Hype Cycle for Manufacturing Digital Optimization and Modernization, 2022

Published 4 August 2022 - ID G00769321 - 106 min read

By Analyst(s): Christian Hestermann, Marc Halpern, Rick Franzosa, Alexander Hoeppe

To respond to disruption and to achieve necessary cost optimization and sustainability targets, manufacturers seek ways to modernize and optimize existing IT environments and solutions. This Hype Cycle identifies innovations for CIOs that will be instrumental in achieving these objectives.

Additional Perspectives

- Summary Translation: Hype Cycle for Manufacturing Digital Optimization and Modernization, 2022
  (13 September2022)

Analysis

What You Need to Know

Gartner confirmed that asset-intensive manufacturers face obstacles to increase their business agility (see 2022 CIO and Technology Executive Agenda: An Asset-Intensive Manufacturing Perspective). They tend to have an IT landscape that is deeply entwined with operational technology (OT) and engineering technology (ET), which makes optimization and modernization more complex and harder for them.

CIOs and IT leaders must adopt composable system-level thinking and composable platform architecture to alleviate the complexity described above (see Innovation Insight for Composable Business for Manufacturers). Composable thinking will improve organizational resilience against disruptions. It will also support sustainability efforts, as leaders in manufacturing industries reduce the technical debt by modernizing their applications (see Manufacturing IT Optimization and Modernization Primer for 2022).

This Hype Cycle identifies opportunities to optimize and modernize, often as a basis for the more abrupt and transformative changes captured by the Hype Cycle for Manufacturing Digital Transformation and Innovation, 2022. Successful adoption of the technologies in this Hype Cycle can be adaptive and emergent.

The Hype Cycle

The innovation profiles between the Innovation Trigger and the Peak of Inflated Expectations represent “composable” business applications, which will deliver packaged business capabilities with multiple, hybrid means for integration. These capabilities can enable organizational breakthroughs in the way that IT, OT and ET collaborate beyond departmental and functional boundaries in complete value chains. The others will help with challenges like sustainability, higher resilience in supply chains and cost containment, which are all rising in importance.

The innovation profiles sliding down into the Trough of Disillusionment reflect opportunities across multiple areas:

- Many have been present for years, such as machine learning, frameworks for model-based manufacturing (MbM) and manufacturing process management (MPM), or concepts such as interenterprise master data management (MDM) and digital thread. Most of these will still need longer to materialize inside manufacturers.
- Others, like robotic process automation (RPA) and low-code platforms, help business technologists to rapidly build support for higher automation of routine tasks and close gaps in older solutions that cannot easily be replaced. Higher levels of automation are essential for cost saving efforts, by avoiding duplicate work.
- The transfer of manufacturing-related solutions to cloud models is ongoing. However, their success depends on widely available technology that ensures that manufacturing plants can continue to operate even when severed from the cloud.

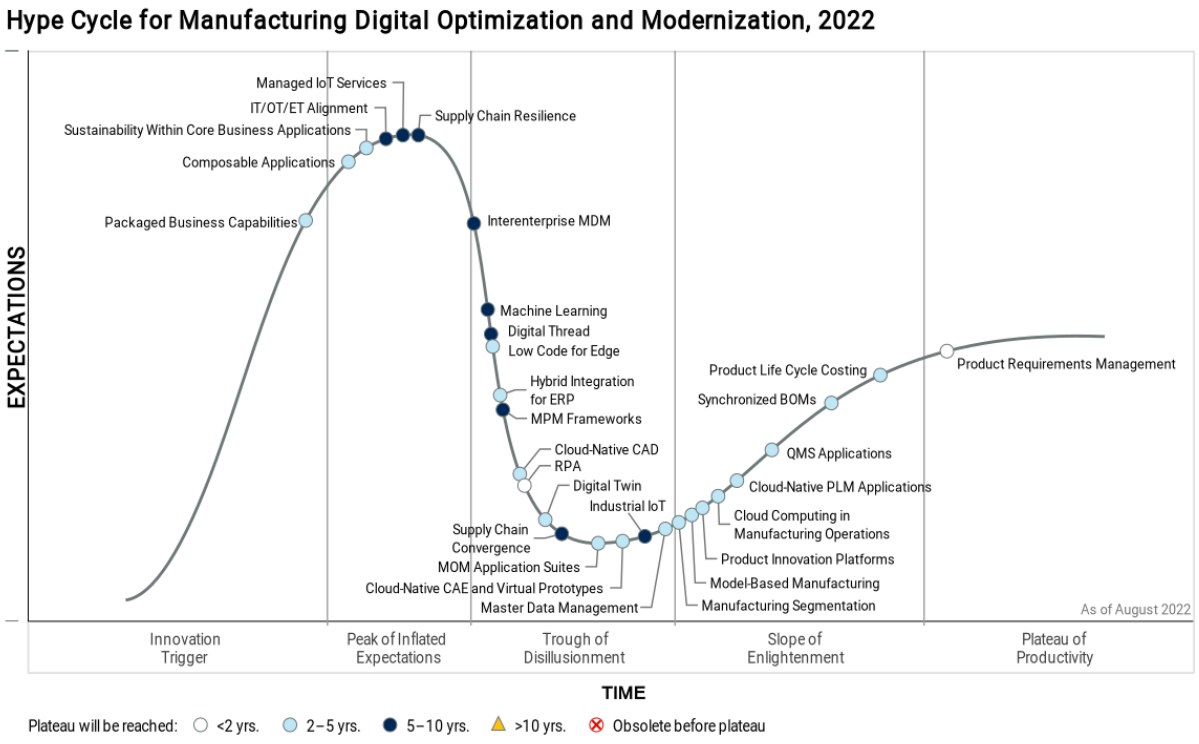
The innovation profiles climbing the Slope of Enlightenment are expanding in value, availability to more users and presence in more manufacturers. Innovation profiles for product requirements management, master data management, synchronized bills of materials (BOMs) or quality management system (QMS), are progressing toward the Plateau of Productivity, because their use is widespread. Companies that have not yet adopted these concepts or technologies risk seriously falling behind their competition and need to speed up their efforts.

Profiles were added this year, such as for supply chain convergence, manufacturing segmentation, industrial Internet of Things (IoT) and managed IoT services, that support manufacturing optimization initiatives. The efforts regarding these mature technologies need to pass beyond experimentation and move on to scaling up those ideas to yield a material impact on financial performance (see Gartner's 2021 Digital Business Acceleration Survey: The Speed of the Game Has Increased).

Many of the innovation profiles have been present on the previous version of this Hype Cycle. The following ones are new:

- Sustainability Within Core Business Applications
- Managed IoT Services
- Supply Chain Resilience
- Supply Chain Convergence
- Industrial IoT
- Manufacturing Segmentation

Figure 1: Hype Cycle for Manufacturing Digital Optimization and Modernization, 2022



Source: Gartner (August 2022)

The Priority Matrix

This Hype Cycle has no transformational profiles that would mature in two years or less. However, a significant number of opportunities will mature in the next two to five years that have high impact. CIOs and IT leaders must prioritize those opportunities for investment, particularly if competitors are already making those investments.

The basic architecture pattern for building or buying composable business applications is crucial for resilience as well as agility to cope with future disruptions, while allowing for cost optimization. Composable principles need to be used in all application initiatives. MPM frameworks, digital twins, and especially, supply chain convergence and resilience retain their transformational character, but will require the collaboration of all departmental functions.

The adoption of cloud-native applications for manufacturing is continuing, albeit slowing down after the push experienced during the COVID-19 pandemic. The speed to reach mainstream adoption is limited, and companies have to deal with the inherent difficulties. Obstacles include less-mature functionality than their on-premises counterparts, frequent forced updates, higher needs for standardization and fear of loss of intellectual property (IP) in a public environment. Digital thread, as an overarching topic, can help organizations determine what the most beneficial digital twin investments will be. Its broad nature prevents speedy adoption for many companies, but once realized, will deliver benefits for cost optimization as well as sustainability initiatives.

Better IT/OT/ET alignment and interenterprise MDM need to address long-established business practices and cultural aspects, which will take five to 10 years to be fully adopted. The same is true for widescale IoT deployments, although this technology also offers opportunities for faster success when deployed alongside other, more mature solutions like manufacturing execution systems (MESs) or manufacturing operations management (MOM) systems.

Table 1: Priority Matrix for Manufacturing Digital Optimization and Modernization, 2022

(Enlarged table in Appendix)

Benefit	Years to Mainstream Adoption			
↓	Less Than 2 Years ↓	2 - 5 Years ↓	5 - 10 Years ↓	More Than 10 Years ↓
Transformational		Composable Applications Digital Twin	MPM Frameworks Supply Chain Convergence Supply Chain Resilience	
High	Product Requirements Management	Cloud Computing in Manufacturing Operations Cloud-Native CAD Cloud-Native CAE and Virtual Prototypes Cloud-Native PLM Applications Hybrid Integration for ERP Low Code for Edge Manufacturing Segmentation Master Data Management Model-Based Manufacturing MOM Application Suites Packaged Business Capabilities Product Innovation Platforms Product Life Cycle Costing QMS Applications Sustainability Within Core Business Applications Synchronized BOMs	Digital Thread Industrial IoT Interenterprise MDM IT/OT/ET Alignment Machine Learning Managed IoT Services	
Moderate	RPA			
Low				

Source: Gartner (August 2022)

Off the Hype Cycle

The following innovation profiles were removed:

- Immersive Experience in Manufacturing Operations, which is now in Hype Cycle for Manufacturing Digital Transformation and Innovation, 2022
- IT/OT Integration, which has been subsumed in IT/OT/ET Alignment
- Engineered Robotic MHA Systems, which is not relevant for this Hype Cycle
- Plant Engineering and Design, which is fully mature
- Asset Performance Management, which is not relevant for this Hype Cycle

- Product Cost Management, which has been renamed to Product Life Cycle Costing this year

On the Rise

Packaged Business Capabilities

Analysis By: Yefim Natis

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Packaged business capabilities (PBC) are the building blocks of composable architectures. They are software components that are wrapped (packaged) to maximize the effectiveness of their reusability, autonomy, orchestration and discoverability by business-oriented tools. These capabilities may represent business logic, process, data, analytics, experience, platform technology or other packaged functionality.

Why This Is Important

Composable architecture is adopted to better support the pace of change required by the fast-changing needs of the business. PBCs help separate the creators of the composable modular building blocks and the composers of the delivered solutions. Such role separation forms the foundation for composability and, consequently, better prepares organizations to sustain and grow their businesses in the face of present and future disruptions.

Business Impact

With composable architecture and PBCs:

- Business technologists and fusion teams are better equipped to control and quickly adapt business processes and experiences to the changing business needs, improving the organization's potential for resilience, adaptability and innovation.
- IT and business professionals are better equipped to combine their talents in the creator-composer process, shifting organizations closer to an effective business-IT operational continuum.

Drivers

- High fragmentation, disruptive change and fierce competition in some industries — such as digital commerce, healthcare, or transportation and supply chain — demand fast realignment and adjustment of business and its digital resources.
- To take advantage of the pace of business change, leading organizations seek faster, safer and more-efficient tools for digital business innovation.
- Increasing participation of business professionals in software engineering requires more business-oriented expression in software modeling, replacing or augmenting the traditional programmatic orientation.
- The increasing democratization of platform technologies is bringing more business professionals to digitalized business capability (application) design work.
- The growing orientation of vendor applications (including SaaS) to API-first and API-only ("headless") design is leading organizations toward composition and integration, instead of the basic customizations of vendor applications.
- The increasing sophistication of agile development practices and managed-product delivery of applications demands more-advanced modularity, autonomy, orchestration and discovery for functions and features of applications.
- Software engineering teams are acting in a more autonomous manner and enterprise architects need new ways to provide business-architectural guidance to application architects.

Obstacles

- Cultural resistance to change, fear of the shifting business priorities and familiarity bias — form barriers to the rapid adoption of the architecture of composability.
- "Composable-washing" by some vendors discredits the model and delays adoption.
- Many application design and composition initiatives remain, by tradition, in central IT, limiting the direct participation of business.
- Fusion team effectiveness is limited, due to cultural challenges and inertia compromising both the technology and the business value of their outcomes.
- Without an effective separation of technologist creators and fusion team composers, the architecture fails to deliver the business effect of composability.

- Enterprise and business architecture designs often lack direct mapping to the modularity of application architectures, making the business-IT design continuum more difficult to achieve.

User Recommendations

- Prioritize expertise in API and event management as precursors of composable architecture.
- Separate the responsibilities of the creators of PBCs and the composers that use them to deliver application processes and experiences to business users.
- Reject any new monolithic solutions proposed by vendors or in-house developers, and plan to renovate or replace the old ones, to enable their participation in composition.
- Prioritize democratized tools suitable for business-IT fusion teams supporting development of composed application experiences.
- Give preference to API-first and API-only (headless) SaaS.
- Build up the business-IT collaboration by forming fusion teams and promoting shared objectives and incentives across areas of the organization contributing resources to a common business outcome.
- Form specially targeted fusion teams that bring together enterprise and application architects to bridge the gap between the business and technology architecture thinking.

Gartner Recommended Reading

Innovation Insight for Composable Modularity of Packaged Business Capabilities

Use Gartner's Reference Model to Deliver Intelligent Composable Business Applications

Kick-Start Your Composable Business Journey With 2 Key Strategies

How to Design Enterprise Applications That Are Composable by Default

Fusion Teams: A New Model for Digital Delivery

At the Peak

Composable Applications

Analysis By: Yefim Natis

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Composable applications are built, in part or in whole, as flexible assemblies (compositions) of well-encapsulated (packaged) modules of business application capabilities that may originate from one or multiple sources. The role of the "composers" is typically performed by members of business-IT fusion teams, while the creators of the packaged building blocks may be application vendors or central IT software engineering teams.

Why This Is Important

Composable applications are designed to support fast-paced business change while protecting the integrity of the outcomes. They use coarse-grained business-centric software modularity to better match digital application capabilities to business operations. Organizations that use composable applications can achieve faster change. Composable applications help support resilience, adaptability and growth of business in the context of increasingly frequent challenges, disruptions and opportunities.

Business Impact

The more composable the organization's application portfolio is, the better the organization is prepared to support changing business requirements through digital innovation. In return, greater confidence in the agility of applications promotes faster business thinking. The improved agility of business technology strengthens the ability of an organization to maintain and grow their business, a high value in the modern context of frequent disruptions and opportunities.

Drivers

- In the continuously changing business context, demand for business adaptability directs organizations toward technology architecture that supports fast, safe and efficient application change.

- The demand for active participation of business decision makers in the design of their digital experiences promotes adoption of technology models that are accessible and useful to business experts in addition to, and in cooperation with, technical professionals.
- The increasing number of vendors offering API-centric SaaS (also known as API products or “headless” SaaS) builds up a portfolio of available business-centric packaged application components — the building blocks of composable business applications.
- Increasing mainstream use of low-code application, integration and automation platforms supports composition of applications using APIs and other forms of encapsulated business software, preparing organizations for composable application engineering.
- Fast-growing competence in mainstream organizations for management of broad collections of APIs and event streams creates a technology foundation for safe operation of a composable business technology environment.

Obstacles

- Limited experience of composable thinking and planning in most software engineering organizations complicates composable design efforts and transition plans.
- Limited practice of business-IT collaboration for application design delays the effective composable design that depends on the complementary expert talents in multidisciplinary fusion teams.
- Most legacy applications can participate in composition via their APIs and/or event streams, but their architecture provides only minimal autonomy, delaying the full positive effect of composable architecture.
- Lack of componentry, development and platform tools dedicated to composable application architecture limits the early success to advanced design teams capable of adapting precursor technologies to new objectives.
- Insufficient mapping of architectural thinking and models between business and technology planners makes digital representation of business functionality less prepared to track the real-world business change.

