Hype Cycle for Managing Operational Technology, 2021

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Initiatives: Manufacturing IT Optimization and Modernization

The blurring of traditional IT and OT (and ET) boundaries provides opportunities for many industrial organizations to become integrated digital businesses. This has heightened the awareness of risk and benefits for CIOs. Use this research to help support your analysis of common OT-related concepts.

Analysis

What You Need to Know

Operational technology (OT) is hardware and software that detects or causes a change in physical processes through the direct monitoring and/or control of physical devices (e.g., industrial equipment) and events in the enterprise. These systems increasingly interoperate across IT, engineering technology (ET) and Internet of Things (IoT) components and architectures. CIOs and CTOs are learning to manage the risks and impacts of converging IT, OT and ET as technologies continue to evolve and become more similar in their architecture.

This Hype Cycle profiles a wide variety of OT-related technologies, processes, techniques and services that will aid in managing, aligning and integrating ET and OT with IT during the next 10 years. CIOs, CTOs and other digital business leaders should use this Hype Cycle to assess the hype and maturity of the profiles described and the implied risks.

The Hype Cycle

The alignment and integration of IT and OT (and ET) are making progress in many companies due to the overlap in technologies and the opportunities for better technology leverage. Nearly 60% of the CIOs from asset-intensive industries that participated in Gartner's 2021 CIO Survey plan to invest in IT/OT alignment in the next three years. [1] So for many CIOs, there is still much planning, investment and progress to make. This progress will be driven by the opportunities brought about by cyber-physical systems and Industrie 4.0 integration needs.

OT products have been designed to provide for critical operational functions, valuing safety and reliability over software maintainability and upgrades. More recently discussions on ET have come to the forefront. ET is the technology domain that enables physics-based and systems centric analysis, problem solving, decision making, designing and producing of equipment and products that impact man-made systems (particularly industrial equipment and infrastructure) and the physical world. ET plays a different role than OT and IT:

- ET is used to define, design, simulate, analyze, visualize and validate.
- OT is used to operate and monitor.
- IT is used to record transactions and business processes.

OT and ET are not just about the use of the data. Some aspects of the Hype Cycle focus on how to manage and secure these technologies. Additionally, OT architectures are historically proprietary and terminology is often industry-specific so the integration of OT takes specialized resources.

This year's Hype Cycle shows a continued progress of combined technology management and integration. There are two clusters of Innovation profiles evident (see Figure 1). Near the Peak of Inflated Expectations there are a few related to managing an OT environment, including some that are still evolving but are expected to be important to organizations;

- Cyber-physical systems
- IT/OT/ET alignment
- Smart robots
- OT professional services
- OT-applied TAM (technology asset management)

