NSRP

SHIP STRUCTURES

APPLICATION PROTOCOL

Overview

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Forward

This interim Part of ISO 10303 has been prepared for the Navy/Industry Digital Data Exchange Standards Committee (NIDDESC).

The need for reliable mechanisms for the exchange of data describing Ship Structural products between dissimilar systems has been recognized as an important capability for several years by industry and government organizations. In particular the U.S. Navy has been very interested in acquiring this capability to support its acquisition and support of naval ships. As a result of this interest, the NIDDESC (Navy/Industry Digital Data Exchange Standards Committee) was formed in 1987 to pursue the development of this capability. Also, the IGES/PDES Organization (IPO) in the U.S. and the International Standards Organization's "Standard for the Exchange of Product Model Data" (ISO 10303/STEP) groups have been pursuing the development of a single international standard for the representation of a wide range of product types.

Between 1996 and 1999, the DARPA/MARITECH sponsored, industry led initiative titled "Development of STEP Ship Product Model Database and Translators for Data Exchange Between U.S. Shipyards" implemented prototype translators for exchange of product model data using the ISO 10303 STEP shipbuilding application protocols (APs). This three-year collaborative effort project known as "MariSTEP" included both shipyards and CAD vendors. As part of MariSTEP, subsets of the ISO shipbuilding schemas for AP 215 Ship Arrangements, AP 216 Ship Moulded Forms, AP 217 Ship Piping and AP 218 Ship Structures were developed for the exchange of detailed design data among the consortium participants. These schema subsets are known as MariSTEP APs 215, 216 and 218 respectively.

In those same years from 1996 and 1999, there was a similar European implementation called "Seasprite" which was sponsored by the European Maritime STEP Association. This project also produced, among other subsets, a subset of the ISO Ship Structures AP 218 to support exchange of the a hull cross section. The MariSPRITE AP 218 Ship Structures and the Seasprite AP 218 Hull Cross Section application protocols were harmonized and implemented by several of the MariSTEP and Seasprite participants. This harmonized schema is known as the "MariSPRITE" AP 218 schema.

This second revision of NSRP 0429 brings the Ship Structure application protocol into agreement with the MariSTEP AP 215 Ship Arrangements, the MariSTEP AP 216 Ship Moulded Forms, and the MariSPRITE AP 218 Ship Structures. The document itself is comprised of 4 parts:

1. Overview
2. Annex A documents the MariSTEP Ship Arrangements
3. Annex B documents the MariSTEP Ship Moulded Forms
4. Annex C documents the MariSPRITE Ship Structure

This Part is one in a series of Parts which together will support the exchange of shipbuilding product model data until the International Standard ISO 10303 shipbuilding APs have been approve as an international standard.

The other Parts are as follows:

Descriptions Methods
Part 1 Overview and Fundamental Principles
Part 11 The EXPRESS Language Reference Manual

Implementation Methods
Part 21 Clear Text Encoding of the Exchange Structure;
Part 22 Standard Data Access Interface Specification;

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Part 518 (CD): Mechanical design shaded representation
Part 519 (FDIS): Geometric tolerances
Part 520: Associative draughting elements

NSRP Shipbuilding Standards
— NSRP 0424 - Piping Application Protocol

— NSRP 0425 - Electrical / Cableway Application Protocol
— NSRP 0426 - HVAC Application Protocol
— NSRP 0428 - Ship Outfit and Furnishings Application Protocol

The reader may obtain information on the other Parts of ISO 10303 from the ISO Central Secretariat.

Introduction

ISO 10303 is an International Standard for the computer-interpretable representation and exchange of product data. The objective is to provide a neutral mechanism capable of describing product data throughout the life cycle of a product, independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving.

This International Standard is organized as a series of parts, each published separately. The Parts of ISO 10303 fall into one of the following series: description methods, integrated resources, application protocols, abstract test suites, implementation methods, and conformance testing. The series is described in ISO 10303-1. This NSRP document is a **subset** of the ISO 10303 application protocols Application Protocols AP 215 Ship Arrangements, 216 Ship Moulded Forms, and 218 Ship Structures and is intended to serve as an interim standard until the full ISO 10303 application protocols are approved as an international standards.

This document specifies an application protocol (AP) for the exchange of ship structural 3D product data. This Application Protocol represents the data needed to support the Detail Design stage in the life cycle of a ship structural system, and much of the data developed during Production Engineering and Preliminary Design. The goal of this standard is to support the exchange of product data that represents the majority of a ship's structural system between different organizations with a need for that data. Such organizations include design agents, lead yard, and collaborative yard. An exchange of data using this AP is predicated upon the development of translation software to input (preprocess) and output (postprocess) the data. Translation software must be implemented on both systems between which data is to be exchanged. The purpose of these translators is to convert data to and from one application system to the neutral representation defined by this AP. This AP also serves to define tests of such translators that will validate certain aspects of their operation.

This application protocol defines the context, scope and information requirements for the exchange of Ship Structural systems and specifies the integrated resources necessary to satisfy these requirements. Application protocols provide the basis for developing implementations of ISO 10303. Additionally, this application protocol enumerates the conformance requirements.

Application protocols are the basis for developing abstract test suites for the conformance testing of implementations. This document is intended for a shipbuilding audience, and as such, assumes a certain level of familiarity with shipbuilding jargon, terms, and terminology. Where deemed appropriate, some definitions have been provided. Italicized text is used to indicate these defined terms in the Scope (Section 1).

Background

Evolution of Ship Product Model Technology

Beginning in the early 1980s, the U.S. marine industry began widespread use of 2D CAD systems for the design and construction of ships for the U.S. Navy. In the early years, the fledgling CAD systems primarily supported automation of drafting for ship drawings, but the technology quickly evolved in the mid 1980s to allow creation of full-scale, intricately detailed, 3-dimensional models of ships within the CAD software.

Soon these 3D CAD models were detailed and accurate enough to support not just automated generation of class and construction drawings for new ship designs, but interference checking and advanced graphical rendering. The quality and visibility of the design allowed design approval from the CAD model in lieu of traditional drawings. The data from the CAD model began to be used for generation of numerical control instructions for fabrication of structural plates or profiles, pipe bending instructions, and bills of material for construction assemblies. At the same time efforts began to integrate the CAD system with the other corporate systems such as material management, purchasing, and robotic systems. Thus, the integrated information infrastructure known as the 'Ship Product Model' was born, and, by the late 1980s, had become the central repository of design and construction information at most of the large U.S. design offices and shipyards.

Simultaneously with the advances in computer technology and integration within the yards, drastic reductions occurred in the Navy's procurement budgets, forcing a corresponding reduction in ship design and construction contracts. More and more, the industry began cross-organizational teaming arrangements to capture at least some of the remaining work. The design and construction of the Seawolf class by Electric Boat and Newport News, and the DDG51 class by Bath Iron Works and Ingalls Shipbuilding are good examples of this collaboration.

While in the early years of CAD use it was typical to install the same system at collaborating partners' sites, by the late 1980s, advances and integration of product model technologies into the business processes at each organization prevented the wholesale replacement of systems to share design and construction information outside of an individual organization.

For both the Seawolf and DDG51 data exchange efforts, direct translators or neutral mechanisms such as IGES, modified to meet the needs of an individual program, were used to allow transfer of the critical design and construction information between organizations. The yards and Navy quickly realized that each new combination of collaborators on each new class had to reinvent the wheel with their own project-specific data exchange agreements and software development. Each new direct translator or project-specific IGES 'flavoring' was useful on only a single ship program. The various data exchange experts within the industry and Navy began to envision creation of a single, industry-wide neutral data transfer specification, jointly developed by consensus of all parties. With this specification, each organization would know in advance what data would or would not be deliverable, and would allow more efficient development of translators that were applicable to all work of the organization rather than to a particular class. In pursuit of this goal, the Navy / Industry Digital Data Exchange Standards Committee (NIDDESC) was created in early 1987.

The NIDDESC Standards

NIDDESC was established to develop product model data exchange standards for the U. S. marine industry. The NIDDESC team was primarily composed of Navy and industry data exchange experts, several of who had previously been involved in implementation of CAD data exchange supporting the design and construction of the Seawolf and DDG-51 classes for the U.S. Navy.

Initially working on IGES and Product Data Exchange using STEP (PDES) exchange specifications within the U.S. IGES / PDES Organization, the team subdivided the product model by discipline and formed cross-organizational teams for the development of STEP exchange specifications. The major subdivisions in the U.S. requirements were Ship Structure, Ship Piping, Ship HVAC, Ship Electrical & Cableway, and Ship Outfit & Furnishing. Each of these teams had the goal of developing an Application Protocol (AP) that could be submitted to the International Organization for Standardization (ISO) for incorporation into STEP. Two other models supported these major subdivisions: Configuration Management and Ship Library Parts. These were not intended as separate APs, but rather to be shared by each of the primary discipline AP's. The process of development for each of the models was:

To develop activity models using the IDEF0 modeling technique. The IDEF0 models define the high-level ship design process and data flows that need to be supported by the models.

To develop information models using the Nijssen Information Analysis Method (NIAM). The NIAM models define the objects and their relationships. This technique was very effective in concisely documenting ideas and facilitating review and discussion within the team.

To develop information models using the EXPRESS language. This provides the computer interpretable version of objects and relationships documented in the NIAM model. A primary advantage of documenting the data models in the EXPRESS language was that tools were becoming available that would automate the development of translator software, for example in the generation of C++ classes from STEP's EXPRESS language.

In April 1993, the U.S. requirements for ship product data models were issued by NIDDESC and efforts began to incorporate the APs into STEP through cooperative international meetings with other members of the maritime industry through quarterly ISO TC184/SC4 (STEP) Shipbuilding Committee meetings. Although the NIDDESC team became inactive at this time, due to the loss of NAVSEA funding, efforts have continued at a much-reduced level since that time under various annual NSRP tasks titled "Convert NIDDESC Standards to ISO Standards".

In 1995, the NIDDESC Application Protocols were issued as National Shipbuilding Research Program (NSRP) reports and the version 1.0 APs have been referenced in at least one Navy RFP as a de facto U.S. standard for delivery of data. The NSRP standards issued were:

NSRP 0424 - Piping Application Protocol
NSRP 0425 - Electrical / Cableway Application Protocol
NSRP 0426 - HVAC Application Protocol
NSRP 0428 - Ship Outfit and Furnishings Application Protocol
NSRP 0429 - Ship Structure Application Protocol

ISO Application Protocols

Over the same time period that NIDDESC was developing Application Protocols to define the needs of the shipbuilding industry in the United States, several efforts were underway in Europe to outline the requirements of shipbuilding for STEP as seen by the European shipyards and regulatory agencies. European initiatives such as NEUTRABAS, MARITIME, ShipSTEP and now EMSA and SeaSprite have contributed significantly to the STEP development efforts, but have provided a different view of the problem than that addressed by the NIDDESC APs. These various efforts have led to the five shipbuilding Application Protocols currently being developed within ISO Technical Committee 184 Sub-Committee 4 that will become international standards by 2001. These APs represent a combination of the NIDDESC efforts, the various European initiatives, and ongoing U.S. participation funded by NSRP and the U.S. shipbuilding industry. Editing responsibilities for the ISO Application Protocols are divided between Europe and the U.S. The NSRP team is responsible for APs 215 and 217, while EMSA and the SeaSprite project are responsible for APs 216, 218, and 226. In general, the APs cover the early design through construction life-cycle stages for any ship, with additional support for certain operational data and class society survey information. Below is a brief review of the scope of each of the APs.

AP 215: Ship Arrangements addresses product model data to support the subdivision of ships into compartments and zones; definition of compartment geometric, functional, and operational properties; compartment connectivity, adjacency, and accessibility; tank capacities; cargo loading for design and operations; ship product structuring by space; weight reporting; and damaged stability.

AP 216 Ship Moulded Forms addresses the transfer of product model data to support the surface definition of hull shell and internal structural systems; station and spacing table definition; principle hull dimensions and characteristics; offset table and ship curve definition; and intact stability.

AP 217: Ship Piping addresses the transfer of product model data to support piping flow; pipe sizing; pipe stress; piping connectivity checks; pipe system testing; interference detection; part fabrication; assembly and installation instructions.

AP 218: Ship Structures addresses the transfer of product model data to support the design, manufacturing and approval of structural systems, plate parts, stiffeners, foundations, and welds. In addition it addresses the preliminary design of the ship structure and detailed design of all kinds of features including profile endcuts and interior, edge and corner cutouts.

AP 226: Ship Mechanical Systems addresses the transfer of product model data to support the design and manufacturing of shipboard mechanical systems.

These APs are the start of a full suite of Shipbuilding Product Model Exchange APs, illustrated in Figure 1, envisioned to support sharing of the entire product model across organizations. Over the past two years, efforts have begun within the NIDDESC working group to plan and fund development of the additional APs. A comprehensive ‘Business Plan’ and ‘Plan of Action and Milestones’ for increased development work under NIDDESC has been recently completed to aid in securing funding for completion of the entire suite of APs.

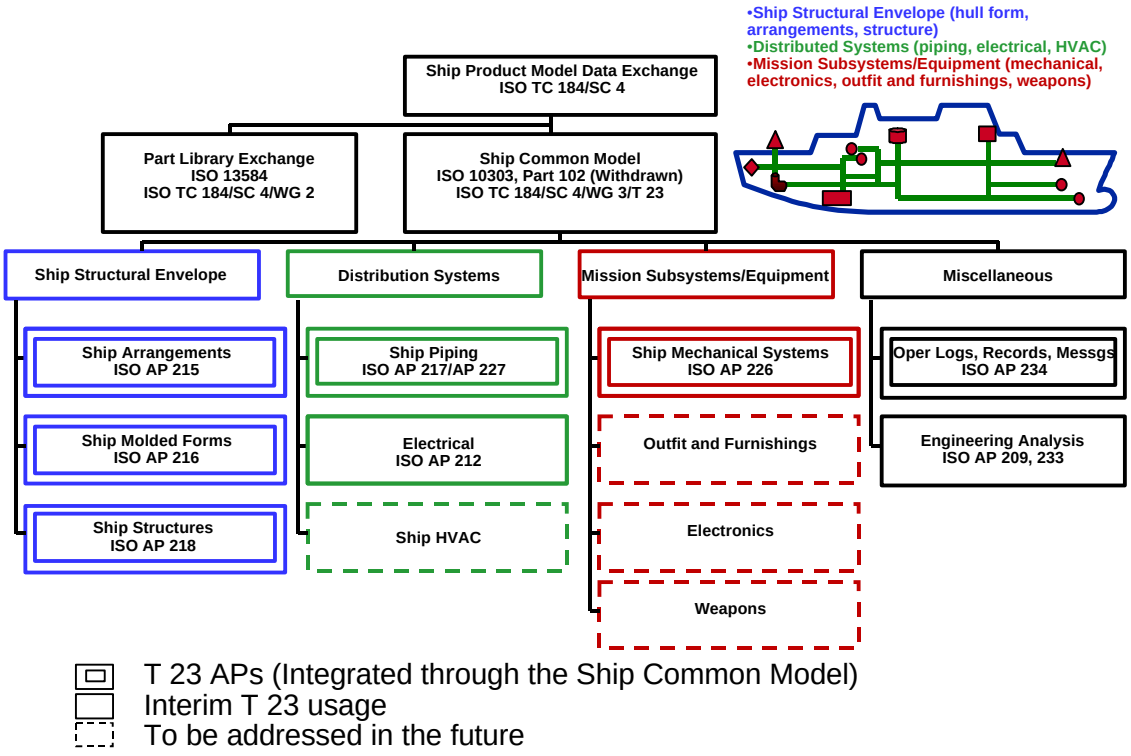

Figure 1: Full Ship Product Model Exchange

1. Scope

NSRP 0429 specifies the structures for the exchange of three-dimensional (3-D) product definition data and its configuration status information for ship structural systems. Configuration in this context pertains to data specific to revision tracking and change history of selected ship structural entities within the Product model. The term exchange is used to narrow the scope to only those data that are transferred between enterprise systems. This is to distinguish it from a data model supporting distributed, multi-user database applications.

In general, the AP has been developed to support the shipbuilding activities and applications associated with Detail Design with some applicability to the early stages of design and manufacturing. This support includes Functional Design and Detail Design.

A more detailed view of the scope for the NIDDESC Ship Structure AP, in an IDEF0 representation, may be found in Section 4, the Application Activity Model. In that model, the significant activities of ship structural design have been examined and modeled. Annex D also provides a more in-depth discussion of the capabilities supported by this AP.

The following represents the data scope of this AP (words or phrases in Italics are defined in clause 3):

a) Product definition data pertaining to the Functional Design phase of a ship's structural system development is in scope;

b) Product definition data pertaining to the Detail Design phase of a ship's structural system development is in scope;

c) Product definition data pertaining to the Production Engineering phase of a ship's structural system development is out of scope;

d) Product definition data pertaining to any lifecycle phase of a ship's structural system development -- other than Functional Design, Detail Design, or Production Engineering--is out of scope;

e) Business data for the management of a design project (e.g. budget, schedules, manpower requirements, etc.) is out of scope;

f) Two-dimensional drawing and textual documentation data associated with a ship's structural system development is out of scope. The product model is intended to support the generation of this type of information, however, other Application Protocols, yet to be developed, will be required.

g) Some data identifying the general characteristics of a ship are in scope, specifically;

   1) Information of a general nature describing the vessel, such as speed, range, class, hull number, homeport, etc.are out of scope;

   2) Data defining the main dimensions (e.g. *Global Coordinate System* and *Length Between Perpendiculars*) of the ship are in scope;

   3) Data defining the *principle characteristics* (e.g. *Beam*, *Depth*, etc.) of the ship are out of scope;

   4) Delivery information, such as the ship's builder, the builder hull number, the date of contract, the date of keel laying, the date of launching, etc., is out of scope;

   5) Information supporting the summary of weights for the various major systems on the vessel (e.g. weight of steel, weight of machinery, weight of spares, etc.) is out of scope;

   6) Data describing the type and manufacturer of the main machinery on the ship is out of scope;

7) Data describing the type and characteristics of the propulsion system for the vessel is out of scope;

8) Information pertaining to the crew size is out of scope;

9) Data summarizing the type and capacity of dry and liquid cargo capable of being loaded on the ship is in scope;

10) Information describing the type and quantity of combat weapon systems installed on the vessel is out of scope;

h) Some product definition data identifying the design loads acting on the structural system is in scope, specifically:

1) Basic loads, such as equipment loads, liquid/tank loads, and standard live loads are in scope;

2) Sea environment loads, such as hull girder loads, sea loads, weather loads, and ship motion loads are out of scope;

3) Operating environment loads, such as slamming, flooding, aircraft landing, tank overfill docking, or underway replenishment loads are out of scope;

4) Combat environment loads, such as shock, air blast, rockets, gun blast reactions, and missile blast reaction loads are out of scope;

5) Thermal loads are out of scope;

6) Data identifying load combinations acting simultaneously on a ship are out of scope;

i) Some product definition data pertaining to Ship Hull Product Structuring is in scope, specifically;

1) Product structuring data necessary to support the definition of *structural assemblies*, sub-assemblies, pre-assemblies, panel assemblies, units, modules, or hull blocks is in scope;

2) Product structuring data among disciplines --specifically structural, mechanical, electrical, and outfitting-- during the functional, detail, and production design phases of a ship structural system's lifecycle is out of scope;

3) Data pertaining to the generation of lists of material --such as *Bill of Material* (BOM) or Advanced Material Lists-- required to manufacture the ship or some portion of it, either by zone, assembly, or functional structural element, is in scope;

4) Data identifying the weight of the various product structures, specifically by system and by assembly, is out of scope;

j) Some product definition data pertaining to Ship Hull Geometry is in scope, specifically;

1) *Ship offset*, curve, surface, and solid geometry used to define the shape of a product model is in scope. The geometric entities deemed as in scope for the AP are: axis placement, transformation, point, line, conic (circle, ellipse, parabola, and hyperbola), b-spline, composite curve, trimmed curve, intersection curve, plane, cylindrical surface, conical surface, spherical surface, toroidal surface, swept surface, surface of revolution, surface of linear extrusion, bounded surface, and b-spline surface. In addition, in order to specify the boundaries of surfaces and establish connectivity between surfaces, the following topologic constructs are in scope: vertex, edge, edge loop, face, and shell. Finally, to support the integration of non-structural entity shapes and interference analysis, the following geometric shape models are in scope: manifold solid boundary representation and CSG solid;

NOTE: The above entity list represents a limited subset of Geometry and Topology entities from PART 42 of ISO 10303.

