The Future of Digital PLM

How AI and Digital Thread are Redefining Product Development and Operations

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The future of product lifecycle management isn't just digital - it's intelligent. Discover how AI is rewriting the rules.

Product lifecycle management (PLM) has historically been the backbone of any product data and information management. The PLM system allows organizations to streamline product development processes across the lifecycle, from product design to engineering, manufacturing and supply chain. The system offers numerous advantages to organizations, including operational, financial, and customer-focused benefits. Using PLM could accelerate market time, innovation, product quality, and enhanced decision-making.

PLM is a comprehensive business approach that supports enterprises in managing the product's entire lifecycle from initial concept through design, manufacturing, service and disposal. PLM integrates people, data, processes and business systems to provide a product information backbone for businesses. It could manage product data throughout the complete lifecycle, integrate various business functions (engineering, manufacturing and service), enable collaboration across internal and external stakeholders, centralize product information in a single source of truth, and automate workflow and approval processes.

Traditional PLM systems presented enterprises with a series of challenges, which hindered the core agenda behind their implementation. These challenges include:

Data Silos & Integration Issues

- Legacy PLM systems often operate in isolation, making sharing data across different departments and systems difficult.
- Poor integration with other enterprise systems like ERP, CRM, and supply chain management tools

Limited Collaboration Capabilities

- Restricted real-time collaboration features, especially for remote teams
- Difficulty in managing concurrent engineering processes
- Version control issues when multiple stakeholders are involved

User Experience and Adoption

- Complex and unintuitive interfaces that require extensive training
- Poor mobile accessibility and modern interface features
- Resistance from users due to complicated workflows

Cost and Resource Intensity

- High initial implementation costs
- Need for specialized IT staff for system management
- Expensive maintenance and upgrade cycles

Apart from the above challenges, enterprises with PLM systems face a few industry-specific challenges, including:

- Managing complex supplier ecosystems, as seen in the automotive, industrial manufacturing, and high-tech sectors, by coordinating with numerous global suppliers to maintain design consistency and quality standards.
- Tracking and managing evolving safety, emissions, quality, and industry-specific regulatory compliance and standards across multiple markets is critical in the automotive, medical devices, energy, and utilities industries.
- Managing numerous product variants, options, and engineering changes while maintaining accurate Bills of Materials (BOMs) and documentation is essential for configuration and change management in the automotive, industrial manufacturing, high-tech, and energy and utilities sectors.
- Managing the development and launch of new products, including comparing with competitors and adapting to short product lifecycles, is crucial for New Product Introduction (NPI) and rapid iteration in the automotive and high-tech industries.
- Enabling seamless cooperation between geographically dispersed design and production teams and managing assets across broad areas facilitates multi-site collaboration. It addresses geographic distribution in the industrial manufacturing and energy & utilities industries.
- Capturing institutional knowledge and creating/maintaining accurate digital representations of physical products, supporting knowledge retention and digital twin implementation in industrial manufacturing.
- Securing sensitive design data while enabling necessary collaboration is vital for intellectual property protection in the high-tech sector.
- Maintain detailed records for regulatory compliance and ensure clear links between customer needs and design implementations, as well as support design history documentation and traceability in medical devices.
- Ensuring PLM processes meet strict quality standards and incorporating risk analysis throughout the product lifecycle is essential for medical device validation, verification, and risk management.
- Managing documentation and changes for decades-operating assets and tracking maintenance history, addressing long product lifecycle management in the energy and utilities sector.
- Tracking and managing electronic component lifecycles is necessary to address component obsolescence in the high-tech industry.

One real-time example is Volkswagen's significant push to reduce the development times of its new car. They aimed to reduce that timeframe to around 36 to 40 months. The organization is adopting virtual testing to speed up design and prototyping, utilizing common platforms across multiple models to save time and resources. Similarly, Bosch uses software to optimize production scheduling of PCBAs to reduce programming cycle times.

To mitigate these challenges, enterprises are embracing digital technologies. Digital advancement has brought several shifts in integrating PLM with manufacturing setups. The digital thread is essentially a data-driven framework that creates a seamless flow of information throughout the entire lifecycle of a product or asset. This seamless digital thread integration could connect data across the entire product lifecycle – from initial concept through design, manufacturing, service, and end-of-life enabling real-time collaboration, better traceability, and data-driven decision-making at each stage.

