

METRIC

DOD-STD-2137(SH)
13 April 1982

MILITARY STANDARD

MASS PROPERTIES
TECHNICAL REQUIREMENTS
FOR SURFACE SHIPS
(METRIC)



AMSC No. IN3184

AREA MISC

DOD-STD-2137(SH)
13 April 1982

DEPARTMENT OF DEFENSE
Washington, DC 20362

Mass Properties Technical Requirements
for Surface Ships

DOD-STD-2137(SH)

1. This Military Standard is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 3112, Department of the Navy, Washington, DC 20362 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

DOD-STD-2137(SH)
13 April 1982

FOREWORD

Purpose. The purpose of this standard is to delineate the mass properties technical requirements for surface ships.

Background. This standard satisfies a requirement to combine all mass properties control technical requirements for all phases of U.S. Navy surface ship acquisition contracts into a single document.

Concept. This standard includes pertinent definitions and mass properties report content and procedures for both the pre-detail design and detail design, and construction phases. All sections are self-sufficient in technical coverage; however, they must be considered in conjunction with the policy and procedures of the basic document to be applied effectively.

Benefits. This standard defines mass properties technical requirements and discusses different types of mass properties estimates and reports. It will assist in achieving more uniformity by standardizing the mass properties reporting system.

DOD-STD-2137(SH)

13 April 1982

CONTENTS

Paragraph		<u>Page</u>
1.	SCOPE	1
1.1	Scope	1
1.2	Reports interface	1
2.	REFERENCED DOCUMENTS	1
2.1	Issues of documents	1
2.2	Other publications	1
3.	DEFINITIONS	2
3.1	Accepted mass properties estimate (AmPE)	2
3.2	Accepted ship report	2
3.3	Acquisition margin	2
3.4	Actual mass	2
3.5	Baseline mass properties estimate	2
3.6	Calculated mass	2
3.7	Capacity load condition (condition E)	2
3.8	Category	3
3.9	Category system	3
3.10	Contract data requirements list (CDRL) - DD Form 1423	3
3.11	Contract design margin	3
3.12	Contract design mass properties estimate	3
3.13	Contract modification margin	3
3.14	Contract modification report	3
3.15	Contractor's design mass properties estimate	3
3.16	Current mass	3
3.17	Density factors	3
3.18	Design and mass properties data sheet	4
3.19	Design data package	4
3.20	Detail design and building margin	4
3.21	Estimated mass	4
3.22	Feasibility design mass properties estimate	4
3.23	Final mass properties report	4
3.24	Full load condition (condition D)	4
3.25	Government-furnished material (GFM) margin	5
3.26	Government-furnished material (GFM) report	5
3.27	Group	5
3.28	Inch-pound units	5
3.29	Inclining experiment	5
3.30	Input data cards	5
3.31	Light ship condition (condition A)	5
3.32	Longitudinal lever	6

DOD-STD-2137(SH)

13 April 1982

CONTENTS (Continued)

		<u>Page</u>
Paragraph		
3.33	Mass distribution	6
3.34	Mass moment	6
3.35	Mass properties control	6
3.36	Mass properties data	6
3.37	Mass properties reporting	6
3.38	Percent completion	6
3.39	Preliminary design margin	6
3.40	Preliminary design mass properties estimate	6
3.41	Quarterly mass properties report	6
3.42	SI units	7
3.43	Standard longitudinal station breakdown	7
3.44	Three-digit system	7
3.45	Transverse lever	7
3.46	Vertical lever	7
4.	GENERAL REQUIREMENTS	7
4.1	Determination of mass properties data	7
4.2	General report requirements	7
4.2.1	Loading conditions	8
4.2.2	Margins	8
4.2.3	Three-digit system	8
4.2.4	Summaries	8
4.2.5	Mass moment of inertia	8
4.2.6	Reporting system units	9
4.2.7	Mass properties changes	9
4.2.8	Table of contents	9
4.2.9	Special coding	9
4.2.10	Lever symbol	9
4.2.11	Mass properties data	9
4.2.12	Paper	9
4.2.13	Supporting documents	9
4.3	Classified reports	9
5.	DETAIL REQUIREMENTS	10
5.1	Pre-detail design phase	10
5.1.1	Mass properties estimates and reports	10
5.1.1.1	Design mass properties estimates	10
5.1.1.2	Baseline mass properties estimates	10
5.1.1.3	Interim mass properties reports	10
5.1.2	Supplemental documents	11
5.1.2.1	Top level specification input	11
5.1.2.2	Ship Specifications section	11
5.1.2.3	Contract data requirements list (CDRL)	11
5.1.2.4	Design notebook - mass properties	11
5.1.2.5	Schedule "A" mass properties input	12
5.1.2.6	Mass properties trade-off studies	12
5.1.2.7	Input data cards	12
5.1.2.8	Mass distribution report	12

DOD-STD-2137(SH)
13 April 1982

CONTENTS (Continued)

	<u>Page</u>
Paragraph 5.2	12
5.2.1	13
5.2.1.1	13
5.2.1.2	14
5.2.1.3	14
5.2.1.4	15
5.2.1.5	15
5.2.1.6	15
5.2.2	16
5.2.2.1	16
5.2.2.2	17
5.2.2.3	18
5.2.2.4	18
5.2.3	19
5.2.3.1	19
5.2.3.2	20
5.2.3.3	20
5.2.3.4	20
5.2.3.5	20

FIGURES

Figure 1.	21
2.	22
3.	23
4.	24
5.	25
6.	26

APPENDICES

Appendix A	29
B	37

DOD-STD-2137(SH)

13 April 1982

1. SCOPE

1.1 Scope. This standard establishes mass properties estimate and report content and procedures for all design phases of surface ship acquisition including: feasibility studies, preliminary design, contract design, detail design, and construction.

1.2 Reports interface. The interface of mass properties estimates and reports is depicted in figure 1.

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

STANDARD

MILITARY

DOD-STD-1690 - Maritime Metric Practice Guide.

PUBLICATIONS

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

0900-LP-039-9010 - Ship Work Breakdown Structure.

0900-LP-039-9020 - Ship Work Breakdown Structure for Nuclear Propulsion Plant (U).

0902-LP-002-2000 - Bureau of Ships Consolidated Index of Drawings, Materials and Services Related to Construction and Conversion.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following document forms a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN NATIONAL STANDARDS INSTITUTE, INC. (ANSI)

X3.4 - Code for Information Interchange.

(Application for copies should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.)

(Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

DOD-STD-2137(SH)
13 April 1982

3. DEFINITIONS

3.1 Accepted mass properties estimate (AMPE). AMPE is the best evaluation of the ship with respect to mass and the vertical, longitudinal, and transverse location of the center of gravity. It is derived by comparison and analysis of the contract design mass properties estimate and the contractor's design mass properties estimate.

3.2 Accepted ship report. An accepted ship report includes the displacement, height of the ship's center of gravity above the bottom of the keel (KG), trim, and list values of the inclining experiment preliminary report, from which the net mass properties effect of adjudicated and unadjudicated contract modifications and mass properties changes due to Government-furnished material (GFM) have been algebraically subtracted.

3.3 Acquisition margin. Acquisition margins are mass and KG allowances included in the mass properties estimates to cover the inherent limits of precision and the undefined variations of component mass and centers of gravity that take place throughout the design phases and during the construction of a ship. In order to provide for adequate mass properties control and configurations control, acquisition margins are divided into five elements: preliminary design margin, contract design margin, detail design and building margin, contract modification margin, and GFM margin.

3.4 Actual mass. Actual mass is the value obtained by an actual measurement of material on a scale.

3.5 Baseline mass properties estimate. Baseline mass properties estimate is the mass properties estimate of the light ship, full load, capacity load, and any other specified load condition prepared during the functional preliminary allocated, or allocated baseline design phase.

3.6 Calculated mass. Calculated mass is mass computed from ship construction drawings and vendor drawings.

3.7 Capacity load condition (condition E). The capacity load condition is the ship complete and ready for service in every respect. It is light ship (condition A) plus the following variable loads: maximum number of officers, crew, and passengers that can be accommodated and their effects; maximum stowage of ammunition in magazines and ready service spaces; full allowance of aircraft and vehicles (empty mass with full allowance of repair parts and stores); maximum amount of provisions and stores that can be carried in the assigned spaces; and maximum capacity of liquids in tanks. Fuel and lube oil shall not exceed 95 percent of tank capacity, unless such tanks are compensating. Compensating tanks shall be considered filled with 95 percent fuel and 5 percent salt water. Maximum amounts of cargo and supplies, other than for ship's own use, shall be included to the full capacity of the assigned spaces. This load condition shall not exceed the limiting drafts.

DOD-STD-2137(SH)

13 April 1982

3.8 Category. Category is a fundamental unit of machinery mass classification for nuclear-propelled ships as defined in NAVSEA 0900-LP-039-9020.

3.9 Category system. Category system is a system of machinery mass classification for nuclear-propelled ships as defined in NAVSEA 0900-LP-039-9020.

3.10 Contract data requirements list (CDRL) - DD Form 1423. A CDRL is a contract form listing all data items selected from an authorized data list to be delivered under the contract. It includes the frequency, submittal and distribution requirements.