2) The distinction between geometry that defines the ship versus geometry that is derived from this *definition geometry* is in scope. The need to categorize geometry in this manner stems from contractual issues associated with data warranty. Usage of geometry derived by approximation or interpolation carries an implied risk as to its accuracy and validity. The criteria and conditions for suitability of this *derived geometry* is project dependent and outside the scope of this AP;

3) The linear, radial and normal tolerances associated with point, curve, and surface ship hull geometry are in scope;

4) The distinction between *faired* and *unfaired molded* hullform and hull surface *trace* geometry is out of scope;

5) The process of generating a *faired molded hullform* is out of scope;

6) The specification of the continuity across joined curves and surfaces is in scope;

7) Configuration Management information concerning ship geometry elements is in scope. This includes, but is not limited to, the date and time of creation, the creating person and organization, the software application name, version, and developing company (i.e. vendor) responsible for creating the geometry, the date and time of last modification, and the person and organization last modifying the data;

8) The relationship between intersecting curve and surface geometry elements and the resulting point and curve geometry is in scope;

9) The separation of the *molded hullform* into distinct hullform sections, each with its own local co-ordinate system, is in scope;

10) The definition of hullform reference elements such as the *Forward Perpendicular*, the *Aft Perpendicular*, the Centerline, the Baseline, *Amidships*, etc. for a molded hullform are in scope;

11) The definition of hullform geometry elements is in scope. Those provided for are Hull Shell, *Deck*, *Transverse Bulkhead*, *Longitudinal Bulkhead*, *Station*, *Frame*, *Waterline*, Buttock, *Diagonal*, Sight Edge, Knuckle, Tangent, and Reference;

12) The specification of *features* appropriates to and associated with the hullform geometry elements are in out of scope. Included are Camber, Deadrise, Flare, Sheer, and Tumblehome;

k) Product definition data pertaining to a ship's internal subdivision is in scope, specifically:

1) Data describing the subdivision of a ship into compartments, tanks, cargo holds, etc. is in scope;

2) Data identifying logical boundaries subdividing the ship into zones for the purpose of controlling access, designating design authority, applying specific design requirements (e.g. design zone, fire zone, subsafe zone, collective-protective systems zone, etc.) is in scope;

3) Data required for the determination of compartment adjacency is in scope.

l) Some product definition data pertaining to ship structural parts is in scope, specifically:

1) Data signifying the functional purpose (e.g. *deck* system, *superstructure* system, *bulkhead* system, etc.) of structural parts is in scope;

2) Data related to the design and manufacture of planar and non-planar structural plate parts is in scope;

3) Data specific to the design and manufacture of straight and curved structural stiffener parts is in scope;

4) Data associated with the identification, cataloging, grouping by library, instancing, and referencing of government, industry, company, or project specific standard parts is in scope;

5) The definition of *features* --cutouts, edge preparations (e.g. bevels, chamfers, fillets, grinding, etc)-- associated with structural parts is in scope;

6) Data identifying and representing the shape of non-plate, non-stiffener *special ship parts* (e.g. castings, forgings, etc.) is out of scope;

7) Data describing the design and manufacture of special ship parts is out of scope;

8) An *implicit shape definition* for structural parts and features, independent of a particular geometric solid modeling technique, is in scope;

9) Multiple shape representations for a structural part are in scope. These shapes may be function specific, such as an *analysis shape*, a *flat-pattern shape*, or an *interference shape*, and they may be *explicit shapes* specific to a particular geometric modeling representation, such as B-rep or CSG solid;

10) The reference to Government, Industry, and/or Organization specifications or production procedures pertaining to acceptable design criteria, manufacturing processes, and material requirements which are invoked during the functional, detail, and production design stages of a structural part's lifecycle is in scope;

11) Data specific to the determination of the weight and *centroid* for structural parts is out of scope;

12) The state --that is the collection of graphic and non-graphic attributes-- of a structural part at specific stages in the lifecycle is out of scope;

13) The recursive decomposition of structural parts into other structural parts within a single lifecycle stage is in scope;

14) The relationship of structural parts to one another --such as design parts decomposing into other design parts, detailed parts derived from design parts, or detailed parts generating production parts-- as they progress through the lifecycle is in scope;

15) Data relating structural parts with their *raw material stock* is out of scope;

m) Some product definition data pertaining to ship *structural connections/joints* is in scope, specifically:

1) Data defining the *functional connectivity* of structural parts to one another is in scope;

2) Data describing the physical joint manifestation of a connection resulting from a functional connectivity requirement is in scope;

3) Data implicitly defining the geometric features associated with a structural part as a result of a connection/joint is in scope;

4) Data specifying and/or referencing the welding processes, procedures, and details required for fixed joints is out of scope;

5) Data specifying the details of bolted fastener sets connecting structural parts with other structural parts or engineering part occurrences (e.g. piping part occurrence, HVAC part occurrence, discrete part occurrence, outfit & furnishing part occurrence, etc.) is out of scope;

6) Data specifying the details of moveable joints composed of simple pinned connections is out of scope;

7) Design, detailing, and production of articulated joints and/or linkages is out of scope;

n) Product definition data pertaining to ship *structural openings* is in scope, specifically:

1) Data pertaining to the description of openings in structural parts whose definition, orientation, and location are completely independent of any other structural or engineering part (e.g. pipe, HVAC, discrete, or outfit part occurrence) is in scope;

2) Data related to describing structural openings resulting from *system penetrations* –the penetration of a structural part by another structural part or an engineering part-- such that the definition, orientation, and location is dependent on the penetrating part (e.g. *ratholes*, stiffener *cutouts*, etc.) is in scope;

3) The maintenance of the relationship of the structural part, the penetrating part, and the structural opening is in scope;

4) Data correlating structural openings that bridge two or more structural parts, and hence, don't physically exist until the structural parts are joined in an assembly is in scope;

5) Data describing attaching parts --structural parts added as compensation for material lost as a result of penetrating a structural part-- is in scope;

o) Product definition data associated with revision tracking and change history (i.e. configuration management) is out of scope, specifically:

1) Data pertaining to the configuration management of structural part occurrences is out of scope;

2) Data pertaining to the configuration management of structural assemblies is out of scope;

3) Data pertaining to the configuration management of molded hullform geometry is out of scope;

4) Data pertaining to the configuration management of the ship, with respect to it's structural components, is out of scope;

5) Data pertaining to the configuration management of the internal subdivision is out of scope;

6) Data referencing documents identifying the reason for a design change is out of scope;

7) Data pertaining to the configuration management of the design change process is out of scope;

2. Normative References

The following standards contain provision which, through reference in this text, constitute provisions of this part of ISO 10303. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 10303 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of the IEC and ISO maintain registers of currently valid International Standards.

ISO 31:1994, *Quantities and Units.*
ISO 1000:1992, *SI units and recommendations for the use of their multiples and of certain other units.*
ISO 8824-1:1994. *Information Technology — Open Systems Interconnection — Abstract Syntax Notation One (ASN.1) — Part 1: Specification of Basic notation.*
ISO 10303-1:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 1: Overview and fundamental principles.*
ISO 10303-11:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 11: Description methods: The EXPRESS language reference manual.*
ISO 10303-21:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 21: Implementation methods: Clear text encoding of the exchange structure.*
ISO 10303-31:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 31: Conformance testing methodology and framework: General concepts.*
ISO 10303-42:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 42: Integrated generic resources: Geometric and topological representation.*
ISO 10303-43:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 43: Integrated generic resources: Representation structures.*
ISO 10303-44:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 44: Integrated generic resources: Product structure configuration.*
ISO 10303-46:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 46: Integrated generic resources: Visual presentation.*
ISO 10303-508: — [1] *Industrial automation systems and integration — Product data representation and exchange — Part 508: Application interpreted constructs: Geometrically bounded wireframe*
ISO 10303-510: — [1] *Industrial automation systems and integration — Product data representation and exchange — Part 510: Application interpreted constructs: Non-manifold surface representation*

NSRP 0424 - Piping Application Protocol
NSRP 0425 - Electrical / Cableway Application Protocol
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NSRP 0428 - Ship Outfit and Furnishings Application Protocol

3. Definitions and abbreviations

These definitions apply to terms used in the Foreword, Introduction and Scope (clause 1) sections of this document. They are not meant to be an exhaustive list of Shipbuilding jargon, terms, and terminology. Readers desiring a more complete list of definitions covering this topic are referred to references 8 and 11 of section 3.7 below.

3.1 Terms defined in ISO 10303-1

This part of ISO 10303 makes use of the following terms defined in ISO 10303-1:

— application;
— application activity model (AAM);
— application context;
— application interpreted model (AIM);
— application object;
— application protocol (AP);
— application reference model (ARM);
— computer aided design (CAD);
— computer aided manufacture (CAM);
— conformance class;
— conformance requirement;
— data;
— data exchange;
— implementation method;
— information;
— integrated resource;
— interpretation;
— PICS proforma;
— product;
— product data;
— unit of functionality (UoF).

3.2 Terms defined in ISO 10303-31

This part of ISO 10303 makes use of the following terms defined in ISO 10303-31:

— conformance testing;
— postprocessor;
— preprocessor;

3.3 Terms defined in ISO 10303-41

This part of ISO 10303 makes use of the following terms defined in ISO 10303-41:

— address;
— approval status;
— area measure;
— date and time;
— derived unit;
— identifier;
— label;
— length measure;
— mass measure;
— named unit;

— organization;
— person;
— person and organization;
— plane angle measure;
— positive length measure;
— ratio measure;
— shape representation;
— text;
— time measure;
— vertex.

3.4 Terms defined in ISO 10303-42

This part of ISO 10303 makes use of the following terms defined in ISO 10303-42:

— axis2 placement 3d;
— boundary;
— bounded curve;
— box domain;
— cartesian point;
— circle;
— closed curve;
— connected;
— curve;
— edge;
— edge curve;
— geometric representation context;
— line;
— open curve;
— orientable;
— placement;
— point;
— surface;
— vector;

3.5 Other definitions

For the purposes of this part of ISO 10303, the following definitions apply:

3.5.1 after perpendicular

A vertical line located at the intersection of the summer load (design) waterline and the after side of the rudder post or sternpost, or the centerline of the rudder stock if there is no rudder post or sternpost.

3.5.2 amidships

A point located exactly mid-way between the Forward and After Perpendiculars. It is primarily used as a reference to locate or measure items longitudinally on a ship.

3.5.3 baseline

An imaginary horizontal line used in design and production from which measurements are referenced (base-line is measure zero vertically)

3.5.4 beam

One type of structural stiffener which may or may not lie on a surface and may or may not be a profile. NOTE – In a different context, beam is also the term used for one of the main dimensions.

3.5.5 bill of material (BOM)

A list of all raw material stock required to fabricate the product.
NOTE – The BOM may be for an individual part, for an aggregation of parts (i.e., an assembly), or for a selected volumetric region (i.e., a zone) of the ship.

3.5.6 bulkhead

The vertical partition walls that subdivide the interior of a ship into compartments or rooms. The various types of bulkheads are distinguished by their location, use, kind of material, or method of fabrication, such as forepeak, longitudinal, transverse, watertight, wire mesh, pilaster, etc. Bulkheads that contribute to the strength of a vessel are called strength bulkheads, those that are essential to the watertight subdivision are watertight or oiltight bulkheads and gastight bulkheads serve to prevent the passage of gases or fumes.

3.5.7 buttock

One type of hullform element representing the intersection of a vertical, longitudinal plane with the hull surface.

3.5.8 camber

The change in vertical measurement of a deck relative to the deck at centerline.
NOTE – A positive value of a camber would mean that the deck at side is lower than the deck at centerline. Sometimes this value is expressed as a slope (such as mm per m) or as an angle.

3.5.9 cargo holds

Compartments in a ship that is assigned to carry cargo.
NOTE – Types of cargo include dry, liquid and gaseous commodities.

3.5.10 centerline

An imaginary horizontal datum line used in design and production from which measurements are referenced. NOTE – It divides the ship longitudinally into port and starboard sides.

3.5.11 centroid

The center of an item, area or volume measured with respect to some defined location. Within shipbuilding, it is expressed as a vertical component measured above the baseline, a transverse component measured from the centerline and a longitudinal component measured from either Amidships, or the Forward Perpendicular.

3.5.12 classification

The process of ensuring that a ship is designed, built and maintained to a prescribed standard. NOTE – This is done by periodic surveys of the ship.

3.5.13 collective-protective system zone

A region of a ship completely isolated from the outside environment for the purposes of protecting the crew from breathing toxic or germ infected air. This is accomplished by maintaining a positive air pressure with respect to non-protected regions.

3.5.14 combat systems

Systems on board naval ships used for Communication and Battle.
NOTE – Communication is carried out for detection of targets, disturbing enemy communication signals and with weapon systems on board the ship. Battle systems are the weapon systems on board the ship.

3.5.15 compartment

One type of space that represents the spatial partitioning of the interior of the ship for the purposes of segregating dry and liquid cargo, passengers, crew, machinery, equipment, etc.
NOTE – A compartment is represented by a closed, bounded volume defined in one of three ways:
– topologically by a collection of hullform elements (such as longitudinal and transverse bulkheads, decks, hull shell, etc.) and/or non structural joiner bulkheads;
– geometrically by one or more surfaces;
– by a combination of both.

3.5.16 crew size

The number and composition of the crew for a ship.
NOTE – There may exist various lists of crew-size, depending on the mission of a ship. There will be a minimum and a maximum size of crew.

3.5.17 cutouts

The results of removing a portion of a structural part, usually along one of its edges, to allow a stiffener to pass through the part.
NOTE – Typically, these cutouts have standard patterns and are parametrically defined based on the type and size of the penetrating stiffener.

3.5.18 configuration management

Addresses the specific needs of the shipbuilding community with regards to the version control, approval status, product structure, and ”as-built” condition of ship structure product model data.

3.5.19 deadrise

One of two ways of defining the linear change in the vertical measurement of the bottom of the ship from some inboard point to some outboard point, traditionally from the keel to the turn of bilge. NOTE – Adeadrise would mean that the bottom of the ship would be mmhigher at the outboard location than at the centre line. It is sometimes expressed as a slope (such as mm per m).

3.5.20 deadweight

The difference between the lightship weight and loaded displacement.
EXAMPLE – The weight of cargo plus weights of fuel, stores, water ballast, fresh water, crew passengers and baggage.

3.5.21 deck

One type of hullform element representing a vertical division of the internal space of a ship, equivalent to the function of a floor in a multi-storied building. It is the plating, planking, or covering of any tier of beams either in the hull or superstructure of a ship.
NOTE – It may extend over completely or only partially across the ship. Likewise it may extend over the complete length of the ship or only over selected portions of the length. It may be planar and orthogonal to the baseline (in which case its shape may be implicitly defined by a single vertical measurement), completely flat (i.e., planar) and not aligned with the baseline, or non-planar (i.e., 3-dimensional). Decks are usually designated by their location as boat deck, bridge, deck, etc. or by functional purpose such as freeboard deck and subdivision deck.

3.5.22 definition geometry

A designation for geometry that defines the shape representation of an item.
NOTE – There is a contractual implication with respect to guaranteed accuracy associated with this type of geometry.

3.5.23 depth

The vertical distance between the ship's baseline and a horizontal level in the ship.
EXAMPLE – The depth to a specific waterline, depth to the main deck, depth to the uppermost continuous deck.

3.5.24 design load

The load that the ship is designed to carry or to withstand.
NOTE – It is used to for instance present the design displacement, design strength.

3.5.25 design zone

An abstract boundary identifying a region of a ship with unique requirements or characteristics which must be specially treated in the design phase.
NOTE – These zones carry designations such as Fire Zone, CPS Zone, Subsafe Zone and Ship Work Authorization Boundary Zone.

3.5.26 diagonal

One type of hullform element representing the intersection of the hull surface with longitudinally oriented plane inclined to both the vertical and transverse global co-ordinate system axes.

3.5.27 docking loads

Loads acting upon the structural elements of the ship that are the result of the forces that occur when docking the ship.

3.5.28 dry cargo

A type of solid cargo that is stored in bulk
NOTE – a type, a capacity and a density can describe Dry cargo.

3.5.29 engineering part

A supertype of part occurrences (i.e. Device Occurrence, Distribution Part Occurrence, or Discrete Part Occurrence) that are configuration managed. These part occurrences are separate and distinct from Structural Part Occurrences.

3.5.30 equipment loads

Loads acting upon the structural elements of the ship that are the result of the forces that occur due to the presence or use of equipment on the ship.

3.5.31 explicit shape

The collection of geometry, conforming to specific geometric modeling representations such as B-rep, defining the shape of a structural part.
NOTE – There may be more than one explicit shape for a single part. The explicit shape may have embedded in it the geometry associated with the part's features.

3.5.32 features

Design or manufacturing characteristics of some aspect of a structural part.
EXAMPLE – The part features are holes, cutouts, edge bevels and fillets.

3.5.33 flare

The transverse measurement indicating how much greater a waterline's half-breadth is compared to the half-breadth of the design waterline, measured at the same longitudinal reference.
NOTE – An mm flare for a waterline means that the moulded hullform is mm wider at that waterline than it is at the design waterline.

3.5.34 fire zone

An abstract boundary defining a region of the ship requiring special consideration with regard to its ability to contain and/or withstand a fire.
NOTE – There may be several fire zones on a ship, each with different characteristics.

3.5.35 flooding loads

Loads acting upon the structural elements of the ship that are the result of the forces that occur when flooding compartments or spaces in the ship.

3.5.36 forward perpendicular

A vertical line at the intersection of the foreside of the stem profile and the summer load (i.e. design) waterline. It is commonly used as a reference point for measuring or locating items longitudinally on a ship.

3.5.37 frame

A term used to designate one of the transverse members that make up the riblike part of the skeleton of a ship. The frames act as stiffeners, holding the outside plating in shape and maintaining the transverse form of the ship.

3.5.38 functional structural element

A classification of ship structure associated with a particular system view of the ship.

3.5.39 geometry of the ship hull

The collection of geometry-elements that define the shape of the watertight envelope of the ship.
NOTE – This typically includes the underwater shell, the uppermost watertight deck or decks, and the internal watertight transverse and longitudinal bulkheads.

3.5.40 hogging

The situation of a vessel in still water as well as in a seaway, in which a vessel is bending: the deck of the ship would be in tension, the bottom will be in compression.

3.5.41 homeport

The name of the city or naval base from which the ship is assigned to operate.

3.5.42 hull girder loads

Loads acting upon hull girder that are the result of the forces that are transmitted from the applicable surrounding structural elements.

3.5.43 hull number

A number assigned to the ship for its life. When combined with a naval ship type abbreviation, it identifies the vessel.

3.5.44 hull shell

One type of hullform element representing the outermost, watertight envelope of a hullform section.
NOTE – Depending on the context of hullform section, this shell may represent the outer boundary of the ship itself, the rudder, sonar dome, etc.

3.5.45 hullform

The collection of geometry that defines the shape of the watertight envelope of the ship. This typically includes the underwater shell, the uppermost watertight deck or decks, and the internal watertight transverse and longitudinal bulkheads.

3.5.46 hullform sections

Entities indicating whether or not the hullform section has been faired.
NOTE – If the section is faired, then all hullform elements contained in the section are assumed to be faired. A complete moulded hullform is fair if all its hullform sections are fair.

3.5.47 HVAC part

A subtype of Distribution Part Occurrence that refers to elements in an HVAC system. It is a supertype for both HVAC components and HVAC duct occurrences.

3.5.48 hydrodynamic

Forces resulting from the flow of liquid around a ship

3.5.49 hydrostatic

Forces acting on the ship as a result of the pressure of air and water onto the outside under-water part of the ship when in calm water and not moving with respect to the fluid.

3.5.50 implicit shape definition

The specification of the shape of a plate or stiffener part that is independent of any specific geometric modeling representation.
NOTE – It is defined by a minimal set of geometry elements and attributes such that an explicit shape could be derived from it.

3.5.51 inspection

A visual, non-destructive examination or test carried out to assess the condition of a component of a ship's system.

3.5.52 interference shape

A collection of geometry defining the shape of a structural part for use in performing an interference analysis.
NOTE – This shape may include allowances for access and removal, insulation and shock clearances.

3.5.53 knuckle

One type of hullform element representing a mathematical 1st order (i.e., tangency) discontinuity between adjoining portions of the hullform, such as a chine.

3.5.54 length between perpendiculars

The horizontal, longitudinal distance measured between the forward and aft perpendiculars.

3.5.55 lightship weight

The weight of vessel as built.
EXAMPLE – The weight of the ship's hull structure, including the weight of any installed machinery and outfitting. It includes also boiler water, lubricating oil and cooling water system, but excluding the weight of the crew, any passengers and cargoes.

3.5.56 liquid cargo

A type of non-solid cargo that is stored in bulk.
NOTE – a type, a required carriage pressure, a viscosity and a density can describe Liquid cargo.

3.5.57 liquid tank loads

Loads acting upon the structural elements of the ship that are the result of the forces that occur when liquid cargo is stored in the cargo holds.

3.5.58 live loads

Loads acting upon the structural elements of the ship that are a result of the forces that occur when items are movable or are being moved, such as cargo, crew or passengers.

3.5.59 longitudinal bulkhead

One type of hullform element representing a transverse division of the internal space of a ship, equivalent to the function of a wall in a building.
NOTE – It may extend over one, several or all decks. Likewise it may extend over the complete length of a ship or only between certain transverse bulkheads. Longitudinal bulkheads are usually classified by their tightness.

3.5.60 main machinery

A type of general characteristic that categorizes the elements that is contained in the class main machinery.
NOTE – The main machinery comprises all equipment used in primary systems (e.g., propulsion, steering and diving).

3.5.61 maintenance phase

The lifecycle stage when the ship is in operation and maintenance is carried out.

3.5.62 manufacturer

A company or organization that makes or delivers parts or material for the ship.

3.5.63 midship

A vertical transverse plane through the ship hull dividing the ship's length between perpendiculars into two.
NOTE – In some cases, the frame the nearest to this plane is assigned the designation amidship frame.

3.5.64 moulded form

A classification of geometry representing a reference location, curve, or surface. Structural members are located relative to the moulded form geometry according to standard practices (e.g., the inside surface of flush shell plating is on the moulded surface).

3.5.65 moulded hullform

The idealized, zero-thickness representation of a ship's hull.

3.5.66 offset

The coordinate value of a point on the intersection line of an orthogonal plane with a ship moulded form.
NOTE – The offset is defined as the distance to the centreplane, or the distance to amidships if the plane lies in the longitudinal direction.

3.5.67 outfit and furnishing

A supertype of parts that represent non-structural and non-distributed system parts
NOTE – The outfit and furnishings include such things as manholes, hatches, joiner bulkheads, ladders, gratings and windows.

3.5.68 predesign phase

The lifecycle phase when a first estimation of main characteristics for the ship are established, possibly based on previous designs

3.5.69 production engineering

The stage within the ship life cycle when the ship is being built based on the production design.
NOTE – A subdivision can be made into structural part manufacturing and assembly manufacturing.

3.5.70 propulsion system

The system used to move the ship through the water.
NOTE – This can either be in a longitudinal (like the main propeller) or in a transverse (like bow-thruster) direction or a combination of both.

3.5.71 ratholes

The results of removing a portions of a structural part.
NOTE – The ratholes are usually in the shape of a semi-circle along one of its edges, in order to provide clearance between the part and a seam weld on an abutting part.

3.5.72 raw material stock

The plate and structural shape material that is purchased from either a steel mill or distributor, from which structural parts are cut.

NOTE – Typically, catalogues identify the range of sizes and cross-sectional shapes that can be selected. This raw material stock may be associated with a specific certification, heat treatment and chemical composition.

3.5.73 reference geometry

One type of hullform element representing information symbolically defined in the hullform model and not intended to be an exact or complete geometric definition.
NOTE – Reference geometry may be used when the relationship between product model components is being stressed, not the geometric description.
EXAMPLE – The outline of the propeller blade or the shaft centerline for a moulded hullform.

3.5.74 sagging

The situation of a vessel in still water as well as in a seaway, in which a vessel is bending: the bottom of the ship would be in tension, the deck will be in compression.
NOTE – This is a reverse form of hogging with excess weight amidships.

3.5.75 sea loads

Loads acting upon the structural elements of the ship that are the result of the forces that occur due to wind and water.

3.5.76 sheer

The change in height of a sloping deck as it progresses from the bow to the stern
NOTE – It is most commonly used on ships to counter the pitching motion effects by providing more freeboard near the ends of the vessel. Sheer for a deck is the measure on the centerline and is always constrained to be linear. Each deck is limited to one sheer definition at the bow and one at the stern.

3.5.77 ship class

The grouping of multiple ships built from a single design, identified as similar by the use of a class name.

3.5.78 ship motion loads

Loads acting upon the structural elements of the ship that are a result of the forces that occur when the ship moves in the water (i.e., rolling, heeling and pitching).

3.5.79 ship offset

A point used as a co-ordinate for a location on a ship’s hull form, appendage or deck.

3.5.80 ship range

A measure of a ship’s ability to remain at sea in order to perform a mission.
NOTE – It typically refers to a combination of distance and speed.

3.5.81 sight edge

One type of hullform element representing aspects of the moulded hullform that is highly visible to distant observers of the ship.
NOTE – For this reason, their shape is controlled, to a great extent, by appearance and aesthetic appeal.

3.5.82 slamming loads

Loads acting upon the structural elements of the ship that are a result of the forces that occur when a ship end (stem or stern) rises above the water surface and than falls back into it.

3.5.83 special ship parts

Ship parts that are formed by forging or casting processes.