AI/ML applications, on the other hand, are bringing plenty of opportunities, such as generative design tools that can automatically create and optimize product designs based on specified constraints and requirements and natural language processing to extract insights from unstructured data like customer feedback and technical documentation.

Concept	Design	Prototype	Production	Service and Support	Phase-out and Disposal
Trend forecasting	Design analysis & automated simulation	Material Selection – based on cost, and environmental impact	Supply Chain management	Intelligent customer support	Reusability
Idea scoring and Selection	Generation of 2D and 3D images	CAD automation	Workforce augmentation	Demand forecasting	End of life analysis
Regulation inquires	Error detection/ Predictive analysis	Test data analysis	Root cause analysis/impact analysis	Improvement feedback loop	Waste management
	Workflow automation	Knowledge management	Data analysis and reporting	Field Service optimization	Circular economy initiatives.

Figure 1: Potential Use Cases Could Be Transformed Using AI in PLM

The effectiveness of a digital thread implementation largely depends on how well PLM is integrated with other enterprise systems and how completely it captures product data from concept through retirement. A few of the critical integration points include

- **Data Foundation:** PLM systems provide the structured repository where product definition data originates and is maintained, serving as the authoritative source for digital thread connections.
- **System Integration Hub:** PLM is a central integration platform that connects various enterprise systems (ERP, MES, CRM, etc.) to enable seamless data flow throughout the digital thread.
- **Configuration Management:** PLM maintains product configurations and their evolution, allowing the digital thread to trace product variations and changes over time accurately.
- **Process Orchestration:** PLM manages the workflows and business processes that guide data through different lifecycle stages, defining how information flows along the digital thread.
- **Change Management:** When engineering changes occur, PLM propagates these changes across the digital thread, ensuring all downstream systems and stakeholders receive updated information.
- **Requirements Traceability:** PLM links customer requirements to design specifications, manufacturing processes, and service procedures, creating a traceable thread from customer needs to deliver functionality.
- **Digital Continuity:** Digital thread bridges traditionally siloed departments (engineering, manufacturing, service) by maintaining data relationships throughout the product lifecycle.

The infusion of AI can have immense benefits across different stages of PLM and can improve processes at each stage. This could be from ideation, design, BOM management, production, and service excellence.

PLM Integration with AI: Benefits Across the Product Lifecycle

Ideation: Traditional PLM adopts AI-driven product intelligence that replaces manual analysis with advanced algorithms for market research. Organizations gain deeper insights into emerging trends, competitive landscapes, and untapped opportunities. This intelligence ensures new products precisely align with customer needs, reducing the risk of market misalignment and increasing innovation success rates.

Design: AI systems coordinate multidisciplinary teams across design, engineering, simulation, and marketing in a unified environment. AI advancements could transform design iterations to become more agile and responsive to testing feedback. The seamless collaboration accelerates product development timelines, reduces design flaws, and enables faster market entry, directly improving time-to-profit metrics while enhancing product quality.

BOM Management: Advanced algorithms manage complex product information structures connecting definitions, manufacturing specifications, materials, documentation, and pricing. AI-driven PLM allows cross-functional collaboration to improve with real-time information sharing. AI-enhanced CAD system integration ensures greater specification accuracy, reduces planning errors, and creates a more efficient product development ecosystem with fewer revision cycles.

Production: Intelligent systems manage product changes and cost structures throughout manufacturing processes. Using AI, Change Management becomes more systematic with better documentation and communication. It also improves cost management through AI-identified optimization opportunities, leading to more efficient resource allocation, reduced waste, and maintained profit margins despite market pressures.

Intelligent Handover: Another advantage of integrating PLM with AI is that it helps enterprises build intelligent handover by synchronizing various forms of product data like design data, engineering bills of materials, manufacturing bills, and data related to orders, projects, installation, service, and equipment. This approach of intelligent handover facilitates the transfer of product models and their transformation into different views or formats as needed by various stakeholders or phases of the lifecycle. This capability is fundamental to realizing the digital thread concept, as it ensures that product information is not only transferred but also adapted and optimized as it progresses through its various stages.

