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DIGITAL INDUSTRIES SOFTWARE

The marine executive's guide to realizing digital transformation

Equip your shipyards and vessels for data-driven shipbuilding excellence

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Executive summary

Three key competencies drive the success of next-generation shipbuilding under today's evolving and highly challenging market conditions. First, your organization must be able to tap – with ease and immediacy – the wealth of industry know-how you have built, often over decades. Second, you must be able to give your architects, designers and engineers the latitude and creative license to incorporate the latest vessel and shipyard innovations, many of which are becoming essential to competitive success.

Third, and underpinning the other two competencies, it is imperative that your organization advances in **digital transformation maturit**y. Digitalization provides your organization with open access to the knowledge that has historically resided only in the minds of your engineers and skilled workforce members or in out-of-the-way archives and data vaults. Digitalization also enables automated performance of repetitive, meticulous tasks, leaving valuable human assets unencumbered by these mundane duties.

What is the best way to navigate your shipbuilding digital transformation journey? How can you confidently select and deploy technology that is fully equipped to support your end-to-end vessel lifecycle, including design, manufacturing, operation and repair, both now and into the future? Siemens Digital Industries Software is ready to help you answer these critical questions. Through our decades of service to makers of ships, boats, submarines and offshore structures, we have cultivated a collaborative expertise that we employ to assist shipbuilders as they pursue excellence in the three key competencies.

This eBook offers a guidepost for marine executives to learn more about accelerated digital transformation. We define the stages of digital transformation maturity and provide insights to help you craft your organization's unique digital journey. Leveraging our insights and your hard-earned knowledge of your maritime sector, your organization can vitalize the industry while realizing business leadership and market success.

The urgency of digital transformation

There's new excitement over innovations coming to the maritime market. Autonomous ships. Propulsion systems powered by sustainable fuels. Additive manufacturing and other new materials and processes. Robotic shipyard automation.

These innovations epitomize an industry undergoing constant change, and in some cases, major metamorphosis. An extensive reframing of the marine business is underway, and this may temper excitement with an undercurrent of uncertainty or apprehension among your organization's decision-makers.

The fluidity of the marketplace poses growing challenges to shipbuilders:

Cost competition. As ship owners and operators face narrow profit margins and supply chain disruptions, they seek more cost-effective vessels, delivered faster. In this environment, shipbuilders must not only manage their own supply chain volatility and profitability challenges but also produce naval and commercial vessels that are more affordable, offer lower total cost of ownership and ensure higher operational availability.

Workforce changes. Shipyards must be staffed with workers skilled in traditional trades – welding, pipefitting, electrical – and also those with specialized skills required for innovative materials and processes. Yet high retirement rates and small candidate pools make it difficult to recruit and retain these workers.

Time to market. Most shipyards struggle to meet launch dates even when building conventional ships, and today's innovative, complex ship designs compound these difficulties. Poor shipyard infrastructure, internal team silos, outdated processes, workforce shortages and supply chain volatility all contribute to unacceptably long vessel construction times.

Operational availability. Ship owners and operators want to extend the operational life of their existing fleets as the cost of new vessels skyrockets. The internet of things (IoT) and predictive software would help manage maintenance, repair and overhaul (MRO) costs by offering real-time feedback on operational health and predictive maintenance, but most vessels are not yet equipped with these technologies.

Decarbonization. Innovation toward more sustainable fleets is crucial since the United Nations International Maritime Organization (IMO) adopted aggressive new targets for CO_2 and greenhouse gas (GHG) emission reductions. Compared to 2008, commercial ships are to reduce emissions of CO_2 40% and GHG 30% by 2030, and by 2050 achieve net-zero GHG emissions with a 70% reduction in CO_2.

While these challenges are daunting, they also represent opportunities. Marine organizations that embrace accelerated digital transformation maturity will not only survive but flourish and command global leadership in this marketplace.

The foundation of digital transformation maturity

The challenges we just enumerated make clear the objective a modern shipbuilder must achieve: **to build more optimized vessels faster, for far less cost, while multiplying the impact of each workforce member.**

A strategic approach to accelerating digital transformation maturity empowers marine organizations to achieve this objective. It enables you to:

- Streamline design, engineering and manufacturing
- Connect systems and processes to trace a finished vessel back to the original design
- Optimize the shipyard to modernize and automate production methods
- Develop and achieve first-class capabilities in areas of specialization
- Transfer knowledge of an older skilled retiring workforce to newcomers

To attain these benefits, today's digital solutions offer unprecedented interoperability, simulation and automated data traceability. Robust software and systems connect product lifecycle management (PLM) and enterprise resource planning (ERP) so that every team works within the same platform with access to the right data and information, updated in real time. They incorporate Industry 4.0 technologies such as IoT, big data and cloud applications. And in ways we detail below, they leverage industrial-grade artificial intelligence (AI) to ensure that shipbuilders meet their budgets and timelines.