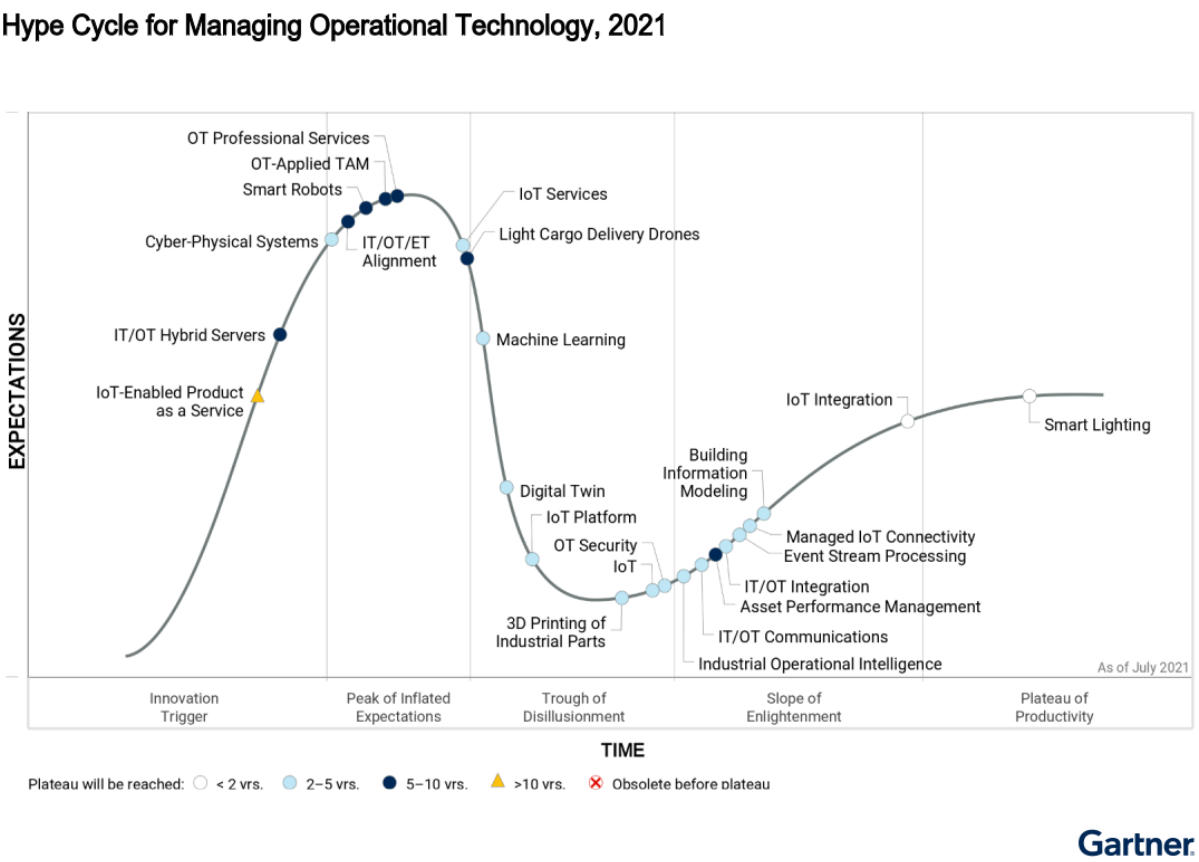
On the Slope of Enlightenment there is a further cluster of more mature technologies marching toward business as usual. These include:

- BIM (building information modeling)
- Event stream processing
- IT/OT integration

- Asset performance management
- IT/OT communications

What is evident from these two clusters is that the pragmatic results-oriented topics have been adopted more quickly than the management oriented topics such as the use of technology asset management (TAM) and professional services. Companies should be wary of advancing with integration of solutions without the commensurate management of an OT environment being in place.

Figure 1: Hype Cycle for Managing Operational Technology, 2021



Source: Gartner (July 2021)

Downloadable graphic: Hype Cycle for Managing Operational Technology, 2021

The Priority Matrix

CIOs need to immediately prepare for the impact of innovations critical to their organization that are two years away from reaching mainstream adoption, specifically:

- **IoT integration** — Clearly identify what IoT integration functionality is needed for IoT projects. Avoid simplistic approaches to IoT integration (e.g., "APIs = integration") that cannot alone address all your needs (e.g., does not also address functionality such as IoT data translation, OT integration). Hire and/or train software engineers with IoT integration skills.
- **Smart lighting** — Ensure there is a business and technology solution to obtain sensor and operational data from new smart lighting system deployments to support goals such as integration with production scheduling, or office space booking and capital cost reduction.

Additionally the transformational innovations reaching near-term maturity (2-5 years) should be included in CIOs plan for technology assessments in the coming years;

- Cyber-physical systems
- Digital twin
- Event stream processing
- IoT
- Machine learning

Table 1: Priority Matrix for Managing Operational Technology, 2021

(Enlarged table in Appendix)

Benefit	Years to Mainstream Adoption			
↓	Less Than 2 Years ↓	2 - 5 Years ↓	5 - 10 Years ↓	More Than 10 Years ↓
Transformational		Cyber-Physical Systems Digital Twin Event Stream Processing IoT Machine Learning		IoT-Enabled Product as a Service
High	IoT Integration Smart Lighting	Building Information Modeling Industrial Operational Intelligence IoT Platform IoT Services IT/OT Integration Managed IoT Connectivity OT Security	Asset Performance Management IT/OT/ET Alignment IT/OT Hybrid Servers Light Cargo Delivery Drones OT Professional Services Smart Robots	
Moderate		3D Printing of Industrial Parts IT/OT Communications	OT-Applied TAM	
Low				

Gartner (July 2021)