GenAI in PLM Implementation: Additionally, GenAI could add value and accelerate the PLM implementation where the technology could help teams to convert legacy documentation into precise, structured functional specifications for systems, encompassing process mapping and requirement analysis. GenAI also optimizes workflows by pinpointing inefficiencies and generating improved process maps. Ultimately, automated training and user guide creation powered by GenAI ensures faster and more effective user adoption.

Aftermarket being revolutionized by AI-driven PLM: AI-driven PLM is transforming the aftermarket by enabling predictive maintenance, optimizing spare parts management, and enhancing service support. AI forecasts component failures by analyzing vast datasets, allowing proactive interventions and minimizing downtime. For instance, aerospace companies like Rolls-Royce utilize AI to monitor engine performance, predict maintenance needs and reduce operational disruptions. Similarly, in automotive, manufacturers employ AI to analyze vehicle sensor data, providing personalized maintenance schedules and optimizing spare parts inventory. AI-powered chatbots and virtual assistants, like those used by GE Healthcare, offer instant customer support and resolve issues efficiently. Furthermore, AI optimizes reverse logistics by analyzing return data, enabling efficient refurbishment and reducing waste. These applications demonstrate how AI-driven PLM shifts the aftermarket from reactive to proactive, improving efficiency, customer satisfaction, and profitability.

Reassuring sustainability focus with PLM & AI: The PLM system driven by AI technology could support enterprises in being sustainable and aware throughout the product lifecycle. A few examples include:

- **Design & Concept:** PLM integrates sustainability early, using material databases and LCA tools. AI can optimize material selection based on environmental impact and predict lifecycle impacts from design variations, suggesting eco-friendly alternatives.
  - One area that every organization can focus on is sustainable material selection. AI-driven PLM systems can help in creating comprehensive databases detailing the environmental impact of materials (carbon footprint, recyclability, toxicity, resource depletion), enabling informed decision-making at the design stage, bringing in circular economy concepts by supporting the selection of recyclable, renewable, and biodegradable materials, integration of lifecycle assessment (LCA) tools to evaluate the product's environmental impact throughout its lifecycle, guiding material choices towards lower environmental footprints.
  - Another aspect is the growing importance of full material disclosure (FMD) and its integration into the PLM system. This could bring transparency, regulatory compliance, risk management, etc. FMD also plays a vital role in sustainability as it allows companies to assess the environmental impact of their materials and make informed decisions about material selection. It can also lead to using more sustainable materials, reducing the overall environmental footprint of products.
- **Development & Manufacturing:** PLM optimizes resource usage, reduces waste, and ensures supply chain transparency. AI can analyze manufacturing data to identify inefficiencies, predict equipment failures for preventative maintenance, and optimize resource allocation for a minimal environmental footprint.
- **Usage & Maintenance:** PLM enables predictive maintenance and efficient service lifecycles. AI can analyze product usage data to predict maintenance needs, optimize service schedules, and provide personalized recommendations for extending product lifespan.
- **End-of-Life:** PLM facilitates recyclability, disassembly, and circular economy practices. AI can analyze product composition and material data to optimize recycling processes, identify valuable components for remanufacturing, and automate end-of-life logistics.

For example, GKN has established a 'Product Sustainability Office' that helps to improve understanding and measurement of the carbon impact of the products. The customer's expectation has pushed GKN to take up the life cycle assessment, where the organization has to review its supply chain, materials procured, and environmental footprint. By having PLM as a centralized tool, the organization recognized significant performance by reducing 10.5% of its carbon emissions.

Hitachi Digital Services and PLM: Hitachi Digital Services (HDS) implements proven, real-world solutions that drive measurable impact in digital PLM and digital thread. The provider's expertise spans industries including automotive, transportation, energy and utilities, high-tech, and med-tech