Digital transformation maturity is built on three critical features of today's digital technology:

Combine virtual and physical worlds with the most comprehensive digital twin. When all aspects of the real product and production environments are represented in the digital twin, marine organizations can generate new insights to continuously optimize vessel design, production and operations.

Provide multidisciplinary connectivity to facilitate optimization. Personalized easy-to-use tools disseminate information that is centralized and updated in real time. Design, engineering and manufacturing teams can exchange and use this information with extraordinary efficiency.

Capitalize on a flexible, open ecosystem. This approach creates an integrated environment that supports legacy applications, leverages new solutions and quickly incorporates new technologies. Using a closed loop, data is fed back into digital twin models that are continuously refined.

These features enable digital transformation to reach every domain in your organization.

The five levels of digital transformation maturity

As you face today's demands for ship and shipyard cost-efficiency, innovation and sustainability, accelerating your marine organization's digitalization journey is essential to your success. This digital journey is uniquely supported by Siemens in two ways. First, the open, flexible, scalable Siemens Xcelerator platform enables the interoperability, simulation and automated data critical to next-generation shipbuilding.

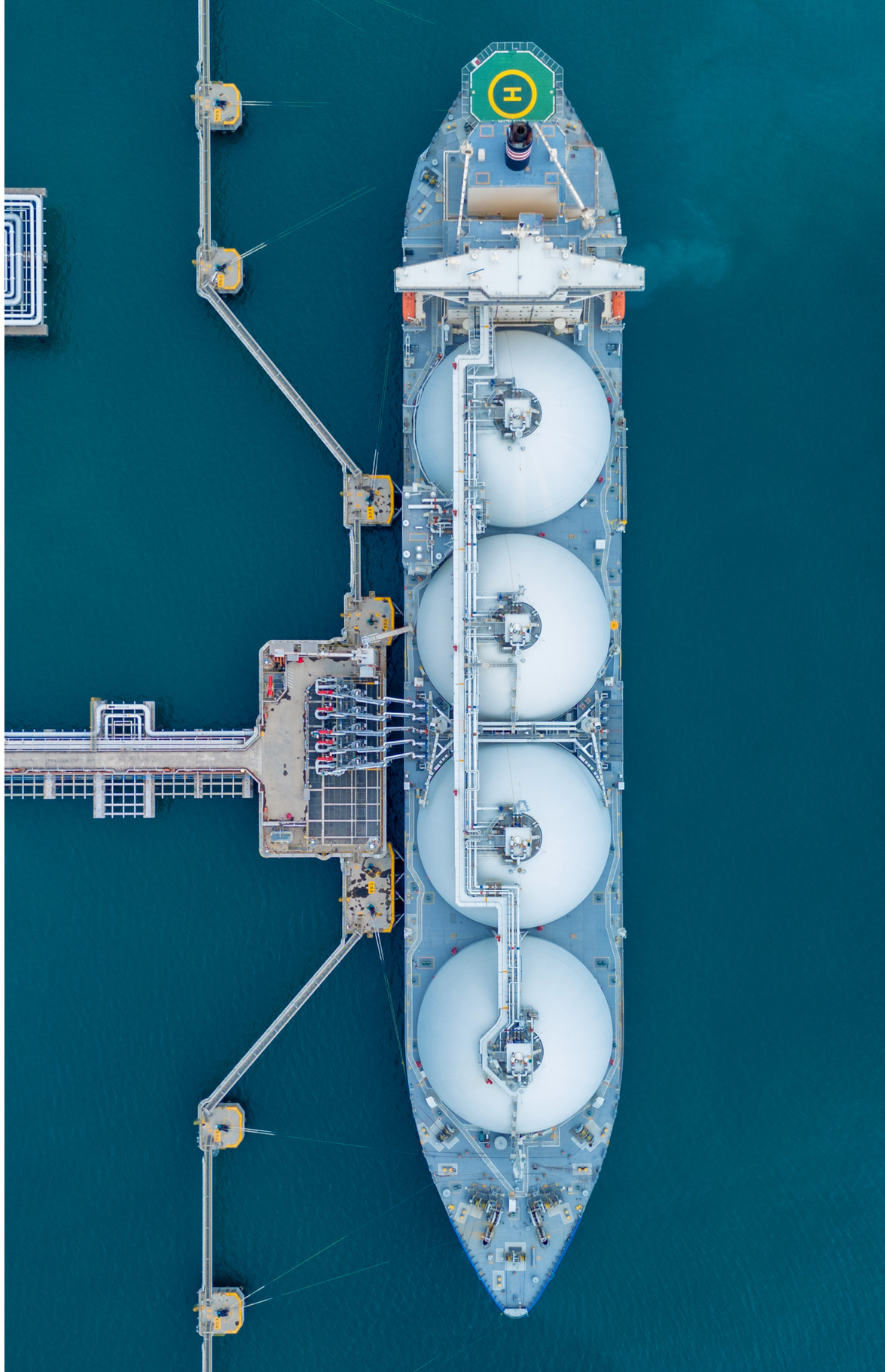
Second, Siemens' five levels of digital transformation maturity provides a roadmap to building more innovative, optimized vessels faster, at lower cost, while multiplying the impact of every human asset, from naval architects to skilled trades personnel. It helps you assess where you are on your digitalization journey and then develop a strategy for maturing your digital transformation.

