The basic principles of creating an information model in PDM-systems as a means of vessel lifecycle management

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Abstract. This article focuses on approaches based on shipbuilding simulation such as digital shipbuilding, simulation-based design, and virtual shipyard. The approaches to the construction of the lifecycle Electronic Information Model of a Ship (EMIS) for the vessel design and construction are considered. The principle of creating an electronic information model as a basis for a vessel’s lifecycle is considered. The necessary initial technical requirements for the of an electronic information model creation are discussed. In the process of creating an electronic information model of shipbuilding products at all lifecycle stages, a concept of the information model of the product was developed. Analysis of the tools (software) that are currently on the world market was carried out by the authors to implement the above concept of creating the information model. The expert analysis indicates importance of selection of the EIMC structure type before initiation of implementing the lifecycle of a particular ship, provided that PLM systems are used.

1. Introduction
The industrial method of shipbuilding is a combination of methods and techniques for manufacturing the ship structure and construction of a vessel as a whole. A modern industrial method of vessels manufacturing includes a fundamental technology and technology of separate manufacturing processes (for certain types of shipbuilding production) [1]. The fundamental technology regulates the vessel construction method, the hull forming method, the vessel sectioning into assembly units, etc. The technology of separate manufacturing processes regulates ways of work performing, manufacturing equipment, rigging out, facilities and devices, depending on the types of shipbuilding production [2, 3, 4].
There are the following methods of vessels building:
- constituent part;
- sectional;
- block;
- modular (modular-aggregative).
From a technological point of view, modular principles of construction a vessel are more effective: a modular-aggregative method for designing and construction vessels, a modular system for construction, finishing and equipping of shipboard spaces [5, 6, 7].

The industrial manufacturing method assumes that a mechanism has been created at the enterprise that guarantees accurate multiple reproduction of products with all permissible changes in the current state of the enterprise: changing suppliers of materials and devices, changing production technologies, staff turnover, etc. [2].

In the modern world the serial products design and manufacturing of most industrial enterprises in the shipbuilding industry are not fully “industrial” in terms of the industrial production definition given above despite all the achievements of science and technology.

Often the availability of CAD and CNC machines cannot hide the fact that manufacturing remains only with partial or full automation of individual sections [8] during the construction of vessels in manufacturing.

The quality and speed of both the development and manufacture of the vessel as a whole still, first of all, depend on the actual qualifications and experience of the engineer, designer, technologist or worker, and the process itself is not always amenable to objective planning. Meanwhile, the industrial method of development and manufacturing implies the establishing of such a production process which guarantees such characteristics of the process as: repeatability, testability, standardization, unification, normalization, independence from the realizer personal characteristics, production predictability, etc. All the above characteristics apply to both the product itself and the technological processes of its design and manufacturing.

That is why the information solution for an industrial enterprise, the transition to digital approaches, will allow the implementation of products manufacturing industrial way, which means, at a minimum, the above-mentioned basic characteristics of products and the processes of their production: design, engineering, modeling, manufacturing preparation, checkout, etc.

2. The basic concept of an information model construction

In the process of creating an information model of shipbuilding products at all lifecycle stages [9], a concept was developed that can be expressed in the following paragraphs [10]:

- An information model of a product at all lifecycle stages can be displayed simultaneously in various hierarchical structures of interest at a particular lifecycle stage.
- The information model should contain ALL information about the product and the elements of the hierarchical representation at ALL lifecycle stages.
- The information model should be able to present an information retrieval which is necessary for enterprises operating at different lifecycle stages.

The necessary information retrievals provided for various enterprises at different lifecycle stages should be made from a single database when connected to it or transmitted through export and import mechanisms to the enterprise databases with the possibility of further synchronization aimed at providing relevant information at the time of access to the enterprise databases [11, 12, 13, 14].

It is advisable to create an information model and replenish data, starting from the design stage and then replenishing data during construction, operation, modernization, etc. Only in this case the electronic information model of the product (EIMP) will be complete and the necessary information retrieval will be presented for the next lifecycle stages and will not require additional costs.

A certain subject (the information model holder responsible for updating information in the event of its replenishment or change in the course of its lifecycle) is needed. The model holder may be, for example, the manufacturing plant, the main customer depending on different conditions.

