The procedure of developing the 3D model of a small-tonnage steel ship

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Abstract. This article deals with issues of development and consistency of industrial digital 3D-models of ships. Such models will incorporate a volumetric digital representation of the ship, hull structures, equipment, pipelines and pipe fittings, electrical equipment, propulsion devices, hull fittings that are described as a symbiosis of geometric models and numeric or alphanumeric attributes. The article describes an analysis of typical discrepancies (collisions), which would occur in a 3D model while designing a small-tonnage ship. The article provides some recommendations for the procedure of developing the 3D model of a small-tonnage steel ship. Those recommendations will considerably enhance the quality and speed of the development by avoiding a large number of typical collisions in the 3D model, while working in parallel. The proposed recommendations and rules have been worked out based on years of experience of developing 3D models of ships in high-level CAD. The worked-out-by-the-authors rules of priorities and sequence of developing a digital 3D model of the ship allow optimization of man-hours and ensure consistency of work being performed by different disciplines within the entity-the developer of the model.

1. Introduction

State-of-the-art industrial information technologies are based on the concept of the common information area (coalition for networked information) of an industrial enterprise, i.e. CALS-technologies (Continuous Acquisition and Lifecycle Support). Another commonly used term is PLM (Product Lifecycle Management).

From the point of view of their practical implementation, both CALS- and PLM-technologies are based on a continuous data-centric electronic model of the industrial production (enterprise), or the 3D model of the object if an engineering facility is the case. In shipbuilding, the ship is such an object.

The 3D model of a ship is a volumetric digital representation of the ship, which consists of hull structures, equipment, pipelines and pipe fittings, electrical equipment, propulsion devices, hull fittings, that are described as a symbiosis of geometric models and numeric or alphanumeric attributes.

The development of such models is a sophisticated, multilevel process due to a high degree of complexity and completeness of those models with objects heterogeneous by both their functionality and software description. Many experts from various production units, departments and even from individual entities are generally involved in the development of the ship’s 3D model. All the participants developing the model work simultaneously.

Prior to initiation of developing the 3D model of a ship, general arrangement should be worked out and thereby all units participating in the development start working in parallel to fill the model with the required elements in accordance with disciplines associated with those units. That is often done within
the same space (compartment) which would result in miscellaneous collisions.

Thus, prioritization is vital when considering arrangement of equipment and systems for outfitting ship rooms.

2. Research methodology and typical discrepancies
From the structural point of view, small-tonnage ships feature small compartments, confine passage ways and service areas, which will significantly influence selection and layout of equipment and associated elements.

On the basis of more than ten-year experience of developing 3D models of actually built offshore facilities within the framework of high-level Tribon M1.2-3 CAD, the authors of the article have performed an expert analysis of the most probable causes of occurrence of collisions and discrepancies in the 3D model in the process of its development.

General collisions, which would occur in a 3D model while designing a small-tonnage ship, are listed below:

- pipeline/air duct/cable run blocks access to/exit from a room;
- pipeline/air duct/cable run blocks access to equipment or service area;
- pipelines clashes with cable runs;
- equipment installation prevents a door (or another closure) from being opened by 90°, or blocks the doorway;
- pipeline/air duct/cable run reduced cargo area or equipment service area.

Typical collisions are illustrated in Figures 1-3.

![Figure 1. Pipeline run blocks access to/exit from a room.](image1)

![Figure 2. Pipelines clashes with cable runs.](image2)
3. Rules and procedure of developing the 3D model of a small-tonnage ship

What is to be modelled is steelwork, equipment, pipelines and cable runs, at a level of detail to provide valuable insight towards mutual arrangement of its main (or pre-assembled) elements.

Figure 3. Equipment installation prevents a door (or another closure) from being opened by 90°.

