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# Development of the Abstract Test Cases of Ship STEP

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**Abstract**

Ship STEP(Standard for the Exchange of Product Model Data) which is composed of AP 215 (Ship Arrangement), AP 216(Ship Hull Form), AP 218 (Ship Structure), has been developed more than last 10 years and it is now at the stage just before IS(International Standard). It is expected that ship STEP would be used for the seamless data exchange among various CAD/CAM/CAE systems of shipbuilding process. In this paper the huge and complicated data structure of ship STEP is briefly reviewed at the level of ARM(Application Reference Model) and some abstract test cases which will be included as part of the standards are introduced. Basically ship STEP has common data model to be used without losing compatibility among those three different ship AP's, and it is defined as the modeling framework. Typical cases of data exchange during shipbuilding process, such as hull form data exchange between design office and model basin, midship structure data between shipbuilding yard and classification society are reviewed and STEP physical data are generated using commercial geometric modeling kernel. Test cases of ship arrangement at initial design stage and hydrodynamic data of crude oil carrier are also included.

**Keywords: ship STEP, exchange of product model data, ATS**

## 1 Introduction

The Standard for the Exchange of Product Model Data (ISO 10303), better known as STEP, has been developed to enhance the interoperability of product data among heterogeneous information systems. Each application protocol (AP) applies to various engineering product such as airplane, car, ship, plant, architecture, etc.

In case of shipbuilding industry, they have short time design process when compared to aerospace or automotive industry. To meet such short design process time, they have to use various kinds of design systems simultaneously that narrowly customized to specific work process. As a result it becomes very important how to make data exchange smoothly among those different information systems. Another aspect of STEP is considered to maintain the usefulness of product data during the life-cycle of the product (Kim 1997). The life-cycle of ship usually spans longer than 20 years which is several times of most information system. When information system is changed to new one or at least to new version, then most product data generated by former system become obsolete and so drawings have been used as means of conserving product data up to present. Although it may not imminent, the STEP technology will innovate the way product data is generated, transferred and stored.

STEP is not the first kinds of its purpose. Before it there had been another standard, IGES (Initial Graphics Exchange Specification), but it failed to survive because the levels supported by commercial CAD systems were not same resulting only partial success of data exchange. The experience of IGES had lead those who were developing STEP into to make the standard to be equipped with conformance test set so that it will assure flawless data exchange between different information systems. The conformance test set is composed of a number of abstract test cases.

In this paper some experience of developing abstract test cases (ATC) of ship STEP is introduced. It includes the ATC of AP 215(ship arrangement), AP 216(ship hull form), AP 218(ship structure)(ISO 10303-215 2002, ISO 10303-216 2002, ISO 10303-218 2002)

## 2 Ship STEP

A product model is a set of objects and relationships between the objects. While the objects describe the assemblies and components of the products, the relationships describe the architecture of the product. As the base for different activities, from idea to final product, the product model is the key to successful product realization. As a knowledge base it contains geometric and technical data but can also refer to company specific information, product background, history, synthesis and analysis results, reasons for decisions etc.

The ship product differs from many other products by

- it's complexity - a variety of different production branches and organizations have to collaborate in a coordinated way.
- it's uniqueness - ships are usually built in very small series of 1 to a few.

which positions it closer to a power plant that to a car while being a vessel. This creates specific requirements on the handling of the product data.

The complexity of the ship causes the fact that not all information about this product is possible to be handled by one specific software but a variety of systems in the different organizations involved and even within one organization (e.g. the ship yard) is necessary to create, process and maintain the data. This creates the problem that this data needs to be shared or even exchanged between the systems which either requires a lot of time consuming and error prone conversions or an underlying data structure that is commonly available to the different systems.