A few of the differentiators include -

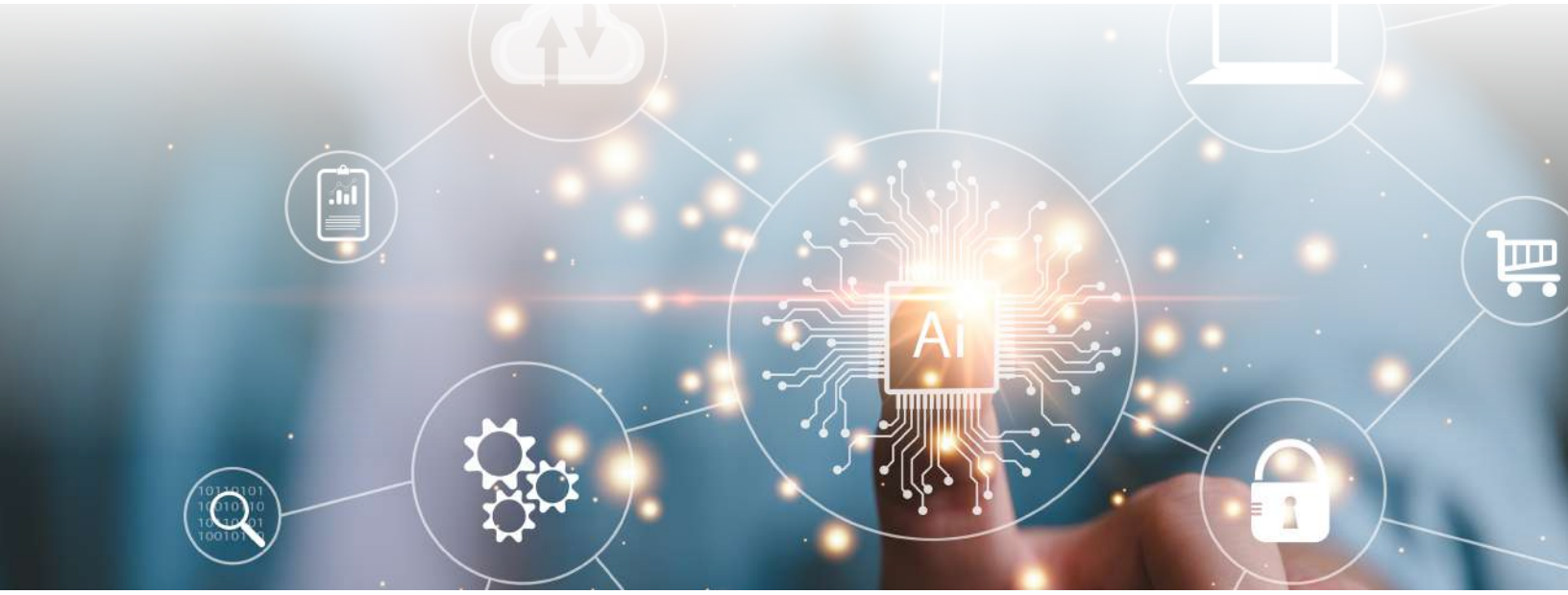
- **End-to-End Integration:** HDS brings comprehensive capability by breaking down into silos, creating seamless connectivity across functions including marketing and sales, product engineering and development, supply chain, manufacturing, quality, regulatory, and service operations.
- **AI-powered Innovation:** HDS integrates AI and GenAI to enhance every phase of the product lifecycle, from predictive quality inspections to AI-driven generative design and systems engineering.

HDS employs a robust digital PLM strategy that includes the implementation of digital threads to ensure seamless data flow across the entire product lifecycle—from initial engineering and design to production, maintenance, and eventual decommissioning. This integrated approach enhances collaboration and real-time visibility, enabling organizations to optimize their product development and operational processes. By harnessing AI and advanced analytics, HDS provides intelligent insights that predict potential issues, optimize maintenance schedules, and improve decision-making across various functions. Advanced algorithms analyze vast amounts of data, enabling predictive maintenance, anomaly detection, and enhanced operational performance.

Through digital twin technology, HDS creates virtual replicas of physical assets and systems, offering real-time monitoring and simulation capabilities that help understand system behavior, test scenarios without physical intervention, and drive improvements in product design and operational efficiency. Integrating PLM tools with other enterprise systems, such as ERP and MES, ensures that all product-related data is consistent and accessible across departments, facilitating coordinated efforts and reducing time-to-market. Intelligent manufacturing solutions enable real-time workflow, automated reporting, and seamless integration with IoT devices, providing immediate responses to issues, optimizing efficiency, and reducing downtime.