3.5.84 station

The intersection of a transverse plane with the moulded hullform.
NOTE – Typically the shape of the ship is defined by 20 stations equally spaced along the length of the vessel. These stations define the cross-sectional shape and are used along with the waterlines and buttocks to represent the 3-dimensional wireframe shape of the ship.

3.5.85 structural assembly

A hierarchical, building block view of individual structural parts comprising a ship
NOTE – Parts are joined together to form successively larger building blocks. These interim products are referred to as assemblies.

3.5.86 structural connections and joints

The connectivity between structural parts and other structural parts where the geometry and topology of the connection is static and does not change as a result of the connection.
NOTE – A connection represents a requirement that two parts be joined and may decompose into lower level connection requirements. Eventually, a connection requirement is fulfilled by a joint that represents a physical realization of the connection requirement.

3.5.87 structural opening

An opening in a structural part to allow penetration by another structural part, penetration of a distribution system part, passage of air or liquid, access through a structural part, lightening of a structural part to improve structural efficiency, or clearance between joined structural parts.

3.5.88 structural part occurrence

A collection of information common to all parts that have been defined in and/or stored in a library or catalogue that can only be determined when the instance is placed in the ship
NOTE – A structural part occurrence may be associated with only one specific structural part that represents a single, consistent partial definition.

3.5.89 structural plate

A type of structural shape part that forms a separation between compartments.
NOTE – It is defined to lie on a ship surface.

3.5.90 structural stiffener

A type of structural shape part that serves to locally stiffen a structural plate part.
NOTE – Hence, it must be defined to lie on a ship surface. As such, the surface normal and the trace tangent are used to establish the plane for the cross-section. The cross-section is always placed on this plane based on the occurrence's vertex/point.

3.5.91 subdivision

The internal, spatial partitioning of a ship into volumetric-based zones or compartments for the purposes of improving survivability in the event of damage or to segregate areas of the vessel different purposes, such as the carriage of liquids, cargo, passengers, etc.

3.5.92 subsafe zone

An abstract boundary defining a region of a ship with special design or production requirements with regard to safety criteria for use on a submersible vessel.

3.5.93 superstructure

A decked-over structure above the upper deck.
NOTE – The outboard sides of a superstructure are formed by the shell plating, as distinguished from a deckhouse that does not extend outboard to the shell plating.

3.5.94 system penetrations

The intersection of piping, HVAC or outfitting part with a structural part (i.e., non-structural system penetration) or the intersection of one structural part with another structural part (i.e., a structural system penetration).

3.5.95 tangent

A type of hullform element representing a path where portions of the moulded hullform meet such that their 1st derivative is constant.

3.5.96 tank overfill loads

Loads acting upon the structural elements of the ship that are the result of the forces that occur when a tank in the ship is filled above the maximum volume.
NOTE – The above-maximum volume will leave through the tank-overflow pipe, raising the pressure in the tank to the head of the overflow-pipe level. When the tank-overflow pipe is too small to let the liquid escape, then the pressure increases to the level of that of the filling-device.

3.5.97 tanks

A type of cargo hold especially designed for carrying liquids.

3.5.98 thermal loads

Loads acting upon the structural elements of the ship that are the result of the forces due to differences in temperature.

3.5.99 transverse bulkhead

One type of hullform element representing a longitudinal division of the internal space of a ship, equivalent to the function of a wall in a building.
NOTE – It may extend over completely from the bottom to the top of the ship, or only between certain decks. Likewise it may extend over the complete width of the ship or only between certain longitudinal bulkheads. Transverse bulkheads are usually classified by their tightness.

3.5.100 tumblehome

One type of moulded hullform feature that is a collection of measurements representing the amount the moulded hullform's beam narrows above the design waterline.
NOTE – Tumblehome is the opposite of flare.

3.5.101 underway replenishment loads

Loads acting upon the structural elements of the ship that are the result of the forces that occur when one ship is tied to another during operation so as to transfer goods between the two ships.

3.5.102 vessel heel

Rotation of a ship about the logintudinal axis.

3.5.103 vessel trim

Rotation of a ship about the transverse axis.

3.5.104 waterline

The intersection line of the water's surface with the ship's hull when the ship is afloat.

3.5.105 weather loads

Loads acting upon the structural elements of the ship that are the result of environmental forces such as wind, rain, snow and ice.

3.5.106 weight of machinery

The total weight of the main machinery that is on the ship.
NOTE – During the various lifecycle phases this may vary from an estimated value (design) to a measured value (construction).

3.5.107 weight of spares

The total weight of the spare parts that are on the ship.
NOTE – During the various lifecycle phases this may vary from an estimated value (design) to a measured value (operation).

3.5.108 weight of steel

The total weight of the structural steel parts that make up the ship.
NOTE – During the various lifecycle phases this may vary from an estimated value (design) to a measured.

3.5.109 zone

An abstract boundary identifying a region of a ship with unique requirements or characteristics that must be specially treated in the design and/or manufacturing process. Typically, these zones carry such designations as Design Zone, Fire Zone, CPS Zone, Subsafe Zone, Ship Work Authorization Boundary Zone, etc.

3.6 Abbreviations

For the purposes of this Part of ISO 10303, the following abbreviations apply:

— AAM Application Activity Model
— AIC Application Interpreted Construct
— AIM Application Interpreted Model
— AP Application Protocol
— ARM Application Reference Model
— CAD Computer Aided Design
— CAM Computer Aided Manufacture
— IMO International Maritime Organization
— PICS Protocol Implementation Conformance Statement
— SI System International

— SOLAS Safety of Life at Sea
— UoF Units of Functionality

3.7 Bibliography

— Application Protocol Status Report, MariSTEP Technical Report, STEP-PMC-0004.
— Life Cycle Selection Report, MariSTEP Technical Report, STEP-PMC-0005.
— AP Subset Selection Report, MariSTEP Technical Report, STEP-PMC-0006.
— Implementation Schema Development Report, MariSTEP Technical Report, STEP-PMC-0007.
— System Requirements Document (SRD), MariSTEP Program Document, STEP-PMC-0009.
— Parts Library Specification for Stages 1 and 2, MariSTEP Technical Report, STEP-TEAM-0011.
— PMDB and Test Data Definition Report, MariSTEP Technical Report, STEP-TEAM-0012.
— 10303 ISO TC 184/SC4/ N WG3 531 - AP 215 Ship Arrangements.
— ISO 10303 ISO TC 184/SC4/ N WG3 729- AP 216 Ship Moulded Forms.
— ISO 10303 ISO TC 184/SC4/ N WG3 494 - AP 217 Ship Piping.
— ISO 10303 ISO TC 184/SC4/ N WG3 708 - AP 218 Ship Structures.

4. Information Requirements – Application Activity Model

The application activity model (AAM) is provided as an aid in understanding the scope and information requirements defined in this application protocol. The model is presented as a set of figures that contain the activity diagrams and a set of definitions of the activities and their data. Activities and data flows that are out of scope are marked with an asterisk.
Table 1-1 NSRP Ship Structures Activities indicates which activities are included in the NSRP 0429 Version 2.0 Ship Structures Application Protocol and its schemas: 1) Ship Arrangement, 2) Ship Molded Forms, 3) Ship Structure.