The complexity also creates the need for co-ordination between the numerous different organizations and between the departments within these organizations which requires configuration management information to be available and maintained by the systems. Different versions of a design for instance can exist in parallel at the same time and are used by different organizations (e.g. the yard's design office and design subcontractors) due to concurrent engineering

Ship STEP has been developed under the assumption that a ship product model can be divided into separated parts, and each part includes a functional element along the whole lifecycle of the ship. Product model schemas are being developed for each AP. The reasons for this division are the distribution of modeling work and the need to exchange subsets of the product model between agents in the marine industry, not to mention the practical aspects of exchanging the data associated with an entire ship. The whole ship product model includes the followings ;

- Ship structural envelop
  - Ship arrangement (AP 215), Ship hull form (AP 216), Ship structure (AP 218)
- Distribution system
  - Ship piping (AP 227 ed.2), Electrical (AP 212), Ship HVAC (AP 227 ed.2)
- Mission subsystems/equipment
  - Ship mechanical system (AP 227 ed.2), Electronics, Weapons
- Miscellaneous
  - Operation logs (ISO 15926), Engineering analysis, Ship hydromechanics

# 3 Ship Common Model (SCM)

Each AP has four major parts:

- an Application Activity Model (AAM) to describe and decompose the activities, input and output objects, controls and modifiers.
- an Application Reference Model (ARM) to describe the information objects required, their structure and attributes.
- an Application Interpreted Model (AIM) to map the requirements to the types of objects understandable to other CAD systems.
- an Abstract Test Suite (ATS) to test and confirm the reliability of STEP product data. It is composed of a number of abstract test cases (ATC).

To protect against errors where the design information for a ship defined in separate AP's differ from each other, common elements are defined as a ship common model(SCM), and each AP utilizes SCM. The available ship application protocols are AP 215, AP 216 and AP 218.

The SCM forms the basis for the ARM of all shipbuilding APs under development and to come. It provides a Modelling Framework for the APs that represent the Ship Product Model, a set of independent and re-usable product-structure Domain Models that are required for more than one Application Protocol, as well as a set of commonly used constructs refereed to as Common Utilities such as those used for configuration control and management concepts. The goal of the Ship Common Model is to ensure to the integration and overall consistency of the ARMs of the different ship APs. Thus, it is a means of integrating the requirements specified to a uniform conceptual model.

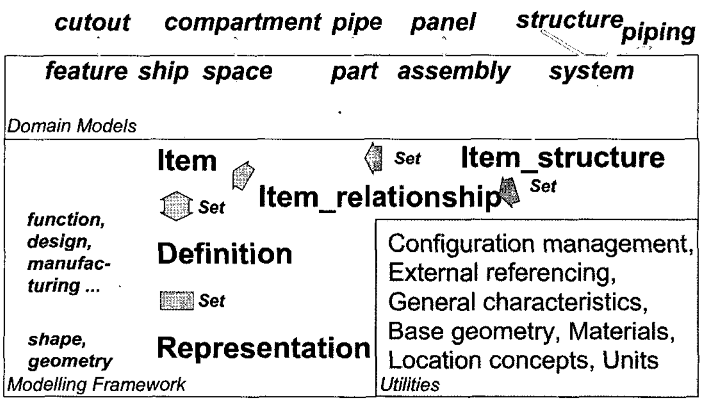


**Figure 1:** Parts of SCM

As mentioned above, the Ship Common Model can be split into three parts, the Modelling Framework, a set of Domain Models, and a set of Common Utilities such as configuration management concepts and measurement units (Figure 1).

The Modelling Framework as part of the Ship Common Model provides the realization of the general idea of

- how to relate concepts
- how to define their properties
- how to represent them

On top of the Modelling Framework, the Domain Models provide a set of templates for the organisation of the product being modelled along a number of different axes or views, such as

- Parts
- Features
- Product Structure by System
- Product Structure by Space
- Product Structure by Assembly

The Common Utilities are a group of constructs that will be required by most AP's. They differ from the Modelling Framework and the Domain Models through the fact that for the majority of cases, the Common Utilities are ready for use and do not require any further specialisation for use in an ARM. Many have been created specifically for shipbuilding although some may be able to be used externally. The Common Utilities group together the following Units of Functionality:

Ship General Characteristics; including the basic ship's length, breadth, type and class Location Concepts, including the global co-ordinate system, local co-ordinate systems, spacing grids etc.

