



**DIGITAL INDUSTRIES SOFTWARE**

# The artificial intelligence tide

Revolutionizing marine engineering for a sustainable and efficient future

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Artificial intelligence (AI) is fundamentally reshaping the marine engineering sector. Early adopters report significant gains: 30 percent reduction in maintenance costs and 25 percent improvement in operational efficiency.<sup>1</sup>

This e-book examines how machine learning (ML), natural language processing, computer vision and generative AI create new paradigms for vessel design, operation and maintenance. Key benefits include 8 to 12 percent improvements in hydrodynamic efficiency due to generative design,<sup>2,3</sup> 5 to 15 percent fuel consumption reductions via real-time analysis,<sup>1</sup> and a 40 percent decrease in safety incidents due to using predictive analytics.<sup>4,5</sup>

Implementation challenges include data quality issues, legacy system integration and maritime connectivity limitations. We provide a practical road map guiding organizations through assessment, infrastructure development, pilot programs and deployment.

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# 1. Introduction

Marine engineering faces escalating pressure to improve efficiency, enhance safety, meet environmental regulations and reduce costs in a competitive global market. Industry benchmarks suggest a need for 15 to 20 percent efficiency improvements to remain competitive.<sup>4</sup>

AI technologies are emerging as transformative forces rather than merely supplementary tools. The Thomson Reuters “Future of Professionals Report 2023” indicated 83 percent of professionals believed AI will increase productivity and create new economic value.<sup>6</sup> Within maritime, Lloyd’s Register found organizations integrating AI solutions achieved 22 percent better operational efficiency and 30 percent less unplanned downtime.<sup>1</sup>

This e-book explores how AI enables marine engineers to move beyond reactive problem-solving to proactive optimization, predictive insights and innovative design exploration, creating new paradigms for the entire vessel lifecycle.<sup>7,8</sup>

By combining traditional maritime expertise with advanced AI capabilities, organizations can revolutionize vessel design, optimize operations and advance sustainability. Embracing this AI tide is a strategic imperative for maritime innovation leadership.



# 2. AI technologies in marine engineering

The Designcenter™ software portfolio and Insights Hub™, the industrial IoT as a service solution delivering Siemens Production Copilot exemplifies how advanced AI and generative design are being deployed in real-world marine engineering projects, enabling predictive maintenance and rapid design iteration. Designcenter and Insights Hub are part of the Siemens Xcelerator business platform of software, hardware and services.

## 2.1 Key technologies

Technology	Function	Key benefits	Maritime application
Machine learning	Analyzes operational data to predict future performance	95% accuracy in predictive maintenance	Forecasts component failures 2-3 weeks in advance, reducing emergency repairs by 40%. <sup>9</sup>
Natural language processing	Transforms technical documentation into actionable insights	65% faster information retrieval	Enables quick querying of specifications, maintenance records and regulations. <sup>10</sup>
Computer vision	Detect structural defects as small as 0.5mm	35% more thorough inspections in 50% less time	Automated drone/robot inspections of hulls and components. <sup>4</sup>
Generative AI	Explores thousands of design variations simultaneously	8-12% improvement in hydrodynamic efficiency	Optimizes hull forms, propulsion systems and structural layouts. <sup>2,3</sup>

## 2.2 Industrial generative AI applications

Generative AI is revolutionizing marine engineering in several key areas. In design optimization, it assesses thousands of design variations at once, with estimates suggesting an 8 to 12 percent improvement in hydrodynamic efficiency compared to traditional methods. For component design, generative AI enables engineers to optimize individual parts, potentially achieving material savings of 15 to 30 percent while simultaneously enhancing performance characteristics. When it comes to rapid prototyping, virtual testing powered by AI significantly reduces the need for physical prototypes, allowing for three to four times more design iterations within the same timeframe. Additionally, in environmental impact assessment, generative AI can simulate emissions and environmental effects across thousands of scenarios, helping to reduce environmental footprints by up to 25 percent.

