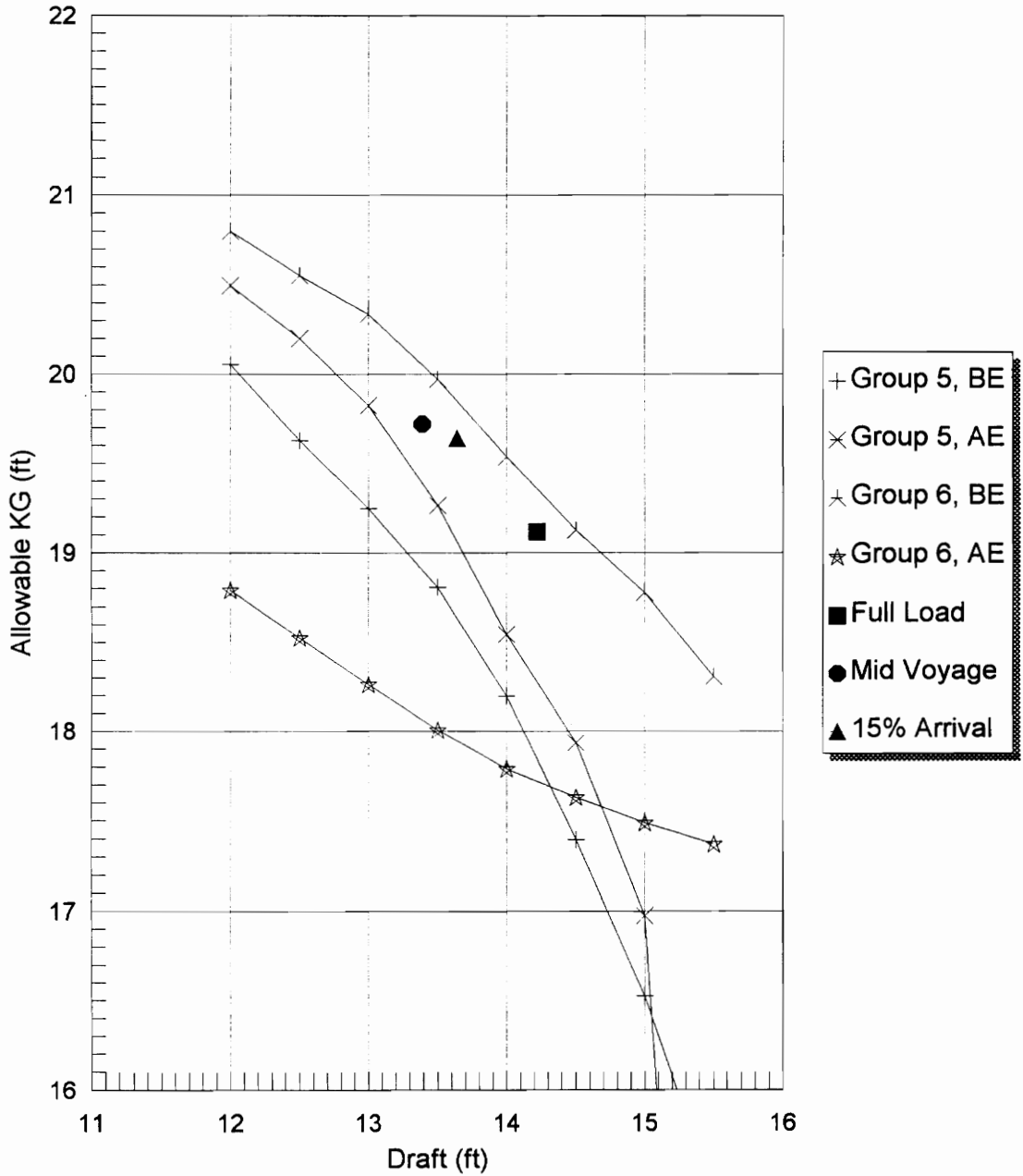
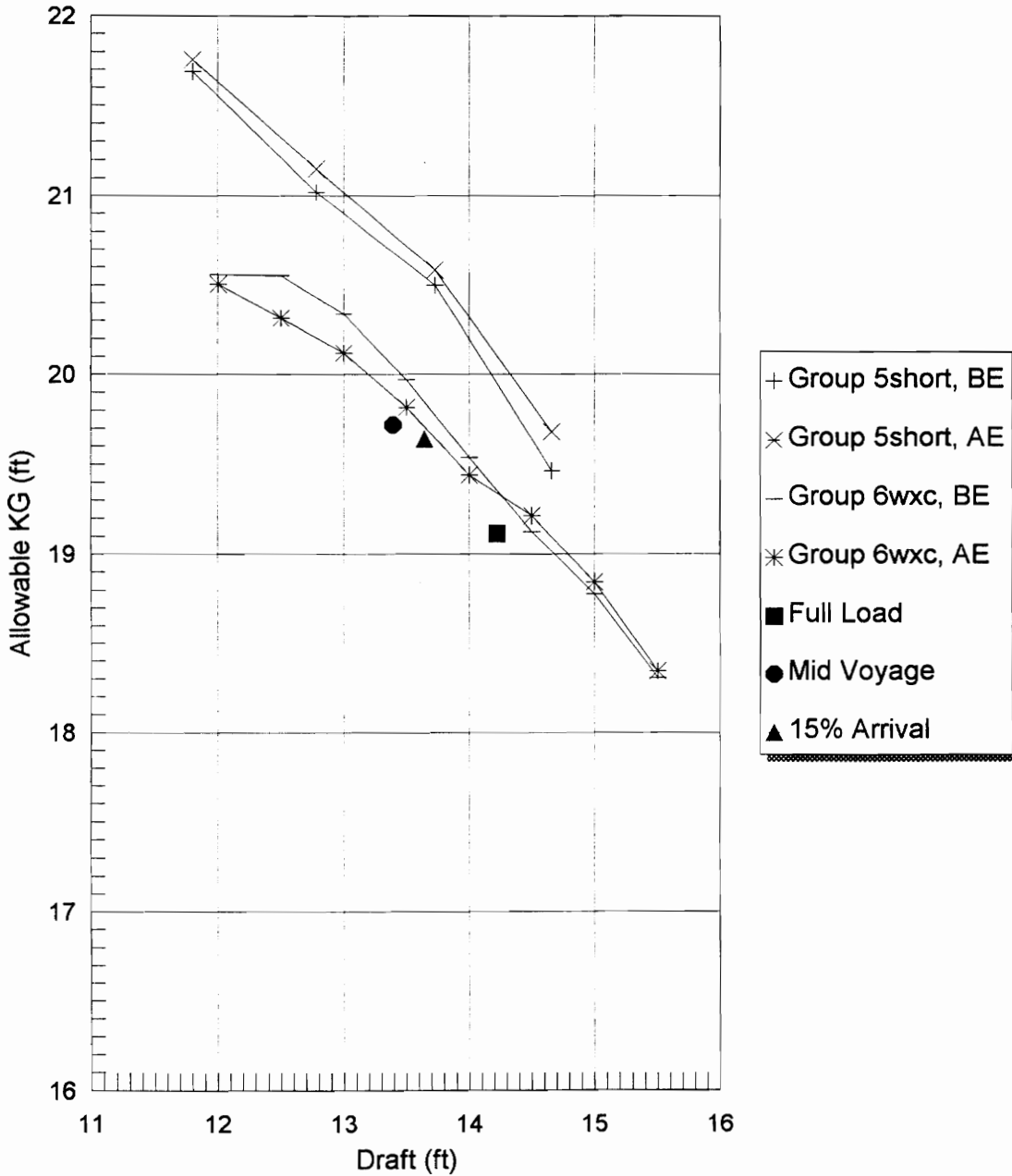


Figure 17

Charting Conversion - Allowable KG vs. Draft

Post 12/92 Rules - Group 5 (with Bhd. @ Fr.60) and 6 (with 4-72-3/4 x-connect) -



6.0 Weights

6.1 Requirements Summary

The requirements for the conversion studies consist of assessing current lightship and full load condition values due to changes from the original T-AGOS mission. The appropriate margins were then applied to the weight and KG for acquisition/conversion adjustments. List and trim are controlled during the entire burn/ballast sequence in accordance with the Trim and Stability Book, ref (1), which will be corrected to suit the conversions by the shipbuilder. Appendix (D) contains the simplified weight and KG estimates based on additions and removals of lightship and load items for both conversions.

6.2 Approach/Margins

The preconversion lightship weights and moments were obtained from ref (1). A correction for the last inclining experiment performed by USCG will be incorporated into the final version of the design team's weight estimate. Load items were estimated from the final shipbuilder's weight report. The total additions and subtractions to the preconversion ship were aggregated and margins applied. The weight and KG margins are in accordance with NAVSEA conversion criteria and were agreed to by NOAA SPO. The baseline margins used were as follows:

Table 13 - Weight and KG Margins (Charting and TAO Convs.)

<u>Item</u>	<u>Weight Margin</u>	<u>KG Margin</u>
Contract design	0%	0%
Design and Build	4.5%	5.5%
Contract Modification	1.0%	0.75%
GFM	0.75%	0.1%

Note that the above percentages are applied to the entire lightship weight for Contract Modification and GFM margins, while they are applied only to the additions and subtractions for the Design and Build margins. This is the usual procedure for calculating margins based on NAVSEA design experience. Note that there are no design or service life margins. Although this is not preferred, given the difficulty of meeting subchapter U stability criteria NOAA

has agreed to this policy. In any case, basing the contract modification and the GFM margins on the entire lightship weight versus just the additions and subtractions affords a high degree of conservatism, particularly for the TAO Conversion. Of course, the above margins are not applied to the new fixed ballast added on the Charting Conversion.

6.3 Conclusions/Recommendations

6.3.1 Charting Conversion

The total impact of margins increases the full load weight and KG by 43 tons and .58'. The total full load weight and KG impact due to the conversion with margins reduces the weight by 186 tons but raised the KG by 1.08' over the T-AGOS 13 class. This is primarily due to the high KG of the heavy conversion items, e.g., survey launches, davits, & midships crane. Due to the removal of very heavy T-AGOS mission equipment and the large reduction in required fuel, the weight has gone down by an estimated 186 tons. Reducing the fuel has the added benefit of reducing the ballast needed to correct for trim. This allowed the ballast tanks with the highest free surface correction, 4-86-1/2 to be converted into voids, thereby reducing the free surface correction by 205 foot-tons by USCG criteria.

6.3.2 TAO Conversion

The total impact of all the margins increases the fully loaded weight and KG by 37 tons and .42'. The total full load weight and KG impact due to the conversion with margins reduces the weight by 109 tons but raised the KG by .6' over the T-AGOS 13 class. The KG did not rise as high, nor was the weight reduced as much as on the charting conversion. This is primarily due to the higher fuel load and great reduction in auxiliary systems weight over charting conversion. No reduction in free surface correction was possible with the conversion.

7.0 Hotel Services (Impacts of Increasing Accommodations)

The accommodations have increased from a preconversion level of 33, to 42 on the Charting Conversion. This section will discuss the impacts on distributive systems which service the mission complement and crew. The hotel services which will be discussed are the potable water, sanitation, electrical, and the HVAC systems.

7.1 Potable Water System

7.1.1 Distillers

The existing distillers for the potable water system have the capability to supply a crew size of 42. The required distiller capacity is in conformance with Navy Design Data Sheet 531 (DDS-531). The use of DDS-531 was appropriate because NOAA has no approved design standards for potable water systems and because the design data sheet has provisions for calculating distiller plant capacity for commercial vessels. The conversion requirements do call out for adherence to U.S. Public Health Service Vessel Construction Regulations, which specify a minimum potable water holding capacity and usage rate. These regulations do not specify water needed for vehicle washdown, however, and are much less conservative than the requirements of DDS-531.

The required distiller capacity is based upon the consumption rate of the crew and equipment aboard the vessel. Each member of the crew requires 60 gallons of water per day. With a crew size of 42, the crew consumes 2520 gallons per day. The Charting Conversion is also outfitted with 4 HSLs and a work boat which are assumed to be periodically washed down with potable water. According to the DDS, each boat will require 40 gallons per day. The boats will require 200 gallons per day of washdown water. Finally, 50 gallons per day are required for machinery plant make-up. The summation of consumption for the vessel is 2770 gallons per day. The DDS also applies a 10 percent growth margin on water consumption for the vessel when sizing the distillers. Thus, with the 10 percent growth margin, the vessel will consume 3047 gallons per day.

The T-AGOS Conversion is currently outfitted with 2-3000 gallon per day distillers. With the 10% growth margin applied, a single distillers can roughly produce the amount of potable water required by the vessel. The second distiller will serve as a standby unit.

7.1.2 Potable Water Storage Tanks

The existing potable water tanks have the capability to supply the crew size of 42 required on the charting conversion. The method of verifying the required storage capacity was with the U.S. Public Health Standards "Handbook on Sanitation of Vessel Construction". The Coast Guard defers to this FDA handbook which recommends a 2 day supply of 30 gallons per person. The potable water tank capacity of the T-AGOS 13 is 4882 gallons. Since both vehicle washdown and the 10% growth factor specified within Navy DDS-531 are not NOAA requirements, the tank has a 2 day supply of approximately 57 gallons per person.

7.2 Sanitation System

7.2.1 Marine Sanitation Device

The Marine Sanitation Device (MSD) for the existing sanitation system has the processing capability to provide for a crew size of 42. The method of verifying the required capacity of the MSD was with the standard navy design criteria for this device. The design standard is that each person produces 30 gallons of both black and grey water a day. For a crew size of 42, the vessel will produce 2520 gallons per day of black and grey water to be processed by the MSD. The MSD aboard the T-AGOS 13 is a 3600 gallon per day USCG approved Type II Omnipure unit. According to ABS, this device will discharge processed waste in accordance to both USCG and MARPOL regulations. Note that if needed, gray water can be dumped directly overboard (also in accordance with both MARPOL and CFR requirements).

7.2.2 Black and Grey Water Holding Capacity

The T-AGOS 13 does not have dedicated black and grey water holding tanks. The current method of operation is that after the black and gray water is processed by the MSD, it is discharged overboard. There is a small lift tank and an overflow tank associated with the MSD, but they are not sized for holding waste water during transit. Holding of both treated black and gray water is not required by either MARPOL or CFR requirements

7.3 HVAC and Electrical Generation

The HVAC and Electrical Generation systems can easily accommodate the increase in load when the crew size grows to 42 people. This is due to the removal of SURTASS related spaces and equipment. See section 8.1 for details of the electrical load estimate.

8.0 **Deck Systems**

This section describes the various deck machinery, including cranes, winches, mooring fittings, and boats required on the conversions. Details of most of the equipment described are shown on figures (18) and (19) for the TAO and Charting conversions, respectively. Additional equipment located at the bow is depicted on the general arrangement drawings in section (3).

8.1 Cranes

The T-AGOS 13 class is provided with one Allied Marine TB9-37 telescopic boom crane. The crane was used for changing out the SURTASS array reels on the fantail. No other cranes were provided on the T-AGOS 13 class, stores were loaded from shore side cranes. Ship checks aboard T-AGOS 13 and 18 revealed that both the existing TB9-37 cranes are in good material condition and can be reused. Both conversion designs are dependent on handling mission items with deck cranes.

8.1.1 Charting Conversion

In order to meet the requirements for stores strikedown, two new hydraulic reticulating sea cranes are added on the Foc'sle. They provide the specified outreach and pier side load handling capability.

One new hydraulic general purpose/DOLPHIN handling crane is added amidships. It has sufficient outreach and dynamic capacity to service the J-frame, CTD winch, and survey launch cockpits.

The existing Allied Marine Crane is relocated on the fantail. It is used to launch the workboat and access the scientific stores hatch.

8.1.2 TAO Conversion

The existing Allied Marine Crane is relocated on the Foc'sle for stores handling. It can only reach over the starboard side, but this is acceptable to NOAA.

Two new reticulating cranes are located on the fantail. They are used for transferring buoys to and from the A-frame and dropping buoy anchors.

A reticulating crane is located at amidships for servicing the J-frame and moving buoy components to the buoy assembly area.

8.2 Boat Handling

8.2.1 Rescue Boat

Both conversions are required to meet 46CFR Subchapter U. In order to meet subchapter U requirements for lifesaving equipment, lifeboats are required for ships engaged on international voyages or for all ships greater than 1600 gross US tons.

The T-AGOS 13 class is certified at 1493 gross US Tons, the charting conversion will likely exceed this tonnage with additional enclosed deck house, unless tonnage openings can be installed. In any case, follow-on charting conversions will operate off the coast of Alaska, and voyages from the continental US to Alaska or Hawaii are considered "international" by 46CFR. The TAO conversion operates regularly in international waters.

Fortunately, the international SOLAS (Safety Of Life At Sea) convention states that ship under 85 meters (279 feet) can carry an approved rescue boat and liferafts in lieu of lifeboats. It is highly unlikely the local USCG inspector will require lifeboats if the conversions are in compliance

with SOLAS. At the time of this writing, NOAA has decided to take that small risk and install liferafts (150% capacity per side) and a SOLAS approved rescue boat launched from a Miranda davit aboard both conversions.

8.2.2 Charting Conversion

In addition to the rescue boat, the charting conversion will serve as a platform for four hydrographic survey launches (HSL's) and a work boat. The four HSL's are launched and recovered from the 01 level. Schat Davit has provided a design for hydro-electric davits to fit the existing Jensen 29' survey launches in the NOAA fleet, to be outfitted aboard the ship. The davits are specially designed to fit within the tight deck at edge area available. The davits are serviced from two central HPU's located beneath the raised deck on the starboard side fantail. Boats may be launched both port and starboard simultaneously. Local controls for each pair of davits will be located outboard on the 01 level with a view of the waterline.

The davits depicted are similar to those of the T-AGS 51 class. They are crescent type davits, hinged at the deck level such that the davit arms will swing outboard over the deck edge. The launches can then be lowered to the Main Deck for personnel embarkation. Platforms are provided for loading the boats while in their cradles. The weight and configuration of the davits is based on those of the T-AGS 51 class, which was designed to accommodate a 34', 15,408 lb fully loaded launch plus a 20% growth margin.

The work boat is a 19' Boston Whaler with a 70 HP gasoline outboard. A hard chine boat is required since NOAA will ground the boat frequently to place GPS position indicators.

8.2.3 TAO Conversion

The TAO support mission requires one workboat in addition to the rescue boat discussed above. The existing 17 foot Avon RIB, which serves as a rescue boat on the T-AGOS 13 class, is being reused for this purpose. The workboat is launched from either of the two fantail cranes. It is used to drive up to the TAO buoys and secure them for retrieval, or it can serve as a platform for light buoy maintenance such as battery change-out.