User Recommendations

- Promote composable thinking throughout the organization. All delivered application designs must be ready to participate in the changing business context by providing a collection of published business-centric APIs. More advanced designs would optimize business granularity, autonomy, orchestration and independent discovery of the application components.
- Build competence in API and event stream management as the precursor to managing composable application building blocks.
- Use low-code technologies to facilitate design collaboration of business and technology experts.
- Prioritize formation of business-IT fusion teams to support faster and more effective adaptive change of business applications.
- Build an investment case for composability by highlighting how aging digital assets endanger the future success of the business by forming barriers to keeping up with the pace of market change.
- Gradually modernize (or replace) existing applications toward architecture of business-centric modularity.

Sample Vendors

Alloy; Boost; Contentful; Elasticpath; Shippo; Stripe

Gartner Recommended Reading

Becoming Composable: A Gartner Trend Insight Report

Predicts 2022: Composable Applications Accelerate Digital Business

Use Gartner's Reference Model to Deliver Intelligent Composable Business Applications

How to Design Enterprise Applications That Are Composable by Default

Sustainability Within Core Business Applications

Analysis By: Simon Mingay, Sarah Watt

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Embedding of key sustainability and environmental, social and governance (ESG) data, metrics, processes and capabilities within core business applications such as ERP, manufacturing execution systems (MES), supply chain planning and management applications enables improved decision making, optimizations, democratization and visibility of data.

Why This Is Important

Sustainability cannot be managed effectively as a discrete area of performance. Enterprises must be able to include sustainability goals and data, alongside other business objectives and data, to enable integrated optimizations of enterprise operations (notably but not exclusively energy and greenhouse gas emissions). Execution of sustainability goals requires democratization and integration of data into core business applications to inform sound decision making, balancing trade-offs between cost, cash, service, and environmental or social impacts.

Business Impact

Executives must empower operational managers across the whole business to optimize execution of sustainability goals. ESG and sustainability data visibility, integrated with existing core business data and processes, aligned to appropriate roles and functions, creates accountability and informed optimized action, and enables better automated process execution. It enables putting decision-making frameworks in place that include sustainability-related factors in addition to traditional business levers, and enables roles to understand how their actions directly impact a broader set of enterprise goals and activities.

Drivers

- Enterprises with ambitious ESG and sustainability goals have a sense of urgency to substantially improve the sustainability-related capabilities of their core business applications.
- Enterprises quickly run out of the more obvious and low-hanging fruit for improving their sustainability and ESG performance. Next steps require more effective insight and decision making.
- Effective analytics and insight require the integration of ESG and sustainability data, processes and metrics into the business to enable new points of optimization, and to link with financial and other operational data.
- CIOs are reluctant to add new application vendors and software, preferring to extend capabilities supported in the existing applications portfolio.
- The need to improve data quality and reduce gaps in data collection and usage across a variety of business activities and processes.
- Empowering employees and automating process execution and decision making will ensure that sustainability objectives are achieved in more scenarios, rather than being an afterthought or an exceptional isolated initiative.

Obstacles

- Sustainability and ESG data has historically been highly fragmented and suffered from significant gaps, with any consolidated view held only by a few specialist roles, or in niche applications and/or spreadsheets.
- Best-of-breed or niche application vendors will move much more quickly than many of the established ERP and enterprise business application vendors, but integrating their specialized solutions into major core applications is not well supported by their legacy architectures.
- Best practices, standards and regulations in relation to ESG and sustainability data and processes are immature and changing quickly, making it tempting for incumbent application vendors to delay investment.
- Complexity and immaturity of decision-making frameworks. For example, if shipping costs 0.5% more for the carbon-neutral option, would this be acceptable to the organization? Challenges of balancing short-term and long-term needs and costs.
- Lack of data, not just within the enterprise, but examples where the data simply does not exist — such as reliable, accurate Scope 3 emissions data.

User Recommendations

- **Process and Data Integration:** Embed sustainability and ESG into your enterprise, application and data architectures, and technology roadmaps.
- **Long-Term Strategy:** Work with ERP and core business application vendors to integrate ESG and sustainability. Meanwhile, apply a more tactical and innovation-led approach to meet needs with narrower point solutions, but be aware of necessary integration and data management efforts.
- **Vendor Assessment:** Assess current core business application portfolio to understand the sustainability and ESG data and capabilities that are supported.
- **Vendor Roadmaps:** Engage with your existing application vendors to understand and influence their sustainability and ESG roadmaps.
- **Materiality:** Leverage the enterprise materiality assessment to decide which sustainability and ESG issues and associated capabilities and data points should be implemented or made available.
- **Decision Making:** Put in place frameworks that codify the integration of sustainability and ESG data as part of decision making.
- **Data Fabric:** Analyze the practicalities of complementary solutions such as a data fabric approach.

Sample Vendors

ASM Pacific Technology (Critical Manufacturing); Dassault Systèmes; Infor; Microsoft; OMP; Oracle; SAP

Gartner Recommended Reading

Predicts 2022: Manufacturing CIOs Increase Responsibilities for Sustainability and Operations

Manufacturing Insight: How to Position Manufacturing Solutions for Sustainability

From Logical Data Warehouse to Data Fabric

Data and Analytics Essentials: Data Fabric

A Framework for Sustainable Technology

IT/OT/ET Alignment

Analysis By: Kristian Steenstrup, Marc Halpern

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

IT/OT/ET alignment refers to the coordination of information technology (IT), operational technology (OT), and engineering technology (ET) through shared standards and governance. Each plays a complementary but mutually reinforcing role to the other two technologies. While IT records transactions and business processes, OT operates and monitors industrial assets (e.g., SCADA), and ET is used to define, design, simulate, analyze, visualize and validate those assets (e.g., GIS, CAD/CAM).

Why This Is Important

For asset intensive industries, system interoperability is improved when OT-enabled machines and ET and IT systems and processes share infrastructure and planning. As a result, organizations are implementing common architecture plans and common standards for the components acquired, and increasingly look for vendors that support this direction. Most companies are beginning this exercise and are more aware of the benefits while still conscious of the obstacles and problems.

Business Impact

We see movement of IT/OT/ET alignment with clients who are working through the complexities of culture and politics. This change follows the realization of technology commonality, its opportunities and benefits, and the risk of doing nothing.

The impact of IT/OT/ET alignment is mainly focused on two aspects:

1. More efficient use of technology to support resources across IT, OT and ET investments.

2. Easier sharing of data from design documents (ET) to operational systems (OT) and business administration.

Drivers

- Cost reduction by not duplicating licensing, maintenance and support for common software components.
- Cost reduction by consolidating and collocating servers and back-end hardware in a common data center.
- Agility by being able to start new hybrid IT/OT/ET projects quicker and reacting to changes in a consistent way.
- Risk avoidance by aligning security, patching, disaster recovery and upgrading processes.
- Benefits of using the same support and configuration tools, support contracts and purchase processes.
- Easier access to ET and OT data for IT analysis such as predictive maintenance and production optimization.
- Leverage of OT performance data in product development using ET systems.
- Design of ET systems that better cater to OT effectiveness and future OT system support and data acquisition.
- Interest in leveraging cloud capabilities to achieve cost optimization and flexibility across the three domains (where possible).

Obstacles

- Coordination between three separate domains is complex technically and politically.
- Possible increase in cost on the OT or ET side initially, as technology investments are made to bring software up to the required IT standard/version and to deal with any license compliance gaps.
- Common for software asset management (SAM) to involve significant resources in the early stages, with savings being identified once the software position has been baselined accurately and compliance issues resolved.
- The benefits in terms of cost savings tend to be medium or long term, not short term.
- The entrenched separate positions and practices associated with OT and ET systems and their criticality, safety and stability, means that realignment takes time.
- Different cultures and approaches of IT departments, manufacturing/operations and design/engineering, which will have to be orchestrated.

User Recommendations

- Establish a common governance model across the three domains.
- Examine technology management processes to determine how much IT process is applicable to OT and ET, how the unique needs of OT and ET must be recognized and supported, and how to get them aligned by design, not as an afterthought.
- Include OT and ET requirements in enterprise risk management by adopting an integrated security strategy across IT, OT, ET, physical security and CPS for greater visibility.
- Create combined hardware platform and architecture policies to ensure compatibility between IT, OT and ET systems by formulating compatible governance for software, communications and infrastructure.
- Use RACI analysis to help manage this transition and to map out organizational responsibilities for different parts of the technology environment.

Sample Vendors

Bentley Systems; PTC; Siemens

Gartner Recommended Reading

Quick Answer: What Are IT/OT Alignment and IT/OT Integration?

Manufacturing Insight: How to Position Hybrid IT/OT Offerings

How IT Standards Can Be Applied to OT

Survey Analysis: IT/OT Alignment and Integration

When Does a CIO Need to Be Involved in OT?

Managed IoT Services

Analysis By: Eric Goodness, Emil Berthelsen

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Managed IoT services are third-party services that support part or all of the production of an IoT solution by an end user on an ongoing basis. Delivery of managed IoT services is most often enabled by cloud-based tools and skilled personnel observing structured processes in an operations center. However, there is a demand for on-premises delivery, especially where IoT integrates with a certain class of OT systems.

Why This Is Important

Managed IoT services integrate and aggregate a range of technologies included within the categories of edge devices, IoT platforms and IoT-enabled applications. Overall, managed IoT services converge IT and OT through integration, and offload the day-to-day monitoring, management and related analytics of IoT systems that contribute to business outcomes. Additionally, the service addresses a significant lack of skills to design, build and run IoT solutions.

Business Impact

There is an increasing demand for IoT-enabled business benefits, such as improved customer experience, creating new servitized products, and new revenue and insights from data. Enterprises are investing in managed IoT services to reduce the time to value of deploying IoT and shift the risk of IoT success to external providers to guarantee outcomes associated with digital business. Perhaps the fastest-growing use of managed IoT services lies with manufacturers creating smart connected products.

Drivers

Managed IoT services moved further toward the Peak of Inflated Expectations on the Hype Cycle. The move is based on the increase in IT-centric and IoT service providers now offering managed IoT services, and the use-case examples being shared with Gartner. Enterprises recognize the need to offload the management of their IoT solutions for a number of reasons, including:

- Cost reductions
- Access to skills that do not exist within the company
- Improved user experience, such as the use of predictive maintenance
- Too large scope and scale of the deployed solution to create a platform and organization dedicated to effective monitoring and management to guarantee a certain level of availability and performance
- Security

Obstacles

- A lack of end-user experience for upfront planning and strategy development for these services
- An inability to focus on simply scoped use cases, such as condition-based monitoring of a non-IT asset, which are generally more successful than broader, far-reaching digital transformation projects
- A lack of experience to identify and define remedies for nonperformance based on business impact
- A lack of service providers with deep expertise and experience across a wide range of use cases

User Recommendations

Align managed service provider (MSP) attributes and capabilities within your sourcing selection criteria, including foundational elements, such as:

- Expertise in creating and managing complex multisourcing agreements that span the technologies, service delivery, and outcomes and SLAs
- Professional services for the integration of devices and platforms, and pushing sensor data to enterprise applications
- Alignment of your key performance indicators (KPIs) with the SLAs of the managed services proposed

Sample Vendors

Accenture; Atos; Cognizant; Insight; Orange Business Services; Tata Consultancy Services (TCS); Wipro

Gartner Recommended Reading

Forecast: Internet of Things, Endpoints and Communications, Worldwide, 2021-2031, 1Q22 Update

3 Areas to Drive IoT Differentiation Beyond Functions and Features

Supply Chain Resilience

Analysis By: Koray Kose

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Resilience is the ability of an organization to avoid, absorb and recover from major disruptions through a risk-balanced approach from product design, supply chain strategy to network design. Achieving a resilient supply chain that maintains the ability and agility to execute effectively depends on how well the CSCO achieves stakeholder alignment across functions.

Why This Is Important

The unprecedented level of disruption in global supply chains and price inflation is transforming existing notions of resilient operations. Additional challenges such as those from active conflict, severe weather, cybercrime, trade policy uncertainty and other risks, make improving supply chains' resilience as a key competitive advantage to meet customer needs a key priority. At the same time, the pressure to manage traditional key performance indicators like cost still remains.

Business Impact

Given the interconnected nature of risks, the increasingly high cost of reacting to them and the higher frequency with which they occur, the inflection point between investing to improve resilience and cost-efficiency is shifting. Rather than viewing the expense of upfront investments for resilience as inefficient, leading organizations are looking at them more favorably as ways to protect revenue and grow market share at the expense of less resilient competitors.

Drivers

- Over the last several decades, global supply chains have fine-tuned operating models that are facilitated by low cost country sourcing, inexpensive labor, specialized providers in a few geographic clusters, just-in-time inventory policies, efficient and cost-optimized global logistics, and benign international trade policies. The latest series of extraordinary supply chain disruptions is only the latest in a time of growing external shocks that have led companies to reassess their heavy weighting toward short term and fragile cost efficiency strategies.
- Every crisis has led to expensive workarounds and disruptions to continuity of service to customers, which can range from minor delays to calamitous stoppages of supply. Companies of varying sizes, in different industries or geographies will need to dynamically adjust their need for greater resilience based on their risk appetite, risk capacity and the relative ease of adjustment given the availability of and ability to reconfigure established supply ecosystems.
- Improving supply chains' resilience is not a binary all-or-nothing act. Actions can range from risk monitoring in the supplier and service provider network to shifting to existing supply or manufacturing locations for multisourcing on the low cost end. On the other end of the spectrum, resilience could revolve around product design changes and qualifying alternate suppliers that could require significant amounts of time and money or a capital intensive shift operating models from global ones to regional or hybrid ones.
- As resilience rarely comes for free, successful options will be led by strong market leaders making big bets to transform their networks. Hybrid supply chain models that continue to utilize global networks for key components, or manufacturing steps that are hard to shift while creating regional networks for final assembly and proximity to markets is one such example. Resilience will almost always pay off in volatile and highly uncertain, fast paced environments.

Obstacles

- Cash-rich organizations are much better placed to invest in resilience than their weaker counterparts. However, not investing into resilience will deplete funds in many point-in-time siloed response activities, so it's not a choice but a must.
- Resilience depends on its' degree of supply chain visibility available to manage risks. Many don't have visibility into the extended, n-tier supplier network. Significant ongoing investments in supply chain visibility and risk monitoring is essential in this evolving space.
- Off-the-shelf tools may not be able to solve resiliency challenges across the network. Investments into emerging technologies like graph technology, blockchain and advanced analytics to drive insights and improve risk-based decision making becomes essential.
- Resilience is uniquely difficult to provide a return on investment for. Resilience is an ongoing investment into people, processes and technologies as it needs to constantly challenge the status quo for something better.

User Recommendations

- Emphasize maintaining continuity of supply to customers and factor in the cost of long-term risk response actions.
- Identify and prioritize risks and key points of failure using a value-at-risk approach. Focus on forward looking scenarios that could be backcasted to relevant remediating actions that could be done today.
- Define pragmatic service levels with time to recover and time to survive analysis as not every service level is sustainable during disruptions. Setting clear expectations in cost and service will prepare stakeholders and keep engagement levels high.
- Enhance visibility to the supply network and invest into strategic supply redundancies, mitigating single and sole sources and other bottlenecks.
- Determine and define the organization's risk appetite, key risk indicators, and resilience investments into people, processes and technologies to be executed swiftly and reviewed periodically.
- Review resilience scenarios and investments as risk signals and environments change.