- Ship Moulded Geometry such as ship point, curve and surface
- Configuration Management, like approval, versioning and change management
- item Ship itself since all data defining the product need to be related to the product which is ship
- Measurements, the types of measures to be used such as metres, kilogram or second etc.
- External Referencing Mechanisms allowing to point to information that is outside of the scope of a certain data exchange

# 4 Abstract Test Cases

ATS is composed of a number of ATCs, each consisting of a preprocessor and a postprocessor test case. The test cases address a number of test purposes that are representing the syntax, structure and semantics to be tested. Whether or not the IUT(Implementation Under Test) conforms to the requirements of the test is determined by supplying the IUT an instance described by the input specification and judging the results according to the verdict criteria defined for the test case (Figure 2).

The specification of actual data values in a test purpose goes beyond the testing of the structure of data types and relationships. In general, data for individual attributes are assumed to be specific selections from a range of possible values.

Since testing all possible instantiated models is impossible, reasonable heuristics shall be adopted which focus conformance testing on a useful set of representative test data values that are valid for the application domain and worth the cost of testing

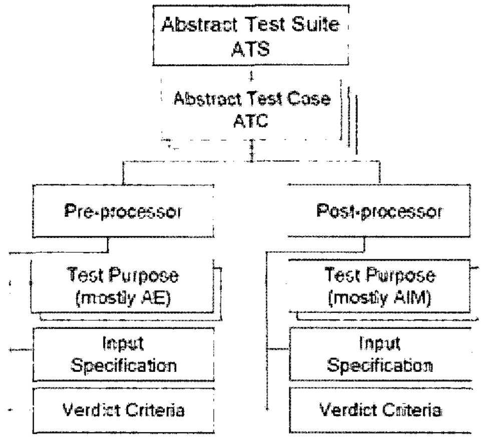


**Figure 2:** Structure of ATS

A test purpose is a description of an objective to be tested to assess if a specific requirement is met by an implementation. The challenge of test purpose development is to produce a set of test purposes that is finite and manageable in size, but is also comprehensive and explicit enough to avoid misinterpretation of the standard.

Each abstract test case specifies input data to be provided to the implementation under test, along with the associated verdict criteria.

The abstract test suite shall contain abstract test cases that apply to preprocessors and postprocessors. Preprocessor and postprocessor input specifications with the same input semantics are documented together in the same abstract test case.

Abstract test cases may be sequenced in any manner the developers deem useful. Abstract test cases may be grouped according to basic tests driven by the minimal entity set. Abstract test cases may also be ordered according to AP conformance classes. If abstract test cases apply to more than one conformance class, a table shall be included in annex A of the abstract test suite that identifies for each conformance class the set of abstract test cases that apply.

Each abstract test case will contain the specification for the input data to be used when developing and running an executable version of that abstract test case. One way of creating ATCs for the Ship APs is to create one ATC for each BB. This approach would benefit from the modular nature of the BBs and would solve some of the concerns with respect to designing ATCs (Figure 3):

## 5 ARM of Ship APs

There are two major tasks when creating a part of a product model:

- defining concepts by specifying their properties
- describing how concepts are related to each other.

The properties of a concept are, in terms of modeling in EXPRESS, attributes of an entity. Instantiating a concept would therefore require every non-optional ‘entity’-attribute to be available.

As the amount of information known about a concept - it’s properties - usually grows during it’s lifecycle and therefore is only ‘complete’ at the end of it’s life time this dependency is often not desired. It can be removed by separating the concept from it’s properties - just from the modeling point of view - and allowing the concept to exist in an incomplete state until all of it's properties are specified (i.e. making it just a placeholder without attributes, but able to join relationships to other concepts).

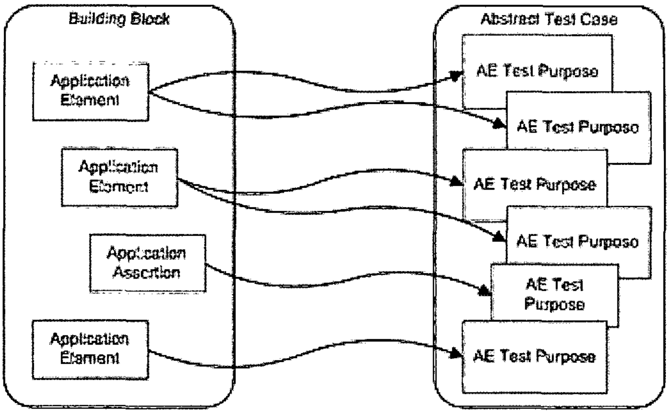


**Figure 3:** Mapping BB to ATC

Thus, in the ship common model concepts may exist while the level of completeness of the real world objects or ideas that they represent is reflected by the definitions that carry the properties. The SCM provides for this through the use of two constructs (Figure 4)