Figure (18) - Working Deck Arrangement TAO Conversion

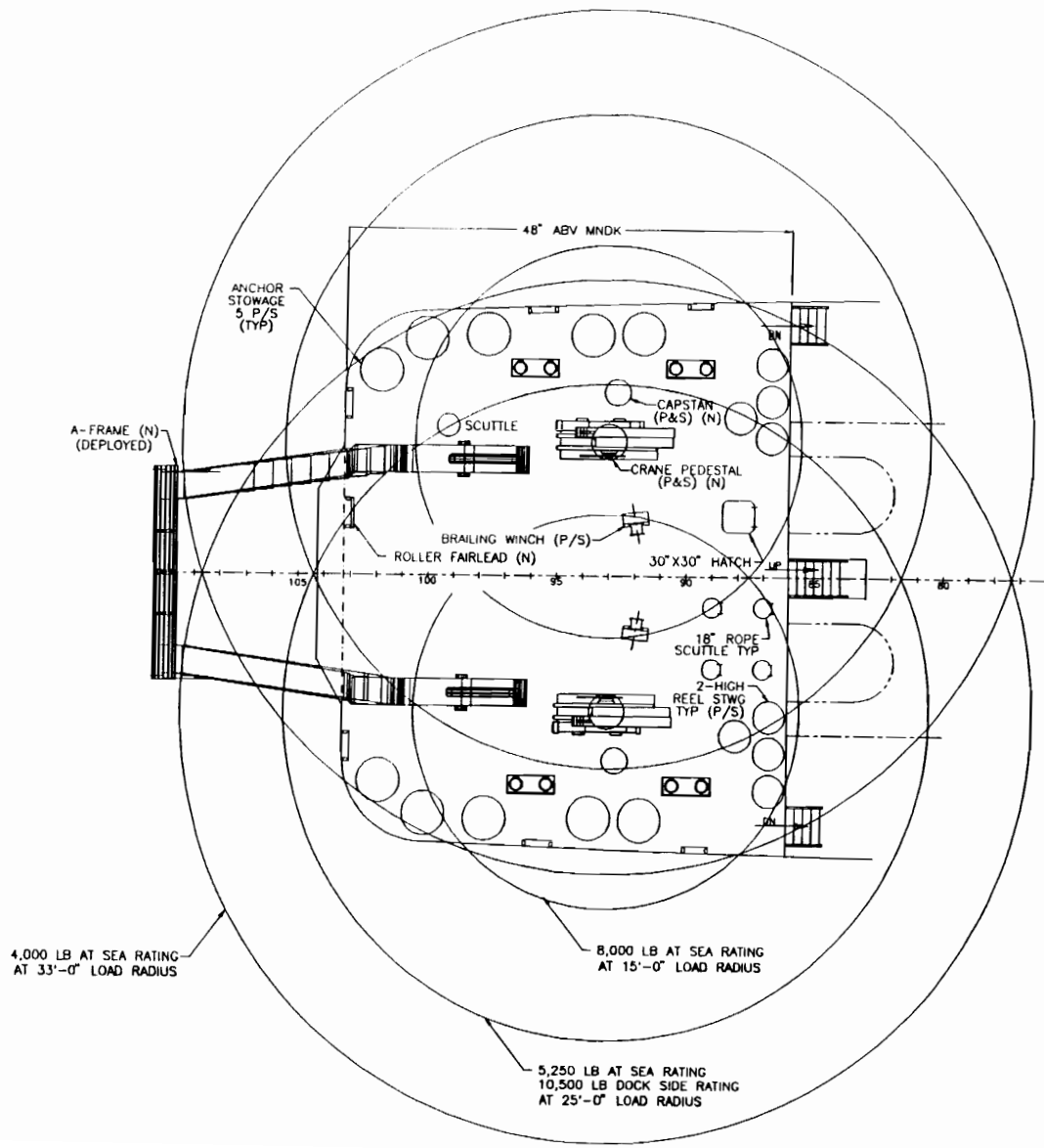


Figure (19) - Boat/ROV Launching Arrangement Charting Conversion

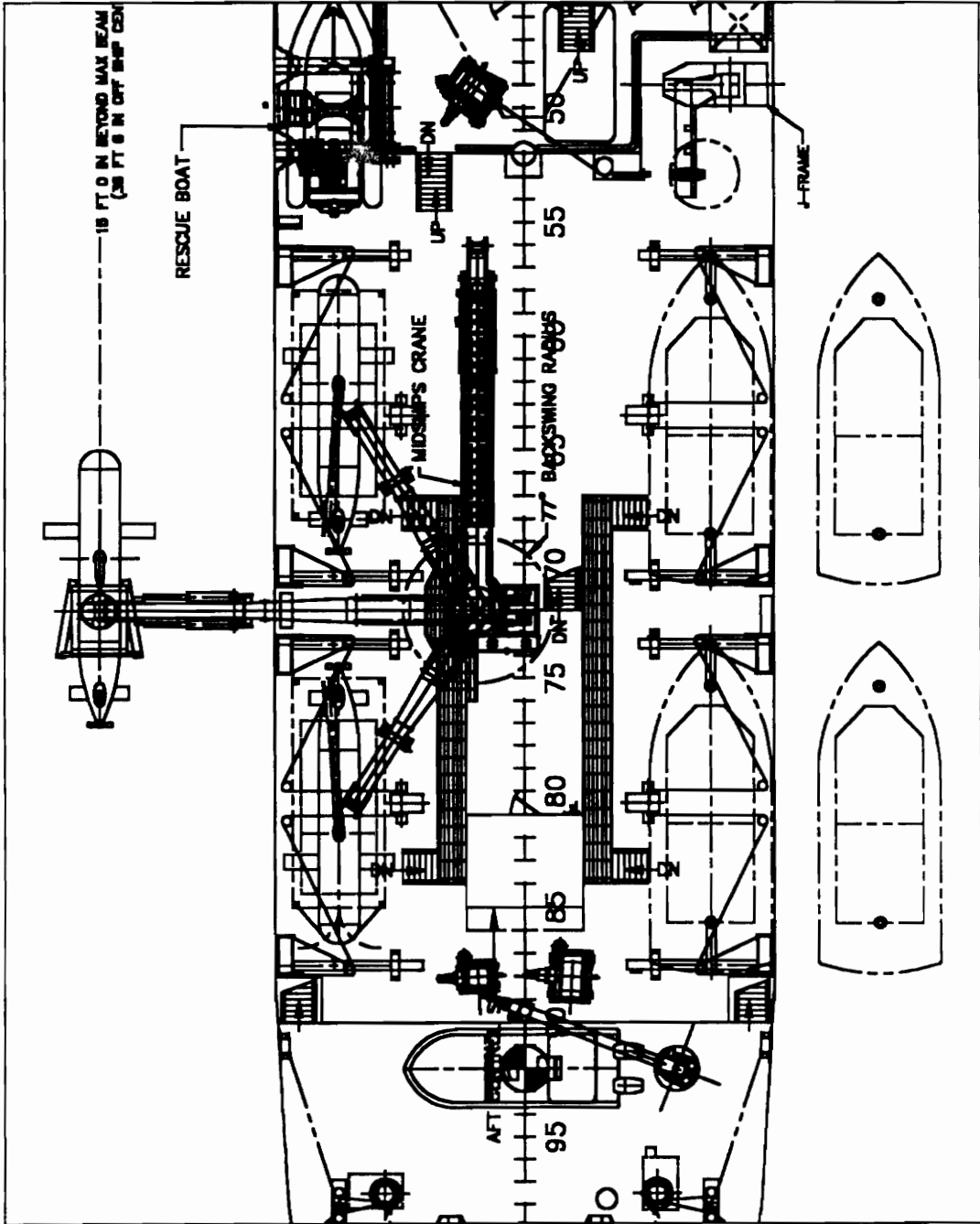
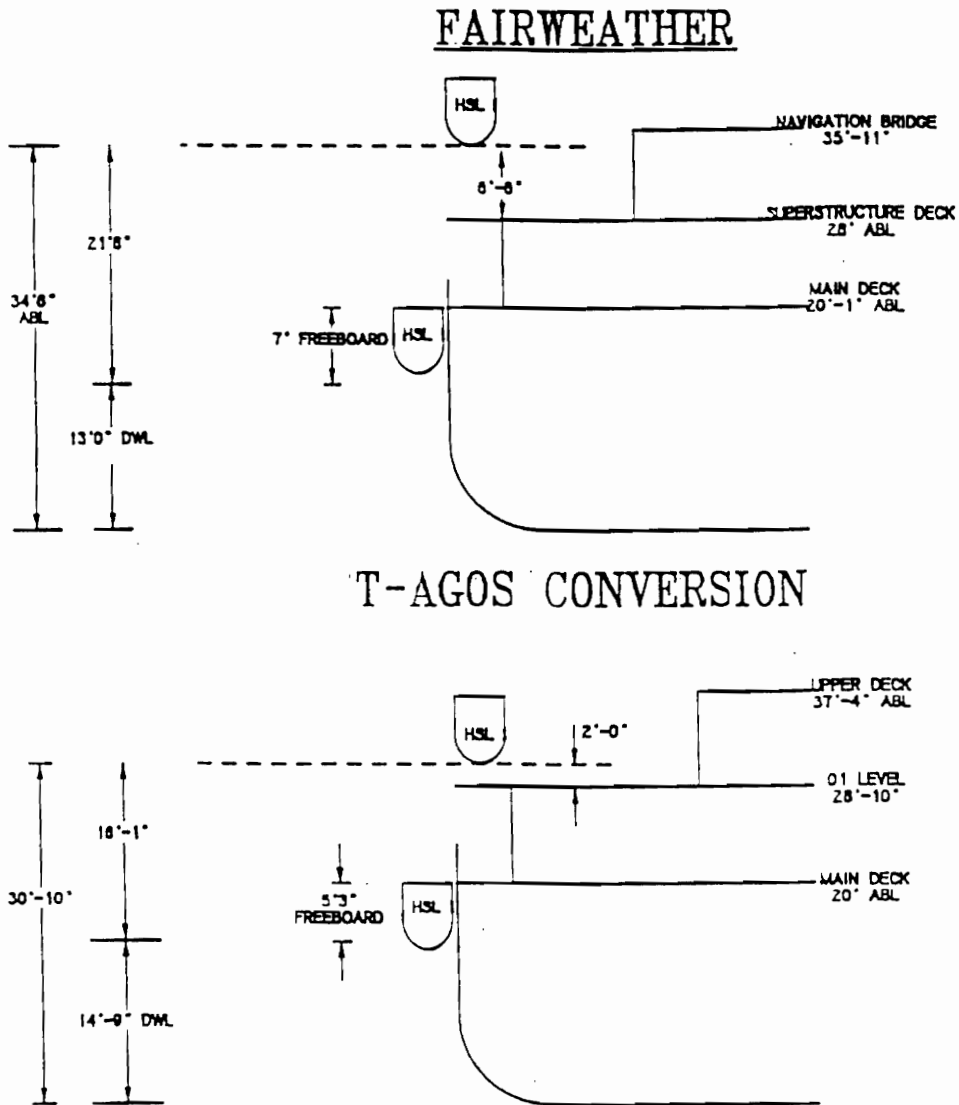


Figure (20) - Boat Handling Comparison, NOAA Ship Fairweather vs. T-AGOS Charting Conversion



8.3 Winches and Frames

8.3.1 Charting Conversion

Three winches are included in the requirements; a Conductivity, Temperature, and Depth (CTD) Winch; a High Speed High Resolution (HSHR) Winch; and a Side Scan Sonar Winch.

The CTD winch is used for oceanographic missions. The winch is associated with the J-Frame and the system is used for collecting water samples with a rosette and for data calibration during survey operations. The HSHR and side scan sonar winches are used for deploying and towing bottom mapping sonars. These fish are both rigged and towed through the A-Frame on the working deck. The HSHR winch can be towed at speeds of up to 10 knots.

8.3.2 TAO Conversion

The TAO conversion is outfitted with two brailing winches used to retrieve and deploy the TAO buoys, and the CTD winch used for the oceanographic mission. The brailing winches are faired through the A-Frame, which is sized to accommodate an assembled buoy. The A-Frame is loaded via either of the two fantail cranes. The TAO is also equipped with a J-Frame sized to accommodate operations with a CTD Rosette of up to 6 feet in diameter.

8.4 Mooring and Anchoring

The after mooring fittings and capstans were relocated both port and starboard to the raised fantail on both conversions. The fittings were relocated to provide maximum working deck area and to comply with Panama Canal transit requirements, which are specified in both conversion's requirements documents. T-AGOS 13 class vessels are not in compliance with Panama Canal Regulations.

In order to meet these regulations, one set of chocks is located as close to centerline as possible, just outboard the A-frame on both conversions. The forward mooring rings are replaced with Panama Canal chocks. The aft capstans were enlarged so that the ships can be moved along a pier without using the bow thruster.

The anchor windlass is being upgraded to a higher powered model and an alignment problem with the haws pipe is being corrected as a repair item.

9.0 Machinery

9.1 Electric Plant/New Load Estimate

9.1.1 Existing Configuration

The T-AGOS 13 class is outfitted with four 600 KW ship service diesel generators (SSDG's) connected to a 600 V switchboard. Three 500 KVA transformers, or two 400 amp shore power connections service the 450 V switchboard. A 250 KW emergency generator is started automatically on loss of power to the 450V switchboard.

Clean power for sensitive mission electronics is filtered through two 400 HZ, and two 60 HZ motor generator sets. Two uninterruptable power supplies (UPS) are also available.

9.1.2 Plant Modifications

No modifications to the existing generators or switchboards are to be undertaken. The 400 HZ MG will be removed, however, since no new mission equipment on either conversion will run on this frequency. Clean power on both conversions will be obtained by filtering through the existing 60 HZ MG sets. The two uninterruptable power supplies will be used in case of generator casualties. These battery back-ups will provide a minimum of 15 minutes of power to mission electronics allowing time for data storage and normal shutdown.

9.1.3 Electrical Load Analysis

9.1.3.1 Charting Conversion - The electric load was estimated using the T-AGOS 13 as built electric load analysis as the baseline. The post conversion electric load differs from the as built in two areas. All SURTASS related equipment, which was required for the surveillance mission of the T-AGOS vessels was removed. Secondly, new mission equipment has been added to establish the post conversion estimates. The major systems added to the charting conversion include:

1. Hydraulic Power Units (HPU) that supply the HSL and rescue boat davits, A-frame and J-frame.
2. Winches for CTD, side-scan and HSHR side-scan operations.
3. Amidships and forward stores handling cranes.
4. Sonar systems
5. Computers and plotting equipment.

The various operating conditions which follow are for the T-AGOS 13 class. The operating speed for the cruising and towing conditions are 11 and 3 knots respectively. No new categories were created to reflect unique operating modes for the T-AGOS charting conversion. All T-AGOS conversion operating modes can be grouped into the existing T-AGOS 13 categories for a feasibility level estimate.

The following operating modes can be grouped in the existing T-AGOS 13 class towing category:

- (1) HSL launch and recovery
- (2) Hull mounted multibeam operations
- (3) Side-scan sonar operations.
- (4) On station oceanographic operations. Power used for propulsion during towing can be used for station keeping with use of the bow thruster and propulsion motors.

The following operating modes can be grouped in the existing T-AGOS 13 class cruising category:

- (1) Transit to and from mission area.
- (2) Future HSHR side-scan sonar operations.

Table 15 is a comparison of pre and post T-AGOS conversion electric load with SURTASS related equipment removed and NOAA mission related equipment added. The existing plant is capable of supplying all necessary ship, mission, and emergency loads. Values for the post conversion electrical load were obtained from ref (a).

Table 14 - Charting Conversion Electrical Load Summary

Operating Condition	Preconversion Electric Load (KW)	SURTASS Electric Load (KW)	Post Conversion Electric Load (KW)
Connected Load	3565.8	205.7	3527.9
Shore	722.6	23.6	703.8
Anchor	759.1	44.7	724.8
Summer Cruise	1627.0	61.7	1572.6
Winter Cruise	1704.4	63.0	1648.7
Summer Towing	709.0	66.1	667.0
Winter Towing	742.1	67.1	699.1
Emergency Connected Load	106.8	1.4	105.4

9.1.3.2 TAO Conversion

The same procedure of eliminating SURTASS related equipment and replacing with TAO support mission equipment is used. Although the connected load is actually higher than the preconversion case, due to the small load factors associated with the mission equipment the existing plant is sufficient to meet all operational and emergency scenarios.

The actual TAO Support mission is compared with summer towing on the following chart. It is less demanding than the preconversion winter towing scenario, which is compared to the oceanography portion of the TAO mission. Winter conditions associated with the preconversion analysis are not actually realistic in the tropical waters where the TAO support conversion will operate. Values for the post conversion electrical load were obtained from ref (c).

Table 15 - TAO Conversion Electrical Load Summary

Operating Condition	Preconversion Electric Load (KW)	SURTASS Electric Load (KW)	Post Conversion Electric Load (KW)
Connected Load	3565.8	205.7	3945.7
Shore	722.6	23.6	454.0
Anchor	759.1	44.7	773.3
Summer Cruise	1627.0	61.7	1682.4
Winter Cruise	1704.4	63.0	1569.2
Summer Towing	709.0	66.1	601.9
Winter Towing	742.1	67.1	535.5
Emergency Connected Load	106.8	1.4	50.9

9.2 Bow Thruster Options

A major concern that had arisen with the Charting Conversion was the possibility of bubble sweepdown interfering with hull mounted sonar operations. This necessitated the following trade-off which were performed during the feasibility study design phase for the Charting Conversion.

One, out of many sources of air for bubbles on T-AGOS 13 class vessels is the installed tunnel type bow thruster. The tunnel type thruster is a problem when the vessel pitches to such a degree that the tunnel emerges and fills with air. When the tunnel submerges, the contained air discharges from the tunnel and the resulting bubbles sweep along the hull.

The possibility of adding doors to the thruster tunnel, or of replacing the tunnel thruster with either a trainable or jet type, is examined in this section. Another possibility was to redesign the tunnel such that bubbles would be trapped and vented to a point above the waterline. It is quite likely that none of these "solutions" would improve sonar performance enough to warrant their implementation.

In order to determine if the sweepdown phenomena would be a problem without performing expensive trials, the ships operability in sea states high enough to surface the thruster tunnel was investigated by NAVSEA using the Navy's Ship Motions Program (SMP). The SMP results revealed that the tunnel would only emerge infrequently in head seas of sea state 5 or 6 at the more common wave periods. MSC operational data from the T-AGOS missions show that accelerations in these types of seas reduce crew effectiveness to such a degree that charting missions would undoubtedly be cancelled in any case.

9.2.1 Bow Thruster Doors

The installation of powered bow thruster doors is still listed as a requirement for the charting conversion. Those responsible for setting requirements at the Office of NOAA Corps (ONCO) wrote this into the requirements since they were concerned that the existing tunnel would facilitate aerated water sweeping in way of the new sonar transducers. This is an understandable concern given the lack of analytical techniques to predict bubble sweepdown, and the importance of the mapping sonar's performance to the ship's mission. Because of this, NAVSEA investigated options

including adding the doors to the existing tunnel type thruster, locating the new hull mounted multibeam sonar so as to minimize the effect of bubble sweepdown, and changing out the bow thruster to a trainable type.

Research has revealed that NATO's R/V ALLIANCE has powered bow thruster doors for its tunnel type thruster. The doors were designed and fabricated by the shipyard that built the vessel since commercial off-the-shelf doors were not available.

The bow thruster doors on the Alliance are a simple design. Each set of doors consists of two semicircle sections that are flush with hull when they are in the closed position. Each door section is mounted off center to a shaft that is oriented parallel to the flow past the tunnel openings. The reason for this orientation is to have the bow thruster doors parallel to sea water flow when they are in the open position. This orientation in turn minimizes flow generated noise past the open doors.

The bow thruster doors are actuated by a dedicated hydraulic system. The hydraulic system consists of a hydraulic power unit and associated equipment, a control system and a hydraulic actuator for each door section. The actuators rotate a door section open or closed via a lever arm connected to each door section shaft. The hydraulic system is also outfitted with a hand pump for back-up purposes.

The bow thruster door system will require additional space within the vessel. Space reservation will be required for the hydraulic power unit and actuators. The HPU could be located within the Emergency Generator Room or one of the forward storerooms on the Main Deck. If the HPU is located within one of the storerooms, it will be segregated from the rest of the space in a separate fire insulated compartment.

The fuel tanks surrounding the Bow Thruster Room will have to decrease in size to provide a space for the hydraulic door actuators. The notch in the fuel tank will be in the area of the thruster tunnel/shell interface. The size of the notch must be large enough to provide space for the actuators, and to perform maintenance on the system.

The weight and stability impact of the new installation will be minimal since it is low in the ship and relatively light weight. Installation of the system (and the additional bulkheads/flats necessary to enclose the hydraulic

actuators) may even make it desirable to remove some fixed ballast.

The operators of the R/V Alliance have complaints concerning their bow thruster door system. They feel the bow thruster door system is not as sturdy as the surrounding hull structure. Because of this, they feel the bow thruster doors are more prone to damage from debris in both open and closed positions. They also complain that the doors produce flow noise when they are in the open position and the vessel is experiencing pitch and roll.

9.2.2 Bow Thruster Change-out

Since bow thruster doors were found to be unacceptable, a bow thruster change out was investigated. The choices available are either a trainable or jet type of bow thruster. A trainable type of bow thruster is totally contained in the hull when it is not being used. When the bow thruster is operating, it is lowered beneath the hull and trainable in any position. The first advantage of a trainable type thruster is that maximum thrust is available in any direction. The other types of thrusters do not have this characteristic. The second advantage is when the trainable type of thruster is retracted, no hull openings are present since the bottom of the thruster seals the opening.

There are a number of disadvantages for a trainable type of thruster. When the thruster is being used, it increases the operational draft of the vessel as the thruster is lowered beneath the hull; this would limit shallow water operations. Also, the trainable thruster requires additional volume within the hull for the system. A third disadvantage is that major structural modifications would be required since this system is positioned on centerline.

9.2.3 Findings & Recommendation

Given the maintenance problems associated with the addition of bow thruster doors, and the expense of changing out the existing thruster, NAVSEA recommended that the new sonar be mounted at the bow just forward of the thruster tunnel, and that no doors be added.

SMP analysis has shown that this location will only emerge from the water in very high seas at certain wave periods and headings. Two sonar manufacturers (Simrad and Atlas) who

sell shallow depth multibeam swath sonars were contacted and agreed that the proposed location was acceptable. At the time of this writing, the requirements document still calls out for bow thruster doors, but NOAA has verbally agreed not to include doors in the baseline of the Charting Conversion.

9.3 Main Deck High Hat Space Utilization

NOAA SPO was concerned that after working deck operations would be hindered by the low freeboard on the fantail, particularly with removal of the existing eight foot bulwark. To address this concern, the conversions entail raising the Main Deck seven feet on the charting conversion and four feet on the TAO conversion creating poop decks with usable volume beneath. This section will discuss how the newly created volume will be utilized by locating unmanned machinery in these locations.

9.3.1 Current Unmanned Machinery Room Configuration

On the T-AGOS 13 there are two unmanned machinery rooms located on the Main Deck aft of the frame 52 fire zone boundary; the Fan Room and the HPU Room. The Fan Room has three fan systems located within it. The first is the 10,800 cfm HVAC system which solely serves the SURTASS Operations Center on the 01 Level. The second is the 2055 cfm HVAC system which serves the Main Deck aft of the frame 52 fire zone boundary. The third is the 1445 cfm exhaust system which serves the previously defined Main Deck area and the Main Control Station.

The Hydraulic Power Unit (HPU) Room contains two separate systems. The first is the HPU system which supplies the array winch and fairlead. The second is the 1645 cfm supply system which supplies preheated make-up air to the HPU room, both HVAC systems located in the after Main Deck fan room, and the Main Control Station.

9.3.2 Main Deck Fan Room Requirements - Charting Conversion

The spaces to receive HVAC from the after Main Deck Fan Room have decreased dramatically with the alteration of the general arrangements for the conversion. The major change is the deletion of the volume utilized by the SURTASS Operations Center (SOC). Because of this, the 10,800 cfm HVAC system that solely served this space is no longer needed. With the deletion of the SOC HVAC system and

addition of the new fan room below the Poop Deck, the footprint necessary for the after Main Deck Fan Room is decreased substantially.

As stated previously, the aft Main Deck Fan Room currently serves the HVAC requirements for spaces aft of the frame 52 fire zone boundary. Air conditioned spaces including three crew staterooms and the Array Winch Shop have been deleted from the preconversion arrangements. The only additional air conditioned spaces added to the converted arrangements are the Data Processing Room, Scientific Storeroom, Aft Control Station, and Diver's Change Room. The result of this change is that the HVAC loading has increased while the net area served by the existing Main Deck system has remained approximately the same. The reasons for the HVAC load increases are three fold. First, the environmental load has increased because the spaces served extend from the deckhouse and have multiple sides in contact with the weather. Second, the thermal load has increased due to the quantity of electronic equipment located within the lab. Finally, there are four new spaces which have been added. In order to meet these new HVAC loads, a new fan room has been added beneath the raised poop deck to serve the Data Processing Room, Scientific Storeroom, and Aft Control Station. All other spaces aft of FR 52 will be served by the existing fan room at FR 67 which has been reduced in size due to the new poop deck fan room, deletion of the SOC, and the new weather passage on the Main Deck.

9.3.3 Main Deck Fan Room Requirements TAO Conversion

The former SOC space has been converted into new manned mission areas. Because of this, the existing aft Main Deck fan room has not changed. Although the load has decreased due to deletion of SOC Computer equipment, the new, smaller, Computer Lab and the new Scientific Storeroom have approximately the same cooling requirements such that no new systems are needed.

9.4 Hydraulic Power Requirements

Space reservations are included within the converted general arrangements for centralized HPU Rooms on both conversions. The HPUs will supply the hydraulic power demands of the A and J frames, aft and amidship cranes, and the HSL and Rescue Boat Davits. The HPU Rooms will also house the motors for the newly enlarged capstans called out in both ship's requirements documents, so that they can be kept out of the weather. The former Array Fluid Collection Tank

necessary to hold spilled array fluid on the T-AGOS mission will be converted into a hydraulic fluid collection tank on the TAO Support conversion; this is necessary due to the limited overhead available beneath the Poop Deck on the TAO.

9.5 Environmental/Regulatory Body Impacts

This section examines the impacts of new regulatory body and environmental laws which may effect the conversions. In order to determine what, if any, new regulations would have an impact, the American Bureau of Shipping (ABS) was asked to investigate any modifications necessary to conform to Subchapter U. Appendix (b) lists the sections of the CFR which will require attention during specification development. Systems which have been investigated at SPO's request include fixed fire extinguishing and refrigeration.

The impacts of meeting Subchapter U requirements go beyond those of damaged stability discussed in section (4). The CFR also contains pertinent regulations effecting the HVAC design of the Wet Labs and Paint Lockers, structural safety factors on oceanographic handling gear, and requirements for fire protection equipment. Work package and specification development will be performed with these regulations in mind.

9.5.1 HALON Replacement

The T-AGOS 13 class uses HALON to extinguish fires within machinery compartments and the Paint Locker. After investigating the development schedule for the new Navy alternative fire extinguishing agent, it was agreed that a new system could not be designed for the conversions given the current schedule. If NOAA desires, however, new locations for additional extinguishing bottles could be investigated during specification development.