Gartner Recommended Reading

Creating a Supply Chain Resilience Framework

7 Risk Areas Every Executive Should Expect and Manage Following the Russian Invasion of Ukraine

Global vs. Regional Supply Chains — Identifying the Right Approach for Your Network

Infographic: Supply Chain Visibility Is Fundamental to Resilience in Supply Ecosystems

Market Guide for Supplier Risk Management Solutions

Sliding into the Trough

Interenterprise MDM

Analysis By: Guido De Simoni, Simon Walker, Sally Parker

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Definition:

Interenterprise MDM is a technology-enabled discipline supporting shared governance and utilization of common master data assets across two or more interrelated businesses. Interenterprise MDM enables the creation of shared master data assets used within data pools or consortiums (such as those supporting product data or commercial credit data), data marketplaces and exchanges, and shared reference datasets.

Why This Is Important

Commercial trade depends on increasingly complex digital ecosystems, making it harder for businesses to optimize their interactions with other businesses. Global supply chains, distributor networks, third-party e-commerce and outsourced customer service are examples where the exchange of master data (like customer or product data) between business entities is a critical dependency. Interenterprise MDM provides efficient B2B data exchange through shared governance of master data assets.

Business Impact

Interenterprise MDM optimizes processes that span two or more businesses by enabling the uniformity, accuracy, stewardship and semantic consistency of the master data assets used in those processes. A shared approach to governance policies and MDM allows for scalability and automation by removing silos across processes and for data integration within organizations. Any relationship between businesses that is facilitated by the exchange of master data can benefit from interenterprise MDM.

Drivers

The fundamental driver for investing in interenterprise MDM is about taking an effective shared approach to the management of master data assets used across interdependent business processes spanning more than one business entity. Use cases include:

- Optimizing the processes involved in moving goods, including raw materials, through a supply chain.
- Increasing the speed and efficiency of the process of procuring goods or services, often in support of inventory optimization efforts.
- Selling, marketing or distributing products or services in third-party channels through the use of shared product (and related) definitions and catalogs.
- Utilizing external resources to manage customer service or support processes.
- Creating a consistent customer definition/view in support of a complex multichannel partner or reseller network.
- Connecting product and customer transactions across consistent master identifiers between offline and online retail experiences.
- The reduction in data management costs that result from taking a shared approach to the governance and stewardship of a shared pool of master data assets.
- Increased efficiencies realized by taking a data hub approach to integrating master data across business entities, as opposed to multiple point-to-point integrations.

Obstacles

- The dynamics of certain market segments that provide a limited number of large players the power to dictate master data standards to their customers or suppliers.
- A lack of data and analytics governance maturity within organizations, particularly around an inability of organizations to make a connection between investments in MDM and desired business outcomes.
- Political and cultural forces within organizations, which create fear and uncertainties around the acceptability or legality of external master data sharing.
- Limited market opportunities to participate in data pools, consortiums or other similar approaches to external master data sharing.
- The time, resources and organizational model needed to create a data governance body that works for shared mutual interests, and not the interests of any one corporate entity.

User Recommendations

For companies that would benefit by taking more of an interenterprise approach to MDM, we recommend:

- Take an outcome-driven approach to identity use cases that would be optimized by interenterprise MDM. Use a limited number of use cases to limit your scope and build a business case.
- Evaluate participation in data exchanges or consortiums to support the use cases you have identified for optimization.
- Engage directly with your business/trade partners to collaborate to identify areas of mutual benefit where no data consortiums (or similar) exist to support your use cases.
- Address any existing barriers to external data sharing by taking a “must share data unless” approach, including a recalibration of the real business risks of external master data sharing.
- Evaluate the impacts on people, processes and technologies needed to support an interenterprise MDM business case, along with the impacts on any existing governance processes.

Sample Vendors

CDQ; Precisely

Gartner Recommended Reading

Data Sharing Is a Business Necessity to Accelerate Digital Business

Machine Learning

Analysis By: Simon Jacobson, Scot Kim

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Emerging

Definition:

Machine learning (ML) is an AI discipline that uses statistical models to identify predicted insights and logical patterns based on the analysis of large sets of data. There are three major subdisciplines related to the types of observation provided. These are supervised learning (observations contain input/output pairs [aka labeled data]), unsupervised learning (labels are omitted) and reinforcement learning (evaluations are given of how good or bad a situation is).

Why This Is Important

Rather than relying on manual or conventional analytics, ML takes advantage of large amounts of structured data (text), and unstructured data (videos, images and other data to identify patterns) to generate insights and predict outcomes. In manufacturing operations, ML is an essential enabler of smart factories and facilitating connected factory workers. It can improve different facets of operational excellence and boost reliability of supply, while freeing up HR to focus on higher-value tasks.

Business Impact

ML algorithms identify undetected patterns across data that users typically would not inherently find. ML algorithms rely on data to identify patterns to generate insights and predict trends. These insights improve over time, as algorithms self-learn/retune from prior performance. ML, however, is not a panacea. Successfully cultivated strategies are built on common workstreams and digital roadmaps that promote scalability so maximum value is gleaned.

Drivers

- Algorithms are not new in manufacturing, yet the adoption of modern tools lags behind other supply chain functions, such as planning. In the past year, pilots have increased as companies become more bullish on automation as a way to efficiently run shifts and maximize the value of production data. Typical use cases include eliminating unplanned downtime and stoppages, increasing yield optimization, reducing energy usage, improving product quality or stabilizing production processes.
- This zeal — combined with pandemic-driven objectives to identify trends and plan resources and capacity more effectively — pump up the ML hype. Adoption, however, will be staggered due to extensive and lengthy pilots. Providers, in an effort to modernize incumbent systems, are simplifying their tools to develop algorithms. On the other hand, this needs time to evolve and mature (especially for advanced techniques such as unsupervised learning).
- Increased leverage of edge computing is expanding the interest in ML.

Obstacles

- **Data complexity:** Having the right data in the right formats, managing the relationships between different data, and then the context to train models takes time. Each of the following provides different kinds of data: IT and OT across legacy data sources, vision systems, edge devices and transactional systems — to name a few.
- **Heterogeneous systems and data sources:** ML is an integral part of provider offerings spanning industrial IoT platforms, hyperscalers, OT providers, and multiple point or niche solutions. This creates selection and integration challenges.
- **Skills:** There is high demand — and insufficient supply within the current manufacturing workforce — for data science, engineering and infrastructure talent to develop, test, train and maintain algorithms.
- **Bias:** Lack of algorithmic trust, combined with concerns over job loss and upskilling requirements, can limit maximizing ML's value.

User Recommendations

- Assess the speed of response and frequency of prediction needed. In many instances, traditional analytics techniques, such as descriptive and diagnostic analytics, can be more effective.
- Quantify the technical resources and skills development required for process engineers, data scientists and other production workers to not only build and train ML models, but also interpret the signals.
- Ensure the availability, readiness and context of the data that will be used by ML algorithms. Given the diverse use cases, and that ML relies on training datasets to identify patterns and relationships, having the right data is essential.
- Capture governance parameters properly across the different sources to ensure algorithms work. Ensure that all data sources are aligned to the overall data schema to dictate common parameters.

Sample Vendors

Amazon Web Services; Braincube; Cognite; Drishti; Flutura; Google; Microsoft; Rockwell Automation; Sight Machine

Gartner Recommended Reading

Leading Upskilling Initiatives in Data Science and Machine Learning

Tool: Vendor Identification for Data Science and Machine Learning Platforms

A Guidance Framework for Operationalizing Machine Learning

The State of Data Science and Machine Learning

Top 5 Strategic Technology Trends in Manufacturing Industries for 2021

Digital Thread

Analysis By: Christian Hestermann, Rick Franzosa, Marc Halpern

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

A digital thread is a framework of roles, processes and tools that enables the collection, organization and presentation of data for multiple factors that influence a product or process and their evolutions over their respective life cycles. The integration and organization of data and information enable multiple users to access, integrate, organize, trace and transform disparate technical and knowledge-based data from multiple operational and enterprise-level systems.

Why This Is Important

Digital thread is a fundamental concept of digital manufacturing. The digital thread connects multiple data and information sources across design, manufacturing and supply chain systems and processes. It can then connect the evolution of design requirements through production, delivery and service and then retirement or reuse to ensure a compliant and quality product is delivered to the customer.

Business Impact

CIOs and supply chain leaders looking to invest in and manage the digital thread:

- Digital threads improve the efficiency of decision making on cost, quality, traceability and regulatory compliance of design, production, use and service of products.
- They provide insights to variations in cost and quality metrics impacted by changes to product designs and configurations through digital threads.
- Their dynamic nature can streamline execution of standard work and improve the engagement of suppliers.
- A digital thread can help organizations determine the most beneficial investments in the evolution of a product and its digital twin by providing insight into how the product reached its current state.

Drivers

- Technology advances and growing experience at governing data are enabling digital threads. Growing volumes of data come from a rising number of connected products supported by IoT platforms, edge devices and sensors. New technologies and tools (cloud services, Industrial IoT platforms, and automated data synchronization and validation) can access, verify, validate and synchronize data — as well as analytics for simulation and pattern analysis. This is more than core MES, PLM and ERP systems can provide when used in isolation.
- The broad vision of PLM encourages digital thread investments. Digital threads encompass a wide time horizon and provide history and context specific to a product's or process's life cycle.
- Manufacturers across multiple industries understand digital thread's criticality to mitigate the complexities and risks associated with new configurations (and product-specific variants) or rising customer demand for smaller order quantities.
- Compliance with regulations, such as those of the U.S. FDA and ITAR, will be more transparent and efficient.
- Mature management of BOMs from engineering (eBOM) through manufacturing (mBOM) through service (sBOM) is a challenge, which digital threads can address.
- Cost optimization and time savings come from shortened decision cycles and improved agility on both global and local bases. Accelerating innovation and bringing products to market faster are also important values gained from digital threads.

Obstacles

- **Intellectual property protection concerns and cyber risks:** These can dissuade members of value chains from participating in digital thread initiatives.
- **Difficulty achieving consensus on architecture and scope:** Different roles in value chains have a stake in digital threads. Each of these roles has different priorities, different content needs and different ways of interacting with data. Satisfying each role causes delays and increases scope, cost and the risk of failure when implementing digital threads.
- **Vendor lock-in:** Manufacturers that rely on a few vendors to deliver large "chunks" of digital threads will likely become increasingly dependent on that vendor, particularly as the content and workflows added to a digital thread increase over time.
- **Technology obsolescence:** Technology advances rapidly expand the possibilities of digital thread architectures. The risk of obsolescence derives from committing to digital thread technologies that become obsolete before the intended life span of the digital thread.

User Recommendations

Supply chain leaders and CIOs looking to invest in and manage the digital thread should:

- Focus on building the digital thread as a representation of a product and all the processes that evolve over the product's life cycles, instead of confining it to engineering and production.
- Use the digital thread as a tool for improving efficient decision making, cost, quality, traceability and regulatory compliance in product design, manufacturing and service.
- Adopt an industry data governance strategy for a digital thread by including members of the value network in planning for data oversight, data orchestration, data curation and data management.
- Overcome the absence of a complete data model by investing in standards to capture and normalize data from different systems.
- Include open standards as much as possible in the digital thread roadmap.

Sample Vendors

Anark; Aras; AVEVA; Dassault Systèmes; DataNovata; Hexagon Manufacturing Intelligence; iBASEt; Microsoft; PTC; Siemens

Gartner Recommended Reading

Innovation Insight for the Digital Thread

Quick Answer: 4 Technical Prerequisites for Successful Digital Twins Implementation in Manufacturing

Implementing the Technical Architecture for Master Data Management

Data Strategy in Manufacturing Organizations, Part 1: How to Build It

Data Strategy in Manufacturing Organizations, Part 2: How to Advance It

Low Code for Edge

Analysis By: Bob Gill

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Low-code solutions for the edge allow simplified development of edge applications through the assembly of prebuilt blocks of code into a working application. The interface may offer a visual “drag and drop” approach, where I/O, functions and processes are represented by visual elements positioned and linked on a “canvas.” Code blocks, or “nodes,” may be created or modified through the use of lower-level languages for extensibility, while prebuilt apps or frameworks can assist the new user.

Why This Is Important

Edge computing applications are often complex, multiplatform, distributed applications made even more difficult by the diversity of devices at the edge and a lack of established standards. Edge-specific low-code solutions provide prebuilt and configured “chunks” of code, which are dragged, dropped and linked together based on business logic or data flows to quickly create functioning edge applications without knowledge of low-level interfaces or structures.

Business Impact

Low-code development for edge applications can provide simplicity, speed and agility to the development of edge applications. They:

- Break complex applications into prebuilt and preintegrated templates and “applets.”
- Enable business unit and operational users to create their own applications.
- Speed time to deployment of apps.
- Break the development bottleneck of waiting for IT and provide a self-service model.

Drivers

- The complexity of writing and maintaining distributed applications in rapidly changing operational settings.
- The need to mask the complexity of diverse devices, data formats and upstream targets
- The Complexity of integrating remote distributed applications with existing back end processes and systems, often “owned” by other business units
- IT-driven development may not possess the business-context and process expertise of the OT-based systems experts
- The need to provide operational users the ability to exercise the infrastructure directly
- The ability to continue to innovate after the SI’s initial building phase.

Obstacles

The current level of granularity and performance of resulting applications may uncover that low-code tools face the following challenges:

- There is a lack of standards or clear leaders.
- Low code’s coarse-grained approach may limit the extensibility of the solution.
- There is a lack of training in app development “hygiene” among nontechnical staff.
- Deeper evaluation of complex apps is needed, especially long-term scalability and total cost of ownership (TCO).

- Putting tools into the hands of business users is powerful, but some degree of governance, particularly regarding manipulation of enterprise data, must be exercised.

User Recommendations

- Detail who will be using these tools and to what end. Governance is still required.
- Evaluate offerings that tend to specialize in the platforms you are implementing.
- Involve IT development for assistance in creating new application modules or scripting to modify existing modules.
- Consider low code a user tool for data analysis and prototyping, but look to IT development or system integrators to move prototypes to enterprisewide, scalable performant systems.

Sample Vendors

Node-RED; Tulip; Vantiq; Virtuoso

Hybrid Integration for ERP

Analysis By: Tim Faith

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Hybrid integration for ERP is a framework of on-premises and cloud-based integration tools and governance methods supporting a range of business-driven use cases. This framework enables integration specialists and business technologists to fulfill diverse integration requirements. The approach includes event-driven/API-enabled integration of applications, services and data; a business service repository; harmonized security architecture; and connectivity to external endpoints.

Why This Is Important

- For ERP integration, hybrid integration framework is a composition of new and existing integration platform (cloud and on-premises) technology.
- Hybrid integration allows the evolution of integration methods, from file-based transfers or batch-based, to real-time event-driven architecture or synchronous API-based.
- Enterprises designing a composable ERP strategy require a comprehensive integration strategy to manage integration as the application landscape, architecture and technology advance.

Business Impact

Application and software engineering leaders responsible for ERP must:

- Catalog all use cases where ERP requires integration — including to applications, data sources and services.
- Identify personas across the business and technology teams that can deliver value in integration efforts.
- Evaluate current capabilities in your enterprise to then identify additional technologies required to enable the integration of specialist applications and platforms to support the organization's business strategy.

