HOLISTIC SHIP DESIGN – ENABLING HOLISTIC THINKING ACROSS ORGANISATIONS WITH DIGITAL COMPONENTS

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SUMMARY

People have been designing and building ships successfully for hundreds of years, constantly adopting new technologies for better ships and improved design and building processes. Digital tools have been around for quite a while, but it is only just recently that initiatives like Industry 4.0 and the Digital Thread are opening a new and more digital world for the marine industry. Tools and workflows are becoming more connected and enabling to design, build and operate ships holistically.

The ship designer, working holistically, needs to integrate the supplier of components in his process. Organisational borders and different IT-Ecosystems must be overcome to meet the common goal: a better ship for the future fleet.

We have learned that today this seems to be a challenge in communication rather than technical limitations.

In this paper we discuss the principle and important key points of how Digital Components will help to integrate the suppliers into a holistic ship design process. We lay out common best practises and lessons learned of how Digital Components should be defined.

NOMENCLATURE

[Symbol]	[Definition]
CAD	Computer-Aided Design
CAM	Computer Aided Manufacturing
CAx	Computer-Aided technologies
GD&T	Geometric Dimensioning and Tolerancing
IP	Intellectual Property
JT	Jupiter Tessellation
KBE	Knowledge Based Engineering
PLM	Product Lifecycle Management
PMI	Product and Manufacturing Information
STEP	Standard for the Exchange of Product model data

1 INTRODUCTION: HOLISTIC SHIP DESIGN AND DIGITAL COMPONENTS

Ships have been successfully built for hundreds of years. Building techniques, tools and knowledge were continuously developed and affected by industrial developments and changes. Currently the 4th industrial revolution is influencing the way ships are planned, designed, built and operated. The concept of the Digital Twin is one well discussed outcome. (1)

To be truly competitive and being able to utilize all the advantages of a digital definition stakeholder involved in ship design, manufacturing and ship operation must understand that they are part of a holistic process. Holistic thinking and design processes will be key factors in order to be commercially-, technically- and environmentally competitive in ship design, building and operation. (2)

Many different stakeholders, among different organisations, are involved in designing and building a ship. Supplier organisations need to be integrated in the holistic design process for successful building and operation of the ship. It is the ship designer that is acting as integrator of all suppliers and typically it is a different set of suppliers per ship design project.

The ship designer is relying on getting a sufficient set of data and information from the suppliers to be able to integrate components into her design successfully. This communicational challenge will be very well addressed by applying the concept of Digital Components as discussed in this paper.

Having the concept of Digital Components as a common industry understanding will provide a tool to the industry for better collaboration and will give a cutting-edge advantage for those using them.

2 FUNCTION OF DIGITAL COMPONENTS IN HOLISTIC SHIP DESIGN

Between the ship designer and the component supplier there is a need for different communication layers:

- Collaboration
- Specifications
- Geometrical

The Digital Component is a single entity which can unite those communication needs as a single item representing the component in digital processes and the definition of the Digital Twin.

The collaboration layer is helping the stakeholders by storing information about product maturity, process and delivery dates and all the information which is relevant for the process of integrating the actual component to the vessels design. This layer is representing relevant functionality to a wide range of involved roles.

The specifications layer is describing direct characteristics of the asset represented by the digital component (i.e. output power of an engine). This layer of data is significant also for non-geometrical design processes such as Systems Engineering. It is interacting with the ship designers requirements management and may change throughout the design process. Therefore it needs to be tightly connected with the collaboration layer, especially with the maturity information.

The geometrical layer of the Digital Component is a 3-Dimensional representation of the asset which has been optimized for the use in other CAx disciplines. Relevant

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information, such as interfaces to other disciplines (i.e. ship structure, piping etc) must be displayed to support the design process. Furthermore, the geometry must be a simplified space reservation body that is sufficient for display purposes [and drawing creation].

3 DIGITAL COMPONENT CATALOGUES AS MARKET ADVANTAGE

Ship Component Suppliers are used to deliver their information/products through the use of PDFs and 2D drawings. Some also supply 3D geometry, however, often without adjusting this geometry to the required purpose. Most examples we have seen were overloaded with details which were irrelevant for the ship design process.
It is crucial for marine equipment suppliers to have routines to keep their information [including the shared geometry] updated and revised to ensure that the correct information is shared with the ship designer.
As more and more Ship Designers and Yards are moving to holistic ship design it will be a competitive advantage for those marine equipment suppliers that are able to supply their customers with usable 3D models with the right information, format and size. Over time, as 3D ship design matures into holistic ship design, it will become a requirement from ship designers to have usable models. Marine suppliers not able to deliver those will be left out. There are already Ship Design companies requiring the availability of usable 3D models as a requirement for their suppliers.
A supplier utilizing input packages for Digital Components as a competitive advantage is PON POWER. The Norwegian Catepillar engine dealer is supplying their customer with ISO14306 files with geometry optimized for the ship design processes in an online catalogue (www.poncept.com). We think that this is an example that other suppliers should learn from.