The T-AGOS 13 is outfitted for two releases of HALON; NOAA design standards require only one release. Since the new fire fighting agent will require three times as many bottles to perform as effectively as HALON, but only one release is required the number of bottles will increase by about 50% if the new agent is installed.

9.5.2 Other Options for Fixed Fire Extinguishing

The Montreal Protocol requires a 100% phaseout of HALON production by 1/1/94. There is no limit on the use of existing systems, however. If NOAA desires, the existing system can be used indefinitely. Extra bottles used for the second release of the agent by MSC could be stockpiled to ensure an adequate supply for some time.

A second alternative would be replacement with carbon dioxide. These systems are considered unsafe by the Navy, however, since suffocation is immediate - unlike HALON or its replacement which give sufficient time for crewmen to escape.

9.5.2 Refrigerant Replacement

The T-AGOS 13 Class currently is outfitted with three 50 ton R-12 compressors used for air conditioning and two 2 ton units used to cool the refrigeration box. The Montreal Protocol requires a 75% production phase down of R-12 by 1994 and a complete phase out by 1996.

NAVSEA (code 05V) is currently studying the replacement of R-12 with HFC - 134A on several navy classes of auxiliaries. Given the schedule of the yard availability, it is recommended that the R-12 be changed out concurrent with the conversion. This approach is in agreement with the NOAA CORPS instruction on refrigerant replacement. Technical and cost data, including any changes in plant capacity associated with the change-out are being developed by NAVSEA. NAVSEA estimates a total cost of \$325,000 to replace the R-12 currently in use.

10.0 Maintenance Concept

10.1 General

Level One Maintenance will be performed by ship's force both at sea and in port. While in port, both government and contractor shipyard personnel working under the port engineer will also be available. The TAO Support ship will be maintained at the Pacific Marine Center in Seattle, Washington while the first of Charting Conversions will be maintained at the Atlantic Marine Center in Norfolk, VA.

According to ref (f), the maintenance philosophy for the conversions will be consistent with that of other new and newly converted NOAA operated ships.

The suits of mission electronics and hardware will require an increase in personnel skill levels, replenishment spares, hardware/software maintenance, and replacement capability over NOAA's existing capability. In order to achieve this increase, NOAA's in-house resources devoted to maintenance will be increased. This will entail performing much of the maintenance now accomplished by the ship's crew and through contracts with commercial facilities, at the home port of the ship. As stated in ref (f), the increased capability of the Marine Centers will become economically feasible due to the extensive fleet modernization and repair effort that NOAA is now undertaking.

Each ship's force under the new maintenance concept will operate and monitor their systems and equipment and perform routine preventative and corrective maintenance. Equipment requiring preventative maintenance aboard the conversions will be specified in a new maintenance plan which will include a computerized data base prepared by the ship builder and kept current by the ships' engineering departments.

MSC currently operates the T-AGOS vessels using their SAMM (Shipboard Automated Maintenance Management) system, which provides automated support for planned maintenance by keeping track of machinery history. It also helps the engineering department plan corrective maintenance and estimate spare parts and material requirements. NOAA is planning to tailor the SAMM system for their use. Larger motors and other machinery will have revolution counters so that usage rates can be tracked and input into NOAA's automated maintenance system.

Routine corrective maintenance will be performed by the ship's force both in port and at sea. HM&E items believed to require a degree of corrective maintenance too high for the ship's force to accomplish should only be repaired shore side, usually at a Marine Center or a commercial shipyard depending on the extent of the repairs necessary.

Electronic components which fail at sea will usually be changed out with spares carried aboard ship; the defective component will be returned to the vendor - see section 9.4.

For structural repairs, shore side personnel under the port engineer with input from ship's force, should inspect the extent of damage or system degradation to determine if it can be repaired by NOAA personnel, or if the repair should be contracted out.

Alterations to the ships or their major subsystems should be centrally coordinated to eliminate unplanned changes in ship capability and to assure that configurations comply with standard marine practice and do not violate federal regulations on shipping and safety.

Prior to a deployment, maintenance and safety checks will be performed as required by the USCG and NOAA Corps operating procedures. Ref (i) was used to prepare figure 21, a simplified maintenance flow diagram; it is generic enough to apply to both conversions. Note that many of the relationships are simplified, for example, some of the tests performed in series may actually be performed in parallel depending on the number of engineers and technicians available for testing.

10.2 Commonality

The conversions will comprise a major portion of NOAA's fleet if all four charting conversions currently under study are accomplished. Therefore, commonality between conversions will be sought after in follow on contracts after the first hull is converted to the charting mission. This approach will provide a much more standardized maintenance approach, greatly simplifying the logistics support requirements for the entire fleet of charting ships.

NOAA's current fleet is operating with obsolete oceanographic deck equipment. Many of the manufacturers are no longer in business and ILS is increasingly difficult to

maintain. Standardization of modern micro-processor based deck equipment will facilitate the gathering of scientific data as well as ease the current supportability problems inherent in NOAA's fleet of aging ships.

10.3 Shipbuilder's Maintenance Requirements

The general section of the shipbuilding specifications for the conversions should specify the following reliability and supportability requirements:

- 1) The reliability of off the shelf items will conform to the minimum MTBF, MTBM, MCT, and MPT requirements as specified within the general section of the conversion specification. Where specific make and model of equipment is called out with an "or equal" clause, the substitute equipment will have as a minimum the same level of maintenance and supportability as the specified piece of equipment. NOAA will reserve the right to approve the alternate equipment.
- 2) Proliferation of different types of equipments will be controlled by NOAA to assure intra-fleet standardization and to reduce support requirements. Where feasible, identical system components will be used throughout the ship(s).
- 3) Unique system and subsystem designs will be limited to those deemed necessary to reduce operational or maintenance requirements or to meet unique safety or mission requirements.
- 4) The general workshops, boat repair shop, and electronic technicians shops on both conversions will be outfitted such that ship's force with limited off ship resources can adequately maintain the ship to meet all mission requirements and prevent catastrophic failure of ship and mission related systems.
- 5) Underway maintenance will be reduced to meet the limits specified by the general requirements document, if the shipbuilder cannot acquire a system meeting these requirements, they may request a waiver from NOAA.
- 6) In order to meet the maintenance requirements set within the specification, the shipbuilder will perform an analysis to assure adequate stowage capability for repair parts.
- 7) The shipbuilder will input maintenance and spare parts

information of all new equipment into NOAA's PC based maintenance system. This will allow the ships' force to readily maintain ship and mission support systems while maintaining the proper number of replacement modules and spares.

10.4 Depot and Supplier Maintenance

Depot level maintenance for the ship systems performed at shipyards and drydocks will be limited to maintenance tasks beyond the scope of the Marine Centers, such as propeller change-out, or where heavy lift capability, or special tools and equipment are required. Depot level maintenance for major subsystems that are easily removable and transportable, such as mission electronics, computers, and radars, will be sent back to the vendor where deemed most cost effective or where intermediate level maintenance at the Marine Centers is impractical. Sufficient spares will be maintained shore side to ensure the ship's operational schedule is not impacted by shipping a system to a vendor for repair.

Overhauls and special availabilities will be planned approximately every 3 or 4 years of the ship's useful service life in order to accomplish complex ship alterations, change-out major subsystems, and to maintain and coat the hull and appendages.

MAINTENANCE FLOW - PREMISSION READINESS TESTS
(FIRST LEVEL)

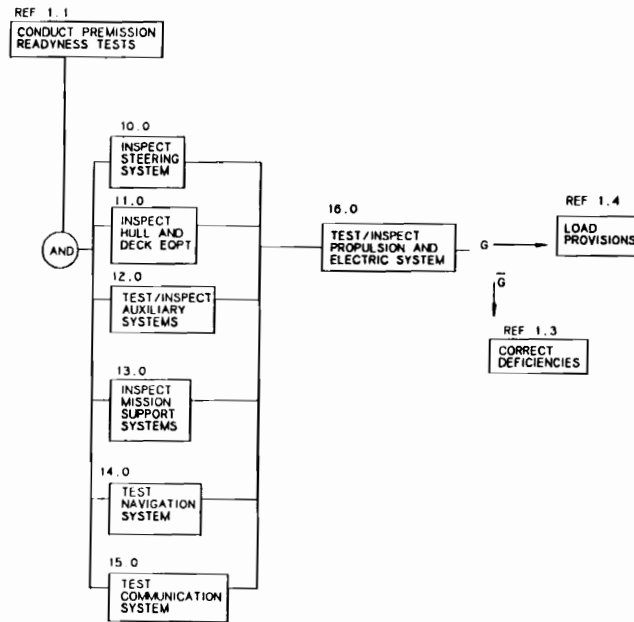


FIGURE (21)

MAINTENANCE FLOW - PREMISSION READINESS TESTS (SECOND LEVEL)

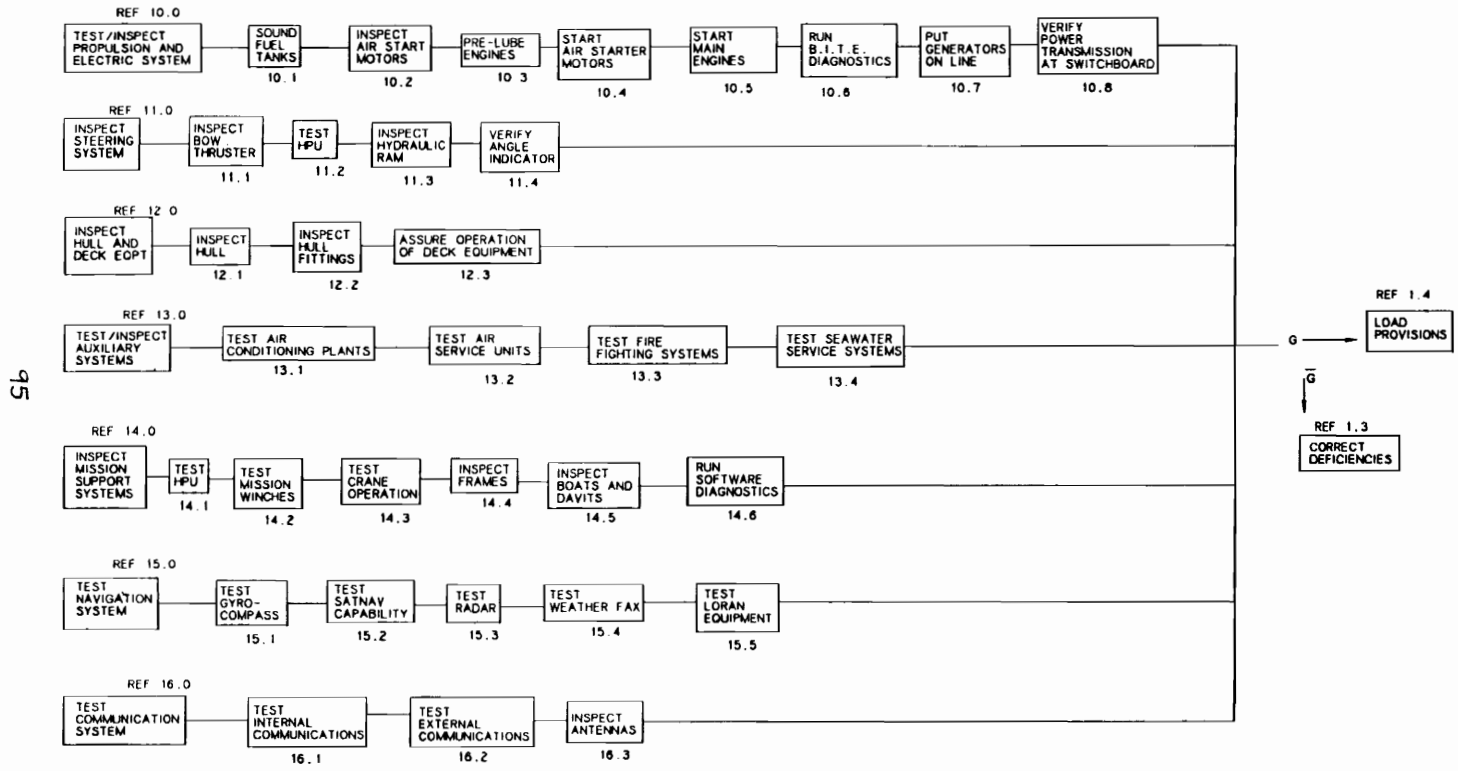


FIGURE (21)

MAINTENANCE FLOW - PERMISSION READINESS TESTS
(THIRD LEVEL)



FIGURE (21)

MAINTENANCE FLOW - PERMISSION READINESS TESTS
(THIRD LEVEL - CONTINUED)

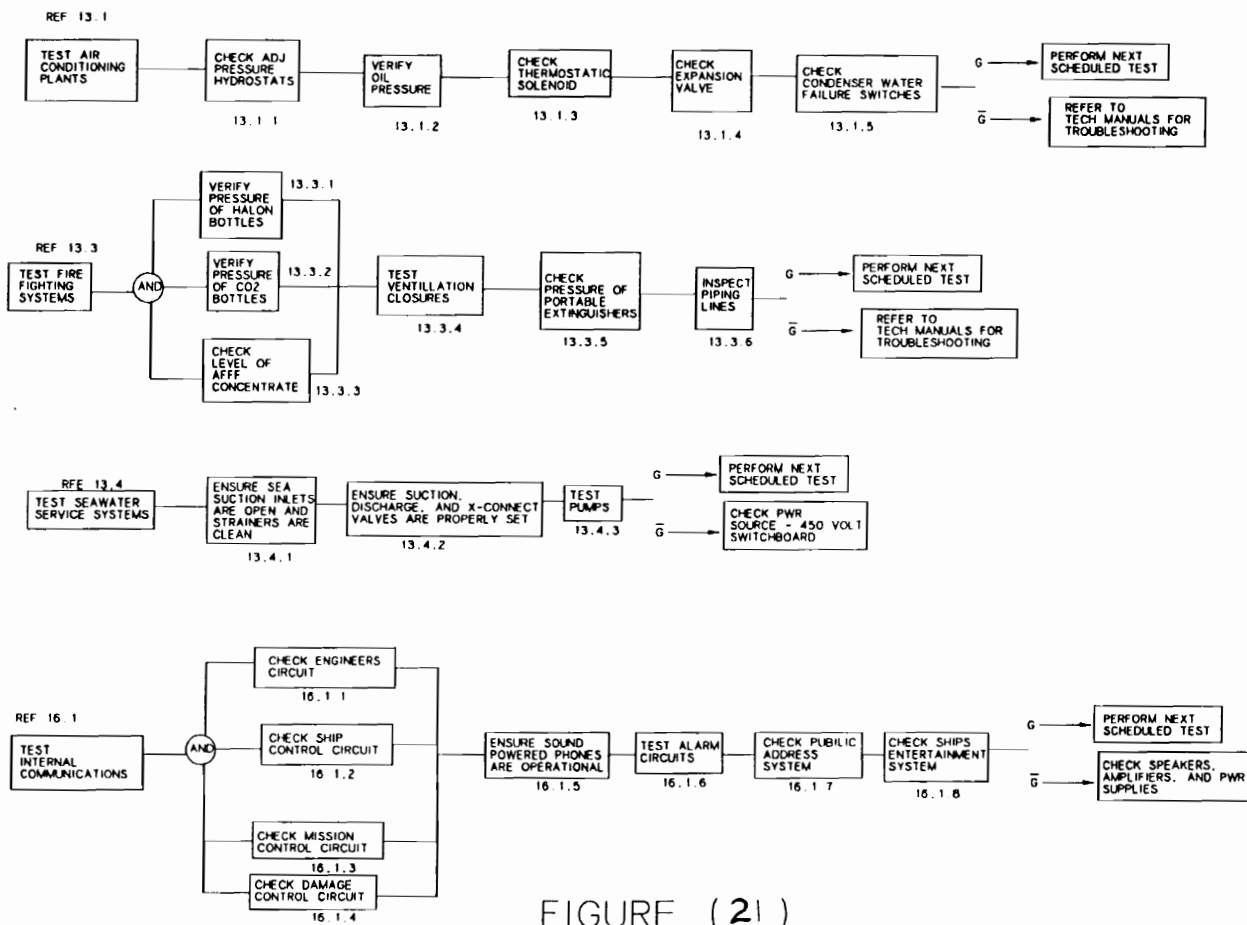


FIGURE (21)

11.0 Repowering Study

11.1 Introduction

The full power speed of the T-AGOS 13 is approximately 11.7 knots in calm water. During full power operations on both conversions, the generating plants possess capacity in excess of ship service and propulsion demands. Because of this, a repowering study was performed during the feasibility design by M. Galecki of NAVSEA, ref (a), to determine the maximum speed of the ship utilizing this excess of power. This section will presents the results of this study.

11.2 Repowering Options

After analyzing the ship service loads of the conversions, it was determined that the two existing 800 HP propulsion motors could be powered with all four existing generators operating at 90 percent loading to increase their horsepower to 960. The next step was to investigate various propulsion train alterations to deliver the 20 percent increase in propulsion power. This was achieved by varying the magnitude of the current and voltage supplied to the propulsion motors. The affects on the propulsion train equipment are presented in a matrix which can be found at the end of this section. The propulsion train equipment considered in the matrix starts with the propulsion switchboards and ends with the propellers.

For Option 1, the propulsion system current was held constant and the voltage was increased until the required power for the propulsion motors was obtained. This option has the smallest impact on the propulsion train equipment. The reason for this is that electrical equipment is rated by current flow. Since the maximum amperage is being held constant at the motor, there is no need to upgrade much equipment for the higher power level.

The addition of step-up transformers are needed for this option. The reason is that the voltage required by the propulsion motors exceeds the capacity of the rectifiers. With the addition of the step-up transformers and the adjustment of the rectifier voltage control, the rectifiers will be able to meet the required output voltage. The circuit breakers will also need some minor adjustment to preclude nuisance tripping since they would now operate at just beyond their design envelope.

Option 2 is the worst case application of Option 1 and illustrates the impact of increasing the voltage to the required level with only the step-up transformers. The rectifiers are not adjusted at all to raise the voltage. The result of this is a higher a.c. amperage level for the propulsion switchboards and will necessitate replacement of the circuit breakers.

For Option 3, the propulsion system voltage was minimally increased to the rectifier's upper voltage control output limit. The system current was then increased till the required power for the propulsion motors was obtained. For this option, the maximum current for the propulsion is potentially beyond the design margin inherent in the motor. This option may be feasible if the capacity of the cooling system can be slightly increased to remove the heat generated by the higher current levels or the motor has sufficient design margin to accommodate the added heating. The circuit breakers will also need some minor adjustment to preclude nuisance tripping since they would now operate at just beyond their design envelope.

Option 4 again minimally increased voltage from the rectifiers and increased motor current indirectly via decreasing the motor field. This increase in motor current is probably well beyond the design margin inherent within the motor. However, an alternative higher power replacement motor of approximately the same size may be possible.

For Options 5 and 6, the propulsion system current was increased and the system voltage was held constant. For both options, the result was that the current increase is probably well beyond the design margin for the propulsion motors. It is highly unlikely the propulsion motors can be altered in any way to operate with the higher current levels. Options 5 and 6 could be pursued if replacement motors of the same approximate frame size were possible.

As stated in the notes for the repowering matrix, all six options have a number of similar requirements. The first is that all the rectifiers in all the options are within their design limits and can be adjusted to deliver the required power. The second is that all the options require the installation of replacement propellers for the higher horsepower levels. Finally, the integral thrust bearing contained in the propulsion motors all need to be upgraded for the higher thrust loading.

11.3 Repowering Study Results

Of all the options studied, Option 1 is the most feasible. The reasoning for this is that all the other options, besides Option 2, require replacement of the existing motors with motors of greater electrical capacity. For Option 1, the existing motor can be used by adding the necessary step-up transformers. The new operating voltage of the propulsion motors would be 895 volts. With this higher operating voltage, the propulsion motors would deliver 960 horsepower at 221 rpm. Adjustments would also be made to the rectifiers, switchboards and propulsion motors to accommodate the higher operating power and voltage. In addition, new propellers would be needed to handle the increase in horsepower. A simplified one line diagram of the proposed electrical system can be found at the end of this section, Figure (6).

The following is an explanation of the above changes necessary to the propulsion train of the T-AGOS 13 to increase its full power speed by half a knot. The existing maximum sustained speed for the T-AGOS 13, and the potential maximum sustained speed with repowering (given the existing generators) are plotted on the speed-power curve for a 14.91 foot draft, figure (3).

11.4 Installation of New Propellers

Reports from the ship indicate that while operating near full power (800 hp, 185 rpm), the ship's speed remains constant when the shaft rpm is increased. A possible reason for this is that the existing 8 foot diameter propellers are designed for slow speed, cavitation free towing. Because of the lack of ship speed increase, any increase in delivered horsepower will not increase the thrust output of the propeller. A solution to this problem would be to install new propellers that could handle the 20 percent increase in horsepower. Studies performed for ref (a) indicated that two 4 bladed, 8.5 foot Troost B Series stock propellers could deliver the required thrust at 221 rpm.

11.5 Potential Replacement of the Shafting and Bearings

The replacement of the shafting and bearings is dependant upon the weight of the replacement propellers. If the replacement propellers weigh the same as the originals, the existing shafting could be used since the torsional and bending stresses would remain the same. Bending stress will rise as the weight of the propeller increases. In addition, if the decision is made to increase shaft torque, torsional stress will increase as well. The resulting increase in the combination of shaft stresses will in turn decrease the Factor of Safety for the existing shafting below what is required. To bring the Factor of Safety back up to the required value, new shafts with larger diameters will be required. With an increase in shaft diameter, new bearings will be needed as well.

11.6 Alteration of Propulsion Motors

A number of alterations will have to be made to the propulsion motors because of the higher operating rpm and power levels. The first is an upgrade to the integral thrust bearing contained in the aft section of each propulsion motor. This is necessary to absorb the higher propeller thrust produced by the replacement propellers. An additional upgrade may have to be performed on the brushes for the higher voltage and speed. The motors are probably still within their structural limits for the higher speed, but this would have to be confirmed with the manufacturer, General Electric, if the study were to proceed from the feasibility design phase.