Proprietary solutions like the HDS Digital PLM Playbook guide organizations through the transformation journey of adopting next-generation digital PLM and digital thread capabilities. The Lumada Platforms enable intelligent asset management, smart manufacturing, and IoT-driven insights. Asset performance management (APM) tools optimize asset performance through predictive analytics and real-time monitoring, while field service management (FSM) solutions enhance the efficiency and effectiveness of field service operations through digital workflows and advanced analytics.

Through these capabilities, frameworks, and proprietary solutions, HDS empowers organizations to significantly improve product development, operational efficiency, and overall business performance. These advanced technologies and integrated approaches enable a seamless, innovative, and agile product lifecycle management environment well-suited for the challenges of Industry 4.0 and beyond.



Case Studies

Case Study 1
Automotive Industry - Accelerating Product Development

A leading automotive manufacturer sought to accelerate its product development cycle and improve product quality. By leveraging HDS Digital PLM and Digital Thread solutions, the company was able to streamline its engineering and design processes. The manufacturer created virtual prototypes that enabled real-time simulations and testing by integrating digital twins, reducing the need for physical prototypes. Advanced AI algorithms provided predictive insights, ensuring early detection of potential design issues and optimizing maintenance schedules. As a result, the manufacturer achieved a 30% reduction in time-to-market and significantly improved product reliability and customer satisfaction.

Case Study 2
Manufacturing Industry - Intelligent Manufacturing Optimization

A global manufacturing company faced challenges with real-time workflow execution and production efficiency. HDS implemented its intelligent manufacturing solutions, integrating the company's PLM systems with IoT devices and MES. Real-time operational insights were provided through advanced data analytics, facilitating immediate responses to production line issues. The digital thread enabled seamless data flow across the production lifecycle, ensuring consistent and accessible information. The company experienced a 25% increase in operational efficiency and a 15% reduction in downtime, improving overall productivity and cost savings.

Case Study 3
Utilities Sector - Enhanced Asset Performance Management

A major utility company aimed to enhance the reliability and performance of its critical assets. HDS's Asset Performance Management solutions, including the Reliability Modeler (RM) and Failure Mode Effect and Criticality Analyzer (FMECA), were deployed to monitor and manage assets proactively. Digital twin technology provides real-time monitoring of asset conditions, enabling predictive maintenance and reducing unexpected failures. The company utilized HDS's comprehensive asset management framework to extend asset life and minimize maintenance costs. This resulted in a 20% reduction in maintenance expenses and a 40% decrease in asset downtime, ensuring consistent and reliable utility services.

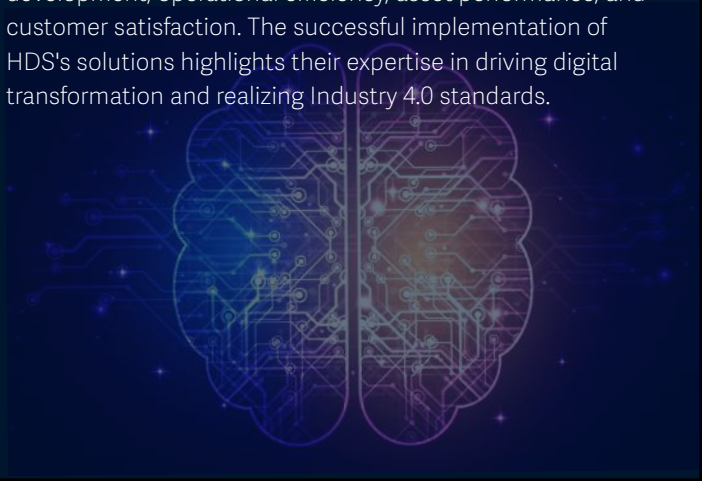
Case Study 4
High-tech Industry - Optimizing Field Service Management

A high-tech company specializing in advanced electronics must optimize its field service operations. HDS's Field Service Management solutions were implemented to streamline service workflows and enhance the efficiency of maintenance activities. Remote service capabilities and advanced analytics allow for accurate and timely repair recommendations. The digital thread ensured service operations aligned with the overall asset management strategy, providing comprehensive visibility and control. The company achieved a 35% improvement in service response times and a 50% increase in customer satisfaction due to the enhanced reliability and performance of its products.