Off the Hype Cycle

- A digital business — Dropped from this Hype Cycle as it is covered in other documents more fully
- Commercial UAV (drones) — It has moved beyond the Plateau of Productivity and is considered normal, unhyped technology. This Hype Cycle includes the successor in the form of a more focused emergent area being light cargo delivery drones, which is more applicable to manufacturing and other asset intensive industries
- Embedded software and system security — Dropped due to decreased client interest; very few inquiries on this topic.
- System engineering software — Dropped from here due to its better applicability in the Hype Cycle for Manufacturing Digital Optimization and Modernization

On the Rise

IoT-Enabled Product as a Service

Analysis By: Eric Goodness

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

IoT-enabled product as a service is a commercial model where businesses acquire "servitized" operational assets as recurring operating charges. Agreements define fitness for purpose and guaranteed outcomes based on asset performance, availability and quality of output. Embedded IoT provides users, manufacturers and financial intermediaries asset data required to audit asset effectiveness and to mediate remedies for nonperformance. Asset control is a solution variable in these contracts.

Why This Is Important

Leasing contracts are well-established in select industries. However, selling equipment and products as a service, based on usage-based fee without terms and revenue commitments, is nascent but emerging. Redefining non-IT assets as an operating expense with conditions for performance and availability is transformational for commercial and industrial enterprises. This business model reduces impediments for purchase or where margins from consumables offset selling equipment at cost or near cost.

Business Impact

IoT-enabled product as a service transforms how manufacturers sell products and services, and how companies consume them. A good model for IoT-enabled product as a service requires an end-to-end IoT distributed architecture that supports a usage-based business asset with contracted guarantees for reliable business outcomes that span asset performance and effectiveness. Such a model reduces the risk of asset investment and performance, and provides clarity to the cost of operations.

Drivers

Drivers that lead enterprises to consider IoT-enabled product as a service include the following:

- Increasingly, the technologies needed to implement the IoT-enabled product as a service business model are readily available at costs that continue to decrease year over year. Key to the reduction in costs is the use of open-source technologies, and the increasing presence of off-the-shelf capabilities to integrate into various IT and OT systems that reduce the costs of development and integration.
- IoT-enabled product as a service speaks to a strong overall business trend to shift business costs from asset ownership and capital expenditure (capex) to asset subscription and operating expenditure (opex).
- There are increasing numbers of financial intermediaries willing to finance large, expensive assets in IoT-enabled product as a service model. This relieves OEMs from owning the very assets they manufacture.
- Additionally, a growing class of IT and OT system integrators have embraced IoT-enabled product as a service as a new revenue stream. These vendors bundle assets with life cycle services that price assets as a service; the model also eliminates the user need to staff for the maintenance and support of the asset.

Obstacles

Obstacles that deter enterprises from considering IoT-enabled product as a service include:

- The adoption of IoT-enabled product as a service includes the complexity of engaging in due diligence for a service that is concept not well-known by many sourcing and vendor management personnel. Users must consider a host of business considerations ahead of procurement, such as hours or coverage for service and support, SLAs and time to cure for business impacting events, determinants for penalties and termination for nonperformance.
- IoT-enabled product as a service requires input from IT and OT executives and operations management. Operations managers must support the performance management approaches and practices of the provider offering revenue-generating assets as a service. The IT organization is key to ensuring the support systems that enable the “servitization” of assets conform with the architecture, systems and security of the buying organization.

User Recommendations

Companies considering IoT-enabled product as a service should consider the following recommendations:

- Perform your own multiyear total cost of ownership analysis to validate the benefits of an IoT-enabled product as a service.
- Work to determine if the manufacturer engages with financial intermediaries to operationalize the as-a-service offerings. Determine if P&C coverage is available to mitigate the risks of engaging in such a model.
- Negotiate agreements that clearly establish mutually agreed SLAs and OLAs for IoT-enabled product-as-a-service performance and reliability.
- Factor in all nonrecurring and recurring charges, terms of agreement and penalties into your IoT-enabled product-as-a-service business model.
- Secure the rights to IoT-enabled product-as-a-service data, including mutual agreements on exactly which data and the methods are required for accessing it.
- Determine which other entities will have access to your data and how your data is monetized by the supporting ecosystem.