- Item - stands for the concept
- Definition - holds the properties

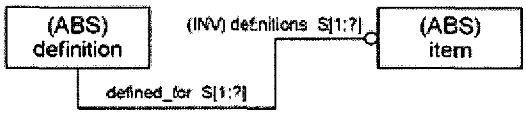


**Figure 4:** Item relationship

Every property of a concept, and therefore, every Definition of a Definable_object, may be described in several different ways. The shape of a plate for example, may be described by parameters length, breadth and thickness, or by topological references to other plates this way specifying the boundary information and the thickness, or as explicit geometry - a curve describing the boundary contour - and the thickness. Each type of description may be useful in a different context or under certain conditions. All have in common that they describe the shape of a plate while doing this in a more or less implicit way. For viewing purposes e.g. it is desirable to have some explicit information available that 'shows' what the Definition is meant to be without being forced to process the description first.

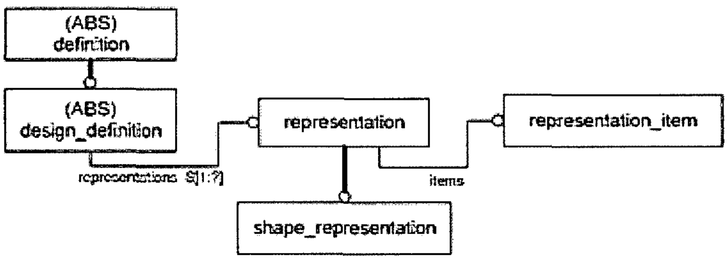


**Figure 5:** Relationship between definitions & representation

Therefore it is worth to distinguish between the more or less implicit description of a concept and the explicit result of that description. In general, the explicit result of the description of a concept shall be modelled as a Representation. A Representation shall carry the explicit result of the description of a concept. A typical relationship between a definition and a representation is shown in the figure below (Figure 5).

*Moulded_form_lines* introduces ship_curve, which is a curve in a specific context. A ship_curve is a curve that is commonly used in naval architecture and that has an associated name (Figure 6).

*Moulded_form_surfaces* introduce *ship_surface*, which is a surface in a specific context. A *ship_surface* is a surface that is commonly used in naval architecture and that has an associated name.

The data associated with a *ship_surface* are the following.

- *surface_class*
- *surface_shape*

The *surface_class* specifies the naval architectural category for the *ship_surface*. The categorisation is based on the distinction between the location of the surface.

The *surface_class* shall be one of the following:

- *external_surface*
- *internal_surface*
- *blending_surface*

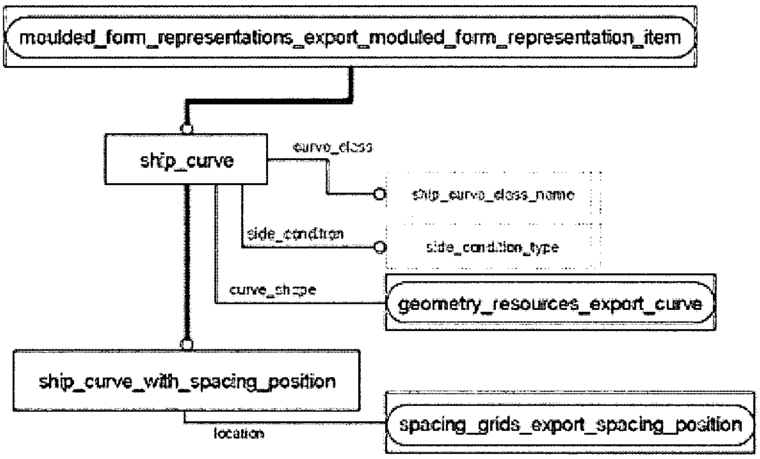


**Figure 6:** Ship curve

A ship's structure, including hull structure, super structure and assemblies within the ship, is within the scope of the ship structural model of STEP AP 218. AP 218 supports the transfer of product model data to support the design, manufacturing and approval of structural systems, plate parts, stiffeners, foundations, and welds. In addition AP218 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. AP218 covers the following product definitions: the ship's general characteristics, the ship's global coordinate system, local coordinate systems and spacing grids, the geometrical representation, the hull plate and the stiffener profiles, the definition of structural features, the design of the welded connections and joints, the specifications of transverse cross-sections, ship design loads including shear forces and bending moments, the weights and centers of gravity, the materials, the configuration management including approval, and versioning and change administration. (Figure 7)