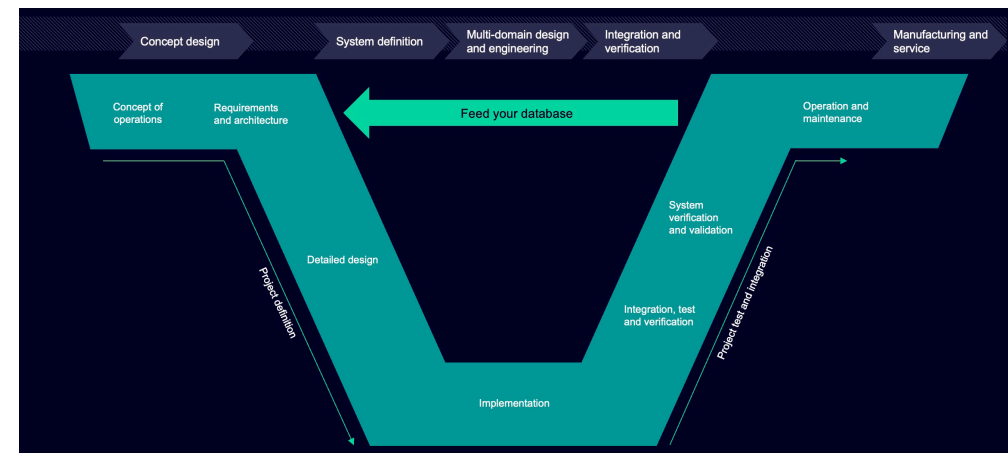


Figure 1. V-shape model with AI enhancement showing bidirectional relationship between development and validation phases.