3. Approaches to the implementation of EIMP

Currently, there are two main approaches to the implementation of EIMP at different stages:

- In the form of separate models presented for one or another lifecycle stage.
- In the form of a single model with the ability to provide the necessary information retrieval for various enterprises and organizations at various lifecycle stages of a shipbuilding product.
The first approach involves the construction of a model and its hierarchy for a particular lifecycle stage with the necessary data and its transfer to some organization. For example, with this approach, it is required to form, for example, an operating hierarchy of product presentation, enter the necessary data into it:

- drawings of rooms, systems, operational documentation for certain systems, equipment, their elements, developed in the design, construction organizations or organizations – suppliers and manufacturers of equipment, systems and their elements;
- data on the logistic support of the structure of each element and the whole product;
- other necessary information at the operation stage.

With this approach, work is needed to collect and enter into the EIMP the information developed at the design and construction stages and necessary at the operation stage directly in the process of creating the EIMP.

This approach has the following disadvantages:

- It is required to organize the process of collecting all the necessary information developed and contained in heterogeneous environments.
- It requires the development of some kind of environment, “uniting” all the necessary information;
- It is necessary to create import mechanisms (excluding data loss and corruption) from heterogeneous systems containing the information necessary for operation in an operational model.

In our opinion these disadvantages impede the rapid and correct creation of EIMP at one or another stage, do not exclude losses and corruptions during export or import into the model of data created in heterogeneous environments. In addition, this approach eliminates the timely automatic synchronization of data in case of changes during the lifecycle (for example, the necessary changes in the operational model after upgrading the vessel, with the replacement of systems, etc.).

The second approach is fully consistent with the basic concept and described by the following logic:

- In the process of all lifecycle stages the data are entered into a single heterogeneous environment.
- It is possible to quickly make the necessary “slice” of information and transfer it to the appropriate organization in the following ways:
  - unloading of the hierarchy necessary elements and data from a single EIMP with their subsequent transfer;
  - organization of access to the necessary “slice” of EIMP information through the network, including remote workstations, as well on low-speed channels. In this case, the EIMP base should have access administration tools. For example, an operating organization sees only an operational model.

In any of the above methods, it is necessary for the EIMP to be physically a single, constantly updated database. In this regard, the concept described above indicates the need for an organization - the holder of the base responsible for the timely replenishment of EIMP information and the provision of necessary information to EIMP-using enterprises. The proposed concept of EIMP implementing can be represented as shown in Figure 1.

4. EIMP creation tools

Analysis of the tools (software) currently on the world market was carried out by the authors to implement the above concept of creating EIMP. As a result of the analysis, the following conclusion was made: practically any system of PDM class can be a tool for creating EIMP:

- SmarTeam;
- TeamCenter;
- Windchill;
- TDMS;
- Aveva Marine;
- T-FLEX CAD.
In addition, the use of other systems is not excluded. All of these systems have the necessary functionality to create EIMP. Despite this, it should be noted that the functionality of SmarTeam, TeamCenter and WindChill systems is redundant and does not have special applications (modules) of shipbuilding specifics. Most of it remains unclaimed when implementing the EIMP. TDMS and Aveva Marine are relatively expensive and developed by foreign companies. The authors adopted a modern high-level CAD system of domestic developers T-FLEX CAD [15] for further development of the management system.

![Diagram of EIMP implementation concept](image)

**Figure 1.** The concept of implementation of EIMP.

The T-FLEX CAD system is fully parametric, based on a fundamentally new approach to creating CAD systems and to an intuitive design of parametric models. Model elements can be related by parameters and geometric relations (parallelism, perpendicularity, tangency, etc.) in T-FLEX CAD. All parameters of the drawing can be expressed using variables, calculated by formulas, selected from databases. Any drawing or 3D model can be included in the user library, and the creation of libraries does not require contacting the developers or programmers. The purchase of special modules for creating libraries is also not required - everything is included in the standard delivery of the system. At the same time, it provides full support for both ESKD and foreign standards.

Considering the concept that the EIMP content should be made dynamically throughout the entire product lifecycle, the work places of these systems should be installed in the design, construction, operating, repairing, upgrading and recycling organization.