Sample Vendors

Caterpillar; Danfoss; Michelin; Philips Healthcare; Toshiba, Xylem

Gartner Recommended Reading

Targeting Buyers and Product Types Is Critical to Planning Solutions to Create IoT-Enabled Product as a Service

Market Trends: Consumption-Based Pricing for On-Premises Infrastructure Is Evolving to an as-a-Service Model

Competitive Landscape: Print as a Service Delivery Model

IT/OT Hybrid Servers

Analysis By: Tony Harvey

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

IT/OT hybrid servers are edge devices that are designed to interface, collect and process data from operational technology systems that provide real-time control of physical systems and industrial processes. They are designed to operate with higher resilience to shock, vibration, humidity and temperature than typical data center servers. Industrial communications interfaces — such as CAN bus, Modbus or Profinet, as well as wireless or 5G technology — may also be included.

Why This Is Important

IT/OT hybrid servers allow the data created by OT systems to be processed in real-time to optimize the process under control. By being connected to IT networks, IT/OT servers allow for the collected data to be used for training AI/ML models to deliver further efficiencies and provide insight into manufacturing and production capacity and scheduling.

Business Impact

IT/OT hybrid servers help enterprises realize the potential of the large pool of data that is generated by OT systems. The ability to use this data will generate new cost efficiencies and innovations in manufacturing and industrial control processes.

Enterprises that do not adopt IT/OT hybrid servers may find themselves left behind as enterprises that successfully integrate these systems into their digital transformation strategy will lower their costs and deliver new services to market faster.

Drivers

- Real-time analysis and decision making based on capturing data to optimize industrial processes
- Near-real-time reporting of, manufacturing and production data
- Device monitoring to enable predictive maintenance of industrial equipment to reduce line stoppages and downtime
- Use of Industrial IoT sensors that require data be processed and stored at edge locations
- Collection of OT data to enable AI/ML training and digital twin model building

Obstacles

- Caution from industrial enterprises about the use of IT systems in industrial process control, where failure could result in loss of life or significant property damage.
- Security risks of connecting industrial process control systems to the internet.
- The disconnect between IT and OT life cycles — where OT systems may last for 20 years or more, but IT systems typically have much shorter and faster life cycles.
- IT and OT are separate groups with different cultures and different perceptions of risk. The differences between these groups must be managed for any successful implementation.
- Complexities in defining what data needs to stay at the edge versus what should be delivered and processed in the cloud.

User Recommendations

CIOs looking to evaluate IT/OT hybrid servers must do so as part of an IT/OT integration program that should:

- Create an integrated IT/OT group that has full responsibility for these solutions.
- Align IT/OT in areas of architecture, governance, security and software management, and infrastructure, support and software acquisition.
- Develop a blended IT/OT culture that mixes the rigor and risk awareness of the OT engineering mindset with the flexibility and tolerance for change that is inherent in an IT mindset.
- Embed risk and security training, awareness and talent in hybrid IT/OT teams to ensure that systems are designed with security in mind.
- Optimize the costs for ongoing support, maintenance/updates and dependencies across the entire combined I/OT environment.

Sample Vendors

Dell EMC; Hewlett Packard Enterprise (HPE); Lenovo; Schneider Electric

Gartner Recommended Reading

Alternative Organizational Models for IT/OT Alignment

2020 Strategic Roadmap for IT/OT Alignment

When Does a CIO Need to Be Involved in OT?

At the Peak

Cyber-Physical Systems

Analysis By: Katell Thielemann

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Adolescent

Definition:

Cyber-physical systems (CPS) are engineered systems that orchestrate sensing, computation, control, networking and analytics to interact with the physical world (including humans).

Why This Is Important

Already being deployed in smart grids, smart buildings or autonomous vehicles, CPS are also core to smart manufacturing, as well as technology deployments under the OT, IIoT and IoT umbrellas. They represent the confluence of physical and virtual systems to connect people, products, data and processes. Deployments can use sensors, robotics, cloud services, analytics, machine learning and secure, high-speed networks to orchestrate data and processes in real time.

Business Impact

Whether in transportation, smart building or healthcare, cyber-physical systems change dynamics by orchestrating data flows between previously disconnected systems, automating unstructured processes, shortening cycle times, and improving product and service quality. In industrial environments, CPS are replacing stand-alone production process control and automation, materials handling systems and transactional workflow systems to promote real-time information gathering and processing.

