LTIMindtree

Forging the future

Navigating the New Era of Industrial Manufacturing

Disruptive Trends Radar 2024 - 2025

Evolution of Technology Trends in the **Industrial Manufacturing Industry**

The future success of manufacturing organizations will rely not just on **adopting new technologies and trends, but on how smoothly they bring them together**.

The post-pandemic landscape has brought a clear surge in digital investments within the manufacturing industry, spanning across sectors such as Industrial, Automotive, Aerospace and Defense (A&D), Process, and Engineering and Construction (E&C). The key areas of focus include:

- **Improved customer experience and commercial excellence**: Establishing Direct-to-Customer relationships and reducing reliance on intermediaries have become critical goals across sectors. Customer experience solutions including eCommerce for Equipment, Services, and Software, are essential for driving cross-selling opportunities and enhancing brand loyalty. This approach requires agile Configure-Price-Quote (CPQ) solutions, especially for managing complex quotes that enable faster responses and higher win rates. In the automotive sector, the shift towards direct customer engagement across sales and service is transformative. Real-time and dynamic pricing models are increasingly important for maintaining competitiveness.

- **AI and data and analytics**: As organizations strive to become more data-driven, there's a shift in focus from merely reducing technical debt (by streamlining pipelines, data organization, and consumption) to creating data products with functional value and agility for critical business functions like Supply Chain, Finance, and Manufacturing. A purposeful AI strategy—encompassing Artificial Intelligence (AI), Machine Learning (ML), and Generative AI (Gen AI)—has become a cornerstone of this evolving data strategy.

- **Integrated supply chain and digital factory modernization**: There is a heightened focus on improved sales, inventory and operations planning functions across industry segments to address key gaps in both inbound and outbound supply chain performance. Integrated digital factory modernization initiatives, aimed at enhancing throughput from existing factory lines, are also gaining momentum. Efforts to automate factory operations, such as transitioning from Dark to Semi-Dark Factory initiatives and incorporating Augmented and Virtual Reality (AR/VR) for worker engagement, training, and productivity, are critical for achieving better predictability and higher output.

- **Connected platforms for aftermarket expansion**: Every customer is rapidly increasing the connected nature of the equipment and services they sell to capitalize on Annual Recurring Revenue (ARR) opportunities. Across sectors, high-margin aftermarket opportunities are at the forefront of these platform-focused strategies.

The future success of manufacturing organizations will depend not only on the adoption of these technologies and trends but, more importantly, on their seamless convergence. Only by integrating these diverse initiatives can companies drive real, sustained growth in a digitally transformed world.

Rajesh Sundaram,
EVP, Chief Business Officer,
Manufacturing

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Transforming Manufacturing: Embracing Modernization and Smart Engineering

A holistic approach **combining technology, training, and worker well-being** drives sustained gains.

In the rapidly evolving landscape of industrial manufacturing, innovation and current technology trends are driving strategic priorities and technological advancements. The industry continues to transform, emphasizing speed and efficiency in today's fast-paced world, and Artifical Intelligence plays a pivotal role across the entire value chain.

Our research concludes that manufacturers increasingly favor Servitization As-a-Service and Direct-to-Consumer (D2C) models. Their goal is to capture lifetime customer value and meet emerging demands better in the longer term. Beyond mere product sales, manufacturers now offer bundled products, software, and service subscriptions. This gradual shift is transforming the aftermarket into the core market. The ongoing servitization blurs the lines between product sales and warranty, fueled by product subsidies.

To remain competitive, manufacturers are turning to manufacturing modernization. Implementing modernization at multiple levels enhances visibility and updates network and cybersecurity foundations. New PLCs (programmable logic controllers), scalers, and MES (manufacturing execution systems) are directly integrated for command and control on the shop floor.

The rise of AI, sensor economy, robotics, digitalization, Industry 4.0, and digital twins underscores the critical need for smart engineering in manufacturing. Customers demand customization, complexity, and speed. Intelligent machines now operate autonomously, adjusting processes via digital instructions. The future lies in integrated production lines with real-time data from sensors and internet connectivity. This shift from manual to smart, adaptive engineering processes highlights the importance of advanced technologies, positioning us at the forefront of manufacturing innovation and excellence.

A larger number of manufacturers focus on improving worker productivity. A holistic approach combining technology, training, and worker well-being drives sustained gains. The focus on productivity influences financial success, operational sustainability, and organizational competitiveness.

Many industrial manufacturers grapple with legacy applications. Modernizing systems is paramount for enhancing operational efficiency. Notably, substantial investments are directed toward migrating to cloud-based and secure systems, bolstering efficiency and operational agility. These transformative efforts position manufacturers as industry leaders, poised to thrive in a competitive market.

We at LTIMindtree, foresee the future of industrial manufacturing shaped by digitization, modernization, smart engineering, worker productivity, and core modernization.

Naushad Khambhawala,
VP, Delivery Head - Manufacturing

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The Journey of Creating the Manufacturing Radar

LTIMindtree Crystal Manufacturing Radar Report **empowers industries to make faster and smarter decisions based on existing and emerging technology trends** in the manufacturing domain.

"The best way to predict the future is to create it." – Alan Kay

Innovation and proactivity go hand in hand in the world of manufacturing. By embracing this mindset, we can anticipate and drive changes, turning visionary ideas into tangible realities that define the collective industrial future. LTIMindtree Crystal Manufacturing Radar Report empowers industries to make faster and smarter decisions based on existing and emerging technology trends in the manufacturing domain.

To craft a comprehensive manufacturing radar, we initiated with an in-depth grasp of the industrial domain's needs, carefully defining the scope, segmentation, and rating parameters to align with stakeholder expectations. The pivotal phase entailed identifying pertinent technology trends which was subjected to a stringent vetting process. Their real-world case studies underpinned the accuracy and pertinence of our analysis, illustrating how innovations like LTIMindtree's smart manufacturing are transforming the sector by boosting efficiency, customer satisfaction, and sustainability.

Our structured methodology captures the essence of being systematic and reflects our unwavering commitment to innovation and proactiveness. This commitment drives us to stay at the forefront of technological evolution, ensuring that our report is reliable and relevant to the ever-changing needs of the manufacturing industry.

Indranil Mitra,
Vice President, Global Technology Office

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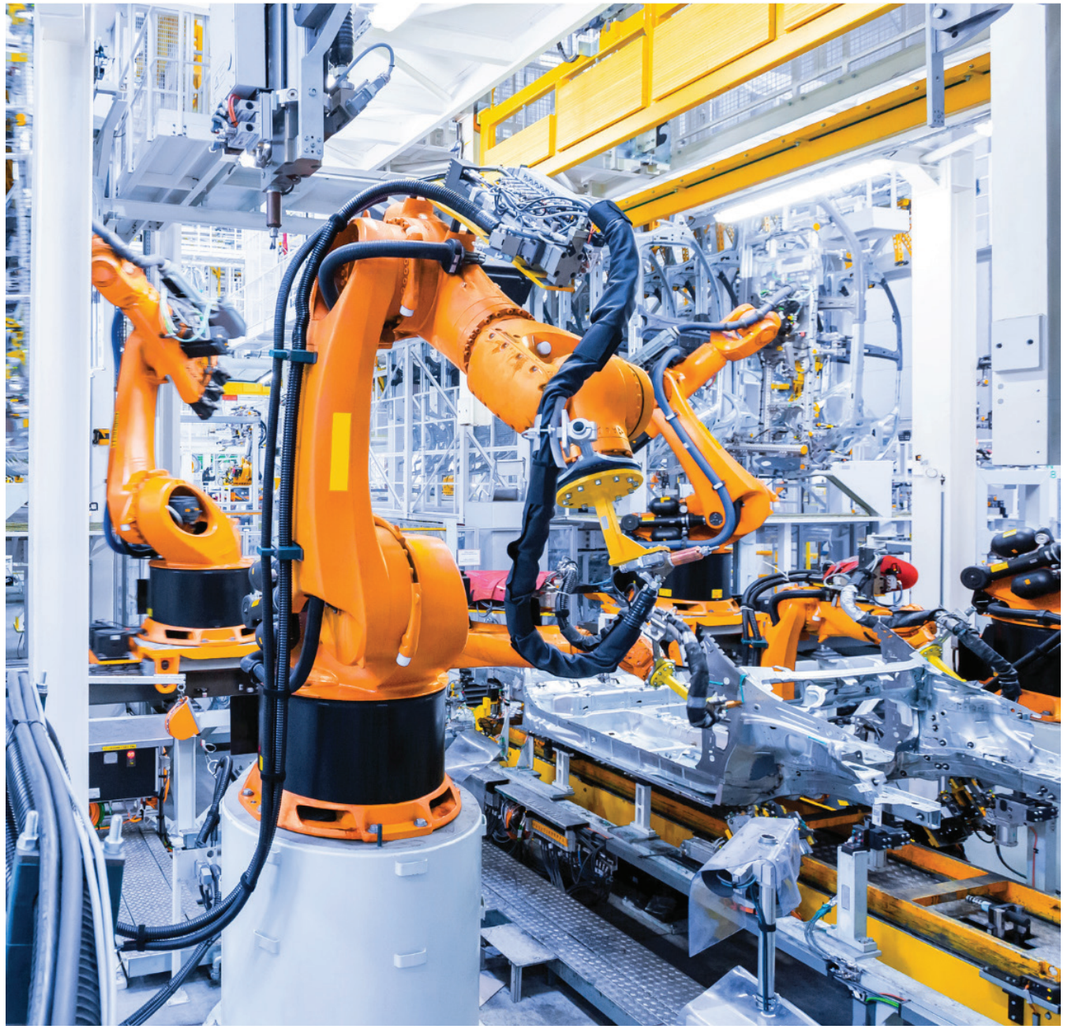

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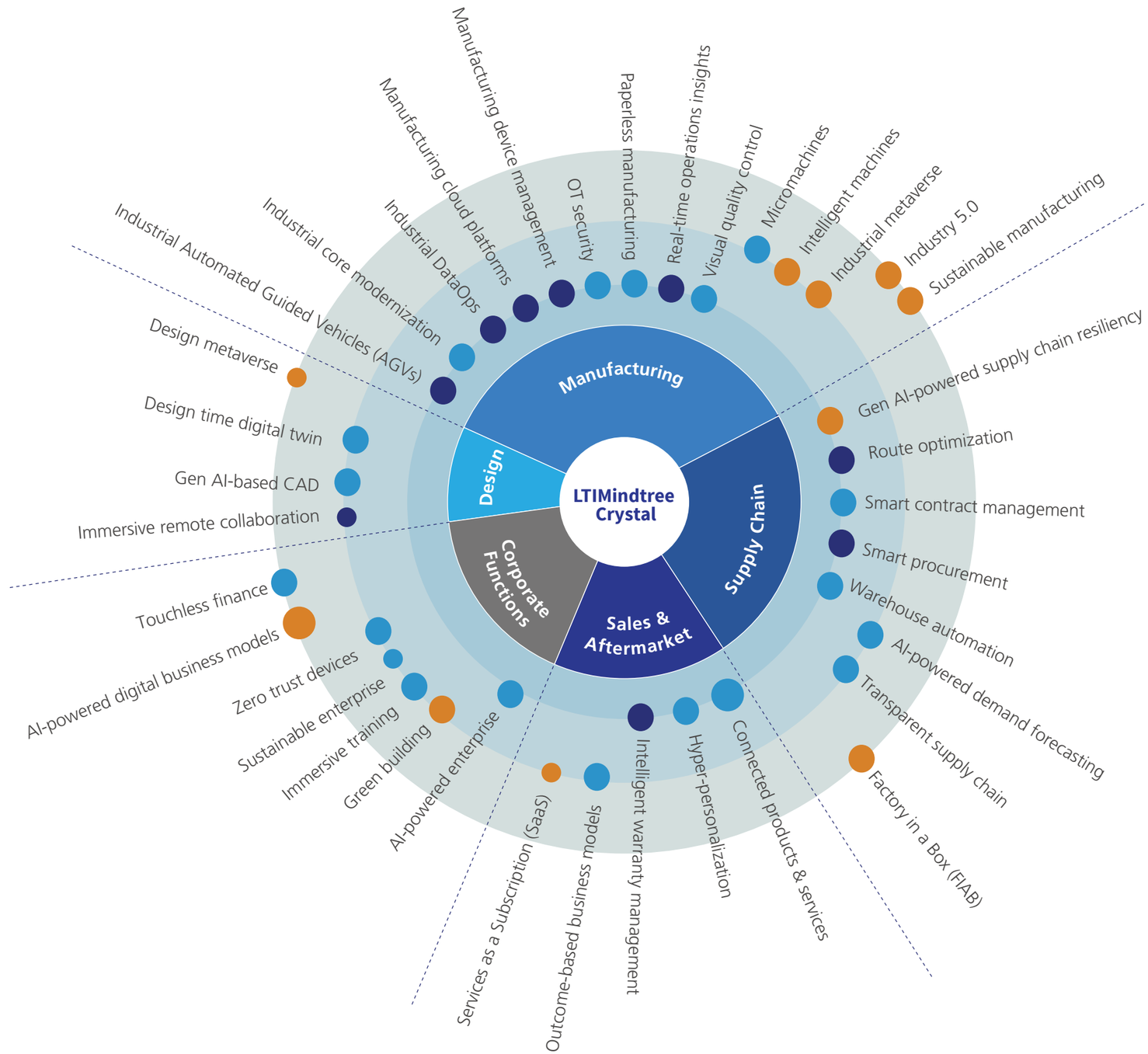
Industrial Manufacturing Disruptive Trends Radar



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Radar Ratings & Definition

Horizon

Horizon refers to the timeframe between the inception of a new technology trend and its adoption by the mainstream

Horizon 1 (0-1 Year)

Trend will be industrialized in less than 1 year

Horizon 2 (1-3 Years)

Trend will be industrialized within 1 to 3 years

Horizon 3 (3+ Years)

Trend will take more than 3 years to reach industrialization state

Market Potential (USD)

The likelihood of the technology trend to generate value across multiple functions

Low

High

Very High

Adoption Phase

Adoption maturity of the technology trend in the market

Emerging

Trend is at its initial stages of adoption, with innovators and early adopters exploring its potential.

Improving

Trend adoption is increasing with proven potential to improve efficiency and effectiveness.

Mature

Trend has achieved widespread acceptance and usage among the general population or targeted audience

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Navigating the Radar

Horizon 1

Manufacturing

- Industrial Automated Guided Vehicles (AGVs)
- Industrial core modernization
- Industrial DataOps
- Manufacturing cloud platforms
- Manufacturing device management
- Operational Technology (OT) security
- Paperless manufacturing
- Real-time operations insights
- Visual quality control

Supply Chain

- Gen AI-powered supply chain resiliency
- Route optimization
- Smart contract management
- Smart procurement
- Warehouse automation

Sales & Aftermarket

- Connected products & services
- Hyper-personalization
- Intelligent warranty management

Corporate Function

- AI-powered enterprise

Horizon 2

Design

- Design-time digital twin
- Gen AI-based CAD
- Immersive remote collaboration

Manufacturing

- Industrial metaverse
- Intelligent machines
- Micromachines

Supply Chain

- AI-powered demand forecasting
- Transparent supply chain

Sales & Aftermarket

- Outcome-based business models
- Services as a Subscription (SaaS)

Corporate Function

- Green building
- Immersive training
- Sustainable enterprise
- Zero trust devices

Horizon 3

Design

- Design metaverse

Manufacturing

- Industry 5.0
- Sustainable manufacturing

Supply Chain

- Factory in a Box (FIAB)

Corporate Function

- Touchless finance
- AI-powered digital business models

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Horizon 1

Trend will be industrialized in less than 1 year

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Industrial Automated Guided Vehicles (AGVs)

Automated Guided Vehicles (AGVs) are self-navigating transport systems or load carriers that move autonomously. They eliminate the need for an onboard operator or driver within a warehouse, distribution center, or manufacturing facility. Industrial AGVs, ranging from autonomous forklifts to driverless trucks, are poised to change logistics and manufacturing processes by enhancing safety, efficiency, and overall quality

Highlights

There have been breakthroughs in sensor and imaging technologies along with significant advancements in natural-language processing. Computer vision has paved the way for enhanced autonomy in self-driving vehicles that offer increased flexibility, precision, and reliability in various applications, including handling systems. AGVs can effectively utilize massive volumes of sensor data to monitor device status. They can gather product-related information (such as location using visual recognition or RFID tags) and track ambient parameters like temperature and humidity. With the integration of IoT, digital twins, and machine intelligence, AGVs are now capable of independently executing more complex tasks.

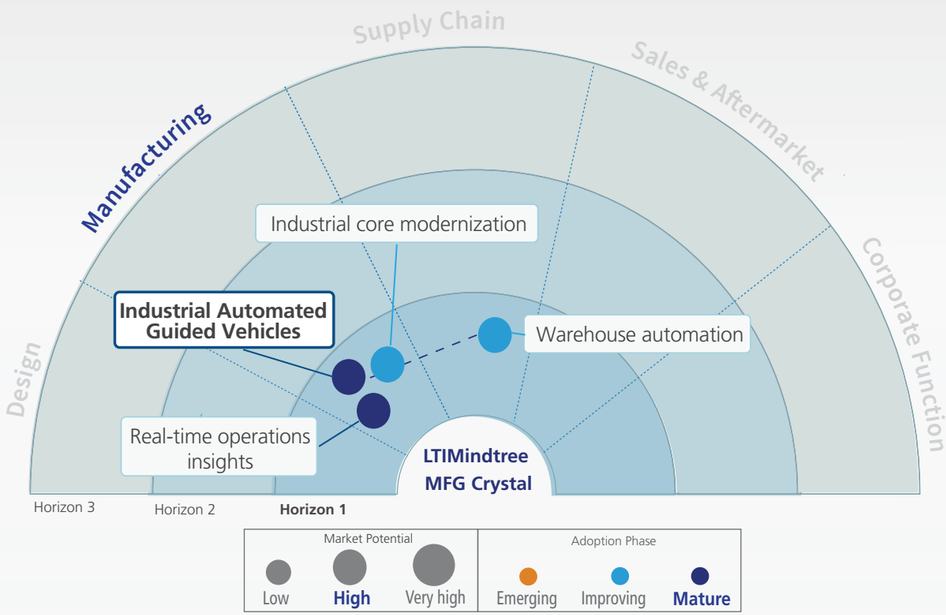
Key Application Areas

Assembly lines: Transporting semi-finished machine parts to the final assembly line, ensuring uninterrupted operations.

Handling finished goods: Transporting finished goods from the shop floor to the warehouse for storage and despatch.

Transportation of raw materials: Transport of raw materials from warehouse to shop floor to ensure uninterrupted production.

Radar View & Related Trends



Key Technologies

Sensor Tech

Enable AGVs to navigate and avoid obstacles by providing real-time environmental data

Edge AI

Processes data locally to reduce latency in decision-making and improve response time

Applied AI

Utilizes ML algorithms to optimize routing, load distribution, and operational efficiency on historical data

Agentic AI

Enables AGVs to act autonomously, making decisions based on real-time data and environmental changes

Featured Story

A leading Japanese automaker implemented industrial AGVs to enhance efficiency and optimize performance on the shop floor. The AGV halts at designated transfer points and signals the door transfer system to automatically load fabricated doors onto individual load movers, which improves productivity and repurposes operatives.

Key Takeaway

The functionalities and characteristics of AGVs are interconnected and can be extended beyond the Industry 4.0 setting. AGVs can be connected to cloud platforms to share their location and content in the vehicle via high-speed connectivity. This data can be analyzed and interpreted by customized monitoring applications.

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Industrial core modernization

Industrial core modernization involves updating fundamental systems and processes to enhance efficiency and adaptability. This includes integrating smart factory technologies like AI and IoT for automation and real-time data analysis. Additionally, it focuses on improving supply chain resilience and efficiency through digital integration, predictive analytics, flexible manufacturing, and advanced inventory management.

Highlights

The industrial manufacturing sector involves highly complex operations, has extensive supply chains, requires advanced technology, and faces fierce competition among manufacturers. Therefore, industrial manufacturing is critical and requires better digital modernization solutions. Industry 4.0 has accelerated the modernization of digital factories in the manufacturing industry. It ensures efficient, sustainable, and seamless manufacturing operations while facilitating other digital modernization services. Forrester Consulting research found that 90% of manufacturing leaders believe a digital transformation strategy is critical for their company's success.

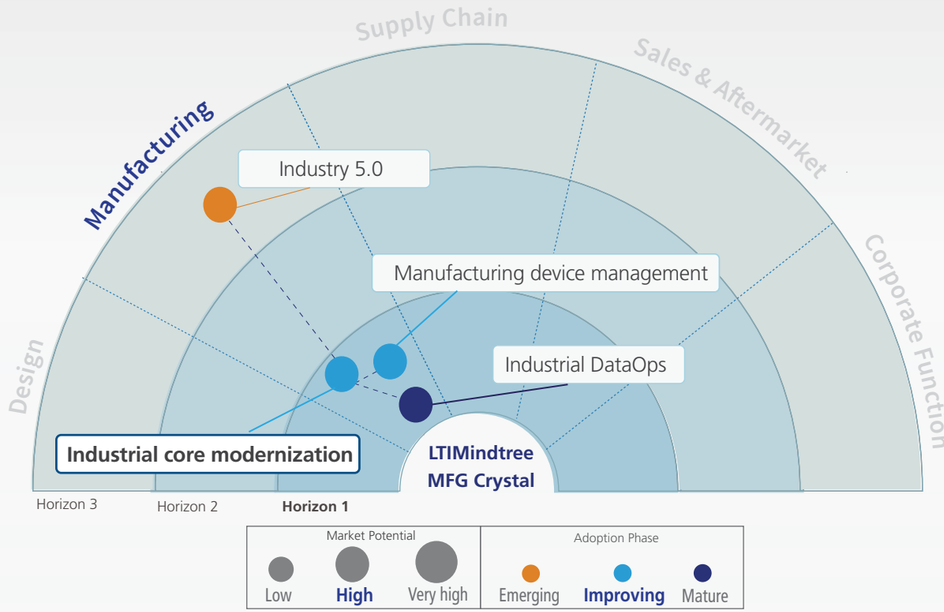
Key Application Areas

Increased process efficiency and faster product delivery: This allows for the removal or minimization of all inefficient manual processes, reducing the usage of physical resources.