4 DEFINITION OF DIGITAL COMPONENTS

The challenge in building a Digital Component is that not only different organisations are involved in the use of this component but also different digital ecosystems.
To integrate the Digital Component holistically in the ship design process it is required to have all layers [of the Digital Component] fully embedded and accessible into the ship designers' PLM System. Today there is no dedicated exchange format for Digital Components identified. There is a range of neutral exchange possibilities for geometry or data which may be used. For the research of this paper PLMXML and ISO14306 was used. The concept of the Digital Component however is not locked to those formats. The key to make the Digital Component a working tool is openness and an understanding of which information should be shared, and how, from the supplier to the ship designer to make the Digital Component work.
The general architecture of the Digital Component is an Item/Item Revision and serves as a single container accommodating the different layers.

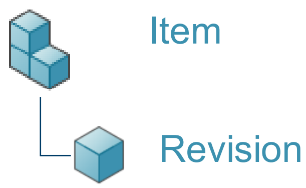

Figure 1: Item and Item Revision

This will also enable control and traceability about the maturity of the Digital Component via Revision Control.

4.1 COLLABORATION

The main purpose of the collaboration layer is to ensure that the right information is accessible at the right time. Modern PLM solutions provide functionality for this, such as revision loading rules. The challenge with the Digital Component is to extend the process across several organisations [supplier and ship designer].
The main entities for the collaboration layers are:

- Identification of the Digital Component
- Maturity of the Digital Component

The identification of the Digital Component needs to be consistent throughout the lifecycle of the component within the Digital Twin. When organising the Digital Component with an Item-Item Revision relation the identification of the Item will ensure this.
The maturity of the Digital Component needs to be traceable and distinct, also across organisational borders. This is a given when using the Revision ID of the Item-Item Revision relation. As best practise we strictly recommend to only allow one status per revision. We encourage a clear definition of the different statuses to ensure a distinct communication. When revising the Digital Component an obsolete status must be applied for a clear communication. The status naming and definition concept need to be clearly understood by all stakeholders. Status proven to be applicable with its definition can be found in Table 1.

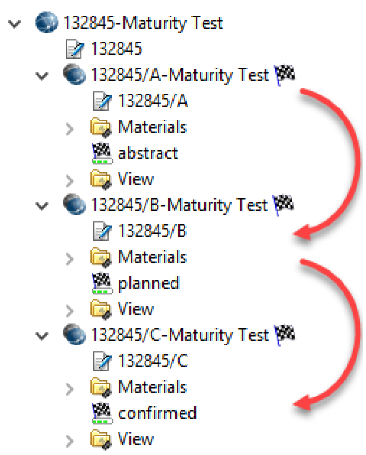

Figure 2: Item with different Revisions and status

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[Status]	[Definition]
Abstract	Placeholder for the need of a component, requirements to be identified.
Planned	The ship designer planned for a specific component, requirements are clear.
Confirmed	Supplier confirmed requirements and all specifications of the component.
Obsolete	Revision is not valid

Table 1: Status definitions for Digital Components

Other information for collaboration may be distributed between Item or Item Revision depending on whether the information might change throughout the lifecycle of the Digital Component or needs to be consistent.
Further recommended collaboration information on the DC Revision might be: Supplier of Component, Supplier contact Information and contact person, Date of status assignment, Assigned Digital Twin, Effectivity in Digital Twin, Classification of the Digital Components function in the Digital Twin.
Some of the information on the collaboration layer is controlled and managed by the PLM system of the ship design organisation. Others may be interfaced. In our research and investigations PLMXML was proven in use.

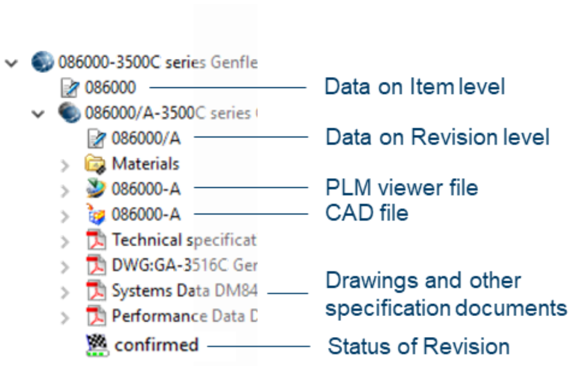

Figure 4: Information Structure of a Digital Component

4.2 SPECIFICATIONS

The set of specifications data can be divided into two parts, the first to be relevant for the holistic design processes and the second is data needed for other references. Other reference data (i.e. installation or maintenance documentation) may be represented in own datasets below the Digital Components Revision. The pdf as a dataset type is typically a good fit, as this already has been established as the communication file type between the supplier and the designer.
The set of specifications which is relevant for holistic design processes needs to be available in a data type accessible by the PLM and CAx solutions of the Digital Twin hosting ecosystem. Use cases may be interactive use of the data in calculations, automated requirement checks, search scenarios.
Exchange of specification with mapping of data types can be achieved quite well with XML based formats, such as PLMXML.