11.7 Addition of Step-Transformers and Rectifier Adjustment

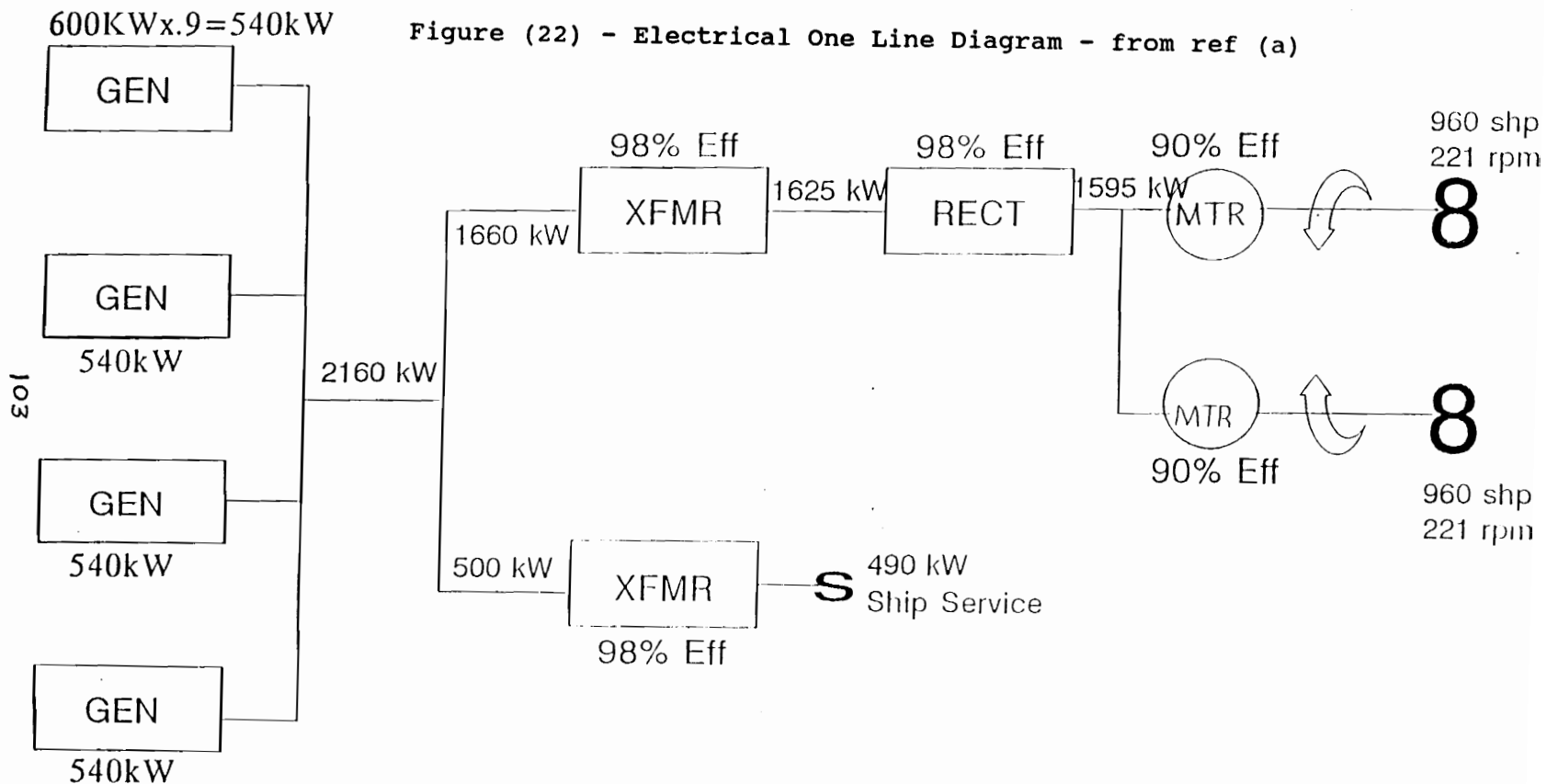
The addition of step-up transformers along with rectifier adjustments will be necessary in order to increase the full power voltage from 750 (present motor input) to 895 volts d.c. rectifier output. The step-up transformers will be connected into the Power Converter Assemblies. These Power Converter Assemblies are located in the 600 volt switchboards within the Main Control Station and contain equipment which controls and regulates voltage and current to the propulsion motors. Alteration of the switchboard will be necessary to accept the buswork and cabling for the transformer connection between the propulsion power converter circuit breakers and the rectifiers. The step-up transformers will be located in the Propulsion Motor Room. In addition, adjustments will have to be performed on the circuit breakers to accommodate the increasing amperage at just above their rating to prevent nuisance tripping.

11.8 General Electric's Involvement as a System Integrator

During procurement, General Electric served as an integrator of the electrical machinery and control systems for the T-AGOS 13. Their services will be required once again in order to modify the existing machinery and control systems to operate at the higher power level.

FULL POWER CONDITION

All Generators Operating at 90%



Repowering Matrix for the T-AGOS Conversions - from ref (a)

Figure 16

Option	Propulsion System Change	Switch-boards (see Note 1)	Propulsion Motors (see note 2)	Shafting (See note 3)	Propeller Speed
1	volts incr mtr amps const min cb amps incr field const	adj SCRs & breakers add 2 xformers & cabling	potential affect on brushes	poten. shafting upgrade	221 rpm
2	volts incr mtr amps const min cb amps incr field const	replace breakers add 2 xformers & cabling	potential affect on brushes	poten. shafting upgrade	221 rpm
3	min volts incr min mtr ams incr min cb amps incr field decreased	adjust breakers and scr's	potentially beyond design margin for cooling	poten. shafting upgrade	198 rpm
4	min volts incr mtr amps incr cb amps incr field decreased	adjust breakers and scr's	potentially beyond design margin for cooling	potent. shafting upgrade	approx 208 rpm
5	volts const motor amps incr cb amps incr field decreased	replace breakers	beyond design margin for cooling	upgrade shafting	approx 200 rpm
6	Volts const mtr amps incr cb amps incr field const	replace breakers	beyond design margin for cooling	upgrade shafting	185 rpm

Note 1: For all options, the rectifiers are within design and can be adjusted to deliver the required power.

Note 2: All propulsion motor modifications require thrust bearing upgrades & there is a potential for brush upgrades as well.

Note 3: For all options, new props will be req'd.

11.8 Repowering Options - Conclusion

Due to the high cost and ship impacts of increasing the speed only about .5 knots, NOAA has decided to not pursue any of the repowering options discussed above and first presented in ref (a). The T-AGOS 13 Class hulls were not designed for high speed operation, producibility was the primary driver in the selection of the hard chine, low speed hull for the T-AGOS missions, which consists primarily of 3 knot towing operations. Reducing the time to get on station was a low priority. NOAA will have to accept the existing top speed.

12.0 Conclusion

Charting Conversion - The T-AGOS 13 Class is a suitable platform to meet all mission requirements for both NOAA Conversion designs. The T-AGOS 13 class vessels cannot, however, match the existing NOAA medium endurance charting ship (Fairweather class) in both speed and number of accommodations.

The chined hull form of the T-AGOS 13 class was originally intended for use as an offshore supply vessel. It is incapable of matching the sustained speed of the Fairweather class without making major modifications to the propulsion system and in fact, installing more power generating capability. Without adding additional power, modifying the motors and other elements of the propulsion system will at best increase the maximum speed from 11.7 to 12.5 knots in calm water. It is highly recommended, therefore, that the repowering option not be pursued further.

Additionally, the Fairweather class provides seventy berths and regularly performs missions with 54 accommodations aboard. The volumetric constraints of the T-AGOS 13 class preclude the addition of berths much beyond the feasibility study level of 42. Going much beyond this level introduces major ship impacts on hotel services, general arrangements, and further reduces the level of habitability, which is already degraded from the preconversion level.

The charting conversion can meet (and usually far exceed) the capabilities of the current NOAA low endurance mapping and charting ship, the Davidson Class. The converted T-AGOS can match the total accommodations of the Davidson Class, while providing greater laboratory space, two additional launches, and a higher endurance.

NOAA intends to use the converted T-AGOS to its full potential, performing missions beyond the capability of the Davidson class, with follow on vessels operating in the waters surrounding Alaska and Hawaii. The only major unresolved technical issue is that of damaged stability. In order to come into compliance with the Subchapter U rules which came into effect 10/12/92, it is required that the bulkhead between the Main Control Station and the Propulsion Motor Room be upgraded to a watertight subdivision (unless margins are reduced to very risky levels and the use of the anti-roll tank is curtailed). NOAA is reluctant to pay for this upgrade, and it remains to be seen how serious NOAA is about complying with Subchapter U letter of the law.

TAO Conversion - Space exists within the existing T-AGOS 13 class superstructure to meet all mission requirements for TAO support. Between the existing SOC space and the conversion of tankage into storeroom space beneath the newly raised fantail, the TAO Support conversion will be the best configured ship to carry out TAO support that NOAA has had at its disposal.

More importantly, the TAO conversion will free up an existing high endurance vessel such as the OCEANOGRAPHER or DISCOVERER which has been used in the past to perform TAO support at the expense of other scientific missions.

New deck equipment in particular, including the new A-frame, which will be the first one in the NOAA fleet large enough to truly accommodate the Atlas Buoys will greatly facilitate buoy retrieval and launching.

As in the Charting Conversion, the only major unresolved issue at this time is meeting Subchapter U damage stability requirements. Due to the TAO conversion's greater displacement, options for meeting the new USCG requirements are even more limited.

As a final note regarding stability, it should be pointed out that none of the existing NOAA platforms to my knowledge are in compliance with Subchapter U. Although NOAA intends all of its new designs to comply with these regulations, options on a conversion are quite limited. Although the T-AGOS 13 class was sold to the Pentagon as a one compartment standard ship, it would not pass USCG criteria (either as-built or new rules) in the subdivision containing the Propulsion Motor Room.

13.0 Literature cited

References

- a) NOAA T-AGOS 13 Class Mapping and Charting Feasibility Study, NAVSEA Report #041-05D-TR-0029, March 1993, Shawn Izenon and Michael Galecki
- b) NAVSEA 05D ROM Study for T-AGOS 13 Conversion to TOGA/TAO Mission, 12 May 1992, Lee/Izenon/Tomer/Cooper
- c) Draft Feasibility Study Report, T-AGOS 13 to TAO Support Conversion, 27 July 1993, John J. McMullen & Associates, Arlington VA.
- d) Preliminary Validation Study Report, NOAA T-AGOS 13 Class Mapping and Charting Conversion, 23 July 1993, M. Rosenblatt & Son, Arlington, VA.
- e) Systems Engineering and Analysis, Benjamin S. Blanchard & Wolter J. Fabrycki, Prentice Hall Intr., 2nd Ed, 1990
- f) 5000 Days at Sea, NOAA Office of Fleet Replacement and Modernization, U.S. Department of Commerce, 1991
- g) Upgrading the NOAA Fleet, Office of NOAA Corps Operations, Rockville, MD., Charles D. Kearse
- h) DOLPHIN Handling System Information Bulletin, Brooke Ocean Technology Limited, Bedford Institute of Oceanography, East Dartmouth, Nova Scotia, Canada, June 1992
- i) Engineer's Operating Manual, Military Sealift Command, T-AGOS 13-15, Halter Marine Inc, New Orleans, LA, 6 Feb 1989
- j) Deck Equipment Commonality Study for the NOAA Fleet, H. David Kaysen, M. Rosenblatt & Son, Arlington, VA 3/31/93
- k) Damage Stability Analysis T-AGOS Class, Designers and Planners, inc., Arlington VA, Prepared for Military Sealift Command 8/7/89
- l) Trim and Stability Booklet for T-AGOS 13 Class (T-AGOS 13 through 18), Approved by USCG 9/14/92 for Subchapter I, MSC Drawing Number 835-6233538 Rev C

References (Cont.)

- m) Engineering 5004, Systems Engineering Process group project, Fall Semester 1992, "Design of an Oceanographic Research Vessel", Group Leader, Shawn Izenon
- n) Speed/Power trial results, FY85 T-AGOS, David Taylor Model Basin, Carderock, MD.

Applicable Design Standards:

- a) Code of Federal Regulations (CFR) Title 46, "Shipping"; Title 33, "Navigation and Navigable Waters"; Title 35, "Panama Canal", Revised as of October 1, 1992
- b) American Bureau of Shipping (ABS), "Rules for Building and Classing Steel Vessels" including all requirements for classification as Maltese Cross Circle A1, AMS, APS, and ACCU
- c) U.S. Public Health Service (USPHS) Vessel Construction Regulations, Publication Number 393, "Handbook on Sanitation of Vessel Construction"
- d) International Regulations for Preventing Collision at Sea, 1972 (72 COLREGS) and subsequent instructions and modifications
- e) American Petroleum Institute (API) Specifications for Offshore Cranes, API 2C
- f) IEEE Standard 45, "Recommended Practice for Electric Installations on Shipboard"

Computer Aided Design Tools:

- a) Ship Hull Characteristics Program (SHCP) Version 4.0, October 1992, Naval Sea Systems Command Code 55W4
- b) Navy Ship Motions Program (SMP) 1987, Naval Sea Systems Command

APPENDIX A

OFFICE OF NOAA CORPS OPERATIONS
FLEET REPLACEMENT AND MODERNIZATION OFFICE

Requirements Document
T-AGOS Conversion for Charting

April 30, 1993

Contents

1. General Information
2. References
3. Dimensional Constraints
4. Performance Requirements
5. Acoustic Survey Operations
6. Working Deck Configuration and Equipment
7. Laboratory Requirements
8. Scientific Instrumentation
9. Other Requirements
10. Accommodations and Habitability
11. Maintenance and Repairs

1. General Information

- a. These requirements address the conversion of a vessel of the U.S. Navy's monohull T-AGOS class to a NOAA charting mission.
- b. Primary and other missions:
Nautical charting
- c. Anticipated homeport:
Norfolk, Virginia
- d. Expected operating area and time of year:
Near shore waters of the east and Gulf of Mexico coasts, any time of year. The vessel is expected to operate in either of the two scenarios listed below:
 - 1) Two launches operating 8 hours per day, and the ship operating 24 hours per day as an additional sounding platform.
 - 2) Four launches operating 8 to 12 hours per day with the ship remaining at anchor for data processing.

- e. Ice class:
Present ABS Class C satisfactory.
- f. Damage stability shall be proved satisfactory prior to making final decisions affecting compartmentation changes.
- g. The converted vessel shall be delivered in ABS Class.
- h. Load line requirements:
The existing load line shall remain in effect for NOAA operation.
- i. Canal transits:
Any existing canal-required outfit items shall be retained.
- j. Standards - The following additional standards shall apply to the converted vessel:
- (1) 46 CFR Subchapter U
 - (2) U.S. Public Health Service Vessel Construction Regulations
 - (3) 72 COLREGS as amended
 - (4) MARPOL 73/78
 - (5) API crane design criteria
 - (6) IEEE 45
 - (7) ABS (Maltese cross) A1(circle E) AMS ACCU
- k. Logistics requirements:
Conversion of the vessel shall be consistent with NOAA's emerging logistics support goals. Materials and coatings shall be selected with the goal of reducing long-term maintenance activity. Maintenance and training will be in accordance with manufacturer's recommendations. Maintenance activity will shift more toward shore support than on present NOAA ships, consistent with reduced manning. The stocking of spares shall be in accordance with the manufacturer's recommendations; however, storerooms aboard ship will focus more on repair support and less on maintenance. Although electronic storage media will see increased

use, a "paperless ship" is not an immediate goal. A planned maintenance management system with inventory control features is required; MSC's Shipboard Automated Management Maintenance Systems (SAMMS) is being adapted to existing NOAA ships and for standardization, shall be applied to this vessel as well. The conversion shall include built-in spare (redundant) equipment with a correspondingly reduced onboard spares inventory, to the maximum extent practicable. Comprehensive training on vessel equipment and operation shall be provided to vessel, marine centers, and, as necessary, mission personnel.

2. References

- a. Dolphin information package.
- b. NOAA CAD Specification Rev. 6.3 dated 12/21/92.
- c. NC Instruction 9602A, "Color and Identification of NOAA Vessels."

3. Dimensional Constraints

The existing length, beam, and draft of the T-AGOS vessels are acceptable. There are no bridge clearance constraints.

4. Performance Requirements

a. Speed:

The existing speed capability of the T-AGOS vessels is approximately 11 knots. This speed is minimally acceptable.

b. Minimum continuous speed:

Present speed is acceptable.

c. Range:

8,000 nautical miles at 11 knots, with a reserve of 15 percent. Stability considerations shall allow the use of the reserve.

d. Stores Endurance:

30 days.

e. Towing Capability:

Side scan sonar (including High Speed High Resolution system) 3 to 10 knots.

f. Maneuverability:

The maneuverability of existing class of vessels is satisfactory.

g. Stationkeeping:

The stationkeeping ability of the T-AGOS vessels is satisfactory. Some degradation of stationkeeping ability is permissible, if it results from the installation of a less-efficient bow thruster for sonar flow optimization.

Dynamic positioning is not required.

h. Precision trackline:

The trackline capability of the T-AGOS vessels is considered satisfactory.

i. Seakeeping:

The present seakeeping capability of the T-AGOS vessels is acceptable.

j. Noise criteria:

Noise criteria for working deck, new and converted spaces are not to exceed the original design standards for the T-AGOS 13 class of vessels.

5. Acoustic Survey Operations

a. Shallow-depth (10 - 150 meters) swath surveys at cruising speed using hull-mounted transducers.

b. Side-scan sonar operations at speeds of 3 knots through cruising speed, with "fish" towed astern.

c. Single-beam (24 khz) fathometer shall operate during survey operations as a check on data quality and as a navigational tool. The main unit will be operated from the bridge with a remote display in the Charting Laboratory.

d. Launch hydrography using four launches.

- e. Charting surveys using two DOLPHINs as a possible future addition.

6. Working Deck Configuration and Equipment

a. Removals:

The removal of existing equipment and structures from the after deck shall be accomplished as necessary to meet these requirements. At a minimum, the following shall be removed:

- (1) After control station, supporting structure, and related items
- (2) Array winch and attachments
- (3) Levelwind and attachments
- (4) Chock/fairlead structure in after bulwark

b. Deck operations to be conducted:

- (1) Boat launching and retrieval
- (2) Side-scan deployment and retrieval
- (3) Velocimeter/CTD/rosette casts
- (4) Bottom sampling
- (5) Miscellaneous crane work
- (6) Vessel line-handling activities
- (7) DOLPHIN launching and recovery

c. Cranes:

- (1) Sufficient crane capacity shall be provided to place the specified loads at the following locations:

Stern A-frame landing area	680 kg (1,500 lbs) at-sea rating
Side J-frame landing area	680 kg (1,500 lbs) at-sea rating
CTD winch drum	1,360 kg (3,000 lbs) dockside rating
Survey launch cockpits (at least 2 launches)	450 kg (1,000 lbs) at-sea rating
Working deck hatches	450 kg (1,000 lbs) at-sea rating
Pierside	1,360 kg (3,000 lbs) dockside rating (at 4.3 m (14 ft) over side of vessel)

At-sea ratings imply use in 2.4 meters (8 ft) significant wave heights, on any heading, at 0 through 6 knots, at the SWL shown. The crane(s) shall also be assigned pierside safe working loads on the basis of no ship motion except static list. The after-crane suit shall also be compatible with the DOLPHIN handling requirement discussed below. The after-crane suite must be capable of placing the accommodation ladder over either side of the vessel.

- (2) A crane designated for pierside use only shall be mounted on the foredeck for stores' loading purposes. This crane will be required to lift a load of 680 kgs (1,500 lbs) at a point 4.3 meters (14 ft) outboard of one side of the vessel. The fore and aft cranes must be mounted so as to service opposite sides of the vessel.

d. Stern A-frame:

An A-frame on centerline at the transom, sized and positioned to deploy and retrieve an object of 1.8 meters (6 ft) height and 1.8 meters (6 ft) diameter over the deck edge, allowing for a distance of .9 meters (3 ft) from the bottom of the sheave to its shackle pin. An A-frame of approximate inside dimensions 4.3 meters (14 ft) high and 3.0 meters (10 ft) wide appears satisfactory. The frame shall pivot on a transverse axis such that the sheave moves in an arc from 1.8 meters (6 ft) inboard of the transom to 2.4 meters (8 ft) outboard. Actuation shall be hydraulic. The frame shall have a safe working load in the outboard position of 4,550 kgs (10,000 lbs), applied within 30 degrees of vertical in any direction by a wire over the sheave from the winch, in 2.4 meters (8 ft) significant wave heights.

e. Side J-frame:

A J-frame at the starboard side, sized and positioned to deploy and retrieve an object of 1.8 meters (6 ft) height and 1.8 meters (6 ft) diameter over the deck edge, allowing for a distance of .9 meters (3 ft) from the bottom of the sheave to its shackle pin. The frame shall pivot on a transverse axis such that the sheave moves in an arc from 1.8 meters (6 ft) inboard of the transom to 2.4 meters (8 ft) outboard. Actuation shall be hydraulic. The frame shall have a

safe working load in the outboard position of 4,550 kgs (10,000 lbs), applied within 30 degrees of vertical in any direction by a wire over the sheave from the winch, in 2.4 meters (8 ft) significant wave heights.

f. Side-scan winch facing stern A-frame:

For conventional side scan sonar operations an aft-facing winch shall be provided, with a capacity of 300 meters of 1.07 cm (.422") electro-mechanical wire, levelwind, and 8-channel slip ring capability. An acceptable winch is the KEM Model KHD-5. The winch shall have hydraulic drive, a top-layer line pull of 250 kgs (550 lbs), and a mid-layer speed of approximately 1 meter/sec (200 ft/min). The mounting foundation of this winch shall be flush with the deck so as to present no tripping hazards when the winch is removed.

An additional winch for HSHR side scan sonar operations will be installed to operate in conjunction with the stern A-frame. This winch shall be outfitted with 400 meters (1,310 ft) of 1.83 cm (.72") diameter electro-mechanical wire. A slip-ring assembly compatible with the HSHR sonar system shall be included. The winch must be capable of retrieving the HSHR "fish" at 1 meter/sec. with the ship steaming at 10 kts.

g. CTD winch facing side J-frame:

An electric or hydraulic CTD winch shall be provided to service the side J-frame. It shall have a capacity of 3,000 meters of .82 cm (.322") electro-mechanical wire. The winch shall be equivalent to the (discontinued) Northern Line 1210, with a top-layer line pull of 680 kgs (1,500 lbs) and a top-layer speed of 2 meters/sec (400 ft/min). A slip-ring assembly shall be included.

h. Boats and boat handling:

- (1) Davits shall be installed for handling four 29 foot survey launches of existing design weighing 6,360 kgs (14,000 lb) each. The pendulum effect shall be minimized. Boarding platforms, a fueling station, 110 VAC power, and seawater supply shall be provided on deck. If future operations require DOLPHINs, two of these launches would be removed to accommodate these DOLPHINs.

- (2) Rescue boat capability shall be provided by a SOLAS approved inboard-diesel RHIB of approximately 6.1 meters (20 ft) in length. Handling shall be by a dedicated system.
- (3) An outboard utility workboat 5.2 to 5.8 meters (17 to 19 ft) in length with a 70 hp outboard engine is required. It may be crane-handled.

i. Dolphin handling:

To accommodate the possible future use of DOLPHINS the deck arrangement shall include provisions for the installation of a DOLPHIN handling system for two DOLPHINS, including cradles and towing boom. See ref (a). DOLPHINS, two survey launches, and work boats would be carried simultaneously. Two of the launches would be removed to accommodate the DOLPHINS. The crane requirements above may satisfy the DOLPHIN crane needs, if of proper capacity and amenable to the installation of a boomhead swing-frame. A dedicated DOLPHIN crane may not be required.

j. Capstans:

Replace the existing aft port and starboard capstans with larger units powered hydraulically or by enclosed electric motors. If electric motors are to be used they shall be located below deck. Capstan barrel shall be 46 cm (18 in) diameter, with a line pull of 4,550 kgs (10,000 lbs) at 10 m/min. (32 ft/min.). A similar unit is the Markey Machinery Co. type CYV-60.

k. Deck configuration:

(Working deck configuration, area apportionment, equipment arrangement, and bulwark extent and height shall be decided with NOS and NCx2, upon reviewing alternatives.)

l. A/J-frame controls:

Primary controls for the A/J frames shall be at the deck edge adjacent to the respective frame. Secondary controls for each shall be located in the after control structure.

m. **Services:**

Power, fresh water, and compressed air shall be provided on the working deck. The principal activity areas shall be lit by floodlights for night operations.

n. **Side-scan handling system:**

A dedicated system independent of a crane shall be installed to move the HSHR side-scan fish from its stowed location to the A-frame with complete control and without pendulum motion.