The levels of digital transformation maturity do not correspond one-to-one with particular software solutions. Instead, as you execute the strategy, you will link multiple solutions across various disciplines and accomplish more than those systems do individually. You will gain the full functionality of each level, which then becomes indispensable to subsequent levels of digital transformation technology.

Incorporating new digital functionality
Siemens Xcelerator is designed to easily incorporate new digital tools into your digital ecosystem as they become available. A recent example is **Siemens immersive engineering and AI-based deep-physics simulation**, which provides purposeful AI tools that can be applied to previously generated designs to accelerate performance prediction and optimization.

NX Immersive Designer, a product within the Siemens immersive engineering portfolio, enables collaborative cross-domain design using a fully immersive infinite canvas. Your team members can also use NX Immersive Designer to experience, interact and collaborate in 3D within the industrial metaverse, thanks to our exclusive partnership with Sony to create the Sony XR head-mounted display.

As you progress in digital transformation maturity, you will be able to leverage future AI capabilities for even greater innovations, design and production efficiencies and vessel performance.



WHAT

Enterprise reference architecture:

Provides secure, traceable, well orchestrated data from requirements to industrial edge – capturing of all data along the lifecycle of assets and systems.

Enterprise interoperability:

Requirements, connected to design, leading to tests, commissioning and then feedback loop from the industrial edge – an authoritative source pulling from all enterprise federated data.

Automate the mundane:

Find mundane tasks where you can remove the “human in the loop” and free valuable human assets to focus on work that really matters.

Auto-generate multiple alternatives:

Generative design for assets, work packages and operations facilitate continuous improvement and optimization studies that support decision making across the asset and system lifecycle.

Model-based financial optimization:

The full stack of data (federated and live feeds) is analyzed and optimized for sustainability (both profitable and ecological) with thousands of iterations and a trained AI environment providing competitive advantage.

Configure → **Connect** → **Automate** → **Generate** → **Optimize**

Initial —— **Digital transformation journey** —— **Mature**

HOW

Create a physics informed digital twin along with a system of BOM, WBS or PBS structures that both internal and 3rd parties adhere to across the enterprise portfolio.

Create a digital backbone with agile APIs to generate the “stack” needed for the enterprise industrial metaverse.

Invest in AI/ML where confidence builds in the reliability of AI. Examples include systems design, risk-based inspection analysis, workforce management and other more routine and repetitive tasks.

Invest in physics based analytics that allow for “tuning” of assets in the virtual world with numerous iterations leading to optimal physical world performance.

Create AI/ML that links markets, supply chain, equipment performance, and maintenance optimization along with nimble low code.

LEVEL 1

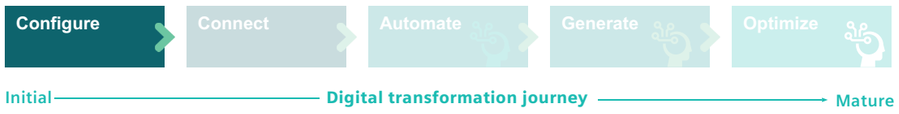
Configure

The first step of digital transformation is to transition from document-based to model-based workflows. At this level, a product data management (PDM) system creates a single virtual location to store assets that were previously kept on paper. PDM digitally configures all product lifecycle information, from target requirements through sea trials, and tracks changes as they occur. It gives your teams ongoing access and search capabilities with these digital assets, making it a simple matter to locate information whenever it is needed.