3.11 Contract design margin. Contract design margin is a mass and KG allowance included in the mass properties estimate to account for increases associated with design development during the contract design phase. This margin is carried in the feasibility and preliminary design phases. No portion of this margin is consumed prior to the start of contract design, nor is any unused margin carried over into the next design phase.

3.12 Contract design mass properties estimate. Contract design mass properties estimate is the mass properties estimate of the light ship, full load, capacity load and any other specified load condition prepared during contract design phase.

3.13 Contract modification margin. Contract modification margin is a mass and a KG allowance included in the mass properties estimates and reports to account for increases associated with contract modifications issued during the detail design and construction phase. No portion of this margin is consumed prior to award of the detail design and construction contract.

3.14 Contract modification report. Contract modification report is a complete listing of contract modifications that supplements the quarterly mass properties report, accepted ship report, and final mass properties report. It constitutes a statement of adjudicated, and currently unadjudicated, mass properties values that will be used to modify the displacement, KG, list, and trim of the accepted mass properties estimate or baseline mass properties estimate.

3.15 Contractor's design mass properties estimate. Contractor's design mass properties estimate is the mass properties estimate prepared by the contractor at the beginning of the detail design and construction phase, based on Ship Specifications and all documents referenced therein.

3.16 Current mass. Current mass is the sum of a combination of the latest estimated, calculated, or actual mass for all items.

3.17 Density factors. Density factors are factors by which the mass of variable loads may be computed. These factors are included in the design data package.

DOD-STD-2137(SH)

13 April 1982

3.18 Design and mass properties data sheet. Design and mass properties data sheet is a mass properties data sheet which includes general data, hull characteristics data, displacement and stability characteristics data, load data, and machinery data as are appropriate to the ship.

3.19 Design data package. Design data package is a package of design information, usually containing curves of form, endurance requirements, density factors, the group summary of the contract design mass properties estimate without margins, and Bonjean curves which is furnished to the contractor after award of contract.

3.20 Detail design and building margin. Detail design and building margin is a mass and KG allowance included in the mass properties estimates and reports to account for design changes to the current mass due to ship construction drawing development, growth of contractor-furnished material, omissions and errors in the accepted or baseline mass properties estimate, as well as differing shipbuilding practices, omissions and errors in the ship construction drawings, unknown mill tolerances outfitting details, variations between the actual ship and its curves of form and similar differences. This margin is to compensate for all contractor-responsible discrepancies between the contract design or baseline mass properties estimate and the results of the inclining experiment, as well as tolerances for experimental variation in the inclining experiment. This mass and KG allowance is carried in the feasibility, preliminary, and contract design phases but no portion of this margin is consumed prior to award of the detail design and construction contract. However, the actual value for mass as well as location for the design and building margin is likely to change at the start of the detail design phase because this margin represents an allowance that is actually the contractor's responsibility. Thus it is subject to negotiation with the contractor selected for detail design and construction.

3.21 Estimated mass. Estimated mass is based on Ship Specifications and preliminary data, including estimated mass values of GFM.

3.22 Feasibility design mass properties estimate. Feasibility design mass properties estimate is the mass properties estimate of the light ship, full load, capacity load and any other specified load condition prepared during the feasibility design phase.

3.23 Final mass properties report. Final mass properties report is a detailed final report of mass properties data for all required loading conditions. This report accurately reflects accumulated values for estimated, calculated, and actual mass properties data for design development including the net effect of changes for GFM and for adjudicated and unadjudicated contract modifications.

3.24 Full load condition (condition D). The full load condition is the ship complete and ready for service in every respect. It is light ship (condition A) plus the following variable loads: authorized complement of officers, crew, and passengers, and their effects; full allowances of

DOD-STD-2137(SH)

13 April 1982

ammunition in magazines and ready service spaces; full allowance of aircraft and vehicles (empty mass with full allowance of repair parts and stores); full supply of provisions and stores for the periods specified in the design characteristics; fuel in amount necessary to meet endurance requirements; anti-roll tank liquid; and all other liquids in tanks to required capacity in accordance with characteristics and existing liquid loading instruction. The ammunition, stores, fuel and other liquids referred to above are for the ship's own use. Cargo (liquid and solid) is included in amounts normally carried or to the specified portion of the full capacity of the assigned spaces.

3.25 Government-furnished material (GFM) margin. GFM margin is a mass and KG allowance included in the mass properties estimates and reports to account for increases caused by the growth in GFM during the detail design and construction phase. No portion of this margin is consumed prior to award of the detail design and construction contract.

3.26 Government-furnished material (GFM) report. GFM report is a list of GFM mass properties data at the time of award of the contract which is updated to indicate any changes to these data.

3.27 Group. Group is a fundamental unit of ship classification, identified by one numeric digit or an alphabetic designator.

3.28 Inch-pound units. The inch-pound units for this standard is a system of units using pounds, long tons, feet, foot-pounds, and foot-tons for reporting mass properties data. These data are carried to the nearest pound and foot-pound at all detail levels. In addition, summaries are converted and reported to the nearest one-hundredth of a long-ton and to the nearest foot-ton. All levers are carried to the nearest one-hundredth of a foot.

3.29 Inclining experiment. The inclining experiment is the procedure for determining the height of the ship's center of gravity by observing the inclination produced by a known transverse mass moment and for determining the displacement and fore-and-aft position of the ship's center of gravity by observing the drafts.

3.30 Input data cards. Input data cards are detailed mass properties data on punched cards which comply with the Navy standard computer program format and are used by NAVSEA to prepare Navy mass properties estimates and reports.

3.31 Light ship condition (condition A). The light ship condition is the ship complete and ready for service in every respect, including permanent ballast (solid and liquid), on-board repair parts, aviation mobile support equipment as assigned, and liquids in machinery at operating levels, without any items of variable load. This condition represents the ship under wartime conditions, with ultimate armament but peacetime boat allowance aboard.

DOD-STD-2137(SH)

13 April 1982

3.32 Longitudinal lever. Longitudinal lever is the perpendicular distance from a transverse plane through the longitudinal reference datum of the ship to the center of gravity of an item. This reference datum shall be located at the forward perpendicular unless otherwise specified by the design contract or the Ship Specifications (Section 096).

3.33 Mass distribution. Mass distribution is the mass distribution of a ship's hull, cargo, armament, etc., measured by the standard longitudinal station breakdown to develop shear forces and bending moments.

3.34 Mass moment. Mass moment is the product of a mass and its lever. For example, the longitudinal mass moment of an item is the product of the mass of the item multiplied by its longitudinal lever.

3.35 Mass properties control. Mass properties control is all the action necessary (e.g., predicting, estimating, calculating, actual mass determining, reporting, analyzing, and evaluation) to ensure that the ship's mass properties data are consistent with the values agreed upon for displacement, KG, list, and trim in the accepted or baseline mass properties estimate.

3.36 Mass properties data. Mass properties data are those physical properties which include mass, center of gravity location, mass moments, moments of inertia and products of inertia, whose values are required to control those characteristics that collectively determine performance and stability.

3.37 Mass properties reporting. Mass properties reporting is that part of mass properties control which constitutes the technical presentation of the best known mass properties data, at periodic designated times throughout the design and building processes.

3.38 Percent completion. Percent completion is the ratio of the current mass less the current estimated mass portion, to the current mass, expressed as a percentage.

3.39 Preliminary design margin. Preliminary design margin is a mass and KG allowance included in the mass properties estimates to account for increases associated with design development during the preliminary design phase. This margin is carried in the feasibility design phase. No portion of this margin is consumed prior to the start of preliminary design, nor is any unused margin carried over into the next design phase.

3.40 Preliminary design mass properties estimate. Preliminary design mass properties estimate is the mass properties estimate of the light ship, full load, capacity load, and any other specified load condition prepared during the preliminary design phase.

3.41 Quarterly mass properties report. Quarterly mass properties report is a summarized mass properties report based on the accepted or baseline mass properties estimate. It reflects accumulated values for

DOD-STD-2137(SH)

13 April 1982

estimated, calculated, and actual mass properties data for design development, including the net effect of changes for GFM and for adjudicated and unadjudicated contract modifications.

3.42 SI units. SI units (International system of units) (see DOD-STD-1690) for this standard is a system of units using kilograms, metric tons, meters, kilogram-meters and metric ton meters for reporting mass property data. These data are carried to the nearest kilogram and kilogram-meter at all detail levels. In addition, summaries are converted and reported to the nearest one-hundredth of a metric ton and to the nearest metric ton-meter. All levers are carried to the nearest one-hundredth of a meter.

3.43 Standard longitudinal station breakdown. Standard longitudinal station breakdown is a mass distribution breakdown system consisting of twenty-two stations designated by the letters A through X (excluding I and O). Each station space is 1/20 of the length between perpendiculars. Station A is the only station forward of the forward perpendicular (FP). Station X is the only station aft of the aft perpendicular (AP). Stations B through W extend from the FP to the AP.

3.44 Three-digit system. Three-digit system is a system for ship classification defined in NAVSEA 0900-LP-039-9010, NAVSEA 0900-LP-039-9020, or NAVSEA 0902-LP-002-2000, as applicable.

3.45 Transverse lever. Transverse lever is the perpendicular distance from the vertical centerline plane of the ship to the center of gravity of an item.