7. **Laboratory Requirements**

- a. Provide charting laboratory space totaling 125 sq meters (1,350 sq ft). This laboratory space may be divided into two separate locations. The data acquisition area shall be located aft of the bridge, approximately 42 sq meters (450 sq ft) in size. The data processing area shall be approximately 83 sq meters (900 sq ft). A detailed furnishings list and arrangements will be provided by NCx2 and NOS. These spaces shall have HVAC, false deck, communications, lighting, and clean and uninterruptible power. A secure storage area of 1.4 sq meters (15 sq ft) shall be provided in the data processing area.
- b. Provide an oceanographic wet lab of approximately 16 sq meters (175 sq ft), adjacent to the J-frame. This space shall have HVAC, communications, compressed air, lighting, power, fresh water supply, and drainage. A detailed furnishings list will be provided NCx2 and NOS.

8. Scientific Instrumentation

The scientific instrumentation requirements for this vessel are listed below. Additional definition will be provided:

ITEM	COMMENT
<p>Communications Equipment (Source: NOAA/NC2; Outfitted as a Class III vessel)</p>	<p>The specific communications equipment to be installed will be determined following a shipcheck. Below is the standard listing for a NOAA vessel conducting similar operations.</p> <p>100 w HF transceiver (2) 100 w HF transceiver, DSC HF watch receiver, DSC, 2,187.5 khz. VHF watch receiver, DSC, channel 70 HF watch receiver 2,182 khz SITOR/PACKET/RTTY modems (2) Personnel computers (2) Marine VHF transceivers (2) NOAA VHF transceiver Hand held marine/NOAA VHF transceivers (12) Weather FAX NAVTEX receivers HF antennas, 35' whip (3) HF antennas, long wire VHF antennas (5) Hand held emergency transceiver (121.5/243 Mhz) Category 1 EPIRB's Class B EPIRB's (5) 9 Ghz search & rescue RADAR beacons (2) INMARSAT standard A system AFARTS receiver INMARSAT standard C system Intercom system General announcing system Sound powered phone system Telephone system Secure telephone High speed/multi-baud rate modems FAX Machine Smart switch (voice, FAX, data) Cellular phone & antenna RJ11 interface for cellular phone Entertainment system AM/SW/FM/TV distribution system & antennas Closed circuit TV system Signal light Fog/anchor signal system</p>

ITEM	COMMENT
Navigation Equipment (Source NOAA/NC2; Assumes a Class III vessel)	The specific navigation equipment to be installed will be determined following a shipcheck. Below is the standard listing for a NOAA vessel conducting similar operations. X-band RADAR system S-band RADAR system Gyro system Magnetic compass C/A code, DGPS capable, GPS receivers LORAN C receiver Doppler speed log Radio direction finder Digital clock
Launch Instrumentation	C/A code, DGPS receiver Magnetic Compass Digital echosounder LORAN C receiver X-band RADAR DAS system Survey echosounder Marine VHF transceiver NOAA VHF transceiver Flux gate gyro compass Standard Launch Instrument Package
Shallow depth Swath Sounding System	FANSWEEP EM 1000 or similar system
Echo Sounder	Exists
Side-Scan Sonar	HSHR and conventional
Scientific Computer Data Acquisition/Data Processing Systems (DAS/DPS)	For ship and launches
SEAS/MET/XBT	
Heave/Roll/Pitch Sensor	
Acoustic Navigation (short baseline)	Similar to Nautronix ATS or ORE Trackpoint II
Winch Instrumentation	For the CTD winch only, with displays at the winch control station, on the bridge, and in the charting lab.
Internal Communications	Including video monitoring on the bridge of all winches, cranes, and A/J-frames

Capacity shall be provided for the following instrumentation, i.e., nothing should be done that would preclude implementation:

ITEM	COMMENT
Gravimeter	Possible future conversion of state-room
Velocimeter/CTD	
Magnetometer	
Sub-Bottom Profiler (3.5 Khz)	
Meteorological System	
Acoustic Water Quality System	
Acoustic Navigation, Long Baseline	
Acoustic Navigation, Short Baseline	
Doppler Current Profiler	

9. Other Requirements

- a. After Controls - The existing after controls for ship handling shall be relocated to an aft-facing location providing the best visibility of J-frame and stern operations. These controls shall be located in a structure sized for two persons and contain the following: engine and rudder controls, gyro repeater, GPS receiver, digital depth display, controls for the two deck winches and the A/J- frames controls shall also be installed here.
- b. Scientific Storage - Approximately 70 cubic meters (2,500 cu ft) of scientific storage volume shall be provided adjacent to the working deck, with crane access from the deck and both deck and internal personnel access. Stores volume shall be computed to a height of 2.0 meters (6'-6"). Assume that 5,100 kgs (5 long tons) of stores will occupy this space. The space shall be ventilated, drained, and provided with light and power.
- c. Vans - Provision to carry two 2.4 x 6.1 meters (8 x 20 ft) ISO vans in place of the two after launches. This would be a temporary installation to serve short term projects. Launches would be removed, davits would remain in place. Vans would be located on deck in the space previously occupied by the launches. Mountings for these vans would be flush with the deck and present no tripping hazards when not in use. For

stability calculations consider the vans to have the same weight as the launches. Electrical power (240 & 120 volt) and fresh water connections will be installed on a near-by bulkhead for making temporary connections to vans.

- d. Tie-Down Points - The location and type of deck and bulkhead tie-downs for the working deck, wet lab, and charting labs will be determined after these areas are defined. Interior spaces will have a grid system of tie-down points with a spacing not to exceed .5 meters. Deck storage areas will have a grid system of tie-down points with spacing not to exceed 1 meter.
- e. Itinerant Load - An itinerant load (exclusive of the DOLPHINS and launches) of 13,240 kgs (13 long tons) shall be accommodated in all stability analyses. No dedicated space is required for this load, but it shall be placed for analysis purposes at 1.5 meters (5 ft) above the main deck level at frame 72.
- f. Stern Ramp - No stern ramp is required.
- g. Antennas - All antennas to be permanently installed are associated with the equipment listed under Section 8: "Scientific Instrumentation".
- h. Dive Locker - A dive locker of 6.5 sq meters (70 sq ft) shall be provided near the working deck, for compressor and gear stowage.
- i. Cable Management - Open and accessible internal wireways shall be run between all mission spaces, including the charting labs, wet lab, and bridge. Watertight cable pass-throughs shall be provided in the after weather bulkheads of the charting labs, wet lab and bridge.
- j. Waste Management - A compactor space of at least 3.7 sq meters (40 sq ft) is required in or near the galley (the present compactor space is too restricted). Separate storage provision for compacted trash shall be provided.
- k. Painting - The paint scheme shall be changed to conform to the requirements of ref (c).
- l. A separate communications space shall be provided. It may be combined with the ET shop and located in the vicinity of the charting laboratory data acquisition area.

- m. Camber and/or sheer shall be provided on any new solid decks for adequate drainage.
- n. Modification of the bow thruster is required to reduce bubble sweepdown over the sonar transducers. Louvered covers over the existing openings or a retractable type thruster are possible options.
- o. The existing exercise room shall be retained.
- p. A general workshop of 11.1 sq meters (120 sq ft) shall be provided.
- q. Engine and rudder controls shall be added on the bridge wings.

10. Accommodations and Habitability

- a. Accommodations - Accommodations shall be provided for a total complement of 38. Four additional berths in double staterooms shall be included to accommodate visiting scientists and gender flexibility. In total 20 double and two single (CO & CME) staterooms shall be provided. Maximum embarked personnel would be 42. All staterooms shall have dedicated storage space for survival suits and life jackets for each occupant.
- b. Mixed-gender crewing will be planned to suit the accommodations available.
- c. The present medical treatment room shall be retained.
- d. The present window-style meal service may be retained.

11. Maintenance and Repairs

- a. Deficiencies in several existing ships systems have been noted since NOAA has obtained these T-AGOS vessels. Specific systems in need of alteration and/or repair will be identified by consulting the delivery cruise report, MSC ship alteration records, shipchecks, ship-specific maintenance records, AMC and NC2. As an example two of the items identified so far are:
 - 1) The main engine cooling water piping system appears inadequate for operating in warm water areas.
 - 2) The anchor windlass is underpowered.
 Several other items are expected to be identified. The

NOAA FRAM Project Office (NCx2) is compiling a listing of these items for inclusion in the conversion specification.

Fleet Replacement and Modernization Project
T-AGOS Conversion for Servicing TOGA-TAO Moorings
Preliminary Requirements Document

Cognizant Program Office: TOGA-TAO Project Office
March 24, 1993

Contents

1. General Information
2. References
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4. Performance Requirements
5. Working Deck Configuration and Equipment
6. Laboratory Requirements
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9. Accommodations and Habitability
10. Maintenance and Repairs

1. General Information

- a. These requirements address the conversion of a vessel of the U.S. Navy's monohull T-AGOS class to a NOAA oceanographic buoy tending mission.
- b. Primary and other missions:
 - 1) Deploying/recovering deep ocean moorings and associated oceanographic observations.
 - 2) Support collection of upper air boundary layer atmospheric data.
- c. Anticipated homeport:

Honolulu, Hawaii.
- d. Expected operating area(s) and time(s) of year:

Equatorial Pacific from Central/South America to the international dateline; year round.
- e. Ice class:

Present ABS Class C satisfactory.

- f. Damage stability shall be proved satisfactory prior to making final decisions affecting compartmentation changes.
- g. The converted vessel shall be delivered in ABS Class.
- h. Load line requirements:

The existing load line shall remain in effect for NOAA operation.
- i. Canal transits:

Any existing canal-required outfit items shall be retained.
- j. Standards - The following additional standards shall apply to the converted vessel:
 - (1) 46 CFR Subchapter U
 - (2) U.S. Public Health Service Vessel Construction Regulations
 - (3) 72 COLREGS as amended
 - (4) MARPOL 73/78
 - (5) API crane design criteria
 - (6) IEEE 45
 - (7) ABS (Maltese cross) A1 (circle E) AMS ACCU.
- k. Logistics requirements:

Conversion of the vessel shall be consistent with NOAA's emerging logistics support goals. Materials and coatings shall be selected with the goal of reducing long-term maintenance activity. Maintenance and training will be in accordance with manufacturer's recommendations. Maintenance activity will shift more toward shore support than on present NOAA ships, consistent with reduced manning. The stocking of spares shall be in accordance with the manufacturer's recommendations; however, storerooms aboard ship will focus more on repair support and less on maintenance. Although electronic storage media will see increased use, a "paperless ship" is not an immediate goal. A planned maintenance management system with inventory control features is required; MSC's SAMMS is being adapted to existing NOAA ships, and for

standardization, shall be applied to this vessel as well. The conversion shall include built-in spare (redundant) equipment, with a correspondingly reduced onboard spares inventory, to the maximum extent practicable. Comprehensive training on vessel equipment and operation shall be provided to vessel, marine center, and, as necessary, mission personnel.

2. References

- a. TAO mooring and ATLAS buoy component inventory.
- b. NOAA CAD Specification Rev. 6.3 dated 12/21/92.
- c. NC Instruction a, "Color and Identification of NOAA Vessels."

3. Dimensional Constraints

The existing length, beam, and draft of the T-AGOS vessels are acceptable. There are no bridge clearance constraints.

4. Performance Requirements

a. Speed:

The existing speed capability of the T-AGOS class is approximately 11 knots. The NOAA mission will benefit from higher speed if a speed improvement of 1 to 2 knots is judged feasible and cost effective.

b. Minimum continuous speed:

Mission requires extended time maneuvering on station at 0 to 2 knots for periods of 12 to 14 hours at a time.

c. Range and Mission Profile:

The most demanding cruise consists of a transit of 5,500 nautical miles including 230 hours spent on station at 2 knots or less. At 10 knots this cruise would last 33 days. It is desirable but not mandatory that two cruises of this duration would be conducted without refueling. A 15 percent fuel reserve shall be required. Stability considerations shall allow the use of the reserve.

d. Stores Endurance:

35 days.

e. Towing Capability:

Towing forces are below 6,800 kg (15,000 lbs).

f. Maneuverability:

The maneuverability of existing vessel is satisfactory.

g. Stationkeeping:

The stationkeeping ability of existing vessel is satisfactory. Slight degradation of stationkeeping ability is permissible, if it results from the installation of a less-efficient bow thruster for speed improvements.

Dynamic positioning is not required.

Precision trackline is not required.

h. Seakeeping:

The present seakeeping capability of the T-AGOS vessels is acceptable.

i. Noise criteria:

Noise levels for working deck, new, and converted spaces are not to exceed the original design standards for the T-AGOS 13 class of vessels.

5. Working Deck Configuration and Equipment

a. Removals:

The removal of existing equipment and structures from the after deck shall be accomplished as necessary to meet these requirements. At a minimum, the following shall be removed:

- (1) After control station, supporting structure, and related items.
- (2) Array winch and attachments.
- (3) Levelwind and attachments.
- (4) Chock/fairlead structure in after bulwark.

b. Deck operations to be conducted:

- (1) Mooring deployment and retrieval.
- (2) CTD/rosette casts.

- (3) Miscellaneous crane work, to include loading of vessel pierside with own cranes.
- (4) Vessel line-handling activities.
- (5) Boat launching and retrieval.

c. Cranes:

- (1) Sufficient crane capacity shall be provided to place the specified loads at the following locations:

Stern A-frame landing area	3,640 kg (8,000 lb) at-sea rating
Side J-frame landing area	680 kg (1,500 lb) at-sea rating
Decktop of SOC space	680 kg (1,500 lb) at-sea rating
Hatches to scientific stores	450 kg (1,000 lb) at-sea rating
Pierside	3,182 kg (7,000 lb) dockside (at 4.3 m (14 ft) over one side of the vessel)
Utility workboat	450 kg (1,000 lb) at-sea rating
5 ft aft of stern	2,000 kg (6,600 lb) at-sea rating
Buoy staging areas	910 kg (2,000 lb) at-sea rating

At-sea ratings imply use in 2.4 meter (8-foot) significant wave heights, on any heading, at 0 through 6 knots, at the safe working load (SWL) shown. The crane(s) shall also be assigned pierside safe working loads on the basis of no ship motion except static list. The after crane suite must be capable of placing the accommodation ladder over either side of the vessel. For safety considerations the whip length on the crane should be as short as possible; therefore, articulated cranes are preferred.

A crane designated for pierside use only shall be mounted on the foredeck for stores loading purposes. This crane will be required to lift a load of 680 kg (1,500 lbs) at a point 4.3 meters (14 feet) outboard of one side of the vessel.

d. Stern A-frame:

An A-frame on centerline at the transom, of approximate inside dimensions 6.1 meters (20 feet) high and 4.6 meters (15 feet) wide (horizontal width at deck level to a height of 4.6 meters off the deck) is

satisfactory. The frame shall pivot on a transverse axis such that the sheave moves in an arc from 3.6 meters (12 feet) inboard and outboard of the transom. Actuation shall be hydraulic. The frame shall have a safe working load in the outboard position of 9,100 kg (20,000 lbs), applied within 30 degrees of vertical in any direction by a wire over the sheave from the winch, in 3 meter (10-foot) significant wave heights.

e. Side J-frame:

A J-frame at the starboard side, sized and positioned to deploy and retrieve an object of 2 meter (6 foot) height and 2 meter (6 foot) diameter over the deck edge, allowing for a distance of 1 meter (3 feet) from the bottom of the sheave to its shackle pin. The frame shall pivot on a longitudinal axis such that the sheave moves in an arc from 2 meters (6 feet) inboard to 2.4 meters (8 feet) outboard. Actuation shall be hydraulic. The frame shall have a safe working load in the outboard position of 4,536 kg (10,000 lbs), applied within 30 degrees of vertical in any direction by a wire over the sheave from the winch, in 3 meter (10 foot) significant wave heights. The position of the J-frame shall be as near to amidships as the ship's arrangement allows. The O-1 level is an acceptable location for the base of the J-frame.

f. CTD Winch:

An electric CTD winch shall be provided to service the side J-frame. It shall have a capacity of 10,000 meters (33,000 feet) of 8.2 mm (0.322 inch) electro-mechanical wire. The winch shall be equivalent to a MARKEY DESH-5.

g. Boats and boat handling:

- (1) Rescue boat capability shall be provided by a SOLAS-approved inboard-diesel RHIB of approximately 6.1 meters (20 feet) in length. Handling shall be by a dedicated system similar to the Caley or Miranda davits.
- (2) An outboard utility workboat 4.6 - 5.2 meters (15 to 17 feet) in length is required with a 25-hp tiller controlled outboard engine. A soft bottom inflatable is required. It may be crane-handled.

h. Capstans:

Replace the existing aft port and starboard capstans with larger units powered hydraulically or by enclosed electric motors. If electric motors are used, they shall be located below deck. Capstan barrel shall be approximately 46 cm (18 inches) in diameter, with a line pull 4,550 kg (10,000 lbs) at 10m/min (32 ft/min). A similar unit is the Markey Machinery Co. type CYV-60.

For buoy deployment and recovery, two centrally located brailing winches are required. Barrel diameter shall be .41-.46 meter (16 - 18 inches). The units shall be rated for continuous duty (6 hours' operation - 2-hour rest period.) Speed and line-pull capacity shall be in the range of 40 m/min at 1,140 kg (2,500 lbs) and 10m/min at 4,550 kg (10,000 lbs).

i. Deck configuration:

The after working deck shall be raised to a height 3.0 to 3.6 meters (10 -12 feet) above the waterline. At least 151 sq meters (1,600 sq ft) of deck space shall be dedicated for deck storage, this space may be on different decks. An area of 57 sq meters (600 sq ft) shall be reserved for a clear working area on the fantail forward of the A-frame on the centerline of the vessel.

j. A/J-frame controls:

Primary controls for the A/J-frames shall be at the deck edge adjacent to the respective frame. Secondary controls for the J-frame shall be located at the CTD winch operator's station.

k. Winch Operator's Station:

The winch operator's station shall include the winch and secondary J-frame controls. It shall protect the operator in the event of breakage of the winch wire and provide a good view of the winch and side CTD landing area.

l. Services:

Power (120, 240, & 440 volt AC), fresh water, and compressed air shall be provided on the working deck. The principal activity areas shall be lit by flood lights for night operations.

6. Laboratory Requirements

- a. Provide an air-conditioned, 19 sq meter (200 sq ft) workroom for mooring instrument repair and storage of spare instruments, tools, etc.
- b. Provide a computer laboratory space of 23 sq meters (350 sq ft) for scientific data collection instrumentation. A detailed furnishings list and arrangement will be provided. These spaces shall have HVAC, communications, lighting, and clean and uninterruptible power. See table 1.
- c. Provide a wet lab of at least 9.3 sq meters (100 sq ft), adjacent to the J-frame and CTD landing area. This space shall have HVAC, communications, compressed air, lighting, power, fresh water supply, and drainage. A detailed furnishings list will be provided. See table 1.
- d. An autosalinometer room adjacent to the wet laboratory is required. It shall have a dedicated HVAC system to maintain constant temperature for proper operation of the salinometer instrument. See table 1.
- e. Provide an operations office of 9.3 sq meters (100 sq ft) adjacent to the computer laboratory. A detailed furnishings list will be provided.
- f. A summary of minimum size laboratory and mission spaces is listed in table 1. If space allows these areas will be enlarged proportionally to include as much of the existing SOC space as possible.

MISSION SPACES			
Space	Quantity	Sq meters/ Sq Ft Each	Comment
Instrument Repair area	1	19/200	Repair of mooring and electronics equipment
Computer laboratory	1	23/350	Mission and ship operations computer systems located here
Wet laboratory	1	9.3/100	Detailed furnishings list will be provided
Mission/Operations office	1	9.3/100	Detailed furnishings list will be provided
Autosalinometer room	1	5.6/60	Temperature controlled, located adjacent to wet lab

Table 1 Mission Spaces

7. Scientific Instrumentation

The scientific instrumentation requirements for this vessel are listed below. Additional definition will be provided:

ITEM	COMMENT
<p>Communications Equipment (Source: NOAA/NC2; Outfitted as a Class I vessel)</p>	<p>The specific communications equipment to be installed will be determined following a shipcheck. Below is the standard listing for a NOAA vessel conducting similar operations</p> <p>1 kw HF transceiver system 100 w HF transceiver HF watch receiver, DSC, multi-freq. VHF watch receiver, DSC, channel 70 HF watch receiver 2182 khz SITOR/PACKET/RTTY modems (2) personal computers (2) Marine VHF transceivers (2) NOAA VHF transceiver Hand held marine/NOAA VHF transceivers (13) Aircraft transceiver Weather FAX NAVTEX receivers HF antennas, 35' whip (4) HF antennas, long wire (2) VHF antennas (5) Passive VHF distribution system Hand held emergency transceiver (121.5/243 Mhz) Category 1 EPIRB's (remote activation) (2) Class B EPIRB's (9) 9 Ghz search & rescue RADAR beacons (2) INMARSAT standard A system AFARTS receiver INMARSAT standard C system Intercom system General announcing system Sound powered phone system Telephone system Secure telephone High speed/multi-baud rate modems FAX Machine Smart switch (voice, FAX, data) Cellular phone & antenna RJ11 interface for cellular phone Entertainment system AM/SW/FM/TV distribution system & antennas Closed circuit TV system Signal light Fog/anchor signal system</p>

Navigation Equipment (Source NOAA/NC2; Assumes a Class I vessel)	The specific navigation equipment to be installed will be determined following a shipcheck. Below is the standard listing for a NOAA vessel conducting similar operations X-band RADAR system S-band RADAR system Gyro system Magnetic compass C/A code, DGPS capable, GPS receivers LORAN C receiver Doppler speed log Radio direction finder Digital clock
Buoy tracking antenna	Mounted on a mast with 360 degree view of horizon Size approx. .03 meter tall, whip type
Upper Air Sounding System (Similar to OMEGA balloon sounding system)	1 - 1 9in rack will be required in Computer Laboratory, 12 - 7 cu meter helium bottles required
Wind Profiler	Mounted on deck with a foot print of 3.7 x 3.7 meters (12x12 ft), 320 kg (700 lb), 1- 19 in rack in Computer Laboratory
Deep Water Narrow Beam Echo Sounder	Similar to ODEC 5,000 meter depths 12Khz
Navigation Echo Sounder (24 kHz)	Connect existing transducer to a DSF 6000N
Acoustic Doppler Current Profiler	
Scientific Computer Data Acquisition/Data Processing Systems (DAS)	Located in Computer Laboratory
SEAS/MET/XBT/XSV/XCTD	Integrated with DAS
Thermosalinograph	
Winch Instrumentation (scope, speed, tension) integrate with DAS	For the CTD winch only, with displays at the winch control station, on the bridge, and in the Computer Laboratory
Internal Communications	Including video monitoring on the bridge of all winches, cranes, and A/J-frames
CTD with Rosette and Niskin bottles	Weight fully laden is 2,400 lbs w/ 24- 10 liter bottles
Autosal Salinometer (2 required)	Located in Autosal. room
Uncontaminated Seawater Delivery System to Wet Laboratory	Teflon pipe system, 25 liter/min flow rate including a backup pump

Table 2 Scientific Instrumentation

Capacity shall be provided for the following instrumentation, i.e., nothing should be done that would preclude implementation:

Deep water Multibeam Sonar	Seabeam 2,000 or equivalent (optional)
Gravimeter	L&R or Equivalent (optional)
Sub-Bottom Profiler (3.5 kHz)	(optional)

8. Other Requirements

- a. After Ship Handling Controls - The existing after controls for ship handling shall be relocated to an aft facing location providing an unobstructed view of mooring activity on the working deck. These controls shall be located in a structure sized for two persons and contain the following: engine & rudder controls, gyro repeater, GPS receiver, and digital depth display.
- b. Scientific Storage - Approximately 34 cu meters (1,200 cu ft) of scientific storage volume shall be provided near to the working deck, with crane access from the deck and both deck and internal personnel access. Stores volume shall be computed to a height no higher than 2 meters (6.5 feet). Assume that 5,100 kg (5 LT) of stores will occupy this space. The space shall be ventilated, drained, and provided with light and power.
- c. Vans - If space allows, provide for two sets of ISO deck fittings for 8 feet x 20 feet containers. For stability calculations the vans shall have an assumed weight of 7,130 kg (7 LT) each. Electrical power (240 and 120 volt) and freshwater connections will be installed on a nearby bulkhead for making temporary connections to vans.
- d. Tie-Down Points - The location and type of deck and bulkhead tie downs for the working deck, wet lab, computer laboratory, and workroom will be determined during design. Interior spaces will have a grid system of tie-down points with a spacing not to exceed .05 meter. Deck storage areas will have a grid system of tie-down points with spacing not to exceed 1 meter.
- e. Itinerant Load - An itinerant load of 60 long tons (LT) shall be accommodated in all stability analyses. This load is composed of the items in b. Scientific Storage

and c. Vans above, all items in f. Deck Storage below, with the remainder evenly distributed on the deck.