Data-driven equipment maintenance and workforce cooperation: This technology enables real-time data exchange between human workers, machines, software systems, and other operational process components.

Effective business management, planning, and analytics: The flow of time series data generates automatic reports with business analytics, predictions, and planning.

Radar View & Related Trends



Key Technologies

Internet of Thinking

Connects machines and devices, enabling real-time monitoring and data collection for improved operations

Digital Twin

Virtual replica of physical assets that simulate operations for better monitoring and predictive maintenance

Self-Adaptive Security

Applies real-time, AI-driven defense mechanisms to detect, respond to, and mitigate cyber threats

Applied AI

Optimizes manufacturing processes through predictive maintenance, quality control, and intelligent automation solutions

Featured Story

A notable case study in industrial core modernization with 5G enablement involves the collaboration between Fraunhofer Institute for Production Technology and a Swedish-based networking and telecommunications company. By integrating 5G, they achieved real-time process control, significantly reducing manufacturing failures and downtime. This modernization led to annual savings of approximately EUR 27 million for a single factory.

Key Takeaway

Digitalization drives manufacturing industries to adopt intelligent manufacturing strategies. These strategies are driven by internal demands like cost reduction, operational efficiency improvements, innovation, and R&D. They are also influenced by external pressures from evolving client needs and customer-experience requirements.

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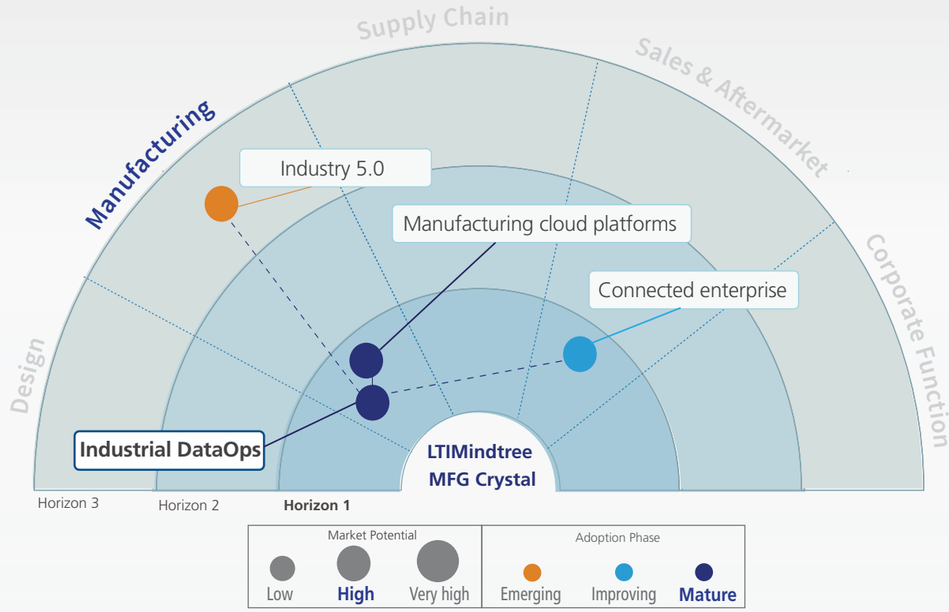
Industrial DataOps

Industrial DataOps integrates digital technology with operational processes to foster a closed-loop manufacturing approach. It aligns information technology (IT) workflows with operational technology (OT), improving data utilization and connectivity. Synchronizing production across product design and planning creates a network of information. This convergence involves process alignment, data convergence, software integration, and physical device updates, resulting in reduced downtime, enhanced asset utilization, and streamlined processes.

Highlights

Today's manufacturers face hurdles across supply chains, inventory management, quality assurance, point of sale, and data security. This is because historical process isolation hinders integration, affecting IT and OT system interoperability. Breaking down such silos allows departments to collaborate more cohesively, ultimately enhancing customer satisfaction. Achieving tangible business results necessitates restructuring roles and addressing integration challenges using a unified data model to enable smooth communication and collaboration among various departments. Implementing digital twins offers significant advantages for industrial manufacturers by bridging the gap between IT and OT. These digital replicas of physical products, processes, shop floors, or machines serve as valuable assets for manufacturers and designers.

Radar View & Related Trends



Key Application Areas

Predictive maintenance: Using real-time data from OT systems to predict equipment failures and optimize maintenance schedules reduces downtime and costs.

Quality control and process optimization: Integrating IT systems with OT data to monitor and optimize manufacturing processes ensures consistent quality and efficiency.

Inventory and supply chain management: Leveraging IT/OT integration improves inventory visibility, automates replenishment processes, and optimizes supply chain operations.

Key Technologies

Data Fabric
Enables seamless, real-time data flow, integration, and automation across manufacturing operations in DataOps

Regulatory Tech
Ensures data quality, security, and compliance across industrial systems

Edge AI
Process data locally near devices to reduce latency and improve real-time decision-making

Sensor Tech
Collects data from connected sensors and devices for better monitoring and automation of industrial processes

Featured Story

A Fortune 50 automotive manufacturer wanted to move from a manual, error-prone, calendar-based maintenance system to a condition-based maintenance solution. LTIMindtree implemented a scalable AWS-based solution that automated the monitoring and maintenance of shop floor assets. It helped reduce approximately 1000 hours of manual inspection per plant and improved MTTR (mean time to repair) by 200 minutes.

Key Takeaway

Industrial DataOps helps manufacturers stay ahead of their competitors by improving overall operational efficiency and enhanced data visibility to improved security and increased innovation. These further amplify the potential for transformative changes in the manufacturing industry.

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Manufacturing cloud platforms

A manufacturing cloud platform is a digital solution that helps streamline and optimize manufacturing processes like production planning, supply chain management, inventory tracking, quality control, etc. These platforms provide real-time visibility, collaboration, and analytics capabilities to manufacturers, enabling them to improve efficiency, reduce costs, and enhance product quality.

Highlights

Cloud platforms have gained remarkable momentum in recent years, with many manufacturing organizations adopting them to transform their operations. Manufacturers are increasingly turning to cloud-based platforms to encourage data sharing, collaboration, and automation across the supply chain. It has empowered them to maintain business continuity and respond rapidly to changing market conditions while reducing manual errors and streamlining work. This leads to faster production cycles and lower costs. Manufacturers can seamlessly connect with suppliers, partners, and customers across geographical boundaries, cultivating greater transparency, agility, and responsiveness. In addition, Industrial Cloud enhances manufacturing by enabling real-time data integration, optimizing operations, and supporting advanced technologies for improved efficiency, flexibility and cost saving.

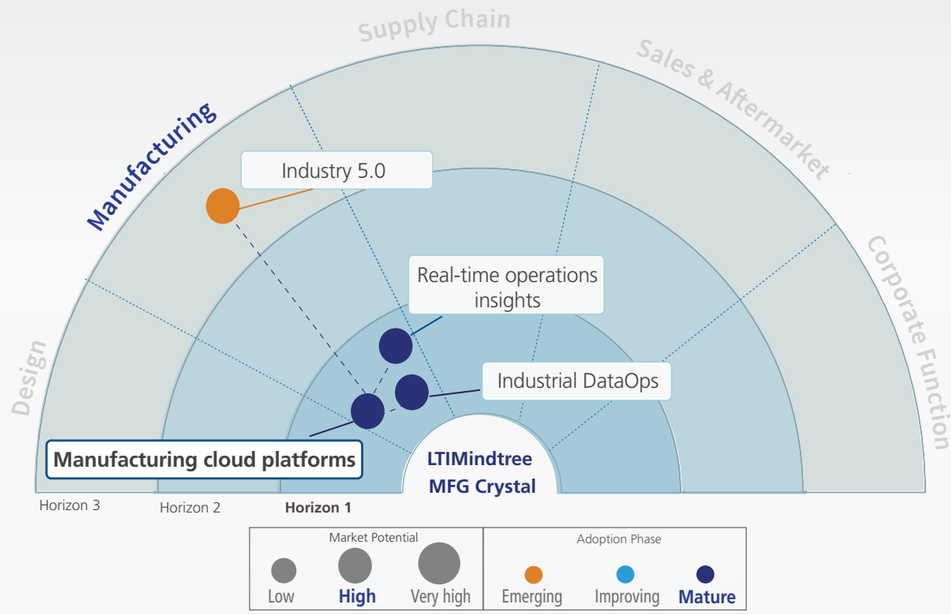
Key Application Areas

Supply chain management: Monitoring and managing the flow of materials from procurement to distribution, global vendors, and contract manufacturers.

Asset tracking and management: Monitoring the location, condition, and performance of assets such as machinery and tools to optimize utilization.

Predictive maintenance: Predict equipment failure, schedule maintenance proactively, and minimize unplanned downtime.

Radar View & Related Trends



Key Technologies

Industry Cloud Platform
Manage workloads more efficiently, accelerate change, and innovate by offering modular, composable solutions

Regulatory Tech
Comply with industry standards

Distributed Cloud
Manufacturing operations to be spread across multiple locations while maintaining centralized control

Data Fabric
Integrates various systems and devices within a manufacturing environment to provide seamless data flow

Featured Story

A precision dies and tools manufacturer in the UAE utilized the Oracle Fusion Cloud Procurement suite to streamline the evaluation of suppliers' financial stability and their capability to deliver quality goods and services punctually. This cloud-enabled suite has facilitated completely paperless digital procurement, reducing purchase order approval times by 40% and processing transactions nearly twice as fast as previously.

Key Takeaway

A manufacturing cloud platform helps ensure business continuity and reduce risks through a secure, transparent, and connected supply chain. It also automates manufacturing factories and empowers the workforce with industrial IoT, data, and AI.

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Manufacturing device management

A manufacturing device management (MDM) system allows organizations to align and control endpoint devices like smartphones. This ensures security and controlled usage from a single console. MDM is a core component of unified endpoint management and enterprise mobility management. The use of MDM in manufacturing has become prominent to ensure enhanced communication, optimize operations, and improve productivity.

Highlights

In manufacturing, mobile device management enables real-time monitoring of devices to ensure they are always operational. It also allows for remote troubleshooting, lowering downtime and increasing productivity. It safeguards sensitive data, and device security is crucial throughout manufacturing. MDM allows organizations to restrict the use of Android tablets for business use, lowering the risk of a data breach. The technology enables whitelisting apps to permit the installation of only approved apps. It safeguards intellectual property and trade secrets in the industrial sector, where ensuring innovation is critical for both economic gain and national security. Manufacturing device management's remote wipe feature allows the deletion of data from lost or stolen devices.

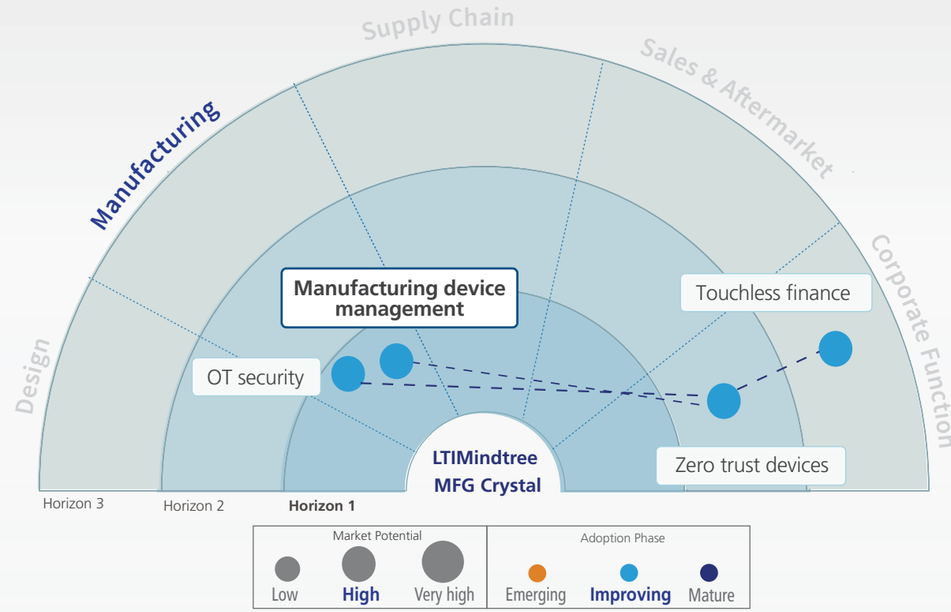
Key Application Areas

IoT for monitoring: It makes the process proactive with thermal and video sensors collecting complete product data.

RFID for inventory tracking: It scans tags and extracts the necessary data for further processing.

Maintenance schedule planning: Avoid ineffective maintenance routines by leveraging industrial IoT and data science for predictive maintenance.

Radar View & Related Trends



Key Technologies

Cybersecurity Mesh

Defines security perimeters in manufacturing environments where numerous devices need protection

Edge AI

Real-time data processing and decision-making at the source of data generation

Sensor Tech

Track various parameters such as temperature, pressure, and machine performance

Software-Defined Vehicles

Enhances automation, leading to more efficient and flexible operations

Featured Story

An India-based pharmaceutical manufacturing and marketing company implemented mobile device management to simplify device management and provisioning with Zero Touch Enrolment (ZTE). A robust kiosk and browser solution helped the manufacturing company optimize device usage and prevent the misuse of any provisioned devices.

Key Takeaway

The future of mobile device management in manufacturing involves zero-trust security, AI integration, unified endpoint management, user privacy, bring-your-own-device (BYOD) policies, product innovation, and collaborative governance.

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Operational technology security

Operational Technology (OT) security refers to the software and hardware infrastructure required to monitor, identify, and regulate device changes, processes, and events. This technology assists industrial manufacturing companies in securing systems and networks against cyber-attacks. It also offers various security technology solutions, including powerful firewalls, security information and events management systems, and identity access tools.

Highlights

OT security promotes a holistic and complete approach to creating a safe and secure OT control environment for industrial businesses. This technique lays the groundwork for an OT security strategy and improvement program. The increased availability of high-speed internet and a need for data-driven insights are expected to boost the number of connected devices in manufacturing. IIoT offers benefits like real-time data collection and better operations. However, increasing the number of connected devices in an OT context presents issues. The use of OT security in industrial production is growing to combat risks such as ransomware, distributed denial-of-service (DDoS), malware, online threats, and supply chain assaults. Future AI-based technology adoption will increase spam and phishing campaigns, precision assaults on edge devices, and external data gathering for improved attack planning.

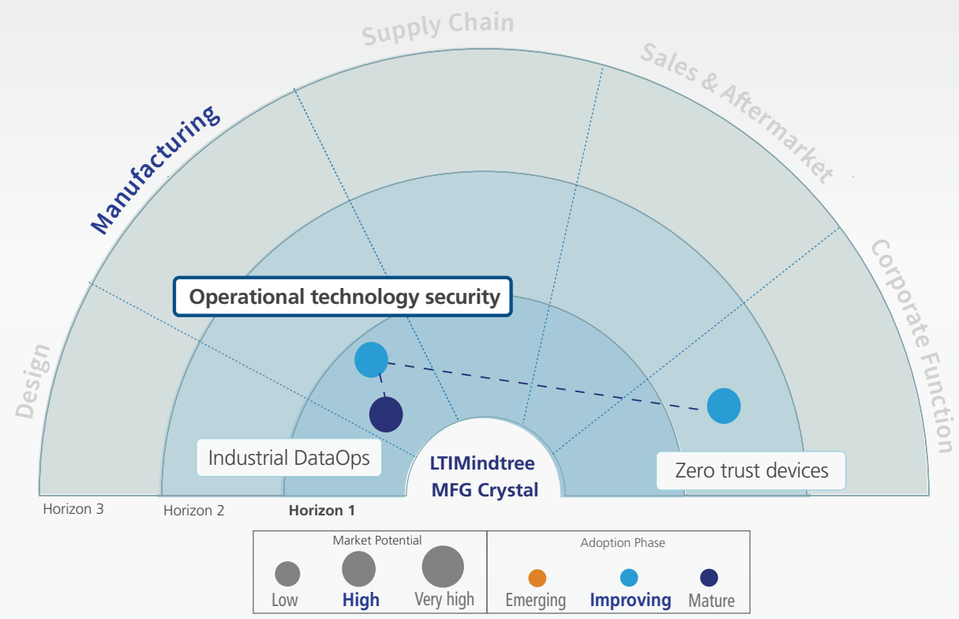
Key Application Areas

Cyber-attack mapping: This gives real-time visual representations of cyber-attacks.

OT asset management: It helps identify and consistently manage data, personnel, devices, systems, and facilities.

OT security monitoring: This helps protect and control critical infrastructures such as power stations, transportation networks, and smart city appliances.

Radar View & Related Trends



Key Technologies

Zero Trust Architecture

Continuous verification of user and device identities, ensuring that only authorized entities have access

Digital Identity

Multi-factor authentication, biometrics, and digital certificates to verify identities

Deception Technology

Introduce decoys to mimic real OT systems, luring attackers away from critical assets

Self-Adaptive Security

Protect OT environments by continuously evolving to counter new and emerging threats

Featured Story

LTIMindtree designed and implemented an OT security control framework and cybersecurity architecture for the Middle East's largest multi-commodity mining and metals firm. The corporation required an innovative layout for its industrial plant's information technology (IT) and operational technology (OT). This has helped the corporation centralize the management of the plant's OT assets for a more unified view and better visibility of hazards.

Key Takeaway

Insecure OT devices will be vulnerable to viruses and vulnerabilities. Adopting OT security helps organizations meet dynamic, complicated, and expanding OT/ IIoT cybersecurity challenges. It allows industries to automate and optimize labor and operations and simplify divisions.

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Paperless manufacturing

Paperless manufacturing refers to eliminating physical documents and materials while implementing digital logs and forms in the production process. This involves using paperless machines, digital data, and automation to enhance efficiency and reduce costs. It eliminates physical paper with software, driving lean initiatives and continuous improvement. Paperless manufacturing ensures a digital trail is left behind for all activities, driving error-proof manufacturing.

Highlights

Manufacturing organizations are increasingly adopting paperless manufacturing to gain the maximum benefits of digitalization. It solves strategic issues with increased efficiency and is a huge technological step moving forward. Traditional paper-based systems were inefficient and could not be leveraged for storing and sharing information. They were prone to human errors, misplacement of documents, and sometimes illegible handwriting. Digital data in manufacturing overcomes most of the challenges and enables faster production with increased accuracy. It enables improved security for the storage of sensitive information and reduces the risk of a data breach without the need for physical printing. It also helps to avoid paper usage and contributes towards sustainability goals. Major challenges in implementing paperless manufacturing are the changing mindset of people in a traditional setup and the investment required in terms of hardware, software, and personnel.

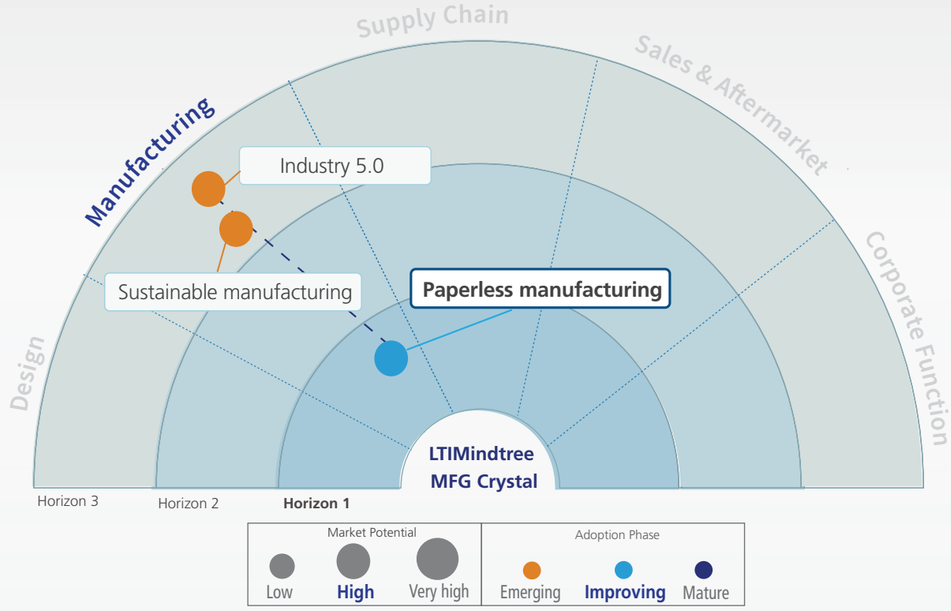
Key Application Areas

Improved operational efficiency: Digital records help with data capture and reduce manual documentation.