Drivers

- The constant change in applications brought about by customization, upgrades or SaaS updates disrupts integrations, thus disrupting the business. This problem leads to rising interest in artificial intelligence and machine learning in integration technology — Gartner refers to this as AI-assisted Integration. Machines are learning to map data, transport massive volumes of data, and build and repair the interfaces. This allows integration vendors to provide support for the constantly changing connectors, APIs and data models of ERP application vendors.
- Integration platforms enable replacing components of the ERP suite without having to adopt an “all or nothing” replacement strategy. This provides more flexibility while maintaining data, process and security integrity.
- Establishing a set of connecting technology and governance policies can provide the enterprise with the necessary data management, security, development and integration visibility.
- Organizations need to enable agility and address resource constraints by expanding integration enablement responsibilities beyond IT teams. Hybrid integration allows them to enable multiple integration personas to support their integration strategy.
- Some organizations are leveraging a “business technologist” approach of enabling key users to activate integration technology (where practical and when the tools are available) to improve efficiency, business agility and ability to deliver value optimally.

Obstacles

- Many vendors historically offering cloud-based applications are now embedding integration capabilities as part of the SaaS. However, it might not be an optimal approach from a broader and overarching integration strategy standpoint. Existing legacy technologies may still be in place, which decreases the need or the short-term value of the new capabilities.
- If organizations with multiple SaaS providers focus on tactical, short-term benefits derived from SaaS-embedded capabilities, they risk technical and governance challenges.
- Traditional approaches to integration are inadequate to support composable ERP and digital businesses that increasingly leverage APIs and event-driven architecture.
- Collectively combining integration platform as a service (iPaaS), traditional integration platform software, API management and other capabilities is not yet as widely adopted as each of these technologies individually.

User Recommendations

- Determine your organization's requirements for ERP application integration by developing both a composable ERP strategy and a corresponding hybrid integration strategy.
- Calculate the complexity and frequency of integrations required, as well as the volume and type of data within the integrations. Adopt and deploy a hybrid integration capability framework to support the dynamic nature of your applications.
- Acquire the necessary integration components from only as many vendors as necessary to fulfill the use cases. Determine whether some of the components you need are already part of your portfolio, or if your incumbent integration vendors already provide them. Replace components that no longer apply.
- Do not assume that ERP vendor-provided integration tools will meet all integration, data management, security or automation needs. Evaluate the cloud integration platforms and options in the market, and utilize all applicable toolsets in accordance with your integration strategy.

Sample Vendors

Boomi; Informatica; Jitterbit; MuleSoft; SnapLogic; TIBCO Software; Workato

Gartner Recommended Reading

Create a Future-Proof Integration Strategy for Your ERP

How to Deliver a Truly Hybrid Integration Platform in Steps

Choosing Application Integration Platform Technology

Choose the Best Integration Tool for Your Needs Based on the Three Basic Patterns of Integration

Ensure Your Integration Strategy Supports Modern Integration Trends

MPM Frameworks

Analysis By: Rick Franzosa, Marc Halpern

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

A manufacturing process management (MPM) framework enables data sharing and workflow from the virtual world of product and manufacturing process design to the physical world of manufacturing execution and transactions. This includes product and process design, manufacturing operations, material requirements planning and sourcing.

Why This Is Important

- Complexities of orchestrating ERP, PLM and MES have been an obstacle to improving business performance. MPM frameworks can break down those barriers, and can be a competitive differentiator for manufacturers.
- Digital technology advances make the establishment of an MPM framework in a manufacturing environment more feasible.
- Companies that succeed at enabling MPM frameworks will have a competitive advantage.
- MPM frameworks are the foundation of the design-to-manufacturing digital thread.

Business Impact

MPM frameworks:

- Streamline the processes, and workflows from design to production, while continuously improving design for manufacturability in discrete industries and process robustness in process industries through closed-loop information flow.
- Reduce the cost and risk of introducing rapid engineering or customer changes to orders in progress.
- Provide design visibility to manufacturing planners and feedback from the factory floor to engineering to improve design for manufacturability.

Drivers

- Manufacturers must deliver increasingly complex products at a reduced product cost, time to delivery, and consistently higher product quality. This motivates more investment in MPM frameworks to deliver those capabilities.
- Traditional systems that support the design-through-manufacturing process are often disconnected or overlapping solutions focused on product definition (CAD/CAM/PLM), production management (ERP, supply chain management) and manufacturing operations management (MES, simulation).
- Manufacturers seek to improve reuse of product and process content to deliver and support individualized products.
- Manufacturers seek accuracy and automation of complex engineering change management cycles to become more competitive.
- Manufacturing environments are becoming more complex to meet regulatory compliance and sustainability goals.

Obstacles

- Manufacturers struggle with the complexity of the business case for MPM. Executives worry about the high cost of data cleansing and prep, risk of failure and long implementation time.
- Lack of consensus on how to align the IT roadmap with engineering and manufacturing priorities hampers implementation of MPM technologies by manufacturing operations leaders.
- Supply chain complexities and the diversity of data that needs to be included pose significant business alignment, process and technical difficulties when strategizing and implementing digital threads at the core of MPM frameworks.
- Manufacturers struggle with identifying the root causes of bottlenecks as they try to coordinate the multiple constituencies and priorities of supply chain management, product management, production management and process control.
- Vendors are investing in platforms to accelerate the advancement of MPM frameworks, but there is an absence of true end-to-end solutions spanning ERP, MES and PLM.

User Recommendations

- Implement MPM frameworks by first performing a return-on-investment analysis, including a risk management strategy for MPM, involving a team including product design through delivery and service stakeholders.
- Prepare design through service operations teams for the MPM transformation by organizing educational workshops to educate them on updated ways of working aligned to revised job performance metrics.
- Create an MPM framework to connect categories of digital data by performing an assessment on the diffuse value to other functions and stakeholders.

Sample Vendors

Anark; AspenTech; AVEVA; Dassault Systèmes; iBASEt; Oracle; Proplanner; PTC; SAP; Siemens Digital Industries Software

Gartner Recommended Reading

Innovation Insight for the Digital Thread

Cloud-Native CAD

Analysis By: Marc Halpern

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Cloud-native computer-aided design (CAD) is a design software developed from fundamental cloud architecture principles to run efficiently in the cloud. Such software is used to create product designs that include mechanical, electronic and software components. Cloud-native CAD can also be used for architectural design. It typically includes collaboration and data management functions.

Why This Is Important

- CAD is core to digital business for discrete manufacturers, particularly those with complex or continually evolving product designs.
- Cloud-native CAD takes better advantage of cloud computing power and cloud security than mainstream CAD software hosted on the cloud or run on-premises.
- These cloud-native applications enable a higher degree of collaborative capability and productivity for users working remotely.

Business Impact

Businesses benefit from cloud-native CAD software because:

- It makes joint design and engineering easier by including collaboration capabilities, online design communities and social networking, both for internal team members and for external suppliers and partners.
- It simplifies revision and access control of both CAD models and data.
- The risk of using the wrong copy of a CAD model is minimal, since only one version of the model is created or modified.

Drivers

- The 2020 pandemic forced a significant shift from working in the office to working at home, generating a need for access to better-performing CAD software outside the office. This preference for remote work will continue postpandemic.
- Using cloud-native CAD software can cost less than maintaining internal IT infrastructure — excluding fees to software providers.
- The prevalence of SaaS for other business software encourages deploying cloud-native CAD software as well.
- Manufacturers seek means to reduce IT infrastructure costs for managing and upgrading CAD software.
- Cloud-native applications and business models can help manufacturers improve design collaboration with partners, suppliers and customers.
- Users will likely experience fewer revision control problems because they are all working with a single instance of design content.

Obstacles

- Large companies express continuing, albeit diminishing, discomfort with having sensitive design data outside their four walls.
- The culture and processes associated with on-premises CAD software are deeply ingrained in millions of CAD users.
- Cloud-native CAD requires user retraining due to changes in the UI and changes in available functions for creating and modifying parts and assemblies.
- Integrating cloud-native CAD software with complementary applications, such as CAE and PLM, can be challenging.
- Companies depend on large databases of designs that run on legacy software supporting proprietary formats. Such designs are difficult to upgrade for new CAD software.
- Adopting cloud-native CAD may require laborious conversion of needed legacy CAD data.
- Migrating from heavily customized on-premises CAD to more standardized cloud-native CAD can incur the loss of valued custom functions and workflows.
- Cloud storage costs for CAD data will likely increase.

User Recommendations

- Assess whether the CAD offered is actually architected to run on-premises but advertised as running on the cloud. A cloud-native capability runs more efficiently on the cloud than a ported or hosted on-premises application does.
- Evaluate the IT organization's corporate risk policy and security posture for cloud-native CAD and simulation applications. If IT concludes that this is a risk, it should explore options to mitigate those risks (e.g., via a private cloud) and conduct a risk-reward analysis.
- Perform total cost of ownership (TCO) assessments before adopting cloud-native CAD software, and include the one-time costs for data migration/conversion, integration and training. If the TCO for cloud-native design software is higher than on-premises costs, the company should include the value of the business benefits as part of the analysis.

Sample Vendors

Autodesk; Dassault Systèmes; PTC

Gartner Recommended Reading

What Manufacturing CIOs Must Consider Before Adopting Cloud Applications

Toolkit: A Decision Framework for Adopting Manufacturing Applications in the Cloud

Understanding Cloud Data Management Architectures: Hybrid Cloud, Multicloud and Intercloud

A CTO's Guide to Cloud-Native: Answering the Top 10 FAQs

RPA

Analysis By: Simon Bailey

Benefit Rating: Moderate

Market Penetration: More than 50% of target audience

Maturity: Mature mainstream

Definition:

Robotic process automation (RPA) technology uses scripts to guide automation to replicate the user interface (UI) that a human would use to conduct tasks on structured digital data. These scripts integrate applications via the UI and are orchestrated via a controller dashboard, which automates routine, repetitive, rule-based and predictable tasks using structured digital data. RPA is one of the less capable hyperautomation tools, so it should not be your only consideration.

Why This Is Important

RPA can execute scripted tasks around the clock, faster, with fewer errors and at less cost than manually executing the same process for tasks that are routine, repetitive, rule-based and predictable. This capability can be offered as a stand-alone technology solution, or it can come integrated as part of a broader solution. End-user adoption has been consistently growing, and tools are expanding to automate more extensive process workflows. Vendors have grown and made extensive R&D investments.

Business Impact

Stand-alone RPA can be an inexpensive, quick fix to reduce manual workload, improve efficiency, speed up processes and eliminate keying errors. To learn more about integrated RPA, supply chain leaders can talk to specific technology vendors to explore the degree of current and future RPA support that they can offer or that is built into their tools.

Drivers

- The desire to automate has been heightened with the sharp increase in working from home due to the COVID-19 pandemic, which requires the default to be digital. RPA is a general purpose solution, but many point solutions and more capable tools are also available to support this space.
- RPA allows organizations to automate manual work and look at new ways to automate work to deliver business outcomes, but in terms of adoption, supply chains were generally slower to react to RPA hype than, for example, finance. They now face a choice, either play catch-up and apply RPA at scale or skip RPA altogether in favor of newer, more capable hyperautomation tools.
- The business case for RPA must look at: the total cost to operate a process today, the potential for improved business outcomes and the total cost of ownership (TCO) of the RPA solution. TCO is driven by the pricing model of the RPA vendor (typically, annual robot licenses or RPA as a service) and the capability that exists within the enterprise (e.g., ability to write own scripts).
- Even if an organization has been outsourcing or offshoring heavily labor-based data entry work for some time, automation tools, including RPA, could still decrease costs further and increase quality.

Obstacles

- A rush to RPA can lead supply chain leaders to neglect addressing the poorly formed/followed processes. Business processes that need redesigning should be redesigned, and so, at best, RPA can be seen as a temporary solution to automate while a more enduring plan is executed.
- Some supply chain leaders try to bypass IT as they look to reduce costs by automating with RPA. In doing so, they introduce issues with poor governance, poor data and a lack of a center of excellence, and also overlook better alternatives.
- As companies move from pilot to scale with RPA they often lack appropriate oversight, and UI-level integration leads to further technical debt as companies underestimate the ongoing governance and maintenance of RPA scripts.

User Recommendations

- Like other hyperautomation tools, choose RPA based on lowest risk, quantified business impact and ease of implementation.
- Use RPA only for task-level, not process-level, automation and pair it with other tools to add capability that RPA lacks (e.g.,combine RPA with document ingestion tools such as optical character recognition (OCR) tools to handle ingesting semistructured paper-based data formats such as orders and invoices).
- Identify use cases through uncovering non-value-added activity such as high levels of manual rekeying with high-error rates.
- Validate applicability by focusing on standardized, repetitive tasks that occur between stable systems using structured, stable data. Leave any complex logic to rule engines or AI tools instead of the RPA tool; make the RPA tool the executor only.
- Quantify potential benefits based on an ROI calculation that not only includes resources but also positive impact on areas like customer experience and potential to drive growth.

Gartner Recommended Reading

Supply Chain Executive Report: Pursuing an Autonomous Supply Chain With Hyperautomation

Case Study: An Approach for Autonomous Supply Chain Transformation (Schneider Electric)

Digital Twin

Analysis By: Alfonso Velosa, Marc Halpern

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Definition:

A digital twin is a technology-enabled proxy that mirrors the state of a thing such as an asset, person, organization or process. The three types of digital twins are discrete, composite and organizational. Digital twin elements include model, data, unique 1-to-1 association and monitorability. Digital twins are built in software (analytics, 3D models, CRM, IoT platforms). At least some stateful data about the thing must be sourced via monitoring, such as telemetry, application state changes.

Why This Is Important

Enterprises are using digital twins to create virtual representations of previously opaque entities or activities for process, cost, revenue or other business objectives. For instance, improving patient outcomes due to visibility of the entire person across siloed systems or reducing unplanned outages by monitoring equipment state. Technology providers are developing new revenue streams and customer engagement by developing and selling digital twin enabling products and services.

Business Impact

Enterprises are implementing twins to:

- Enable the business to enrich decisions — for example, to lower maintenance costs, increase asset uptime and improve supply chain responsiveness.
- Contribute to differentiation, new service models and obtaining customer data for OEMs.
- Improve health monitoring, employee safety and customer transactions using digital twins of people.
- Drive new business models, such as product as a service and new data monetization approaches.

Drivers

- Enterprises are accelerating their adoption of digital twins to support a broad variety of business outcomes: reducing cost structure through improved remote monitoring of assets; optimization of equipment and processes by aligning asset digital twins into a range of solutions, such as predictive analytics and field service management; product differentiation via stakeholder visualization and control of assets, as well as new customer monetization strategies via digital-twin-enabled services.
- Asset-intensive industries, such as oil and gas, manufacturing, automotive, and utilities are leading in using digital twins to improve business operations.
- Military equipment and service companies on a global basis have seen a consolidated push toward using digital twins and model-based systems engineering from national ministries or departments of defense.
- Leading-edge enterprises are implementing digital twins to model IT organizations, financial exchanges, and supply chain processes for cost optimization and process improvement purposes.
- IT organizations use digital twins as defined models that establish what is “meaningful” data. Data in digital twins is vetted and qualified, thus representative of reality. This prevents IT and business teams investing time analyzing relationships, and can concentrate on the outputs and decisions.
- Technology providers have woken up to the potential ways they can serve their customers and drive new revenue models using their digital-twin-enabling product portfolios.
- Consortia such as the Digital Twin Consortium and the National Digital Twin programme (NDTp) run by the Centre for Digital Built Britain contribute to digital twin visibility and business cases.