- f. Deck Storage - Provide storage space for 10 - 1,450 kg (4,200 lbs) railroad wheel anchors in the immediate vicinity of the stern A-frame. Provide space adjacent to the clear working area (See section 5.i) for at least 10 small wooden reels of mooring cable. Provide storage space for eight- 8-foot diameter, 800 lb toroid surface buoys. The toroids are generally stored disassembled, two high. Two elevated buoy assembly areas must be provided which allow the lower bridle to be attached to the toroid, a minimum height of 7 feet under the buoy is required for this.
- g. Stern Ramp - No stern ramp is required.
- h. Waste Management - A compactor space of at least 3.7 sq meters (40 sq ft) is required near the galley (the present compactor space is too restricted). Provide a separate storage area for compacted trash.
- i. Painting - The paint scheme shall be changed to conform to the requirements of ref. (c).
- j. All new decks will have camber and/or sheer to facilitate water runoff.
- k. Operations spaces shall be included as per Table 3 below:

Operations Spaces			
Space	Quantity	Sq meters/ Sq Ft Each	Comment
ET shop	1	7.4/80	Locate near computer lab and bridge
Dive locker	1	9.3/100	Dive gear, compressor, tanks
Boat workshop	1	9.3/100	Include workbenches & toolboards
Foul weather gear locker	1	2.8/30	Interior access with ventilation system, near after working deck
Boat gear locker	1	2.8/30	

Table 3 Operations Spaces

9. Accommodations and Habitability

- a. Accommodations - Anticipated number of berths is 33, if additional berthing is required, single staterooms will be converted to doubles.
- b. Mixed-gender crewing will be planned to suit the accommodations available.
- c. The present medical treatment room shall be retained.
- d. The present window-style meal service will be retained.

10. Maintenance and Repairs

- a. Deficiencies in several existing ships systems have been noted since NOAA has obtained this vessel. Specific systems in need of alteration and/or repair will be identified by consulting the delivery cruise report, MSC ship alteration records, shipchecks, ship-specific maintenance records, AMC, and NC2. As an example, two of the items identified so far are:

- 1) The main engine cooling water piping system appears inadequate for operating in tropical waters.
- 2) The anchor windlass is underpowered.

Several other items are expected to be identified. The NOAA FRAM Project Office (NCx2) is compiling a listing of these items for inclusion in the conversion specification.

APPENDIX B



29 September 1992

Refer to: RWN/wsl
File Ref: 92-W-979
PID 199960

Commander
Naval Sea Systems Command
NAVSEA 504B
Department of the Navy
Washington, D.C. 20362-5101

Attention: Mr. Howard Fireman

Subject: Review of Subchapter U Requirements for
T-AGOS 13 Conversion

Dear Mr. Fireman:

As requested we have made a general comparison of the requirements for certification of a vessel under 46 CFR Subchapter U vs. Subchapter I. We have also reviewed the findings outlined in NAVSEA 50122 memo (undated) on the subject matter and advise as follows:

It is noted that

1. For the subject vessel, as a U.S. Government owned vessel compliance with USCG Regulations or 46 CFR Subchapters U and I is not required. However, we note that compliance with USCG Regulations is desired only to the extent practicable without adversely affecting the vessel's intended mission.
2. If the vessel is engaged on international voyages (46 CFR 188.10-35) compliance with and certification under the requirements of SOLAS 74, MARPOL 73/78, and 1966 Load Line Convention are necessary.
3. If the vessel is to be engaged in commercial activities a Load Line Certificate is required.
4. T-AGOS 13 was reportedly constructed to meet the requirements of Subchapter I with the possible exception of SOLAS and MARPOL requirements. Therefore a review for compliance with SOLAS & MARPOL is recommended.

Additional requirements which would be applicable under Subchapter U include the following:

189.35-9 (c)(1)	Wet Weight Handling Gear
190.03	Subdivision and Stability (See Subchapter S) 173.070
	Requiring Damaged Stability
190.05-10,-20	Requirements for Laboratories and Chemical Store Rooms
190.15	Ventilation for Fuel with Low F.P. (110°F)

- 10(b) Means of Stopping Ventilation to Labs and Store Rooms from Outside the Space
- Part 193 Fire Protection Equipment
- 193.10.10(1)(1) For Fixed Systems only CO₂ Indicated
- Part 194 Hoses and Hydrants are Required in way of Labs.
- 195.09 Handling, Use and Control of Explosives and Other Hazardous Materials
- 195.11 Scientific Equipment
- 196.80 Portable Vans and Tanks
- 196.85 Explosive Handling Plan
- Magazine Control

These requirements have been generally identified in the NAVSEA 50122 memo except as further outlined below.

- 189.35-9(c)(1) Wet Weight Handling Gear should be designed to 1.5 times the breaking strength of the wire rope in use on the device.
- 190.03 Subdivision and Stability (173.070) requires compliance as for a passenger vessel (see attached) Type II, one compartment flooding, category Z vessel.

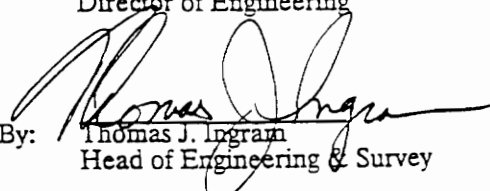
The ability to comply with the above should be verified. Any alteration required to meet the stability and subdivision regulation should meet the appropriate USCG and ABS standards. The use of class 2 or 3 sliding watertight doors identified in the NAVSEA 50122 memo might be a typical requirement depending upon the outcome of the review.

Aside from the stability/subdivision question the only major area of non-compliance is the noted lack of survival craft of the specified types and capacities. To provide a minimum recognized survival craft capacity we would recommend compliance with SOLAS Chapter III Regulation 26 (1.3) (copy attached) for cargo vessels of less than 85m by using inflatable liferafts along with an approved rescue boat. This would also permit certification under SOLAS for Safety Equipment by the USCG should an international voyage be required. SOLAS Certificates for Radio Telephone would be issued by the FCC and ABS would issue the Safety Construction Certificate for this vessel.

Very truly yours,

ABS AMERICAS

Glenn Ashe
Director of Engineering

By: 
Thomas J. Ingram
Head of Engineering & Survey



27 January 1993

Refer to: TJI/wsl
File Ref: 93-W-071
PID 199960

U.S. Coast Guard
Marine Safety Center
400 Seventh Street, N.W.
Washington, D.C. 20590-0001

Attention: CDR Scott Davis
Chief Hull Division

Subject: Stability Requirements for Subchapter U Vessel
"Adventurous" T-AGOS.13

Gentlemen:

Further to our recent telephone conversations concerning the damage stability requirements for the subject vessel, we have been requested by the NOAA project office that is handling the feasibility studies, to determine your comments concerning the following items:

- 1) The subject vessel was originally certified by the USCG as a Subchapter I Cargo and Misc. Vessel, however, NOAA has decided to change the vessel to a Subchapter U Oceanographic Research Vessel. The vessel presently has a cross-flooding valve for a pair of fuel tanks. This valve is located in a passageway above the bulkhead deck and is to be opened when damage occurs to the Motor Room to equalize the compartments within 15 minutes and provide sufficient damage stability in the final stages of flooding. This cross flooding does not strictly meet the requirements of 46 CFR 171.080e(1)(i) since it is not automatic. NOAA proposes to remove this valve and provide a cross connection that would prevent transfer of fuel from one wing tank to the other except at large heel angles. Please confirm that this proposed arrangement would be acceptable.
- 2) Feasibility Studies are being conducted to examine the possibility of providing four survey launches for the charting and mapping mission. The weight estimate is plotted against the required GM curves in Figure (1). The required GM curves were developed using the following assumptions:
 - a) Heel only to the margin (less than 7 degrees)
 - b) No equalization (i.e. cross connection) after damage.
- 3) In regard to the actual damage stability calculation, the preliminary results indicate that the margin line will be submerged prior to equalization and after equalization the margin line will not be submerged. We understand that 46 CFR 171.080 for existing vessels does not permit submergence of the margin line at any time and special consideration may be given on a case by case basis. Please advise if temporary submergence of the margin line during

equalization provided there are no points of down flooding is acceptable. As an alternative, we discussed the option of NOAA electing to use the new vessel damage stability requirements USCG 171.080 that came into effect on 10 Dec. 1992. Since this requirement is considered a higher level requirement than the existing requirement, the owner could request special consideration by the USCG (reference telephone conversation T. Ingram, ABS and J. Persons, USCG as evidence of satisfactory damage stability. Please confirm that this alternative method would be acceptable.

- 4) As can be seen from Figure (1) the anti-roll tank must be dumped in order to meet stability after damage criteria. Clearly, this cannot be a truly automatic procedure. The procedure would require that a button in the pilot house be pushed in order for the tank to be emptied of its contents. Would the Coast Guard allow this procedure, thus enabling use of the anti-roll tank under normal intact operating conditions?

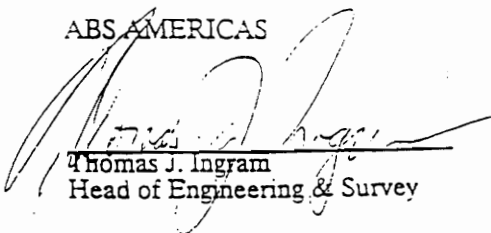
In summary we request your comments ASAP on the following questions:

- 1) At the option of the owner, may the new vessel stability requirements of 46 CFR 171 which came into effect Dec. 1992 be used as an alternative to the existing vessel requirements, since the new requirement permit the submergence of the margin line during equalization?
- 2) Under the existing vessel stability requirements 46 CFR 171 would the USCG permit the temporary submergence of the margin line during equalization provided that no points of down flooding exist?
- 3) Would the use of anti-roll tanks be permitted in the stability analysis even though automatic dumping cannot be provided?
- 4) Would the proposed arrangement of the cross flooding system be acceptable for automatic equalization?

Should you have any questions on the above, please contact the undersigned or R.W. Norris at (703) 892-2493.

Very truly yours,

ABS AMERICAS



Thomas J. Ingram
Head of Engineering & Survey

FAX (202) 366-3877

16710/HALT 1123-1128
16703/46 CFR 171.080
Fax H2-30622
14 July 1993

ABS Americas
Attn: Mr. Thomas J Ingram
Government Services Unit
2011 Crystal Drive
Suite 903
Arlington, VA 22202

Subj: HALTER HULLS 1123-1128
T-AGOS 13
Oceanographic Research Vessel (U)
Ocean Service
Damage Stability Requirements

Ref: (a) Your letter Ref:93-W-071 dated 27 Jan 93

Dear Mr. Ingram:

The following comments are provided in response to your request in reference (a) for written guidance regarding damage stability requirements for the subject vessels. We apologize for the confusion and delay in responding, as we found no record of initial receipt. For clarity, the comments are arranged in the same order as the questions listed in the summary to reference (a).

1. It appears from reference (a) that the proposed conversion of the subject vessels meets the definition in 46 USC 2101(14a) of a "major conversion." Accordingly, the damage survival criteria for vessels constructed on or after December 10, 1992, contained in 46 CFR 171.080(e), may apply to these vessels. You should contact Commandant (C-MVT) for a determination as to whether this project constitutes a major conversion.

For vessels which are constructed prior to, and which do not undergo a major conversion after, 10 December 1992, the damage survival criteria of 46 CFR 171.080(d) apply. At the option of the owner of such a vessel the criteria of 46 CFR 171.080(e) may be applied instead.

2. For all vessels to which 46 CFR 171.080(d) apply, the margin line may be temporarily submerged. There is no specific limit on the non-equalized maximum angle of heel in the transient damage condition provided the requirements of 46 CFR 171.080(e)(8) are met and no downflooding points are submerged. For vessels to which 46 CFR 171.080(e) apply, the transient damage condition is specifically addressed by 46 CFR 171.080(e)(7) & (8).

3. It is permissible to require that the anti-roll tanks be dumped in order to meet the damage stability criteria of 46 CFR 171.080(d) provided no down flooding points are submerged and the provisions of 46 CFR 171.080(e)(8) are met prior to dumping the tanks. Similarly, it is permissible to require that the anti-roll tanks be dumped in order to meet the damage stability criteria of 46 CFR 171.080(e) provided no down flooding points are submerged and the provisions of 46 CFR 171.080(e)(7) & (8) are met prior to dumping the tanks.

Ser N2-30622
14 July 1993

Subj: Halter Hulls 1123-1128, Damage Stability

4. The following are general guidelines regarding the arrangements of equalization systems:

A. Equalization systems on vessels of 150 gross tons or more in ocean service must be automatic unless the Commanding Officer, Marine Safety Center considers it impracticable to make the equalization automatic in accordance with 46 CFR 171.080(f)(1)(i)(A). Equalization is considered "automatic" if a high hat cross-flooding pipe arrangement can be provided such that:

- i. the top of the high hat cross-flooding pipe is always far enough below the lightest operating waterline for which equalization is required to ensure adequate hydrostatic head to equalize the cross-connected tanks in 15 minutes or less; and
- ii. there is no transfer of liquid between the cross-connected tanks in the intact condition up to a heel angle of 40 degrees.

B. For arrangements where it is "impracticable" to make the equalization automatic, a cross-flooding pipe arrangement with an in-line valve is acceptable provided the cross-flooding valve controls are located above the bulkhead deck in accordance with 46 CFR 171.080(f)(1)(i)(B), and the equalization is fully accomplished within 15 minutes in accordance with 46 CFR 171.080(f)(1)(ii).

C. In every case the cross-flooding piping must be located entirely inboard of the Beam/5 transverse extent of damage required by 46 CFR Table 171.080(a).

D. Whenever automatic or manual equalization is employed to meet the damage stability criteria of 46 CFR 171.080(d) or (e) the transient (before equalization) condition must be evaluated to the standards outlined in paragraph 2 above.

Sincerely,

S. E. DAVIS
Commander, U. S. Coast Guard
Chief, Hull Division
By direction of the Commanding Officer

APPENDIX C

NOAA T-AGOS 13 CONVERSION TO CHARTING MISSION
4 LAUNCH, EXTENDED 01 LEVEL, WITH ANTIROLL TANK

OPTION #7 1/26/93

GROUP	WEIGHT (LTONS)	VCG (FT)	VMOM (FT-LTON)	LCG (FT)	LMOM (FT-LTON)	TCG (FT)	TMOM (FT-LTON)
LIGHTSHIP W/OUT ROLL TANK	1458.6	20.7	30192.4	98.6	143771.2	0.0	0.0
REMOVALS - BASELINE							
151 SURTASS WINCH ARR & DET	-0.4	20.9	-7.4	180.0	-63.7	0.0	0.0
151 WINCH STA SUPPORTS	-3.9	30.1	-116.3	172.5	-665.9	1.5	-5.8
153 WINCH CONTROL STA	-4.9	38.2	-185.5	174.2	-844.7	1.0	-5.0
154 WINCH STA TOP	-0.6	45.6	-26.5	175.3	-101.7	0.0	0.0
171 MAIN MAST	-4.7	61.8	-290.0	116.3	-545.4	0.0	0.0
185 SURTASS HULL STRL FDNS	-3.9	20.5	-80.3	179.7	-702.6	1.5	-5.9
185 ARRAY MOD STOWAGE UNIT	-1.2	22.2	-26.6	164.6	-197.5	0.0	0.0
252 PROPUL CTRLS WINCH CONTRL ST	-0.2	39.5	-6.7	177.0	-30.1	0.0	0.0
436 SURTASS SYS CKT &WRG	-0.1	35.3	-3.9	106.7	-11.7	2.5	-0.3
462 SURTASS ELECT EQPT SOC	-24.1	32.8	-791.2	126.0	-3036.6	0.0	0.0
462 SURTASS ANT EQPT	-0.7	81.0	-54.3	114.0	-76.4	0.0	0.0
491 ELECT TEST EQPT	-1.1	33.3	-37.2	139.8	-156.5	5.5	-6.2
*512 HYDRAULIC POWER UNIT	-0.7	24.0	-16.8	155.0	-108.5	10.0	-7.0
523 NBC WASHDOWN SYS	-0.1	44.4	-6.2	101.9	-14.3	0.3	-0.0
532 SURTASS COOL WTR SYS	-0.7	24.0	-16.0	126.0	-84.4	-6.3	4.2
532 SURTASS COOL WTR PANEL	-0.1	34.1	-2.9	119.0	-10.1	-15.7	1.3
556 ARRAY FLUID SYS	-0.5	31.1	-16.8	175.6	-94.8	-1.9	1.0
556 ARRAY WINCH HYDR PIPE	-0.5	21.0	-10.1	164.0	-78.7	13.0	-6.2
582 CAPSTANS - FWD	-1.4	39.4	-54.0	7.0	-9.6	3.3	-4.5
582 CAPSTANS - AFT	-1.4	23.0	-31.5	180.0	-246.6	0.0	0.0
583 17 FT RESCUE BT RHIB	-0.4	41.0	-16.4	118.0	-47.2	16.0	-6.4
583 RESCUE DAVIT	-0.8	43.0	-32.3	110.0	-82.5	18.0	-13.5
583 TELESCOPING BOOM CRANE	-7.5	37.8	-282.5	152.6	-1141.7	-0.1	0.7
591 ARRAY WINCH & ARRAY	-63.8	28.0	-1787.5	182.0	-11618.9	1.5	-95.8
591 ARRAY MOD STWG MAIN DK	-3.6	26.0	-92.8	164.0	-585.5	0.0	0.0
591 ARRAY MOD STWG FCSLE DK	-0.9	33.8	-30.1	156.0	-138.8	0.0	0.0
595 ARRAY OVERBOARDING SYS	-11.2	27.0	-301.3	206.0	-2299.0	0.0	0.0
622 GRATING MAIN DECK	-9.0	22.0	-197.8	175.3	-1579.0	-0.2	1.7
622 FALSE DECK SOC	-4.0	29.5	-117.1	119.7	-475.0	0.2	-0.7
623 ARRAY/WINCH LADDERS	-0.0	20.8	-0.8	159.4	-6.4	0.0	0.0
623 SATCOM ANT MAST	-0.2	57.7	-11.5	121.6	-24.3	0.0	0.0
631 PAINT	0.0	18.5	0.0	94.0	0.0	-0.0	0.0
634 DECK COVERING SOC	-0.5	29.4	-13.5	125.5	-57.7	4.1	-1.9
634 WINCH CTRL STA DECK COVERING	-0.0	37.4	-1.5	172.9	-6.9	1.2	-0.0
663 MISSION OPS RM	-1.6	32.1	-52.2	123.0	-200.5	-5.9	9.6
663 WINCH CTRL STA	-0.0	41.8	-1.7	180.0	-7.2	0.0	0.0
663 VAULT	-0.3	32.2	-9.7	116.9	-35.1	-1.0	0.3
663 VESTIBULE	-0.2	31.9	-5.4	116.4	-19.8	3.1	-0.5
*671 PAINT LOCKER	-0.9	25.0	-22.5	155.0	-139.5	-12.0	10.8
665 ELECTRONICS SHOP	-2.9	31.7	-92.8	141.2	-413.8	5.2	-15.4
665 ARRAY WINCH SHOP	-0.9	24.0	-21.6	156.0	-140.4	-7.0	6.3
REMOVALS - DESIGN SPECIFIC							
*623 ACCOM LADDER	-0.4	40.4	-16.2	142.0	-56.8	0.0	0.0
*582 AFT CHOCKS	-0.2	21.0	-4.0	188.0	-36.0	0.0	0.0
*582 AFT BITTS	-0.3	21.0	-6.3	186.0	-55.8	0.0	0.0
*671 SHORING	-0.4	40.0	-16.5	135.0	-55.8	0.0	0.0
*321 SHORE POWER CABLE REELS	-0.6	32.0	-19.5	152.0	-92.7	0.0	0.0
*100 DECK (03 LEVEL 277 SQFT)	-2.5	46.5	-114.4	85.0	-209.1	-2.0	4.9
*120 BHD (STR,01 LVL,FR 42-51)	-2.3	44.0	-99.0	94.0	-211.5	0.0	0.0