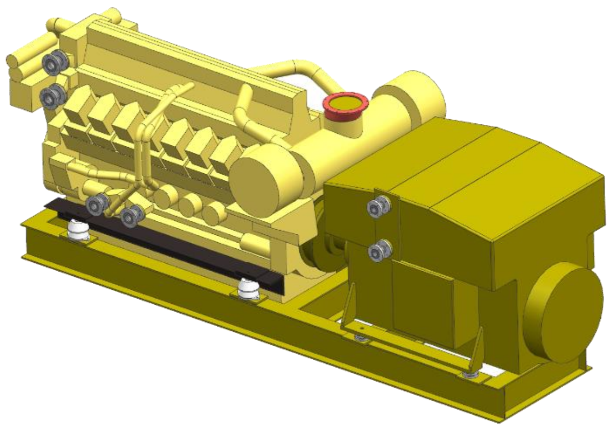

Figure 3: Optimized Geometry from Pon Power

4.3 GEOMETRY

Exchanging and sharing a geometrical representation of a Digital Component is a challenge in two aspects. In many scenarios the geometry will have to be exchanged between two different CAD authoring tools. In most scenarios the amount of geometrical information available at the supplier is way more extensive than needed in the design process and will overload the Digital Twin.
To exchange data between different CAD systems there is a wide range of formats available. It is important to ensure that the suppliers deliver a proper export from their CAD authoring tool which will be compatible to the import functionalities of the ship designers CAD authoring tool. Also, the aspect of visualisation of the Digital Twin (i.e. from the PLM system) is a use case to consider. As a format with high durability we have utilized ISO 14306 (JT). A benefit to mention here is that there are viewers for JT available as well as a wide range of CAD systems with export and import engines for this format.
In addition to JT, the ISO 10303 (STEP) was tested for certain scenarios. A clear benefit of the STEP format is that many CAD tools have sophisticated export and import engines for this format. Compared to JT, file sizes are larger. The AP 242 STEP protocol has comparable tessellation capabilities to JT. For the visualisation aspect this protocol is preferable.
Both formats support GD&T (or PMI) capabilities which can be utilized for highlighting Interfaces and their details to the component.
Independent of the format to exchange, the geometry must get some relevant reduction in complexity. In many cases suppliers have their own comprehensive digital description [even a Digital Twin] of their product which is to be integrated in the ship design. This comprehensive definition will be a complete overload for the holistic ship design process. Functionality wise, a space reservation of the component is needed to be placed in the ship design. The space reservation needs to feature the relevant interfaces so the space reservation can be integrated in ship structural and routing processes.
When creating the space reservation, visualisation purposes as well as potential drawing creation of the Digital Component should be kept in mind.

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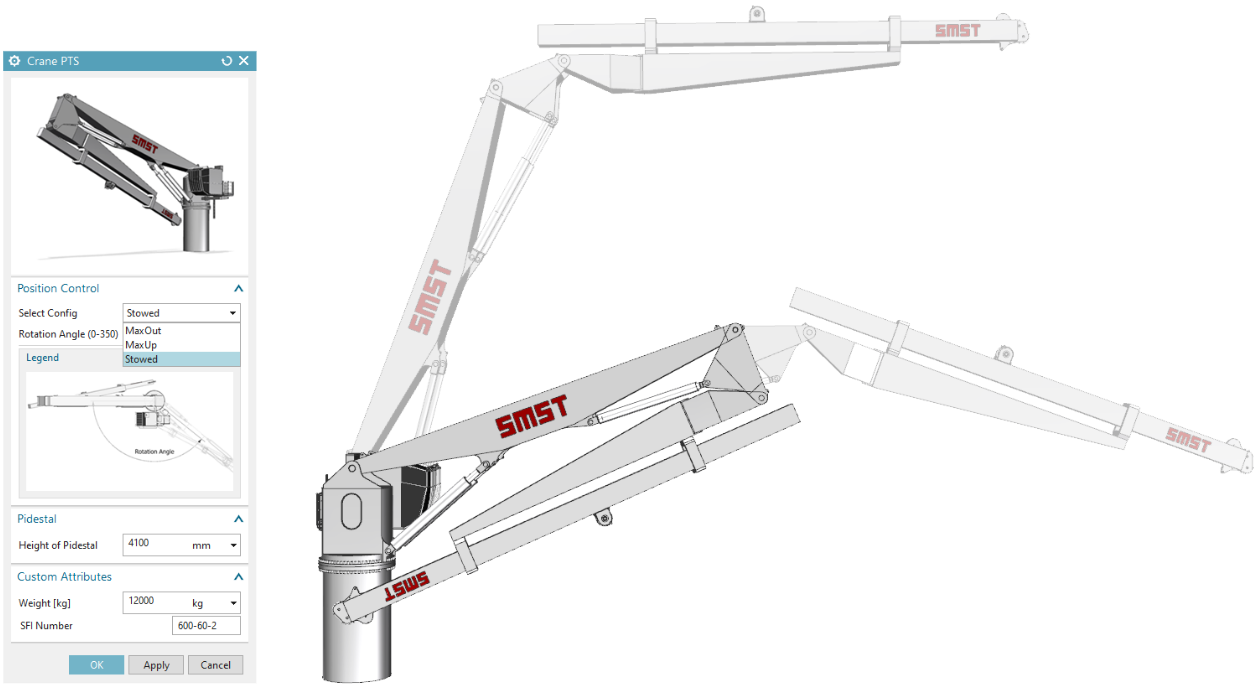