Increased sustainability: Reduced paper usage drives sustainable operations and eliminates wastage.

Added compliance: Increased traceability, data integrity, and protection against unauthorized access leads to compliant operations.

Radar View & Related Trends



Key Technologies

Digital Twin

Creates a virtual replica of physical assets, processes, or systems

Internet of Thinking

Minimizes unexpected breakdowns and extends the lifespan of machinery

Sensor Tech

Track the movement and usage of materials and components in real-time

Edge AI

Dynamically adjusts equipment settings to optimize energy usage

Featured Story

A U.S.-based manufacturer of tilt-pad fluid film thrust and journal bearings faced productivity challenges due to reliance on paper job packets. After consulting a recognized U.S. software provider, they adopted data management software for digital job detail storage. This system centralized file versions and enabled multi-location access, saving manufacturer's 20 hours weekly.

Key Takeaway

Paperless manufacturing is emerging as a key concept for efficiency, sustainability and competitiveness. It can simplify and improve operations while saving costs at the same time. Manufacturers that embrace digital initiatives position themselves for innovation and sustainable growth in an increasingly competitive market.

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Real-time operations insights

Real-time operations insights in manufacturing refer to the process of collecting, analyzing, and interpreting data in real time. Technologies like big data analytics leverage analysis techniques such as descriptive analytics, predictive analytics, ML, etc. These techniques are used at every stage of real-time production, providing immediate insights that help operators take necessary actions.

Highlights

A real-time manufacturing analytics system supported by big data connects all departments and stakeholders involved in production processes. The system helps in standardizing methodology, terminology, and reporting procedures across all factory sites. Manufacturers leverage real-time operational data for analysis and apply it to identify and rectify bottlenecks and monitor real-time production lines. Descriptive analytics helps get consolidated insights into past design features, specifications, etc., leading to a quicker understanding of the historical design performances and benefits. Predictive analytics provides innovative and tailored designs and development methodologies based on historical and incremental data available by using inbuilt predictive algorithms. On the other hand, prescriptive analytics provides real-time and agile solutions based on the data feed.

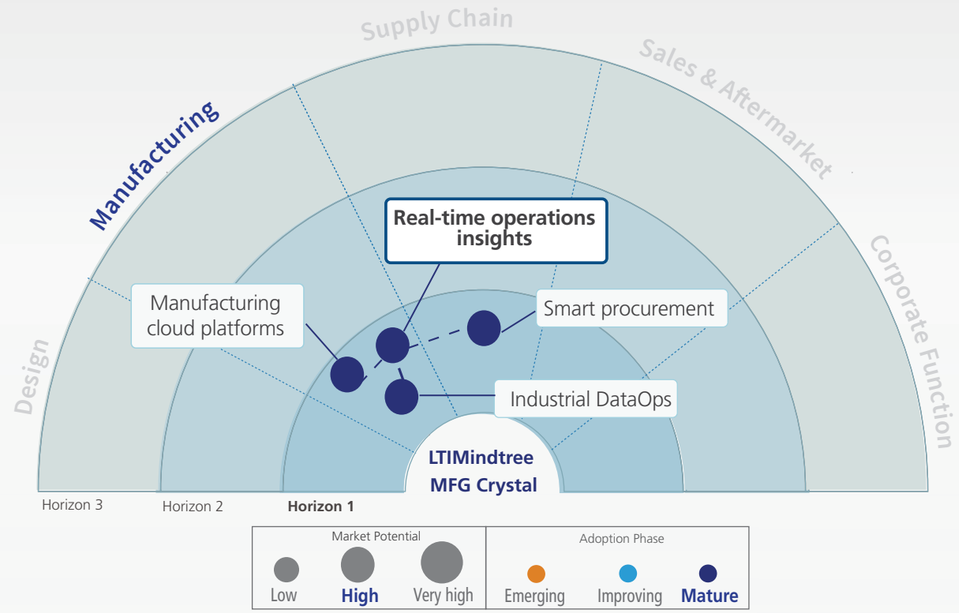
Key Application Areas

Deeper insights into requirements: Big data analytics enhances manufacturers' understanding of customer needs and forecasts into future trends resources.

Predictive product designs: Predictive analytics to generate the best designs based on historical and incremental data.

Speeding up the assembly: With big data analytics in manufacturing, organizations can now segment their production and identify the units that are manufactured faster.

Radar View & Related Trends



Key Technologies

Edge AI
On-site data processing for real-time insights, optimizing production efficiency

Gen AI
Enables rapid scenario modelling, predictive analytics enhancing decision making

Sensor Tech
Gathers real-time data to monitor and maintain optimal production processes

Augmented Reality
Guides operators with instant insights for maintenance and quality checks

Featured Story

A global escalator and elevator manufacturer faced major challenges due to non-uniformity in the sales discount process, resulting in fluctuating profit margins and profitability. LTIMindtree implemented a solution involving analytics over the sales data using Azure AutoML. As a result, the manufacturer's revenue in France rose by 40% YoY and profit by 3%. In Germany, its revenue rose by 23% YoY and profit by 4.5%.

Key Takeaway

Real-time analytics leveraging big data is the secret behind manufacturers experiencing high production efficiency, better prediction of anomalies, and getting competitive advantage. To leverage the full benefit of the technology, big data needs to be integrated with technologies like IoT, sensors, and AI.

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Visual quality control

Visual Quality Control enables systems to understand visual inputs from real-world scenarios. Deep learning data models then accurately identify, classify, analyze, and process the inputs into meaningful decision-making. This enables Visual Quality Control systems to identify anomalies. They detect defects or missing components in an industrial product, irregular manufacturing lines, visible wear and tear in machine parts, and other similar tasks.

Highlights

Traditional quality inspection relies on human judgment, perception, and availability of resources. These perceptions often fall short on subjectivity, human capability, and training time, leading to an average of 20% of potential sales due to poor quality of manufactured goods. However, AI and image recognition advancements can overcome this challenge with greater efficiency and accuracy. AI-powered Visual Quality Control provides consistent detection at remarkable speed and accuracy, significantly improving overall efficiency and reducing time for inspection. With continuous data analysis, these models can self-learn and evolve to handle complex defect patterns and deliver efficient output. Challenges for Visual Quality control in Industrial manufacturing include lack of skilled professionals, expensive hardware and high-quality data.

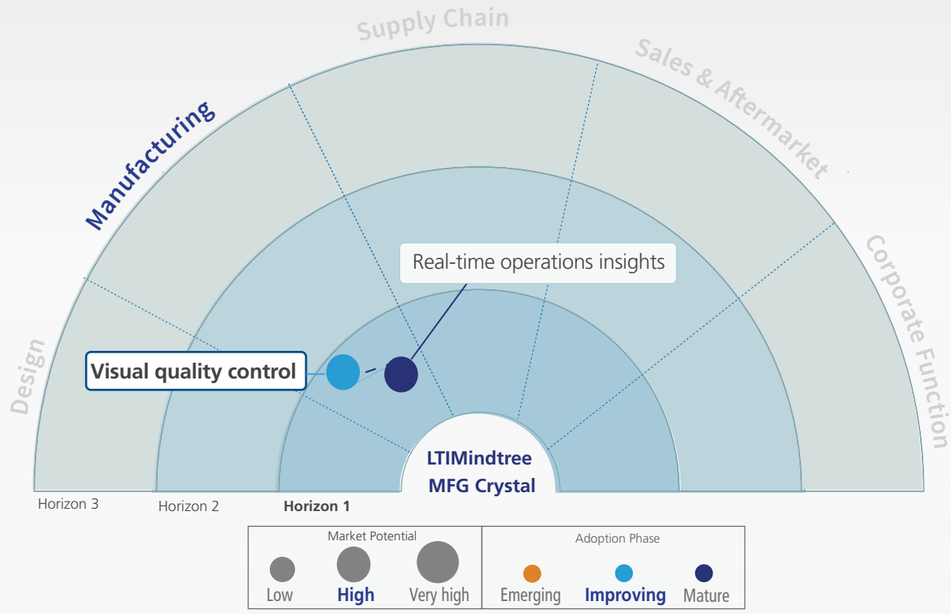
Key Application Areas

Quality inspection: Visual Quality Control enables automated visual inspection for anomaly detection to identify defective products.

Assembly process automation: It simplifies part detection and orientation alignment with robots in the assembly process.

Continuous dimension monitoring: Tracking dimensions in real-time ensures correct product fit and size.

Radar View & Related Trends



Key Technologies

Computer Vision

Detect defects, measure dimensions, and ensure that products meet quality standards with high accuracy

Edge AI

Analyze images and videos to identify defects, anomalies, or non-conformities in products during production

Augmented Reality

Overlay digital information on physical products, assisting workers in identifying defects and ensuring quality standards are met

Applied AI

Provide consistent inspection results, reducing the variability associated with human inspectors

Featured Story

LTIMindtree implemented a Visual Quality Control-based solution for an automobile manufacturer. The company faced challenges such as inadequate quality check processes, manual errors during the inspection, and root-cause defect detection. LTIMindtree developed the solution with the help of AWS services for porosity detection. The solution helped the manufacturer with a 100% defect detection, faster corrective actions, and minimized wastage.

Key Takeaway

Visual Quality Control offers a consistent, faster, and automated solution to a process that struggled with delayed response time, manual errors, and subjective nature. Leveraging CV reduces costs and improves product reliability, boosts competitiveness, and improves operational efficiency.

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Gen AI-powered supply chain resiliency

Manufacturing organizations are increasingly deploying Gen AI into their supply chains for demand planning and procurement to gain insights. Gen AI implementation helps manufacturing organizations analyze operational data, plan for procurement, optimize inventory, mitigate risks, and improve customer service. It can perform root-cause analysis to reduce defects and unlock untapped productivity. These insights can unlock untapped productivity, leading to greater production output.

Highlights

Supply chain disruptions are impacting manufacturers in multiple ways. In addition to long-term supply chain issues, industrial manufacturers are expected to source materials more responsibly, ethically, and sustainably. To achieve this, supply chain visibility is the top priority of supply chain executives. Gen AI acts like a supply chain consultant, enabling greater visibility across multi-layered networks and recommending best-fit suppliers based on key KPIs. Some of them are bill of materials (BOM), raw material availability, delivery schedules, and sustainability metrics (Sustainability KPIs). Gen AI powered supply chain improves demand forecasting and inventory optimization. Enhances customer confidence and satisfaction and improves compliance & better risk management. According to a Gartner survey from Jan 2024, half of supply chain leaders from 127 global companies plan to implement Gen AI in the next 12 months. About 14% of them are already in the implementation stage.

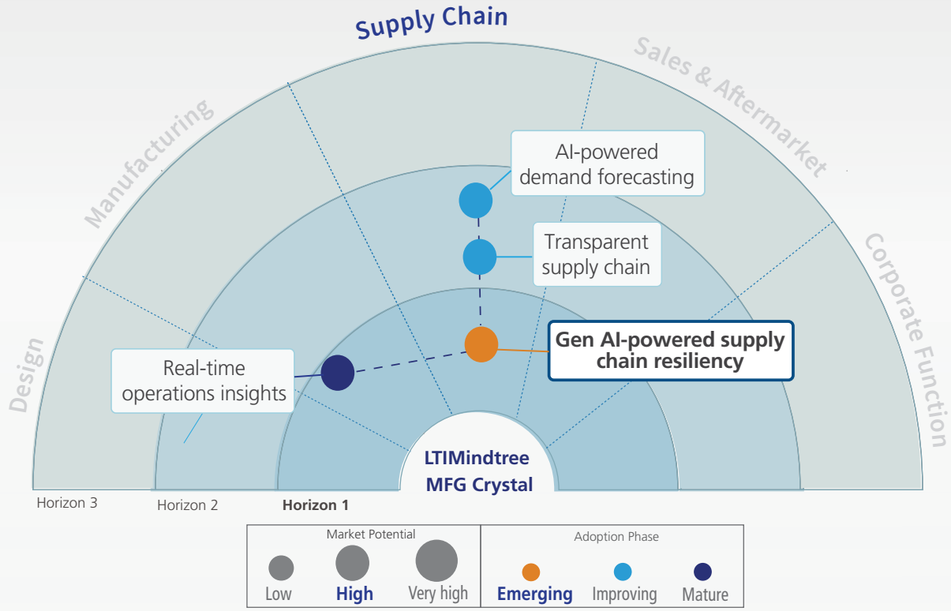
Key Application Areas

Demand forecasting: Leveraging historical and external data to create probabilistic models improved accuracy in demand forecasting.

Inventory optimization: Analyzing lead times, market trends, and sales data prevented stockouts.

Supplier selection: Selecting the right supplier based on quality, cost, lead time, and geographical location was made easier.

Radar View & Related Trends



Key Technologies

Gen AI

Identify bottlenecks and potential disruptions by analyzing data from various sources

Internet of Thinking

Monitor goods, vehicles, and equipment location, speed, and movement real-time

Edge Computing

Route optimization based on real-time traffic disruptions and inventory backup

Sensor Tech

Process real-time data for faster deliveries, optimized load management, etc

Featured Story

An American multinational retailer implemented an automated supplier negotiation solution that could read contracts, understand priorities, and negotiate through a chatbot. The solution leveraged historical price trends, competitor costs, and commodity values. After the pilot run, the solution tail-ended 64% of supplier contracts and extended payment terms by an average of 35 days.

Key Takeaway

Implementing Gen AI powered Supply Chain has tremendous resilience and scalability potential. Its application is gaining traction; however, aspects such as integration, talent, and data are some of the challenges that need to be addressed for a successful outcome.

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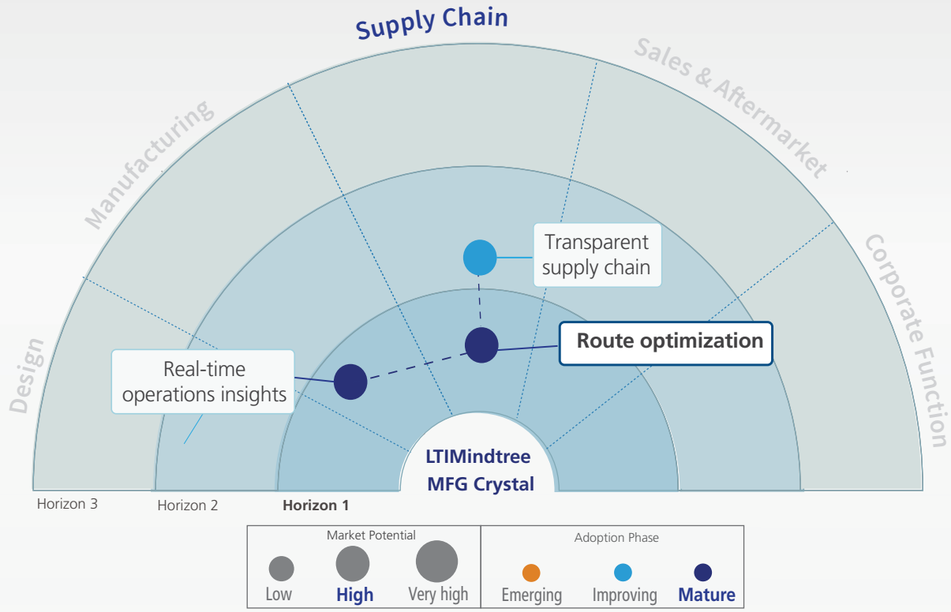
Route optimization

Route optimization is a strategic approach to planning the fastest and most cost-efficient route for transporting goods from one place to another. Factors like distance, traffic conditions, delivery time windows, vehicle capacity, and customer preferences determine the optimal sequence and allocation of stops along a given route. Route optimization software can generate optimal routes for each delivery vehicle by analyzing the above factors using generative AI.

Highlights

Route planning and optimization are facilitated by the IoT, which connects transportation, cargo, and warehouses. They also connect external data sources like weather, events, and traffic flows to enhance visibility and streamline shipping processes. Data-driven analytics from route optimization software can significantly decrease transit time while ensuring over 90% reliability. This solution offers seamless end-to-end consignment visibility, temperature-controlled features, and real-time tracking. Businesses can make informed decisions using real-time information from route optimization software to enhance their shipping operations. They can develop various strategies such as rerouting trucks, adjusting warehouse locations, reallocating resources, and more.

Radar View & Related Trends



Key Application Areas

Real-time traffic analysis: This analysis generates optimal routes for each delivery vehicle, improving efficiency and reducing transportation costs.

Inventory control and management: Utilizing RFID in product tags tracks product flow, streamlines inventory management, and provides access to up-to-date information.

Dynamic routing system: Employing an ML algorithm solves complex routing problems, enabling last-mile delivery, lowering fuel consumption, and reducing carbon footprint.

Key Technologies

Decision Intelligence

Data driven insights to optimize insights, reducing transit time, fuel costs etc.

Digital Twins

Allows real-time simulation and optimization of routes, inventory and production

Edge AI

Processes locations and traffic data locally, enabling immediate route selection

Satellite Internet

Ensures seamless connectivity, enabling data-driven decision-making

Featured Story

A distribution company employed generative AI to streamline warehouse layouts, resulting in increased efficiency and decreased operational costs. The AI model creates optimal warehouse designs that minimize travel time and maximize storage capacity by examining warehouse operations, inventory flow, and space utilization data.

Key Takeaway

Strategic supply chain design and daily operational supply management are expected to merge into a unified, data-driven route planning and optimization process that yields excellent results. Developing a network structure to handle current and future supply disruptions and demand changes is crucial for the survival of logistics, supply chain, automotive, and other industries.

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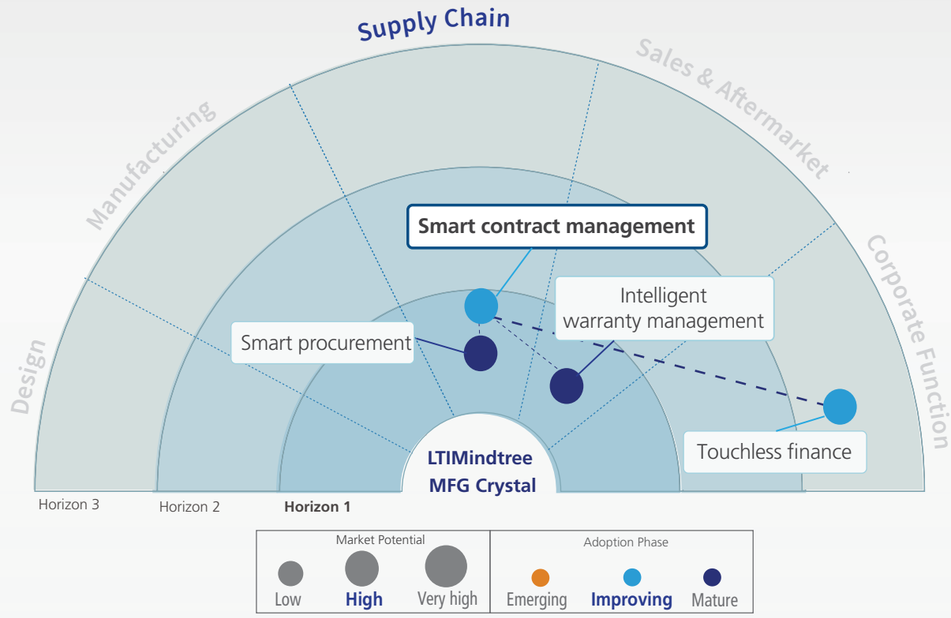
Smart contract management

Smart contract management involves using blockchain technology to automate and streamline contract-related processes within the manufacturing supply chain. These contracts can automate various tasks and transactions, such as purchase orders, delivery schedules, and payment terms. They also help manufacturers track the movement of goods, verify product authenticity, and ensure compliance with contractual obligations.

Highlights

Manufacturers are always trying to gain a competitive edge in an interconnected and data-driven environment. Hence, smart contract management is expected to play a pivotal role in transforming the supply chain, drive operational excellence, mitigate risks, and deliver customer satisfaction. It addresses various pain areas pertaining to cost reduction. It also enhances transparency and traceability by streamlining contract-related processes such as procurement, invoicing, and payment. This leads to faster transaction speeds and improved process efficiency, as well as optimized inventory management to minimize stockouts and reduce lead time.

Radar View & Related Trends



Key Application Areas

Automated procurement: Execute purchase orders and verify supplier credentials.

Inventory management: Minimize stockouts, coordinate deliveries with suppliers, and reduce excess inventory holding costs.

Quality control and compliance: Specify the quality specifications for raw materials and automatically reject or approve deliveries.

Key Technologies

Blockchain

Ensures tamper-proof transactions, enhancing tracibility and trust among the stakeholders

Distributed Ledger Technology

Enhances transparency and security, facilitating collaboration and reducing errors

Gen AI

Automates contract creation, ensures compliance, and streamlines negotiations.

Featured Story

A global automotive parts manufacturer faced challenges such as file retrieval, lack of a standard approval and signature process, lack of a mechanism to track renewal/expiry of contracts, etc. The manufacturer implemented smart contracts, which simplified approvers/signatories for contracts, retrieval of files, and timely reminders before the end of contract dates.

Key Takeaway

Smart contract management can have a transformative impact on supply chain transparency. It facilitates just-in-time manufacturing and ensures secure payment processes, thereby streamlining operations, reducing the risk of fraud, and improving compliance.