3.46 Vertical lever. Vertical lever is the perpendicular distance from a horizontal plane through the molded baseline of the ship to the center of gravity of an item.

4. GENERAL REQUIREMENTS

4.1 Determination of mass properties data. As ship design or ship construction drawings are prepared and as material is selected, acquired, or received, the mass and centers of gravity of all items that comprise the ship shall be determined and reflected in the mass properties estimates and reports. In addition, the mass properties data for all components and material, and their overall effect on the ship's displacement, center of gravity, list, and trim shall be determined. These data may be obtained by estimation or calculation during feasibility, preliminary and contract design, and by a combination of estimation or calculation of ship construction drawings and by actual mass determination of items during detail design and construction.

4.2 General report requirements. The design contract or the Ship Specifications (Section 096) will invoke this standard and will establish technical data to be prepared, modifications, or exceptions. The contract data requirements list (CDRL) will establish requirements for deliverables such as: submittal data, frequency of submittal, number of copies, and

DOD-STD-2137(SH)

13 April 1982

recipients. The general requirements for the mass properties estimates and reports listed in this standard shall be in accordance with the criteria specified in 4.2.1 through 4.3. The estimates and reports shall be as specified in the CDRL.

4.2.1 Loading conditions. Loading conditions normally required will be light ship, full load, and capacity load conditions. However, such required loading conditions for a specific ship will be specified in the design contract or Ship Specifications (Section 096).

4.2.2 Margins. Required acquisition margins shall be included in the estimates and reports. Departures from original baseline values are reflected by concurrent adjustments to the appropriate acquisition margin account. Acquisition margins are required during pre-detail design phase. Normally, only the detail design and building margin is required during detail design and construction phase. Additional margins, if required, will be specified in the Ship Specifications (Section 096).

4.2.3 Three-digit system. Items shall be grouped in accordance with the three-digit system. To demonstrate the amount of detail required, an example will be furnished upon request and will consist of a typical mass properties estimate in which all mass, lever, and mass moment values have been deleted. This example may also be used as a guide for determination of classification grouping. Normally, the three-digit system to be used is "Ship Work Breakdown Structure" (SWBS). An alternative system, the "Bureau of Ships Consolidated Index" (BSCI), will be specified in the design contract or Ship Specifications (Section 096) if applicable.

4.2.4 Summaries. Summaries shall be included for all required loading conditions and their associated drafts (forward, aft, and mean), list, trim, KG, and metacentric height (GM), uncorrected and corrected for free surface effect of liquids in tanks (with and without the net effect of adjudicated and unadjudicated contract modifications, and net mass and mass moment changes in GFM).^{1/}

4.2.5 Mass moment of inertia. When specifically required by the Ship Specifications (Section 096), mass moment of inertia data for each loading condition of the ship shall be included. Current detail data and engineering information shall be used to develop this mass moment of inertia data. The minimum data to be included are as follows:

- (a) Roll, pitch, and yaw moments of inertia about the centroidal axes.
- (b) Principal axes inclinations.
- (c) Roll, pitch, and yaw moments of inertia about the principal axes.

^{1/}This portion is not applicable to pre-detail design phase estimates or reports.

DOD-STD-2137(SH)

13 April 1982

4.2.6 Reporting system units. Unless otherwise specified, estimates, reports, and other specified mass properties documentation and data shall utilize SI units. The design contract or the Ship Specifications (Section 096) will invoke the inch-pound units when applicable.

4.2.7 Mass properties changes. The mass properties reports shall include reasons for mass properties changes (in accordance with the three-digit system) from the previous estimates and reports, and shall also include recommendations for reversing unsatisfactory trends toward exceeding the established margins or limits. Reasons for mass properties changes are only required for the second and subsequent reports within a design phase.

4.2.8 Table of contents. The estimates and reports shall contain a table of contents.

4.2.9 Special coding. An explanatory note and remark section shall be included to define special coding symbols such as: material codes, GFM indicators, and reasons for change indicators.

4.2.10 Lever symbol. Vertical levers shall be indicated by "-" for below the baseline, and "+" or blank for above the baseline. Longitudinal levers shall be indicated by "F" or "-" for forward of the reference plane, and "A" or "+" or blank for aft of the reference plane. Transverse levers shall be indicated by "P" or "+" or blank for port, and "A" or "-" for starboard.

4.2.11 Mass properties data. Estimates and reports shall be in detail and shall include latest evaluation of mass data and vertical, longitudinal, and transverse levers and mass moments for each item.

4.2.12 Paper. The estimates and reports shall be machine written on paper no larger than 230 millimeters by 355 millimeters (9 inches by 14 inches) and shall be protected by hard covers but not permanently bound. The original or reproducible copy shall be suitable for microfilming.

4.2.13 Supporting documents. Background information studies, directives, correspondence, and all detail calculations pertaining to mass properties data, including density factors, shall be included in the submittal of the estimate or report. These documents are not required to be submitted with interim reports, unless specifically requested by the design contract.

4.3 Classified reports. Mass properties reports containing confidential data shall be marked in accordance with security requirements of the contract. Whenever possible, classified or proprietary material or data shall be downgraded by deleting classified or proprietary portions that do not impair the usefulness of the document.

DOD-STD-2137(SH)

13 April 1982

5. DETAIL REQUIREMENTS

5.1 Pre-detail design phase. Estimates, reports, and supplemental documents for this design phase shall be in accordance with 5.1.1, unless otherwise so stated.

5.1.1 Mass properties estimates and reports. Mass properties estimates and reports prepared during this phase typically consist of design mass properties estimates or baseline mass properties estimates, and interim reports. These estimates and reports are in detail and summarized in tabular form as follows:

- (a) Three-digit system number and title.
- (b) Original mass.
- (c) Current mass.
- (d) Current vertical lever.
- (e) Current vertical mass moment.
- (f) Current longitudinal lever.
- (g) Current longitudinal mass moment.
- (h) Current transverse lever.
- (i) Current transverse mass moment.

The mass properties data included in these estimates and reports are based on the characteristics, applicable specifications, and preliminary information.

5.1.1.1 Design mass properties estimates. The final estimate produced during a given design phase is designated the design mass properties estimate. This estimate will reflect the appropriate title, such as: Feasibility Design Mass Properties Estimate, Preliminary Design Mass Properties Estimate or Contract Design Mass Properties Estimate. The requirements for the estimates are as outlined in 5.1.1 above.

5.1.1.2 Baseline mass properties estimates. The final estimate produced during a given baseline design phase is designated the baseline mass properties estimate. This estimate will reflect the appropriate title, such as: Functional Baseline Mass Properties Estimate, Preliminary Allocated Baseline Mass Properties Estimate or Allocated Baseline Mass Properties Estimate. The requirements for the estimates are as outlined in 5.1.1 above.

5.1.1.3 Interim mass properties reports. Mass properties estimates produced periodically during a given design or baseline phase are designated interim mass properties reports, except the final report of the phase is designated the design or baseline mass properties estimate. This interim report summarizes the current mass properties status of the design and highlights changes that occurred in the reporting period. The reports provide a comparison between estimated mass properties data and the

DOD-STD-2137(SH)

13 April 1982

constraints necessary for a satisfactory ship design with respect to displacement, KG, list, and trim. The report shall reflect the appropriate title, such as: Preliminary Design - Interim Mass Properties Report, or Functional Baseline - Interim Mass Properties Report. The report shall contain the following:

- (a) Previous design phase group level summary.
- (b) Previous report group level summary.
- (c) Current group level estimate and, when required, the element level estimate and longitudinal mass distribution data.
- (d) Net change, by group and total, between (a) and (c) above.
- (e) Net change, by group and total, between (b) and (c) above.
- (f) Margin status, loads, full load displacement, KG, list, and trim changes corresponding to net changes calculated for (d) and (e) above.
- (g) A brief narrative providing reasons for significant change since previous report classified by group and element in which the change occurred.

5.1.2 Supplemental documents. The supplemental documents specified in 5.1.2.1 through 5.1.2.8 shall provide additional information, mass properties data calculations and background data during the pre-detail design phase.

5.1.2.1 Top level specification input. Inputs to provide information to the top level specification (TLS), regarding mass properties and center of gravity constraints in the design as well as to establish the mass properties control program for the ship acquisition process. This specification shall include the constraints on displacement, KG, list and trim for light ship, full load, and capacity load. List and mass properties control actions to be developed for the design, such as reporting procedures and an engineering management plan for mass properties control highlighting sensitive aspects shall also be included.

5.1.2.2 Ship Specifications section. The Ship Specifications sections shall be in the form of marked-up computer baseline specification sections unless otherwise approved by the cognizant NAVSEA code. Specifically, the required loading conditions, mass properties reporting units, the required three-digit system, margins to be included and monitored, and other special requirements are established and invoked.

5.1.2.3 Contract data requirements list (CDRL). A CDRL will be developed during the pre-detail design phase for the detail design and construction phase and will become part of the ship acquisition contract.

