



**SIEMENS**

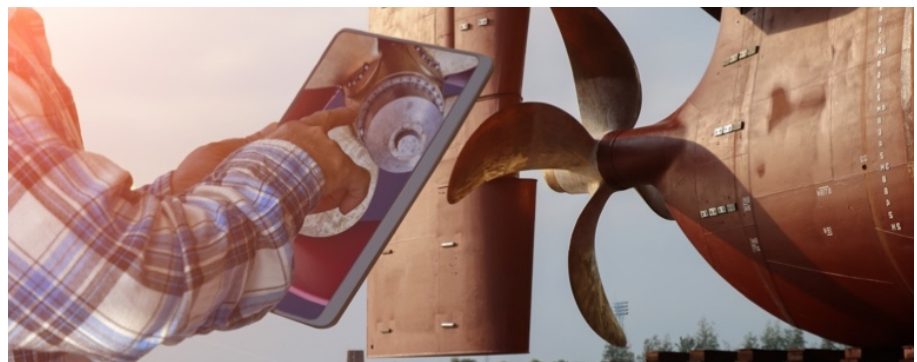
*Ingenuity for life*

# Digital Ship Construction

Shipyards 4.0: Bringing the digital twin to the shop floor

## Rising complexity on the shop floor

Stricter environmental/safety regulations and increasingly customized functional requirements have been driving the demand for higher value-added vessels. These vessels are not only more complex to design and engineer, they are also more complex to build. This wave of complexity is hitting the shop floor just as increased competition and rising economic uncertainty are forcing shipyards to reduce their production costs and time-to-market. Shipyards must deliver on spec, on time and on budget if they are to remain competitive. But when margins are already so low, how can shipbuilders keep reducing production costs without compromising quality?



# Processes that have worked so far will become inefficient as the complexity of design and build increases

## The importance of planning

For most shipbuilding projects, 80 to 90 percent of the project's total cost will be spent during construction: material, labor, equipment, system suppliers, overhead, etc. As a result, efficient planning can have a huge impact on bottom-line profitability. Planning facilitates collaboration and cross-team synchronization, minimizes risks and uncertainties, and supports configuration and change management. Shipyards are fully aware of this and have implemented enterprise planning tools to support the planning of ship design and build. As ship complexity increases and more high-tech equipment and systems are required onboard, adhering to the right work sequence is critical to avoid rework and delays. This is done by strictly following the master production schedule (MPS), which was developed during the design stage as part of the design for production strategy, based on the required production timeline and product mix, the layout of the shipyard(s), and the product flow.

As part of the MPS, a material requirements plan (MRP) is created. The MRP breaks out the bill-of-materials (BOM) and details plans for work orders and purchase orders. Most shipbuilders have implemented an MRP software-based system to take inventory of the components and raw materials on hand, identify which additional ones are needed and schedule their production or purchase. To be successful, this system must be fully integrated with the enterprise resource planning (ERP) system. Today, a typical shipbuilding environment can count several geographically dispersed shipyards, each with its own set of suppliers and co-makers. Thus, the overall ERP system needs to be able to be used to organize materials and equipment by individual shipyard and intercommunicate those needs to enable each shipyard to redistribute stock for better end-to-end enterprise productivity.

Although implementing an MRP system as part of the shipyard's ERP backbone has led to a significant increase in productivity, there have been limitations. For example, the computer-aided design (CAD) tools shipbuilders rely on are often legacy, closed-loop systems, with no interface for data exchange. In addition, with no automated feedback loop between the functional areas of engineering, manufacturing and logistics, updates need to be done manually in a process that is both time-consuming and error-prone. Shipbuilders are

aware that there are some digital solutions available for these purposes, but they are unsure of their possibilities and return-on-investment (ROI).

## Why planning is not enough

Shipbuilders are conservative, cost averse and wary of investing in upgrading processes that have historically worked for them. When looking at new digital technologies, they consider the cost of the software, but also the cost of tasking their best employees to work with the software provider on a potentially lengthy implementation. What they do not consider is processes that have worked so far will become inefficient as the complexity of design and build increases.