Obstacles

- Most enterprises often lack business objectives, consensus on the scope, structure, process or teams to start developing business-focused digital twins.
- Few enterprises have the skilled fusion teams — business, finance and technology — required for the collaboration to develop digital twins.
- These teams must conceive, create and maintain portfolios of digital twins including the models that are synchronized to the real entities, yet few enterprises have the budgets to do so.
- Digital twins challenge most enterprises technically due to the blend of operational and information technologies needed to develop and maintain them.
- Consortium and standards bodies remain emergent, with many vendors pushing proprietary formats. There is a lack of standards for a broad range of digital twin integration, metadata and other technical issues.
- Most vendors are still ramping up their go-to-market strategy to build a digital twin business, creating market confusion and excess hype.

User Recommendations

- Work with business leaders to establish realistic expectations for how digital twins can support business objectives and establish KPIs to measure success.
- Engage the business unit to identify champions, get budget support and co-create the digital twin strategy.
- Avoid digital twin projects that lack a business sponsor and objective as they will waste IT resources and undermine adoption.
- Identify IT organization gaps and build a roadmap to drive IT learning opportunities, internal skills investment plan, and partner selection strategy.
- Build an IT digital twins roadmap that defines and executes on a portfolio of digital twin products. Use this approach to help mitigate the hype around proprietary vendor approaches.
- Incorporate IT best practices for software asset development and management, security, and integration.
- Assess the use cases and architectural and technical implications of composite and organizational digital twins.
- Prepare a long-term governance strategy.

Sample Vendors

Alibaba Cloud; Altair; Ansys; Element; e-Magic; Google; KONGSBERG; Tada; Twin Health

Gartner Recommended Reading

Toolkit: 5 Digital Twin/IoT Project Success Drivers

Survey Analysis: Digital Twin Expansion Plans Signal New Software Skills Investments Are Required

Quick Answer: How Can Software Engineering Leaders Successfully Expand Their Digital Twin Portfolios?

Digital Twins Drive Next-Generation Digital Operations

Quick Answer: What Is a Digital Twin?

Supply Chain Convergence

Analysis By: Dwight Klappich

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Supply chain convergence is where supply chain functional silos are broken down and end-to-end business processes span, synchronize and optimize across traditional functional domains.

Why This Is Important

To get beyond Stage 3 maturity, supply chain organizations must embrace convergence as both a business and an IT vision and strategy. Companies continue struggling to systematically integrate end-to-end (E2E) business processes in the fragmented supply chain functional and IT environments prevalent in most organizations. Coordinating, let alone optimizing, E2E processes across application silos remains elusive, but with the emergence of composable application platforms, this is becoming more attainable.

Business Impact

Supply chain maturity and supply chain convergence attainment are closely aligned, wherein higher-maturity organizations are more likely to address the cultural and operational issues necessary to reach higher levels of convergence. Breaking down the functional silos by leveraging technology to assemble composite processes across domains addresses the urgency to pursue convergence as companies seek higher maturity and as new business models (like digital) drive transformational change.

Drivers

- E2E processes are horizontal and often span multiple functional organizations and systems. Most organizations are organized by functional silos, but once a company makes the commitment to think horizontally, aligning processes will become a necessity.
- New opportunities for process improvement will require organizations to adapt their cultures and operational environments to coordinate and synchronize E2E processes, such as selling, buying or making. This will require supply chain capabilities and systems to converge across and between traditional supply chain management functional silos. However, until recently, technology was a barrier, but with the emergence of composable application platforms, this is now more technically feasible.
- While companies recognized the problem, until recently, they didn't have the technology to allow them to effectively orchestrate or optimize these E2E processes. Technology, notably microservice-based architectures, is making this more realistic.
- With the emergence of composable microservice-based technical architectures, in some cases, companies can soon assemble packaged business capabilities (PBCs), irrespective of the functional domain the services typically belong to, which will lay the foundation for Stage 3 and beyond convergence.
- Convergence will drive the next wave of business value as early adopters leverage process improvements to gain a competitive advantage. Because it's better at orchestrating the E2E process, its value will be seen first. But as they mature, companies will increasingly apply optimization capabilities to these E2E processes to allow them to perform better.
- While initially convergence strategies will be focused inside-out and within the enterprise, to mature further, companies must shift their focus to an outside-in perspective. Companies must consider the role of multienterprise business networks and how these can enable integrated and synchronized cross-enterprise processes.

Obstacles

- Until recently, most organizations have been stuck at analytical or transactional integration convergence, because the technology was not available to effectively progress to E2E process orchestration convergence or beyond. Now with composable microservice-based applications, the technology is catching up to the need, making achieving Stage 3 convergence maturity more achievable.
- Organizational culture will continue to be a barrier to achieving convergence, as too many operations continue to cling to rigid functional silos with processes optimized vertically within a function, but suboptimal across functional silos.
- Low-stage-maturity organizations will struggle to break the contentious functional bias inherent in many supply chain organizations in order to have any hope of evolving to convergence.
- Cultural resistance continues to be an adoption barrier for many organizations. Uncertainty as to “Why are we doing this?” remains an obstacle.

User Recommendations

- Evaluate how fundamental operational processes are linked with and affected by processes that are controlled by other functional groups and systems within and outside their organizations.
- Adapt your organizational cultures and operational environments to enable coordination and synchronization of E2E processes by shifting your paradigms from a vertical (functional) view of the world to a horizontal (E2E process) view of the world.
- Break down functional silos by creating composite business processes that bring together subprocesses and activities across specific domains. More broadly, Gartner refers to this concept as “the composable enterprise,” where composable thinking, composable business architecture and composable microservice-based PBCs are applied to provide E2E business process agility and flexibility.
- Evaluate how fundamental operational processes are linked with and affected by processes that are controlled by other functional groups and systems within and outside their organizations.

Gartner Recommended Reading

Unify End-to-End Supply Chain Processes With Supply Chain Convergence

Understand the Need for Supply Chain Execution and Manufacturing Operations Management Convergence

Becoming Composable: A Gartner Trend Insight Report

MOM Application Suites

Analysis By: Rick Franzosa, Christian Hestermann

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Manufacturing operations management (MOM) application suites extend manufacturing execution systems (MES) beyond production-execution management to include detailed production scheduling, production resource management (materials, assets and labor), process and product reliability (quality and compliance), and manufacturing data analytics.

Why This Is Important

The importance of MOM application suites is based on the need for extended capabilities across manufacturing to provide more flexibility and agility at the plant level. They accomplish this by minimizing the need for communication with upstream systems (ERP/PLM/SCM) to make better decisions and respond in near real time to events on the plant floor.

Business Impact

The business impacts of MOM application suites are:

- They enable process optimization across different manufacturing disciplines. The trade-offs are required process changes and integration discipline between MOM suites and other enterprise applications.
- Process change will be high as MOM applications enable manufacturing operations process optimization and replace multiple disparate applications from different sources. This helps accelerate continuous improvement initiatives and digitization.

Drivers

- Users need capabilities beyond core manufacturing execution systems (MES) to continuously improve upon efficiency, quality and cost. Seamless integration with capabilities such as material handling and warehouse management system (WMS), detailed plant-level scheduling, quality management and intraplant logistics are required to streamline plant processes.
- Increased focus on capabilities, to support better manufacturing employee decision making and competency, fuel the need for better visibility to data from multiple manufacturing disciplines. This can be enhanced by MOM application suites that support a more diverse set of manufacturing functions.
- Manufacturers are looking for a common, scalable platform that can be deployed across multiple sites, enforcing standards and providing a unified view of production data.

Obstacles

- MOM application suites are positioned as functional applications, not enterprise applications, which creates an obstacle to enterprise and manufacturing network goals.
- They rarely have the same breadth of functionality as the built-for-purpose applications in production scheduling, resource management, quality or data analytics. Its value comes in providing an integrated, manufacturing plant-specific suite of tools.
- The preferred vendor approach to building MOM application suites involves adopting another platform that can add complications and costly integration points between the MOM platform and enterprise applications.
- MOM implementations are more complex than MES, and are more likely to encounter cost overruns and are difficult to scale.
- Supply chain and manufacturing operations convergence are hampered by site- or plant-specific duplicative functions such as scheduling, inventory management and quality management.

User Recommendations

- Build out MOM functionality by examining the need in each solution area, and define where it makes sense to provide a capability (e.g., production scheduling, materials management and quality) as part of a MOM application suite, versus using a built-for-purpose enterprise-level application.
- Ensure implementation success by aligning the MOM application suites to your proven manufacturing operation processes and systems.
- Minimize MOM application suite integration challenges by teaming IT and end-user communities to define process and integration roadmaps that optimize end-user adoption and reduce integration complexity.

Sample Vendors

ABB; AVEVA; Critical Manufacturing; Dassault Systèmes; iBASEt; iTAC Software; Parsec; Rockwell Automation; SAP; Siemens Digital Industries Software

Gartner Recommended Reading

Critical Capabilities for Manufacturing Execution Systems

Magic Quadrant for Manufacturing Execution Systems

Ignition Guide to Selecting a Manufacturing Operations Software Vendor

Innovation Insight for Smart Factory

Understand the Need for Supply Chain Execution and Manufacturing Operations Management Convergence

Cloud-Native CAE and Virtual Prototypes

Analysis By: Marc Halpern

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Adolescent

Definition:

Computer-aided engineering (CAE) and simulation offer the ability to model, predict, understand behavior, or virtually experience any modeled product, system or process for any given environment within which the model or system operates. Cloud-native capabilities refer to software that is newly developed or rewritten to take full advantage of cloud reach, scalable compute power and data storage capacity.

Why This Is Important

Cloud-native computer-aided engineering, simulation and virtual prototyping software provide greater accessibility to CAE and virtual prototyping applications. Users have greater agility to do work that might demand high-performance computing, from any location and with access to the computing power that the cloud offers. The cloud-native applications enable an unprecedented degree of productivity for remote users, possibly accelerating engineering work.

Business Impact

Users gain productivity because:

- The throughput for cloud-native CAE and simulations can be faster than on-premises CAE because such software has been architected to take advantage of cloud processor power.
- The new generation of software makes collaboration easier by engaging online design communities and social networking from any location with internet access.
- The hardware cost to use cloud-native software should be lower than maintaining on-premises high-performance computing, excluding fees to software providers.

Drivers

- Prevalence of SaaS for other business software encourages moving engineering and simulation capabilities to the cloud as well.
- The evolution of simulation technology has made efficient cloud-native solutions more affordable and accessible.
- The 2020 COVID-19 pandemic forced a significant shift from working in the office to working at home, generating the need for access to well-performing simulation software outside the office.
- As simulation use increases across engineering disciplines, users need more compute power, which the cloud can provide.
- Based on an increasing amount of client feedback, mainstream on-premises engineering and simulation software running on VPNs does not provide needed performance for users operating in remote locations.
- Manufacturers can reduce IT costs for having, managing, and upgrading engineering and simulation software with it being in the cloud versus on-premises.
- Manufacturers seek means to improve collaboration across partners, suppliers and customers that cloud-native applications and business models enable.

Obstacles

- Cloud-native engineering and simulation software has less mature functionality compared to on-premises software.
- It takes time for users to build confidence in the results that new simulation software produces. Since users already have confidence in the existing on-premises tools, they are inhibited from adopting new tools.
- Manufacturers fear that they will lose tacit intellectual property that evolved over many years when migrating from highly customized on-premises applications to new cloud-native software.
- Prospective users express concern about increased vendor lock-in diminishing their power when negotiating contracts.
- There is less confidence in vendor business models where there are additional charges for the number of CPUs used and the amount of storage used, as is often the case for simulation software.

User Recommendations

- Evaluate the IT organization's corporate policy and security risk assessment for cloud-native CAE and simulation applications. If IT still concludes that this is a risk, it should explore options to mitigate those risks, for example, via a private cloud, and conduct a risk/value analysis.
- Perform total cost of ownership (TCO) assessments to compare the costs with owning on-premises software before adopting cloud-native simulation software. If the TCO for cloud-native CAE and simulation software is higher than on-premises costs, the company should include the value of the business benefits as part of the analysis.
- Factor variability in pricing based on network demand, compute resources needed and data storage charges into any TCO analysis.
- Assess the functionality of cloud-native CAE applications compared to on-premises CAE capabilities. If functionality gaps exist, then weigh the functionality trade-offs against price/performance of cloud versus on-premises offerings.

Sample Vendors

Ansys; Autodesk; Dive; ESI Group; ESTECO; Rescale; SimScale; UberCloud

Gartner Recommended Reading

What Manufacturing CIOs Must Consider Before Adopting Cloud Applications

Toolkit: A Decision Framework for Adopting Manufacturing Applications in the Cloud

Toolkit: Stop Firefighting and Start Trailblazing Digital Initiatives — Virtual Edition

Understanding Cloud Data Management Architectures: Hybrid Cloud, Multicloud and Intercloud

Industrial IoT

Analysis By: Simon Jacobson, Scot Kim

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

The industrial Internet of Things (IIoT) is a subsegment of the greater market of IoT. In manufacturing, it is used to improve asset management decision making and operational visibility as well as control for plant infrastructure and equipment within asset-intensive industries and environments.

Why This Is Important

IIoT is a core building block for smart factories, improving their reliability and accessibility by extending, augmenting or replacing operational technology (OT). IIoT improves how data sources (historic and real-time across operations and systems) are accessed, analyzed and leveraged. Overlay IIoT platforms and solutions pave the way for how to leverage cloud, edge computing/devices, sensors and AI/ML to optimize performance through enabled applications and a digital thread across operations.

Business Impact

IIoT provides access to a wider range and deeper set of data sources with the power of extracting insights and improving data-based decision making and therefore operational performance, influences trade-offs across the network and identifies future opportunities for automation and cost-efficiencies.

Drivers

- Better cost-efficiency in industrial operations by extending the functional life of capital assets
- Improved productivity and operational excellence through optimized asset performance
- Improved data-driven decision making by frontline workers
- Ambitious automation designs and the exploration of how certain processes can be managed remotely
- Establishment of distributed manufacturing networks and “as a service” models
- Smart manufacturing, Industrie 4.0, proliferating industry consortia and nationally driven industrialization initiatives placing IIoT at the center of their platforms

Obstacles

- Organizational complexity, cultural impediments and process (re)engineering are required for success.
- IT and OT heterogeneity catalyzes architectural debates and turf wars and impedes progress.
- Components for successful IIoT implementation are complex and of diverse maturity levels.
- Security concerns go beyond data confidentiality, integrity and availability to encompass the safety and reliability of physical operations.
- IIoT projects inherently introduce new integration challenges, making firms navigate a sea of standards, reference models and proprietary protocols.
- Resource requirements (skills, cost and integration) are often underestimated.
- Provider options continue to expand and create complications for manufacturing systems' strategies.
- Even with robust ROI, the funding models for scalability are elusive.
- The knowledge to build, partner or acquire IIoT expertise and technologies is lacking.
- IoT-enabling technologies without any business value or business buy-in are still preferred.

User Recommendations

- Develop a plan to map data, processes and use cases with site capabilities. Then segment use-case pursuits into those that will enhance the core of operations as well as those that will foster future innovation and process capabilities.
- Use a maturity-based continuum to develop the roadmap by aligning current and future use with both site and supply chain business objectives. Leverage a maturity-based continuum to holistically plan architecture, deployment models, standard work and interoperability.
- Ensure alignment between IT, OT, engineering technologies (ET), frontline workers and line-of-business stakeholders so they can accurately budget resources, identify the role of standards and clarify expected benefits.
- Diligently examine the trade-offs around buy/build/acquire/partner based on in-house capabilities, time, budget and deployment environment.