5.1.2.4 Design notebook - mass properties. The design mass properties notebook summarizes in chronological order, events that occurred during the design development (including margin determination) with cited references to studies and reports, as applicable. This notebook documents the evolution of the ship design, while highlighting the major problem areas and resolutions encountered during the design as reflected in the development of the mass properties estimate. In addition, the design

DOD-STD-2137(SH)
13 April 1982

notebook documents the mass properties issues and decisions related to the development of the mass process. All information used in the development of the estimate, such as engineer's notes, memoranda, records of telephone conversations, material equipment lists, factors and equations, shall be contained in the design notebook so as to form a complete historical record and background supporting the mass properties estimate and design history. All pertinent mass properties data shall be included in tabular form for this notebook.

5.1.2.5 Schedule "A" mass properties input. During the pre-detail design phase, a list of GFM is developed for inclusion into the ship construction contract. The preliminary copy of this list will be provided the design contractor for inclusion of unit mass and center of gravity information. This GFM data is used in developing the final Schedule "A" listing.

5.1.2.6 Mass properties trade-off studies. Trade-off studies comprise various engineering and technical studies directed toward determining detail mass properties data. These analytical studies are used to support design change proposals. These studies are delivered on an "as requested basis", and contain detailed mass properties calculations reflecting the impact of the study on ship displacement, KG, list and trim. There is no fixed format for the mass properties calculations, but the SWBS classification system shall be used.

5.1.2.7 Input data cards. The input data cards provide inputs to the Navy standard mass properties computer program. The card format shall be as described in appendix A and shall reflect the same data used in the preparation of the estimates or reports they accompany. These data may be magnetic tape in lieu of cards. Submittal by magnetic tape shall comply with the requirements set forth in ANSI X3.4.

5.1.2.8 Mass distribution report. A longitudinal mass distribution shall be provided in a tabulated format in accordance with the standard longitudinal station breakdown (see 3.43). Mass and longitudinal center of gravity shall be determined for each ship station for both light ship and full load condition. The resultant total mass and longitudinal center of gravity for the mass distribution report shall equal the values reflected in the basic mass properties estimate or report for the same reporting period.

5.2 Detail design and construction phase. Estimates, reports, and supplemental documents for this design phase shall be in accordance with 5.2.1 through 5.2.1.1.2. All required loading conditions shall be included in the estimates and reports. Where two or more ships of the same class are being built from the same ship construction drawings at the same shipyard under the same contract, the mass properties data of all items shall be determined for only the first ship. Deviations in design or construction from the first ship (including different manufacturers of materials or components from the first ship) shall be reported in the quarterly mass properties reports and the final mass properties report. The contractor

DOD-STD-2137(SH)
13 April 1982

and NAVSEA shall agree on a schedule for selected areas of estimates and reports that will be scheduled for timely calculation during the detail design and the process for reviewing appropriate drawings. These selected areas and the review process shall be agreed on prior to or concurrently with establishing the accepted mass properties estimate.

5.2.1 Mass properties estimates and reports. Mass properties estimates and reports prepared during this phase consist of contractor's design mass properties estimate, accepted mass properties estimate or baseline mass properties estimate, quarterly mass properties report, and final mass properties report. These estimates and reports are in detail and summarized in tabular form as follows:

- (a) Three-digit system number and title.
- (b) Original mass (not required for the contractor's design, accepted, or baseline mass properties estimate).
- (c) Current mass.
- (d) Current vertical lever.
- (e) Current vertical mass moment.
- (f) Current longitudinal lever.
- (g) Current longitudinal mass moment.
- (h) Current transverse lever.
- (i) Current transverse mass moment.
- (j) Current percent completion (not required for the contractor's design, accepted, or baseline mass properties estimate).
- (k) Special coding symbols.

Calculations and actual mass determinations shall be terminated for each report and the preparation of each report shall have begun sufficiently early so that the required submittal date of the report is not compromised.

5.2.1.1 Determination of mass properties data. Mass properties data may be obtained by a combination of estimation or calculation of ship construction drawings and by actual mass determination. The actual mass of all components and equipments, exceeding 225 kilograms (500 pounds), both contractor and Government responsible, shall be determined and centers of gravity estimated or calculated to establish the accuracy of estimated and calculated mass properties values. The actual mass values for materials and for components and equipments which are less than 225 kilograms (500 pounds) shall be determined on a selective or sampling basis, as determined by the contractor, to provide unit mass data for items such as insulation, steel, sheathing, piping, and the components and equipments under 225 kilograms (500 pounds). Where factors or percentages are utilized, such as for estimating and calculating paint, mill tolerance, and welding values, the contractor shall substantiate these values by realistic background information, both current and historical. Historical paint, mill tolerance, and welding factors background information shall be forwarded with the contractor's design or baseline mass properties estimate. Final values for paint, mill tolerance, and welding factors based on current ship information shall be forwarded with the final mass properties report.

DOD-STD-2137(SH)
13 April 1982

5.2.1.1.1 Where development has occurred to a component, system or portion of structure and reliable information or completed ship construction drawings are not available for the specific area of development, a re-estimate shall be made to obtain the most accurate current mass.

5.2.1.1.2 To minimize the amount of actual mass determination necessary by the contractor in order to comply with the Ship Specifications, the contractor shall, in his acquisition documents, require subcontractors or vendors to submit information on the current mass and location of the centers of gravity of all major assemblies, equipment, fittings, or components to be installed on the ship. It is suggested that information be submitted by subcontractors or vendors in the following sequence:

- (a) Estimate of mass shall be contained in the proposal by the subcontractors or vendors for a particular component, major assembly, equipment, or fitting.
- (b) Calculated mass of the component, major assembly, equipment, or fitting when its design is completed.
- (c) Actual mass of the component, major assembly, equipment or fitting when its design is completed.

5.2.1.2 Contractor's design mass properties estimate. The contractor's design mass properties estimate establishes the contractor's estimate of the ship mass properties data at the beginning of detail design and construction phase based on the Ship Specifications contract drawings, contract guidance drawings, and the design data package. It consists of the contractor's estimate of the light ship, full load, and capacity load displacements and their associated drafts (forward, aft, and mean), list, trim, KG and GM, uncorrected and corrected for free surface effect of liquids in tanks. Other loading conditions may be invoked by Section 096 of the Ship Specifications. Items shall be grouped in accordance with the three-digit system and by category for nuclear powered ship. The estimate shall contain estimated values for detail design and building margin. The contractor shall be prepared to substantiate mass and KG values proposed for this margin by realistic comparisons with recent similar ships or technical analysis. Other acquisition margin values may be required to Section 096 of the Ship Specifications for inclusion in this estimate. The variable load shall be distributed realistically throughout the ship in appropriate spaces. The mass of materials stowed or of liquid loaded in any one space or tank shall not exceed the capacity, based on the density factor for the space or tank. Historical background information for paint, mill tolerance, and welding factors used in developing this data shall be included in the estimate. The estimate shall be in tabular form as outlined in 5.2.1.

5.2.1.3 Accepted mass properties estimate. After submittal of the contractor's design mass properties estimate, the contractor and NAVSEA agree on the accepted mass properties estimate. To expedite this agreement, the contractor shall, upon request, visit NAVSEA after submittal

DOD-STD-2137(SH)

13 April 1982

of the contractor's design mass properties estimate. The accepted mass properties estimate shall include all details, summaries, and margins required for the contractor's design mass properties estimate. The estimate shall be in tabular form as outlined in 5.2.1.

5.2.1.4 Baseline mass properties estimate (BLMPE). In the detail design and construction phase, the BLMPE is entitled lead or follow ship allocated baseline mass properties estimate as appropriate. This estimate is the best evaluation of the ship with respect to mass and the vertical, longitudinal, and transverse location of the center of gravity. It is derived by comparison to an analysis of the preliminary allocated baseline mass properties estimate (PABLMPE) by the Government and the contractor. The BLMPE shall include all detail, summaries, and margins required for PABLMPE. The estimate shall be in tabular form as outlined in 5.2.1.

5.2.1.5 Quarterly mass properties report. This report shall reflect the latest evaluation, as constructed, of the ship's displacement, KG, trim, and list, and their relationship to the accepted or baseline mass properties estimate values for displacement and KG, and specified limits for trim and lists. Each report shall contain current values for displacement, drafts (forward, aft, and mean), trim, list, GM, and KG, with and without the net effect of adjudicated and unadjudicated contract modification and mass and mass moment changes in GFM, along with the status of all required margins. These values shall be for light ship, full load, and capacity load conditions. Other loading conditions may be invoked by Section 096 of the Ship Specifications. The quarterly mass properties report shall include reasons for mass and mass moment changes (in accordance with the three-digit system) from previous estimates and reports, with supporting details, if requested, and shall also include recommendations for reversing trends toward exceeding the established margins or limits. Items shall be grouped and detailed as in the accepted mass properties estimate or baseline mass properties estimate. Each item shall be marked to indicate whether the information given is based on estimating, calculating, or actual mass determination. Summaries shall include percent completion. (This shall be shown for each one-digit and three-digit system summary and for the ship as a whole.) The quarterly mass properties report shall also include a tabulation and description of unit mass for all equipments and components exceeding 225 kilograms (500 pounds) for which an actual mass determination was performed during the reporting period. The report shall be in tabular form as outlined in 5.2.1.