Drivers

- Customer or citizen demand for more, faster, cheaper and better products/services
- New digital business models
- Productivity and maintenance improvements
- Labor cost reduction made possible by CPS

- CPS-enabled operational excellence and enhanced operational data gathering
- Improved situational awareness in operations or mission-critical environments
- Need to keep up with competitive landscape

Obstacles

- Since CPS connect both cyber and physical worlds, security is particularly critical in production and operational-centric industries. As the risk lens expands to the physical plane, beyond cybersecurity, concerns over physical perimeter breaches, jamming, hacking, spoofing, tampering, command intrusion or malware implanted in physical assets need to be addressed.
- Several deployment-related obstacles also exist. These include complex architectural requirements and design approaches from many disciplines involved; sense and control loops that must be designed to evolve with business needs; need for significant computational resources; and a variety of sensory input/output devices.
- Business goals need to be determined for CPS deployment, including data analytics expectations.
- Interoperability with legacy systems is lacking.
- As CPS are usually highly automated, new skills are needed for operating and maintaining.

User Recommendations

- Determine the business value of CPS deployment by weighing benefits against cost, complexity and security.
- Promote the use of standards and interoperability recommendations to manage complexity, enable scalability and extensibility, and to ensure focus on security and safety imperatives.
- Make sure that any deployment is negotiated with CPS OEMs to ensure upgrades can be easily incorporated, as emerging technologies such as cloud computing and 5G will greatly impact these systems.

Sample Vendors

ABB; Honeywell; Rockwell Automation; Schneider Electric; Siemens; Yokogawa

Gartner Recommended Reading

How Cyber-Physical Systems Impact Organizational Risks

Facing New Threats — Cyber-Physical Systems

Facing New Vulnerabilities — Cyber-Physical Systems

How to Develop a Security Vision and Strategy for Cyber-Physical Systems

Focus More on the Realities of Cyber-Physical Systems Security Than on the Concepts of IoT

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 orchestration 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 such as manufacturing, system interoperability is improved when OT-enabled machines and ET and IT systems share infrastructure. As a result, Gartner sees organizations implementing common architecture plans and common standards for the components acquired, and increasingly looking 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 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.

Obstacles

- Possible increase in cost on the OT or ET side initially, as purchases are made to bring software up to the 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

- 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

2020 Strategic Roadmap for IT/OT Alignment

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

How IT Standards Can Be Applied to OT

Alternative Organizational Models for IT/OT Alignment

Smart Robots

Analysis By: Annette Jump

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

A smart robot is an AI-powered, often-mobile machine designed to autonomously execute one or more physical tasks (create predictable outcomes and learn within a range of defined parameters or unpredictable outcomes but within a specific range of parameters). Smart robots can be split into different types based on the tasks/use cases, such as personal, logistics and industrial.

Why This Is Important

Smart robotics is an AI use case, while robotics in general does not certainly imply AI. Smart robots have had less adoption compared with industrial counterparts but received great hype in the marketplace, which is why smart robots are still climbing the Peak of Inflated Expectations. The pandemic increased interest in smart robots, as they can provide logistic support and automation, and support social distancing, while enterprises can demonstrate ROI, without significant capital expenditure.

Business Impact

Smart robots will make their initial business impact across a wide spectrum of asset-centric, product-centric and service-centric industries. Their ability to reduce physical risk to humans from doing specific tasks, as well as do work with greater reliability, lower costs and higher productivity, is common across these industries. Smart robots are already being deployed among humans to work in logistics and social venues, as well as safety applications.

Drivers

- The market is becoming more dynamic with technical developments of the last two years, enabling a host of new use cases that have changed how smart robots are perceived and how they can deliver value.
- The physical building blocks of smart robots — motors, actuators, chassis and wheels — have incrementally improved over time. However, areas such as Internet of Things (IoT) integration, edge AI and conversational capabilities have seen fundamental breakthroughs. This changes the paradigm for robot deployments.
- Specialization also is very important to success, as no smart robot can address all industry-specific use cases.
- The COVID-19 pandemic has accelerated smart robot adoption, and typical use cases include:
- Logistics and warehousing — Medical/healthcare: Patient care, medical materials handling, interdepartment deliveries and sanitization; Goods delivery due to social distancing and quarantine with COVID-19; Manufacturing: Product assembly, stock replenishment, support of remote operations and quality control (QC) check; Last-mile delivery; Inspection of industrial objects or equipment; Surgical robots; Agriculture: Harvesting and processing crops; Reception/concierge in hospitality, retail, hospitals, airports and so forth.