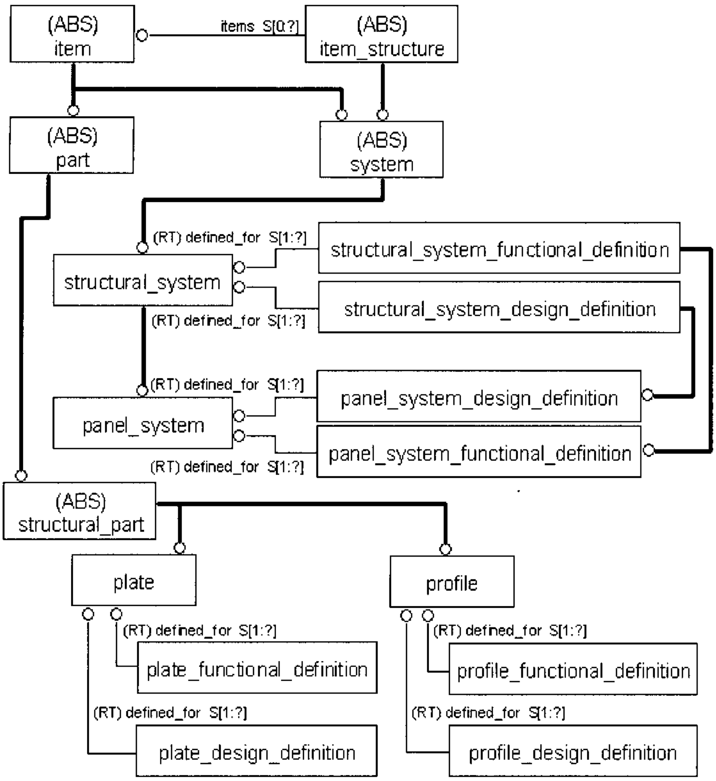


**Figure 7:** Partial representation of ship structure

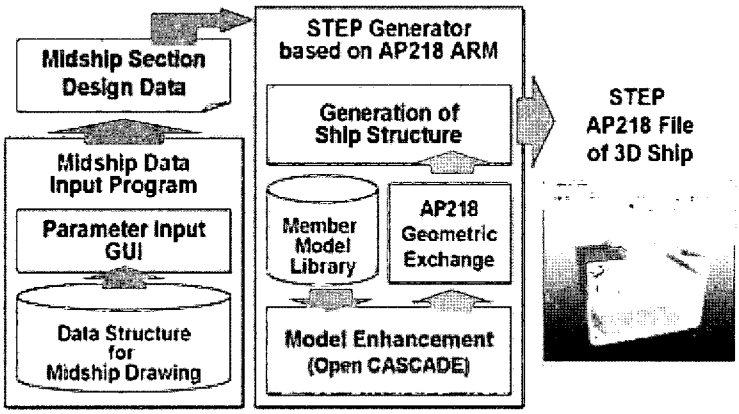


**Figure 8:** Architecture of structural STEP data generation system

# 6 System Development

A 3D ship model generation system from 2D design information was developed. To transform the 2D information into 3D ship model based on STEP AP218, the mapping between these data structures and the enhancement of information has been developed. Figure 8 shows the architecture of the 3D ship structure generation system. The system has two modules, the midship data input module and the STEP AP218 generator. The user generates design information of the midship section through the data structure based on the proposed information model of midship drawing and the parameter input GUI that supports the data model. The generated data is then processed by the STEP generator. The 2D design data of a plate is transmitted into the modeling library, which generates the shape of the plate through the data mapping and enhancement processes. The AP218 3D shape of the design data, which is generated by the modeling library, is finally stored as a STEP physical file (Hwang 2004).