5.2.1.6 Final mass properties report. A final report shall reflect the final values of the ship's displacement, KG, trim, and list and their relationship to the accepted or baseline mass properties estimate values for displacement and KG, and specified limits for trim and lists. This report shall contain final values for displacements, drafts (forward, aft, and mean), trim, list, GM, and KG, with or without the net effect of adjudicated and unadjudicated contract modifications, and mass and mass moment changes in GFM. Other loading conditions may be invoked by Section 096 of the Ship Specifications. Items in this report shall be grouped and

DOD-STD-2137(SH)

13 April 1982

detailed as in the accepted or baseline mass properties estimate. Each item shall be marked to indicate whether the information given is based on estimating, calculating, or actual mass determination. Descriptions of items shall include the types, sizes, ratings or capacities, and the number of units or items reported so that unit mass values may be obtained. The final mass properties report shall reflect accurately the condition of the ship as built. This report shall contain the final actual values for all required acquisition margins. Summaries shall include percent completion. (This shall be shown for each one-digit and three-digit system summary and for the ship as a whole.) The final mass properties report shall also include a tabulation of description and unit mass for all equipments and components exceeding 225 kilograms (500 pounds) for which an actual mass determination was performed during this final reporting period. Final values for paint, mill tolerance and welding factors based on current ship information shall be forwarded with the final mass properties report. The report shall be in tabular form as outlined in 5.2.1.

5.2.2 Supplemental mass properties reports. The following supplemental mass properties reports, specified in 5.2.2.1 through 5.2.2.4.1 provide additional information and background data during the detail design phase.

5.2.2.1 GFM reports. In addition to recording mass and mass moments data of GFM material in accordance with the three-digit and category (nuclear only) systems in the contractor's design mass properties estimate and accepted or baseline mass properties estimate, a separate report of GFM mass properties data, excluding that of any Government-furnished structural steel shall be developed. This report supplements the contractor's design mass properties estimate, accepted mass properties estimate or baseline mass properties estimate, quarterly mass properties report, and final mass properties report. These GFM reports are supplemental information to the quarterly and final mass properties reports, and shall reflect concurrent mass properties information for the period of the report they accompany. Net changes in GFM mass properties data are adjudicated prior to the performance of inclining experiment and are used to modify the displacement and KG of the accepted or baseline mass properties estimate.

5.2.2.1:1 Changes of line items in the GFM list or inadvertent omission or inclusion of a GFM item from the accepted mass properties estimate or baseline mass properties estimate shall not be grounds for making additions, deletions, or substitutions of line items of the GFM reports. Any change to the GFM list shall be accomplished by a contract modification. The corresponding mass properties changes shall be part of the contract modification report and not be reported in the GFM report. Deletions from the GFM report shall be accomplished by using the accepted or baseline mass properties estimate values as the current mass and mass moment values at the time of deletion and in all subsequent GFM reports. The reduced mass and mass moment values resulting from such deletions shall be reflected in the adjudication of the contract modification.

DOD-STD-2137(SH)

13 April 1982

5.2.2.1.2 If acquisition responsibility passes from Government to contractor, the accepted mass properties estimate or baseline mass properties estimate values shall be used as the current mass and mass moment values in the GFM report, and the contract modification shall be adjudicated to reflect any net mass and mass moment change. If acquisition responsibility passes from contractor to Government, the GFM report shall remain unchanged and the contract modification shall be adjudicated to reflect any net mass and mass moment change. Where no contract modification is involved, or where later information indicates a difference between the mass and mass moment of a GFM item and its mass and mass moment as listed in the accepted or baseline mass properties estimate column, the updated mass and corresponding mass moments shall be listed under the "current" columns of the above tabulation. Any mass and mass moment changes to such items due to contract modification shall be excluded from the GFM report. This report, in tabular form with subtotals and totals, shall include columns containing the following information:

- (a) Identification by three-digit system.
- (b) Schedule "A" line and item number.^{2/}
- (c) Description of item.
- (d) Mass from the accepted or baseline mass properties estimate.
- (e) Current estimated, calculated, or actual mass.
- (f) Current vertical lever.
- (g) Current vertical mass moment.
- (h) Current longitudinal lever.
- (i) Current longitudinal mass moment.
- (j) Current transverse lever.
- (k) Current transverse mass moment.

5.2.2.2 Contract modification report. Prior to, or concurrently with, each claim for equitable adjustment in price and delivery asserted pursuant to the changes clause of the contract, an estimate of the net mass and mass moment change resulting from the contract modification shall be prepared and submitted to the Supervisor. A separate summary listing of adjudicated and unadjudicated contract modifications (including field changes) shall be prepared. This report shall include all contract modifications listed numerically by NAVSEA number and include the title, net change in mass and mass moments and whether or not the change has been adjudicated. This report supplements the quarterly mass properties report, final mass properties report and accepted ship report. Where the contract modification reports are submitted as supplemental information to the

^{2/} If the unit mass of a number of the same items is less than 50 kilograms (100 pounds), but the items have a collective mass of over 50 kilograms (100 pounds) and are in the same location, the collective mass may be listed as one or more line items and reported in accordance with the three-digit system.

DOD-STD-2137(SH)

13 April 1982

quarterly and final mass properties reports, they shall reflect concurrent mass properties information for the period of the report they accompany. The report that supplements the accepted ship report shall include those changes accomplished at the date of the inclining experiment.

5.2.2.2.1 Supporting details for each change shall be incorporated into the body of the quarterly mass properties reports and the final mass properties report in accordance with the three-digit and category (nuclear only) systems. Each item shall be marked to indicate whether the information is based on estimating, calculating, or actual mass determination, and whether or not the item is GFM. These detail line items shall be referenced in the reasons for change listing included with the mass properties reports. Prior to adjudication of the contract modification, the effect of mass and mass moment changes to these line items shall also be incorporated into the contract modification summary listing. After the contract modification has been adjudicated, any mass and mass moment changes to these details shall be treated as any other detail line item in the mass properties reports. The values for the contract modification, as reflected in the summary listing, shall not be changed after the contract modification has been adjudicated. The report shall be in summary form and of the format in accordance with figures 2 or 3, as required by the CDRL. This listing shall be totaled to present the net effect of all contract modifications.

5.2.2.3 Accepted ship report. The accepted ship report highlights the differences between the accepted mass properties estimate or the baseline mass properties estimate and the ship as inclined. This report shall be in summary form and of the format in accordance with figures 4 and 5, as required by the CDRL. If the final inclining experiment report differs significantly from the preliminary report of inclining, the accepted ship report will be revised by NAVSEA to reflect these differences.

5.2.2.4 Machinery mass properties report (nuclear). Machinery mass properties reports for nuclear ships shall be submitted in the category system. The report shall be divided into two sections. Section I shall contain nuclear machinery items; Section II shall contain the remaining items of the category system. The following summary sheets shall be in each report:

- (a) A listing of a total for each three-digit group within each of the categories A through M. Sub-totals shall be listed for each category, and a grand total for nuclear propulsion machinery.
- (b) Same as (a) with the exception that Section I and II shall be listed separately with a sub-total for each section, and a grand total for nuclear propulsion machinery.
- (c) A listing of a total of categories A through M for each three-digit group to make a grand total for nuclear propulsion machinery.

The totals for all summaries should be the same.

DOD-STD-2137(SH)

13 April 1982

5.2.2.4.1 The reports shall include the following information in tabular form:

- (a) Mass values from the accepted mass properties estimate or baseline mass properties estimate.
- (b) Current mass of each item.
- (c) Vertical levers.
- (d) Vertical mass moments.
- (e) Longitudinal levers.
- (f) Longitudinal mass moments.
- (g) Transverse levers.
- (h) Transverse mass moments.

Where these reports are submitted with the contractor's design mass properties estimate, the accepted mass properties estimate or the baseline mass properties estimate, the quarterly mass properties reports, and the final mass properties report, they shall reflect concurrent mass properties information for the period of the report they accompany.

5.2.3 Supplemental documents. The following supplemental documents when required by the CDRL, provide additional information and background data during the detail design and construction phase.

5.2.3.1 Mass properties control plan. This plan shall be general in nature and shall outline the procedures to be followed in meeting the mass properties control responsibilities described in the specifications. The plan shall include, as a minimum, technical aspects of the following topics:

- (a) A discussion which includes the contractor's evaluation of the condition of the design with respect to the ship's naval architectural characteristics, including discussion of special mass properties problems, and where emphasis on mass properties control is to be applied.
- (b) A discussion and understanding of the method to be used in adjusting margin mass and mass moment values.
- (c) A schedule for briefings of management concerning the ship's naval architectural condition throughout the detail design and construction phase. The individual who will give the briefings shall be identified.
- (d) Priority of computer time, if utilized.
- (e) Discussion and a listing of the equipments such as scales and balances including their capacity and accuracy and pertinent calibration data to be used in performing actual measurement.
- (f) Discussion demonstrating understanding of the actual mass determination requirements.
- (g) A discussion of the detail to which the ship construction drawings will be calculated and the recommended selected areas of the estimates and reports that will be scheduled for timely calculations during the design phase of the contract.