Figure 5: Digital Component prepared with different arrangements

5 ENABLING TECHNOLOGY

Our background and experience comes from working with Siemens PLM Software. As a provider, Siemens PLM Software differs from its competition in its openness and a devoted alignment to its customers. Unlike its major competitors, Siemens PLM Software has shared its technology and promoted openness. Good examples are JT that has become an ISO standard (14306) and Parasolid that is used by several hundred competing companies in CAx.

Siemens PLM Software heritage from both CAE and CAM solutions being able to communicate with different systems. This heritage, Siemens builds on in both CAD and PLM.

Major customers such as Samsung, Daimler Benz and Rolls Royce are driving the technology forward together with our 90 000 other customers with more than 11 million seats. The basis of the technology is shared by different industries like Automotive, Defence and Aerospace, Machinery, Marine and High-Tech.

Ship design- and building solutions are built upon a shared technology base with other industries, meaning that Siemens PLM Software can share developing costs on diverse industries and a large number of users and offer the latest state of the art software in the various industries. Ship design customers in Europe, USA and the Far East have been instrumental in developing the solution for commercial ship design into a leading-edge position. Because we share destiny with more than 11 million seats Siemens PLM Software is able to preserve its leading technology position in a world of accelerating technology and disruptive initiatives.

Ship design- and building is one of the most complex processes among the industries. Legacy vice it has also been a scattered process with many different systems and information silos. Like most other industries the product [the vessel] is becoming more and more complex. Customers have more sophisticated needs and green politics is driving the demands for efficient and innovative solutions. Digitalization will eventually transform the marine industry and create a new generation of Digital Shipyards. To meet these demands ship design customers need a good foundation and partnership [to their software providers] that can meet an ever more complex and compelling environment. Traditional providers of ships design software do not have either the muscles or the technology to fulfil these needs.

Siemens PLM Software with its openness and willingness to share and work together with customers contributes to competitiveness and secures an ongoing improvement. These customers can build upon Digital excellence and leverage the power of emerging technologies across organizations giving them ability to transform data into actionable insight and ultimately gaining business advantages. Those customers will be able to capitalize on digital disruption and make the right decisions going forward in a competitive digital world.

6 CONCLUSION

The Digital Component can enable a closer cooperation between the supplier and ship designer. It is not only sharing geometry and information, the Digital Component can help the ship designer to integrate the supplier into the design process.

Marine equipment suppliers adopting the basics about Digital Components published in this paper will get a powerful advantage to compete on their market.

Ship Designer will benefit by a more efficient and transparent design process.

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8 AUTHORS BIOGRAPHY

Torben-H. Wölke (Stachowski) currently holds the position of Technical Lead Shipdesign in Digitread and, being a Naval Architect, is responsible for activities in the ship building industry.
Torben is dedicated in developing new digital ship design processes and has been since he started working with it in 2010. As the link between end user and software development he helps to get Siemens PLM products ready for the commercial ship building market.

Marius Slagsvold is a Solutions Architect and Product Manager for CAx in Digitread AS. Marius is motivated by helping future and existing customers succeed in their engineering workflows and everyday challenges by utilizing state of the art solutions from Siemens PLM.

Helge Kjeilen is Chairman and owner in Digitread AS distributing and supporting Siemens PLM Software. During his career starting in 1981 he founded and co-found several Nordic IT companies. Helge has also worked as Country Manager in both Apollo Computer and Prime Computervision. For 25 years Helge has severed as board member in Wittusen & Jensen. Helge Kjeilen has a Master of Business and marketing (MBM), Field of study Business Administration and Royal Norwegian Naval Academy, OKA. Helge has for 7 years been sensor for Master thesis at Norwegian University of Science and Technology.

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