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Smart procurement

Smart procurement refers to using innovative technologies, such as AI, ML, data analytics, automation, RPA, etc. These technologies streamline procurement processes and free professionals from repetitive tasks to increase productivity and reduce manual errors. Industrial manufacturers are moving away from traditional systems and procurement practices to improve agility, decision-making, and operational efficiency and reduce risks and costs.

Highlights

Industrial manufacturing firms struggle with inefficiency, higher operating costs, and risks such as manual errors. Introducing smart procurement in a macro climate that is seemingly unpredictable can help the procurement function emerge as a strategic division rather than a cost-saving department. Smart procurement focuses on building resilience, refining supply chain visibility, and agility solutions like Blockchain, AI, IoT & cloud-based platforms. This enhances supplier collaboration, risk management, and demand forecasting. Amazon Business published a Procurement Data Report in 2024. It mentions that 98% of respondents reported planning investments in analytics and insights tools, automation, and AI for their procurement operations in the next few years.

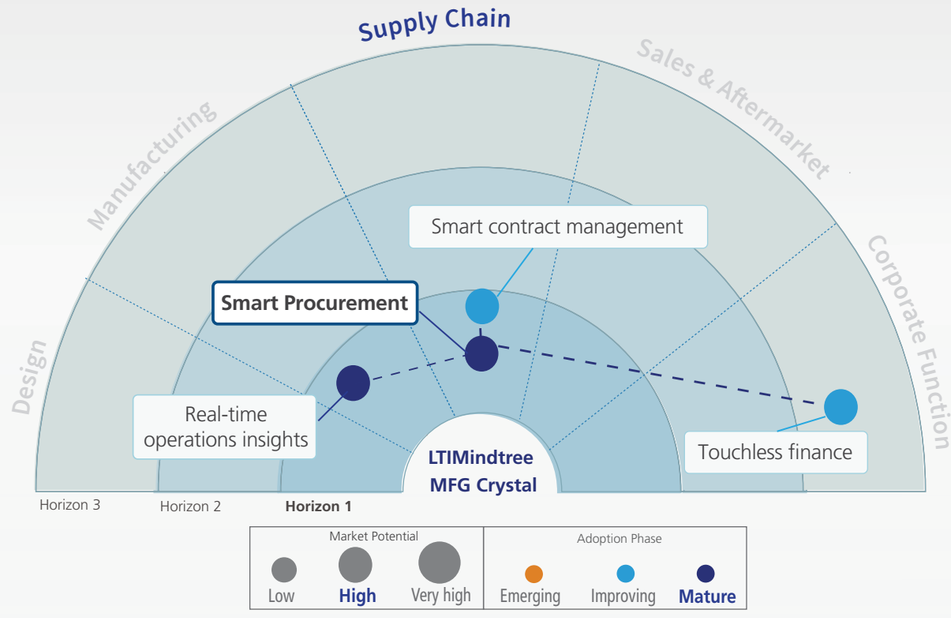
Key Application Areas

Sustainability and ethical sourcing: It helps track ethically sourced materials to ensure a sustainable supply chain.

Risk management: Data analytics can help forecast supply chain disruptions due to unnatural causes.

Inventory management: It prevents stock-outs, reduces transportation costs, and ensures optimal stock levels.

Radar View & Related Trends



Key Technologies

Blockchain
Ensures transparent and secure transactions in supply chain

Hybrid Cloud
Scalable and on-demand procurement processes enabling collaboration and real-time visibility

Decision Intelligence
Effective decision-making in procurement by providing actionable insights and improving collaboration

Data Fabric
Comprehensive and agile approach to data management, facilitating better insights and operational efficiency

Featured Story

A Sweden-based automotive manufacturer was leveraging disparate ordering systems with manual processes.These systems did not allow for customized raw material ordering and posed challenges in order tracking. After implementing the LTIMindtree Smart Procurement solution, the client achieved a 50% reduction in maintenance costs, real-time supplier integration, and an automated product selection and approvals workflow.

Key Takeaway

Implementing intelligent procurement can convert a cost center, traditionally seen as a crucial strategic function, into an efficient operation that positively influences an organization's performance and competitive edge.

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Warehouse automation

Warehouse automation uses technologies like robots, computer systems, and automated material handling equipment to enhance productivity and safety and streamline operations. It is gaining popularity in modern logistics, and technologies like AI and IoT will play a vital role in the advancement of warehouse automation. Key innovations include goods-to-person systems, automated storage and retrieval systems, autonomous mobile robots, pick and put-to-light systems, voice picking, and automated sortation systems.

Highlights

Technologies like Automated Guided Vehicles (AGV) and autonomous mobile robots (AMR) for agile operations, advanced automated storage and retrieval (ASRS) with robotic arms, and AI and AI/ML for predictive analytics will transform warehousing. Blockchain will enhance supply chain transparency, IoT will provide real-time inventory data, and cloud-based warehouse management systems (WMS) will offer remote management. In addition, data analytics will drive performance optimization, ensuring competitive and efficient warehouse operations. Warehouse automation significantly enhances operations, achieving 99% inventory accuracy and reducing labor costs by 3%. Smart warehouses leveraging IoT and AI, boost productivity and cut costs.

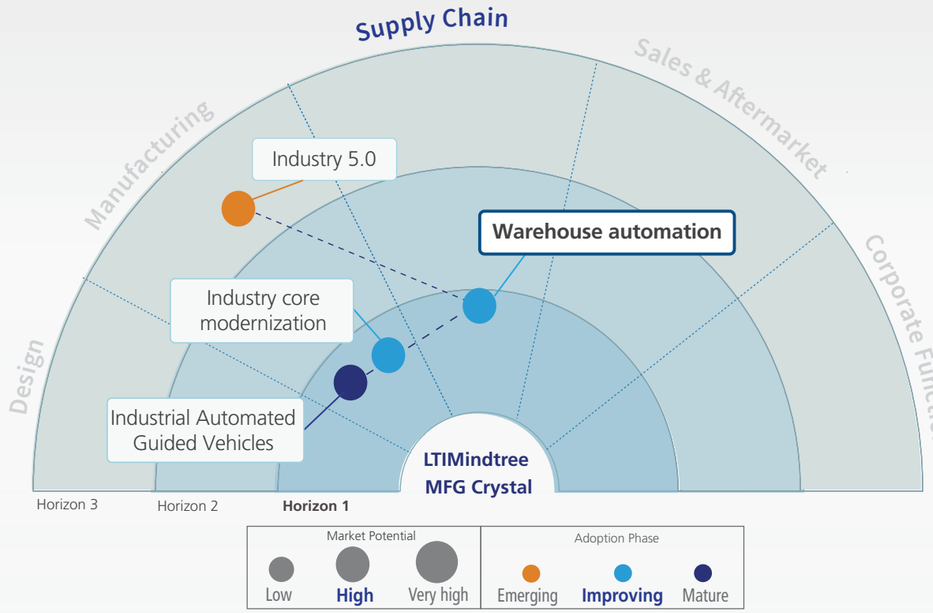
Key Application Areas

Automated storage and retrieval systems (AS/RS): Efficiently store and retrieve products using robotics and conveyor systems

Warehouse management systems (WMS): Optimize inventory management order processing and source allocation

AI and ML: Predict demand, optimize routes, and improve decision-making process

Radar View & Related Trends



Key Technologies

Wearable Technologies

Enable hands-free operation to increases productivity

Zero Trust Architecture

All data transmitted within the network is encrypted to protect it from interception and tampering

Augmented Reality

Overlay visual guidance reduces errors and speeds up the picking process

Software-Defined Vehicles

Navigate warehouse floors autonomously to transport goods

Featured Story

LTIMindtree harmonized warehouse processes for a Denmark-based stone wool insulation manufacturer. We conducted a global business Blueprint workshop for 36 warehouses in 30 countries. They implemented handling unit management with SSCC number, RFID, and GPS solutions for operational efficiency and developed a custom Fiori app for forklift operations.

Key Takeaway

Embracing automation and data-driven insights futureproofs warehouses. It also boosts competitiveness and ensures success in evolving logistics, positioning businesses to thrive in the dynamic warehousing landscape.

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Connected products and services

Connected products and services empowers field service personnel and technicians with technology. It equips them to serve customers better during servicing, installation, commissioning, downtime, breakdown, etc., and become a powerful sales engine. It also focusses significantly on being transparent which builds customer trust by giving field team members access to real-time information and resources and enabling them to deliver optimal services during sales and after-sales.

Highlights

Connected services enables seamless integration of IoT machine data with field service systems, providing service professionals and technicians with real-time proactive information about field assets, delivered via technologies like cloud to their mobile devices. These solutions will be essential for delivering more intelligent data, transforming how technicians operate in the field while improving the quality of the service they are able to provide. The key difference between connected products & services and traditional field service is the addition of IoT devices and the shift in the revenue model. The manufacturer tries to handle all preventative maintenance and charges a premium price to keep the client's equipment up and running. Other benefits of this solution for manufacturers include decreased downtime and increased customer satisfaction.

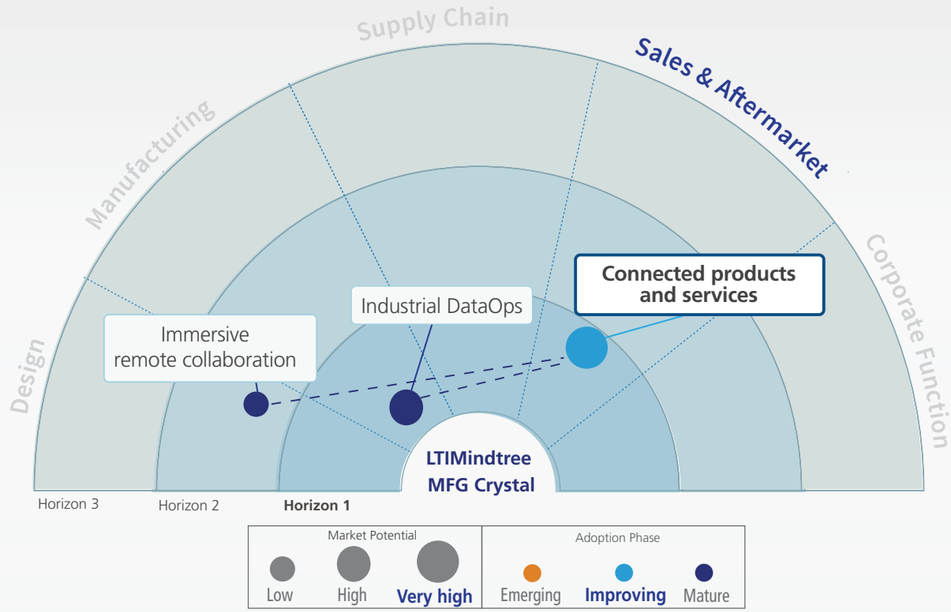
Key Application Areas

Real-time diagnostics: IoT sensors help detect issues at the initial stages of manufacturing.

Improved customer experience: Pre-empt issues and respond proactively.

Remote monitoring: Automatically tells service teams when installed equipment is not operating to specification or needs attention.

Radar View & Related Trends



Key Technologies

Internet of Thinking

Monitor and manage internet-connected devices and equipment from the cloud

Edge Computing

Analyse data at collection point for precise insights.

Mixed Reality

Delivering continuous service while reducing costs associated with in-person visits

Featured Story

An Italian machinery manufacturer faced challenges due to heavy usage and strict hygiene standards, resulting in frequent maintenance and costly downtime. They adopted connected field services by optimizing maintenance based on real-time usage through an integrated after-sales service monitoring system. This allowed them to provide a high level of predictive customer service consistently.

Key Takeaway

Integrating connected products and services optimization solutions properly and executing a change management strategy can set organizations up for lasting field service success. This will transform organizations into customer-centric, new-age, and digital organizations

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Hyper-personalization

Manufacturers who implement hyper-personalization in their operations are often tipped to benefit from improved customer service and improved productivity. It benefits various stakeholders with additional offerings in sales process, customer during the installation process and customer/technician during after-sales Focusing on the right platforms and technologies from Industry 4.0 can hugely benefit manufacturers with agile and customer-focused production.

Highlights

Hyper-personalization in industrial manufacturing involves customizing products, services, and experiences to meet the unique needs and preferences of customers. Various technologies play a crucial role in achieving hyper-personalization by leveraging data, analytics, and automation processes. A vast amount of customer data and behavior is extensively analyzed by AI and big data analytics. This offers insights into individual preferences, allowing manufacturers to proactively deliver personalized solutions. Additionally, AI-driven predictive maintenance is used to foresee machine failures. It allows scheduled maintenance, reducing downtime and improving overall efficiency. Hyper-personalization can be achieved by leveraging AI and analytics. It includes digital twins in the sales process and augmented reality (AR) to visualize and customize products in real-time marketing activities. It also uses chatbots and virtual assistance for personalized customer support, etc.

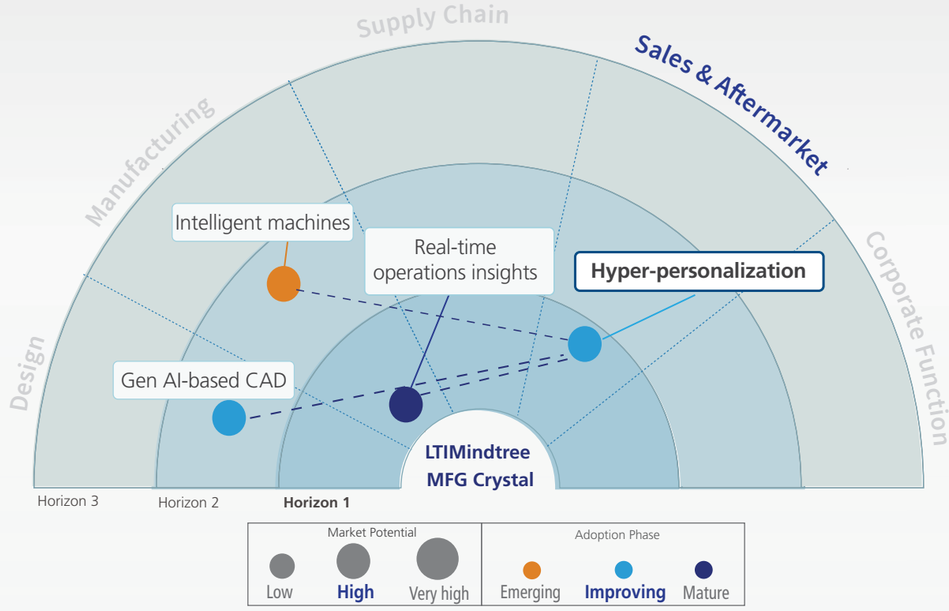
Key Application Areas

Customer data analysis: Gain insights into customer priorities and preferences.

Personalized customer support: Customize quickly through chatbots and virtual assistance.

Supply chain optimization: Optimize the supply chain by predicting demand patterns, helping manufacturers maintain optimal inventory levels.

Radar View & Related Trends



Key Technologies

Machine Learning

Used to predict customer needs and optimize production process using historical data

NLP

Enables understanding and processing of customer queries and feedback for personalized communication

Conversational Systems

Chatbots enhance hyper-personalization by providing tailored support, recommendations, and real-time engagements

Decision Intelligence

Analyze past data to forecast the future of customer behavior and tailor offerings

Featured Story

A leading Japanese car manufacturer partnered with a top IT service provider to enhance the creative concept of their video advertisements for its launch campaign. They leveraged AI to combine preferred activities in unique and entertaining ways. AI generated multiple fresh pairings that seemed unrelated at first. Later these innovative combinations were then incorporated into the ad content and tailored to specific audience segments based on their traditional interests.

Key Takeaway

Implementing AI-driven hyper-personalization strategies can help manufacturers create a more agile, customer-centric, and efficient production process, leading to customized offerings in the manufacturing industry.

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Intelligent warranty management

Intelligent warranty management refers to using technology to automate claim processing according to industrial manufacturer policies. Typically, it covers a mix of claims related to extended warranty, used parts warranty, standard warranty, product recalls, etc. Many industrial manufacturers have been using traditional warranty systems, leading to reduced customer satisfaction, increased timelines, and loss of trust.

Highlights

Existing warranty practices continue to drain margins significantly. This is due to the lack of agreement on targets, high total cost of ownership, fragmented responsibilities, and ill-equipped systems to deal with the rising data complexity. On average, warranty claims expenses for industrial manufacturing companies' range between 1.5% - 2.5% of their annual revenue. This leads to poor customer experience and revenue losses to the tune of billions of dollars across the industry. Intelligent Warranty Management leverages new-age technologies such as automation, ML, AI, Advanced Analytics, etc., for a systematic data-driven process. It enables all stakeholders to leverage warranty data to identify the areas requiring improvement and cost control while ensuring high customer satisfaction and accurate warranty forecasting.

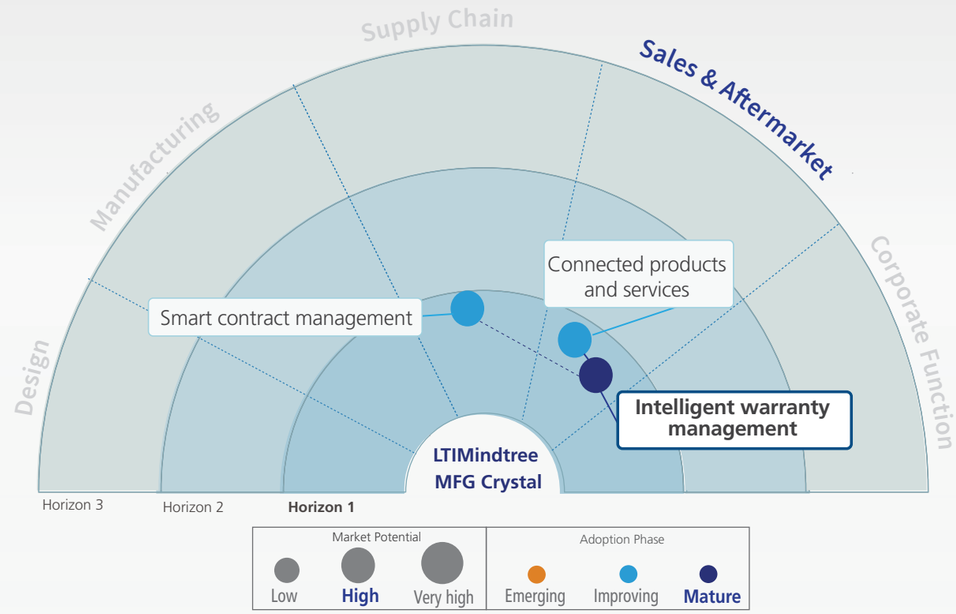
Key Application Areas

Effective product management: The technology enabled an effective understanding of operational issues within the product based on warranty data.

Increased customer satisfaction: Predictive insights make for faster warranty and claims processes and increase customer confidence and sales.

Minimize losses: It helps avoid invalid or fraudulent warranty claims, increasing topline revenues.

Radar View & Related Trends



Key Technologies

Hyper-personalization
Tailor warranty services to individual customer need

Blockchain
Provides a secure, transparent, and immutable ledger for recording warranty claims and transactions

Hyperautomation
Speeds up claim processing, reduces human error, and lowers operational costs.

Decision Intelligence
Enhances the accuracy and effectiveness of decisions related to warranty claims

Featured Story

A leading industrial manufacturer of refrigeration systems was facing several challenges. Third-party service centers raised fraudulent claims; decision cycles were longer, the warranty process involved manual intervention, and auditing of service centers was delayed, resulting in delayed insights. LTIMindtree helped the client implement a warranty solution that integrated AI, ML, and Natural Language Generation (NLG) technologies with an intuitive conversational interface.

Key Takeaway

In an increasingly competitive global market, it has become imperative for industrial manufacturers to differentiate their products by offering better after-sales services. Intelligent warranty management powered by new-age technologies promises to increase customer satisfaction, leading to increased business and revenue growth.

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AI-powered enterprise

AI-powered enterprise involves capturing, storing, sharing, and harnessing knowledge across all levels of the organization to improve decision-making, innovation, and operational efficiency. In the manufacturing context, knowledge management plays a crucial role in centralizing and standardizing information across the entire design, shipping, and return processing cycle, product use, customer support, and field service.

Highlights

The potential value of AI-powered enterprise in industrial manufacturing lies in its ability to drive operational excellence, innovation, risk mitigation, employee development, regulatory compliance, and customer satisfaction. A Gen AI-powered Knowledge Management system can analyze production data, equipment performance metrics, and maintenance records to optimize production processes. IoT-enabled KM systems integrate real-time data collected by IoT sensors embedded in industrial equipment to provide actionable insights. These insights can be used for predictive maintenance, process optimization, and quality control in manufacturing operations. Digital twins facilitate knowledge management by providing a digital representation of production lines and supply chain operations to allow manufacturers to simulate scenarios, test hypotheses and optimize processes.