DOD-STD-2137(SH)

13 April 1982

- (h) The reporting schedule and cut-off dates for mass properties calculations.
- (i) The planned action for verification of mill tolerances, welding, and paint factors.
- (j) The management and technical authority of the mass properties control coordinator relative to the overall design effort anticipated.
- (k) The method of communicating the condition of the ship to line personnel.
- (l) The management action which will be taken upon detection of mass properties trends tending to cause estimated values to be exceeded.
- (m) The method and degree of mass properties control that will be required of contractors.

5.2.3.2 Mass properties design data sheet. The mass properties design data sheet shall contain the required information and shall be of the format indicated in figure 6 which is an example of a steam powered ship. Major load and machinery items as appropriate to the applicable ship shall be listed. This sheet shall include a note indicating whether the units are in the SI system or inch-pound system.

5.2.3.3 Mass distribution report. A longitudinal mass distribution shall be developed in a tabulated format in accordance with the standard longitudinal station breakdown (see 3.43). Mass and longitudinal center of gravity shall be determined for each ship station for both light ship and full load condition. The resultant total mass and longitudinal center of gravity for the mass distribution report shall equal the values reflected in the basic mass properties estimate or report for the same reporting period.

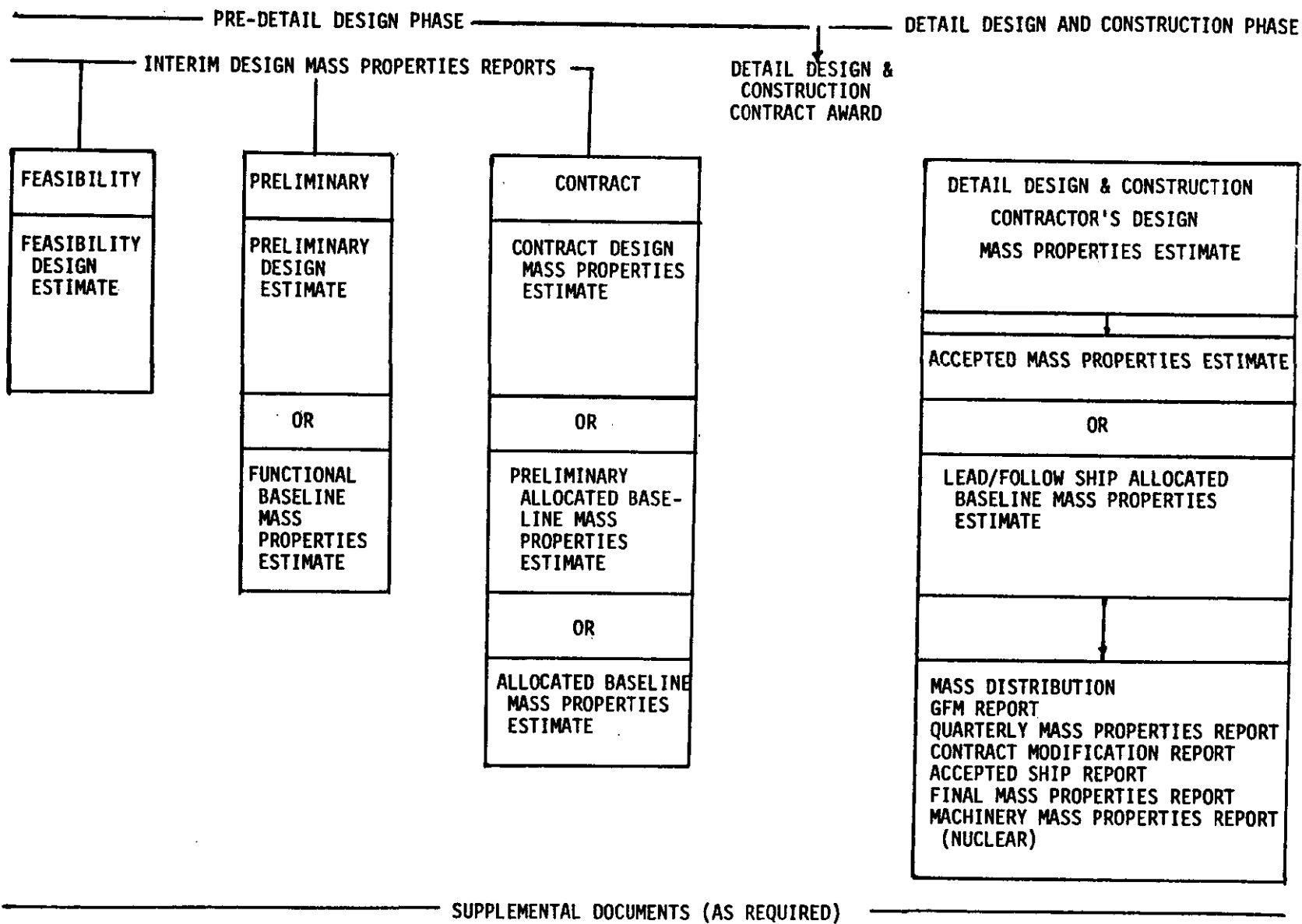
5.2.3.4 Input data cards. The input data cards provide inputs to the Navy standard mass properties computer program. The card format shall be as described in appendix A and shall reflect the same data used in the preparation of the estimates or reports they accompany. These data may be magnetic tape in lieu of cards. Submittal by magnetic tape shall comply with the requirements set forth in ANSI X3.4.

5.2.3.5 Mass properties trade-off studies. Trade-off studies comprise various engineering and technical studies directed toward determining detail mass properties data. These analytical studies are used to support design change proposals and to support recommendations for reversing trends toward exceeding established margins or limits. These studies are conducted on an "as requested basis", and contain detailed mass properties calculations reflecting the impact of the study on ship displacement, KG, list and trim. There is no fixed format for the mass properties calculations, but the SWBS classification system shall be used.

Preparing activity:

Navy - SH

(Project MISC-ND38)



21

DOD-STD-2137(SH)
13 April 1982

FIGURE 1. Interface of mass properties reports in design and construction.

CONTRACT MODIFICATION SUMMARY

NAVSEA HMR OR FMR	STATUS (See note 1)	MASS CHANGE	VERTICAL MASS MOMENT CHANGE	LONGITUDINAL MASS MOMENT CHANGE	TRANSVERSE MASS MOMENT CHANGE	REPORT NO. (See note 2)
SUMMARY (See note 3)						

NOTES

1. "A" indicates adjudicated; "U" indicates unadjudicated.
2. Include the report number where last change to the line item was incorporated.
3. This summary is entered in the line entitled "Net Effect of Contract Mods" of figure 4.

FIGURE 2. Contract modification summary (accepted mass properties estimate).

SH 12059

CONTRACT MODIFICATION SUMMARY

NAVSEA HMR OR FMR	STATUS (See note 1)	MASS CHANGE	VERTICAL MASS MOMENT CHANGE	LONGITUDINAL MASS MOMENT CHANGE	TRANSVERSE MASS MOMENT CHANGE	REPORT NO. (See note 2)
Current Summary (Margin Used)						
Original Allocated Baseline Values						
Net difference between Original and Current (Unused Margin) (See note 3)						

NOTES:

1. "A" indicates adjudicated; "U" indicates unadjudicated.
2. Include the report number where last change to the line item was incorporated.
3. This summary is entered in the line entitled "Contract Mod" of figure 5.

SH 12060

FIGURE 3. Contract modification summary (baseline mass properties estimate).

ACCEPTED SHIP REPORT

	Mass	Vertical		Longitudinal		Transverse		Trim (F) / (A)	List (P) / (S)
		KG	Mass Mom	LCG	Mass Mom	TCG	Mass Mom		
Inclining Experiment (Condition A)									
Full Load Loads from AMPE (Add)									
Load Changes Due to Contract Mods									
Current Full Load (Total)									
Net Effect of Contract Mods (deduct) (See note 1)									
GFM Net Changes (deduct) (See note 2)									
Contractor Responsible Values (Total)									
Accepted Mass Properties Estimate Values								(See note 3)	(See note 3)

NOTES:

1. Represents summation of adjudicated and unadjudicated values for all contract modifications accomplished at date of inclining experiment including those affecting variable loads (see figure 2).
2. Represents values shown in Standard Form 30 "SUPPLEMENTAL AGREEMENT" for net mass and mass moment differences in GFM from accepted mass properties estimate values.
3. Insert tolerances agreed to or limits in Section 070 of the Ship Specifications.

FIGURE 4. Accepted ship report (accepted mass properties estimate).

SH 12061

DOD-STD-2137(SH)
13 APR 11 1982

ACCEPTED SHIP REPORT

	Mass	Vertical		Longitudinal		Transverse		Trim (F) / (A)	List (P) / (S)
		KG	Mass Mom	LCG	Mass Mom	TCG	Mass Mom		
Inclining Experiment (Cond.A)									
Current Full Load Loads (Add)									
Current Full Load Condition									
Unused Government Margin (See note 1)									
Contract Mod (Add) (See note 2)									
GFM (Add)									
Current Full Load Cond (with Unused Govern- ment Margins)									
ABLMP Full Load Condition Values								(See note 3)	(See note 3)

NOTES:

1. For any margin that is not applicable, insert N/A in the Mass column.
2. Represents unused margins as reflected in figure 3.
3. Insert tolerances agreed to or limits in Section 070 of the Ship Specifications.

FIGURE 5. Accepted ship report (baseline mass properties estimate).