The 3D-model must incorporate the following:

- Steelwork, at a level of detail to enable issue of detailed documentation. What is to be modelled is both individual elements and details (drain holes, flange edging, etc.).
- Mechanical equipment, electrical equipment and furnishing of rooms are modelled at a detail appropriate to develop material- and equipment take-offs. Fasteners to be ordered in sets are not to be modelled.
- Personnel passage ways (to be modelled as a solid).
- Pipelines having equal to or greater than DN=50. Lesser diameter pipelines are not modelled. Pipelines are modelled with a due consideration of insulation. Pipe fittings and end mating flanges are modelled as part of pipelines. Pipeline hangers are modelled as appropriate, as an example of their typical construction solution.
- Instruments on pipelines and otherwise as appropriate, except for instruments supplied as part of pre-fabricated units, SKIDs, equipment.
- Electrical equipment with 100 mm or greater in any of the sizes, light fixtures, loud speakers, display panels, etc., except for electrical equipment supplied as part of pre-fabricated units, SKIDs.
- Cable runs greater or equal to 100 mm in width are modelled as a solid.
- Railing with stanchions for securing electrical equipment.
- Ladders and gagways.
- Insulation and lining of rooms.
- Air ducts, considering insulation.
- Cranes, crane pedestals and crane boom rests, as well as miscellaneous specific equipment.

The authors recommend using the below listed priorities of arrangement of equipment and systems inside rooms and compartments of small-tonnage steel ships:

- it is necessary to review the ship general arrangement drawing and find out all “prohibited areas” on that. Arrangement of any equipment, cable runs or pipelines within “prohibited areas” is not allowed;
- it is necessary to highlight all main directions of running large diameter piping, which will take priority over other systems and cable runs crossing the main directions;
- system pipelines and runs with strict restrictions, as imposed by codes effective in the
project, for bending radii and/or run inclination angles and/or equipment entry/connection angles (only at entry/connection locations) take priority over any other pipelines and runs;

- system pipelines and runs with a greater typical size of the section (i.e. length of the greater side of the section, diameter) take priority over any other pipelines and runs, except for the above mentioned ones;
- system pipelines and runs with a greater sectional area take priority over any other pipelines and runs, except for the above mentioned ones;
- shape and maximal sizes of cut-out’s for penetration of pipelines, air ducts and cable runs – as per RD5.1122-91 “Rules of Construction of Sea-Going Ships” (ref. item 1.2.5.4, Table 1.2.5.4-2) (Figures 4, 5 and Table 1).

![Figure 4. Shape and location of cut-outs of Type I.](image1)

![Figure 5. Shape and location of cutouts of Type II.](image2)

### Table 1. Maximal sizes of cutouts for penetrations.

| Shape and location of cutouts | b | L | r | a | Area of application |
|------------------------------|---|---|---|---|-------------------|
| **Type I**                  |   | 0.25h at most | 2r |   | in beams, carlines, frames and bulkhead stiffeners |
| **Type II**                 | 0.4h at most | h at most | 2 times wall thickness at least, or 20mm, whichever is greater | L | |

4. Conclusion
The worked-out methodology establishing the procedure of developing the 3D model of a small-tonnage ship has been tried out in designing the research/survey vessel Pioneer-M. The research/survey vessel Pioneer-M is designed to provide integrated support of research/survey operations by use of replaceable Mobile Naval Research Laboratories arranged in 20ST containers. The vessel 3D model design was fully developed by the Institute of the National Technological Initiative, Sevastopol State University (Figure 6).

The vessel design was developed with support from the Agency for Strategic Initiatives and from the United Shipbuilding Corporation. Nowadays, preparatory work for the construction of the vessel is underway.

The worked-out-by-the-authors rules of priorities and sequence of developing a digital 3D model of the ship allow optimization of man-hours and ensure consistency of work being performed by different disciplines within the entity—the developer of the model.

Further work is anticipated to formalize the 3D design process within the framework of use of PLM and the development of procedure-oriented algorithms determining the procedure of development.
Figure 6. The research/survey vessel Pioneer-M 3D model design.

References

[1] Malay P 2015 Ship work breakdown structures through different ship lifecycle stages ICCAS 2015 1 1-15

[2] Sthéfano L A; Thiago G M; Henrique M G 2015 Product life-cycle management in ship design : From concept to decommission in a virtual environment 29th European Conference on Modelling and Simulation (ECMS) SVT 88

[3] Chou Y C, Jen F 2004 Applying Neural Networks In Quality Function Deployment Process For Conceptual Design Journal of the Chinese Institute of Industrial Engineers 587-596

[4] Zorriassatine F, Wykes C, Gindy N 2003 A survey of virtual prototyping techniques for mechanical product development Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture 217 513-530.