Obstacles

- Despite some advancements in AI, product and material experimentation in 2020, the progress beyond proofs of concept (POCs) is relatively slow. Companies are still trying to identify valuable business use cases and assess ROI for robots. Therefore, the position of “smart robots” still remains on the Innovation Trigger curve.
- Hype and expectations will continue to build around smart robots during the next few years, as providers expand their offerings and explore new technologies, like reinforcement learning to drive continuous loop of learning for robots and swarm management.
- Lack of ubiquitous wireless connectivity solutions outside of smart spaces and immaturity of edge AI technologies can inhibit the pace at which smart robots become semiautomated and mobile.
- The need to offload computation to the cloud will decrease from 2024, as robots will make more autonomous decisions.
- The continuous evolution of pricing models, like buy, monthly lease or hourly charge versus robot as a service for robotic solutions, can create some uncertainty for organizations.

User Recommendations

- Evaluate smart robots as both substitutes and complements to their human workforce in manufacturing, distribution, logistics, retail, healthcare or defense.
- Begin pilots designed to assess product capability and quantify benefits, especially as ROI is possible even with small-scale deployments.
- Examine current business processes into which smart robots can be deployed now and in three to five years for large-scale deployment.
- Consider different purchase models for smart robots.
- Dissolve the reluctance from staff by developing training resources to introduce robots alongside humans, as an assistant.
- Ensure there are sufficient cloud computing resources to support high-speed and low-latency connectivity in the next two years.
- Evaluate multiple global and regional providers due to fragmentation within the robot landscape.

Sample Vendors

Amazon; Ava Robotics; Geek+; iRobot; Locus Robotics; Rethink Robotics; SoftBank Robotics; Symbotic; Temi; UBTECH

Gartner Recommended Reading

Emerging Technologies Venture Capital Growth Insights: Robots

Emerging Technologies: Smart Robots Will Augment Human Workers, Not Replace Them

Market Trends: 4 Technologies That Will Revolutionize Drones and Robots

OT Professional Services

Analysis By: Kristian Steenstrup

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Operational technology (OT) professional services encompass professional services delivered by consulting companies with engineering capabilities and engineering services, OT system integrators, and OT system OEMs. The services focus on data collection and control of equipment (integration), such as heavy machinery as well as OT cybersecurity, product management tools and processes. Providers supporting these services typically offer industry-specific or product-specific OT system knowledge.

Why This Is Important

Industrial verticals like power, oil and gas, manufacturing, and transportation should consider OT professional services. The market is split between OT vendors offering professional services, pure OT service providers and industrial IoT-focused companies. The rise of IoT means that IT-centric service providers may disrupt the OT professional services market. The conservative and risk-averse nature of the market creates slower growth than we would see in an equivalent IT-oriented market.

Business Impact

- CIOs have an opportunity to accelerate their transformation by utilizing OT professional services in coordination with OT leaders.
- OT professional services can support industries to deploy digital solutions for business initiatives that drive key outcomes — such as cybersecurity, asset optimization and operational efficiency — and provide operational cost reductions and savings.

Drivers

- Business initiatives driven by the proliferation of digital business and Industrie 4.0 continue to increase enterprise spending on OT professional services.
- There is interest in integrating industrial IoT into OT platforms that could be easier to unlock with professional services help.
- Many clients will look to their OT vendors to provide these services because they are most familiar with the equipment and OT systems deployed.
- OT professional services providers bring deep vertical knowledge, equipment knowledge and updated strategies to manage and leverage OT environments.

Obstacles

- The position of this innovation profile is stalled. We expected that industrial-focused enterprises would continue to gain confidence, leveraging technologies such as IoT and deploying digital solutions across the enterprise. However, the use of OT professional services struggles to gain traction with businesses.
- Providers struggle to provide enough marketing to tip the balance.
- OT services are more industry- and equipment-specific than IT services, and therefore more specialized and fragmented.
- Risks exist if the OT service provider does not have sufficient experience in your platforms and industry.