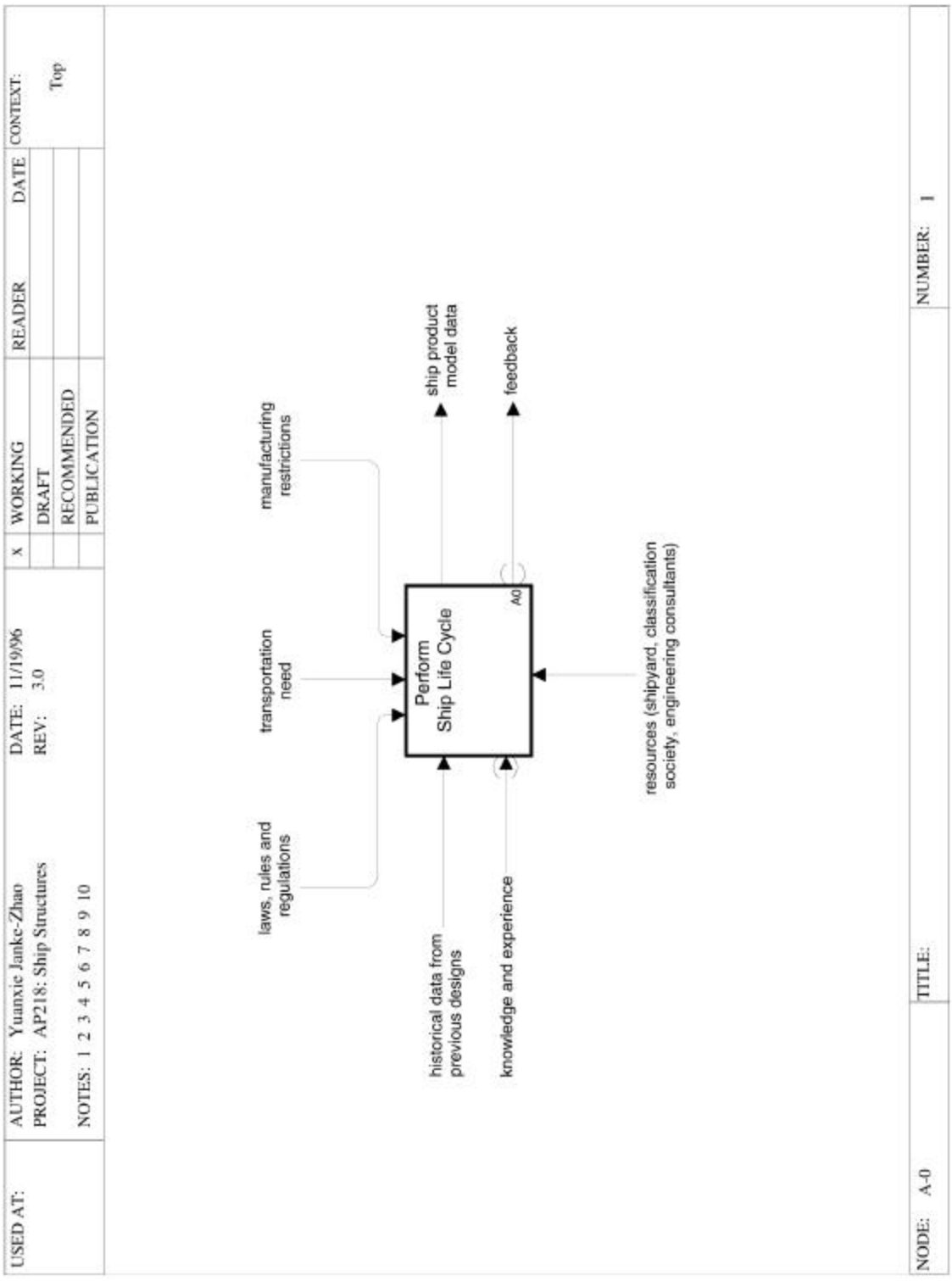

Figure 2: Node A - Ship Life Cycle

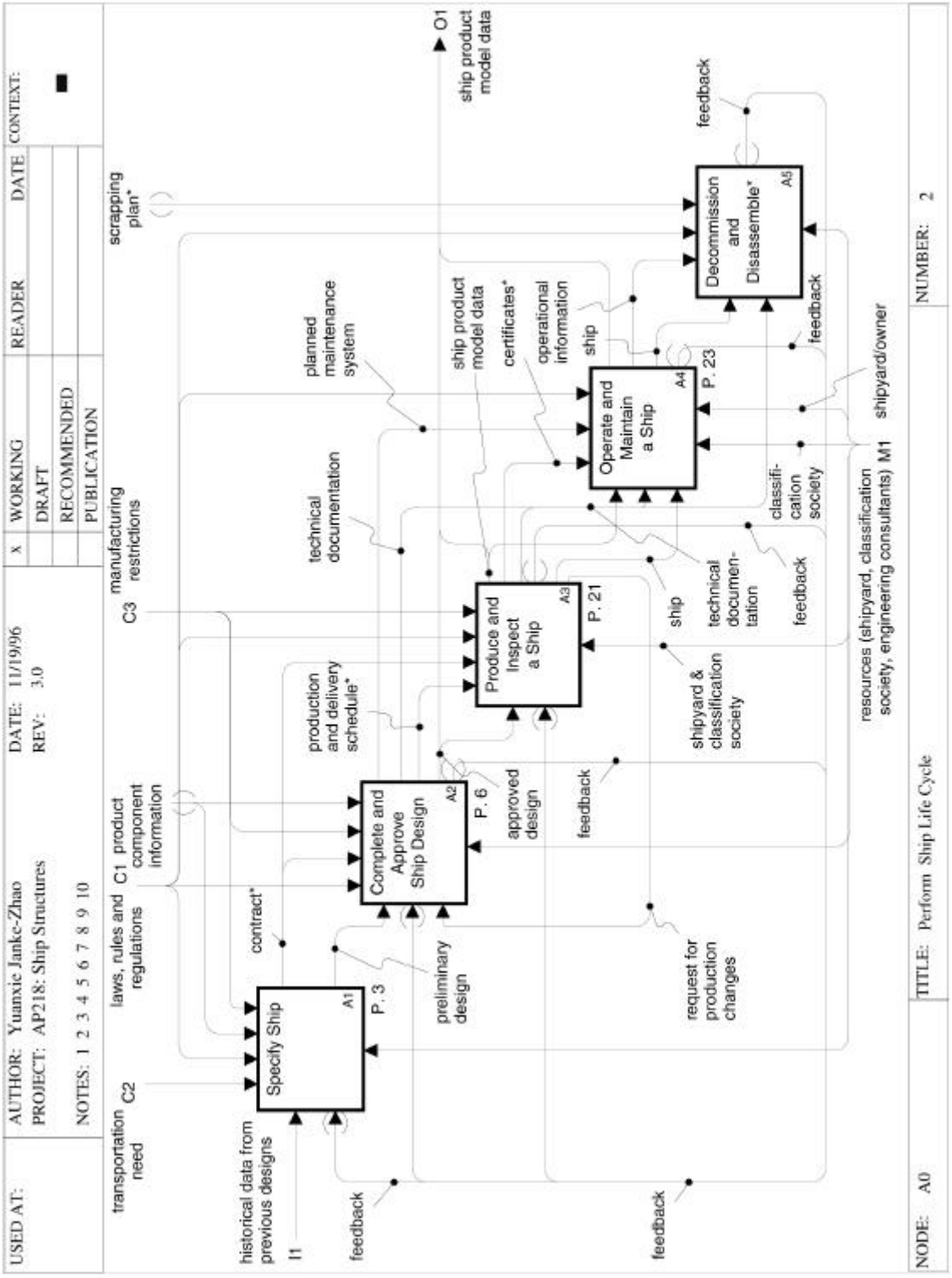

Figure 3: Node A0 - Ship Life Cycle

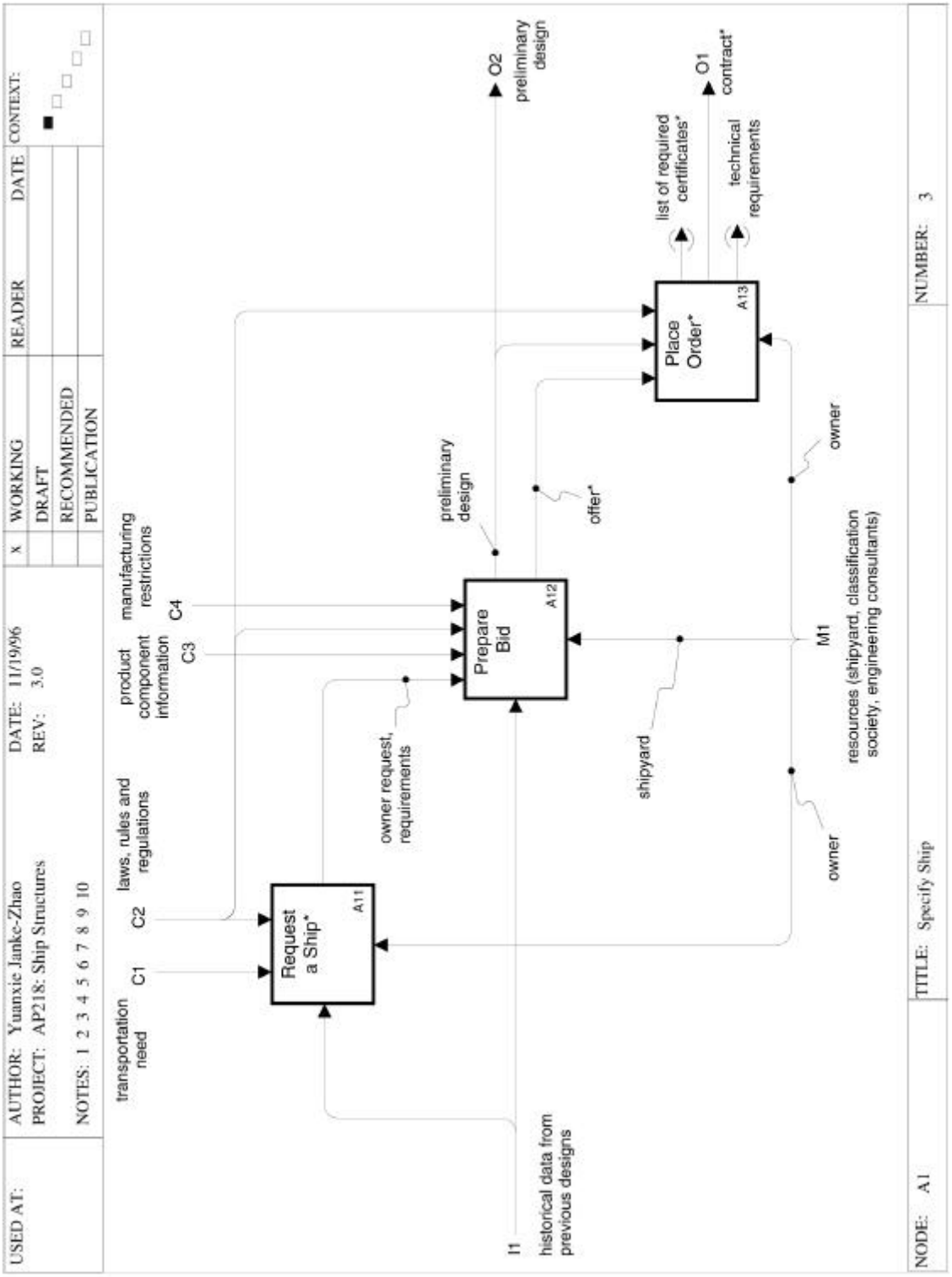

Figure 4: Node A1 - Specify Ship

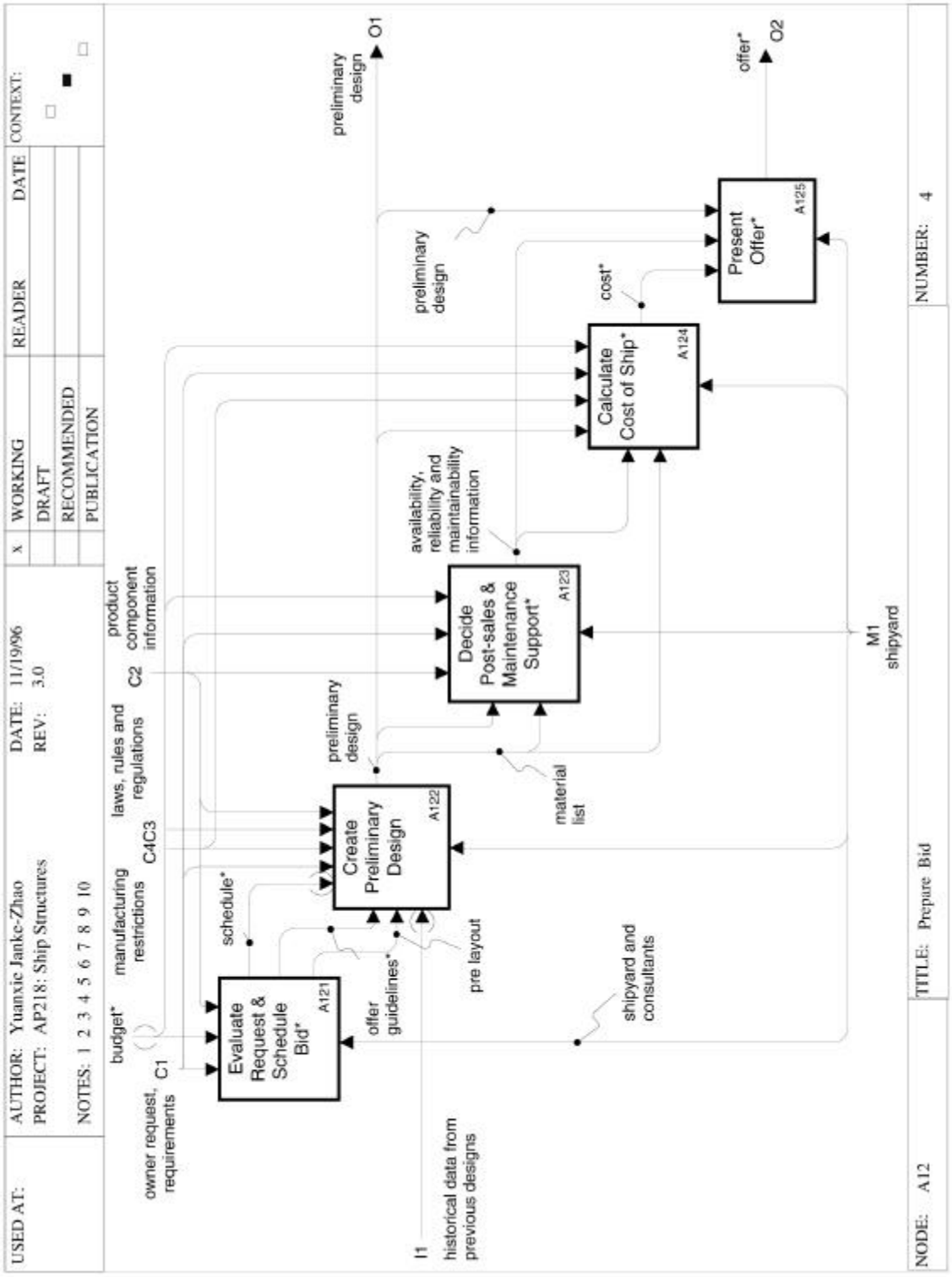

Figure 5: Node A12- Prepare Bid

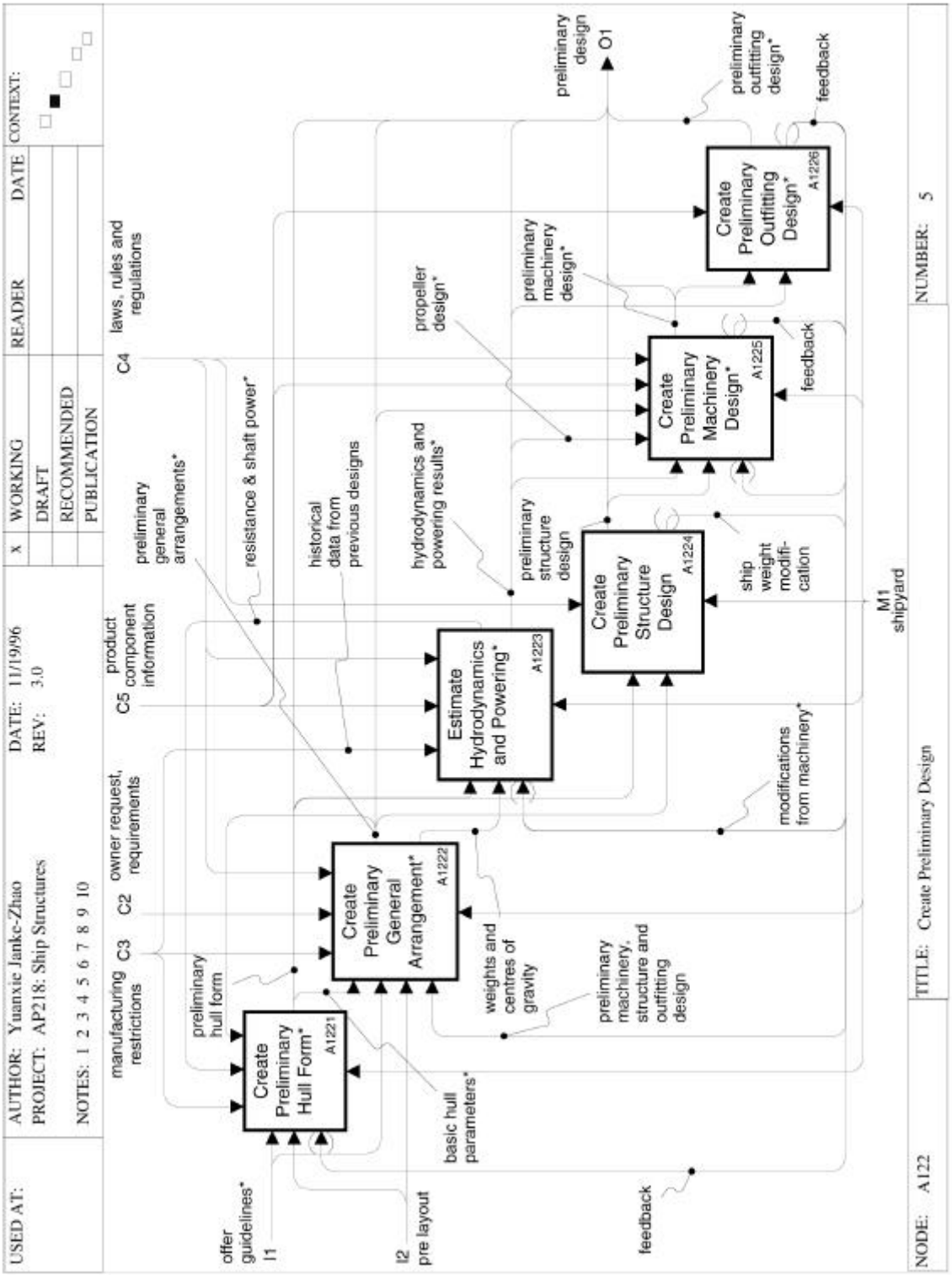

Figure 6: Node A122 - Create Preliminary Design

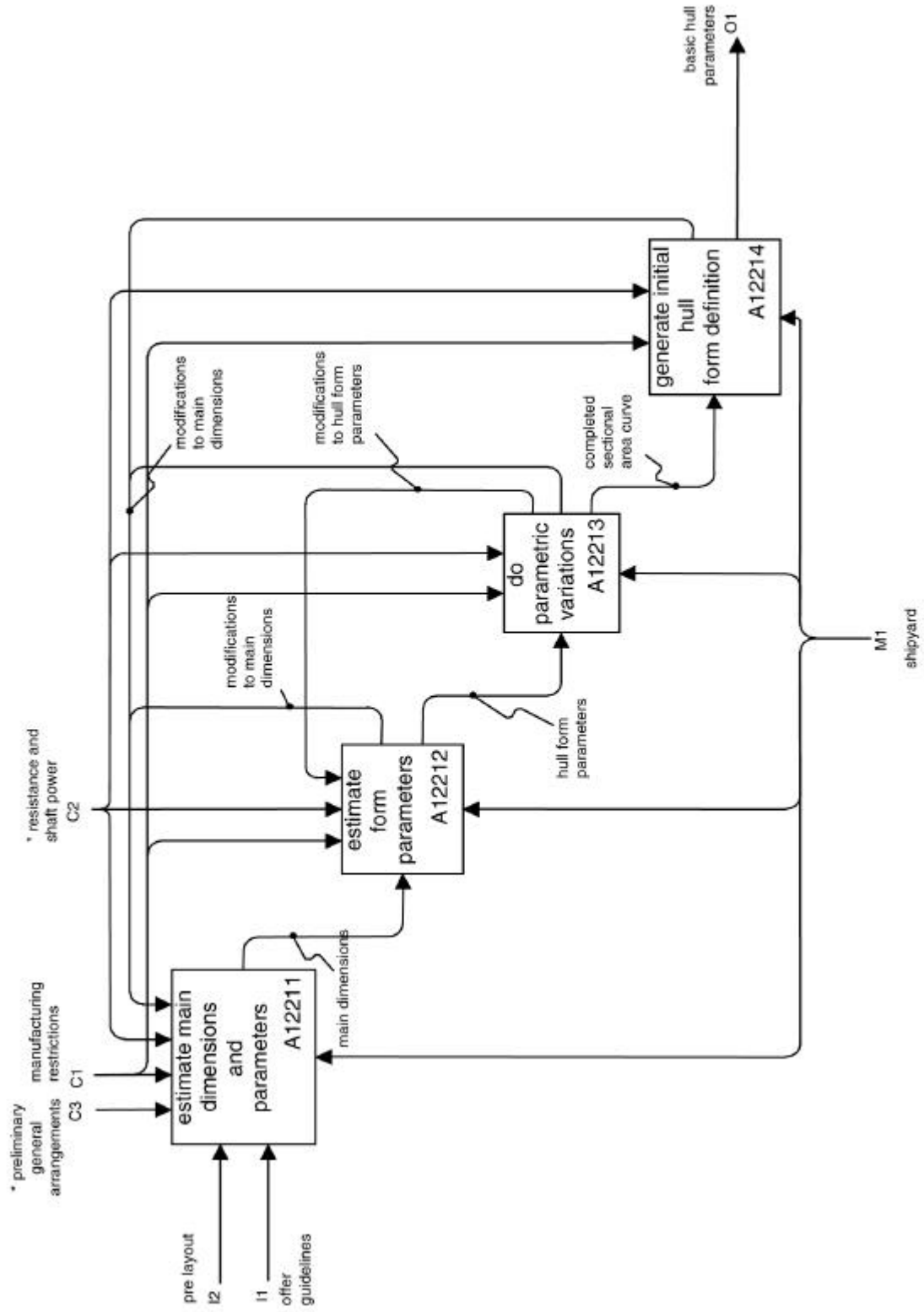

Figure 7: Node A1221- Create Prelimary Hull Form

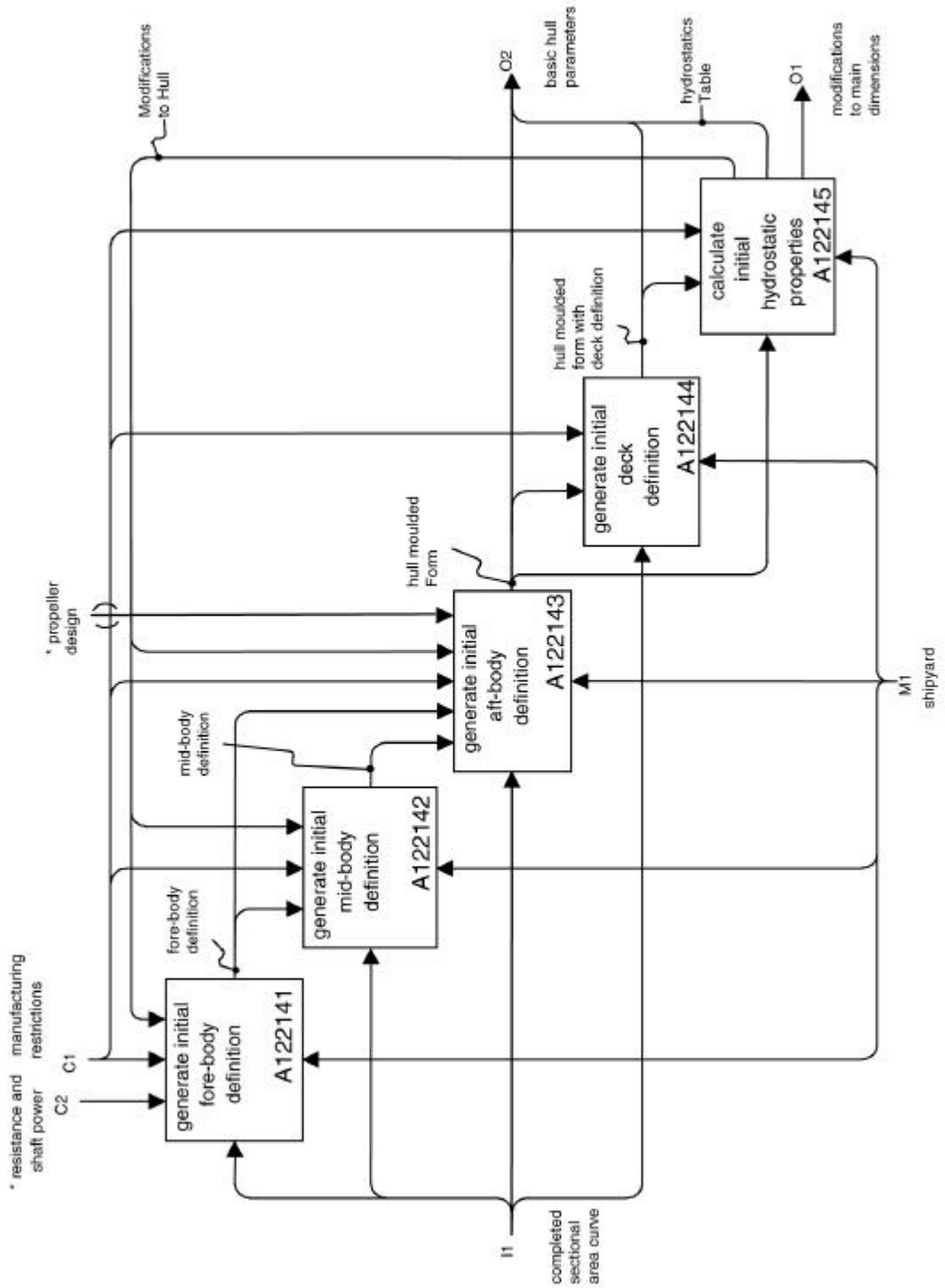

Figure 8: Node A12214- Generate Initial Hull Form

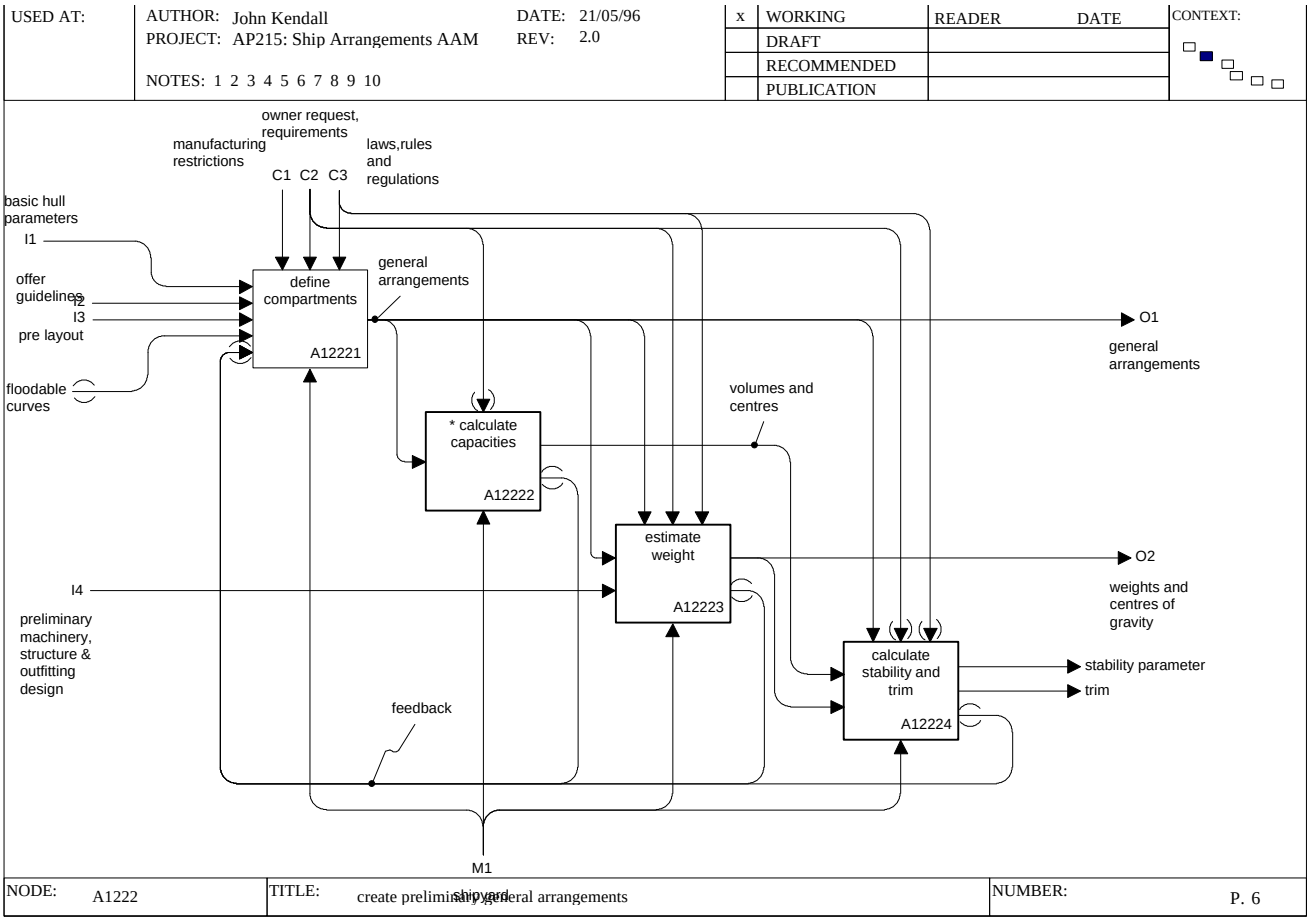

Figure 9: Node A1222 - Create Preliminary General

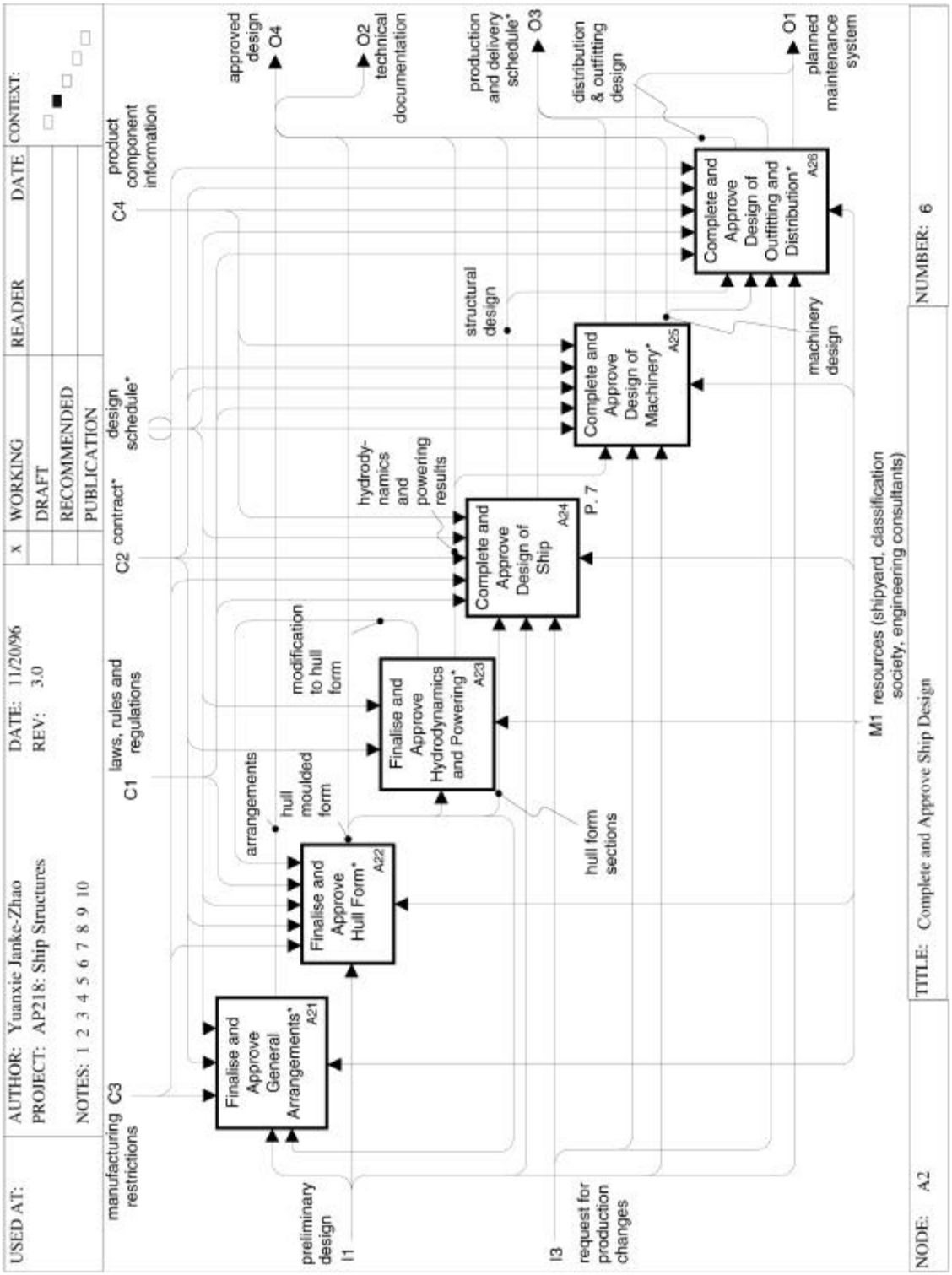

Figure 10: Node A2 - Create and Approve Ship Design

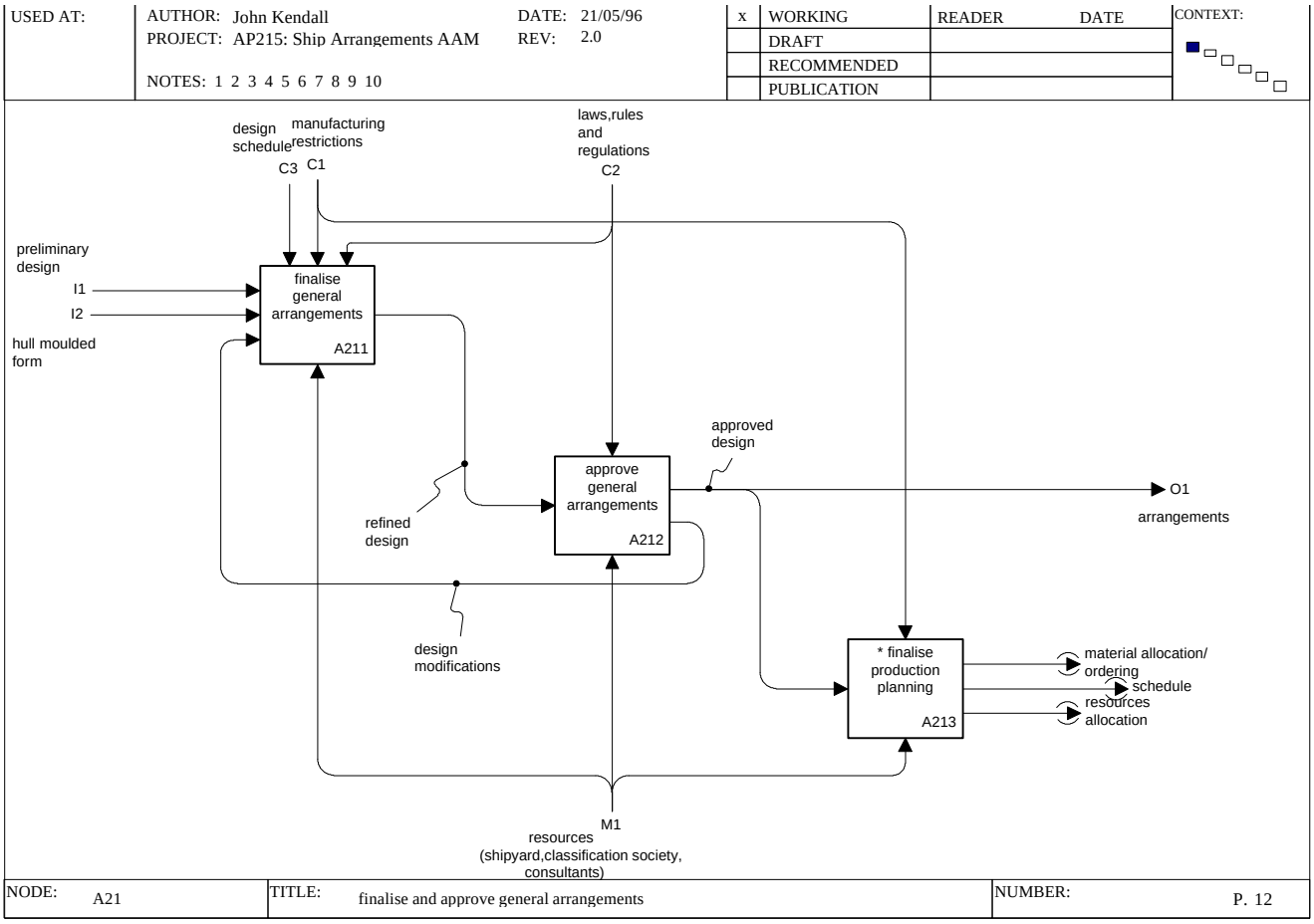

Figure 11: Node A21 - Finalize and Approve General

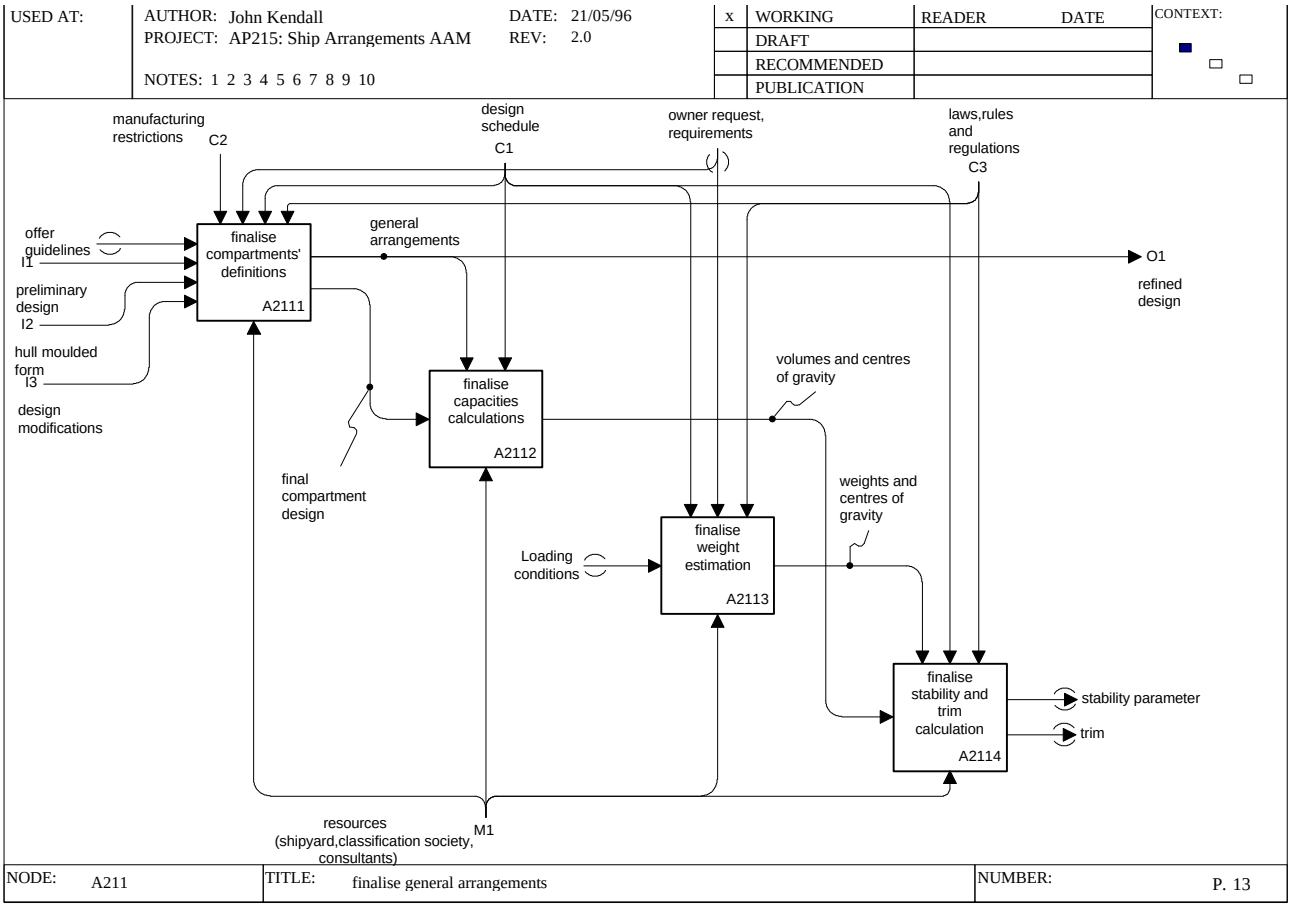

Figure 12: Node A211 - Finalize General Arrangement

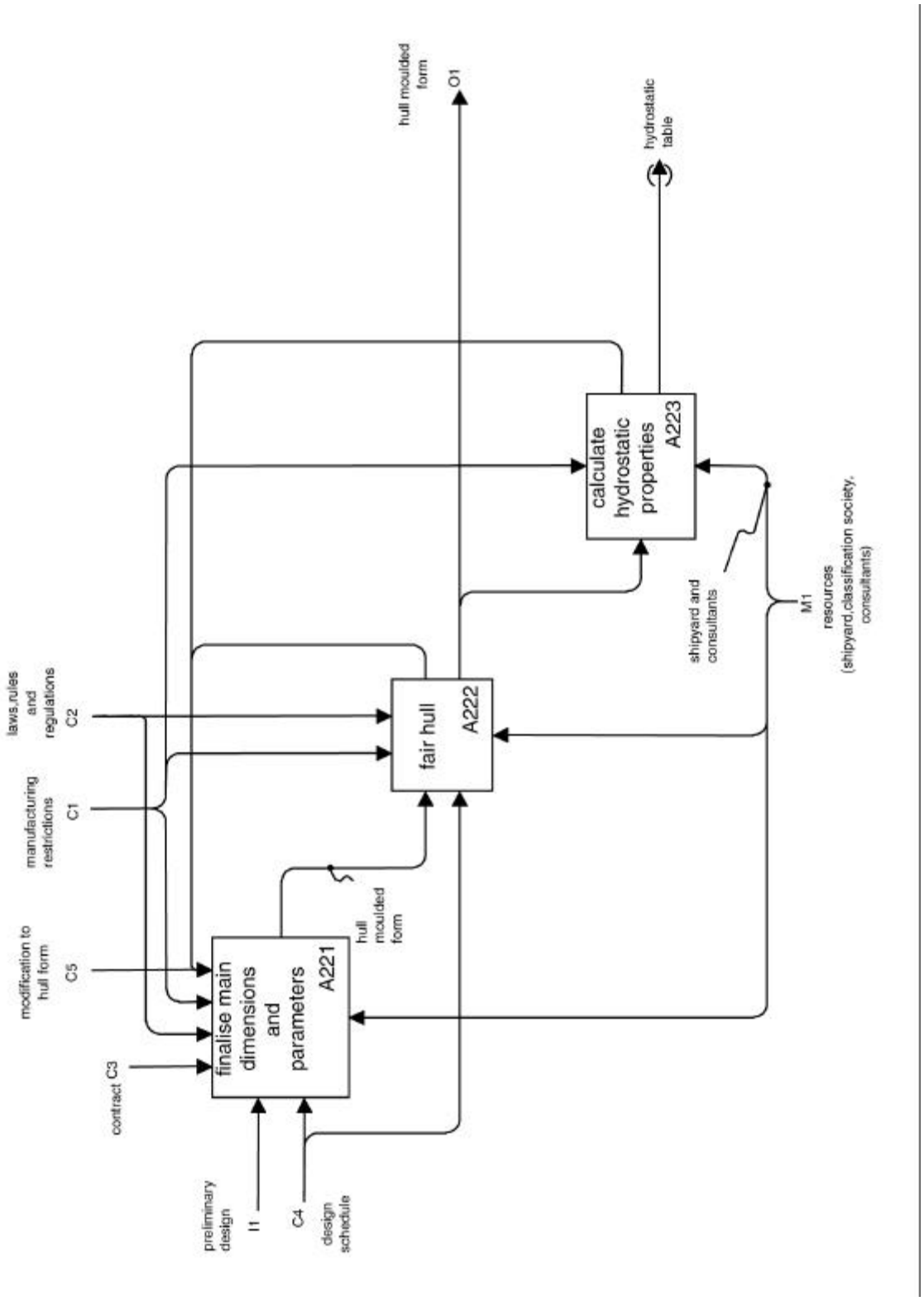

Figure 13: Node A22 - Finalize and Approve Hull Form

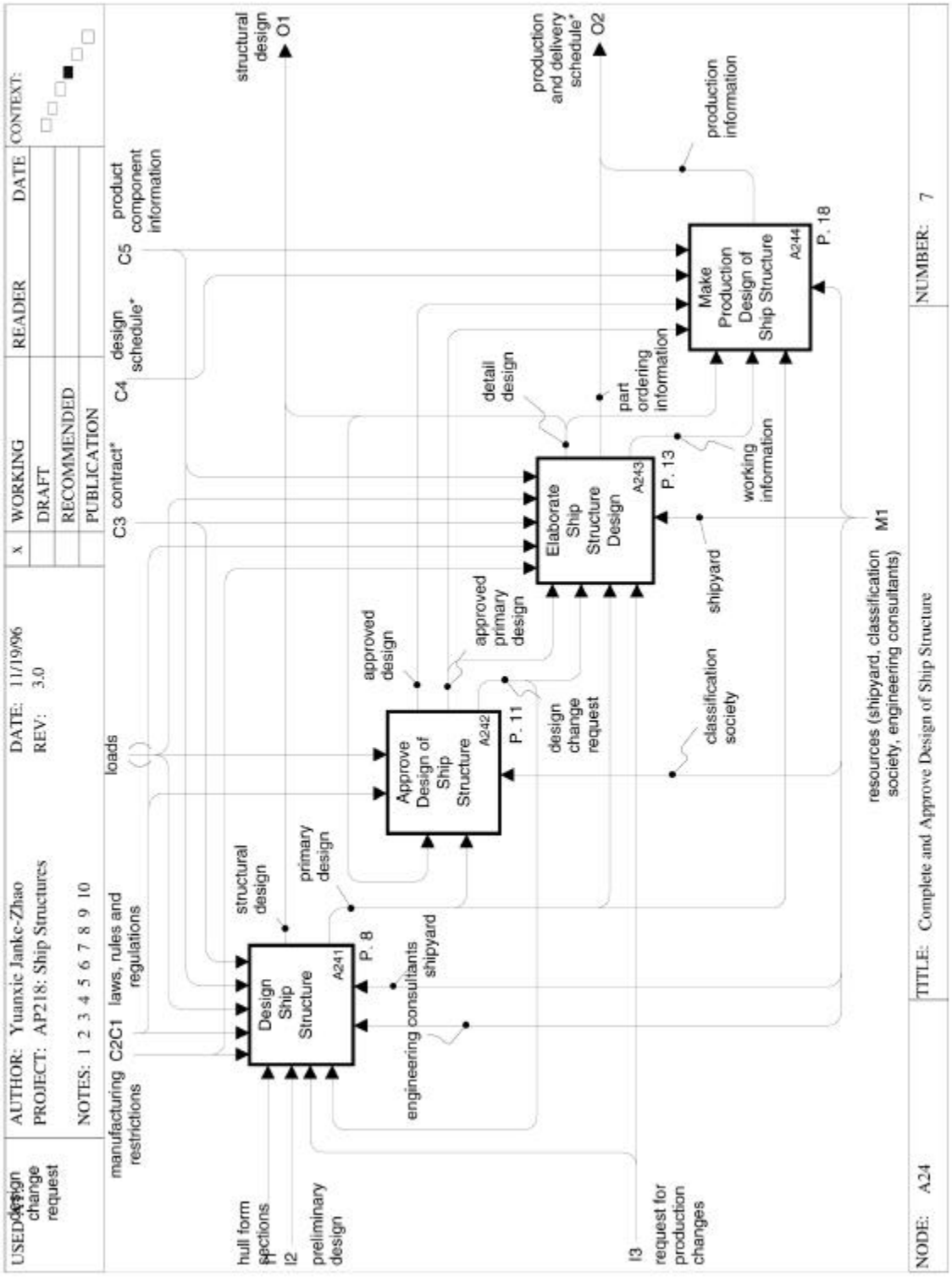

Figure 14: Node A24 - Complete & Approve Design of Ship Structure

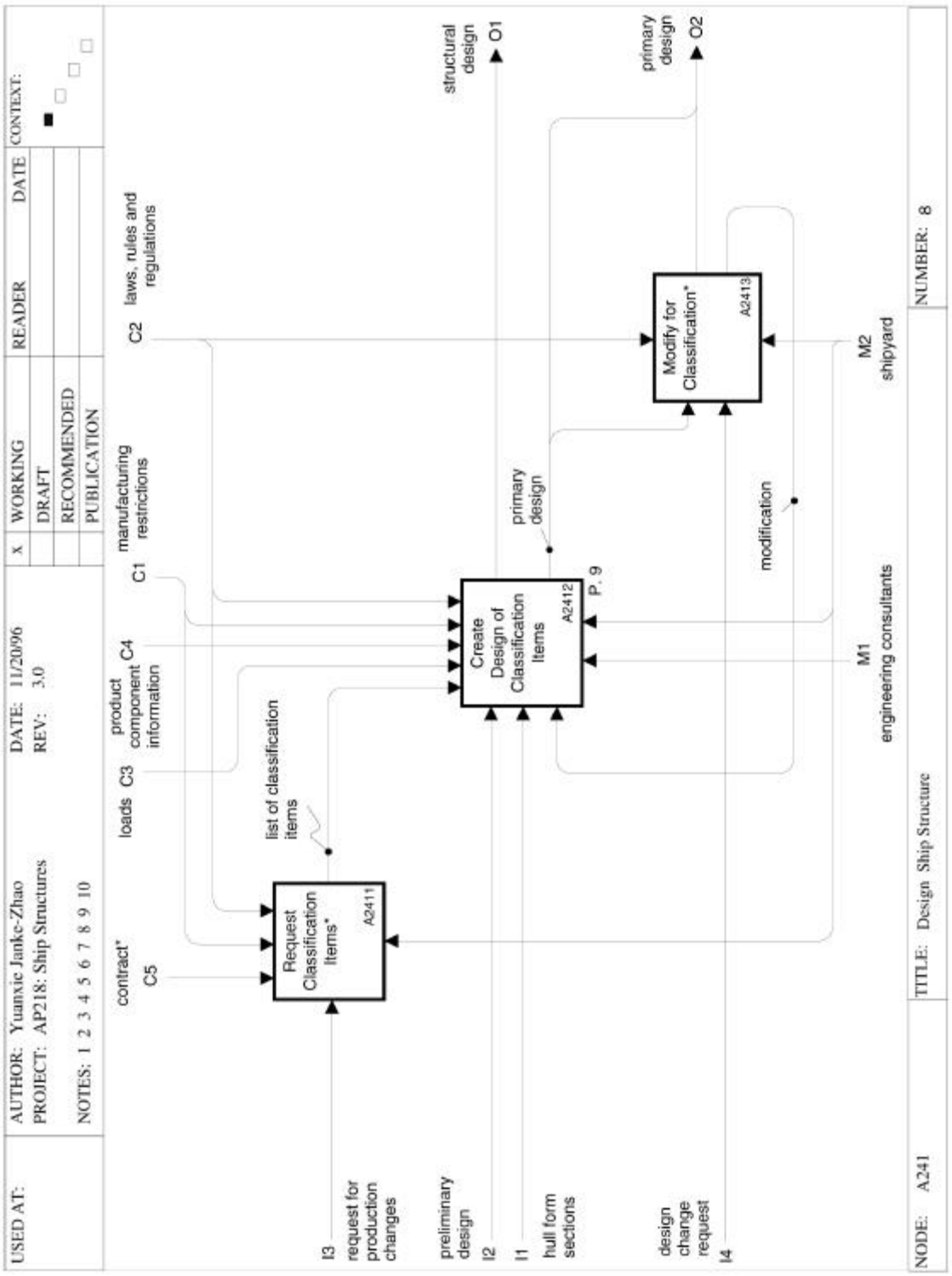

Figure 15: Node A241 - Design Ship Structure

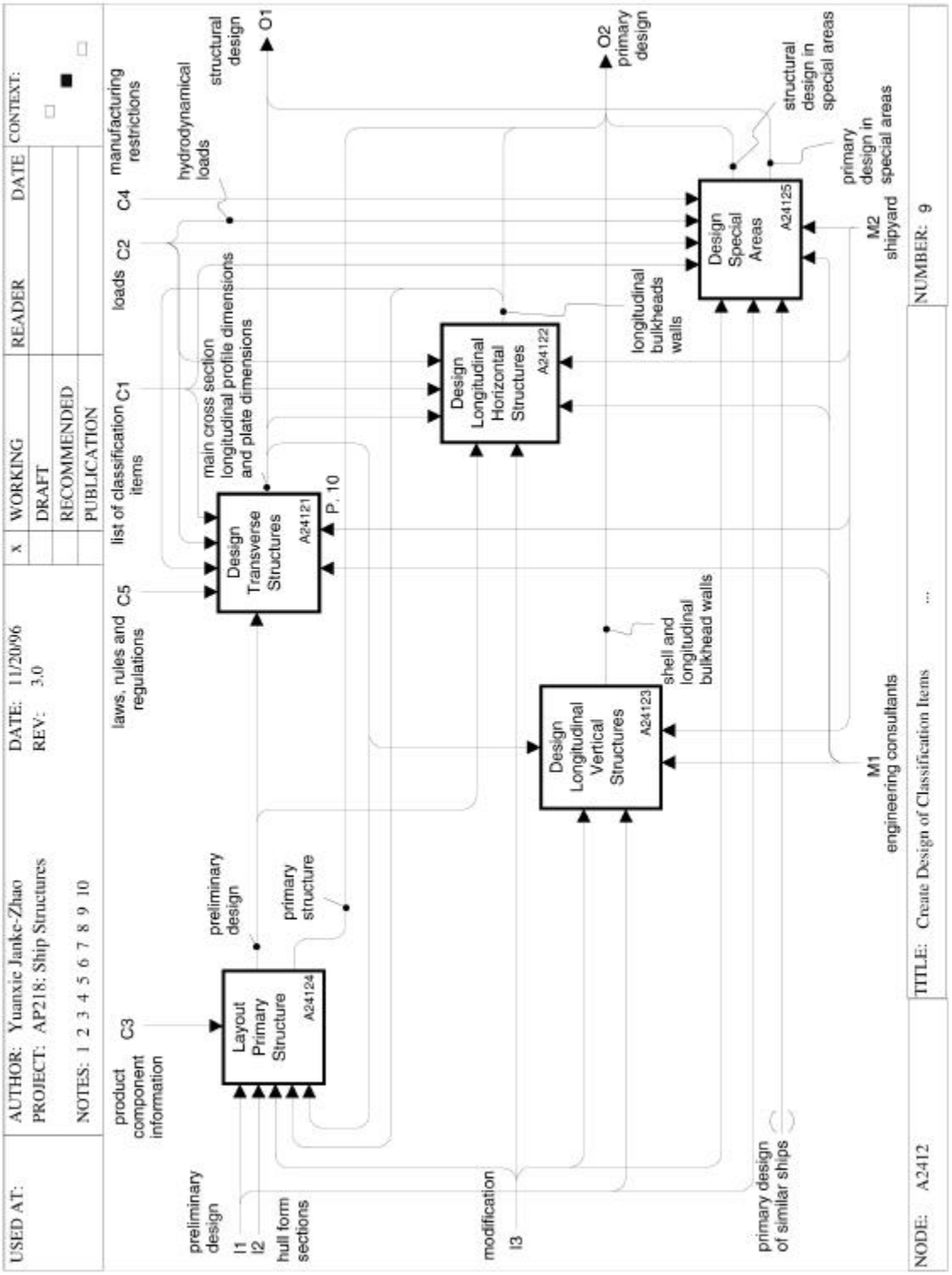

Figure 16: Node A2412 - Create Design of Classification Items