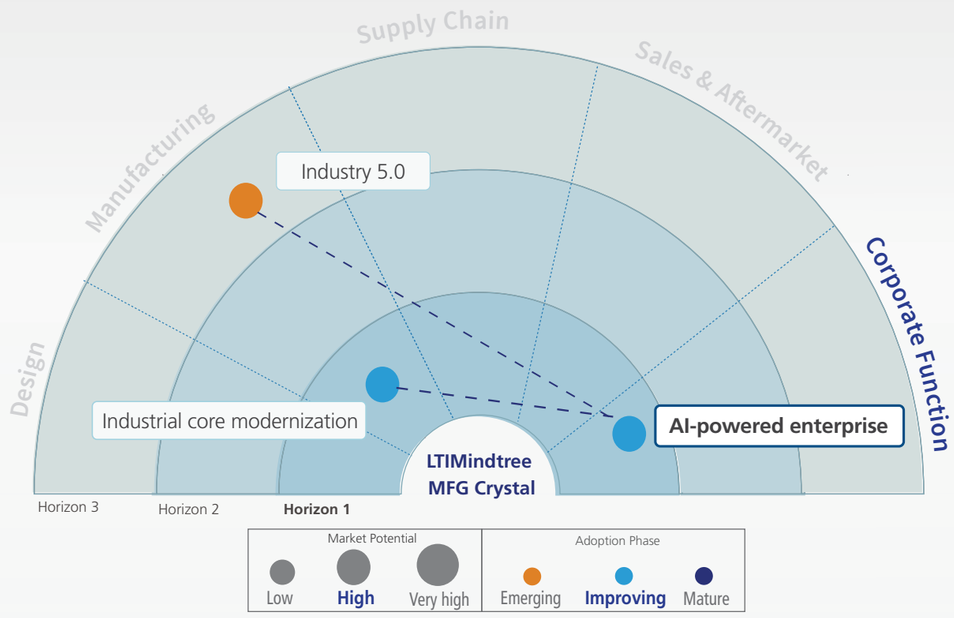
Key Application Areas

Implementing predictive analytics: Integrate with predictive analytics tools to analyze equipment data such as sensor readings and temperature fluctuations.

Reducing costs and downtime: Predictive maintenance strategies enabled by KM help industrial manufacturers minimize production disruptions and associated costs.

Capturing equipment knowledge: Capturing and documenting information about industrial equipment, saves time and improves efficiency.

Radar View & Related Trends



Key Technologies

Gen AI
Customizing content, comprehending user intent, and effectively organizing information

Computer Vision
Analyze photographs and videos from the repository to generate on-demand outputs

Data Fabric
Systematic organization of data from repositories and on-demand reproduction.

AI TRiSM
Validate data accuracy and integrity, ensuring reliable decision-making

Featured Story

A major aircraft OEM implemented KBE (Knowledge-Based Engineering) to capture the knowledge of engineering products and their design processes and embed it into a software system. Automation solutions helped meet original timelines with significant savings in effort (33%) and cycle approach (33%) compared to the conventional approach. Significant improvement with a lighter-weight design was achieved.

Key Takeaway

AI-powered enterprise enables industrial manufacturers to optimize processes, enhance decision-making, foster collaboration, and improve performance continuously enabled by Gen AI powered knowledge management. Additionally, it equips manufacturers to adapt to changing market dynamics, mitigate risks, and sustain long-term success.

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Horizon 2

Trend will be industrialized within 1 to 3 years

Design-time digital twin

A design-time digital twin in a manufacturing set-up allows the integration of digital twin technology in the early stages of product development. This allows the customer to fully test the product by carrying out multiple simulations in a virtual environment before being finalized by the customer. Since complex machines can incorporate multiple libraries of digital twin models of key components, it becomes increasingly beneficial to combine and check for the best product fit.

Highlights

Implementing digital twins in the design stage of industrial manufacturing allows the manufacturer to explore various design options without getting into the costly physical prototyping stage. It improves time-to-market up to 50% and product quality up to 25%. The design stage incorporates visualization and scientific modeling techniques with the creation of 2D drawings and 3D models leveraging various powerful design tools. It helps in what-if scenario planning and aspects such as fluid flow, biochemical processes, structural deformation, etc. According to a McKinsey survey from 2022, 86% of respondents said digital twins are applicable to their organization. While 44% have already implemented a digital twin, 15% plan to deploy one.

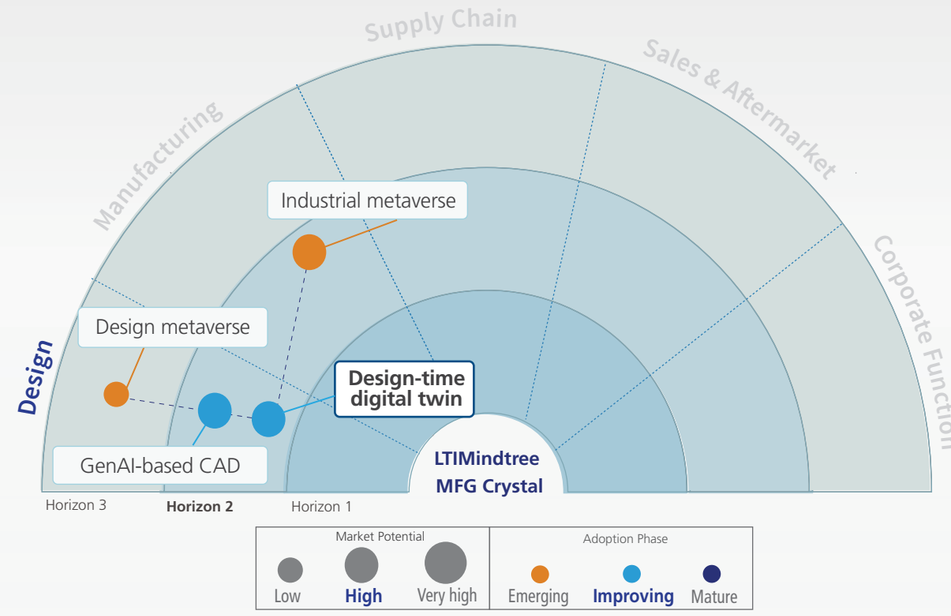
Key Application Areas

Faster product development cycle: Speeds up design and engineering cycles while cutting down on costs.

Possibility of multiple prototypes: Manufacturing firms can create multiple versions to check the best-fit product.

Promotes innovation: It allows prototyping and testing of new products, saving costs and driving innovation.

Radar View & Related Trends



Key Technologies

Digital Twin

Optimize design for performance, efficiency while saving costs for costly prototypes

Spatial Computing

Enhances interaction by integrating physical and digital elements seamlessly.

Mixed Reality

Design and collaborate on 3D models of prototypes to expedite resolution.

Featured Story

LTIMindtree implemented digital twins for a leading US-based pump manufacturer. The implementation led to increased real-time condition monitoring of pumps, with time to predict failures. Predictive analytics enabled service prioritization and better outage and spare parts planning. This led to 99% asset availability, 8% reduction in unscheduled maintenance, and 12% reduction in production downtime.

Key Takeaway

Digital twins in design and development significantly improve product development by reducing development times by 20% to 50%. They have also been reported to have 25% lesser quality issues and a higher chance of succeeding commercially.

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Gen AI-based CAD

Gen AI can analyze vast databases of existing designs and historical data to suggest innovative design options based on project requirements, industry standards, and user preferences. ML can interpret design patterns and predict components needed. This allows automating drafting tasks, like creating repetitive elements or generating bills of materials, reducing manual work and minimizing errors. This can accelerate the design process and spark creative solutions.

Highlights

In the rapidly evolving technology landscape, AI has emerged as a driving force behind transformations across the manufacturing industry. Gen AI, known for its content creation and enhancement capabilities, is playing a significant role in shaping the advancement of manufacturing practices. In a diligent fusion of art and science, Gen AI utilizes ML algorithms to assess every possible design solution for a specific problem, subsequently generating an array of design alternatives. This technology-driven approach unveils design possibilities much beyond human cognitive abilities, uncovering innovative designs and structures. It can enable rapid prototyping and mass production in assembly lines where many different parts are manufactured every day. This results in a transformative shift in product innovation, creating new-age creations that are efficient, cost-effective, and unique. The shift effectively positions businesses at the forefront of the industries.

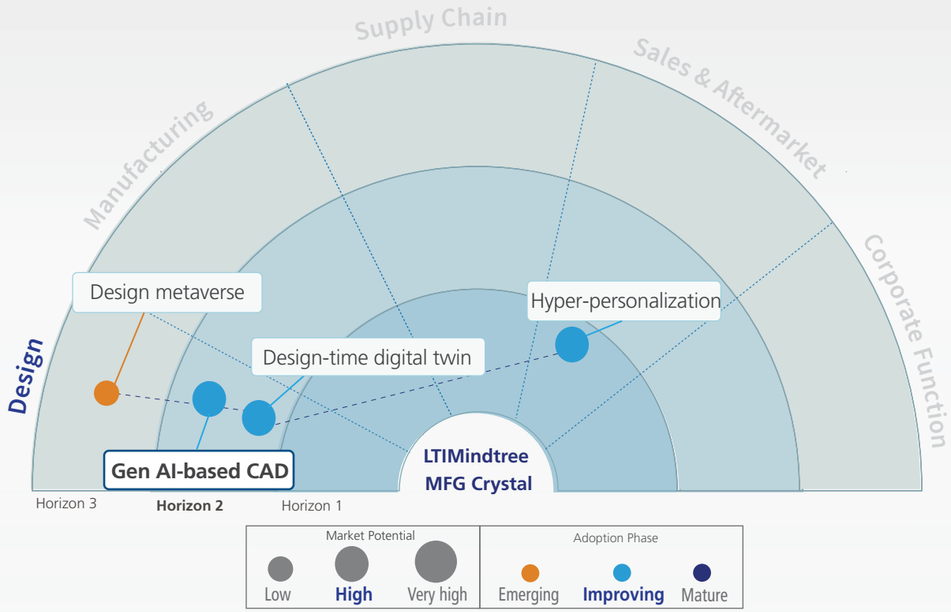
Key Application Areas

Facility design and engineering: A virtual design of new equipment or a structure can be created.

Supply chain integration: A virtual design of new equipment or a structure can be created.

Simulation and analysis: A virtual design of new equipment or a structure can be created.

Radar View & Related Trends



Key Technologies

NLP

Enables designers to interact with CAD systems via voice or text, simplifying design

Edge AI

Enhance real-time processing of design simulations and optimization locally

Blockchain

Secure intellectual property and design integrity through decentralized design record-keeping.

Digital Twin

AI simulations evaluate design scenarios virtually, providing instant feedback and improving product designs.

Featured Story

A well-known car manufacturer designed an electric mini-bus using a generative AI design. To eliminate excess weight and material while maintaining strength, the team used a design provided by generative AI for lightweighting. The team innovatively explored multiple methods to reduce wheel mass, carefully evaluating various manufacturing techniques. As a result, the manufacturer successfully achieved an impressive 18% reduction in wheel weight.

Key Takeaway

Gen AI is evolving as a catalyst in modernizing the design and manufacturing of industrial products. It can surely speed up the design process and transform it into a highly innovative, unique, and error-free product design.

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Immersive remote collaboration

Immersive technologies, such as AR and VR, extend and deepen the potential of manual collaboration in industrial manufacturing. They allow users to see beyond their natural vision and imaginative capabilities. Providing technicians and engineers with an immersive reality experience is transforming design and manufacturing efficiency and effectiveness.

Highlights

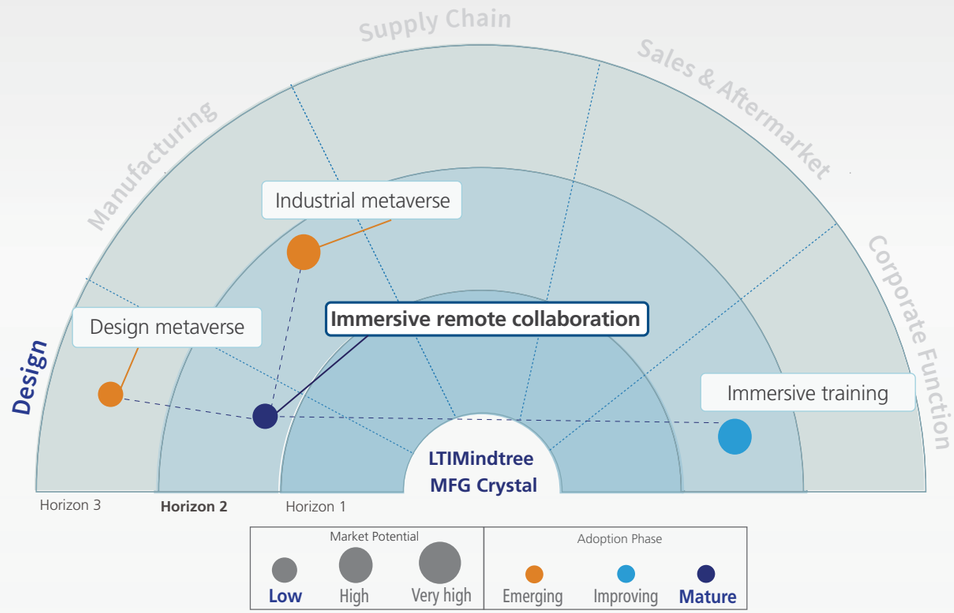
The global pandemic has impacted every industry, including manufacturing. Immersive technologies like AR, VR, and Mixed Reality (MR) top the list of highly envisioned technologies in the remote collaboration space in manufacturing industries. In recent years, immersive technologies have enhanced holographic technology from being a mode of amusement to a full-fledged interactive application in manufacturing service lines. Immersive applications connected with IoT and sensors provide real-time manufacturing updates and alerts to technicians working on the floor or remotely. If technicians encounter any issues, they can use holographic visualization to recreate the problem and produce innovative solutions. Immersive technologies can also help manufacturers inspect the machinery, maintain, and keep digital logs instead of paper based.

Key Application Areas

Safety and regulatory compliance: Safety incidents are avoided when technicians can troubleshoot problems in a virtual environment without disassembling the equipment.

Reliability engineering: Design for reliability and asset optimization initiatives can thrive when there is a virtual playground for experimentation and improvement.

Radar View & Related Trends



Key Technologies

Augmented Reality (AR)

Overlays digital designs onto the real world for ineteractive feedback

Virtual Reality (VR)

Immersive environments for real-time design collaboration and visualization

Digital Twin

Virtual replica of products for testing and collaboration

Mixed Reality (MR)

Enables collaborative design by merging digital models with physical environment for real-time interaction

Featured Story

An American aerospace and defense manufacturer utilized augmented reality (AR) to enhance efficiency in constructing the Artemis II spacecraft. By using AR goggles, instructions were superimposed in 3D space directly onto the physical spacecraft, eliminating the need to interpret procedures from text or 2D screens. This approach allowed them to finalize the manufacturing process in 90% less time across four different locations compared to conventional techniques.

Key Takeaway

In today's digital era, immersive technologies play a crucial role in remote collaboration, driving higher efficiency, productivity, and reliability in industrial manufacturing. Immersive technologies, especially AR and MR, are poised to solve a remarkable number of problems.

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Industrial metaverse

A digital environment allows us to detect and rectify errors faster than the physical world. An Industrial Metaverse enables gauging a 3D representation of the manufacturing environment with the amalgamation of various technologies such as AR, VR, and connected devices. It can be used to create a virtual layout of the factory and plan before proceeding with the costs associated with building it. According to a Big 4 consulting firm survey, manufacturers anticipate that the industrial metaverse could lead to a 12% gain in labor productivity, which might help address the ongoing labor shortages.

Highlights

The manufacturing industry is well-positioned to adopt the industrial metaverse due to its continued emphasis on digital transformation and its journey towards the smart factory. According to a World Economic Forum (WEF) Survey from 2024, most manufacturing companies have already deployed core technologies that drive the industrial metaverse. Most companies are either implementing technologies such as data analytics, cloud, AI, 5G, and IoT technologies across multiple projects/processes, or they are experimenting with one-offs. About 79% of executives in industrial manufacturing believe their organization's vision or long-term strategy is already inspired by primary metaverse technologies. According to a Manufacturing Leadership Council study - 2023, around 80% of manufacturing leaders believe that metaverse will reform manufacturing within the next five years .

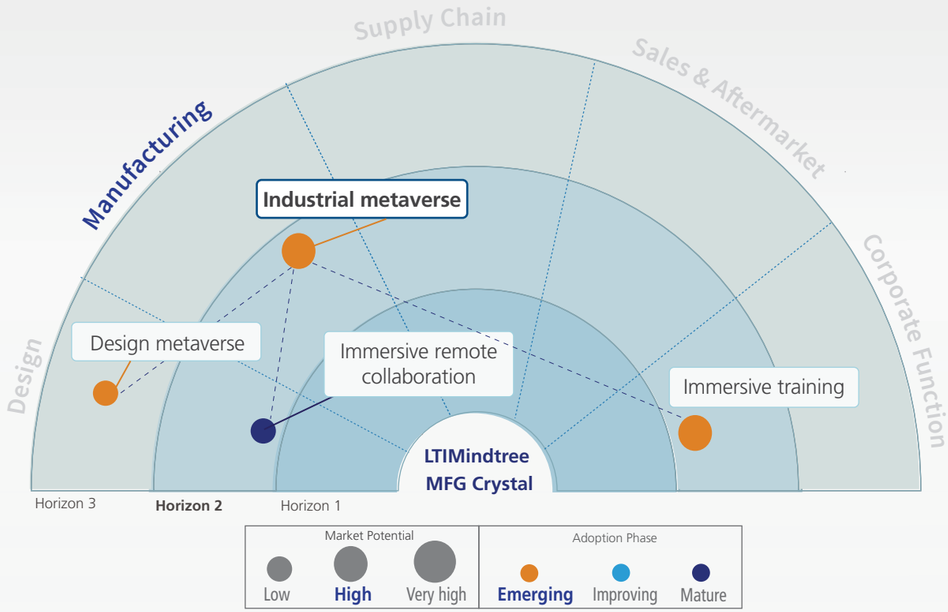
Key Application Areas

Facility design and engineering: Create structural virtual designs to identify issues before investing in building it.

Virtual product R&D, prototyping, and testing: Create virtual product prototypes to save costs and time in actual prototypes

Predictive maintenance: Helps determine whether equipment requires maintenance

Radar View & Related Trends



Key Technologies

Wearable Technologies

Enable hands-free operation particularly useful in complex industrial environments

Mixed Reality

Provide immersive experiences for training, maintenance and design

Digital Twins

Allows for real-time monitoring, simulation, and optimization

Humanized User Interface

Interfaces that are intuitive and user-friendly, making it easier for workers to interact with complex systems

Featured Story

A global leader in aircraft manufacturing plans to leverage the industrial metaverse by integrating 3D digital models, collaborative robots, and mixed-reality headsets for global mechanics. The digital system will unite design, production, and services, enabling real-time simulations and enhanced collaboration. The aircraft manufacturer aims to prevent issues observed in its commercial aircraft, streamlining manufacturing processes and improving quality control for future aircraft development.

Key Takeaway

Manufacturers are optimistic about the industrial metaverse's continued potential, which could help them unlock measurable value and build new markets. However, a cautious approach is required since it requires robust cybersecurity measures, without which the consequences could be significant.

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Intelligent machines

Intelligent machines employ automation, data collection, AI, machine learning (ML), or other technological integrations to establish ideal production conditions. Additionally, it involves monitoring the performance of every production process element, including assessing the overall equipment efficiency (OEE).

Highlights

Intelligent manufacturing focuses on optimizing data usage across processes through automation, networking, ML, and AI. The World Economic Forum (WEF) forecasts that the worldwide market for AI in manufacturing will be worth USD 20.8 billion by 2028. Intelligent machines collect and analyze data to evaluate the state of manufacturing lines. This will help businesses migrate to the ideal environment, ensuring high-quality output. Intelligent machines also provide alerts about serious concerns that demand attention. These difficulties might include malfunctioning equipment, poor function execution, or faults in finished items. Manufacturers highly emphasize AI in their pursuit of intelligent manufacturing and developing intelligent, networked, and efficient production processes.

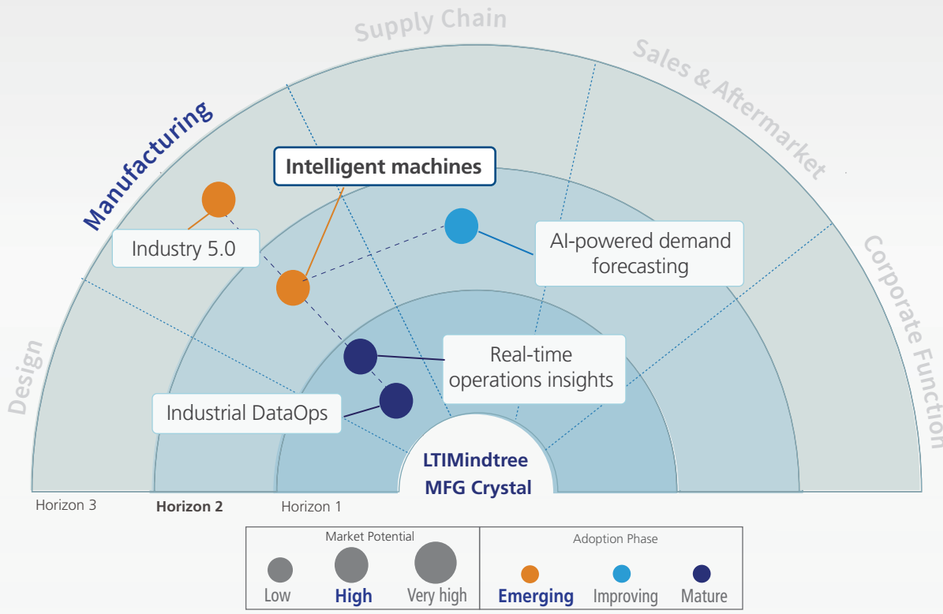
Key Application Areas

Predictive maintenance:
IoT-enabled devices coupled with predictive analytics identify patterns and detect anomalies.