5. **The presentation format of the vessel electronic model in T-FLEX**

One of the proposed approaches in the implementation of the project for the construction and building of a small research vessel in the design office of Sevastopol State University is the use of the T-FLEX system. The system (module T-FLEX CAD) is successfully used:

- in the design (design of various equipment, tools; development of punch sand press molds designs; design of finished products, etc.) (Figure 2, 3);
for solving technological tasks (design of scheduled maintenance task card, specifications, data
preparation for the development of technological processes, preparation of information for
systems programming equipment with CNC);
• in the tasks of construction and architecture;
• in the development of various types of schemes;
• with processes and mechanisms of dynamic graphic modeling;
• in the tasks of decoration and design.
The most effective T-FLEX CAD is used in those areas where the idea of parametric design is most
fully implemented, where it is necessary to cover all the design stages (initial design, rough drawing,
working drawing).

![Figure 2. Creating the vessel fragment.](image)

![Figure 3. Designing and filling the block with details.](image)

The T-FLEX system is a set of applications combined into a single user-friendly and intuitive
interface. For EIMP correct interaction with the user, standard applications must be grouped into
several global software modules, each of which performs its own task.
The authors propose to determine the following global modules in the system:

**Design.** The main graphics module in which the designer works. A three-dimensional model of the
vessel's project is created in this module. This model is stored in the T-FLEXdesign bases. The choice
of design components is carried out in accordance with the specification. Basic moments are:
• creation and modification of project components;
• detailed consideration and study of the projected model in a three-dimensional space;
• generate reports for customized specifications;
• check for collisions between model elements.

**Drawing.** The module is used to create drawings.
Annotations can be associated with model elements or simple graphic elements (text, lines, etc.). Annotations associated with the model elements will move in the drawings when the element position in space changes. Dimensions are design distances between connection points in a 3-dimensional space (so-called P-Point). Dimensions are calculated automatically and recalculated every time a drawing is updated. Information for the drawing can be requested from the model databases, but the model cannot be changed from the drawing. The basis is a model. The drawing is based on the model. Figure 4 shows an example of displaying a drawing in the Drawing module.

![Figure 4. Drawing display.](image)

**Isometrics.** A module for the release of pipelines isometric drawings for installation works. Isometric drawings may include:
- material Lists;
- automatic splitting of complex drawings;
- user customizable frames and stamps;
- other parameters required at the manufacturing stage.

**Administration.** Large projects usually require the appropriate settings. These functions are performed by the Admin module:
- distribution of user rights (Teams, Users);
- creating databases of various types (Design, Catalog, Draft, etc.);
- create database sets or database groups (MDBs);
- database management and maintenance.

**Catalogs.** Modules for creating and modifying the catalog of elements that are used in the design.
- Directory bases store the information about the elements geometry, interelement coupling, working volumes (insulation, service area).
- Detailed information of metal components, piping, electrics and HVAC, etc. are stored in the Catalogs.
- Catalog databases are connected to the model databases, and a certain set of elements becomes available to the designer.
- The T-FLEX system also integrates catalog components into specifications.
- It is possible to work simultaneously with several projects in a T-FLEX system, using the same components and specifications catalogs.

**Properties.** This module is used to create a properties database. This database includes material properties and component data. It is used for calculation packages.
Attributes. This module is used to create UDA – custom attributes that can be used in drawings and reports.

6. Data Storage and Database Hierarchy
The data in the databases are stored in a tree form. There are couplings between the elements like Parent-Descendant and other relations inherent in the tree form. The hierarchy of the following elements in the tree is shown in Figure 5.

![Hierarchy tree of the elements.](image)

General levels of hierarchy:
- **PROJECT.** After creating the database, it stores a single element - the project. Each database has its own project element, as the first element in the hierarchy.
- **SITE.** The second level of the hierarchy follows below the project level – site. The site can be considered as an administrative level that allows one to logically structure the project elements. For example, a whole project or part of a large project. It is possible to create many sites for data organizing in the project.
- **ZONE.** The zone will be the next level below the site. Also it is not necessary to use the zone to determine the physical area, it is more appropriate to use them to combine similar data to facilitate work, for example, the division within the one site into zones by subjects.

The site and zone levels are present in the project, regardless of the subject in which the specialist conducts the design and must be present in the project. The designer works in a specific area of a specific site, creating one’s own part of the overall project.

7. Conclusions
It is obvious that the ideology application of the lifecycle information model based on the use of a modern product like T-FLEX will allow one to:
- automate connection between the plant and the design office;
- fully automate the manufacturing of the product at the plant itself;
- automate the system of the vessel maintenance and modernization after delivery to the customer;
organize an effective production management system, for example, on the basis of the Material Requirements Planning standard (MRP).

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