The configuration level of digital transformation has supported shipbuilders' longstanding **design spiral** approach to ship design and engineering. Dedicated digital point solutions such as CAD and ERP systems have accelerated the iterative, sequential design tasks of individual domain teams within the design spiral. Digital configuration provides a comprehensive picture and full access to each of your assets.

However, these numerous teams often have adopted different systems as they focus on specific aspects of ship design and performance. As a result, the product development process is disjointed at the configuration level. Siloed data handling of each domain leads to delayed and error-prone data sharing. So, for example, at this level of maturity the impact of an electrical design change on the vessel's fluid and thermal performance would have to be manually reconciled.

Disconnected work performed by isolated departments is increasingly problematic for shipbuilders as they face a proliferation of shipbuilding complexity, cost and regulatory demands. Limitations of the configuration level, ultimately, lead to less-than-optimal ship designs.



LEVEL 2

Connect

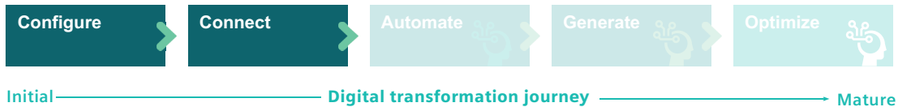
The second level of digital transformation maturity connects data sets, breaks down departmental silos and automatically communicates information among domains. A common digital backbone provides visibility and access to design, engineering and production data that is continuously kept up to date. Digital continuity accelerates cross-domain dialogue and activities, no matter where the information is created, while ensuring accuracy and version control.

Shipbuilders can use these automatic connections to bypass some of the limitations of the design spiral and implement an integrated ship design and engineering approach. Creating one collaborative environment to explore, assess and optimize design alternatives, the second level of digital transformation maturity is supported by integrated tools that include mechanical, collaboration, electronics simulation, manufacturing and operation. It also incorporates an app development platform and IoT. With these capabilities, your teams can collaborate effectively and efficiently to optimize both shipyard and vessel performance.

Shipyards can optimize shipbuilding processes, improve planning and reduce costs. Your teams can confidently perform concurrent design-build operations and achieve right-first-time construction. You gain higher shipyard productivity at lower cost and accomplish more on-time deliveries.

As you embark on new projects, your team members can reuse and expand upon previously generated design data while continuously accessing a central model that is always up to date and that incorporates design changes ‘live,’ as they happen.

This level of digital transformation maturity helps to reduce costs and enables shipbuilders to meet targets with confidence. By reducing manual interventions and accelerating linked design and engineering processes, connected digital systems equip you to streamline all stages of design, engineering and construction up to final verification and commissioning of your vessel.



LEVEL 3

Automate

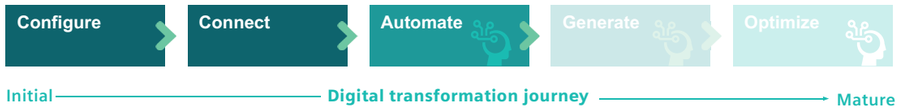
In ship design departments, at the shipyard and in the information exchange between these two domains, the next level of digital transformation maturity automates tasks that previously required manual intervention. It eliminates the heavy lifting of manually setting up, maintaining and moving data, and it knows how the information from various domains interrelates. Digital automation lets your shipbuilding teams virtually simulate, visualize, analyze and optimize not only vessel design but also shipyard production systems and logistics processes.

The automation level enables continuous optimization of ship design, engineering and construction across all stakeholders and the entire lifecycle. With mundane tasks performed automatically in the background, your workforce can collaborate more efficiently and focus more fully on innovation and performance outcomes.

Naval architects and design engineers can make decisions at the requirements or design level, because the system automatically determines the impact of each decision and handles all updates. Reports, simulation and test results, procedures, process control and more are immediately available in an interconnected ecosystem.

Shipyard teams, including construction planners, engineers, supervisors and skilled trade specialists, will find relief from labor-intensive construction activities. Digitalization at this level automates the creation of electronic work instructions for manual tasks. It shortens the learning curve for new staff members by enabling training simulations in virtual and augmented realities. It also supports automated equipment as it is adopted, such as robotic welders. The digital solution automatically manages design and schedule changes, routing information to relevant departments and eliminating omissions that have hindered traditional construction engineering and caused extra work.