Optimized supply chain:
Optimization makes supply chains resilient and disruption-proof.

Increased asset performance:
Reduce downtime in the event of equipment failure and boost output.

Radar View & Related Trends



Key Technologies

Ambient Computing

Operate in a more integrated and responsive manner, allowing for real-time adjustments and optimizations based on environmental conditions

Sensor Tech

Collect accurate data for monitoring and maintaining optimal production conditions

Applied AI

Process industrial data to identify complex patterns, such as determining the most efficient sequence of operations

Hyper-personalization

Customizing production runs to meet specific customer demands, thereby increasing customer satisfaction and reducing inventory costs

Featured Story

LTIMindtree developed an integrated platform for battery technology solution providers, including connected operations and an end-to-end battery traceability system. The platform collects process-specific data from both the production and after-sales value chains. Using manufacturing, aftersales, and business analytics, we created a linked operation to eliminate claim fraud and speed up the reverse supply chain.

Key Takeaway

Digitalization drives manufacturing industries to adopt intelligent manufacturing strategies. These strategies are driven by internal demands like cost reduction, operational efficiency improvements, innovation, and R&D. They are also influenced by external pressures from evolving client needs and customer-experience requirements.

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Micromachines

Micromachines or Micro-electro-mechanical systems (MEMS) are also known as microsystems technology (MST) or micromachines. Micromachines is a broad phrase that includes many designs, methods, and processes used to produce tiny mechanical parts at the microscopic level via microfabrication. Connected micromachine technology integrates mechanical components, sensors, actuators, and electronics using microfabrication.

Highlights

Micromachines are critical for boosting industrial automation by expanding the capabilities of goods like industrial robots. Companies may hesitate to adopt this technology due to high initial expenses and a lack of established practices. Micromachines offer the advantage of widespread sensor connectivity. It is useful for industrial and consumer applications due to its low power consumption and cheap mass manufacturing cost. The increasing number of devices and enhanced functionality enabled by this technology will help the growth of the micromachines market. Its applications in industrial manufacturing include miniature diagnostic sensors, consumer electronics, automotive technology, energy harvesting, and Internet of Things (IoT) applications. Micromachine-induced 3D printing has emerged as a feasible technology for designing creative new structures, allowing for faster and more cost-effective production of current systems.

Key Application Areas

Measure physical parameters: The technology allows increased measuring of physical parameters to implement monitoring and control applications.

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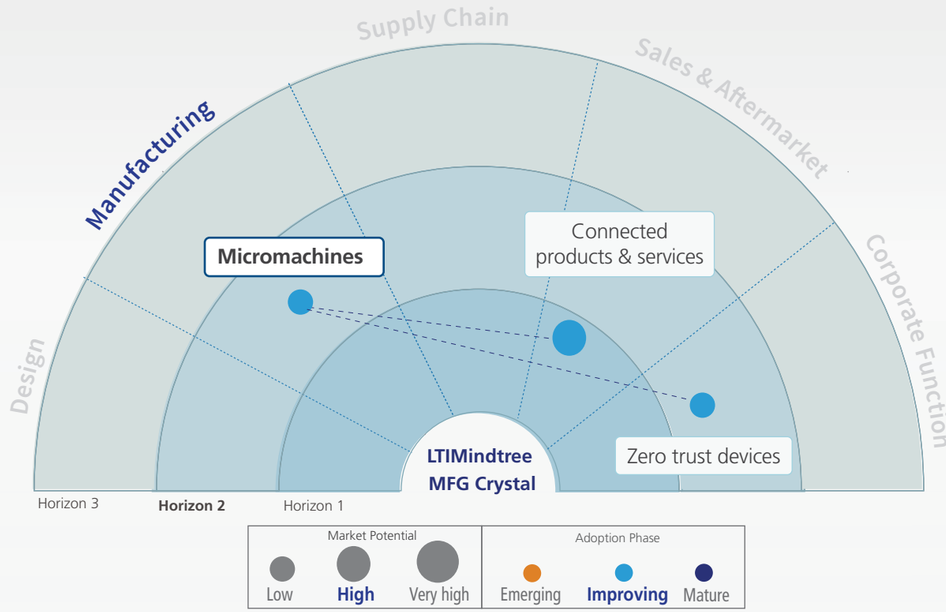
Radar View & Related Trends



Key Technologies

LPWAN

Enable real-time monitoring and data collection from remote or hard-to-reach locations

Edge AI

Precise monitoring and control of processes, ensuring high quality and efficiency

Sensor Tech

Enable safe human-robot interactions by detecting proximity and preventing collisions

Data Fabric

Manage the vast amounts of data generated by MEMS devices

Key Takeaway

Micromachines are gaining popularity due to ongoing innovations within IoT technology. This will enhance cost, size, and performance in various applications and is expected to expand as industrial manufacturing processes progress toward smaller features and components.

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AI-powered demand forecasting

AI is vital in enhancing supply chain resilience by improving decision-making and efficiency. AI-powered demand forecasting in industrial manufacturing can forecast customer demand, optimize inventory and production, and manage the supply chain. The rising popularity of AI and ML has propelled advanced analytics to the forefront of demand forecasting. By scrutinizing vast datasets, these technologies uncover valuable insights into customer behavior. These insights empower organizations to make informed decisions and stay ahead in the competitive manufacturing landscape.

Highlights

In industrial manufacturing, ML plays a crucial role in demand forecasting. It leverages real-time data streams like new product introductions, seasonality data, warehouse records, and social media trends. ML algorithms empower companies to anticipate customer demand accurately. AI and ML surpass traditional models in demand forecasting by adapting to changing environments and identifying complex patterns. According to a McKinsey study, these AI-driven systems enhance forecast precision, slashing errors by 20% to 50% by discerning non-linear connections and subtle buying signals. This translates to reduced lost sales and inventory shortages by up to 65%. Furthermore, ML contributes to streamlined operations, cutting warehousing costs by 5% to 10% and administration expenses by 25% to 40%, fostering a more responsive and efficient manufacturing ecosystem.

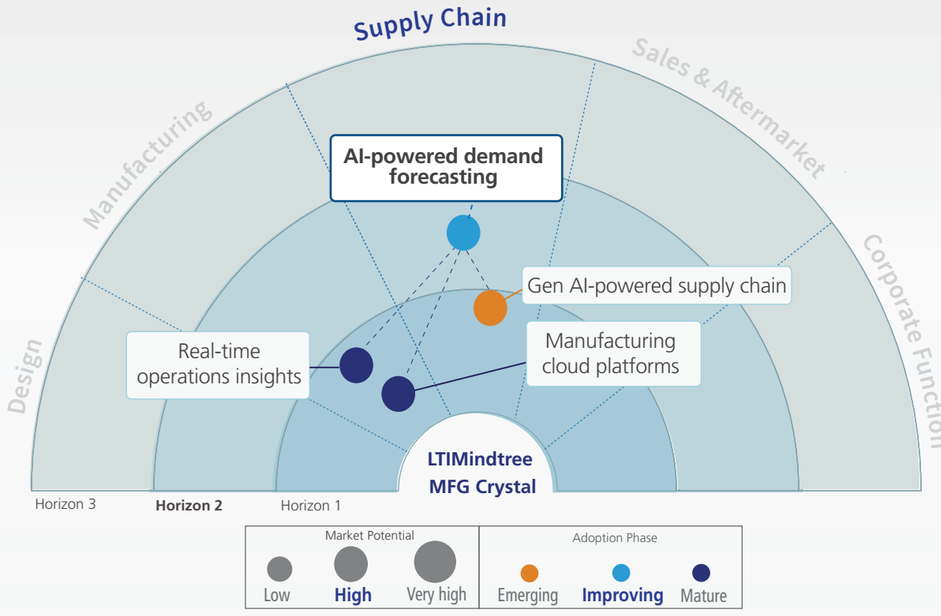
Key Application Areas

Inventory optimization: Predict demand patterns accurately to optimize inventory levels.

Production planning: Analyze real-time data to assist in production schedules and minimize downtime.

Supply chain management: Enhance supply chain visibility, enable proactive decision-making, and minimize disruptions.

Radar View & Related Trends



Key Technologies

Machine Learning
Forecast customer demand & efficiency of inventory, production, and supply chain.

Gen AI
Integrates sales data and customer info to predict demand.

Internet of Things (IoT)
Collect real-time data to manage production schedules as per demand.

Decision Intelligence
Analyse historical data to manage inventory and avoid overstock/backorders.

Featured Story

A U.S.-based automotive manufacturer leveraged advanced ML algorithms to implement an intelligent cloud-based demand forecasting solution. The solution correlates market signals with demand patterns, providing accurate recommendations and live visualization for enhanced decision-making. This has helped the manufacturer reduce forecasting errors for newly launched products by 50% and decrease excess inventory by 10%.

Key Takeaway

AI-powered demand forecasting reshapes industrial manufacturing by improving forecast accuracy, optimizing processes, and enhancing customer satisfaction through real-time data analytics and advanced AI technologies.

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Transparent supply chain

A transparent supply chain is the ability to make information from the supply chain accessible to various stakeholders. It helps to understand where and how products are being transformed and transferred. Such a supply chain verifies the origin and movement of materials, components, and final products. Stakeholders such as investors, regulators, customers, and external stakeholders can openly access and leverage the information that helps build trust.

Highlights

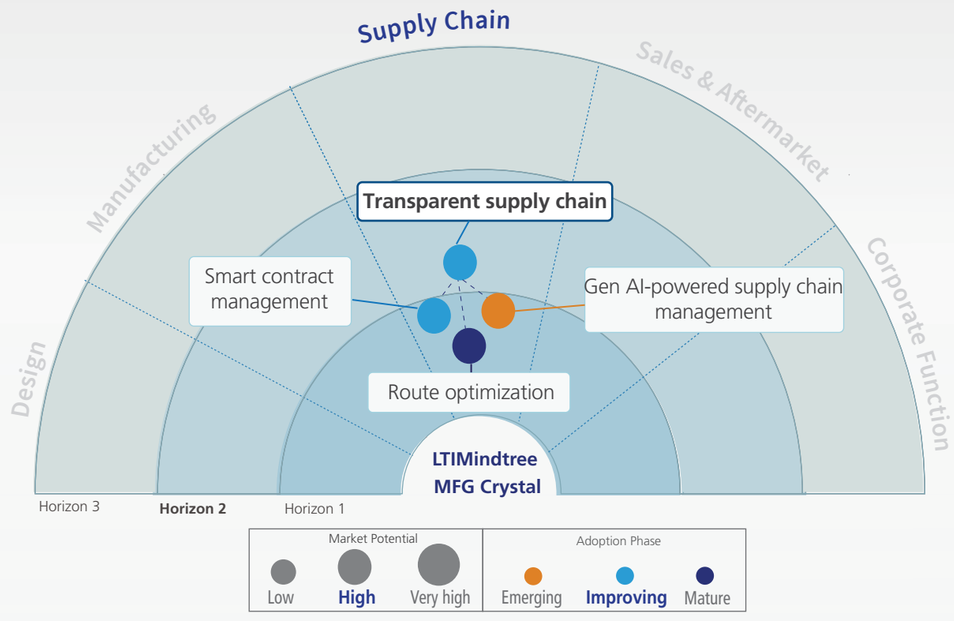
A non-transparent supply chain generally damages reputation and causes the loss of business time and resources. A fully transparent supply chain builds consumer confidence and promotes environmentally friendly sourced and manufactured products. It leverages technologies such as advanced analytics, blockchain, and AI to track and trace goods in the supply chain. An increasing number of customers demand sources of raw materials and are willing to pay extra for sustainably acquired raw materials. According to an IBM survey from 2022 across industries, 73% of consumers voted traceability important to them, and 71% agreed to pay a premium. Newer regulations are constantly being introduced in the industrial manufacturing sector. These regulations require manufacturers to comply with ethical labor practices, due diligence, and sustainable sourced raw materials. This helps increase trust in the manufacturer.

Key Application Areas

Increased sustainability across the value chain: The technology promotes sustainable and ethical manufacturing and brand image.

Improved regulatory compliance: It helps in navigating regulatory frameworks and compliance.

Radar View & Related Trends



Key Technologies

Blockchain

Ensures secure transparent transactions and tracebility of products throughout the supply chain

Digital Twin

Creates virtual models of supply chain processes to simulate, analyze and optimize performance

Applied AI

Uses ML to improve demand forecasting, inventory management, and supply chain efficiency.

NLP

Facilitates communication and data extraction from unstructured sources, improving information flow.

Featured Story

A Swiss steel wheel manufacturer deployed cloud-based supply chain management solutions and integrated IoT technology embedded with AI capabilities. The aim was to improve visibility across the supply chain and analyze sensor data to predict failures. With fully integrated supply chain and ERP applications, the manufacturer easily streamlined data flow to headquarters, enabling real-time financial management and invoicing.

Key Takeaway

Many organizations have started incorporating sustainability into their corporate strategy, and this number is expected to grow in the upcoming years. Transparent supply chains are indomitable in enabling sustainability across many industrial manufacturers and their customers.

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Outcome-based business models

Outcome-based business models are service business models that concentrate on the results, quality, and effectiveness of the services offered rather than specifying a certain number of tasks, maintenance activities, repairs, or other resources. The model enables manufacturers to profit from the value their products provide through improved services and warranties, using technologies like IoT, AI, and ML to precisely measure and manage outcomes, underpinning outcome-based monetization.

Highlights

The dynamic nature of industrial manufacturing requires manufacturers to continually innovate and adapt. Today, customers expect greater value from their products and services. To drive revenue and profit growth while enhancing customer loyalty, top industrial manufacturing companies are turning to advanced service-based models like subscription and outcome-based frameworks based on AI, ML & Predictive models. Industrial manufacturers not only get to offer high-quality products but also provide unique value to their consumers. While product-based business models often face unpredictable revenue due to varying overall and seasonal sales, outcome-based models ensure a stable revenue stream and regular customer feedback. The manufacturer gains a more robust, steady revenue stream through service agreements, while the customer enjoys increased product uptime, minimized operational risks, and potentially lower total costs.

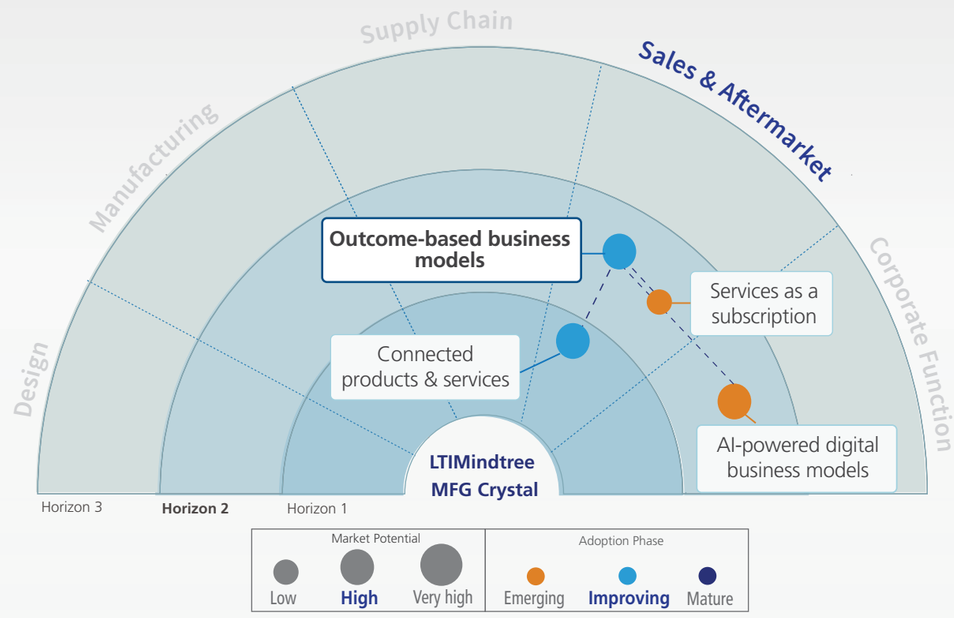
Key Application Areas

Product innovation: Insights gained enable ongoing enhancements to products and the creation of new service offerings.

Product-service integration: Primary product is embedded within a comprehensive solution that encompasses continuous services.

Targeted customer results: Prioritise desired results, enabling in reaching their objectives rather than merely selling a tangible product.

Radar View & Related Trends



Key Technologies

Adaptive AI
Enables predictive maintenance, quality control and real-time optimization ensuring efficiency & quality

AI-as-a-serive
Allows to leverage sophisticated AI solutions on-demand to drive result and remain agile

Edge AI
Provides fast, cost-efficient local optimization, supporting real-time outcome-based manufacturing.

Internet of Thinking
Combines IoT, edge computing, and analytics to provide a robust framework for operations.

Featured Story

An aircraft engine manufacturer adopted an outcome-based service model instead of selling engines outright. This approach enabled cost savings by charging fees for each maintenance and repair visit based on the number of flight hours. Additionally, it incentivized Rolls-Royce to enhance engine reliability and extend on-wing life through proactive maintenance efforts.

Key Takeaway

The outcome-based business model is gaining traction in Industrial manufacturing because it offers cost savings, scalability, and better customer experiences. By providing access to the latest technologies on a pay-as-you-go basis with lower entry costs, it helps customers stay competitive in an evolving market.

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Services as a Subscription (SaaS)

Service as a subscription (SaaS) is a business model that allows industrial manufacturers to offer their products and services as recurring, flexible, and scalable subscriptions. In response to Industry 4.0 and IoT, manufacturers have increasingly adopted data driven strategies including data analytics for customer insights. The COVID-19 pandemic accelerated these efforts, leading many to shift towards digital, customer-centric approaches, resulting in the rise of subscription service models in industrial manufacturing.

Highlights

In industrial manufacturing, subscription models are driving recurring revenue by leveraging data to better understand customer needs, fostering loyalty and enabling cost predictability. According to the Business Innovation Observatory of European Commission, over 70% of manufacturers view services as a key differentiator, with service-based models leading to 5 to 10% annual growth and generating half of their revenue. Common subscription-based services include maintenance, equipment monitoring, safety analysis, and location tracking, which help extend product lifespan and reduce operation costs. The rise of IoT and software integrations demand continuous collaboration between manufacturers and customers, emphasizing mutual dependency. In future, as services as a subscription model grows, emerging trends will likely standardize contracts, blending aspects of hire, maintenance, and software subscriptions.

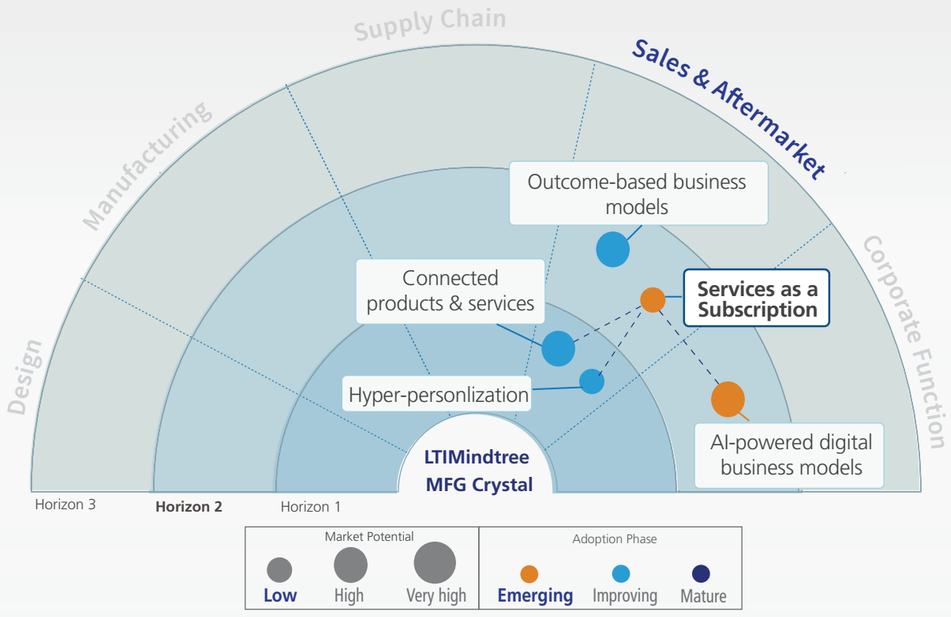
Key Application Areas

Predictive Maintenance: Schedule repairs using IoT data, minimizing downtoime

Equipment Monitoring and Optimization: Track performace to enhance efficiency and longevity.

Software and Analytics Access: Provide subscription-based access to advanced analytics tools

Radar View & Related Trends



Key Technologies

Gen AI

Enables customized product designs, supply chain forecasting and real-time tracking of the products

Decision Intelligence

Data driven insights, optimizing operations and improves real-time decision making

Augmented Reality

Provides an effective tool for maintenance, training, and remote support, improving efficiency and reducing errors.

Featured Story

A U.S. based leading construction and mining equipment manufacturer offers a subscription-based service that provides remote monitoring, predictive maintenance alerts, and performance analytics for their machinery. Customers benefit from real-time insights into equipment health and usage enabling them to optimize operations, reduce downtime, and manage cost effectively.