Indicate Security Classification

MASS PROPERTIES DESIGN DATA SHEET

USS

GENERAL DATA

Type:
 Endurance:
 Trial Speed:
 Complement:

HULL CHARACTERISTICS

LOA: DWL from baseline:
 LBP: Max. beam molded:
 MP: Mean depth at side:
 Prismatic coef: Depth at CL, Mid. Sect:
 Block coef: Speed to length ratio:
 Midship coef: Cubic number:
 Waterplane coef: Volume of hull:

DISPLACEMENT AND STABILITY CHARACTERISTICS

Limiting drafts:
 Full load drafts:
 Limiting KG:
 Trim:

Displacement: COND A COND D
 KM:
 KG:
 GM:
 GM (corr. free surf):

* Metric tons or long tons

MACHINERY

Boilers
 Turbines
 Reduction gears
 Thrust bearings
 Main force draft blowers
 Main condenser
 Propeller

Kilograms or pounds

MASS PROPERTIES SUMMARY DATA

<u>GROUP</u>	<u>MASS*</u>	<u>VCG</u>	<u>LCG</u>
1. Hull Structure			
2. Propulsion			
3. Electric Plant			
4. Command & Control			
5. Auxiliary System			
6. Outfit and Furn.			
7. Armament			
Total Light Ship			

FULL LOADS

<u>LOAD</u>	<u>MASS*</u>	<u>VCG</u>	<u>LCG</u>
Crew and effects			
Ammunition			
Provisions & stores			
General stores			
Cargo			
Lube oil			
Reserve feed water			
Fuel			
Contaminated oil			
Others as applicable			
Total Loads			

PROPULSION CHARACTERISTICS

Full power:
 Cruising:
 Steam conditions:

PROPULSION PLANT

<u>MACHINERY</u>	<u>No. per ship</u>	<u>Rating</u>	<u>Manufacturer</u>	<u>Unit mass#, dry</u>
------------------	---------------------	---------------	---------------------	------------------------

Indicate Security Classification

FIGURE 6. Mass properties design data sheet format.

Indicate Security Classification

<u>MACHINERY</u>	<u>No. per ship</u>	<u>ELECTRIC PLANT</u>	<u>Rating</u>	<u>Manufacturer</u>	<u>Unit mass#, dry</u>
SS generators					
Emergency generators					
Motor generators					
		<u>AUXILIARY PLANTS</u>			
Distillers					
Air condition					
Refrig. units (ships)					
Refrig. units (cargo)					
Air compressors					
Rudder					
Anchors					
# Kilograms or pounds					

27/28

Indicate Security Classification

FIGURE 6. Mass properties design data sheet format. - Continued

DOD-STD-2137(SH)
13 April 1982

DOD-STD-2137(SH)

13 April 1982

APPENDIX A

INPUT DATA CARD FORMAT

10. Scope. This appendix contains the required format for completing the standard Navy mass properties report input data cards.

20. Format. Input data cards when required by the design contract or Ship Specifications shall be interpreted and shall be punched in binary coded decimal (BCD) in accordance with the format specified in this appendix. The format is as follows:

- (a) Columns 1 through 5, element numbers. Columns 1 through 3 are based on the Ship Work Breakdown Structure (SWBS) (see NAVSEA 0900-LP-039-9010) or Bureau of Ships Consolidated Index (BSCI) of Drawings, Materials and Services Related to Construction and Conversion (see NAVSEA 0902-LP-002-2000). Columns 4 and 5 provide for special subtotals within an element number. Columns 4 and 5 shall contain only numeric data. Generally, two zeroes are used to designate a SWBS or BSCI element title. For example, Main Deck would be designated 13100 for SWBS or 10700 for BSCI. It is noted that SWBS subgroups ending in a zero are not to be used for mass properties input data such as 110, 120, 230, 240, etc.
- (b) Column 6. Column 6 is used for functional category designation when required for nuclear powered ships. These categories are defined by NAVSEA 0900-LP-039-9020 for SWBS and NAVSEA 0902-LP-002-2000 for BSCI.
- (c) Columns 7 through 10, item number. The item number provides the means of identification of each line within any five-digit element number. The following rules apply:
 - (1) Each line shall have an item number.
 - (2) All title cards representing any of the basic SWBS or BSCI title shall include a "ZERO" in column 10.
Note: Titles for special subtotals within a SWBS element may contain any item number desired.
 - (3) Care shall be taken not to repeat any item numbers within a five-digit element.
 - (4) Do not use any leading zeroes in the item number such as 0010.
 - (5) Item numbers for entries should be entered in increments of ten such as 10, 20, and 30 in lieu of 1, 2, and 3.
 - (6) All item numbers shall be right justified.

- (d) Column 11, station. This column is used in conjunction with the standard longitudinal mass distribution for subsequent strength calculations. For mass distribution, the ship is divided into 22 stations which are lettered A through X (excluding I and O). Station A is designated to contain all items whose longitudinal center of gravity (LCG) is forward of the forward perpendicular. Station B contains all items with an LCG between the forward perpendicular and ship station 1. Station C contains items between ship station 1 and ship station 2, and so on to Station X which contains all items aft of the aft perpendicular. For each item (except title cards and items with no mass), column 11 shall contain a letter from A through X (excluding I and O) unless one of the following special options is used:
- (1) An asterisk inserted in column 11 for any item indicates the mass will be automatically distributed in a 22-station longitudinal distribution in proportion to the basic hull structure. The basic hull structure for SWBS consists of group 1 from 110 through 159, except 114 and 123 through 126; and for BSCI, consists of group 1 from 100 through 111 plus 114. Items in the basic hull structure shall not use the "*" option.
 - (2) A digit 2 through 9 in column 11 indicates the mass for the given item will be distributed over 2 through 9 stations centered about the item's LCG. If enough stations are not available to do a particular distribution, the distribution will be done over as many stations as are available. For instance, if a six-station distribution is required within two stations of either end of the ship, then a four-station distribution will occur.
- (e) Column 12, special designator. This column shall contain designators established by the Government. Where no designator is applicable, this column shall be left blank. In the event of a conflict in determining which designation is to be used, the order of precedence shall be by alphabetical order. This designator provides for dual purpose as follows:
- (1) Provides for extractions across the entire ship for summaries such as plates, extruded shapes, weldments, primary, secondary, and others as required.
 - (2) Provides for listing within the three-digit element such as controls, components, distribution, and others as required.

DOD-STD-2137(SH)
 APPENDIX A
 13 April 1982

(3) The following designators are applicable:

- C - Controls, such as valves, switches, regulators, gear boxes, and shutters.
- D - Distribution items, such as ducts, pipe, wire, wireways, connectors, waveguides, propeller shafts, and propeller shaft bearings.
- E - Plating and sheeting.
- F - Forgings, extruded shapes, rolled shapes, built-up shapes, and castings.
- G - Weldments.
- M - Major components such as air conditioner units, antennas, actuators, batteries, blowers, boilers, compressors, computers, cranes, davits, distillers, transmitters, receivers, transceivers, engines, fans, generators, motors, propellers, pumps, turbines, winches, and replenishment at sea (RAS) equipment.
- P - Secondary, peripheral, and interface components, such as hydraulic reservoirs, electrical power supplies, nonintegral tanks, filters, heat exchangers (for system), and sub-bases.

(f) Column 13, special modifier. This column shall contain a modifier established by the Government for the column 12 designator for those items in groups 1 through 7 only, i.e. not including items of variable load. In the event a modifier cannot be determined, a "Z" shall be inserted. This modifier also provides for dual purposes, as follows:

- (1) Provide for extractions across the entire ship for various material types, such as all steel, all aluminum, and others, as required.
- (2) Provide for special systems summaries across the entire ship or within certain elements such as all payload, all habitability, and special systems such as hydrofoils and air cushions.
- (3) The following modifiers are applicable:

- A - Aluminum.
- B - Brass and bronze.
- C - Copper, copper-nickel, and nickel-copper.
- D - Ordinary strength steel.
- E - Higher strength steel.
- F - Fiberglass, plastic, and insulation material.
- H - Habitability items, such as berthings, clothing and personal effects stowage, leisure systems, sanitary systems, messing, personal service, utility, and work systems. (This modifier shall supersede any material type modifiers.)

DOD-STD-2137(SH)

APPENDIX A

13 April 1982

- J - Wood material.
- K - Liquids.
- L - Lead.
- M - Miscellaneous metallic material.
- N - Miscellaneous nonmetallic material.
- P - Payload which includes items that are peculiar to the specific missions of a particular ship, such as minesweep gear on a minesweeper, oceanographic gear on an oceanographic ship, etc. (This modifier shall supersede any material modifiers.)
- W - Welding, riveting, and fastening.