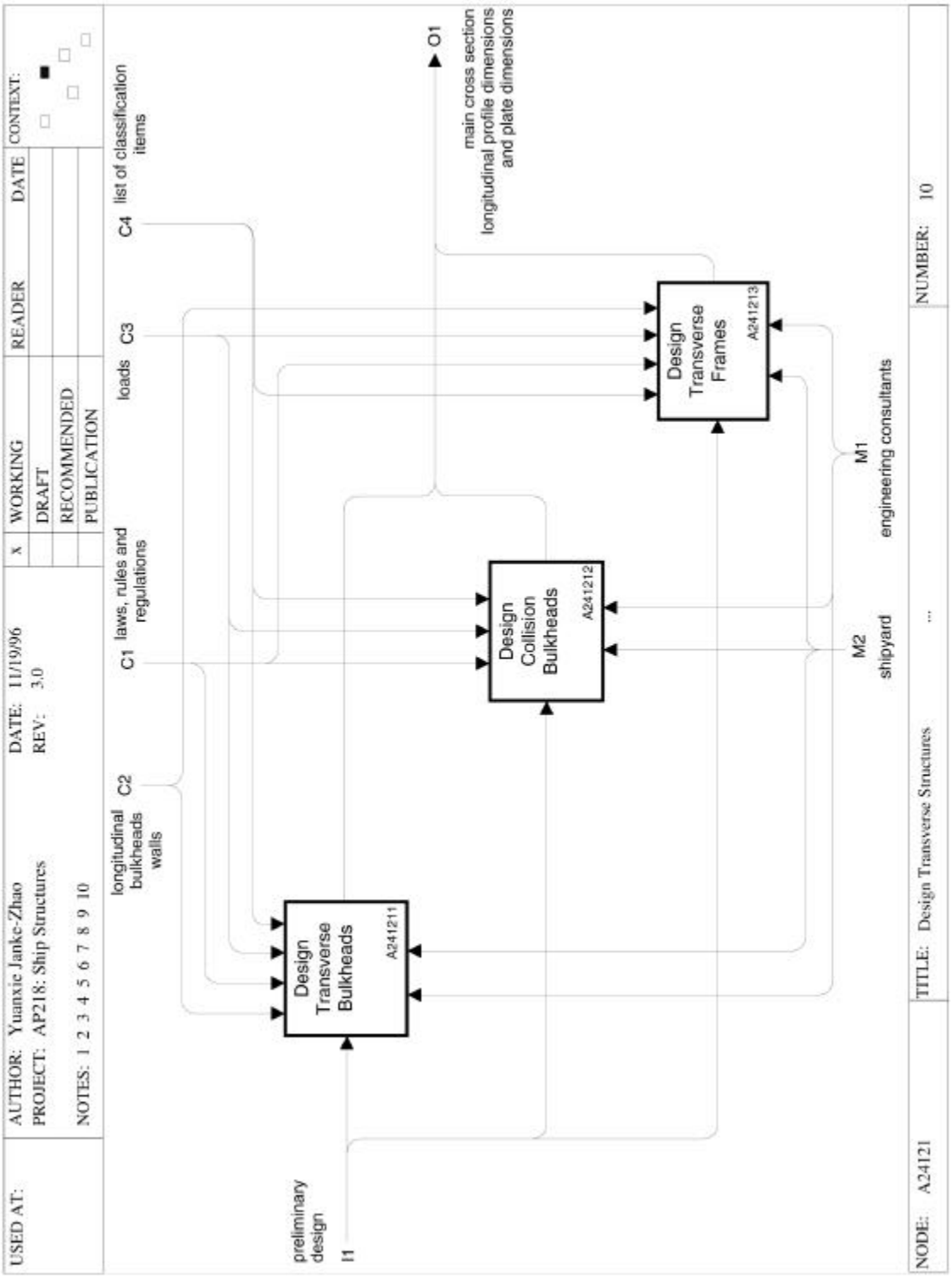

Figure 17: Node A24121 - Design Transverse Structures

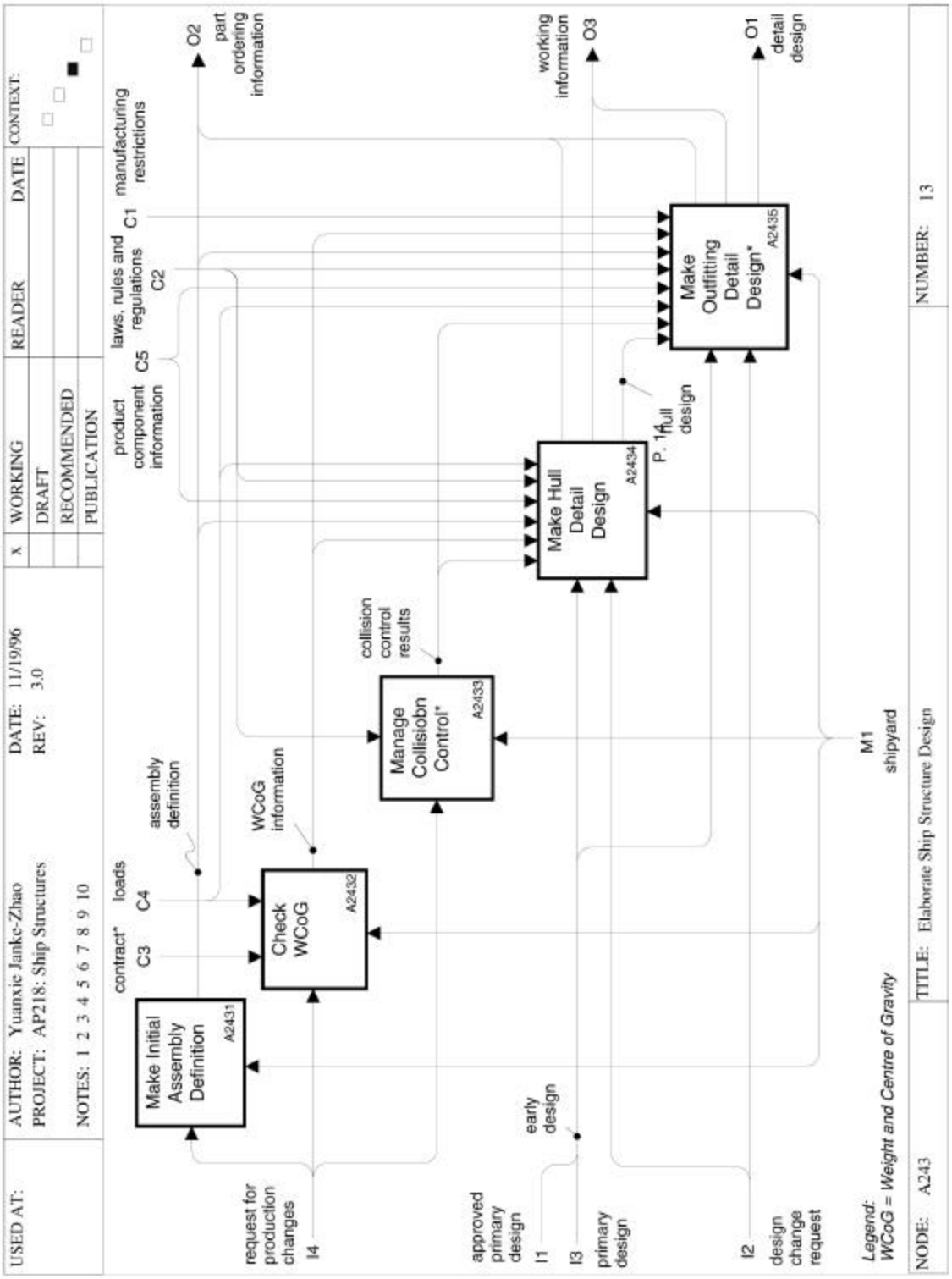

Figure 18: Node A243 – Elaborate Ship Structure Design

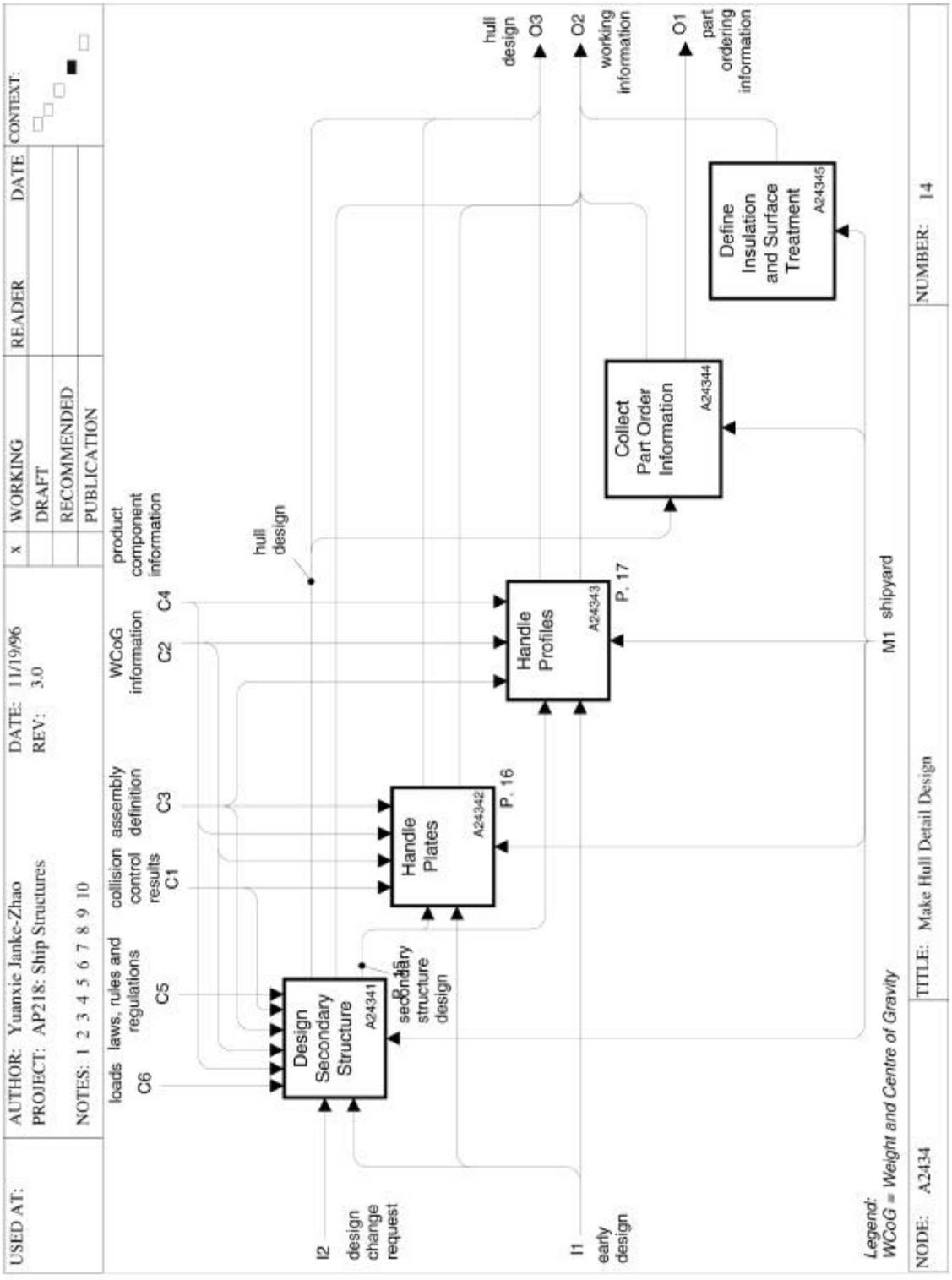

Figure 19: Node A2434 – Make Hull Detail Design

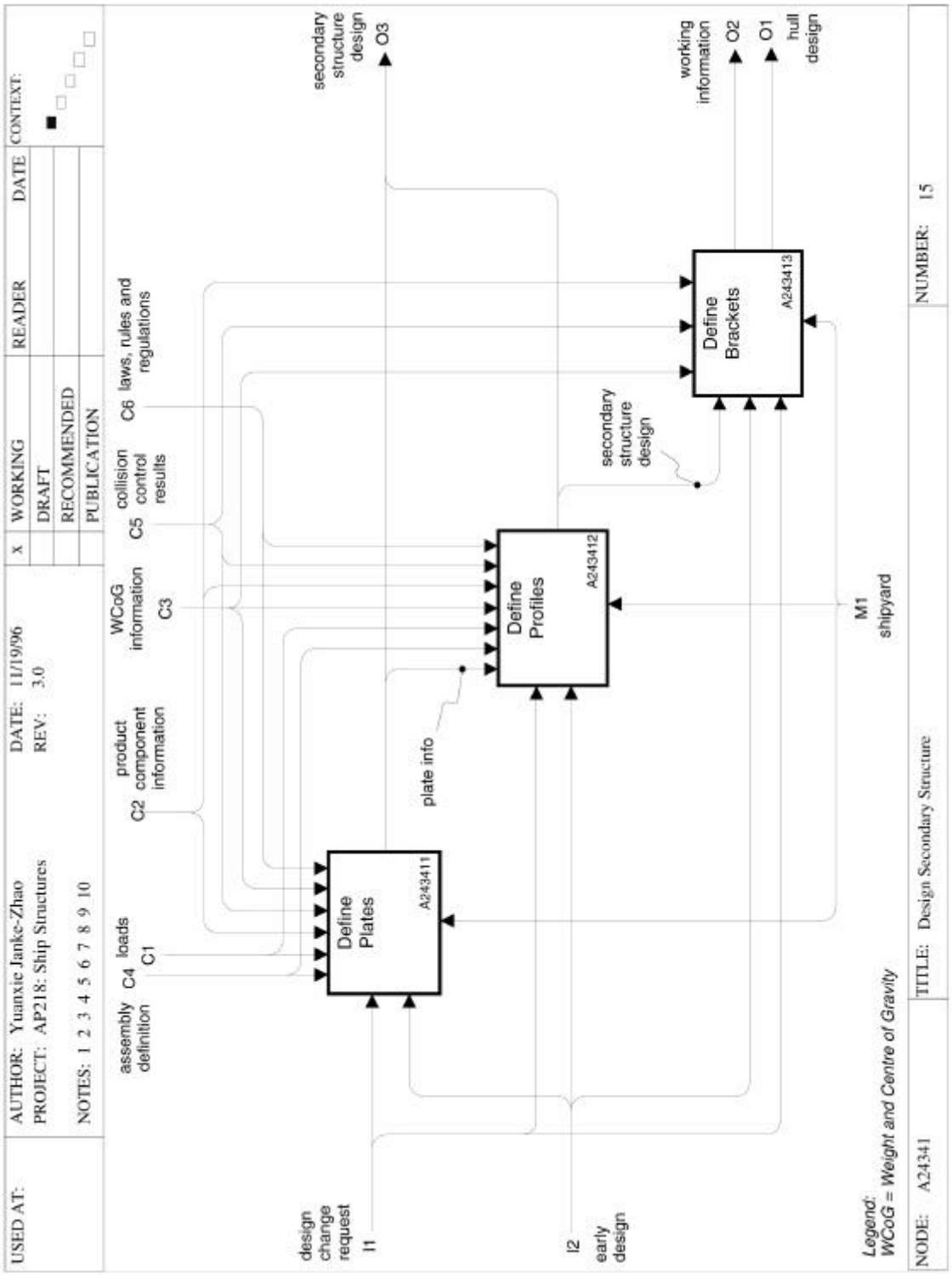

Figure 20: Node A24341 - Design Secondary Structure

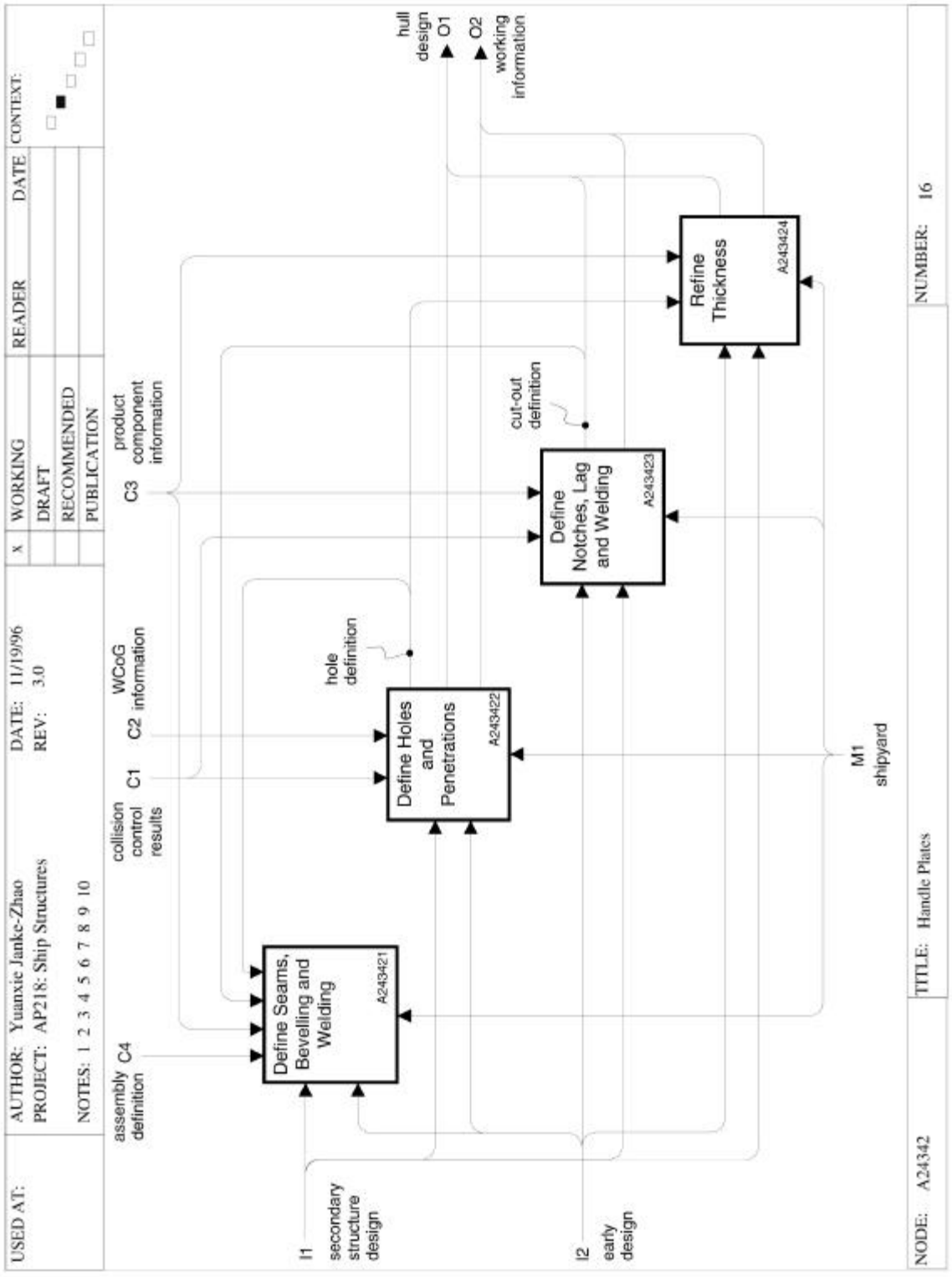

Figure 21: Node A24342 – Handle Plates

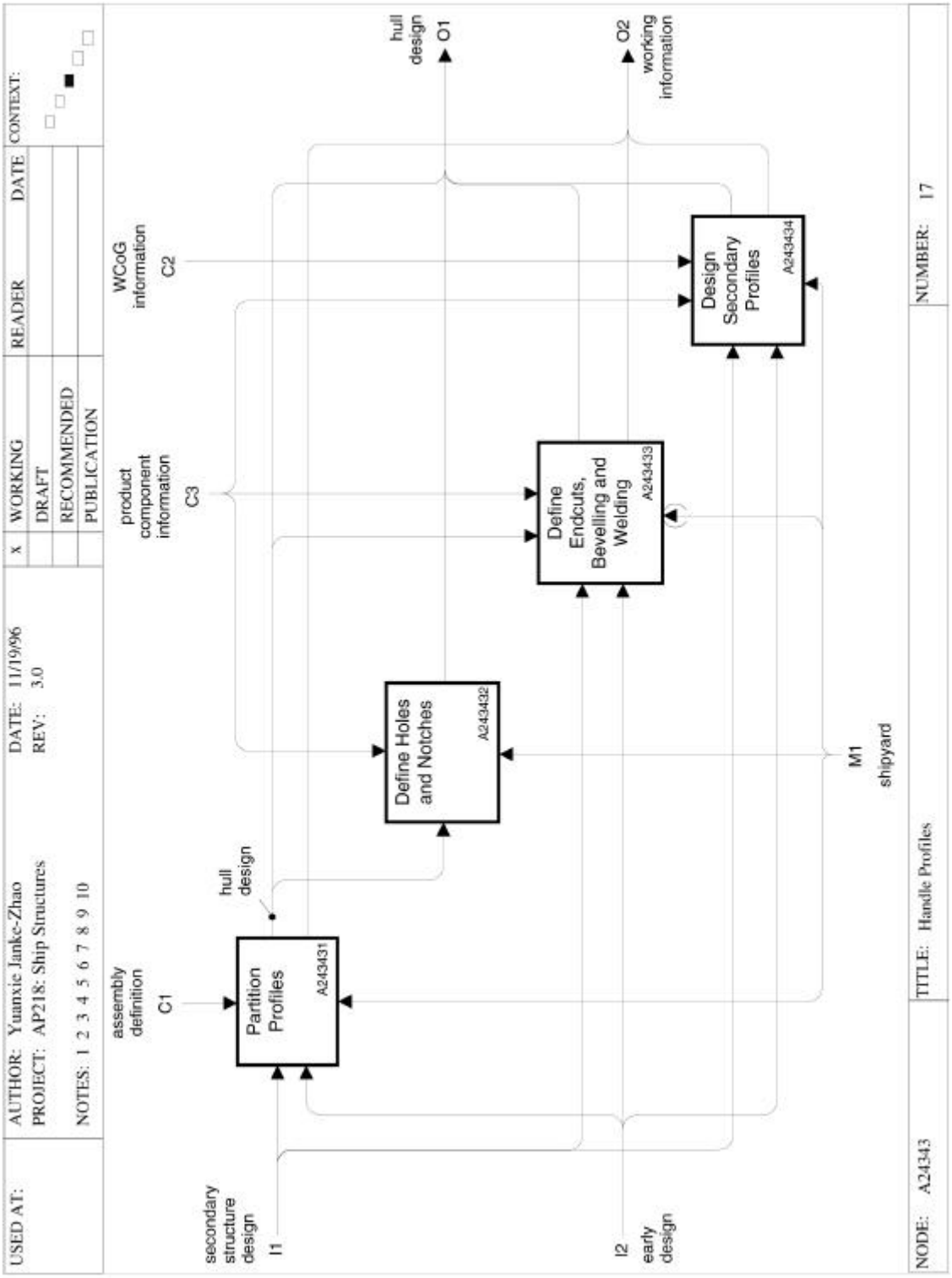

Figure 22: Node A24343 – Handle Profiles

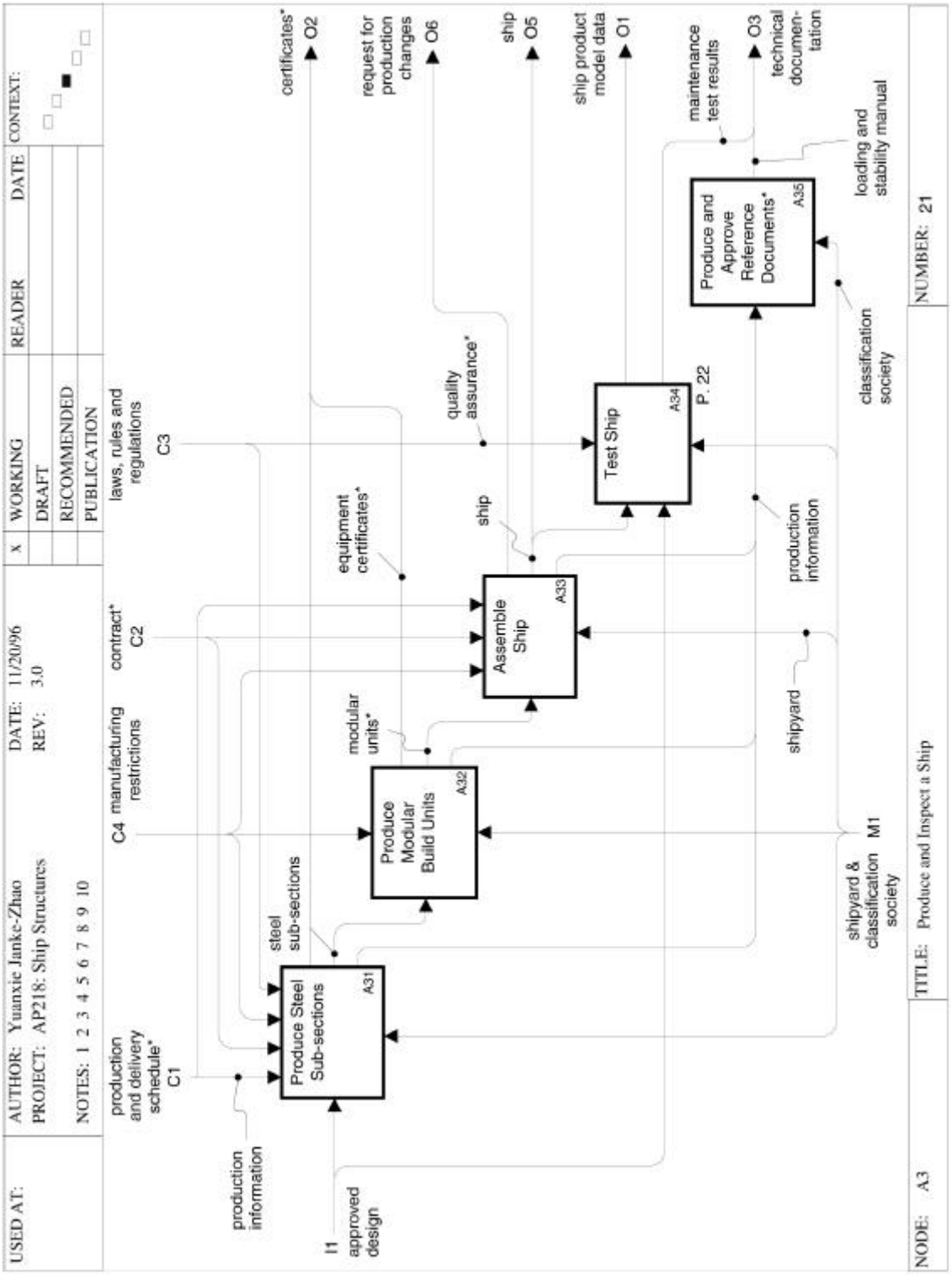

Figure 23: Node A3 – Produce and Inspect a Ship

Table 1-1 NSRP Ship Structures Activities

Node	Name	Figure	Description
A	Ship life cycle	1	Top level activity
A0	Perform Ship life cycle	3	High level activities associated
A1	Specify ship	4	All activities associated with the production of a detailed specification of the ship prior to a contract being placed.
A12	Prepare bid	5	This activity includes all activities of the yard regarding preparation and submission of the offer to the ship owner for the ship to be built.
A122	Create preliminary design	6	All design activities relevant in a very preliminary stage of ship design in consideration of classification rules, national/international demands, shipyard constraints and owner requirements. The aim of this task is to make a shipyard offer.
A1221	Create preliminary hull form	7	The activity that is the first step of designing a ship. Using parent ships main dimensions and form parameters one or more preliminary hull forms will be generated.
A12214	Generate initial hull form definition	8	The activity that is the first step of designing a ship. Using parent ships main dimensions and form parameters one or more preliminary hull forms will be generated.
A1222	Create preliminary general arrangements	9	The activity that produces the preliminary compartmentation plans from the preliminary hull form definition.
A12221	Define compartments		This activity deals with a preliminary establishment of main parameters. Main particulars are length between perpendiculars, breadth, depth, draught, Deadweight, Displacement and block coefficient. Also form parameters will be established like prismatic coefficient, waterline coefficient, midship section coefficient and angle of entrance of waterline.
A2	Complete and approve ship design	10	The production and approval of ship design product data, documents and the classification drawings using the preliminary design from the bid preparation, as well as the required rules and regulations. The result of this activity is the approved design and the production and delivery schedule.