Key Takeaway

Before investing in a subscription model, industrial manufacturers should prioritize customer centricity by ensuring uptime, competitive pricing, and adaptability to shifting demands and crises, maintaining reliability and service excellence.

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Green building

Green building involves using resource-efficient and environmentally responsible processes throughout a building's life cycle, from design to renovation and deconstruction. It aims to reduce energy consumption, water usage, and waste generation while minimizing harmful emissions. Green buildings prioritize the use of locally sourced material with low embodied energy, recycled content, and certifications such as Forest Stewardship Council for wood products.

Highlights

According to a recent report by Anarock, a leading Indian real estate services company, green buildings can minimize energy consumption by 20-30% and water usage by 30-50%. Green buildings have a lower carbon impact on the environment compared to traditional structures and cost about 3% - 5% higher than conventional buildings. They are designed to maximize operational efficiency and productivity. Features such as efficient lighting, HVAC systems, and automation improve workflow, and facility performance. Technologies such as generative AI can potentially change the way green buildings are designed and built. With the use of AI algorithms, the orientation of a building can be optimized to maximize energy efficiency and minimize energy consumption. Additionally, generative AI can also be leveraged to optimize the use of materials and resources in building construction. This will help reduce waste and improve the sustainability of the building.

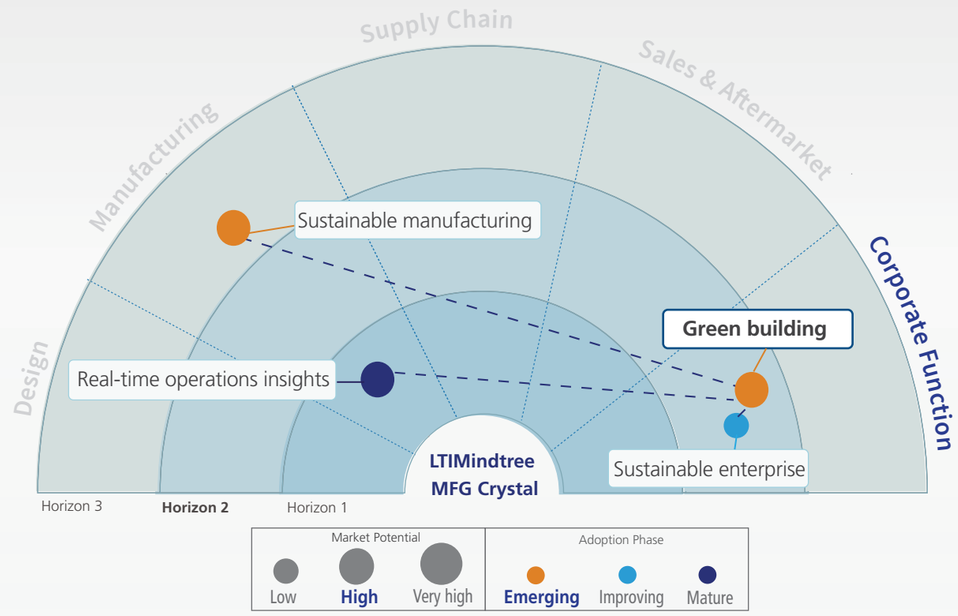
Key Application Areas

Energy efficient design: Features such as insulated building envelop and high-efficiency lighting systems reduce energy consumption.

Water conservation: Installing water-efficient fixtures and closed-loop water systems reduce water consumption and minimize wastewater generation.

Waste reduction and recycling: Landfill waste is minimized, leading to resource conservation.

Radar View & Related Trends



Key Technologies

Sensor Tech
Real-time monitoring of energy use and environment, enabling automated responses

Machine Learning
Predicts energy demand, optimizing system performance and reducing waste

Digital Twins
Virtual building replicas for energy optimization and performance simulations.

Decision Intelligence
Optimize resource use, energy efficiency, and sustainability in green building manufacturing.

Featured Story

A well-known HVAC manufacturer implemented green building practices by selecting energy-efficient air-conditioning systems tailored for different areas. They used multi-split VRV systems with adjustable power consumption for offices and an air-cooled inverter liquid chiller for factories. Standalone wall-mounted split systems were used for individual function rooms, all designed for optimal comfort with minimal carbon emissions.

Key Takeaway

Integrating green building principles in manufacturing facilities can help industrial manufacturers enhance environmental performance and comply with regulations. They can save costs and also contribute to long-term sustainability by reducing energy and water consumption.

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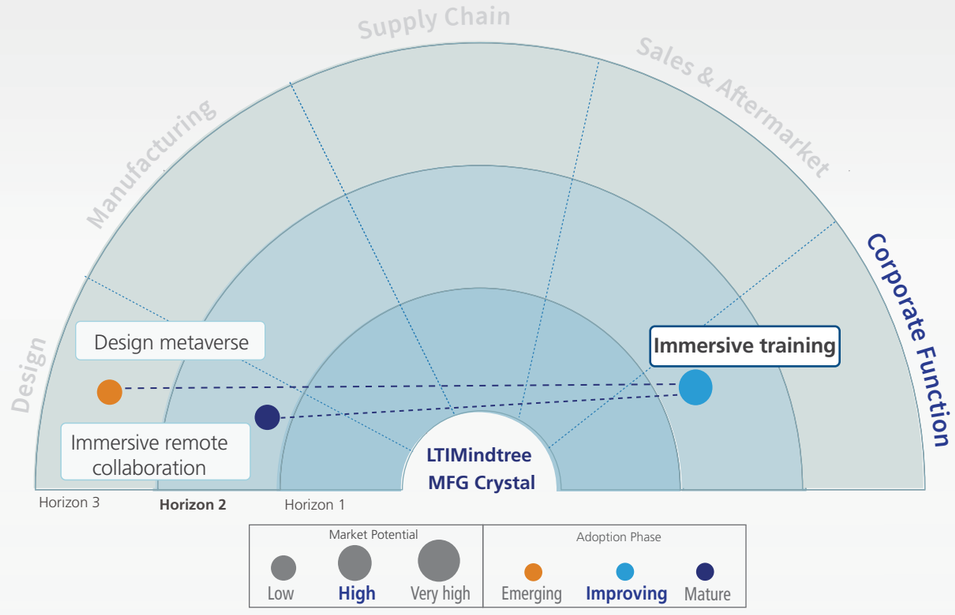
Immersive training

Immersive training is a strategy that uses both AR and virtual reality (VR) to imitate real-world scenarios while teaching workers in a safe, engaging, and immersive training environment. Its benefits are many, ranging from cheaper training costs and improved knowledge retention to quicker item delivery and more efficient assembly lines and maintenance activities.

Highlights

There is a significant transformation occurring in the user experience about how workers are receiving training in the digital space. Users' perspectives are changing due to AI and interactive technologies like AR, VR, and MR. In the industrial business, this transformation is creating multisensory user experiences. Training workers for tasks like simulation training, product training, expert coaching, facility management training, safety product training, and expert capture can be quite challenging. Employers frequently educate employees on safety precautions through instructional videos and written manuals. Utilizing AR and VR in training and preparation significantly reduces the occurrence of workplace accidents. According to Ford's research, leveraging VR training significantly reduced employee injuries by 70%.

Radar View & Related Trends



Key Application Areas

Safety training: Virtual reality simulations enable learners to demonstrate safety practices in a controlled setting.

Employee instruction and training: It is possible to create simulations of work settings or tasks that workers will have to accomplish.

360-degree virtual factory tours for onboarding: New hires may use a VR headset to explore the manufacturing facility's layout, process, and key areas.

Key Technologies

Augmented Reality (AR)

Overlays digital information onto the real world for interactive learning

Virtual Reality (VR)

Simulates realistics enviornments for hands-on training experience

Mixed Reality

Combine AR and VR for an enhanced interactive training experience.

Digital Twin

Virtual replica of systems for practical, scenario-based training.

Featured Story

A Swiss multinational food and drink manufacturing firm leveraged immersive solutions to arrange virtual reality tours of its premises. The tours gave salesmen the opportunity to see how the company makes its pet food items. This gave them a better grasp of the manufacturing process, educated them, and hence inspired more trust in their customers.

Key Takeaway

Augmented and virtual reality are transforming industrial training. Interactive equipment simulations and virtual factory tours help workers learn and prepare more effectively. Immersive training will become more vital as technology advances and new relevant applications emerge in various fields.

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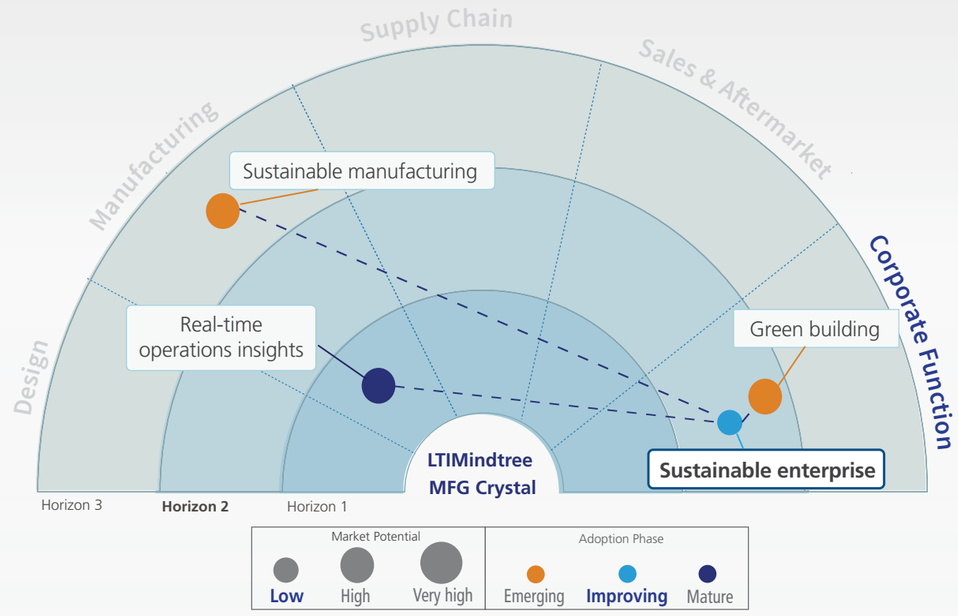
Sustainable enterprise

Sustainable enterprise comprises of the practices, policies, and procedures that organizations undertake to comply with local, state, and/or federal environmental legislation. This includes monitoring and regulating the release of chemicals and other by-products of industrial processes into the local air, water, or waste streams. It is one of the most efficient ways to reduce an organization's negative impact on the environment.

Highlights

Newer processes and operations always improve the quality, speed, and reliability of the products; but also results in higher chemical and industrial waste discharge in air, water, and soil. Hence, it has become immensely important for industries to track, monitor, and reduce harmful emissions into the environment. International standards, like ISO 14001, have been institutionalized for sustainable enterprise. Following these standards, industries can enhance their environmental performance and meet their improvement goals. Another simple but effective model for EMS is the Plan-Do-Check-Act, a basic framework that lays the foundation for setting goals (including compliance goals). Once established, a sustainable enterprise can always be improved for better efficiency.

Radar View & Related Trends



Key Application Areas

Regulatory compliance: A robust EMS helps organizations adhere to compliance requirements from local/state authorities.

Emission tracking: It helps in tracking and recording industrial waste.

Industrial hazardous materials tracking systems

Key Technologies

Gen AI
Identify patterns, predict environmental impacts, and manage strategies proactively

Internet of Thinking
Monitor air, water, noise, and waste levels in real-time.

Blockchain
Enhances transparency and accountability in monitoring environmental impacts.

AI TRiSM
Validate data accuracy and integrity, ensuring reliable decision-making.

Featured Story

A leading US-based printing and graphics company implemented environment management systems with the objective of identifying and addressing environmental aspects and developing policies to become a sustainable enterprise. The company conducted comprehensive activities like setting up a dedicated council to manage waste ink management, haze removal, and water use.

Key Takeaway

Environmental management system can benefit industrial manufacturers in becoming a sustainable enterprise by providing the framework to allow meaningful and long-lasting changes to be made. Implementing a system of continuous improvement gives organizations the opportunity to consistently raise environmental standards and policies.

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Zero trust devices

Increased usage of IoT, cloud computing, and other technologies in the manufacturing space has led to a large number of connected devices. These devices could be unsecured or prone to attacks, resulting in risks to the business. A zero-trust approach incorporates various safety measures such as device trustworthiness, embedded security, certificate lifecycle management, authentication, etc. A holistic zero-trust implementation ensures trusted digital credentials at every step of the supply chain.

Highlights

According to an IBM report, the average global cost of a data breach in the manufacturing sector in 2022 amounted to USD 4.35 million. Manufacturing facilities are becoming more interconnected, with numerous devices, sensors, and endpoints communicating over networks. Therefore, it is imperative to prioritize the implementation of a zero-trust approach within manufacturing plants to safeguard sensitive information and operations. Zero-trust policies at the device level mandate continuous verification of identity, authorization, and context before allowing any modifications to the control system. It safeguards against the misuse of stolen credentials, ensuring that users are limited to specific programmable logic controllers (PLCs) and functions based on their assigned roles. To enable troubleshooting, identity credentials can be issued, granting access solely to designated PLCs for specific functions. Any attempts to operate beyond the permitted parameters are automatically blocked.

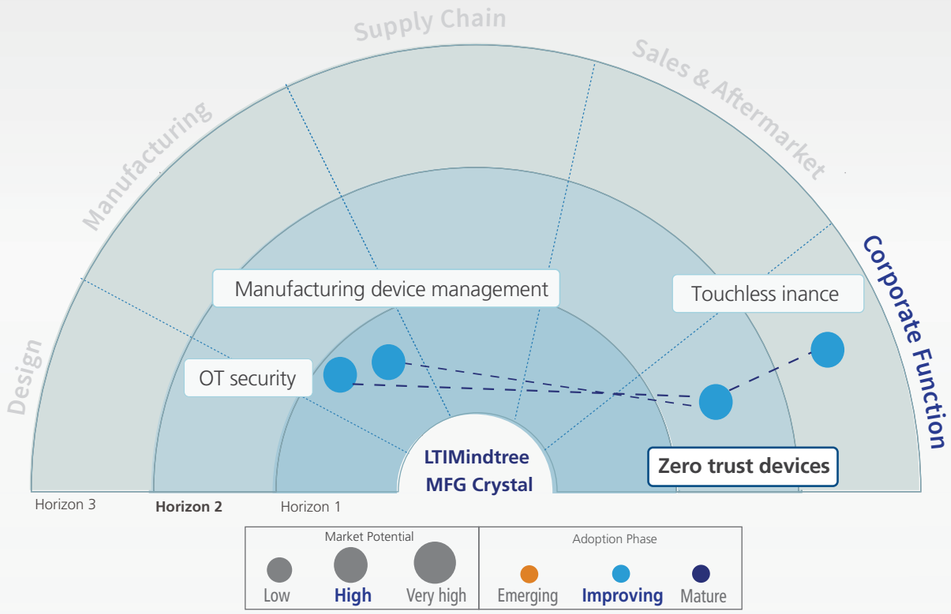
Key Application Areas

Facility design and engineering:
Before building anything, a virtual design of new equipment or a structure can be created.

Supply chain integration:
Supply chain partners integrated into the design and production process can provide inputs on component design.

Simulation and analysis:
Aerodynamic simulations and performance analysis can be performed without a physical prototype.

Radar View & Related Trends



Key Technologies

Zero Trust Architecture
Verification of user and device identities, ensuring that only authorized entities have access

Self-Adaptive Security
Proactive, context-aware approach to cybersecurity, enhancing ability to protect data and assets

Deception Technology
Decoys to mimic real OT systems, luring attackers away from critical assets.

Featured Story

A leading Japanese multinational manufacturing company undergoing restructuring adopted the Secure Access Service Edge (SASE) framework. It was set up alongside a cloud-based security system offered by a leading digital communication organization. Through SASE, the manufacturing company successfully linked over 155,000 devices to the cloud securely and efficiently.

Key Takeaway

It is crucial for manufacturers to prioritize zero-trust protection based on the potential impacts When considering investments, as operational reliability of the plant floor hinges on the reliability of its PLCs. Once zero-trust is in place, the control systems, IoT devices, sensors on the plant floor are completely secure, enabling the manufacturer to enhance security throughout the production networks.

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Horizon 3

Trend will take more than 3 years to reach industrialization state

Design metaverse

In industrial manufacturing, the concept of a design metaverse refers to a virtual environment where all aspects of product design and production are integrated and interconnected. Different tools and technologies, such as computer-aided manufacturing, product lifecycle management, IoT, and AI, are utilized to facilitate design iteration and optimization, simulation, and analysis, as well as collaborative workflows.

Highlights

Metaverse has huge potential to enable businesses to interact with detailed virtual representations of products, machinery, and entire production facilities. It helps optimize product designs and make data-driven decisions. The industrial metaverse is being driven by advanced technologies such as digital twins, AI and ML, extended reality, blockchain, as well as cloud and edge computing. These innovations have progressed to the point where they can revolutionise the manufacturing sector by seamlessly merging the digital and physical realms. Virtual Reality (VR) is another technology that augments the capabilities of the metaverse. It gives design engineers the flexibility to create industrial designs with precise detailing.

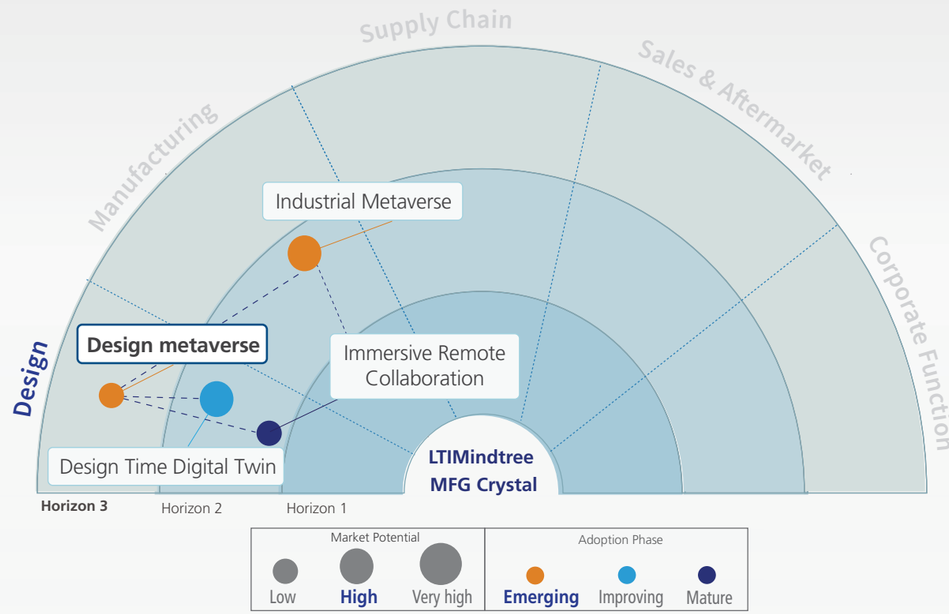
Key Application Areas

Facility design and engineering: Before building anything, a virtual design of new equipment or a structure can be created.

Supply chain integration: Supply chain partners integrated into the design and production process can provide inputs on component design.

Simulation and analysis: Aerodynamic simulations and performance analysis can be performed without a physical prototype.

Radar View & Related Trends



Key Technologies

Mixed Reality

Create immersive factory layout experiences, prototype, and test designs

Augmented Reality

Facilitating remote design reviews, conducting simulation-based testing, with real-time feedback

Virtual Reality

Virtual prototyping, training, assembly, and collaboration for quick resolution.

Featured Story

A global EPC (Engineering, Procurement, and Construction) company faced the challenge of increased error possibility. They were viewing building information modeling (BIM) data on small PC monitors and mobile devices. To tackle this issue, they leveraged the design metaverse, which allowed them to use a VR device to gain immersive design viewing on a 1:1 scale.

Key Takeaway

The design metaverse has the potential to transform the entire product development lifecycle. It can enable manufacturers to achieve faster time to market, higher product quality, enhanced collaboration, and improved customer satisfaction.

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Industry 5.0

Industry 5.0 is a new phase of industrialization that goes beyond mere efficiency and productivity. It prioritizes the well-being of workers and places them at the heart of the production process. By harnessing new technologies like AI and automation, it aims to create prosperity beyond employment and economic growth while transitioning towards a sustainable, human-centered, and resilient industry.

Highlights

Industry 5.0 aims to harness the potential of digitalization, big data, and artificial intelligence (AI) to enhance production flexibility during periods of upheaval. The target is to fortify value chains, prioritize worker-centric technology, and promote circularity and sustainability. Industry 5.0 will augment the organization's journey with a sharp focus on areas like worker empowerment that would cover human-machine interaction, upskilling of workers, and enablement with digital devices and automation. Some examples of worker empowerment include FACTS4WORKERS, EVRYON, Human Manufacturing, etc. Ensuring security in Industry 5.0 will pose a significant challenge. The authentication methods utilized in the industry are essential for enabling seamless interaction with various devices and safeguarding against future quantum computing advancements in deploying IoT nodes.