# 3. Applications and benefits

## 3.1 AI copilots for marine engineers

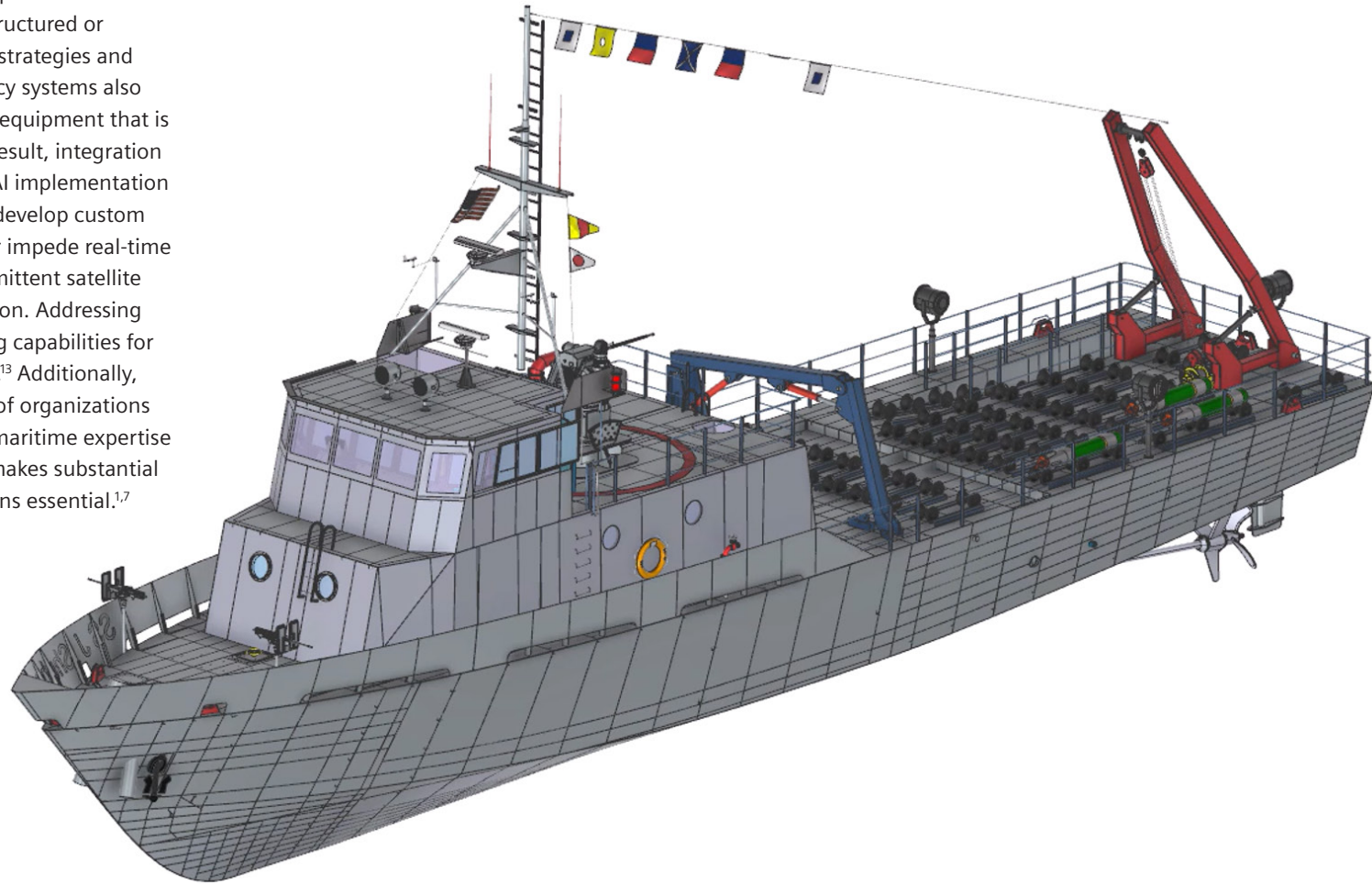
AI copilots integrate directly into marine engineers' workflows, providing real-time support across various domains. For design assistance, these copilots cross-reference design parameters against historical data and regulations, suggesting modifications to improve performance metrics. As a result, design iterations are completed 30 percent faster and first-pass design quality improves by 25 percent.<sup>3,11</sup> In workflow optimization, AI automates routine calculations, documentation and compliance checks, freeing engineers to focus on complex problem-solving. Organizations report that engineers gain up to 40 percent more time for high-value tasks.<sup>7,11</sup> For predictive maintenance, AI copilots monitor thousands of sensor inputs to identify patterns preceding equipment failures, which leads to 15 to 25 percent reductions in maintenance costs and 30 to 50 percent less unplanned downtime.<sup>1,5</sup> Additionally, in knowledge management, these systems retrieve relevant information from vast technical libraries instantly, enabling engineers to retrieve information 65 percent faster and improve decision quality.<sup>11,10</sup> Siemens' AI copilots and Digital Twin solutions empower marine engineers to optimize vessel performance in real time, reduce manual workload and accelerate innovation cycles.

## 3.2 Quantifiable benefits

AI integration delivers measurable advantages across marine operations. It enhances efficiency by reducing the manual workload by 20 to 30 percent, enabling engineers to handle more projects simultaneously.<sup>8</sup> Decision-making is improved by 40 percent thanks to data-driven insights.<sup>7,6</sup> Cost savings are realized by a 50 percent reduction in unexpected equipment failures,<sup>1,9</sup> a 10 to 15 percent improvement in optimizing material usage<sup>3</sup> and a typical return-on-investment (ROI) within 12 to 18 months. Innovation is accelerated, with companies using generative AI reporting 35 percent more patent applications and 45 percent more design innovations.<sup>2,12</sup> Additionally, risk reduction is achieved by identifying potential issues before physical implementation, which leads to a 40 to 60 percent decrease in late-cycle design changes.<sup>3</sup>

# 4. Implementation challenges

Despite the compelling benefits, the adoption of AI in marine engineering presents several significant hurdles. Data quality and availability remain the primary obstacles for 68 percent of maritime organizations, as data is often siloed, unstructured or inconsistent, thus requiring robust governance strategies and standardization efforts.<sup>1</sup> The integration of legacy systems also poses challenges, with many vessels relying on equipment that is decades old and lacks modern interfaces. As a result, integration costs can account for 30 to 40 percent of total AI implementation budgets, necessitating specialized expertise to develop custom interfaces.<sup>3</sup> Maritime connectivity issues further impede real-time AI applications, as limited bandwidth and intermittent satellite connections in remote environments are common. Addressing these challenges often requires edge computing capabilities for local data processing when connectivity is poor.<sup>13</sup> Additionally, there is a significant skills gap, with 73 percent of organizations struggling to recruit personnel who have both maritime expertise and knowledge in AI or data science. This gap makes substantial training investments and academic collaborations essential.<sup>17</sup>



# 5. Case studies

Siemens' partnership with Compute Maritime and the deployment of Designcenter with AI validation tools resulted in a 65% reduction in design validation time and a 30% improvement in first-pass design quality. These results underscore Siemens' commitment to Digital Transformation in marine engineering.