- (g) Columns 14 through 45, description. Use these 32 columns to adequately describe each item. Whatever is entered on the input data card is reproduced exactly on the mass properties estimate or report printout. Any combination of alpha-numeric characters or blanks can be used. Clear and complete description is essential. Note: If budget mass is being used, see 20(h) of this appendix, description field for SWBS or BSCI element titles shall not extend past column 37.
- (h) Columns 38 through 45, budget mass. Budget mass, if used, is entered in integer kilograms (pounds) on SWBS or BSCI title cards only. This allows mass values from 0 to 99,999,999 kilograms (pounds) (to be entered 99999999).
- (i) Columns 46 through 53, unit mass. Always enter unit mass of any item in kilograms (pounds). The broken line on the Standard Navy Transmittal Form (NAVSEA 5230/32) between columns 51 and 52 provides a decimal point, allowing a unit mass up to 999,999.99 kilograms (pounds). When the unit mass is a whole number, enter zeroes behind the decimal line in columns 52 and 53. If the mass is a deduction, enter a minus sign (-) immediately before the unit mass number.
- (j) Columns 54 through 57, number of units. Values from .001 to 999 units can be entered. This number is multiplied by unit mass to produce total mass for each line item. Unit mass, number of units, and total mass are all printed in the detail output. If a decimal number is being used in number of units, the decimal point must be punched.
- (k) Columns 58 through 62, vertical center of gravity (VCG). Use these columns for entering the VCG of each item, in meters (feet) and hundredths. When the VCG is a whole number, enter zeroes behind the decimal line between columns 60 and 61. (The VCG will be multiplied by the computed total mass and the resultant vertical mass moment will be printed.) If the VCG is negative (a mass below the baseline), enter a minus (-) sign immediately before the VCG number.

DOD-STD-2137(SH)
 APPENDIX A
 13 April 1982

- (1) Columns 63 through 67, longitudinal center of gravity (LCG). Use these columns for entering the LCG of each item, referenced in meters (feet) and hundredths forward or aft of the longitudinal reference datum. (The LCG will be multiplied by the computed total mass and the resultant longitudinal mass moment will be printed.) Always enter a positive LCG, no sign is necessary. When the LCG is a whole number, enter zeroes behind the decimal line between columns 65 and 66.
- (m) Column 68, LCG sign. As mentioned above, the LCG is always entered as a positive value. Enter "F" or "A" to indicate whether the mass is located forward or aft of the longitudinal reference datum. A blank in column 68 is interpreted to mean "A" of aft.
- (n) Columns 69 through 73 - Transverse center of gravity (TCG). Use these columns for entering the TCG of each item, referenced in meters (feet) and hundredths port or starboard of the centerline. When the TCG is a whole number, enter a zero behind the decimal line between columns 71 and 72. (The TCG will be multiplied by the total mass and the resultant transverse mass moment will be printed.) Always enter a positive TCG, no sign is necessary. If the TCG is not applicable, leave columns 69 through 73 blank.
- (o) Column 74, TCG sign. As mentioned above, the TCG is always entered as a positive value. Enter "P" or "S" to indicate whether the mass is port or starboard of the centerline. A blank in column 74 is interpreted to mean "P" or port.
- (p) Column 75, reservation indicator (RES). This column is used to indicate mass reservation items or design responsibility. The letter "R" shall be used to designate a reservation item. The letters "A" through "Z" (except "R") may be used as required, to indicate design responsibility such as:
- H - Hull design.
 M - Machinery design.
 E - Electrical design.
- (q) Column 76, reason for change. This column is used to indicate reason for change as follows:
- 0 - Nomenclature change (no mass properties change).
 1 - Contract modification change.
 2 - Government furnished material change.
 3 - Change to class status such as estimated to calculated or calculated to actual.
 4-9 and A-Z user assigned reasons. The column appears under "CHG" in the output.

DOD-STD-2137(SH)
 APPENDIX A
 13 April 1982

- (r) Column 77, material source indicator. The column is used to indicate the source of an item as follows:
- G - Government-furnished material.
 - F - Contractor-fabricated material.
 - P - Contractor-purchased material.
- (s) Column 78, class status. Use to indicate the confidence of the mass value entered for the line item as follows:
- E - Estimated mass.
 - C - Calculated mass.
 - A - Actual (scale) mass.
 - V - Vendor or catalog mass (to be changed to "A" upon actual mass determination of the item).
- (t) Columns 79 through 80, report number. Enter the report number where the change was first incorporated. Report number "AO" shall be used for the first submittal of input data cards. Cards changed prior to the first periodic mass property report shall carry report number "BO" for the first such change, "CO" for the second, etc. The first periodic mass properties report shall have column 79 blank and "1" in column 80, etc. Deletion cards shall contain the letters "DD" in columns 79 and 80 in lieu of a report number.
- (u) General input data card requirements.
- (1) Loads
- a. Load title cards. Title cards shall be prepared for each required load condition and for each load element comprising that condition in accordance with SWBS (this classification system is applicable to BSCI loads also) in the following format:
 - Column 1 - Alpha load condition designator.
 - Column 2-3 - Load element number.
 - Column 4-5 - Zeroes.
 - Column 10 - Zero.
 - Column 14 through 37 - Load element title.
 - b. Load detail cards. Loads for SWBS and BSCI are classified in much the same manner as light ship elements in groups 1-7 and follow the same format. Input data cards must be prepared for all detail load items comprising the full load condition (F in column 1). The letters A through L are used in column 1 to indicate various other loading conditions.

DOD-STD-2137(SH)

APPENDIX A

13 April 1982

- (2) Margins. Margins for SWBS and BSCI are classified in accordance with SWBS. The mass and mass moment of each margin will be automatically distributed over the 22 longitudinal stations in proportion to the light ship mass distribution. The margins can be either input as a total mass, or as a percentage of total light ship displacement. Margin cards are prepared in a similar manner to light ship details. The first card of the margin group shall be a title card of the form "M0000----0----Margins" beginning on column 1. Margin depletions are handled as negative detail mass entries in the same manner as light ship details and follow the same format. Margin options are as follows:
- a. Option 1 - input mass. Enter the total margin mass in kilograms (pounds) in columns 46-53, and centers of gravity as desired. All or any center of gravity may be left blank. The margins will then be automatically positioned at the light ship center of gravity.
 - b. Option 2 - percentages. Margin may be computed as a percentage of total light ship. In the UNIT MASS, columns 46-53, enter the percentage desired (e.g., 4 percent = 4.00). Enter zero in column 57 of number of units. Center of gravity may be entered or left blank. If left blank, margins will be placed at light ship center of gravity.
- (3) Title cards. Seven title cards, one for each of the groups 1 through 7, are included in the Navy program. All other title cards shall be prepared by the user. It is required that a title card be prepared for each of the SWBS or BSCI elements.

DOD-STD-2137(SH)

13 April 1982

APPENDIX B

DATA REQUIREMENTS

10. DATA

10.1 Data requirements. When this standard is used in a contract which incorporates a DD Form 1423 and invokes the provisions of 7-104.9(n) of the Defense Acquisition Regulation (DAR), the data requirements identified below will be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (DD Form 1423) incorporated into the contract. When the provisions of DAR 7-104.9(n) are not invoked, the data specified below will be delivered by the contractor in accordance with the contract requirements. Deliverable data required by this standard is cited in the following paragraphs:

<u>Paragraph</u>	<u>Data requirement</u>	<u>Applicable DID</u>	<u>Option</u>
5.1 through 5.1.2.1, 5.1.2.4 through 5.1.2.8, 5.2 through 5.2.3.5, figures 2 through 5, and Appendix A	Mass properties estimates and reports for surface ships	DI-E-2185	-----
5.1.2.2	Ship specifications section	UDI-E-26485	-----
5.1.2.3	Contract data require- ments list	DI-A-23434	-----

(Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

10.1.1 The data requirements of 10.1 and any task in the standard required to be performed to meet a data requirement may be waived by the contracting/acquisition activity upon certification by the offeror that identical data were submitted by the offeror and accepted by the Government under a previous contract for identical item acquired to this standard. This does not apply to specific data which may be required for each contract, regardless of whether an identical item has been supplied previously (for example, test reports).

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL		OMB Approval No. 22-R255
<p>INSTRUCTIONS: The purpose of this form is to solicit beneficial comments which will help achieve procurement of suitable products at reasonable cost and minimum delay, or will otherwise enhance use of the document. DoD contractors, government activities, or manufacturers/vendors who are prospective suppliers of the product are invited to submit comments to the government. Fold on lines on reverse side, staple in corner, and send to preparing activity. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements. Attach any pertinent data which may be of use in improving this document. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity.</p>		
DOCUMENT IDENTIFIER AND TITLE DOD-STD-2137(SH)		
NAME OF ORGANIZATION AND ADDRESS	CONTRACT NUMBER	
	MATERIAL PROCURED UNDER A <input type="checkbox"/> DIRECT GOVERNMENT CONTRACT <input type="checkbox"/> SUBCONTRACT	
<p>1. HAS ANY PART OF THE DOCUMENT CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE? A. GIVE PARAGRAPH NUMBER AND WORDING.</p> <p>B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES</p>		
2. COMMENTS ON ANY DOCUMENT REQUIREMENT CONSIDERED TOO RIGID		
<p>3. IS THE DOCUMENT RESTRICTIVE? <input type="checkbox"/> YES <input type="checkbox"/> NO (If "Yes", in what way?)</p>		
4. REMARKS		
SUBMITTED BY (Printed or typed name and address - Optional)		TELEPHONE NO.
		DATE

DD FORM 1426
1 JAN 72

REPLACES EDITION OF 1 JAN 66 WHICH MAY BE USED

S/N 0102-014-1802