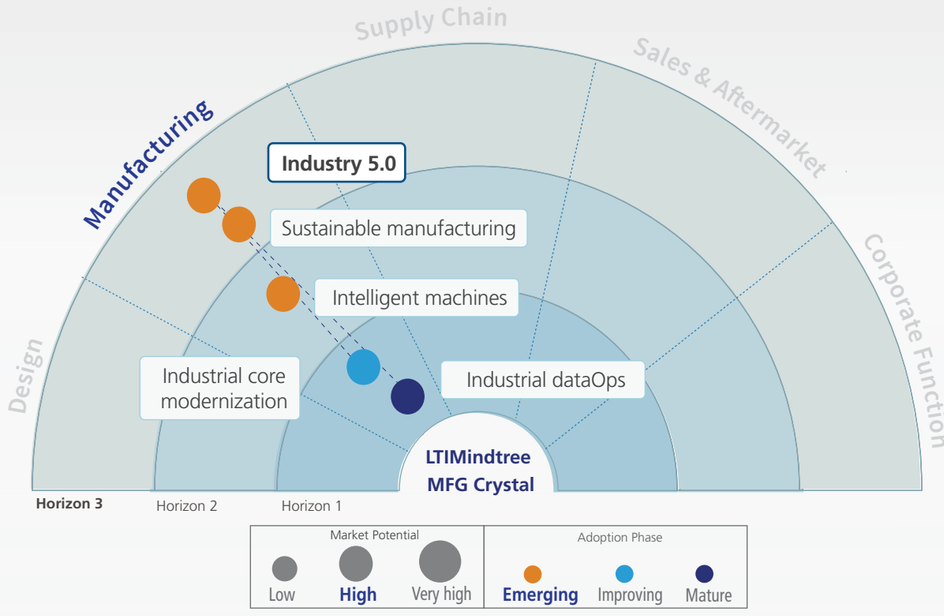
Key Application Areas

Human-robot collaborative assembly: The solution increased the robot's collaboration skills, such as load sharing and human touch recognition, to increase its adaptability.

Remote monitoring: Greater remote monitoring systems to enhance defect detection and prediction.

Hyper-customization: Increased cooperation between COBOTS and humans helps meet the hyper-personalization and hyper-customization needs.

Radar View & Related Trends



Key Technologies

Agentic AI

Enable adaptive manufacturing processes, allowing human workers to focus on more complex activities

Ambient Computing

Embed computing capabiity into machinery to provide real-time insights directly in the work environment

Sensor Tech

Ensure that the application of technology is not only efficient but also contributes to long-term ecological balance.

Hyperautomation

Enhance operational efficiency and flexibility, allowing rapid adaptation to changing market demands

Featured Story

A UK-based technical injection molding company adopted the Matics platform to improve mold maintenance, control over mold usage, and overall production efficiency. Matics increased the firm's process and production efficiency. This has helped to achieve Industry 4.0, which emphasizes human-machine collaboration to optimize production, operations, and boring activities.

Key Takeaway

Robotics and analytics are expected to improve decision-making processes, optimize production, and promote circularity and sustainability initiatives, thus promoting Industry 5.0. How organizations manage human-robot collaborations and utilize data to generate insights and make timely decisions will determine the return on investments.

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Sustainable manufacturing

Industrial manufacturing initiatives prioritize sustainability by implementing eco-friendly processes, infrastructure, and materials. These efforts aim to minimize environmental impacts through efficient practices, digital tools, and initiatives such as waste reduction and predictive analytics. With sustainable manufacturing practices, several organizations focus on meeting their present needs while safeguarding the ability of future generations to meet their own needs.

Highlights

Industrial manufacturing plants relying on energy can enhance sustainability by transitioning to renewable sources like solar, wind, and hydrogen. The shift bolsters companies' green credentials. Governments encourage manufacturing companies to deploy sustainable practices and invest in renewable energy sources. Following the Inflation Reduction Act of 2022 (IRA), the US invested USD 91 billion in over 200 manufacturing projects. They included 38 solar projects, 27 storage projects, 14 wind projects, and six hydrogen projects. The aim was to boost solar, wind, and storage deployment to 850 GW by 2030. In addition, automation aids in emission control through devices like Continuous Emissions Monitoring Systems (CEMS) and carbon capture systems. Smart automation, AI, and the IIoT can enhance sustainability.

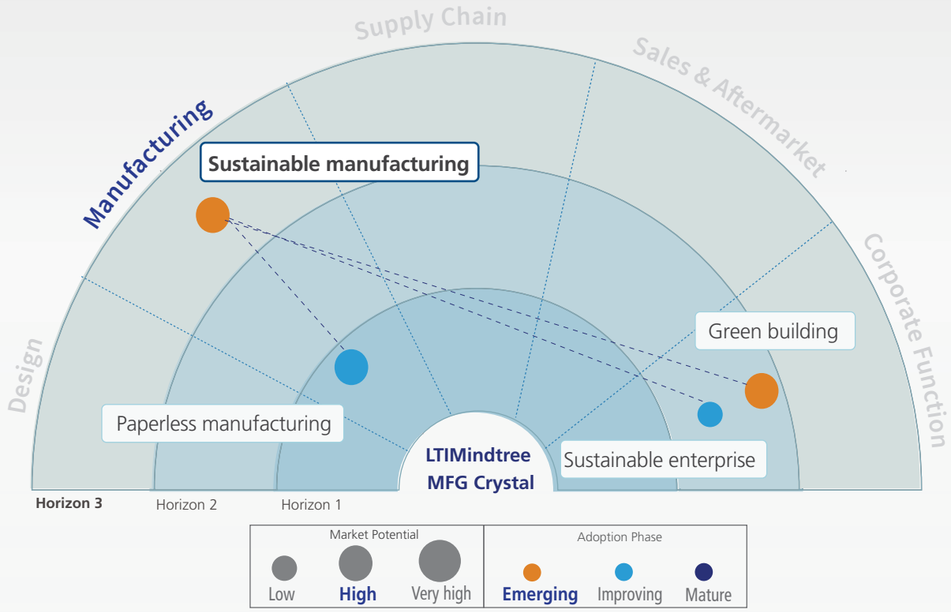
Key Application Areas

Cobots: Reduce waste by performing complex tasks accurately and consistently.

Remote monitoring: Greater remote monitoring systems to enhance defect detection and prediction.

AI: Optimize performance, detect defects, and prevent machinery failure.

Radar View & Related Trends



Key Technologies

Internet of Thinking

Effectively monitor and manage devices and equipment associated with sustainability.

Sensor Tech

Monitor various parameters including emissions, energy consumption, and lean manufacturing.

Regulatory Tech

Generate compliance reports and trigger alerts for deviation from industry standards.

Blockchain

Enhances transparency and accountability in monitoring environmental impacts.

Featured Story

A reputed Danish provider of insulation services and the highest-quality stone wool products integrated the IIoT platform with production machinery. This enabled accurate identification and control of the production process, helping the company improve quality and operational efficiency. The company reduced its production waste by 20%, taking the first step towards its sustainability goals.

Key Takeaway

Introducing sustainability initiatives entails mapping emissions, identifying priority areas, and transforming the industrial ecosystem. Embracing sustainable manufacturing prompts innovation, actionable goals, and a transformative journey toward a promising future.

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Factory in a Box (FIAB)

A Factory in a Box is a modular manufacturing supply chain network that leverages industrial digital technologies. It enhances agility, modularity, mobility, and production without affecting quality and safety. FIAB units are generally located closer to the market and consumers to achieve just-in-time delivery. Its solution includes assembly robots, IoT sensors, and other automated machinery.

Highlights

FIAB can reinvent the supply chain scenarios and may serve as the pioneer of Industry 4.0. A FIAB is expected to empower machines to work without human supervision. This can be achieved by deploying robotics and sensors connected to a network. FIAB systems can make automated decisions based on performance data through this network. Additionally, integrating technologies like AI and IIoT will enable FIAB to enhance process optimization, accuracy, and productivity. However, FIAB implementation comes with challenges. They include pacing the legacy system transformation to match the latest technologies and cybersecurity concerns stemming from digitalization, particularly to facilitate remote operations. A skill gap is also a significant challenge, especially in developing countries.

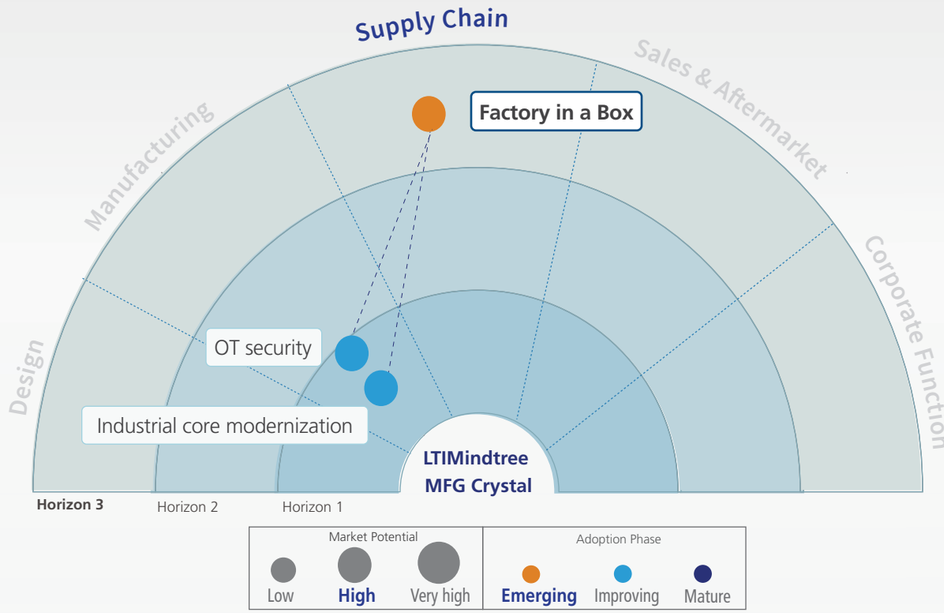
Key Application Areas

Rapid new product introduction: Movement of "Factory in a Box" to partners expedites prototyping.

Training: It provides hands-on experience in manufacturing processes and equipment.

Micro-factory concept: It is a small-scale production unit for niche products.

Radar View & Related Trends



Key Technologies

Internet of Thinking

Improve productivity, process optimization by automating assembly, defect detection, & sorting

Machine Learning

Supports FIAB framework via quality assurance, Nondestructive testing analysis, and defect identification.

Sensor Tech

Collect accurate data to monitor and maintain optimal production conditions.

Agentic AI

Enable adaptive manufacturing processes, allowing human workers to focus on more complex activities.

Featured Story

A major Indian IT services provider implemented a test Factory in a Box for a global pharma company. A metrics dashboard, including live defects and test metrics, was made available to the project and leadership team. Test Utilities RAT (Regulations Acceptance Testing) and RBT (Risk-based testing) helped with early defect detection and reduced report generation effort. Overall, the client achieved a 22% efficiency gain.

Key Takeaway

FIAB, with its rapid deployment of manufacturing capabilities, can be considered a key to a globally decentralized supply chain. Although the adoption of FIAB is slow at present, it is expected to pick up gradually over the next few years.

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Touchless finance

Touchless finance employs a machine-learning engine to continuously monitor and clean invoice records and make real-time predictions, allowing for more efficient operations. It can enhance accuracy and compliance in financial processes by eliminating manual data entry. Additionally, this technology provides real-time insights and analytics, offering decision-makers valuable information to support strategic initiatives.

Highlights

Touchless finance trends in industrial manufacturing improve efficiency and reduce costs in accounts payable processes. These developments rely on advanced automation systems, such as robotic process automation (RPA) and AI, to eliminate manual procedures and errors in financial transactions. This technology enhances financial processes by replicating offline operations, such as manual data entry, through automated systems. Additionally, it automatically notifies approvers, matches purchase orders (POs), and streamlines tasks to minimize errors. Furthermore, in procurement, touchless finance aids in reducing late payments to suppliers and establishing recurring expense payment schedules. The technology determines precise purchase volumes for discounts and facilitates the exchange of financial data and documents such as invoices, purchase orders (POs), and contracts.

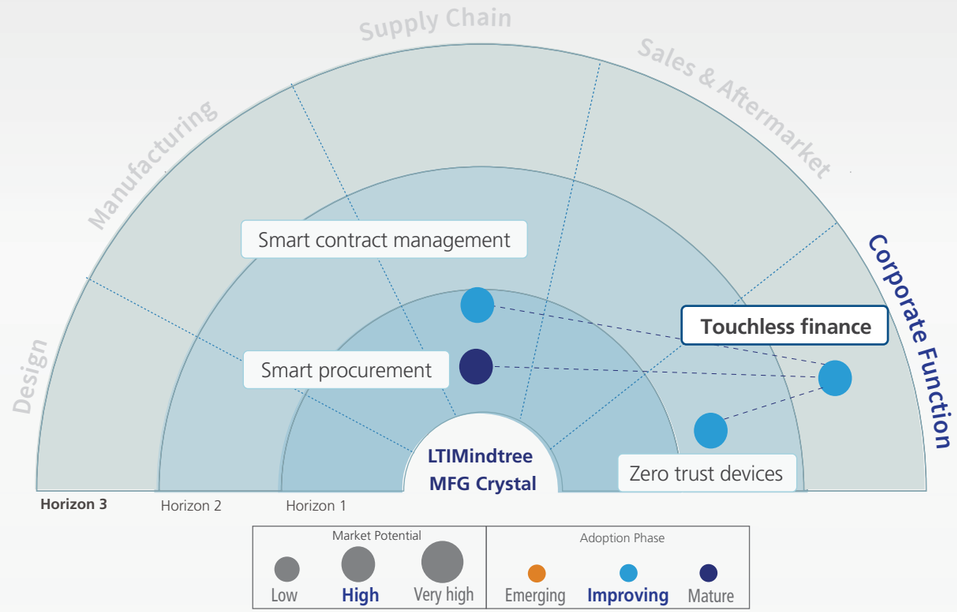
Key Application Areas

Document data capture assistant with vision and voice: The assistant is trained to read, extract, and learn from every document.

Automate the account payable process: PO-based invoices can be automatically approved and posted if the data matches the supporting documents.

Improve invoice data quality: Setting up KPIs to monitor and measure supplier invoice quality can make all the difference.

Radar View & Related Trends



Key Technologies

Agentic AI

Autonomous AI agent can manage financial tasks such as dynamic pricing, automated procurement and smart contracts

Blockchain

Provides a secure, transparent, and transactions, enabling smart contracts for automated financial operations

NLP

Automates interactions like processing invoices or responding to customer inquiries using conversational AI.

Generative AI

Create new financial scenarios or models, optimizing decision-making based on multiple variables

Featured Story

LTIMindtree automated financial operations for a high-end brokerage and wealth management customer. The client's difficulties included numerous modifications to the current ERP, which resulted in higher updates and maintenance costs. LTIMindtree presented a solution that provided a framework for successful remote working and touchless ERP experiences with a one-click data transfer tool and test automation platform.

Key Takeaway

The future of financial operations will involve touchless, data-driven, and intelligent finance factories digitizing large volumes of data, necessitating CFOs to understand how to generate value in this digital economy.

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AI-powered digital business models

In recent years, digital business models have surfaced as groundbreaking alternatives to conventional approaches. Characterized by their use of digital technologies and online platforms, these models unlock unparalleled opportunities for innovation, scalability, and global reach. Adopting digital transformation has become crucial for businesses aiming to succeed in today's economy.

Highlights

The advent of AI has profoundly transformed digital business models, presenting new opportunities for growth and operational efficiency. AI-powered digital business model innovation builds on the positive effects of digitalization; beyond efficiency improvements, manufacturers can explore new products and services, markets, and segments and internationalize operations. AI-driven analytics offer deep insights into customer behavior, facilitating personalized experiences and targeted marketing strategies. It automates routine tasks, boosting operational efficiency and cutting costs, and it enables the development of innovative products and services, thereby unlocking new revenue streams. Implementing AI-driven bots and systems to automate routine tasks results in significant cost reductions and operational efficiencies.

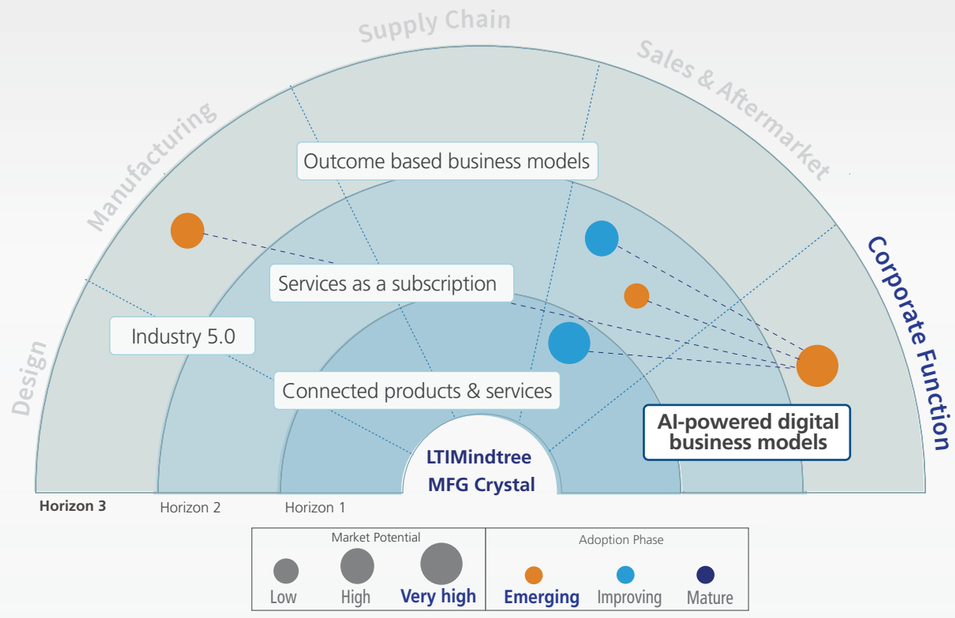
Key Application Areas

Improved Supply Chain
Significant improvements in efficiency, accuracy, and cost-effectiveness.

Cobots:
Increased productivity by navigating intricate areas and identifying objects.

Assembly line optimization:
Reduce downtime & improve workflows by analyzing past metrics data.

Radar View & Related Trends



Key Technologies

Gen AI
Tailoring interactions and offerings to individual preferences.

Industry Cloud Platforms
Enhance performance and efficiency for manufacturing-specific operations.

GraphRAG
Knowledge extraction from multiple documents to provide easy data interpretability

Featured Story

A global industrial manufacturer enhanced its digital workplace experience by introducing a no-code chatbot to address sign-in problems within its corporate finance team. The solution autonomously consolidated and validated data from various sources across the company. This development resulted in higher employee satisfaction, a 30% reduction in login requests, and quicker workforce re-engagement.

Key Takeaway

Conventional manufacturing methods frequently result in the exploitation of resources and labor. Advanced AI and digital technologies have the potential to create innovative product and service models that are not only commercially sustainable but also transformative.

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About LTIMindtree Crystal

LTIMindtree Crystal brings technologies trends to cross-industry enterprises. It presents exciting opportunities in terms of foresight to future-ready businesses keen to make faster and smarter decisions on existing and emerging technology trends. The LTIMindtree Crystal is an output of rigorous research by our team of next-gen technology experts and meticulously rated by our Technology Council across a set of parameters.

We want to thank our Technology Council members for their passion and support in sharing their ratings and feedback. We hope you enjoyed reading the **Industrial Manufacturing Disruptive Trends Report.**

Please reach out to **crystal@ltimindtree.com** for any queries.

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Technology Council

Technology Council is a formal body composed of experts and leaders, from various units.

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Glossary

3D	Three-dimensional
5G	5th Generation of mobile network
AGVs	Automated Guided Vehicles
AI	Artificial Intelligence
AMI	Advanced Manufacturing International
AMR	Autonomous Mobile Robots
AR	Augmented Reality
AS/RS	Automated Storage and Retrieval Systems
AWS	Amazon Web Services
BIM	Building Information Modelling
BYOD	Bring Your Own Device
CAD	Computer-aided Design
CEMS	Continuous Emissions Monitoring Systems
CFS	Connected Field Services
DdoS	Distributed Denial-of-Service
EMS	Environmental Management System
EPC	Engineering, Procurement, and Construction
ERP	Enterprise Resource Planning
FIAB	A Factory in a Box
Gen AI	Generative AI
HVAC	Heating, Ventilating, And Air Conditioning
IIoT	industrial Internet of Things
Industry 4.0	Fourth Industrial Revolution
Industry 5.0	Fifth Industrial Revolution
IoT	Internet of Things
IRA	Inflation Reduction Act of 2022
ISO	International Organization for Standardization
IT	Information Technology
IT -OT -IT	(Information Technology) and OT (Operational Technology)
KBE	Knowledge based Engineering
KM	Knowledge Management
KPIs	Key Performance Indicators
MDM	Manufacturing Device Management
MEMS	Micro Electro Mechanical System
ML	Machine Learning
MR	Mixed Reality
MTTR	Mean Time To Repair
NLG	Natural Language Generation
OEE	Overall Equipment Efficiency
OEM	Original Equipment Manufacturer
OT	Operational Technology
PLC	Programmable Logic Controller's
POs	Purchase Orders
RAT	Regulations Acceptance Testing
RBT	Risk-based testing
RFID	Radio Frequency Identification
RPA	Robotic Process Automation
SaaS	Software as a Service
SAP	SAP SE is a German Multinational Software Company
SASE	Secure Access Service Edge
TAC	Transport Access Control
USD	US Dollar
VR	Virtual Reality
WMS	Warehouse Management Systems
ZTE	Zero Touch Enrolment

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