ORGANIZATION	IMPLEMENTATION	KEY RESULTS
SIEMENS AND COMPUTE MARITIME PARTNERSHIP <sup>11</sup>	Integrated Designcenter with AI validation tools	<ul style="list-style-type: none"> <li>• 65% reduction in design validation time</li> <li>• 30% improvement in first-pass design quality</li> <li>• 40% decrease in engineering change orders</li> <li>• 25% reduction in design cycle time</li> </ul>
INTERNATIONAL SHIPPING COMPANY <sup>9</sup>	AI-powered predictive maintenance across 25 vessels	<ul style="list-style-type: none"> <li>• 45% reduction in unplanned maintenance</li> <li>• 30% decrease in maintenance costs</li> <li>• 22% increase in equipment lifespan</li> <li>• 15% reduction in spare parts inventory</li> </ul>
MARINE ENGINEERING FIRM <sup>2,3</sup>	AI-enhanced simulation tools for propulsion components	<ul style="list-style-type: none"> <li>• 70% fewer physical prototypes required</li> <li>• 45% faster design iteration cycles</li> <li>• 35% improvement in performance characteristics</li> <li>• 25% reduction in development costs</li> </ul>
MARINE EQUIPMENT MANUFACTURER <sup>2,3,11</sup>	Generative Design in Siemens' Designcenter for structural components	<ul style="list-style-type: none"> <li>• 25-30% weight reduction without compromising strength</li> <li>• 15-20% material cost savings</li> <li>• Improved stress distribution and vibration characteristics</li> </ul>

# 6. Implementation road map

Siemens offers end-to-end support, from initial assessment to full-scale deployment, delivering seamless integration of AI technologies into existing marine engineering workflows.

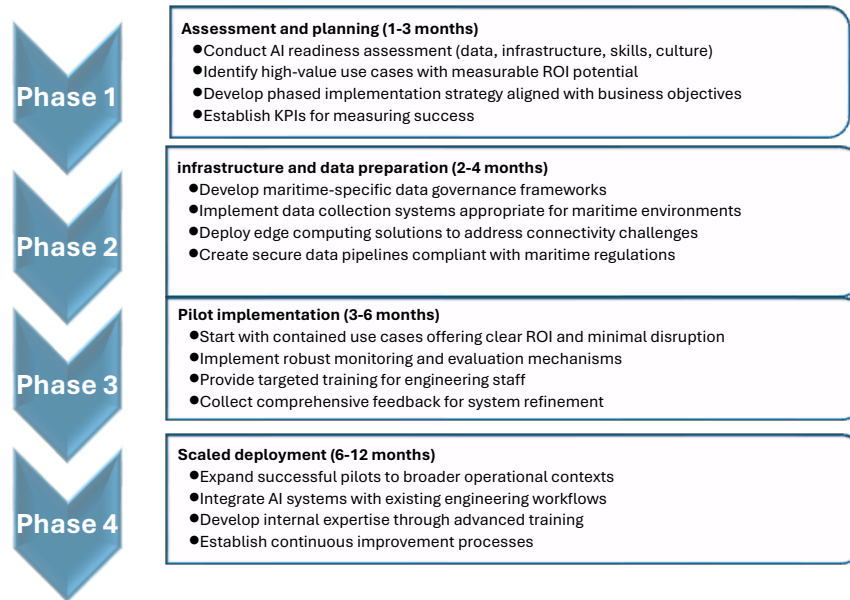


Figure 2. AI implementation road map.