# 7 Results and Discussion

Hull form and midship structure design are the most important design information since all other designs are based on them. Hull form design information flows from initial design department to model test basin and other design department. Structural designer begins their job from midship design and it flows to classification society and other design department. Thus these two design information can be a starting point of ship production. Typical ship hull form model, midship structural model and ship arrangement model are shown in Figure 9~11. The model data were translated into STEP physical data (Figure 12) and confirmed by STEP viewer without any missing information. Besides the geometry data, various engineering information such as hydrostatic calculation sheets and loading manuals can be made as STEP physical data so that it can contribute to reduce much of redundant work.necessary for the exchange of engineering information (Kim 2001).

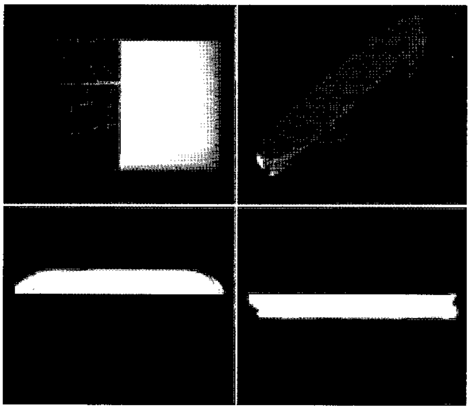

**Figure 9:** Ship hull form

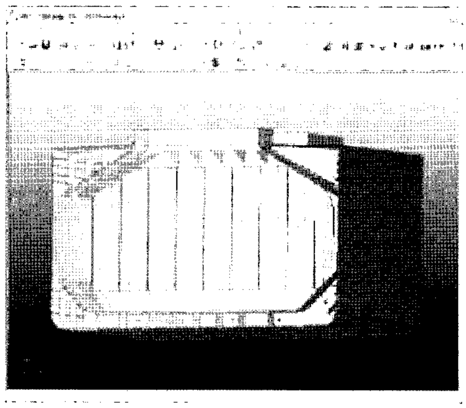

**Figure 10:** Midship structure

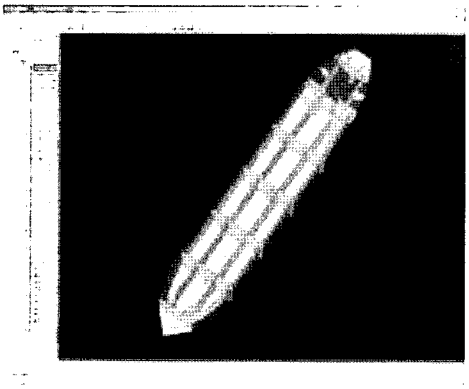

**Figure 11:** Ship arrangement

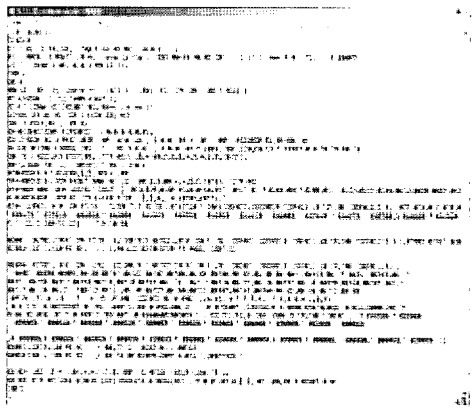

**Figure 12:** STEP physical data

## 8 Concluding Remarks

In theses days many industries try to integrate their engineering information throughout all the process by constructing CIMS or CALS system. To achieve the goal, it is necessary to have a means of seamless data exchange between various heterogeneous systems. Up to present, drawings are the major means of engineering data exchange, but STEP will be the first alternative for that purpose with its rich of contents. Moreover STEP can be used as for the engineering database format. The data model of STEP has basically the type of object oriented model and so suitable for processing the complicate engineering information.

In this paper we show the fundamental concept of ship STEP and some example of abstract test cases to assure the conformance of the physical data. The result was enough good to confirm the flawless data exchange. When they use the STEP technology widely in industry, it will innovate the way of generating, exchanging and storing engineering data resulting real seamless integration.

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