Sample Vendors

Amazon Web Services; Augury; Hitachi; Litmus; Microsoft; PTC; Software AG

Gartner Recommended Reading

Magic Quadrant for Industrial IoT Platforms

Critical Capabilities for Industrial IoT Platforms

Innovation Insight for Smart Factory

The 3-Step Process of Contextualizing IoT and Manufacturing Data to Enable Smart Factories

Emerging Technologies and Trends Impact Radar: Internet of Things for Industrial Manufacturing

Master Data Management

Analysis By: Sally Parker, Simon Walker

Benefit Rating: High

Market Penetration: More than 50% of target audience

Maturity: Mature mainstream

Definition:

Master data management (MDM) is a technology-enabled business discipline in which business and IT work together to ensure the uniformity, accuracy, stewardship, governance, semantic consistency and accountability of the enterprise's official shared master data assets. Master data is the consistent and uniform set of identifiers and extended attributes that describes the core entities of an enterprise.

Why This Is Important

MDM is a cross-organizational, collaborative effort that is focused on the consistency, quality and ongoing stewardship of master data. Master data is that subset of data that describes the core entities of an organization that are required for it to function — such as its customers, citizens, products, suppliers, assets and sites. This master data sits at the heart of the most important business decisions, driving a need for a consistent view across business silos.

Business Impact

MDM initiatives continue to progress as a foundational component of digital transformation programs. Leading organizations draw a causal link between their master data (such as parties, products or assets) and the business outcomes it supports, including:

- Customer/citizen/employee experience
- Customer retention, cross-sell, upsell
- Supply chain optimization
- Risk and regulatory compliance
- Accurate reporting
- Time to market

Thus, initiators of MDM programs extend to a range of vested interest stakeholders, including finance, marketing and supply chain.

If your business strategy depends on the consistency of data within your organization, you will likely consider MDM as an enabler of this strategy. MDM has left the Trough of Disillusionment as organizations better understand both the opportunity and the challenges — challenges many are often now unable to overcome without external guidance.

Drivers

The MDM market continues to evolve and thrive for the following reasons:

- Organizations with complex or heterogeneous application and data landscapes often suffer from inconsistent master data, which without MDM will continue to weaken business-process integrity and outcomes.
- Rapidly evolving business needs that, particularly in uncertain times, translate into greater demand for the benefits afforded by MDM — notability agility. The pandemic, which initially stalled projects, ultimately served to fast-track a broader realization of the causal link between trusted and connected master data and business resilience.
- Increased levels of interest from a broader range of stakeholders (beyond technology), across both private and public sectors.
- Digital transformation requirements are forcing organizations to either start or modernize their MDM programs to leverage more recent cloud-based offerings and new augmented MDM capabilities.
- Cloud-based vendor offerings have lowered the barrier to entry for MDM and increased both interest levels and viability among a broader target audience that comprises small and midsize organizations. The removal of the technological barrier to entry has alleviated the need for deep pockets and supports a more granular and business-led adoption best practice.
- MDM is not a new concept, yet market maturity and penetration of MDM varies considerably across geographies, with North America and Western Europe the most mature. The rest of the world is earlier in the maturity cycle and representative of markets primed for growth.
- A prior hesitance to embark upon MDM initiatives due to complexity and cost is easing. This can be attributed to an increased recognition of the causal link between trusted master data and business agility/outcomes by a broader range of stakeholders.

Obstacles

- Technology blinkers: The prevailing pitfall remains the instinct to treat MDM as a technology initiative in isolation. Technology alone has proven insufficient in solving a challenge that traverses people, process and technology enterprisewide.
- Human factors: Organizations that fail to engage proactively with business stakeholders to determine scope at the offset struggle to meet expectations of value and to establish an operational governance structure in service of MDM.
- Perceived complexity: The MDM solutions market only recently shifted toward subscription pricing, cloud-based offerings and simpler products, which contribute to more approachable solutions and shorter deployment times.
- Skills: Successful MDM implementations require business acumen, technology and governance capabilities. Finding the right balance and availability of these skill sets remains problematic and is driving a need for third-party services as the norm.

User Recommendations

Organizations investigating MDM should:

- Approach MDM as a technology-enabled business initiative.
- Secure executive sponsorship to facilitate cross-organizational collaboration.
- Ensure the causal link between the MDM initiative and the business outcomes it supports are clearly understood and articulated.
- Keep your master data attributes lean and focused.
- Leverage third-party services to fast-track time to value. Over 90% of organizations leverage external support with their MDM strategy and/or implementation. Third parties offering industry expertise and accelerators can greatly impact time to value.

Gartner Recommended Reading

Magic Quadrant for Master Data Management Solutions

Critical Capabilities for Master Data Management Solutions

What Is Modern MDM?

Three Essentials for Starting and Supporting Master Data Management

Climbing the Slope

Manufacturing Segmentation

Analysis By: Jennifer Loveland, Michael Dominy

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Segmentation, as it applies to manufacturing operations, creates multiple standardized approaches to production and assembly processes. Each approach is optimized for a specific goal, such as efficiency, cycle time, customization or flexibility. It is an application of targeted supply chain segmentation to manufacturing processes.

Why This Is Important

Manufacturing leaders traditionally have independent sites, or focus on creating a single global or regional standard for manufacturing. Segmentation groups sites or lines with similar objectives and defines a standard production approach for each segment. This helps manage the complexity of the business while still providing economies of scale. Tailored designs maximize the results achieved for strategies focused on cost, responsiveness, flexibility, agility or resilience.

Business Impact

Segmentation can differentiate within a site or across sites to provide dramatic improvements as it optimizes each for different outcomes. It might inform overall manufacturing network design (i.e., determine the location, ownership and charter for each site), improve asset utilization for cost or increasing flexibility, and reduce changeover times for agility. Standards across lines and factories can make capacity interchangeable to increase options to ensure resilience during disruption.

Drivers

The Hype Cycle position represents an average of varying adoption profiles for segmenting across versus within sites and has moved into the initial stages of the Slope of Enlightenment:

- **Segmentation across sites in the manufacturing network:** Insourced or outsourced factories dedicated to outcomes, activities or geographies is not a new concept. Different standardized production processes by manufacturing site based on business requirements (product, market or customers) and role in the overall network strategy. A site will use global standard metric definitions with target sets based on region or product line, or focus on efficiency, responsiveness (cycle time) or agility (customization or flexibility).
- **Segmentation within a manufacturing site:** Segmentation within sites is less often adopted. Different production strategies for lines within a site are based on the characteristics of products and equipment or business needs. This is most common where large variation in products necessitates frequent changeovers or lengthy equipment setup times. Dedicating lines for high-volume products or customizing lines for small batch runs are common.
- **Resilience and agility:** Given the recent rate of disruptions, 55% of respondents indicate investing in segmentation now to achieve greater resilience and/or agility.
- **Expansion:** Expanding product lines and customer options prompts the view of the manufacturing network as a collection of capabilities that must be optimized.
- **Productivity:** Creating a menu of standard manufacturing approaches optimized for different outcomes boosts productivity, sheds excess capacity and cost, and shortens response times.
- **Innovation:** Experimentation with new technologies (e.g., 3D printing and robots) and new concepts (e.g., multimode facilities and mobile factories) promotes interest in standardizing. Complexity requires a handful of production approaches to achieve multiple outcomes. This uptick in interest accelerates the move to the plateau in the next two to five years.

Obstacles

- The initial segmentation of sites is often not ideally executed and has room for improvement in its definition and impact to the business.
- Inconsistent master data and lack of analytical capabilities to quantify cost/capability trade-offs negatively impact coordination across sites.
- Tailored line designs may require application of new technologies.
- The capabilities of lines will impact the extent that segmentation is possible.

- Regulatory requirements and qualification of production equipment and processes often complicate efforts. This is common in life science industries.
- Complex organizational change at all levels is required to align sites to demand and processes to specific outcomes — often leading to matrixed structures. Incentives, metrics, capacity allocation and productivity targets must shift and will vary by site. Supplier and partner relationships will evolve.

User Recommendations

To apply manufacturing segmentation:

- Formalize any segmentation that has unconsciously arisen within manufacturing sites with differentiated metrics targets.
- Use segmentation within sites with large product variety or long equipment changeover times.
- Segment sites or lines to optimize them for cost, flexibility or responsiveness.
- During network design, evaluate cost-to-serve and target specific sites to customer-centric attributes, such as price, speed of delivery and availability.
- Create interchangeability and redundancy to improve agility and resilience.
- Identify where external manufacturing partners are utilized based on spend and supply complexity.
- Define how manufacturing segmentation fits with other segmentations present in your supply chain.

Implementing and maintaining segmentation requires executive sponsorship and governance specific to each segment. Explicitly define the outcome of each segment, what activities are performed differently and rules for what flows through the segment.

Gartner Recommended Reading

Build Segmentation Into Your Manufacturing Strategy to Deliver Business Outcomes

Segmentation 101: Apply Supply Chain Segmentation to Serve Diverse Needs and Reduce Waste

Five Phases for Successful Supply Chain Segmentation

4 Tactics for CSCOs to Shift Manufacturing From a Cost of Doing Business to a Competitive Weapon

Simplify Supply Chain Network Design to Improve Success of Implementation

Model-Based Manufacturing

Analysis By: Marc Halpern, Rick Franzosa

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Model-based manufacturing (MbM) refers to the use of digital models, rather than document-based content and physical models, to plan, validate and monitor the manufacturing of products.

Why This Is Important

MbM is core to digital manufacturing, which involves the modeling of manufacturing operations and the use of those models to operate the physical processes. MbM is one use case for digital twins in manufacturing companies.

Business Impact

Manufacturers view MbM as a means of cutting iterations out of activities such as defining manufacturing facilities, processes and programming factory automation. Users identify bottlenecks and programming issues by simulating factory operations before commencing factory operations. This can save substantial time and money in automation corrections and reduce scrap resulting from faulty manufacturing ramp-up. Some users reported 20% to 30% cost reductions during scale-up to production.

Drivers

- Manufacturing strategists believe that MbM saves considerable cost and time by reducing the number of iterations necessary to start manufacturing ramp-up.
- The technology enablers, such as Internet of Things, machine learning, modeling tools, simulation tools and remote access, continue to advance — building increased confidence in MbM.

- MbM has a very strong linkage to digital twins and digital threads, which are high in digitalization hype.
- MbM success stories are growing in number, with savings that are compelling enough to minimize initial cost concerns

Obstacles

- MbM requires substantial planning and investment to build the technology platform. It involves the orchestration of engineering technology, information technology and operational technology. Interfaces must be built between ERP, MES/MoM, PLM, modeling tools, automation technologies, IoT and simulation software. The cost and complexity of orchestrating these technologies can be an inhibitor.
- MbM requires training and experience to build skills and confidence. Engineering operations typically have deeply ingrained culture, practices and processes. Discomfort with making these changes can be an obstacle.
- The creation and validation of complex process simulation models requires skill sets that may not be readily available in manufacturing.

User Recommendations

- Plan for MbM by encouraging the creation of an integrated architecture for MbM and a roadmap to accomplish that architecture.
- Manage risk and complexity associated with MbM infrastructure by adopting model-based system engineering approaches to design and validate that the architecture brings together the ET, IT and OT elements.
- MbM must be continually nurtured, maintained, improved and updated as manufacturing knowledge evolves.
- Set expectations properly by explaining to business stakeholders that MbM will require significant initial and ongoing configuration effort. In addition, less-than-optimal results are likely early on, until the enabling tools and their use eventually become more robust and implementers gain experience at orchestrating and interfacing them.
- Advise engineering and manufacturing leaders to adjust job training and performance metrics in ways that encourage MbM adoption, and cultivate collaboration with R&D and engineering to ensure that efforts are aligned.

Sample Vendors

AspenTech; AUCOTEC; Autodesk; AVEVA; Dassault Systèmes; iBASEt; PTC; Rockwell Automation; Siemens Digital Industries Software

Gartner Recommended Reading

Survey Analysis: Companies Heavily Use Digital Twins to Optimize Operations

Innovation Insight for Engineering Technology: Why ET, IT and OT Are More Than the Sum of Their Parts

Innovation Insight for Model-Based System Engineering

Manufacturing Process Management Is Essential to Digital Thread

Magic Quadrant for Manufacturing Execution Systems

Product Innovation Platforms

Analysis By: Marc Halpern

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

A product innovation platform is a cloud-native IT infrastructure that cultivates and supports continuous creativity through collaboration and enriched design functions inspiring new and better products throughout full life cycles and across generations of a product.

Why This Is Important

- Product innovation platforms make transparent many product data management (PDM) functions, such as version control and design history. Thus, they eliminate the PDM tasks, leaving more time for users to focus on creativity.
- Manufacturers seek better means of enabling product developers at different sites to work together more effectively at new product design.
- CIOs seek platform as a service, such as product innovation platforms, to reduce the IT costs of maintaining applications used to design new products.

Business Impact

Manufacturers have greater agility to develop new products with product development team members working in different locations globally. Moreover, product development teams can adapt with greater agility to changing requirements and market conditions.

Advances in social networking enable a greater infusion of new ideas, mashups and domain expertise earlier in the product development phase.

Drivers

- Product development applications, used for decades, are becoming obsolete. Manufacturers seek to modernize the IT infrastructure and applications used for new product development.
- Supply chains and customers are increasingly involved in new product development. Manufacturers, suppliers and customers need a common IT platform that makes communication for product development more efficient.
- Manufacturers seek ways to shorten product development times and reduce costs. They see product innovation platforms as a means to accomplish that.
- Product development team members working from remote locations, instead of at a central location, need a platform with rich collaboration capabilities that also includes requisite design and engineering functionality.
- IT organizations, in an effort to offload technical management of product development applications that demand high-performance computing, seek SaaS and managed services from external partners.

Obstacles

- Product innovation platforms are insufficiently open to working easily and reliably with third-party applications and their data.
- Manufacturers are so deeply invested in their current product development and product life cycle (PLM) environments that it is difficult for engineers and designers to adapt to the new ways of working that product innovation platforms require.
- Manufacturers find it daunting to cleanse legacy data and enable new data architectures to work efficiently and effectively with product innovation platforms.

User Recommendations

- Enable CIOs and IT leaders to keep abreast of product innovation platforms, as these platforms continue to evolve and are adopted to enhance product design, manufacturing activities and product services.
- Acknowledge that these are conceived to run in the cloud and that performance will be a priority, particularly for graphics-intensive visualization, modeling and simulation activities.
- Be acutely aware of software architecture when judging the level of performance running in the cloud and at what cost.
- Make open architecture a priority when selecting these platforms to ensure that they work with complementary applications such as CRM, ERP and MES.
- Take caution to ensure that the platform meets cybersecurity needs.
- Ensure IT organizations use product innovation platform adoption as an opportunity to update product development data and product data architectures.
- Ensure that value networks establish guidelines for sharing and protecting intellectual property.

Sample Vendors

Aras; Autodesk; Dassault Systèmes; Eurostep; Onshape; PTC; SAP; Siemens

Gartner Recommended Reading

2022 CIO and Technology Executive Agenda: An Asset-Intensive Manufacturing Perspective

Cloud Computing in Manufacturing Operations

Analysis By: Rick Franzosa

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Cloud computing is a style of computing in which scalable and elastic IT-enabled capabilities that support manufacturing operations are delivered as a service using internet technologies.