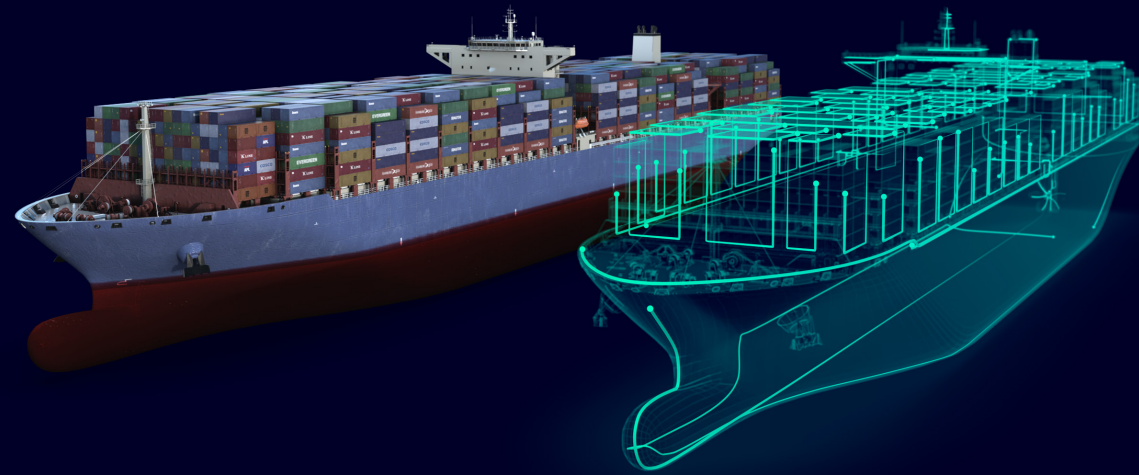
## ROI timeline

- Immediate returns (0 to 12 months): Operational efficiencies, direct cost reductions
- Medium-term (12 to 24 months): Enhanced decision quality, improved designs, increased productivity
- Long-term (24+ months): Innovation acceleration, competitive differentiation, new business models



## 7. Future trends (2025 to 2030)

Three key developments are set to reshape marine engineering in the coming years. First, autonomous systems are on the rise, and by 2027 it is expected that 40 percent of new commercial vessels will incorporate AI-enabled autonomous navigation systems.<sup>4,13</sup> This shift means engineers will increasingly focus on creating human-machine collaboration frameworks and intervention protocols, rather than relying solely on direct control. Second, the emergence of quantum-enhanced AI holds significant promise; commercially viable quantum-enhanced ship design tools could become available by 2028.<sup>13</sup> These tools are anticipated to solve complex fluid dynamics challenges and enable unprecedented levels of hydrodynamic efficiency and material optimization. Third, an advanced Digital Twin will become mainstream, with projections indicating that by 2026, 60 percent of new commercial vessels will feature more than one Digital Twin.<sup>3,13</sup> These virtual replicas will leverage real-time data from thousands of sensors to continuously optimize operational parameters such as engine settings, trim and ballast. Siemens is actively investing in quantum-enhanced AI and advanced Digital Twin technologies, paving the way for the next wave of innovation in marine engineering.