Node	Name	Figure	Description
A21	Finalize and approve general arrangements	11	The activity that details the general arrangement after having created a draft layout. The ship's systems are described by a compartment and access drawing showing the location, the access, and the size of the different compartments.
A211	Finalize general arrangements	12	The activity in which the general arrangements are finalized from the preliminary design.
A22	Finalize and approve hull form	13	The production and approval of ship design product data, documents and the classification drawings using the preliminary design from the bid preparation, as well as the required rules and regulations. The result of this activity is the approved design and the production and delivery schedule.
A221	Finalize main dimensions and parameters		The activity that refines the completion of the main parameters and form parameters.
A222	Fair Hull		The activity that deals with the adjustment of the hull moulded form to correct any surface aberrations.
A24	Complete and approve design of ship structure	14	The completion and approval of the ship structural design.
A241	Design ship structure	15	covering the activities of creating a synthesis of the product specification and transforming them into the physical representation of the product NOTE: In this case the function is understood to contain mainly the activities to satisfy the regulations set up by the classification society.
A2411	Request classification items		collecting the approvable items from the classification society with information about the components and the request for changes NOTE: It produces a list of items that have to be calculated and approved.
A2412	Create design of classification items	16	creating the design of those items required by the classification society EXAMPLE 35: Midship sections, bulkheads, shell profile arrangement and foundations
A24121	Design transverse structures	17	dimensioning the midship section, including plates, shell profiles and shell thickness
A241211	Design transverse bulkheads		design frames between transverse bulkheads NOTE: The frames are the transverse members that make up the riblike part of the skeleton of a ship.

Node	Name	Figure	Description
A241212	Design collision bulkhead		designing the collision bulkhead, specially concerning water resistance and strength in the bow area
A241213	Design transverse frames		design frames between transverse bulkheads NOTE: The frames are the transverse members that make up the riblike part of the skeleton of a ship.
A24122	Design longitudinal, horizontal structures		supporting the design of decks, bottoms and horizontal shell profiles
A24123	Design longitudinal, vertical structures		supporting the design of vertical structural separations such as bulkheads, cofferdams and vertical shell profiles
A24124	Layout preliminary structure		the entry activity for design approval preview and the approval of the primary design
A24125	Design special areas		design areas of the ship not covered by the longitudinal and vertical structure EXAMPLE 36: The engine foundations as well as aft and fore body
A2413	Modify for classification		the function concerned with the items of classification found to be not solved properly according to the rules NOTE: The inputs are the design change requests that are modified to be satisfactory for the technical solution.
A243	Elaborate Ship Structure Design	18	the function giving detailed information to order parts and to manufacture, and giving the physical out-come of the design
A2431	Make initial assembly definition		the first rough division into assemblies NOTE: This is further developed during production design.
A2433	Manage collision control		checking the design for clutches NOTE: The clutches are both hard and soft, between different design parts, such as pipes, equipment items and cable trays.
A2434	Make hull detail design	19	covering the design and realization of the steel structure by the use of plates and as stiffening element the profiles NOTE: Therefore in a first step the secondary structure is defined. Finally the structure is coated and in compartmentalization areas insulation is

Node	Name	Figure	Description
			necessary to be designed.
A24341	Design secondary structure	20	designing structure details not defined in early design
A243411	Design plates		setting the layout of individual plates according to the structural hull design
A243412	Define profiles		setting the position of the profiles according to the structural hull and related design
A243413	Define brackets		add brackets to early and secondary designs
A24342	Handle plates	21	splitting plate parts and add production information
A243421	Define seams, beveling and welding		defining the designed features of structured parts for the welding of plates
A243422	Define holes and penetrations		defining the holes and penetrations according to the other functions of the system that has the connected throughputs
A243423	Define notches, lag and welding		all design activities which are meant to support the welding process
A243424	Refine thickness		refining material strength of the plates NOTE: They are found and fixed as working information for the hull design.
A24343	Handle profiles	22	partition profiles, add production information and design additional and secondary profiles
A243431	Partition profiles		defining the resulting length of plate related stiffeners
A243432	Define holes and notches		all design activities which are meant to support the welding process
A243433	Define endcuts, beveling and welding		fixing the dependent holes and notches in their position when defining the profiles in their length and position
A243434	Design secondary profiles		selecting the detailed length of the individual profiles and their size and cross-section
A24344	Collect part order information		collecting part ordering information to be used in management information systems (MIS) and estimations
A24345	Define insulation and surface treatment		defining the insulation and surface treatment definitions to be used depending on location of structure and functional requirements
A2435	Make outfitting detail design		develop further the outfitting design made at early stages, and design all systems and functionality's not done in early design

Node	Name	Figure	Description
A3	Produce and inspect ship	23	high-level activities such as produce, monitor and inspect ship production. NOTE: Inspect, means the controlling of all activities throughout the whole production life cycle of a ship.
A31	Produce steel sub-sections		producing of the steel sub-sections that make up the structure of the completed ship. NOTE: This is controlled by the schedule, contract, the approved design, and any manufacturing restrictions.
A32	Produce modular build units		producing the modular units which will make up the completed ship NOTE: They are produced from the steel-subsections and their production is controlled by the schedule, contract, the approved design, and any manufacturing restrictions. The results of the activity are the modular units which are assembled into the ship.
A33	Assemble ship		the production stage that assembles the modular units, the serviced parts and additional material which result from the production of a steel sub-section NOTE: The result is an assembled ship that still has to be tested.

5. Implementation Agreements

This section defines the implementation agreements to be followed when exchanging data using the NSRP Ship Structures schemas. The agreements for the NSRP Ship Structures - Arrangements (Annex A) and NSRP Ship Structures - Moulded Forms (Annex B) schemas were identified by the DARPA MARITECH MariSTEP implementation project and are documented in Sections 5.2 and 5.3. The agreements for the NSRP Ship Structures - Structure (Annex C) were identified by the MariSTEP and/or the EMSA Seasprite implementation projects and are documented in Section 5.4.

In general, implementation agreements were found to be needed due to the following:

1) APs ARM was found insufficient to support the requirements for a production environment exchange

2) Modifications to the APs data model would facilitate future implementations

3) Text definitions for the AP entities and attributes were unclear or subject to multiple interpretations.

5.1 Agreements Common to the NSRP Ship Structures Schemas: Arrangements (Annex A), Moulded Forms (Annex B), and Structure (Annex C)

This section defines the usage rules that are common to each of the implementations of the NSRP Ship Structures schemas (Arrangements - Annex A, Moulded Forms - B, and Structure - C).

5.1.1 Optional Attributes

The preprocessor and postprocessor can ignore all optional attributes unless one or more of the following is true. If either of these conditions is true, the attribute must be treated as if it were a “non-optional” (required) attribute.

— The attribute is explicitly stated as required by the agreements in this NSRP document.
— The attribute, attr, is used in a rule (global or domain) which is satisfied only if EXISTS(attr) is TRUE.

5.1.2 Indeterminate Values

If an attribute value is indeterminate (unknown) and is required to produce a valid model, a default value agreed upon by the exchanging parties may be use. An example of such an agreement can be found in Section 5.2.3.

5.1.3 Parts Library

Library parts shall be pre-defined by the exchanging parties. Each shipbuilding environment involved in the exchange will model these library parts in their native environment and provide a mechanism to map the library parts transferred in the STEP exchange to the appropriate library part in the native system.

5.1.4 Part 21 File Header

A Part 21 file shall be created with the following information in the file HEADER section. This level of detail may be used on import to facilitate document / file management and to invoke the appropriate translator software.

5.1.4.1 file_description
The attributes of the file_description entity shall be encoded as described below

5.1.4.1.1 description
A description of the contents of the Part 21 file, e.g. an exchange identifier and/or a dataset identifier.

5.1.4.1.2 implementation_level
An implementation level identifier will denote the ISO Part 21 conformance class adhered to by this exchange. The value shall always be '2; 1'

5.1.4.1.3 file_name
The attributes of the file_name entity shall be encoded as described below.

5.1.4.1.3.1 name
The name shall be the physical name of the file produced by the preprocessor.

5.1.4.1.3.2 time_stamp
The time_stamp shall be the Greenwich Mean Time (GMT) date and time specifying when the exchange structure was created. The string shall correspond to the extended format for the complete calendar date as specified in 5.2.1.1 of ISO 8601 concatenated to the extended format for the time of the day as specified in 5.3.1 of ISO 8601. The letter 'T' shall separate the date and time. The year shall be the full year (four digits).

5.1.4.1.3.3 author
The author shall be the name of person who created or is responsible for creating the Part 21 file.

5.1.4.1.3.4 organization
The member organization shall be the name and mailing address of the organization with which the author is associated.

5.1.4.1.3.5 preprocessor_version
The preprocessor_version shall be the name and version of the translator used to create the exchange structure.

5.1.4.1.3.6 originating_system
The originating_system shall be the system and system version that generated the Part 21 file.

5.1.4.1.3.7 authorization
The authorization shall be the group who authorized the sending of the exchange structure.

5.1.4.1.4 file_schema
The attributes of the file_schema entity shall be encoded as described below

5.1.4.1.4.1 schema_identifiers
The schema_identifiers shall specify the NSRP Ship Structures schema used to generate the Part 21 file and shall consist of the schema name and an object identifier.

1) Schema Name

The schema name shall be the name, in capital letters, of the appropriate NSRP Ship Structures schema as specified below :

— AP215_MARISTEP (for the NSRP arrangements schema)
— AP216_MARISTEP (for the NSRP moulded forms schema)
— HARMONIZED_STRUCTURES_MODEL_V1 (for the NSRP structures schema)

2) Object Identifier

The object identifier shall specify a unique identifier for the schema using a format similar to that defined by ISO 10303 1. Note that this object identifier is normally found in the information object registration annex of an ISO part or AP document. The identifier shall be a concatenation of the following information:

— "NSRP"
— AP number
— schema version
— long or short name schema indicator (1 = long name, 2 = short name). The value shall always be "1".
— NSRP AP conformance class.

5.1.4.1.5 Example Part 21 File Header

```
ISO-10303-21;
HEADER;
 FILE_DESCRIPTION (
 /* description */ ('MariSTEP Test 1A',
                    '5.2.3 Oil Tank'),
 /* imp_level */  '2;1');

 FILE_NAME (
 /* name */      'oil_tank.stp',
 /* timestamp */ '1997-12-15T14:18:59',
 /* author */   ('John Doe'),
 /* org */      ('Intergraph',
                'Huntsville, AL  35894-0001'),
 /* preproc_ver */   'MSTEP v1.0.0',
 /* orig_system */   'I/VDS v2.4.1',
 /* authorization */ 'MariSTEP');

 FILE_SCHEMA (
 /* schema_identifier */('AP215_MARISTEP'));
ENDSEC;
DATA;
```

5.1.5 Common - Exchange Content

This section defines the agreements made for the exchange content of NSRP Ship Structures data using the schemas defined in Annex A (Arrangements), Annex B (Moulded Forms), and Annex C (Structures).

5.1.5.1 Complete Exchange

For every NSRP Ship Structures exchange, each instantiated subtype of item must have at least one instantiated subtype of definition, and each instantiated subtype of design_definition must have a non-empty set of representations.

5.1.5.2 Geometrical Tolerance

Each NSRP Ship Structures exchange shall include one instance of the Tolerance entity. Where possible, the tolerance value in this entity will be used to reconstruct the geometry model in the receiving system.

5.1.5.3 Ship

Every NSRP Ship Structures exchange shall contain one instance the Ship entity.

5.1.5.4 General_Characteristics_Definition

5.1.5.4.1 Global_Axis_Placement

Every NSRP Ship Structures exchange shall contain one instance the Global_Axis_Placement entity to represent the single ship coordinate system. This coordinate system shall be located with the origin at the aft perpendicular, on the baseline, on the centerline, with zero offset, and x positive pointing forward, y positive to port, and z positive pointing upward.

5.1.5.4.2 Principal_Characteristics

The Principal_Characteristics entity shall not be required for NSRP Ship Structures exchanges. If the information contained by this entity is required by the receiving system, the receiving system must allow the information to be input from other sources.

5.1.6 Common - Unused Attributes

The following NSRP Ship Structures schema attributes can be ignored by the postprocessor and need not be stored by the receiving software system. The preprocessor must generate attribute values for mandatory attributes.

- definable_object.id
- definition.local_units

5.1.7 Common Unused GUIDs

The Globally Unambiguous IDentifiers (GUID) for the following definition subtypes can be ignored by the postprocessor and need not be stored by the receiving software system. The preprocessor must assign GUIDs for these entities which are unique in the exchange file. These entities are not configuration managed, but are used only for the purposes of exchange.

STEP ENTITY	COMMENTS
Miscellaneous	
Design Requirement	

5.1.8 Common - Optional/Empty Attributes Required for Exchange

This section defines the NSRP Ship Structures schema attributes that, in the schema, are either declared as optional or can be an empty, but which are required to be present and non-empty.

STEP ENTITY	ATTRIBUTE	COMMENT
Item subtypes	name	Cannot be an empty string
Spacing_Position	name	OPTIONAL in schema but is required in data exchange

5.1.9 Common - Restrictions

This section defines the schema restrictions to NSRP Ship Structures data exchanges.

5.1.9.1 Restrictions on Select Type Values

The following select type values will not be used:

— (None)

5.1.9.2 Restrictions on Enumerated Type Values

The following enumerated type values will not be used:

— (None)

5.1.10 Common - Attribute Precedence

This section defines the order of attribute precedence for entities common to multiple MariSTEP APs which have been applied for the MariSTEP implementation:

— (None)

5.1.11 Common - Attribute Interpretations

This section defines the attribute interpretations that will be followed when exchanging data using the NSRP Ship Structures schemas.

5.1.11.1 Attribute Interpretations by Entity

This section list specific attribute interpretations by entity which are common to the NSRP Ship Structures schemas.

STEP ENTITY	ATTRIBUTE	COMMENT
Miscellaneous		
Axis2_Placement_3d	axis ref_direction	OPTIONAL in schema but is required in NSRP exchange
Face_Based_Surface_Model	name, fbsm_faces	Surfaces which are used to define the faces of a shell for a non-manifold_surface_representation should set the attribute name inherited from representation to a meaningful, non-empty name. borders in the list determines the orientation of the panel_system using the right hand rule.
Global_Axis_Placement	orientation aft_perpendicular_offset	= forward pointing = 0
Item subtypes	name	Cannot be an empty string

5.2 Arrangements Agreements

This section defines the usage rules that are specific to the NSRP Ship Structures - Arrangements (Annex A) schema data exchange.

5.2.1 Arrangements - Exchange Content

This section defines the agreements made for the exchange content of for NSRP Ship Structures - Arrangements (Annex A) schema exchange files.

5.2.1.1 Compartment Definition Relationships

If related compartment_functional_definition and compartment_design_definition entities exist, the compartment_design_to_functional_definition_relationship entity must also exist. If related compartment_property_set and compartment_design_definition entities exists, the compartment_property_to_design_definition_relationship entity must also exist.

5.2.1.2 Compartment Definitions

The entity compartment_design_definition may be exchanged by itself. However, if the compartment_functional_definition and / or the compartment_property_set entities are exchanged, the related compartment_design_definition must also be exchanged.

5.2.1.3 Compartment Functional Use

A compartment shall have only one functional use. For each Compartment_Design_Definition there shall be only one Compartment_Functional_Definition. These definitions are related through one Compartment_Design_to_Functional_Definition_Relationship entity.

5.2.1.4 Definition_Relationship

A Definition_Relationship entity shall be instantiated to express the relationship between zone_design_definition and zone_functional_definition. Definition_Relationship.definition_1 will represent the zone_design_definition and Definition_Relationship.definition_2 will represent the zone_functional_definition.

5.2.1.5 Compartment Geometry

Each Compartment_Design_Definition will point to one representation of type Non_Manifold_Surface_Shape_Representation. Furthermore, the set Non_Manifold_Surface_Shape_Representation.items will contain exactly one Face_Based_Surface_Model whose attribute fbsm_faces will point to one or more Closed_Shells.

5.2.1.6 Zone Geometry

A Zone_Design_Definition will point to a single Non_Manifold_Surface_Shape_Representation that may have multiple Face_Based_Surface_Models that may have multiple Closed_Shells

5.2.2 Arrangements - Unused Attributes

The following NSRP Ship Structures - Arrangements (Annex A) schema attributes can be ignored by the postprocessor and need not be stored by the receiving software system. The preprocessor must generate attribute values for mandatory attributes.

NOTE: For calculated attributes: If calculated by the system, the preprocessor should write the calculated value(s) to the Part 21 file, otherwise the values should be set to zero for real or integer values, (0,0,0) for cartesian point values, and for capacity_properties.capacity_context, set the value to Percent_100_Capacity.

STEP ENTITY	ATTRIBUTE	COMMENT
Attributes Calculated by Receiving System		
capacity_properties	capacity_center capacity_context capacity_level_origin capacity_heel_angle capacity_level capacity_trim_angle capacity_volume	
compartment_areas	horizontal_cross_sectional_area stiffened_surface_area unstiffened_surface_area vertical_longitudinal_cross_sectional_area vertical_transverse_cross_sectional_area	
compartment_volume	centre_of_volume volume	
general_compartment_property_set	permeability	
moments_of_inertia	long_moment_of_inertia trans_moment_of_inertia vert_moment_of_inertia	Schema problem
Other		
definition subtypes	local_units	Use ship global units

5.2.3 Arrangements - Unused GUIDs

The Globally Unambiguous IDentifiers (GUID) for the following definition subtypes can be ignored by the postprocessor and need not be stored by the receiving software system. The preprocessor must assign GUIDs for these entities which are unique in the exchange file. These entities are not configuration managed, but are used only for the purposes of exchange.

STEP ENTITY	COMMENTS
Compartment Functional Definitions	
Compartment_Functional_Definition	
Cargo_Compartment_Functional_Definition	
HabitableCompartment_Functional_Definition	
Machinery_Compartment_Functional_Definition	
Tank_Compartment_Functional_Definition	
Void_Compartment_Functional_Definition	
Compartment Property Sets	
Compartment_Property_Set	
General_Compartment_Property_Set	
Compartment_Naval_Administrative_Property_Set	
Cargo_Compartment_Property_Set	
Tank_Compartment_Property_Set	
Habitable_Compartment_Property_Set	

STEP ENTITY	COMMENTS
Zone Functional Definition	
Zone_Functional_Definition	
Other Definition Subtypes	
Space_Product_Structure_Definition	
Design_Requirement	

5.2.4 Arrangements - Optional/ Empty Attributes Required for Exchange

This section defines the NSRP Ship Structures - (Annex A) schema attributes that, in the schema, are either declared as optional or can be an empty, but which are required to be present and non-empty.

STEP ENTITY	ATTRIBUTE	COMMENT
Panel_System		
Compartment_Design_Defintion	boundaries	Must form a closed volume
Miscellaneous		
Global_Id	company_id local_id	• Cannot be an empty string • Cannot be an empty string

5.2.5 Arrangements - Restrictions

This section defines the schema restrictions specific to NSRP Ship Structures - Arrangements (Annex A) schema data exchanges.

5.2.5.1 Restrictions on Select Type Values

The following select type values will not be used:

— (None)

5.2.5.2 Restrictions on Enumerated Type Values

The following enumerated type values will not be used:

— (None)

5.2.6 Arrangements - Attribute Precedence

This section defines the order of attribute precedence for entity / attributes specific to NSRP Ship Structures - Arrangements schema data exchanges. If the primary attributes are populated, the information in those attributes will take precedence over the secondary attributes.

— (None)

5.2.7 Arrangements - Attribute Interpretation

This section defines the attribute interpretations that will be followed when exchanging data using the NSRP Ship Structures - Arrangements schema data exchange

5.2.7.1 Arrangements - Attribute Interpretation by Entity

This section list specific attribute interpretations by entity.

STEP ENTITY	ATTRIBUTE	COMMENT
Miscellaneous		
Non_Structural_Moulded_Form_Design_Definition	defined_for	-> Ship

5.2.7.2 Ship Units

The attribute ship.units shall be the instantiated as follows:

AP 215

Measure	Unit Name / Dimensions	STEP Entity
length	meters	Length_unit+Si_Unit name = Metre
plane angle	radians	Plane_Angle_Unit+Si_Unit name = Radian
area	meters**2	Area_Unit+Si_Unit name = Metre
volume	meters**3	Si_Unit + Volume_Unit name = Metre
density	kilograms per meters**3	*Requires four new STEP entities:* 1) Derived_Unit elements = Set of Derived_Unit_Elements for mass & volume (*mass)* 2) Derived_Unit_Element unit → SI_Unit *(below)* exponent = 1 3) Si_Unit prefix = kilo name = gram (*volume)* 4) Derived_Unit_Element unit → SI_Unit+Volume_Unit *(use above volume STEP entity)* exponent = -1
area moment of inertia	meters**4	*Requires two new STEP entities:* 1) Derived_Unit elements = Set of one Derived_Unit_Element for area moment_of_inertia 2) Derived_Unit_Element unit → Length_Unit+SI_Unit *(use above length STEP entity)* exponent = 4
luminous intensity	lux	Si_Unit name = Lux

5.2.8 Arrangements - Entity Role In the Exchange

This section contains, in tabular format, additional information regarding entity and how it is to be used within the data exchange file.

STEP ENTITY	Use
Spacing_Position	
Spacing_Position	Used as positions in spacing_table
Longitudinal_Position	Used to define longitudinal positions relative to spacing_positions.
Transverse_Position	Used to define transverse positions relative to spacing_positions.
Vertical_Position	Used to define vertical positions relative to spacing_positions.

5.3 Moulded Forms Agreements

This section defines the schema restrictions specific to the NSRP Ship Structures - Moulded Forms (Annex B) schema data exchange.

5.3.1 Moulded Forms - Exchange Content

This section defines the agreements made for the exchange content of for NSRP Ship Structures - Moulded Forms (Annex B) schema exchange files.

5.3.1.1 Moulded Form - Geometry

Each moulded_form_design_definition must have exactly one representation of type Non-Manifold_Surface_Shape_Representation. Furthermore, the set Non_Manifold_Surface_Shape_Representation items shall contain exactly one Face_Based_Surface_Model.