Case Study 5
Industrial Equipment Manufacturer - Digital PLM Transformation

An industrial equipment manufacturer sought to transform its PLM processes. The company underwent a comprehensive transformation journey by adopting the HDS Digital PLM Playbook. The playbook guided the organization through strategy development, roadmap creation, and seamless integration of digital threads across departments. Advanced AI and digital twin technologies were used to optimize product design, reduce development cycles, and improve operational performance. As a result, the manufacturer experienced a 40% acceleration in product development and a marked increase in operational efficiency and market competitiveness.

These case studies demonstrate HDS's ability to deliver substantial value and transformative outcomes across various industries. By leveraging advanced technologies such as AI, digital twins, and the digital thread, HDS empowers organizations to significantly improve product development, operational efficiency, asset performance, and customer satisfaction. The successful implementation of HDS's solutions highlights their expertise in driving digital transformation and realizing Industry 4.0 standards.

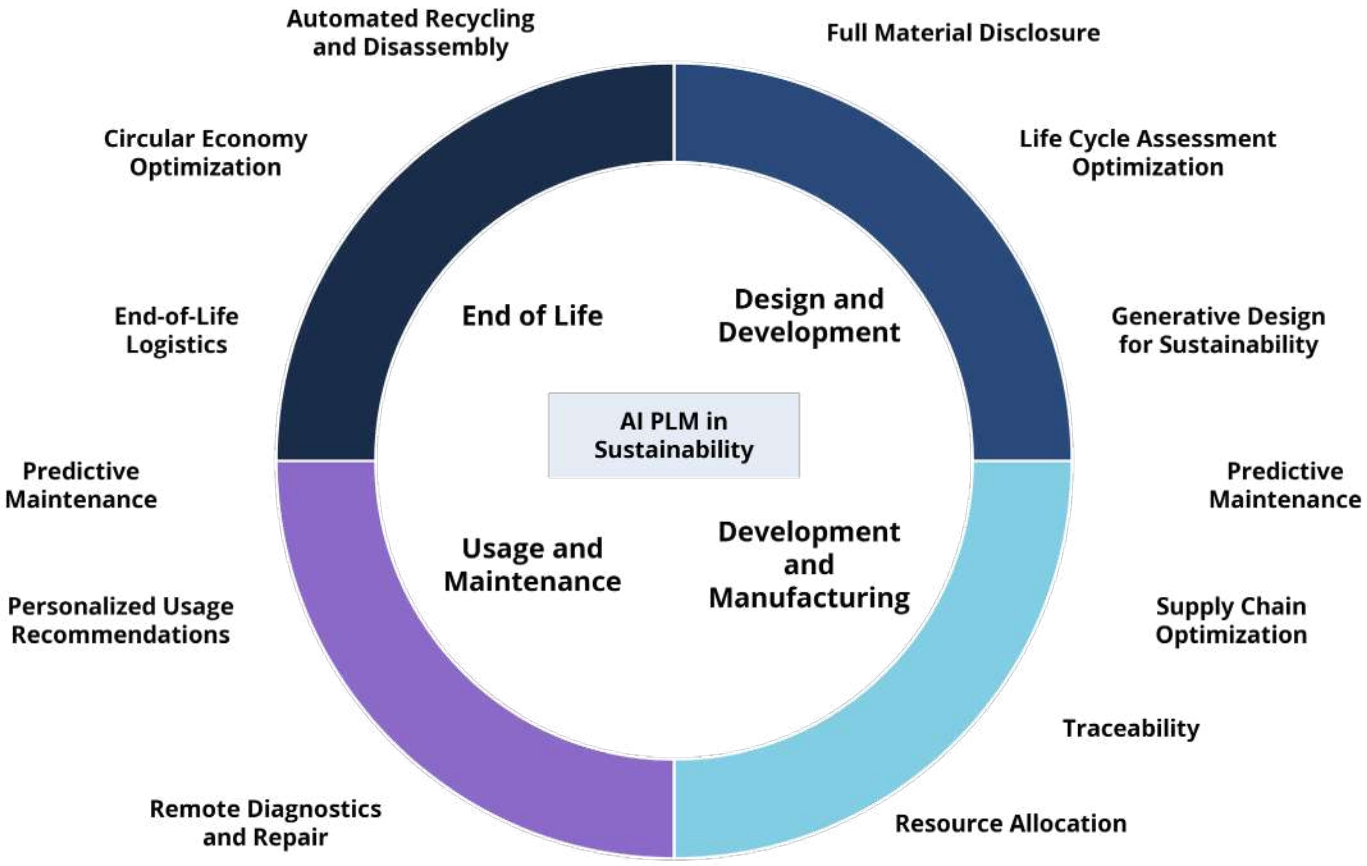


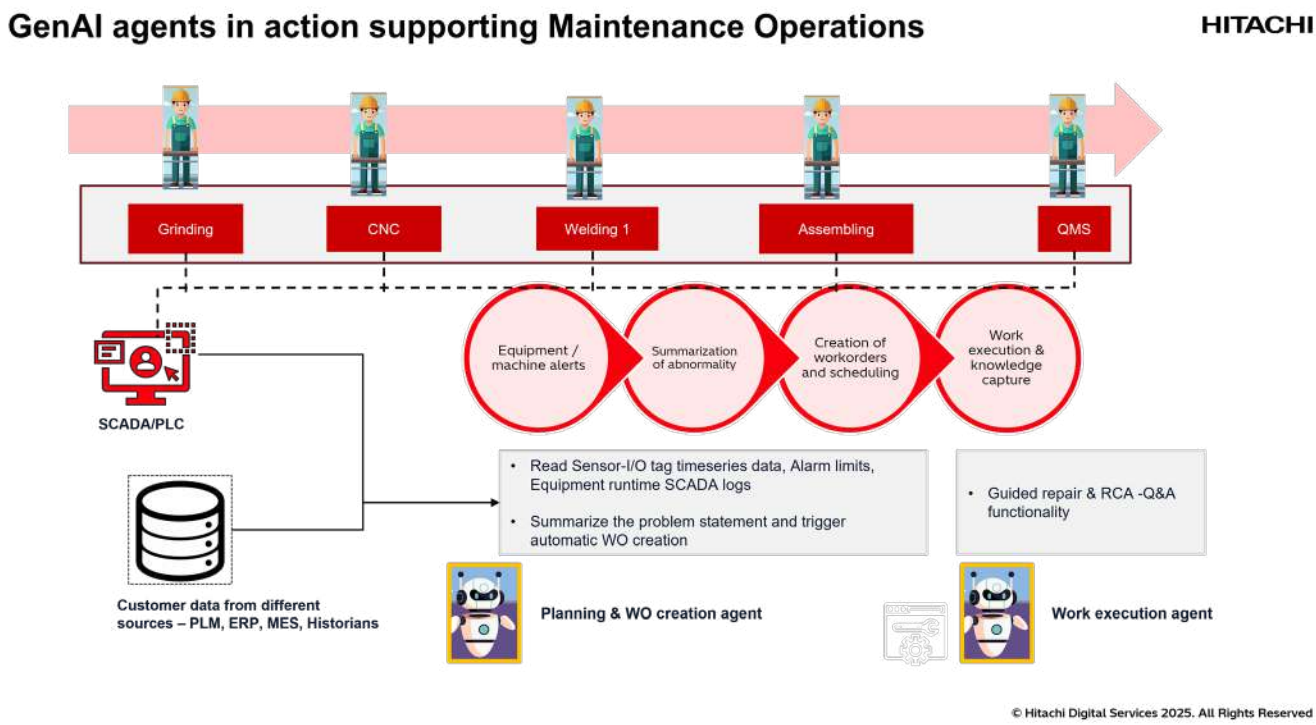
HDS Approach to Integrate AI/GenAI with PLM System

HDS has successfully expanded its use of GenAI in PLM from a proof of concept (PoC) to an enterprise scale. By implementing a clear strategy, HDS has achieved a significant impact by using AI across its value chain. The company has identified several strategic opportunities for integrating AI/GenAI within PLM that could potentially influence solutions in maintenance and repair, operations optimization, quality assurance, and supply chain management.