*120 BHD (STR,02 LVL,104')	-5.3	42.4	-226.4	88.0	-469.9	0.0	0.0
*120 BHD (MNDK LONG,42-86)	-11.2	24.5	-275.1	126.0	-1415.0	0.0	0.0
*621 JNR BHD (02 LVL,24.2')	-0.4	42.4	-17.0	86.0	-34.4	2.0	-0.8
*621 JNR BHD (01 LVL, FR45-52)	-1.2	33.0	-40.6	97.0	-119.3	0.0	0.0
*643 TECH DOUBLE (01-34-2)	-0.6	33.0	-19.9	74.0	-44.7	9.0	-5.4
*643 TECH DOUBLE (01-34-1)	-0.6	33.0	-19.9	72.0	-43.5	-11.0	6.6
*643 TECH DOUBLE (01-42-2)	-0.6	33.0	-19.9	90.0	-54.4	11.0	-6.6
*643 TECH DOUBLE (01-39-1)	-0.6	33.0	-19.9	89.0	-53.8	-10.0	6.0
*643 CREW SR (1-42-2)	-0.4	24.0	-8.5	88.0	-31.1	15.0	-5.3
*643 NURSE SR (1-23-3)	-0.5	24.0	-12.2	52.0	-26.5	-16.0	8.2
*643 CREW SINGLE SR (1-23-2)	-0.4	24.0	-8.5	51.0	-18.0	15.0	-5.3
*643 CREW SINGLE SR (1-47-2)	-0.4	24.0	-8.5	100.0	-35.3	12.0	-4.2
*643 CREW SINGLE SR (1-52-4)	-0.4	24.0	-8.5	108.0	-38.1	12.0	-4.2
*643 CREW SINGLE SR (1-57-2)	-0.4	24.0	-8.5	120.0	-42.4	12.0	-4.2
*643 CREW SINGLE SR (1-51-2)	-0.4	24.0	-8.5	128.0	-45.2	15.0	-5.3
*643 CREW SINGLE SR (1-66-2)	-0.4	24.0	-8.5	139.0	-49.1	15.0	-5.3
*643 CREW MESS	-0.5	24.0	-12.2	27.0	-13.8	24.0	-12.2
*651 GALLEY	-2.3	24.0	-54.2	93.0	-210.2	-15.0	33.9
*641 OFFICERS MESS	-0.9	24.0	-21.1	115.0	-101.2	-12.0	10.6
*644 T/S (1-55-2)	-0.9	24.0	-21.1	133.0	-117.0	10.0	-8.8
*644 T/S (1-65-2)	-0.9	24.0	-21.1	113.0	-99.4	10.0	-8.8
*665 GENERAL WORKSHOP	-3.5	24.0	-84.0	127.0	-444.5	-12.5	43.8
*671 DC LKR (DIDNT MOVE)	0	24.0	0.0	126.0	0.0	-1.0	0.0
*621 BHDS (MN DK JNR, FR 75-AFT)	-0.3	25.0	-8.3	155.0	-51.2	-2.0	0.7
*621 BHDS (MN DK JNR, 42-75, P)	-1.3	25.0	-33.5	114.0	-152.8	12.0	-16.1
*621 BHDS (MN DK FZ)	-0.7	25.0	-17.8	104.0	-73.8	0.0	0.0
*621 BHDS (MN DK JNR, FR52-75)	-1.5	24.0	-36.2	138.0	-208.4	-9.0	13.6
*583 LIFERAFTS (6)	-0.8	40.0	-33.6	110.0	-92.4	0.0	0.0
*100 DECK (SOC)	-19.45	39.5	-768.3	124.0	-2411.8	0.0	0.0
*120 BHDS (SOC)	-11.9	34.0	-404.6	125.0	-1487.5	0.0	0.0
*120 HIGH HAT (SOC)	-1.0	39.5	-37.9	124.0	-119.0	0.0	0.0
*512 HVAC (SOC)	-1.0	24.0	-23.0	140.0	-134.4	-12.0	11.5
*111 BULWARK	-4.6	23.0	-106.0	166.0	-765.3	0.0	0.0
REMOVALS - TOTALS	-241.4	31.2	-7540.6	148.4	-35819.8	0.4	-92.0
ADDITIONS - REQUIREMENTS							
*582 CAPSTANS -FWD	1.7	39.4	67.4	7.0	12.0	3.3	5.6
*582 CAPSTANS - AFT	1.7	26.0	44.5	195.0	333.5	0.0	0.0
*582 AFT CHOCKS	0.2	26.0	5.0	196.0	37.5	0.0	0.0
*582 AFT BITTS	0.3	26.0	7.8	196.0	58.8	0.0	0.0
*671 SHORING	0.4	30.0	12.4	143.0	59.1	1.0	0.4
*321 SHORE POWER CABLE REELS	0.6	31.0	18.9	132.0	80.5	5.0	3.1
*583 HSL 1 & DAVIT	17.2	33.6	577.2	112.0	1924.2	15.7	269.7
*583 HSL 2 & DAVIT	17.2	33.6	577.2	112.0	1924.2	-15.7	-269.7
*583 HSL 3 & DAVIT	17.2	33.6	577.2	150.0	2577.0	15.7	269.7
*583 HSL 4 & DAVIT	17.2	33.6	577.2	156.0	2680.1	-15.7	-269.7
*583 20FT RESCUE BT RHIB	1.3	29.0	38.9	188.0	251.9	14.0	18.8
*583 RESCUE DAVIT	0.8	29.0	21.8	188.0	141.0	14.0	10.5
*583 19FT WORKBOAT	1.3	29.0	36.3	186.0	232.5	-14.0	-17.5
*583 WORKBOAT DAVIT	0.8	29.0	21.8	186.0	139.5	-14.0	-10.5
*583 FWD STORES CRANE- HIAB 80	1.1	44.5	50.6	12.0	13.7	13.0	14.8
*583 AMID STORES CRANE- HIAB 80	1.1	44.5	50.6	108.0	122.9	-3.0	-3.4
*591 SONAR	0.2	2.0	0.3	66.0	9.9	-1.0	-0.2
*591 A-FRAME	8.0	28.0	224.0	210.0	1680.0	0.0	0.0
*591 J-FRAME (2.7 TONS)	0.0	34.0	0.0	94.0	0.0	-20.0	0.0
*591 AFT SIDE SCAN WINCH	0.2	31.0	5.0	174.5	27.9	0.0	0.0
*591 AFT HSHR WINCH	3.2	32.0	102.1	168.0	535.9	0.0	0.0
*591 CTD WINCH	2.8	40.0	110.2	102.0	281.0	-1.0	-2.8
*591 DOLPHIN 1 & CRADLE	0.0	28.0	0.0	172.0	0.0	-9.5	0.0
*591 DOLPHIN 2 & CRADLE	0.0	28.0	0.0	172.0	0.0	-9.5	0.0
*591 DOLPHIN TOWING BOOM	1.3	42.0	56.3	72.0	96.5	20.0	26.8
*591 DOLPHIN CRANE	11.2	38.0	424.1	130.0	1450.8	16.5	184.1
*591 DATA PROCESSING LAB INSTR	3.4	24.0	82.1	166.0	567.7	0.0	0.0
*591 DATA ACQ RM LAB INSTR	1.4	50.0	69.9	65.0	90.8	0.0	0.0
*591 ISO VAN (6.7 TONS)	0.0	50.0	0.0	76.0	0.0	1.0	0.0
*592 DIVE LOCKER	0.5	25.0	11.3	120.0	54.0	-13.0	-5.9
*671 PAINT LOCKER	0.9	24.0	21.6	131.0	117.9	12.0	10.8
*512 HYDRAULIC POWER UNIT	0.7	22.5	15.7	180.0	126.0	-10.0	-7.0
*631 PAINT	0.0	41.0	0.0	86.0	0.0	10.0	0.0
*591 WET LAB	0.9	33	29.7	98	88.2	0	0.0

ADDITIONS - DESIGN SPECIFIC

*100 EXPANDED DECK 01 LVL	6.4	29.0	184.6	177.0	1127.0	0.0	0.0
*100 RAISED DECK, FANTAIL	11.4	25.0	284.8	190.0	2164.1	0.0	0.0
*100 RAISED BLKDS SUPPORTING FANT	3.5	22.5	79.2	183.0	644.2	0.0	0.0
*120 BLKD, DATA ACQ RM	3.2	50.0	161.5	68.0	219.6	0.0	0.0
*100 DECK, DATA ACQ RM	3.9	53.5	207.0	65.0	251.6	0.0	0.0
*100 DECK, AFT OF 86, 01 LVL	0.8	29.0	23.8	174.0	142.7	0.0	0.0
*111 RAISED SHELL PLATING/BULWARK	5.9	26.0	154.2	192.0	1138.6	0.0	0.0
*100 RAISED XVRSE BLKDS,86/94	0.0	23.5	0.0	180.0	0.0	0.0	0.0
*111 BULWARK 42-86, MNDK	5.1	24.5	124.7	126.0	641.3	0.0	0.0
*115 STANCHIONS, LAB	0.5	24.5	13.1	166.0	89.0	0.0	0.0
*115 STANCHIONS, 10 WEAT PASS	1.4	24.5	34.1	126.0	175.1	0.0	0.0
*179 HSL PLATFORMS	1.1	33.0	35.3	142.0	151.9	0.0	0.0
*120 BLKD, AFT STR, 02 LEVEL	1.6	42.0	66.8	81.0	128.8	2.0	3.2
*120 BLKD,FR 45, 01 LEVEL	3.8	34.0	128.9	112.0	424.5	-1.0	-3.8
*120 BLKD,FR 86, AFT STR MM DK	2.9	24.0	69.6	174.0	504.6	0.0	0.0
*505 CROSS CONNECT PIPING	0.4	10.0	3.8	98.0	37.5	0.0	0.0
*643 CREW SR'S (1) TO (2), 02 LVL	0.3	41.0	10.3	75.0	18.8	10.0	2.5
*643 CREW SR'S (1) TO (2), 02 LVL	0.3	41.0	10.3	62.0	15.5	10.0	2.5
*643 CREW SR'S (1) TO (2), 02 LVL	0.3	41.0	10.3	63.0	15.8	-13.0	-3.3
*643 CREW SR'S (1) TO (2), 01 LVL	0.3	33.0	8.3	32.5	8.1	10.0	2.5
*643 CREW SR'S (1) TO (2), 01 LVL	0.3	33.0	8.3	43.0	10.8	12.0	3.0
*643 CREW SR'S (1) TO (2), 01 LVL	0.3	33.0	8.3	52.0	13.0	11.0	2.8
*643 CREW SR'S (1) TO (2), 01 LVL	0.3	33.0	8.3	62.0	15.5	11.0	2.8
*643 CREW SR'S (1) TO (2), 01 LVL	0.3	33.0	8.3	34.0	8.5	-12.0	-3.0
*643 CREW SR'S (1) TO (2), 01 LVL	0.3	33.0	8.3	45.0	11.3	-12.0	-3.0
*643 SR (1), SMALL, NEW	0.3	33.0	8.3	71.0	17.8	-10.0	-2.5
*643 SR (1), SMALL, NEW	0.3	33.0	8.3	81.0	20.3	-9.0	-2.3
*100 DECK (02 LEVEL AFT OF FR44)	2.3	38.3	89.7	100.0	234.0	0.0	0.0
*100 DECK (ACCESS/LKR TOPS, MNDK)	0.4	36.0	15.1	145.0	60.9	5.0	2.1
*120 BLKD (ACCESS, DK GR LKR,MNDK)	2.5	33.0	81.2	144.0	354.2	5.0	12.3
*120 BULKHEAD (MNDK AFT OF 86)	0.0	24.5	0.0	180.0	0.0	0.0	0.0
*120 BULKHEAD (TRNSVSE FR 86)	1.1	24.5	27.4	172.0	192.3	0.0	0.0
*120 BULKHEAD (LONG 42-86)	11.2	24.5	275.1	126.0	1415.0	0.0	0.0
*120 BULKHEAD (TRNSVSE 42)	0.5	24.5	12.5	84.0	42.8	0.0	0.0
*621 BHD (01 LVL, CG LKR)	0.2	34.0	6.8	75.0	15.0	4.0	0.8
*621 BHD (01 LVL, BT LKR)	0.2	34.0	5.8	102.0	17.3	0.0	0.0
*621 BHD (MN DK JNR)	3.6	25.0	90.0	124.0	446.4	5.0	18.0
*167 SCIENT STORES HATCH	0.1	21.0	2.8	169.0	22.8	5.0	0.7
*171 MAIN MAST	1.6	48.0	78.7	118.0	193.5	0.0	0.0
*583 LIFERAFTS (6)	0.8	31.5	26.5	62.0	52.1	0.0	0.0
*623 ACCOM LADDER	0.4	30.0	12.0	137.0	54.8	-7.5	-3.0
*624 INCL LADDERS FR 86	0.2	26.5	4.8	173.0	31.1	0.0	0.0
*624 INCL LADDERS FR 81	0.2	14.0	2.5	162.0	29.2	3.0	0.5
*643 SR (2)	0.6	24.0	15.1	51.0	32.0	15.0	9.4
*643 SR (2)	0.6	24.0	15.1	62.0	38.9	16.0	10.0
*643 SR (2)	0.6	24.0	15.1	52.0	32.7	-16.0	-10.0
*643 SR (2)	0.6	24.0	15.1	89.0	55.9	12.0	7.5
*643 SR (2)	0.6	24.0	15.1	105.0	65.9	13.0	8.2
*644 DECK WR/WC (MN DK)	0.1	24.0	1.9	131.0	10.5	-1.0	-0.1
*665 TRASH STOWAGE RM	0.2	25.0	5.0	120.0	24.0	-6.0	-1.2
*651 GALLEY	2.26	24.0	54.2	77.0	174.0	-5.0	-11.3
*641 MESSROOM	1.39	24.0	33.4	101.0	140.4	-11.0	-15.3
*644 DECK WC/WR (01 LVL)	0.2	34.0	6.8	82.0	16.4	6.0	1.2
*665 ELECTRONICS SHOP	1.5	33.0	49.5	74.0	111.0	9.0	13.5
*671 BOAT LOCKER	0.3	33.0	8.3	109.0	27.3	0.0	0.0
*671 BOAT LOCKER	0.3	24.0	6.0	138.0	34.5	14.0	3.5
*671 DECK GEAR LOCKER	0.2	25.0	5.5	145.0	31.9	-14.0	-3.1
*671 DC LKR (.11 TONS)	0	24.0	0.0	136.0	0.0	-4.0	0.0
*665 GENERAL WORKSHOP	3.5	24.0	84.0	119.0	416.5	12.0	42.0
*663 AFT CNTRL STATION (.6 TONS)	0.0	50.0	0.0	87.0	0.0	-16.0	0.0

ADDITIONS - TOTAL 207.6 31.6 6565.9 135.3 28083.8 1.5 314.8

PRECONVERSION LIGHTSHIP 1458.6 20.7 30192.4 98.6 143771.2 0.0 0.0
 new light ship w/all margins 1469.9 21.4 31388.0 95.5 136035.2 0.2 222.8
 new light ship w/no margins 1424.8 20.5 29217.7 95.5 136035.2 0.2 222.8

NEW LIGHTSHIP	1469.9	21.4	31388.0	95.5	136035.2	0.2	222.8
191 BLST, 4-6-1-F, 179T MAX	0.0	12.0	0.0	22.0	0.0	-6.0	0.0
191 BLST, 4-6-2-F, 179T MAX	0.0	12.0	0.0	22.0	0.0	6.0	0.0
191 BLST, 4-80-2, 54.83T MAX	50.0	10.6	528.5	165.4	8270.0	14.9	744.5
191 BLST, 4-72-4, 128.5T MAX	10.0	4.8	48.0	148.4	1484.0	13.8	138.3
191 BLST, 4-72-2, 180T MAX	0.0	8.0	0.0	157.2	0.0	4.6	0.0
191 BLST, 4-80-1-F, 47.95 MAX	0.0	10.0	0.0	165.3	0.0	-14.7	0.0
191 BLST, 4-72-1-F, 65.46 MAX	0.0	5.3	0.0	154.5	0.0	-4.8	0.0
191 BLST, 4-72-3-F, 65.2 MAX	0.0	6.9	0.0	150.9	0.0	-14.8	0.0
191 BLST, 38.9 TONS MAX SKEG	35.0	3.5	122.5	171.0	5985.0	0.0	0.0
191 BLST, 4-34-01-V, 600.43T MAX	50.4	1.8	90.7	91.4	4608.6	0.0	0.0
ITINERANT LOAD	13.3	33.8	450.0	170.0	2261.0	0.0	0.0
FINAL CONVERTED LIGHTSHIP	1628.6	20.0	32627.7	97.4	158643.8	0.7	1105.6
NEW LOADS							
F11 OFFICERS	1.4	38.4	55.0	56.3	80.0	-0.7	-1.0
F12 TECHNICIANS	1.0	31.8	33.0	58.0	73.0	-2.9	-3.0
F13 CREW	1.4	26.3	31.6	78.8	94.6	12.6	15.1
F31 PROVISIONS	10.2	23.6	240.0	30.7	313.0	-7.6	-77.0
F32 GENERAL STORES	4.2	26.7	112.0	7.0	29.0	-2.3	-10.0
F41 DIESEL FUEL	447.0	10.4	4644.5	105.2	47022.6	-2.6	-1148.6
F46 LUBE OIL	6.6	15.6	102.0	122.0	800.0	1.8	12.0
F49 SPECIAL FUELS & LUBES	0.6	38.8	23.3	171.5	102.9	-6.9	-4.3
F52 FRESH WATER	15.3	7.6	116.0	111.6	1710.0	0.0	0.0
F54 HYDRAULIC FLUID	0.5	39.0	20.3	171.5	89.1	6.5	3.4
*F62 SCIENTIFIC STORES	5.0	14.0	70.0	166.0	830.0	14.0	70.0
TOTAL LOADS	493.2	11.0	5447.7	103.7	51144.2	-2.3	-1143.4
POST-CONVERSION FULL LOAD	2121.8	17.9	38075.4	98.9	209788.0	-0.0	-37.8
ANTI-ROLL TANK (36.1 SLACK)	36.1	16.5	596.0	149.0	5378.9	0.0	0.0
ANTI-ROLL DUMP TANK (36.1)	0.0	2.5	0.0	90.0	0.0	0.0	0.0
TOTAL CONVERTED FULL LOAD	2157.883	17.921	38671.42	99.71202	215166.9	-0.01752	-37.7953
PRE-CONVERSION FULL LOAD	2168.8	17.4	37637.0	102.2	11286.0	-0.1	-110.0
DIESEL FUEL CALCULATION, 447 TONS REQUIRED:							
	WT	VCG	VMOM	LCG	LONGMOM	TCG	TVSE
TOTAL PRE CONVERSION FUEL	626.3	10.7	6676.8	104.2	65252.1	0.1	62.6
4-6-1-F, EMPTY	-41.1	11.99	-492.8	22.0	-904.2	-6.04	248.2
4-6-2-F, 41.1 TONS MAX	-33.4	11.99	-400.5	22.0	-734.8	6.04	-201.7
*4-80-2-F, EMPTY	-32.95	14.05	-462.9	165.8	-5463.1	15.5	-510.1
*4-72-4-F EMPTY	-38.81	10.58	-410.6	152.7	-5924.7	15.4	-596.1
4-80-1-F, FULL	0	14.05	0.0	165.8	0.0	-15.48	0.0
4-72-1-F, FULL	0	10.37	0.0	160.6	0.0	-5.91	0.0
*4-72-2-F 39.2 TONS BELOW STRM	-33.1	8.02	-265.5	157.18	-5202.7	4.58	-151.6
4-72-3-F, FULL	0	10.58	0.0	152.66	0.0	-15.36	0.0
	447.0	10.4	4644.5	105.2	47022.6	-2.6	-1148.6
free surface correction:	2157.883	17.921	38671.42	99.71202	215166.9	-0.01752	-37.7953
WITHOUT ROLL TANK OR DUMP TANK		W/ROLL TANK					
full load w/stab tank: (ft-tons)	2888	2888					
anti-roll tank	-1893	0					
dump tank	-195	0					
4-72-1-f	-5	-5					
4-72-2-f	-38	-38					
4-72-3-f	-41	-41					
4-80-1-f	-33	-33					
total:	683	2771					
correction to gm:	0.316514	1.284129					
corrected gm:	18.23752	19.20513					