As digital automation takes over manual tasks, your design, engineering and construction teams can explore and evaluate more options. They can focus on improvements or novel solutions to find the most efficient ship design and construction approaches – helping your organization to win new ship tenders.



LEVEL 4

Generate

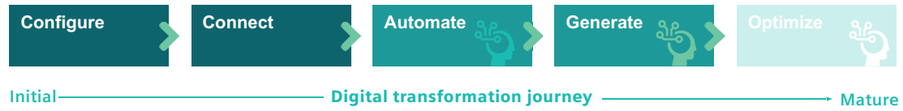
Distinct from the kinds of artificial intelligence that perform personal, academic and business tasks today, industrial grade AI is coming into its own with purpose-driven, reliable and secure applications for shipbuilders and other manufacturers. The generative design stage of digital transformation maturity involves advanced AI, machine learning (ML) and 'data lakes' – the proprietary knowledge that your marine organization has accumulated, often for decades.

Generative design algorithms ingest and sort through all this knowledge in an AI-powered multi-domain solution that creates one-to-many design alternatives. Taking advantage of these AI-based capabilities, naval architects can investigate and optimize multiple design variations, at full scale and under realistic operating conditions. A generative design ecosystem enables them to predict the final vessel's performance before it enters production.

Because they are no longer limited to individually innovating vessel designs and shipyard processes, your architects, designers and engineers can focus their time and effort more effectively, innovating at the systems level and establishing evaluation criteria. These can include cross-domain criteria, such as design-for-manufacture or design-for-service. The generative design system employs knowledge of all previous designs, including what worked and why it worked, to develop a few candidate designs and product manufacturing information (PMI) datasets.

Generative design can be performed within individual departments and domains as well as across the complete vessel or shipyard. Digital systems generate designs for hulls, propulsion systems, electromechanical systems and more, then easily connect these designs to simulation tools to perform virtual testing, measurements and performance analysis. Using these tools, your engineering teams can evaluate candidate designs, select one and perform any needed modifications to take it across the finish line.

With generative design, your time savings grow exponentially as you expedite product development and also multiply the impact of your skilled workforce.



LEVEL 5

Optimize

What if you could feed your digital systems desired outcomes – key performance indicators (KPIs) for vessel and construction performance, such as cost, weight, energy efficiency or service life – instead of (or in addition to) specific design or engineering goals? What if those AI-powered systems could then evaluate generative designs against those KPIs, adjust the design goals, and relaunch the generative design process? How would this transform your shipbuilding paradigm?

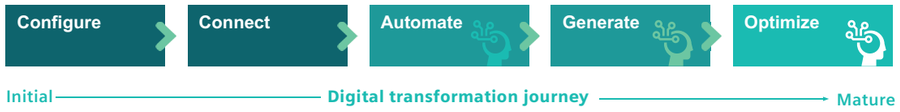
The final step of the digital transformation maturity framework, closed loop optimization (CLO), autonomously generates thousands of iterations and presents your engineering team with the top candidates most likely to meet all your KPIs.

This stage empowers your architects, designers and engineers to think creatively about vessels and shipyard ecosystems that the connected digital systems could bring to fruition. Innovation is constrained only by physical and electromechanical principles, not by human computational capacity.

As each new project unfolds, CLO generates virtual prototypes (digital twins) that are so realistic, they minimize the need for physical prototypes. Decision-makers proceed rapidly through design, simulation and testing, acceptance, verification and commissioning – slashing product development time upwards of 90 percent even as they apply an unprecedented breadth of ingenuity.

Ship owners and operators also experience transformative benefits from CLO digitalization. AI-enabled closed loop management of ship designs, processes, operations and services lets you analyze and aggregate lessons learned within a comprehensive digital twin of each operating vessel. Any authorized stakeholder accesses this data through personalized apps, determines the real-time condition of in-service equipment and implements predictive maintenance.

The five levels of digital transformation maturity set a framework for your company's technological progression and success for today and tomorrow. Yet it affects much more than technology – it uplifts the human culture within your organization in remarkably beneficial ways.



How your organization grows through the transformation journey

While the nature of digital transformation maturity is technological, its most important impact is cultural: accelerated digitalization will help you attract and retain the best people to carry out your shipbuilding mission.