Why This Is Important

Cloud's progress across manufacturing operations varies by industry and use cases. Adoption is relatively high in quality management, asset performance management (APM) and reporting. While manufacturers are not abandoning on-premises models for mission-critical applications, we anticipate further growth in hybrid cloud adoption. Manufacturers are moving to postpandemic modernization, and as a result, remote process/work and intelligent edge devices are reaching greater maturity in support of hybrid cloud deployments.

Business Impact

Impacts of cloud computing in manufacturing include:

- Enabling new styles for technology consumption and information access.
- Contributing toward a flexible and agile manufacturing network when leveraged properly.
- Helping an organization's ability to standardize and improve processes.
- Easing remote access to applications and supporting remote workers.
- Bringing cloud closer to the manufacturing process via edge capability.
- Over time, reducing on-premises IT total cost of ownership (hardware and personnel).

Drivers

- Business initiatives for connected factories and digital supply chains — as well as ongoing advances of IoT and software provider offerings — have made cloud essential in manufacturing operations.
- Provider offerings have evolved across all segments, spanning quality management, manufacturing execution systems (MES), production planning and varying degrees of analytics. New market entrants are taking a “cloud-first” approach, building their applications leveraging cloud infrastructure providers.
- General acceptance of cloud computing grows in all markets as pockets of concern over data security, latency and exchange (between on-premises and cloud) are diminishing.
- Cloud services combined with platform as a service (PaaS) provide cloud application infrastructure services for custom applications and solutions, where the cloud attributes of scale and internet availability encourage innovation and high performance in manufacturing operations applications.

Obstacles

- Although there’s acknowledgment of lower initial cost, customers and vendors are still evaluating and establishing the long-term total cost of ownership (TCO) benefits.
- Some manufacturing environments require on-premises solutions, and hybrid solutions with on-premises and cloud components are nascent.
- Initial cloud-native solutions lack content and maturity of readily available on-premises solutions.
- Buyers have apprehensions for control of cloud costs and vendor monetization of data.
- Cloud-native/cloud-friendly offerings in manufacturing do not reduce the need for complex integration.
- Manufacturers are now concentrating on the details (e.g., cybersecurity, vendor lock-in), and really determining what is mission-critical and what is not.
- Funding models (capital expenditure vs. operating expense) become problematic when replacing perpetual license software with subscription-based offerings, where longevity benefits the vendor.

User Recommendations

- Identify use cases for cloud computing by focusing on broad applicability to enhance existing process capabilities and overcome IT skills deficiencies across multiple sites.
- Minimize disruption by performing hybrid deployments that leverage existing on-premises systems.
- Protect your organization by aggressively addressing and eliminating the challenges of cybersecurity in cloud and hybrid offerings.
- Avoid the mass customization of cloud-based applications to site-specific needs by focusing on shared functional requirements.
- Protect your investment by demanding transparency from vendors regarding their cloud offerings — especially contract life cycle pricing, data ownership and long-term TCO, as well as service levels and security models.
- Establish a clear and realistic understanding of the expected benefits of a move to the cloud by understanding benefits and trade-offs.

Sample Vendors

Amazon Web Services (AWS); AVEVA; GE Digital; Google; iBASEt; Microsoft; Oracle; Plex; SAP; Siemens Digital Industries Software

Gartner Recommended Reading

Cloud Computing in Manufacturing Is Foundational Today and the Requirement to Operate in the Future

Innovation Insight for Smart Factory

Cloud-Native PLM Applications

Analysis By: Marc Halpern, Janet Suleski

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Adolescent

Definition:

Cloud-native product life cycle management (PLM) applications refer to PLM software that is designed from first architectural principles to run on cloud infrastructures. Cloud-native PLM is typically sold and supported as software as a service (SaaS).

Why This Is Important

Cloud-native PLM software is architected to take full advantage of cloud security and other cloud technologies. In contrast, mainstream PLM software operating on a corporate VPN, or hosted on the cloud, offers less business agility because it does not take adequate advantage of the cloud's availability, performance and scalability. Therefore, besides the near-term need to work at home, cloud-native PLM enables a secure yet widespread collaboration within companies with users working remotely and among supply chain partners.

Business Impact

Cloud-native PLM applications:

- Make access to PLM applications easier for different user roles inside and outside an enterprise.
- Streamline the ability to connect new users to PLM software, especially after mergers and acquisitions.
- Streamline collaboration across partners, suppliers and customers.
- Provide scalable computing and scalable storage.
- Reduce IT infrastructure costs.
- Reduce software upgrade efforts.
- Run all users on the same instance of PLM software regardless of location.

Drivers

- The prevalence of SaaS for other business software such as supply chain planning and execution encourages moving PLM to the cloud as well.
- The COVID-19 pandemic forced a significant shift from working in the office to working at home.
- Mainstream PLM software running on virtual private networks does not provide needed performance from remote locations, based on an increasing amount of client feedback.
- Manufacturers seek to reduce IT infrastructure costs for managing and upgrading PLM software.
- Manufacturers seek means to improve collaboration across partners, suppliers and customers.

Obstacles

- Customizing cloud-native PLM requires different technology and skills that many companies have yet to acquire.
- Manufacturers fear that they will lose intellectual property that evolved over many years when migrating from highly customized on-premises applications to new cloud-native PLM software.
- Integrating cloud-native PLM software with complementary applications (e.g., design software, ERP, MES) can be challenging, particularly when the other applications operate on-premises (see Understanding Cloud Data Management Architectures: Hybrid Cloud, Multicloud and Intercloud).
- Prospective users express concern about increased vendor lock-in diminishing their negotiating power.
- Moving legacy data from on-premises to the cloud can be challenging.
- There is relatively less inexperience with in-cloud PLM environments when compared to on-premises environments.
- The overall total cost of ownership (TCO) is often higher for SaaS than for other deployment models despite reducing IT infrastructure costs.

User Recommendations

- Make enterprise-specific cloud platform choices by weighing the trade-offs between cloud-native and other deployment models for data access, application functionality, performance and IT costs.
- Protect data and applications by investing in appropriate cybersecurity measures and contingencies to minimize the risks of security breaches and system failures.
- Streamline on-premises-to-cloud migration by adopting a comprehensive technology modernization and change management roadmap.
- Control costs of running manufacturing-specific, cloud-native business applications by negotiating contractual terms and conditions to protect against software provider lock-in and lockout.

Sample Vendors

Aras; Autodesk; OpenBOM; Oracle; Propel; PTC

Gartner Recommended Reading

What Manufacturing CIOs Must Consider Before Adopting Cloud Applications

Toolkit: A Decision Framework for Adopting Manufacturing Applications in the Cloud

Toolkit: Stop Firefighting and Start Trailblazing Digital Initiatives — Virtual Edition

Understanding Cloud Data Management Architectures: Hybrid Cloud, Multicloud and Intercloud

A CTO's Guide to Cloud-Native: Answering the Top 10 FAQs

QMS Applications

Analysis By: Sam New

Benefit Rating: High

Market Penetration: More than 50% of target audience

Maturity: Mature mainstream

Definition:

Quality management system (QMS) application software is the business information management system that manages quality processes across the organization. These processes may include, but are not limited to, customer requirements, quality documents and standard operating procedures (SOPs), ISO requirements, manufacturing capabilities, robust design, auditing procedures and protocols, nonconformance/risk management activities, testing criteria, and industry-specific regulations.

Why This Is Important

QMS applications provide workflows to manage cross-functional processes such as waste reduction, cost optimization, document management and training. They ensure compliance with policies and regulations, measure quality performance, house quality documents, protect version control, and promote process improvements. QMS applications are essential — companies pursuing enterprise quality management strategies increasingly upgrade, replace and consolidate outdated systems onto a single platform.

Business Impact

QMS applications reduce the risk that requirements impacting quality will be overlooked, reduce the cost and time to enforce quality needs, and enable businesses to systematically review and improve quality metrics.

Drivers

- Key drivers for this replacement and upgrade activity, coupled with the movement toward cloud-hosted solutions, include a desire to harmonize and add common structure to the various methods that have traditionally been enforced on a functional or localized basis. In some industries, this has driven a replacement market.
- Software providers continue to morph their offerings away from siloed, one-off offerings and toward full-scale, configurable platforms with common process and data definitions.
- The QMS market is active with new product launches, enhanced functionality and many vendors building new SaaS solutions that include enticing, business-facing features and low-code accelerators for quality processes.
- Many new low-code application platform (LCAP) QMS vendors are available, making use of broad CSP and workflow capabilities on these platforms to build out robust and secure QMS features. Availability of hyperautomation and AI capabilities on these platforms allow these new vendors to differentiate against legacy QMS providers.

Obstacles

- The lack of a disciplined approach to “enterprise”-quality architecture that balances standard processes and regulatory requirements has delayed QMS adoption.
- Provider-centric challenges continue. These include an inability to offer pricing that matches cloud offerings in other software markets, and an absence of resources dedicated to ongoing technical and customer support.
- Providers have begun incorporating emerging technologies — including robotic process automation (RPA), machine learning (ML), Internet of Things (IoT) and artificial intelligence (AI) — into product roadmaps, but mainstream offerings and widespread user adoption remain limited.

User Recommendations

- Define QMS software requirements by assessing the current state of the quality organization coupled with future business needs. These may include existing systems, industry standards, regulations, desired functionality, and licensing and hosting preferences.
- Assess potential providers' partners by examining relationships with deployment, system integration, hosting and adjacent software spaces.
- Ensure interoperability with existing and planned software solutions by partnering with IT early in the vendor identification phase. Consider compatibility and availability of APIs for ERP, product life cycle management (PLM) and manufacturing execution systems (MES), as well as laboratory information management system (LIMS) and learning management system (LMS) platforms.
- Evaluate the industry depth, geographic reach and product roadmap of providers and their partners by asking questions about each. Be cautious with regard to exciting but nascent product features that have not yet entered mainstream adoption.

Sample Vendors

ETQ; Intelex; MasterControl; Oracle; QAD; SAP; Siemens; Sparta Systems; Veeva Systems

Gartner Recommended Reading

Market Guide for Quality Management System Software

Ensure Success in Quality Management System Software Selection

Tool: Quality Management System Software Vendor Evaluation Model

Synchronized BOMs

Analysis By: Christian Hestermann, Alexander Hoeppe, Marc Halpern

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Practices and technologies for synchronized bills of materials (BOMs) associate and update equivalent items from different BOMs, such as engineering, manufacturing, sales/marketing and service, while allowing each of the items in the BOMs to be labeled and structured differently.

Why This Is Important

Synchronized BOMs reduce errors in product data and streamline design-to-manufacturing-to-service-to-retire workflows. They also shorten the time from design completion to product manufacturing, reducing cost and enhancing product quality. They can reduce scrap, rework, inventory shortages and expedited customer orders since they help ensure continuity of supply. They increase flexibility to deliver individualized products while also making replacement parts easier to identify, improving product service.

Business Impact

Successfully synchronizing BOMs:

- Save time and the cost of updating and validating BOMs by automating activities that have traditionally been manual and error-prone.
- Avoid the risks of wrong orders shipped between suppliers and customers, since BOM changes are automatically translated to BOM item names recognizable to the recipients.
- Make tracking and tracing the origins and sourcing of BOM items more efficient to improve product quality and deliver more reliable product service.

Drivers

- Manufacturers must digitalize to remain competitive, and BOM synchronization is important to digitalize manufacturing. Synchronized BOMs are an essential component of digital thread initiatives.
- In industries such as aerospace and defense and life sciences, traceability is key for regulatory compliance. BOM synchronization is a key enabler for traceability.
- Supply chain efficiency improves cost and time to market. Synchronizing BOMs improves that efficiency because it lessens the ambiguity about which parts BOM items refer to.
- Enhancing product quality and improving customer experience requires synchronizing BOMs to support engineering change control by which valuable product enhancements flow back from manufacturing or service activities into the product design.
- Environmental, social and governance ambitions (ESG) mandate longer lifetimes for a variety of products by servicing and repairing them instead of replacing them. Service and repair activities, whether executed by the original manufacturer or by third party services partners, are enabled by intra- and intercompany BOM synchronization.

Obstacles

- BOMs impact many roles in an enterprise (and supply chain) with different priorities and different ways of working with BOMs. The differences in priorities make it difficult to reach consensus on how to synchronize BOMs.
- Often there is contention about who (and which system) owns BOMs. That responsibility needs to be resolved across multiple roles.
- The automation that synchronizes BOMs can cause errors. It takes time to determine the extent to which the automation is feasible and to build confidence in the automation programmed. Data quality assurance and oversight is key to successful automation.
- BOM information and sync rules are hidden in siloed applications (like product life cycle management (PLM), enterprise resource planning (ERP) and manufacturing operations management (MOM)) and point-to-point interfaces, making it difficult to manage engineering and order changes.
- Replacing OEM parts with substitutes during service life may require changes to BOM structures. This complicates BOM synchronization and management of the life cycle of digital twins.

User Recommendations

CIOs responsible for IT that supports BOMs must:

- Reduce conflicts over BOMs by encouraging engineering, manufacturing, procurement and services owners to plan BOM synchronization strategies.
- Improve the ability to identify the parts and materials in BOMs reliably by working with BOM stakeholders to plan the use of “nonintelligent” and “intelligent” naming for BOM items.
- Improve the efficiency of BoM use across supply chains by structuring BOMs with as few levels of hierarchy as practical.
- Reduce the complexity of managing BOM data by modularizing BOMs based on customer-specific features of the final product to the extent possible.
- Identify technologies that support and automate synchronized BOMs across applications.

- Improve the transparency of BOM content by adopting search and reporting functionality to analyze BOM item usage.
- Rightsize the investment in synchronizing BOMs by studying data architecture, master data management techniques, training and talent to implement it.

Sample Vendors

Aras; Arena; Dassault Systèmes; iBASEt; OpenBOM; Proplanner; PTC; Siemens

Gartner Recommended Reading

2022 CIO and Technology Executive Agenda: An Asset-Intensive Manufacturing Perspective

Innovation Insight for the Digital Thread

The State of Master Data Management

Product Life Cycle Costing

Analysis By: Marc Halpern

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Product cost management technology and discipline predicts, captures and manages product costs over product life cycles. Besides the enabling technology, this includes the discipline, organizational factors and processes to continually improve this competency.

Why This Is Important

Manufacturers must invest more to manage product costs. Products in fast-moving consumer goods have short life cycles, and buyers are extremely price-sensitive. Small price differences for similar products could mean success or failure for these companies. In “heavy industries” such as automotive, aerospace and industrial equipment, small design changes can mean big savings or higher manufacturing costs. This technology can flag big cost differences in all manufacturing industries.

Business Impact

Businesses can improve ROI with cost management software because:

- Its predictions provide guidance to reduce manufacturing and sourcing costs.
- Predicted costs help negotiate with suppliers.
- Predicted costs can guide negotiations with outsourced manufacturing services.
- Analytics generated by such software can offer insights into how costs can be reduced with minimal impact on product performance throughout product life cycles.
- Costing provides insight into target pricing that will deliver profits.

Drivers

- As IT becomes increasingly important to business performance and business leaders involve CIOs more in business strategy, CIOs can add business value by enabling greater product cost savings without compromising product quality.
- Globally, manufacturing is becoming increasingly cost-competitive. Initiatives such as product cost management improve competitiveness.
- Digital methods of managing product costs align with digital business as a top initiative among manufacturers.
- The enabling software applications have become increasingly mature due to enrichment with advanced analytics capabilities and deeper integration with core business applications like PDM, MES and ERP, giving manufacturers more confidence to adopt them.