5.3.1.2 Ship_Curve

For every curve reference by ship_curve.curve_shape, a shape_representation shall exist such that the set shape_representation.items contains the curve.Moulded Forms - Unused Attributes
The following NSRP Ship Structures - Moulded Forms (Annex B) schema attributes can be ignored by the postprocessor and need not be stored by the receiving software system. The preprocessor must generate attribute values for mandatory attributes.

— None

5.3.2 Moulded Forms - Unused GUIDs

The GUIDs for the following definition subtypes can be ignored by the postprocessor and need not be stored by receiving software system. The preprocessor must assign GUIDs for these entities which are unique in the exchange file. These entities are not configuration managed, but are used only for the purposes of exchange.

— None

5.3.3 Moulded Forms - Optional/Empty Attributes Required for Exchange

This section defines the NSRP Ship Structures - Moulded Forms (Annex B) schema attributes that, in the schema, are either declared as optional or can be an empty, but which are required to be present and non-empty.

STEP ENTITY	ATTRIBUTE	COMMENT
Miscellaneous		
Global_Id	company_id local_id	• Cannot be an empty string • Cannot be an empty string

5.3.4 Moulded Forms - Restrictions

This section defines the schema restrictions specific to NSRP Ship Structures - Moulded Forms (Annex B) schema data exchanges.

5.3.4.1 Restrictions on Select Type Values

The following select type values will not be used:

— None

5.3.4.2 Restrictions on Enumerated Type Values

The following enumerated type values will not be used:

— None

5.3.5 Moulded Forms - Attribute Precedence

This section defines the order of attribute precedence for entity / attributes specific to NSRP Ship Structures - Moulded Forms (Annex B) schema data exchanges. If the primary attributes are populated, the information in those attributes will take precedence over the secondary attributes.

— None

5.3.6 Moulded Forms - Attribute Interpretation

This section defines the attribute interpretations that will be followed when exchanging data using the NSRP Ship Structures - Moulded Forms (Annex B) schema data exchange.

5.3.6.1 Attribute Interpretation by Entity

This section list specific attribute interpretations by entity.

— None

5.3.6.2 Ship Units

The attribute ship.units shall be the instantiated as follows:

AP 216

Measure	Unit Name / Dimensions	STEP Entity
length	meters	Length_unit+Si_Unit name = metre

5.3.7 Moulded Forms - Entity Role In the Exchange

This section contains, in tabular format, additional information regarding entity and how it is to be used within the data exchange file.

STEP ENTITY	Use
Spacing_Position	
Spacing_Position	Used as potions in spacing_table
Longitudinal_Position	Used to define longitudinal positions relative to spacing_positions.
Transverse_Position	Used to define transverse positions relative to spacing_positions.
Vertical_Position	Used to define vertical positions relative to spacing_positions.

5.4 Structure Agreements

This section defines the usage rules that are specific to the NSRP Ship Structures - Structure (Annex C) schema data exchange.

5.4.1 Structure - Exchange Content

This section defines the agreements made for the exchange content of for NSRP Ship Structures - Structure (Annex C) schema exchange files.

5.4.1.1 Structure - Geometry

The following agreements reflect the agreements regarding the exchange content of the geometrical information.

5.4.1.1.1 Surface Geometry

The design intent given by Panel_System_Design_Definition.moulded_surface and Plate_System_Design_Definition.moulded_surface shall be defined using explict geometry, e.g. Surface. See Section 5.4.5.1 Restrictions on Select Type Values and 5.4.9.2 Surface Geometry.

5.4.1.1.2 Border Geometry

The design intent given by Panel_System_Design_Definition.border and Plate_System_Design_Definition.border shall be defined using explict curve geometry. See Sections 5.4.5.1 Restrictions on Select Type Values and 5.4.9.1 Curve Geometry.

5.4.1.1.3 Profiles Cross Sections

Profiles shall be defined using Parametric_Profile_Cross_Section entities which define a standard shape by specification of values for a set of pre-defined geometric parameters.

5.4.1.2 Structural System Hierarchy

This section defines the agreements for the composition of a Structural_System.

5.4.1.2.1 Non-Cyclical Tree

Structural system hierarchies are non-cyclical trees. Therefore the concatenated set of all "items" on one tree should contain no duplicates.

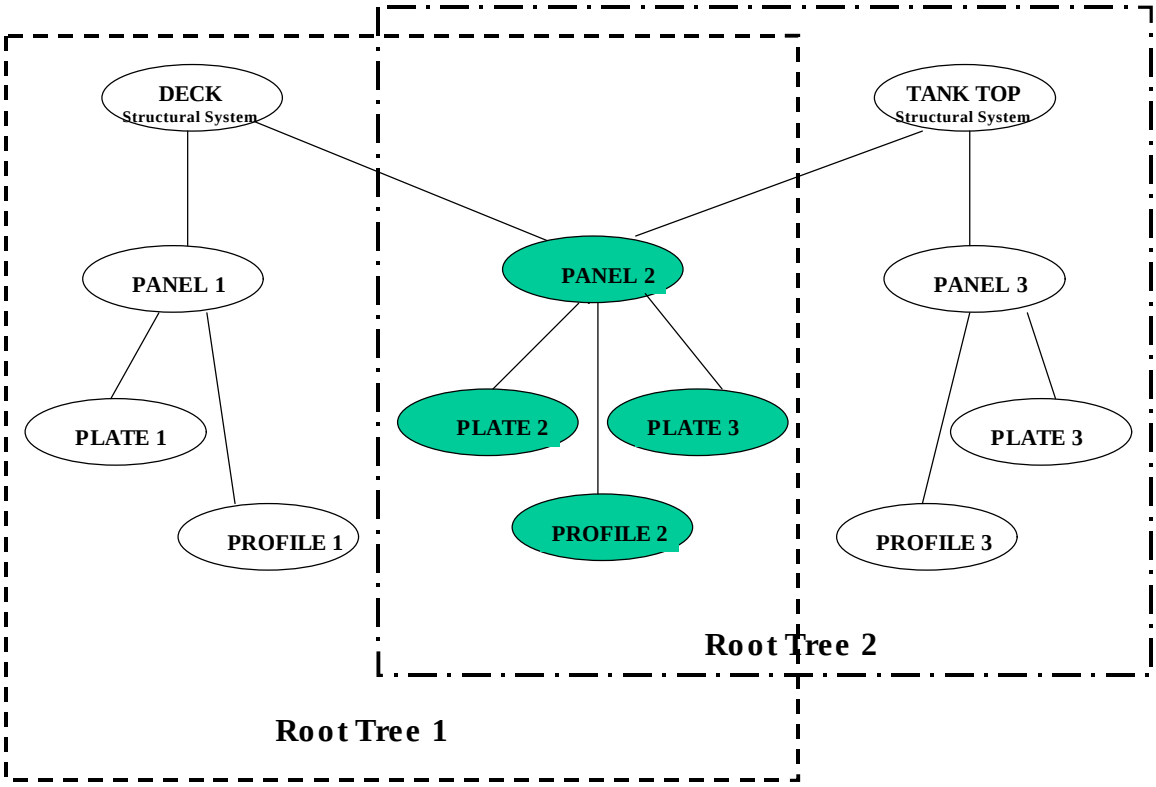

Figure 24: Structural System Tree

5.4.1.2.2 Structural System as Tree Root

A Structural_System entity shall be instantiated as the root of each structural system hierarchy.Plates

Plates shall be a constituent part of at least one Structural_System, there shall not be dangling Plates. A Plate shall appear in one Structural_System tree only. See Figure 25 below.

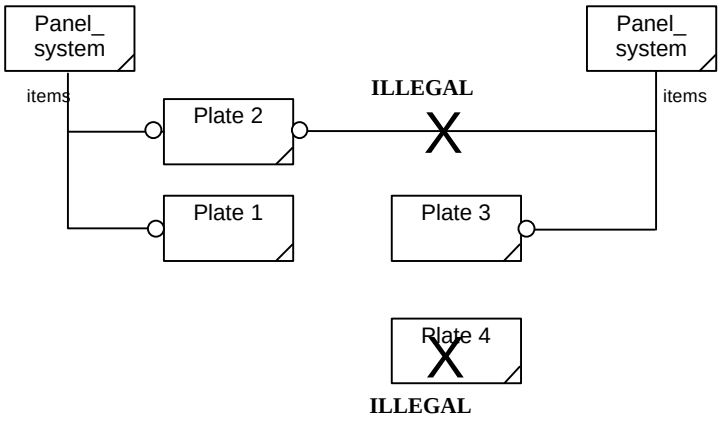

Figure 25: Plates in Structural_systems

5.4.2 Structure Unused Attributes

The following attributes can be ignored by the postprocessor and need not be stored by the receiving software system. The preprocessor must generate attribute values for mandatory attributes.

STEP ENTITY	ATTRIBUTE	COMMENT
Structural_System		
Structural_System	external_items relationships external_relationships	Transfer as empty SETs. Explicit geometry is used for structural systems (no relationships), and External_instance _references will not be used (external_items and external_relationships)
Structural_System_Design_Definition	representations	Transfer as empty SET. Representation can be derived from the representation of the child structural systems, e.g. panel_systems
Structural_System		
Panel_System_Design_Definition	representations	Use design intent given by border and moulded_surface attributes instead
Structural_System		
Plate_Design_Definition	representations	Use design intent given by border and moulded_surface attributes instead
Other		
Definition subtypes	local_units	The global units defined by Ship.units will be used.
Ship_Material_Property	material_reference	Transfer as Optional ($)

5.4.3 Structure - Unused GUIDs

The GUIDs for the following definition subtypes can be ignored by the postprocessor and need not be stored by the receiving software system. The preprocessor must assign GUIDs for these entities which are unique in the exchange file. These entities are not configuration managed, but are used only for the purposes of exchange.

STEP ENTITY	COMMENTS
Structural_System	
Structural_System_Functional_Definition	
Panel_System	
Panel_System_Functional_Definition	
Structural Parts	
Plate_Functional_Definition	
Profile_Functional_Definition	
Features	
Edge_Cutout_Functional_Definition	
Interior_Cutout_Functional_Definition	

STEP ENTITY	COMMENTS
Miscellaneous	
Local_Co_Ordinate_System	GUID needed if want to version the placement of a feature on the structural part (plate, profile)
Ship_Material_Property	GUID needed if want to version the material of the structural part (plate, profile)

5.4.4 Structure - Optional/Empty Attributes Required for Exchange

This section defines the NSRP Ship Structures - Structure (Annex C) schema attributes that, in the schema, are either declared as optional or can be an empty, but which are required to be present and non-empty.

STEP ENTITY	ATTRIBUTE	COMMENT
Panel_System		
Panel_System_Design_Definition	moulded_surface	OPTIONAL in schema but is required in NSRP exchange since not using local coordinate systems for Panel_System_Design_Definition
Plate		
Plate_ Design_Definition	moulded_surface	OPTIONAL in schema but is required in NSRP exchange since not using local coordinate systems for Plate_ Design_Definition
Profile		
Profile_Design_Definition	trace_line	OPTIONAL in schema but is required in NSRP exchange to define extrusion of the profile since not using local_co_ordinate system for profile placement
Miscellaneous		
Axis2_Placement_3d	axis ref_direction	OPTIONAL in schema but is required in NSRP exchange
Global_Id	id	Cannot be an empty string
Item subtypes	name	Cannot be an empty string
Local_Co_Ordinate_System	axis ref_direction	OPTIONAL in schema but is required in NSRP exchange
Spacing_Position and subtypes	name	OPTIONAL in schema but is required in NSRP exchange

5.4.5 Structure - Restrictions

This section defines the schema restrictions specific to NSRP Ship Structures - Structure (Annex C) schema data exchanges.

5.4.5.1 Restrictions on Select Type Values

The following select type values are allowed:

SELECT TYPE	ALLOWED VALUES
Any_Surface	• surface
Panel_System_Boundary	• panel_system_curve_boundary
Plate_Boundary	• bounded_curve
Profile_Trace_Line	• profile_curve_trace_line
Structural_System_Functionality	• deck • main_deck • weather_deck • bottom • inner_bottom • double_bottom • shell • inner_shell • double_shell • bulkhead • longitudinal_bulkhead • transversal_bulkhead • wash_bulkhead • stool • transom • hatchway_coaming • hatchway_sidecoaming • hatchway_endcoaming • frame • web_frame • vertical_web_frame • transverse_web_frame • floor • transverse_floor • cross_tie • stringer • girder
Structural_System_Moulded_Surface	• surface

5.4.5.2 Restrictions on Enumerated Type Values

The following enumerated type values will not be used:

— None

5.4.6 Structure - Attribute Interpretation

This section defines the attribute interpretations that will be followed when exchanging data using the NSRP Ship Structures - Structure (Annex C) schema data exchange.

5.4.6.1 Attribute Interpretations by Entity

This section list specific attribute interpretations by entity.

STEP ENTITY	ATTRIBUTE	COMMENT
Panel_System		
Panel_System_ Design_Definition	border	= List of ordered, multiple Panel_System_Curve_Boundary entities. Note that the order of the borders in the list determines the orientation of the panel_system using the right hand rule.
Panel_System_Curve_Boundary	curve	limited to subtypes defined by 3.5.8.1 below
Face_Based_Surface_Model (Panel_System_Design_Definition.representations→ Non_Manifold_Surface_Shape_Representation→ Face_Based_Surface_Model)	fbsm_faces	= Set of 1 Open_shell
Plate		
Plate_Design_Definition	border	= List of ordered, multiple bounded_curve entities (see Section 1.4.7.4.1). Note that the order of the borders in the list determines the orientation of the moulded_surface using the right hand rule.
Face_Based_Surface_Model (Plate_Design_Definition.representations→ Non_Manifold_Surface_Shape_Representation→ Face_Based_Surface_Model)	fbsm_faces	= Set of 1 Closed_Shell or 1 Open_Shell
Profile		
Profile_Design_Definition	mirrored trace_line	= FALSE = Profile_Curve_Trace_Line
Profile_Curve_Trace_Line	curve	limited to subtypes defined by 3.11.3 below
Feature		
Face_Based_Surface_Model (Bevel_Design_Definition.representations→ Non_Manifold_Surface_Shape_Representation→ Face_Based_Surface_Model) (Rectangular_Cutback_Design_Definition.representations→ Non_Manifold_Surface_Shape_Representation→ Face_Based_Surface_Model) (Round_Corner_Rectangular_Cutout_Design_Definition.representations→Non_Manifold_Surface_Shape_Representation→ Face_Based_Surface_Model) (Drain_Hole_Cutout_Design_Definition.representations→ Non_Manifold_Surface_Shape_Representation→ Face_Based_Surface_Model)	fbsm_faces	= Set of 1 Closed_Shell or 1 Open_Shell
Local_Co_Ordinate_System	parent axis	-> Global_Axis_Placement = w axis direction

STEP ENTITY	ATTRIBUTE	COMMENT
	ref_direction	= u axis direction
Miscellaneous		
Axis2_Placement_3d	axis ref_direction	= w axis direction = u axis direction
Global_Id	id	Cannot be an empty string
Local_Co_Ordinate_System	axis ref_direction	OPTIONAL in schema but is required by NSRP exchange
Ship_Material_Property	defined_for description	may include panel_systems (preliminary design) = <the material name>:<material grade>:<strength level>. Note: These grades will be a superset of the list of standard commercial grades as documented in the IACS Blue Book and agreed to be implemented by the International Association of Classification Societies (IACS). See Section ???? below

5.4.6.2 Ship Units

The attribute ship.units shall be the instantiated as follows:

AP 218

Measure	Unit Name / Dimensions	STEP Entity
length	meters	Length_unit+Si_Unit name = Metre
plane angle	radians	Plane_Angle_Unit+Si_Unit name = Radian
mass	kilograms	Mass_Unit+Si_Unit prefix = Kilo name = Gram
volume	meters**3	Volume_Unit +Si_Unit name = Metre
density	kilograms per meters**3	<u>*METHOD A*</u> *Requires three new STEP entities:* 1) Derived_Unit elements = Set of two Derived_Unit_Elements for density (*mass)* 2) Derived_Unit_Element unit ➔ Mass_Unit+ SI_Unit *(same as above mass STEP entity* exponent = 1 (*volume)* 3) Derived_Unit_Element unit ➔ Length_Unit + SI_Unit *(same as above length STEP entity)*

Measure	Unit Name / Dimensions	STEP Entity
		exponent = -3 **OR** *METHOD B* *Requires three new STEP entities:* 1) Derived_Unit elements = Set of two Derived_Unit_Elements for mass & volume (*mass)* 2) Derived_Unit_Element unit → Mass_unit+ SI_Unit *(use mass STEP entity in Row 3 above)* exponent = 1 (*volume)* 3) Derived_Unit_Element unit → Volume_Unit+SI_Unit *(use volume STEP entity in Row 4 above)* exponent = -1

5.4.7 Structure - Attribute Precedence

This section defines the order of attribute precedence for entity / attributes specific to NSRP Ship Structures - Structure (Annex C) schema data exchanges.

5.4.7.1 Design Intent

For both Panel_System_Design_Definition and Plate_Design_Definition , the design intent geometry defined by the required attributes "border" and "moulded_surface" takes precedence over the explicit geometry defined by the representations attribute.

5.4.8 Structure - Versioning

Versionable_object.version is not used. However, if this attribute is populated, it will follow the format described below.

As long as the versioning entities like version_history are not part of the implementation schemas, simple versioning shall be applied to subtypes of Definition. Simple versioning is provided through the version_id attribute (text string) of entity Versionable_object.
This text string shall consist of a 3-digit version number and a time stamp according to the following specification: VVV:YYYY-MM-DDTHH:MM:SS `/* timestamp */ '1997-12-15T14:18:59',`
Where:
VVV is a 3-digit integer starting at 001 that shall be unique within the context of the same Versionable_object. This version number shall be increased with increments of 1 to indicate the versioning sequence. . The decision of when to update the version number is left to the discretion of the individual shipbuilding environment.

The time shall be in Universal Coordinated Time (UCT). UCT, also called Greenwich Mean Time (GMT) (established in 1884), or Zulu Time (military time), is the time at the prime meridian (International Date Line), and used by numerous agencies worldwide.
UCT is:

- equal to time at longitude 0 degrees ± 7.5 degrees,
- equal to time in Greenwich, England (winter time !).

Example: Versionable_object.version_id = '001:1999-01-10T09:23:32'

5.4.9 Structure - Geometry

This section defines the specific agreements related to structure geometrical attributes and entities.

5.4.9.1 Curve Geometry

Curve geometry will be limited to one of the following subtypes:

— B_Spline_Curve_With_Knots
— B_Spline_Curve_With_Knots +Rational_B_Spline_Curve
— Polyline

5.4.9.2 Surface Geometry

Surface geometry will be limited to one of the following subtypes:

— B_Spline_Surface_With_Knots
— B_Spline_Surface_With_Knots +Rational_B_Spline_Surface
— Plane

5.4.10 Structure - Entity Role In the Exchange

This section contains, in tabular format, additional information regarding entity and how it is to be used within the data exchange file.

STEP ENTITY	Use
Mapping a Feature to a Plate or Profile	
Local_Co_Ordinate_System	Locates an instance of a feature in the ship's global coordinate system.
Placing a Profile	
Profile_Design_Definition	• cross_section attribute identifies the profile_cross_section subtype (see below) • cross_section_placement, mirrored and twist attributes, identify the orientation of the profile library part • trace_line and border attributes define the geometry along which the profile is extruded
Profile_Cross_Section Subtype	identifies the parameters for the cross section which can be used through some mapping to identify the profile library part

5.4.11 Structure - Ship Material

The description attribute of Ship_material shall contain
<the material name>:<material grade>:<strength level>.
These pieces of information will be separated by a colon.
Example: Ship_material.description = 'Steel:A:32'
Permissible values for material name are e.g.:

- Aluminium
- Stainless steel
- Steel

Permissible values for material grade are e.g.:

- A
- B
- D
- E
- F

Each of these may be suffixed by an H indicating hardened steel (e.g. AH).

Permissible values for material strength are e.g.:

- 32
- 36
- 40

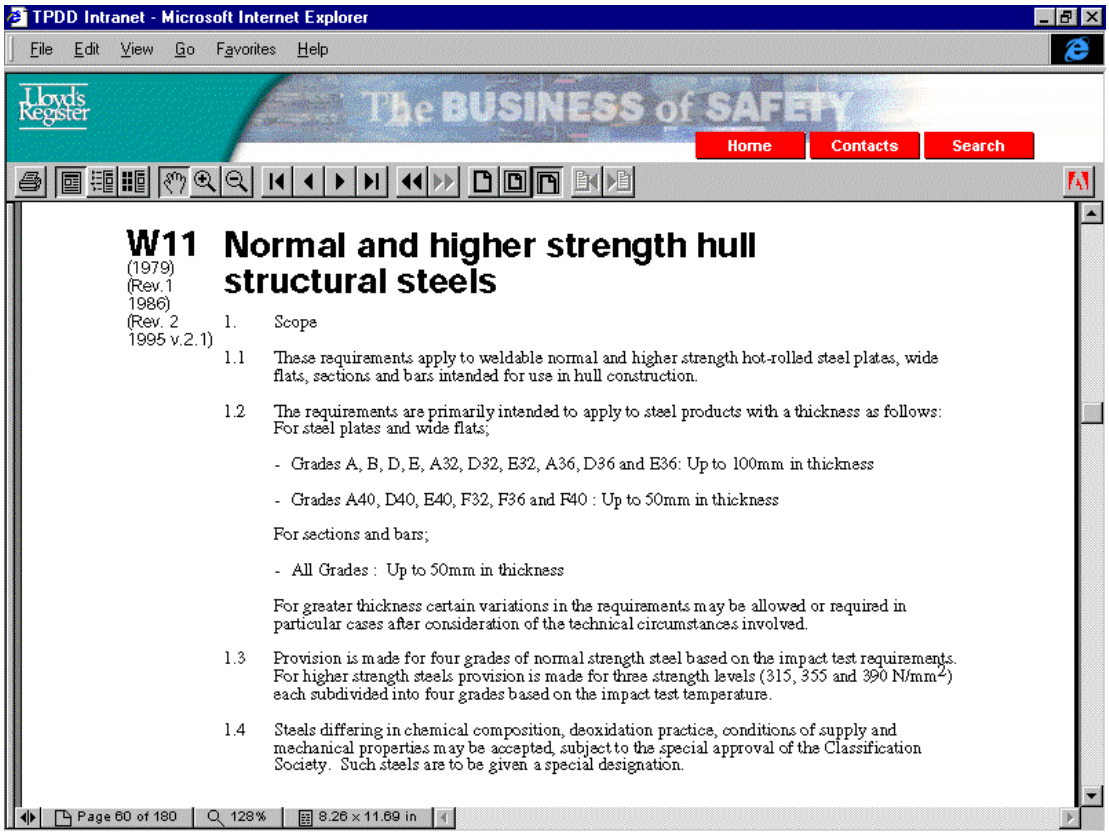

Figure 26: Description of material grades from the IACS Blue Books

REVISION HISTORY

Rev	Rev Date	Revised By	Description	Reason
0	9/30/99		Initial Release	NSRP-0429 Version 2