The shipbuilding industry is facing a shortage of qualified personnel across nearly every department, created by factors ranging from a limited pool of engineering talent to the retirement of those experienced in key trades, such as pipefitting and welding. Additionally, new workforce requirements include an expanded set of specialized skills to execute innovations.

As your step-by-step implementation of new digital tools enables your marine organization to efficiently plan and execute your business activities – vessel design, manufacture, operation and/or repair – your veteran and newly recruited team members will thrive in an increasingly less tedious, more creative environment. In the process of building more optimized, safe and sustainable products, your high-skill workforce gets to focus on the kind of work they spent years of their lives preparing to do – work that they find fulfilling and will want to continue to do at your marine organization.

No matter your current stage of digital transformation, each digital investment will help you attract and retain a quality workforce while raising productivity and profits. Initial systems that improve connectivity and collaboration equip employees to more efficiently find and use relevant information out of the massive ocean of data. They can seamlessly communicate the results of their efforts across departments and domains.

As you move forward with tools that automate, generate and optimize the full spectrum of your business activities, you will multiply the freedom enjoyed by your high-skill people to focus on what they love to do – design, engineering, innovation, shipyard trades – rather than on what they have to do.

Improved workforce retention and human productivity give you a more predictable return on investment. Moreover, your burgeoning digital productivity accelerates product development and production lifecycles substantially. Your vessel owners and operators enjoy greater availability, less costly operations and more effective, life-extending MRO.

Each new investment in digital transformation maturity serves as an effective change agent for implementing your company vision. Accelerated digital transformation maturity brings about:

Speed-to-market – Build more optimized ships faster, accelerating the product development lifecycle across all your business domains, shipyard and supplier network

Workforce productivity and retention – Free high-skill workers from mundane tasks to bring their talent and skills to bear on product and process innovation

Increased margins – Replace physical prototyping and testing with rapid, cost-efficient virtual product development, and streamline and modernize facilities to build ships more efficiently

Industry leadership – Create innovation efficiencies and continuous optimization, meeting performance and sustainability targets in your products and processes

Equipping you for the journey – today and tomorrow

Digital transformation maturity nourishes a vision for the marine industry – that it will build the most sustainable, connected, cost-effective, technologically advanced and adaptable vessels ever – faster, for less cost and with a smaller workforce.

To realize this vision, industry-leading maritime organizations are setting out to develop a clear, practical and implementable plan for their digital transformation journeys. The experience and insights of your workforce may be key to directing this planning. Ask your team members or departments to list three mundane tasks they perform regularly that they don't want to perform anymore. As you determine how each of these tasks affects human productivity and your shipbuilding lifecycle, you can prioritize technology investments likely to have the greatest impact on your business and mission.

The goal of digital transformation maturity for shipbuilders is to empower design, engineering, manufacturing and operations to work together in a fully open, collaborative environment. To achieve this goal and future-proof your shipbuilding enterprise's success, it is essential to transition to an integrated, digital shipyard.

This is not an all-at-once undertaking but a journey – one that requires careful strategic planning and a stepwise approach to digitalization. You must first understand where you are now with digital transformation, then determine where you go next. If this guide has served its purpose, you have a clearer idea of how to accomplish your own digital transformation journey, and some inspirational notions to carry with you along the way.

Siemens is taking the lead in bringing together the digital tools needed for your journey – tools that work in an interoperable way that just doesn't exist anywhere else in the industry.

For shipbuilders, Siemens supports your digital transformation with five key solutions:

1. **Systems engineering**
2. **Integrated ship design and engineering**
3. **Digital ship lifecycle management**
4. **Digital ship construction**
5. **Ship service and maintenance**

As you prioritize these disciplines in accordance with your executive mission and goals, Siemens is ready with the digital solutions that enable faster, lower-cost completion of each innovative vessel launched from your shipyard. You will secure your position as an industry leader, successfully and safely executing the projects and programs that are transforming the maritime horizon.

Click here to read more about our most recent advancements and customer success stories.

About Siemens Digital Industries Software

Siemens Digital Industries Software helps organizations of all sizes digitally transform using software, hardware and services from the Siemens Xcelerator business platform. Siemens' software and the comprehensive digital twin enable companies to optimize their design, engineering and manufacturing processes to turn today's ideas into the sustainable products of the future. From chips to entire systems, from product to process, across all industries, Siemens Digital Industries Software – Accelerating transformation.

For more information on Siemens Digital Industries Software for the marine industry, visit our website or follow us on LinkedIn and Twitter.

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