# 8. Conclusion

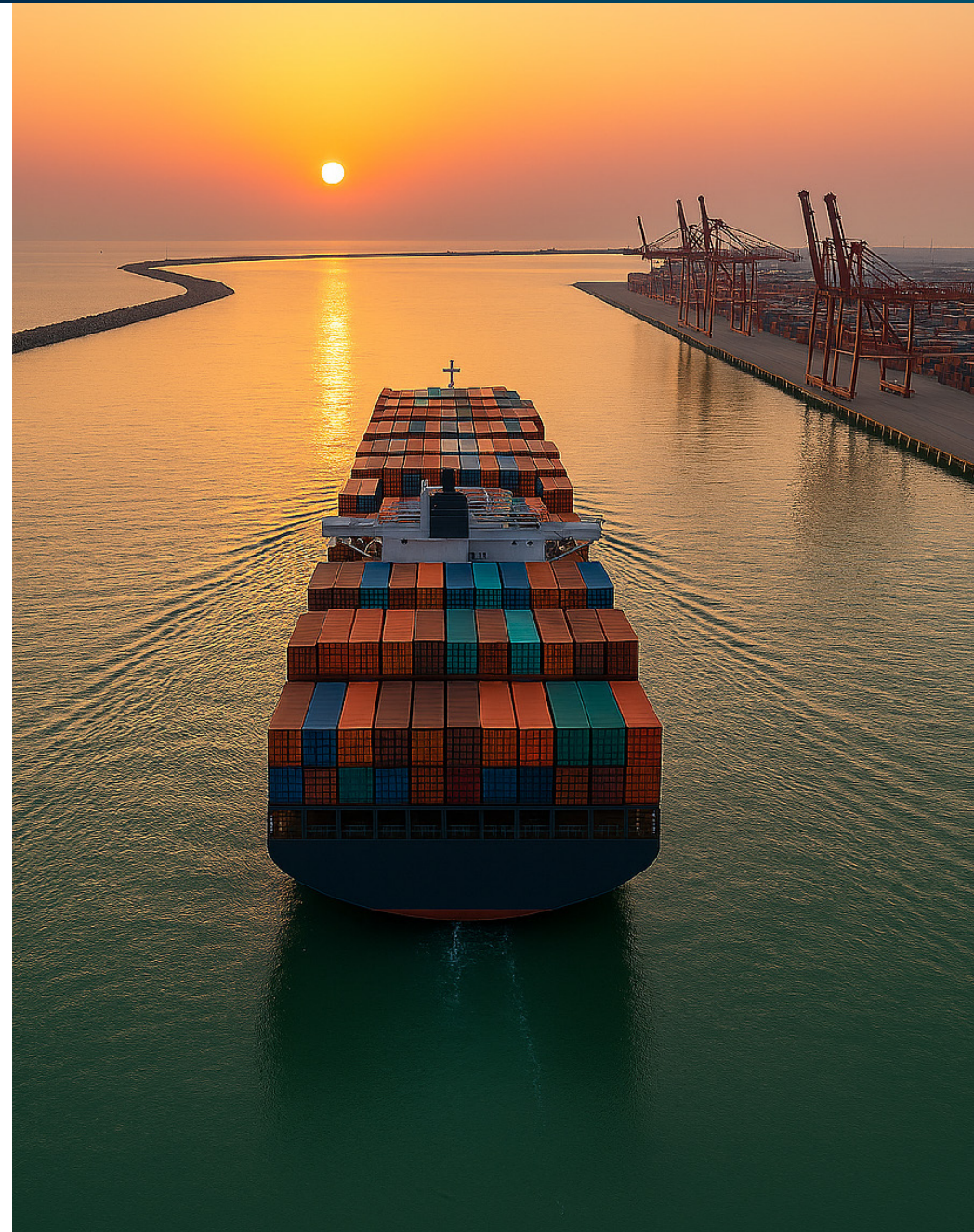
AI is fundamentally reshaping marine engineering with quantifiable benefits: 15 to 25 percent maintenance cost reductions,<sup>9</sup> 5 to 15 percent operational efficiency improvements,<sup>1</sup> and 8 to 12 percent design optimizations.<sup>2,3</sup> These represent significant advances in performance, safety and sustainability.

Successful implementation requires addressing maritime-specific challenges: connectivity issues, legacy system integration, regulatory compliance and developing specialized expertise.<sup>7,4</sup>

Marine professionals who combine traditional maritime knowledge with AI proficiency will drive innovation and solve previously intractable challenges.<sup>6,1</sup> Organizations embracing AI will gain competitive advantages with improved efficiency, enhanced safety and accelerated innovation cycles.

We strongly encourage all marine engineering professionals to begin their AI journey now, starting with targeted applications that demonstrate clear ROI while building the infrastructure, governance and human capital needed for comprehensive implementation. The future of marine engineering is intelligent, and the time to build that future is now.

To learn more about how Siemens can help your organization harness the power of AI in marine engineering, visit [Siemens Digital Industries Software](#) or visit [NX Marine](#).



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