NOAA T-AGOS 13 CONVERSION TO TAO MISSION
WITH ANTIROLL TANK

GROUP	WEIGHT (LTONS)	VCG (FT)	VMOM (FT-LTON)	LCG (FT)	LMOM (FT-LTON)	TCG (FT)	TMOM (FT-LTON)
LIGHTSHIP W/OUT ROLL TANK	1458.6	20.7	30192.4	98.6	143771.2	0.0	0.0
REMOVALS - BASELINE							
151 SURTASS WINCH ARR & DET	-0.4	20.9	-7.4	180.0	-63.7	0.0	0.0
151 WINCH STA SUPPORTS	-3.9	30.1	-116.3	172.5	-665.9	1.5	-5.8
153 WINCH CONTROL STA	-4.9	38.2	-185.5	174.2	-844.7	1.0	-5.0
154 WINCH STA TOP	-0.6	45.6	-26.5	175.3	-101.7	0.0	0.0
171 MAIN MAST	-4.7	61.8	-290.0	116.3	-545.4	0.0	0.0
185 SURTASS HULL STRL FDNS	-3.9	20.5	-80.3	179.7	-702.6	1.5	-5.9
185 ARRAY MOD STOWAGE UNIT	-1.2	22.2	-26.6	164.6	-197.5	0.0	0.0
252 PROPUL CTRLS WINCH CONTRL ST	-0.2	39.5	-6.7	177.0	-30.1	0.0	0.0
314 400 HZ MOTOR GENERATORS	-1.32	15.2	-20.0	140.7	-185.7	-15.0	19.9
436 SURTASS SYS CKT &WRG	-0.1	35.3	-3.9	106.7	-11.7	2.5	-0.3
462 SURTASS ELECT EQPT SOC	-24.1	32.8	-791.2	126.0	-3036.6	0.0	0.0
462 SURTASS ANT EQPT	-0.7	81.0	-54.3	114.0	-76.4	0.0	0.0
491 ELECT TEST EQPT	-1.1	33.3	-37.2	139.8	-156.5	5.5	-6.2
512 HYDRAULIC POWER UNIT	-0.7	24.0	-16.8	155.0	-108.5	10.0	-7.0
523 NBC WASHDOWN SYS	-0.1	44.4	-6.2	101.9	-14.3	0.3	-0.0
532 SURTASS COOL WTR SYS	-0.7	24.0	-16.0	126.0	-84.4	-6.3	4.2
532 SURTASS COOL WTR PANEL	-0.1	34.1	-2.9	119.0	-10.1	-15.7	1.3
556 ARRAY FLUID SYS	-0.5	31.1	-16.8	175.6	-94.8	-1.9	1.0
556 ARRAY WINCH HYDR PIPE	-0.5	21.0	-10.1	164.0	-78.7	13.0	-6.2
582 CAPSTANS -FWD	-1.4	39.4	-54.0	7.0	-9.6	3.3	-4.5
582 CAPSTANS - AFT	-1.4	23.0	-31.5	180.0	-246.6	0.0	0.0
583 17 FT RESCUE BT RHIB	-0.4	41.0	-16.4	118.0	-47.2	16.0	-6.4
583 RESCUE DAVIT	-0.8	43.0	-32.3	110.0	-82.5	18.0	-13.5
583 TELESCOPING BOOM CRANE	-7.5	37.8	-282.5	152.6	-1141.7	-0.1	0.7
591 ARRAY WINCH & ARRAY	-63.8	28.0	-1787.5	182.0	-11618.9	1.5	-95.8
591 ARRAY MOD STWG MAIN DK	-3.6	26.0	-92.8	164.0	-585.5	0.0	0.0
591 ARRAY MOD STWG FCSLE DK	-0.9	33.8	-30.1	156.0	-138.8	0.0	0.0
595 ARRAY OVERBOARDING SYS	-11.2	27.0	-301.3	206.0	-2299.0	0.0	0.0
622 GRATING MAIN DECK	-9.0	22.0	-197.8	175.3	-1579.0	-0.2	1.7
622 FALSE DECK SOC	-4.0	29.5	-117.1	119.7	-475.0	0.2	-0.7
623 ARRAY/WINCH LADDERS	-0.0	20.8	-0.8	159.4	-6.4	0.0	0.0
623 SATCOM ANT MAST	-0.2	57.7	-11.5	121.6	-24.3	0.0	0.0
631 PAINT	0.0	18.5	0.0	94.0	0.0	-0.0	0.0
634 DECK COVERING SOC	-0.5	29.4	-13.5	125.5	-57.7	4.1	-1.9
634 WINCH CTRL STA DECK COVERING	-0.0	37.4	-1.5	172.9	-6.9	1.2	-0.0
663 MISSION OPS RM	-1.6	32.1	-52.2	123.0	-200.5	-5.9	9.6
663 WINCH CTRL STA	-0.0	41.8	-1.7	180.0	-7.2	0.0	0.0
663 VAULT	-0.3	32.2	-9.7	116.9	-35.1	-1.0	0.3
663 VESTIBULE	-0.2	31.9	-5.4	116.4	-19.8	3.1	-0.5
671 PAINT LOCKER	-0.9	25.0	-22.5	155.0	-139.5	-12.0	10.8
665 ELECTRONICS SHOP	-2.9	31.7	-92.8	141.2	-413.8	5.2	-15.4
665 ARRAY WINCH SHOP	-0.9	24.0	-21.6	156.0	-140.4	-7.0	6.3
REMOVALS - DESIGN SPECIFIC							
623 ACCOM LADDER	-0.4	40.4	-16.2	142.0	-56.8	0.0	0.0
582 AFT CHOCKS	-1.0	21.0	-20.7	188.0	-185.4	0.0	0.0
582 AFT BITTS	-0.9	21.0	-19.4	186.0	-172.1	0.0	0.0
671 SHORING	-0.4	40.0	-16.5	135.0	-55.8	0.0	0.0
321 SHORE POWER CABLE REELS	-0.6	32.0	-19.5	152.0	-92.7	0.0	0.0
671 DECK GEAR LOCKER	-0.3	33.0	-8.3	92.0	-23.3	-12.0	3.0
583 LIFERAFTS (6)	-0.8	40.0	-33.6	110.0	-92.4	0.0	0.0
100 DECK (SOC, TOP, PORT)	-3.064	38.0	-116.4	130.0	-398.3	16.5	-50.6
100 DECK (SOC, TOP, STBD)	-3.49	38.0	-132.6	124.0	-432.8	-15.0	52.4
100 DECK (SOC)	-19.45	39.5	-768.3	124.0	-2411.8	0.0	0.0
120 BHDS (SOC)	-11.9	34.0	-404.6	125.0	-1487.5	0.0	0.0
120 HIGH HAT (SOC)	-1.0	39.5	-37.9	124.0	-119.0	0.0	0.0
512 HVAC (SOC)	-1.0	24.0	-23.0	140.0	-134.4	-12.0	11.5
111 BULWARK	-4.6	23.0	-106.0	166.0	-765.3	0.0	0.0
REMOVALS - TOTALS	-209.8	31.5	-6614.5	155.9	-32712.1	0.5	-102.9
ADDITIONS - REQUIREMENTS							
582 CAPSTANS -FWD	1.7	39.4	67.4	7.0	12.0	3.3	5.6
582 CAPSTANS - AFT	1.7	27.0	46.2	195.0	333.5	0.0	0.0
582 AFT CHOCKS	1.0	27.0	26.7	196.0	194.0	0.0	0.0
582 AFT BITTS	0.9	27.0	25.0	196.0	181.3	0.0	0.0
671 SHORING	0.4	39.0	16.1	121.0	50.0	-8.0	-3.3
321 SHORE POWER CABLE REELS	0.6	32.0	19.5	155.0	94.6	14.0	3.5
583 20FT RESCUE BT RHIB	1.3	35.0	46.9	136.0	182.2	18.0	24.1
583 RESCUE DAVIT	0.8	37.0	27.8	136.0	102.0	18.0	13.5
583 17FT WORKBOAT	1.3	32.0	40.0	143.0	178.8	-18.5	-23.1
583 AFT DECK CRANE (PORT)	4.5	31.0	138.3	184.0	820.6	14.5	64.7
583 AFT DECK CRANE (STBD)	2.7	31.0	82.5	179.0	476.1	-15.0	-39.9

583	WORKBOAT DAVIT, CRANE LAUNCH	0.0	37.0	0.0	186.0	0.0	-14.0	0.0
583	FWD STORES CRANE- HIAB 80	1.1	44.5	50.6	12.0	13.7	13.0	14.8
583	AMID STORES CRANE- HIAB 200	1.3	44.5	58.6	144.0	189.6	0.0	0.0
494	WIND PROFILER	0.5	54.5	24.5	68.0	30.6	0.0	0.0
591	SONAR	0.2	2.0	0.3	66.0	9.9	-1.0	-0.2
591	A-FRAME	9.7	30.0	290.7	202.0	1957.4	0.0	0.0
591	J-FRAME	6.1	34.0	206.4	106.0	643.4	-20.0	-121.4
591	BRAILING WINCH (PORT)	10.3	28.5	293.6	180.0	1854.0	4.0	41.2
591	BRAILING WINCH (STBD)	1	28.0	28.0	180.0	180.0	-6.0	-6.0
591	CTD WINCH	2.8	40.0	112.0	109.0	305.2	-3.0	-8.4
591	COMPUTER LAB INSTRUMENTATION	1.5	33.0	49.5	129.0	193.5	-1.0	-1.5
591	ISO VAN (7 TONS)	7.0	41.0	287.0	106.0	742.0	8.0	56.0
591	ISO VAN (7 TONS)	7.0	41.0	287.0	98.0	686.0	-10.0	-70.0
592	DIVE LOCKER	0.5	33.0	14.9	141.0	63.5	-6.0	-2.7
661	MISSION OPS OFFICE	0.4	33.0	11.6	108.0	37.8	12.0	4.2
671	DECK GEAR LOCKER	0.3	33.0	8.3	116.0	29.3	14.0	3.5
671	FOUL WEAT GEAR LOCKER	0.1	33.0	4.1	93.0	11.6	-12.0	-1.5
671	BOAT GEAR LOCKER	0.5	33.0	16.5	142.0	71.0	6.0	3.0
671	PAINT LOCKER	0.9	33.0	29.7	124.0	111.6	-12.0	-10.8
591	AUTOSALINOMETER RM	0.7	33.0	23.1	118.0	82.6	-8.0	-5.6
512	HYDRAULIC POWER UNIT	0.7	22.5	15.7	155.0	108.5	-10.0	-7.0
665	MOORING INSTR REPAIR	0.9	24.0	21.6	156.0	140.4	-7.0	-6.3
591	WET LAB	0.9	33	29.7	109	98.1	-8	-7.2

ADDITIONS - DESIGN SPECIFIC

		0.7						
111	RAISED SHELL PLATING/BULWARK	5.6	24.5	161.7	184.0	1214.4	0.0	0.0
185	FDN FWD STORES CRANE-HIAB 80	0.1	38.0	3.1	12.0	1.0	13.0	1.1
185	FDN AMID STORES CRN-HIAB 200	0.1	38.0	3.6	144.0	13.5	0.0	0.0
185	FDN AFT DECK CRANE (PORT)	0.3	26.0	8.2	184.0	58.3	14.5	4.6
185	FDN AFT DECK CRANE (STBD)	0.2	26.0	4.9	179.0	33.8	-15.0	-2.8
185	FDN, BRAILING WINCH (PORT)	0.7	25.0	18.3	180.0	131.6	4.0	2.9
185	FDN, BRAILING WINCH (STBD)	0.1	25.0	1.8	180.0	12.8	-6.0	-0.4
185	FDN, CTD WINCH	0.2	38.0	7.6	109.0	21.7	-3.0	-0.6
185	FDN, ISO VANS	1.0	38.0	37.8	102.0	101.4	-1.0	-1.0
100	5' RAISED DECK, FANTAIL	18.7	25.0	466.2	186.0	3468.9	0.0	0.0
100	DECK, AFT OF SOC	0.4	38.0	14.8	145.0	56.6	-1.0	-0.4
120	STR BLKD, SOC AREA	6.1	33.0	201.6	124.0	757.6	0.0	0.0
120	STR BLKD, FR 60, 01 LVL	1.0	33.0	33.7	120.0	122.4	-1.0	-1.0
120	BUOY ASSMBY STATION	2.6	28.5	73.0	165.0	422.4	0.0	0.0
120	RAISED LNGT BLKDS, FANTAIL	4.1	22.5	92.2	174.0	713.4	0.0	0.0
671	JOINER, X-VRSE, 01 LVL	0.7	33.0	23.1	127.0	88.9	-1.0	-0.7
671	JOINER, LONG, 01 LVL	1.0	33.0	31.4	118.0	112.1	2.0	1.9
120	RAISED BLKDS XVERSE, FANTAIL	4.4	22.5	99.0	180.0	792.0	0.0	0.0
151	AFT CNTRL STA ARR & DET	0.4	38.0	13.4	155.0	54.8	-8.0	-2.8
151	AFT CNTRL STA SUPPORTS	2.0	31.0	62.0	154.0	308.0	-8.0	-16.0
153	AFT CONTROL STA	3.9	38.0	148.2	174.2	679.3	-8.0	-31.2
154	AFT CNTRL STA TOP	0.6	42.0	24.4	175.3	101.7	-8.0	-4.6
505	CROSS CONNECT PIPING	0.4	10.0	3.8	98.0	37.5	0.0	0.0
167	SCIENT STORES HATCH	0.1	25.0	3.4	166.0	22.4	14.0	1.9
171	MAIN MAST	1.6	48.0	78.7	118.0	193.5	0.0	0.0
583	LIFERAFTS (6)	0.8	31.5	26.5	118.5	99.5	0.0	0.0
623	ACCOM LADDER	0.4	39.0	15.6	110.0	44.0	17.0	6.8
624	INCL LADDERS (FANTAIL)	0.8	22.5	18.0	153.0	122.4	0.0	0.0
665	TRASH STOWAGE RM (IN RAISED	0.2	22.5	4.5	180.0	36.0	-10.0	-2.0
665	ELECTRONICS SHOP	1.5	33.0	49.5	116.0	174.0	12.0	18.0

ADDITIONS - TOTAL 132.6 31.1 4129.5 152.2 20180.6 -0.8 -102.2

PRECONVERSION LIGHTSHIP 1458.6 20.7 30192.4 98.6 143771.2 0.0 0.0
new light ship w/all margins 1421.0 20.8 29502.3 95.0 131239.7 -0.1 -205.1
new light ship w/no margins 1381.4 20.1 27707.5 95.0 131239.7 -0.1 -205.1

NEW LIGHTSHIP 1421.0 20.8 29502.3 95.0 131239.7 -0.1 -205.1

191	BLST, 4-6-1-F, 179T MAX	0.0	12.0	0.0	22.0	0.0	-6.0	0.0
191	BLST, 4-6-2-F, 179T MAX	0.0	12.0	0.0	22.0	0.0	6.0	0.0
191	BLST, 4-80-2, 54.83T MAX	42.7	10.1	431.3	165.3	7058.3	14.7	627.7
191	BLST, 4-72-4, 128.5T MAX	0.0	4.8	0.0	148.4	0.0	13.8	0.0
191	BLST, 4-72-2, 180T MAX	0.0	8.0	0.0	157.2	0.0	4.6	0.0
191	BLST, 4-80-1-F, 47.95 MAX	0.0	10.0	0.0	165.3	0.0	-14.7	0.0
191	BLST, 4-72-1-F, 65.46 MAX	0.0	5.3	0.0	154.5	0.0	-4.8	0.0
191	BLST, 4-72-3-F, 65.2 MAX	0.0	6.9	0.0	150.9	0.0	-14.8	0.0
191	BLST, 38.9 TONS MAX SKEG	35.0	3.5	122.5	171.0	5985.0	0.0	0.0
191	BLST, 4-34-01-V, 600.43T MAX	0.0	1.8	0.0	91.4	0.0	0.0	0.0
	ITINERANT LOAD (02 LVL)	9.7	40.3	391.1	114.0	1105.4	0.0	0.0
	ITINERANT LOAD (FANTAIL)	9.7	28.0	271.5	186.0	1803.5	1.0	9.7
	FINAL CONVERTED LIGHTSHIP	1518.0	20.2	30718.6	97.0	147192.0	0.3	432.3

NEW LOADS

F11 OFFICERS	1.4	38.4	55.0	56.3	80.0	-0.7	-1.0
F12 TECHNICIANS	1.0	31.8	33.0	58.0	73.0	-2.9	-3.0
F13 CREW	1.2	26.3	31.6	78.8	94.6	12.6	15.1
F29 MISSION EXPENDABLES (ROSETTE)	1.1	36.0	38.5	109.0	116.6	-15.0	-16.1
F29 MISSION EXPENDABLES (ANCHORS)	18.8	27.0	506.3	192.0	3600.0	0.0	0.0
F29 MISSION EXPENDABLES (BUOYS)	2.9	40.3	115.1	133.0	380.0	-2.0	-5.7
F31 PROVISIONS	10.2	23.6	240.0	30.7	313.0	-7.6	-77.0
F32 GENERAL STORES	4.2	26.7	112.0	7.0	29.0	-2.3	-10.0
F41 DIESEL FUEL	558.9	10.2	5674.3	96.9	54178.1	-1.1	-637.8
F46 LUBE OIL	6.6	15.6	102.0	122.0	800.0	1.8	12.0
F49 SPECIAL FUELS & LUBES	0.6	38.8	23.3	171.5	102.9	-6.9	-4.3
F52 FRESH WATER	15.3	7.6	116.0	111.6	1710.0	0.0	0.0
F54 HYDRAULIC FLUID	0.5	39.0	20.3	171.5	89.1	6.5	3.4
F62 SCIENTIFIC STORES	5.0	14.0	70.0	166.0	830.0	14.0	70.0
TOTAL LOADS	627.6	11.4	7137.4	99.4	62396.3	-1.0	-654.4
POST-CONVERSION FULL LOAD	2145.6	17.6	37856.0	97.7	209588.3	-0.1	-222.1
ANTI-ROLL TANK (36.1 SLACK)	36.1	16.5	596.0	149.0	5378.9	0.0	0.0
ANTI-ROLL DUMP TANK (36.1)	0.0	2.5	0.0	90.0	0.0	0.0	0.0
TOTAL CONVERTED FULL LOAD	2181.724	17.62462	38452.05	98.53089	214967.2	-0.10179	-222.075

PRE-CONVERSION FULL LOAD 2168.8 17.4 37637.0 102.2 11286.0 -0.1 -110.0

DIESEL FUEL CALCULATION, APPROX 515 TONS REQUIRED:

	WT	VCC	VMOM	LCG	LONGMOM	TCG	TVSE MOMENT
TOTAL PRE CONVERSION FUEL	626.3	10.7	6676.8	104.2	65252.1	0.1	62.6
4-72-2-F (NEW TANKAGE PART FULL)	43.71	7.8	338.8	157.0	6862.5	4.6	199.8
4-80-2-F (10.3 NEW TANKAGE PART)	0	10.0	0.0	165.3	0.0	14.7	0.0
4-72-2-F (EXISTING TANKAGE)	-76.75	11.2	-859.6	159.4	-12234.7	4.8	-367.6
4-80-2-F (EXISTING TANKAGE)	-34.4	14.0	-481.6	165.8	-5701.8	15.5	-532.5
	558.9	10.2	5674.3	96.9	54178.1	-1.1	-637.8

free surface correction: 2181.724 17.62462 38452.05 98.53089 214967.2 -0.10179 -222.075

	WITHOUT ROLL TANK OR DUMP TANK	W/ROLL TANK
full load w/stab tank: (ft-tons)	2888	2888
anti-roll tank	-1893	0
dump tank	-195	0
4-72-1-f	0	0
4-72-2-f	0	0
4-72-3-f	0	0
4-80-1-f	0	0
total:	800	2888

correction to gm: 0.366683 1.323724
 corrected gm: 17.9913 18.94834

TAD CONVERSION MARGINS

with no point design margin:

	wt tons	vcg ft	vert mom
PRECONVERSION LIG	1458.6	20.7	30192.4
BASELINE LOADS	627.577	11.37296	7137.407
BASELINE FULL LOA	2086.147	17.89414	37329.81
estim of lightship removals	-209.83	31.52295	-6614.45
pd wt margin on removals 0%	0	31.52295	0
pd kg margin on removals 0%			0
estimate of lightship adds	132.629	31.13597	4129.533
pd wt margins on additions 0%	0	31.13597	0
pd kg margin on additions 0%			0
light ship with pd margins	1381.369	20.05798	27707.48
proj estim of removals	-209.83	31.52295	-6614.45
d & b margin on removals 4.5%	9.44	31.52295	297.6504
d & b kg margin on removals 5.5%			363.7949
pro est of adds additions	132.629	31.13597	4129.533
d & b wt marg on adds. 4.5%	5.968	31.13597	185.829
d & b kg marg on additions 5.5%			227.124
con mod & gfm wt (1.75%)	24.17396	20.05798	484.8809
con mod & gfm kg marg (.85%)			235.5136
light ship w/all margins	1420.954	20.7623	29502.27

APPENDIX D

CHARTING MISSION - FROM REF (D)
T-AGOS 13 CONVERSION
ENDURANCE FUEL CALCULATION

7/2/93

Attached are fuel oil calculations based on 8000 NM range at a cruise speed of 11 knots.

The following data/inputs were utilized:

- (1) Propulsion HP (1300 HP @ 11 k) was obtained from the speed/power curve on page 13 of the Feasibility Study Report.
- (2) Powertrain efficiencies were obtained from chart on page 49 of Feasibility Study Report.
- (3) Ship services power was obtained from the current electric power load analysis for the Winter Cruise condition.
- (4) Specific fuel consumption (SFC) was obtained from Halter Marine, Inc., Fuel Endurance Calculations Report.

The calculations show that approximately 350 LT of fuel is required, including 15 percent allowance, for 8000 NM range cruising at 11 knots. This compares with 447 LT calculated during the Feasibility Phase using 9000 NM range.

No attempt was made to calculate required FO based on mapping/charting mode and taking into account towing resistance, launch FO consumption, etc. However, a cursory examination of this mode indicates that the 8000 NM cruise mode is governing.

ENDURANCE FUEL

Validation of Feasibility Study Required Fuel Oil:

Current requirement is that the converted ship shall have a range of 8000 NM at the cruise speed of 11 knots. Stores shall be for 30 days.

Approach:

From the speed/power curve of the converted ship on page 13 of the Feasibility Study Report, the required power at 11 knots is 1300 HP at the propeller. Following the power distribution chart on page 49, the corresponding power output of the generators is calculated as follows:

KW1 Propulsion Main Bus

$$\text{KW1} := 1300 \cdot \frac{1}{0.9} \cdot \frac{1}{0.98} \cdot \frac{1}{0.98} \cdot 0.7454 \text{ KW/HP}$$

$$\text{KW1} = 1121.1$$

The current electric power load analysis includes the propulsion main bus items from the Halter load analysis. The total for the category 1 loads, based on an 80 percent propulsion motor load factor, is 1114.2 kW.

The Halter endurance fuel calculation was based on a high speed transmission efficiency of 0.9364, which would result in a KW1 of 907.4 kW. The KW1 calculated above is closer to the measured value, which Halter used in the load analysis.

The additional power requirements, based on the current Winter Cruise condition, are:

KW2 := 34.0 Prop Aux & Steering
 KW3 := 92.8 Auxiliary Machinery
 KW4 := 8.4 Deck Machinery
 KW5 := 4.2 Shops
 KW6 := 10.6 IC & Ships Elex
 KW7 := 96.7 Hotel
 KW8 := 253.2 AC & Vents
 KW9 := 12.5 Power Conver Equip

KW := KW2 + KW3 + KW4 + KW5 + KW6 + KW7 + KW8 + KW9

KW = 512.4

Total generator output at cruise

totalKW := KW1 + KW

totalKW = 1633.5

Output per generator

$$\text{KWper_gen} := \frac{\text{totalKW}}{3}$$

KWper_gen = 544.5

Specific fuel consumption (Halter Marine data)

SFC := 0.562 lb/KW-HR

With 15 percent service factor and a 2 percent tail pipe allowance, the required fuel is

$$\text{Fuel} := \frac{1.15}{.98} \cdot \text{totalKW} \cdot \text{SFC} \cdot \left[\frac{8000}{11} \right] \cdot \left[\frac{1}{2240} \right]$$

Fuel = 349.8 LT

TAO CONVERSION - FROM REF (C)
Calculation of Endurance Fuel Requirements

	Towing	Cruising
Endurance Required, Nautical Miles		
Reference 1	920	10080
Endurance Speed, Knots		
Reference 1	2	10
Full Load Displacement, Tons		
Reference 2 (See Note)	2254	2254
Rated Full Power, KW		
Reference 3	1193.1	1193.1
Design Endurance Power, KW, @ (2)&(3), Reference 2	65.64	938.00
Ratio Design End. Power/Rated Full Power, KW: (5)/(4)	0.055	0.786
Average Endurance, KW: (5)/Transmission Efficiency (Ref. 3)	70.28	1001.71
24 Hour Average Electric Load, KW (Ref. 4)	493.40	561.40
Total Electric Load, KW: (7)+(8)	563.68	1563.11
Total All-Purpose Fuel Consumption, lbs./hr. Fuel Consumption Curve (Ref. 3)	332.00	900.00
Specified Fuel Rate, lbs./kW-hr. (10)/(5)	5.0579	0.9595
Endurance Fuel, Tons, (1)*(5)*(11)/((2)*2240)	68.18	405.00
Endurance Fuel Load w/ Required 15% Margin Applied, Tons	78.41	465.75
Sum Total, Tons=		544.16

References:

1. T-AGOS Conversion Servicing TOGA-TAO Mooring Preliminary Requirements Document, 24 March 1993.
2. Speed/Power Estimate, Fig 3, Feasibility Report
3. T-AGOS 13 Fuel Endurance Calculation, Navsea Drawing No. 835-6233829, Rev. B.
4. Electrical Load Analysis, dated 14 June 1993.

Note:

Information was not available, it is assumed that the value would be similar to the T-AGOS 13, Reference (3) was used for this calculation.