Obstacles

- Adopters need more reliable methods and data to predict the cost of materials, parts, services and processes to build greater confidence in product cost management.
- Product development teams must become more conscious of cost implications when making design decisions. Designing for function and reliability has traditionally been a higher priority. Cost as a priority must be elevated.
- In some manufacturing verticals, particularly durable goods industries, product costing professionals are not adequately connected to product development teams organizationally. This is culturally and organizationally challenging.
- Poor product master data quality across different systems creating, sharing and updating product master data can undermine confidence in cost management software.

User Recommendations

- Find the best software fits for your companies by investigating cost management software options. Consider the trade-offs of product cost management “add-ons” to ERP and PLM software and specialty software.
- Help the business build confidence in this software by encouraging business units to calibrate the software through comparisons of predicted costs and actual costs based on historical data.
- Contribute to the culture and practice of product cost management by working with business leaders to identify subject matter experts and creating a central group that provides ongoing oversight and governance of costing activities
- Ensure product master data quality by creating common data models for product and product-related data, which needs to be updated continuously in course of regular master data governance processes

Sample Vendors

3C Software; aPriori; Boothroyd Dewhurst; Cognition; FOG Software Group (FACTON); Oracle; pVelocity; SAP; Saphirion; Siemens

Gartner Recommended Reading

Proving the Value of a Digital PLM Ecosystem: B2B Discrete Manufacturing

Top 7 Best Practices in PLM Strategy and Implementation for R&D

Video: Cost Management Planning for Heavy Manufacturing in the Wake of COVID-19

Entering the Plateau

Product Requirements Management

Analysis By: Marc Halpern

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Product requirements management (PRM) captures needs ranging from subtle customer preferences to specific technical necessities. The technical necessities can span mechanical, electrical, chemical, material and software dimensions. PRM helps users capture, organize, track and evolve these needs that impact all stages of a product life cycle — spanning design, manufacturing, service life, product discontinuation and disposal.

Why This Is Important

- Understanding what customers, markets and regulatory authorities want from products is fundamental to delivering products and product platforms that are successful.
- As customers demand more customized products, capturing and organizing product requirements is a challenging need that software can address.
- With software as a greater part of physical products, reporting changes to requirements in real time along with the impact of the rest of the product is key to success.

Business Impact

PRM has the following business impacts:

- Helps capture what customers and regulators expect from products
- Shortens the time needed to verify that a product design meets customer needs and regulations such as those addressing sustainability and safety
- Notifies product development teams when product requirements change

- Increases the confidence that products meet market and customer demands when delivered
- Reduces misunderstandings and proactively reduces reworks of designs and products, avoiding delays and increased costs

Drivers

- Manufacturers feel increased pressure to deliver products that satisfy the right customer and market needs.
- Manufacturers seek to extend traceability of products back to requirements, which are the origins of design and how the product evolves and is produced.
- As markets continuously move toward customer-specific products, manufacturers need better means of tracking product requirements for each customer.
- Software requirements are hard to manage, and they change fast. IT enables real-time notification or changes to requirements.
- Product requirements become more complex as markets become more global. Increasingly, manufacturers need enterprisewide management software to keep track of different requirements for different markets as the combinations of requirements become more complex.
- Product development teams are becoming distributed more globally, and a growing number of product developers work from remote locations. Therefore, it becomes increasingly difficult for them to have a common understanding of product requirements as they attempt to work collaboratively. Enterprise PRM software addresses that need.
- Global regulations addressing issues such as sustainability, safety and localized preferences complicates requirements management so PRM is needed.

Obstacles

- The culture of capturing, classifying, prioritizing and reusing product requirements in Microsoft Office applications and even more informally via instant messages and emails, is deeply ingrained. These approaches cause errors due to incomplete communications and late updates. It is challenging to win acceptance of enterprisewide PRM because it requires more discipline and structure.

- Enabling enterprise PRM software requires the import of requirements from many different sources that have different formats and different semantics. Manufacturers struggle with enabling a common format and semantics to import requirements in a common format usable in the PRM application.
- Different categories of requirements across mechanical, electronics, software, system design, government regulations and others need different representations yet must be related since they are interdependent. PRM adopters struggle to find comprehensive approaches to capturing the categories of requirements in a harmonized way.

User Recommendations

- Adopt enterprisewide PRM to replace the informal use of Microsoft Office tools, emails and messaging for requirements that need to be shared.
- Ensure that enterprise PRM offerings are best-in-class solutions that are integrated or interfaced with relevant software categories. Possibilities include product life cycle management (PLM), quality management (QM), CRM, cost management applications ERP, and product development applications.
- Identify and validate the methods of importing requirements from external sources in formats that are usable with the candidate PRM software.
- Apply model-based system engineering techniques to harmonize and relate different categories of requirements for use within PRM software.
- Define guidelines for the use of tools other than PRM software to informally develop requirements, and then formally document the requirements in the enterprise PRM software.
- Adopt job performance metrics and KPIs that encourage using enterprise PRM.

Sample Vendors

BigLever; Dassault Systèmes; IBM; Jama Software; PTC; Siemens

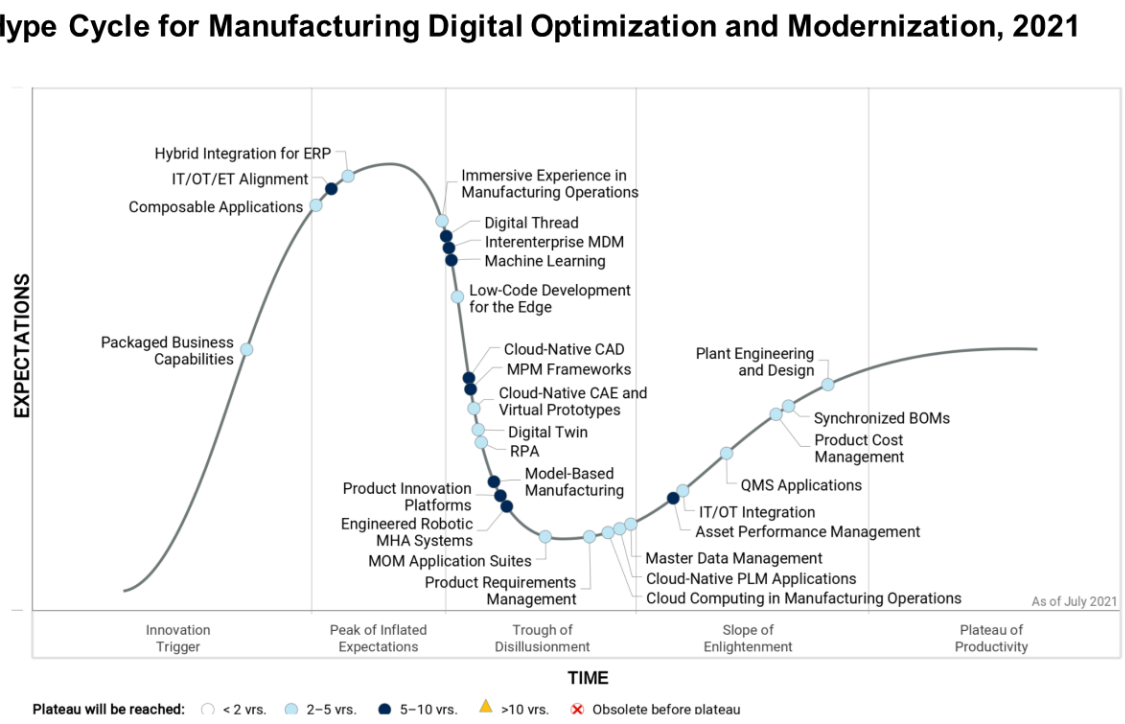
Gartner Recommended Reading

Innovation Insight for Model-Based System Engineering

Proving the Value of a Digital PLM Ecosystem: B2B Discrete Manufacturing

Appendixes

Figure 2: Hype Cycle for Manufacturing Digital Optimization and Modernization, 2021



Source: Gartner (July 2021)

747521

Gartner

Hype Cycle Phases, Benefit Ratings and Maturity Levels

Table 2: Hype Cycle Phases

(Enlarged table in Appendix)

Phase ↓	Definition ↓
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant media and industry interest.
Peak of Inflated Expectations	During this phase of overenthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leaders results in some successes, but more failures, as the innovation is pushed to its limits. The only enterprises making money are conference organizers and content publishers.
Trough of Disillusionment	Because the innovation does not live up to its overinflated expectations, it rapidly becomes unfashionable. Media interest wanes, except for a few cautionary tales.
Slope of Enlightenment	Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the innovation's applicability, risks and benefits. Commercial off-the-shelf methodologies and tools ease the development process.
Plateau of Productivity	The real-world benefits of the innovation are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generations. Growing numbers of organizations feel comfortable with the reduced level of risk; the rapid growth phase of adoption begins. Approximately 20% of the technology's target audience has adopted or is adopting the technology as it enters this phase.
Years to Mainstream Adoption	The time required for the innovation to reach the Plateau of Productivity.

Source: Gartner (August 2022)

Table 3: Benefit Ratings

Benefit Rating ↓	*Definition* ↓
Transformational	Enables new ways of doing business across industries that will result in major shifts in industry dynamics
High	Enables new ways of performing horizontal or vertical processes that will result in significantly increased revenue or cost savings for an enterprise
Moderate	Provides incremental improvements to established processes that will result in increased revenue or cost savings for an enterprise
Low	Slightly improves processes (for example, improved user experience) that will be difficult to translate into increased revenue or cost savings

Source: Gartner (August 2022)

Table 4: Maturity Levels

(Enlarged table in Appendix)

Maturity Levels	Status	Products/Vendors
Embryonic	In labs	None
Emerging	Commercialization by vendors Pilots and deployments by industry leaders	First generation High price Much customization
Adolescent	Maturing technology capabilities and process understanding Uptake beyond early adopters	Second generation Less customization
Early mainstream	Proven technology Vendors, technology and adoption rapidly evolving	Third generation More out-of-box methodologies
Mature mainstream	Robust technology Not much evolution in vendors or technology	Several dominant vendors
Legacy	Not appropriate for new developments Cost of migration constraints replacement	Maintenance revenue focus
Obsolete	Rarely used	Used/resale market only

Source: Gartner (August 2022)

Document Revision History

Hype Cycle for Manufacturing Digital Optimization and Modernization, 2021 - 23 July 2021

Hype Cycle for IT Evolution in Manufacturing, 2019 - 29 July 2019

Hype Cycle for IT Evolution in Manufacturing, 2018 - 1 August 2018

Hype Cycle for Discrete Manufacturing and PLM, 2017 - 26 July 2017

Hype Cycle for Discrete Manufacturing and PLM, 2016 - 2 August 2016

Hype Cycle for Discrete Manufacturing and PLM, 2015 - 20 July 2015

Hype Cycle for Discrete Manufacturing and PLM, 2014 - 25 July 2014

Hype Cycle for Discrete Manufacturing and PLM, 2013 - 31 July 2013

Hype Cycle for Manufacturing Product Life Cycle and Operations Management, 2012 - 23 July 2012

Hype Cycle for Manufacturing Product Life Cycle and Operations Management, 2011 - 27 July 2011

Hype Cycle for Manufacturing Product Life Cycle Management and Production, 2010 - 21 July 2010

Hype Cycle for Manufacturing Product Life Cycle Management and Production, 2009 - 16 July 2009

Recommended by the Authors

Some documents may not be available as part of your current Gartner subscription.

Understanding Gartner's Hype Cycles

Create Your Own Hype Cycle With Gartner's Hype Cycle Builder 2021

Hype Cycle for Manufacturing Digital Transformation and Innovation, 2022

Hype Cycle for Manufacturing Operations Strategy, 2022

Market Guide for PLM Software in Discrete Manufacturing Industries

Manufacturing IT Optimization and Modernization Primer for 2022

2022 CIO and Technology Executive Agenda: An Asset-Intensive Manufacturing Perspective

Innovation Insight for Composable Business for Manufacturers

Magic Quadrant for Manufacturing Execution Systems

Innovation Insight for the Digital Thread

Table 1: Priority Matrix for Manufacturing Digital Optimization and Modernization, 2022

Benefit	*Years to Mainstream Adoption*			
↓	***Less Than 2 Years*** ↓	***2 - 5 Years*** ↓	***5 - 10 Years*** ↓	***More Than 10 Years*** ↓
Transformational		Composable Applications Digital Twin	MPM Frameworks Supply Chain Convergence Supply Chain Resilience	

Benefit	*Years to Mainstream Adoption*			
↓	*Less Than 2 Years* ↓	*2 - 5 Years* ↓	*5 - 10 Years* ↓	*More Than 10 Years* ↓
High	Product Requirements Management	Cloud Computing in Manufacturing Operations Cloud-Native CAD Cloud-Native CAE and Virtual Prototypes Cloud-Native PLM Applications Hybrid Integration for ERP Low Code for Edge Manufacturing Segmentation Master Data Management Model-Based Manufacturing MOM Application Suites Packaged Business Capabilities Product Innovation Platforms Product Life Cycle Costing QMS Applications Sustainability Within Core Business Applications Synchronized BOMs	Digital Thread Industrial IoT Interenterprise MDM IT/OT/ET Alignment Machine Learning Managed IoT Services	
Moderate	RPA			

Benefit	Years to Mainstream Adoption			
↓	Less Than 2 Years ↓	2 - 5 Years ↓	5 - 10 Years ↓	More Than 10 Years ↓
Low				

Source: Gartner (August 2022)

Table 2: Hype Cycle Phases

Phase	*Definition*
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant media and industry interest.
Peak of Inflated Expectations	During this phase of overenthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leaders results in some successes, but more failures, as the innovation is pushed to its limits. The only enterprises making money are conference organizers and content publishers.
Trough of Disillusionment	Because the innovation does not live up to its overinflated expectations, it rapidly becomes unfashionable. Media interest wanes, except for a few cautionary tales.
Slope of Enlightenment	Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the innovation's applicability, risks and benefits. Commercial off-the-shelf methodologies and tools ease the development process.
Plateau of Productivity	The real-world benefits of the innovation are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generations. Growing numbers of organizations feel comfortable with the reduced level of risk; the rapid growth phase of adoption begins. Approximately 20% of the technology's target audience has adopted or is adopting the technology as it enters this phase.
Years to Mainstream Adoption	The time required for the innovation to reach the Plateau of Productivity.

Phase	Definition

Source: Gartner (August 2022)

Table 3: Benefit Ratings

Benefit Rating	Definition
Transformational	Enables new ways of doing business across industries that will result in major shifts in industry dynamics
High	Enables new ways of performing horizontal or vertical processes that will result in significantly increased revenue or cost savings for an enterprise
Moderate	Provides incremental improvements to established processes that will result in increased revenue or cost savings for an enterprise
Low	Slightly improves processes (for example, improved user experience) that will be difficult to translate into increased revenue or cost savings

Source: Gartner (August 2022)

Table 4: Maturity Levels

Maturity Levels ↓	*Status* ↓	*Products/Vendors* ↓
Embryonic	In labs	None
Emerging	Commercialization by vendors Pilots and deployments by industry leaders	First generation High price Much customization
Adolescent	Maturing technology capabilities and process understanding Uptake beyond early adopters	Second generation Less customization
Early mainstream	Proven technology Vendors, technology and adoption rapidly evolving	Third generation More out-of-box methodologies
Mature mainstream	Robust technology Not much evolution in vendors or technology	Several dominant vendors
Legacy	Not appropriate for new developments Cost of migration constraints replacement	Maintenance revenue focus
Obsolete	Rarely used	Used/resale market only

Source: Gartner (August 2022)