With this growing complexity comes the need for a robust requirement, change, configuration, risk and schedule management system. This system needs to encompass all functional areas of the shipyard to ensure that at any given time all teams can access the latest information and work in sync towards a common goal. Only this way can costs be kept at a minimum while overall enterprise productivity is increased.

## The digital shipyard

To optimize manufacturing planning and production, shipbuilders must adopt a holistic digital thread approach to ship construction. This approach relies on the implementation and integration of three core systems: (i) the ERP system, (ii) a streamlined and intuitive product lifecycle management (PLM) platform, (iii) and the manufacturing operations management (MOM) system, an integrated solution that consolidates all production processes, including quality management, advanced planning and scheduling, and manufacturing execution systems in one environment. Having a MOM backbone in place allows shipbuilders to deploy electronic work instructions (EWI) with clear visuals to increase shop floor efficiency.

ERP, PLM and MOM are the three foundational elements of the digital shipyard, or Shipyard 4.0. Traditionally, those three "backbones" have been distinct. However, they must be connected to ensure that design and engineering, production and planning, and logistics are always in sync. This ERP-PLM-MOM closed-loop approach is referred to as the "golden triangle" of lean ship production. It ensures that the product delivery cycle is streamlined, that redundant (and

often prone to error and delay) manual processes are eliminated and that quality issues can be proactively identified and corrected. It enables concurrent design and production with the seamless integration of engineering and manufacturing planning tools so that production can start earlier and is done right the first time.

Shipbuilders can simulate the entire shipbuilding process in an integrated virtual shipyard environment before the first plates are even cut. This allows them to optimize the ship's production sequence and minimize design changes and out-of-sequence work. All vessel-related data can be maintained in a comprehensive digital twin of the vessel, which can then be used as the single source of truth to share real-time project status and ensure efficient collaboration with all parties involved; for example, suppliers, subcontractors, co-makers, class societies and even clients.

Once the golden triangle is in place, customized, low-code, cloud-based applications can be developed to visualize the real-time, synced pool of data and facilitate tasks such as inclination test preparation, smart warehousing, ship inspections, noise measurement, issue management and smart planning. Some of these tools must be able to work offline to capture information on the shop floor where connectivity is limited and upload the data to the PLM system for verification once connectivity is reestablished.

In addition to the digital twin of the vessel, shipbuilders can deploy a digital twin of the shipyard to manage the yard as a capital asset. The health of the most critical production equipment can be monitored for predictive maintenance, thereby avoiding unscheduled downtime and production delays. Simulation can be used to optimize the yard layout for higher efficiency, or to verify the ROI on equipment before purchase.

Production efficiency and quality in the yard can be increased with the introduction of reality technologies, such as virtual and augmented realities, and with the automated control of cutting, grinding, bending and welding systems. Costs can be further decreased by introducing new production methods such as 3D printing, and new materials, such as lighter and stronger composites.

Having a common data backbone across design and manufacturing enables shipbuilders to adopt a modular approach to shipbuilding. The "build anywhere integrate anywhere" strategy allows shipbuilders and co-makers to design, fabricate and test whole sections separately and concurrently, thereby reducing the cycle time of construction, and eventually the cost of production.

Finally, this digital thread approach enables standardization practices based on information re-use. Knowledge and best practices from current and previous projects can be captured and stored in the data backbone, where they can be used to inform shop floor decisions as well as be fed back to the design teams to further optimize designs for production. As the skill gap left by an aging workforce widens, this knowledge can also be leveraged as part of the EWI to train the younger generation of workers and facilitate task execution.

**Conclusion**

Shipbuilding is a complex process. To cut costs and increase productivity without compromising quality, this process needs to be fine-tuned and, as much as possible, automated. This can be done by adopting a digital thread approach to ship construction. By leveraging digital twin technology, digital shipyards can minimize risks and inefficiencies in their current manufacturing process and turn complexity into a competitive advantage.