Some of the solutions offered include:

- **AI-powered Quality Inspection:** This automated quality inspection co-pilot platform ensures high-quality standards while reducing inspection costs and time. Hitachi's Automated Quality Inspection solution leverages advanced robotics and computer vision AI to detect defects with precision and efficiency. It offers enterprises question-and-answer assistance, the ability to view defect-related images for better clarity, generative business intelligence to create dynamic visualization charts for quality managers, and instant insights to streamline workflows and automate tasks, all with human oversight. This platform is tailored for discrete manufacturing, rolling stock, and energy sectors.
- **GenSei-X Industrial Copilot:** This solution focuses on Maintenance and Operation Planning. It provides features such as equipment and machine alerts, summarization of abnormalities, creation of work orders, scheduling, work execution, and knowledge capture.





Way Forward

In an era in which speed and innovation dictate market leadership, a resilient digital operating model emphasizing real-time visibility, intelligent decision-making, and proactive management is imperative to survive and thrive going forward. This resilient operating model ensures that organizations can swiftly adapt to changing market conditions and maintain continuous improvement and high performance. The interconnected systems (Integrating PLM with other enterprise systems, such as ERP and MES) and reimagined processes are needed to ensure consistent and accessible product-related data across operational functions, enable coordinated efforts and reduce time to value of products. Through its advanced capabilities, unique accelerators, and resilient operational models, HDS empowers organizations to transform their PLM processes and excel in the era of Industrial AI. Its strategic use of AI, GenAI, digital twins, and other advanced technologies enables seamless integration, optimized performance, and sustainable growth.

About the Authors

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With over 20 years of experience, Sankar is a recognized industry thought leader who drives strategy, solutions, go-to-market initiatives, and the delivery of integrated digital transformation across products, factories, operations, and sustainability at Hitachi Digital Services. He leads teams that collaborate with companies across various industries to drive large-scale innovation and enable business outcome-focused digital transformation. Sankar partners with leading organizations to shape outcome-driven strategies across engineering & product development, manufacturing & operations, quality & compliance, and sustainability—leveraging design thinking, digital capabilities, and advanced technologies to create meaningful and lasting business impact.

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Rajeev Chatrath is a principal consultant at ISG, specializing in Digital Transformation strategy, R&D transformation, and the adoption of advanced technologies across industries such as Retail, Manufacturing, and Lifesciences. With over 30 years of experience, Rajeev is known for his problem-solving abilities, transparency, and strong client focus, aiming for high client satisfaction. His background includes leadership roles in Digital Advisory and consulting engagements with major engineering firms He holds a Bachelor of Engineering and advanced certifications in Digital Transformation Strategy and Design Thinking, along with being an AWS certified cloud practitioner. Notable achievements include driving digital transformation for clients such as large gigafactories and various manufacturing companies, focusing on creating data-driven organizations and improving operational efficiencies.

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Srinivasan P N is a Senior Lead Analyst at ISG. He is responsible for authoring ISG Provider Lens™ studies on Digital Engineering and AWS Ecosystem Services. His areas of expertise are engineering services, cloud services, and digital transformation. Srinivasan has over a decade of experience in the technology research industry. In his prior role, he delivered research on both primary and secondary research capabilities. Srini is interested in understanding the startup ecosystem, M&As of the tech industry and engineering service capabilities. He also works with advisors with his research skills and writes papers about the latest market developments in the industry.

Hitachi Digital Services, a wholly owned subsidiary of Hitachi, Ltd., is a global systems integrator powering mission-critical platforms with people and technology. We help enterprises build, integrate, and run physical and digital systems with tailored solutions in cloud, data, IoT, and ERP modernization, underpinned by advanced AI.

Combining Information Technology and Operational Technology (ITxOT), we drive efficiency, innovation and growth across industries. With over 110 years of Hitachi Group's engineering and technology leadership, Hitachi Digital Services is powering smarter systems for a safer, more sustainable future for everyone.

ISG (Nasdaq: III) is a global *AI-centered* technology research and advisory firm. A trusted partner to more than 900 clients, including 75 of the world's top 100 enterprises, ISG is a long-time leader in technology and business services that is now at the forefront of leveraging AI to help organizations achieve operational excellence and faster growth. The firm, founded in 2006, is known for its proprietary market data, in-depth knowledge of provider ecosystems, and the expertise of its 1,600 professionals worldwide working together to help clients maximize the value of their technology investments.

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