User Recommendations

Industrial companies are moving forward in the deployment of digital solutions, which increases the need for OT expertise in support of these digital solutions. OT professional services innovation is an inherently verticalized function.

- Seek providers that support your industry with domain-specific operations knowledge. These providers should have an understanding of the OT systems (design and function), data processing and analytics methods, operational data flows, the level of integration required between IT and OT, and the opportunity to leverage OT data for business gain.
- Create a capability assessment that defines your internal OT expertise, as well evaluation criteria to identify and select the best-fit OT professional services provider.
- Partner with OT professional services providers that are aware of the more-prevalent IoT-industry-focused standards, regulations and consortia not only within your industry but your geography.

Sample Vendors

ATOS; Black & Veatch; Hitachi; NTT DATA; Rockwell Automation; Wipro

Gartner Recommended Reading

2020 Strategic Roadmap for IT/OT Alignment

The Importance of OT Integration for Industrie 4.0

OT-Applied TAM

Analysis By: Roger Williams

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Operational technology (OT)-applied technology asset management (TAM) expands the scope of IT asset management concepts beyond traditional technology environments. The goal is to provide information about OT assets, which enables effective life cycle management decisions. Technology assets may include software, hardware and cloud services that generate, receive or process digital information to support business activity, regardless of environment.

Why This Is Important

Increasing IT/OT convergence, such as industrial Internet of Things (IoT), and blurred lines between IT, OT and line of business (LOB) systems are driving higher demand for TAM to be extended to OT systems. Within OT environments, TAM includes the management of software and hardware assets (such as servers, applications supporting manufacturing systems, sensors or operating systems) as well as the management of OT-specific systems that include digital elements.

Business Impact

Evolving TAM to support OT environments delivers the following benefits:

- Reduces hardware and software costs by leveraging existing contracts and technology procurement expertise.
- Reduces risks from software license compliance audits and suboptimal hardware tracking.
- Provides data to a range of stakeholders to assist with decision making and planning, such as for vulnerability remediation and provisioning.

Drivers

- Planning for IT/OT convergence is of growing interest. Many organizations express interest in being able to use a single approach to manage both IT and OT systems. For instance, patching of systems across IT/OT boundaries can introduce risks if vulnerabilities are not addressed in a timely manner due to differing IT and OT approaches to this work.
- Strengthening skills, clarifying responsibilities and adopting consistent TAM approaches provide the context needed to improve the benefits delivered by technology assets within the OT environment, while optimizing costs and risks (such as with OT security and improved service delivery).
- Software audits can trigger TAM engagement with OT. As traditional IT software (including standard OSs such as Windows and Linux) is introduced into OT environments, software vendors are increasingly extending license compliance audits into this space and demanding consumption data about use of their software by OT systems.
- OT software vendors, such as CAD tool providers, are following the lead of traditional IT software vendors in auditing for compliance with software license terms and conditions, increasing the risk of significant unbudgeted costs. When TAM practices, such as software asset management (SAM) discipline, are initially applied, both over- and under-licensing are often identified, along with significant opportunities to leverage existing contracts and consolidate volume purchases.
- Poor hardware asset management practices lead to increased costs on account of adoption of industrial IoT systems and continued challenges with tracking IT hardware in OT environments.

Obstacles

- IT teams lack familiarity with OT systems and vendors, as management of technology assets within the OT space often does not fall within IT's purview.
- There is divergence in how IT and OT vendors work with their customers. OT vendors don't always adhere to IT standards, and OT system development, delivery and support have evolved quite differently due to their differing characteristics.
- Highly diverse and fragmented OT environments make it difficult to create useful groupings to provide tailored yet manageable standards for managing OT systems.
- Very long OT replacement cycles compared to traditional IT systems inhibit the ability to use system refreshes to address security and other nonfunctional requirements.

User Recommendations

- Extend and adapt existing TAM best practices to OT if maturity and capability are high. If maturity and capability are low, create a shared business case and charter to address TAM concerns across both IT and OT environments.
- Baseline the OT environment to identify IT hardware and software assets, as well as OT-specific digital technology assets that would benefit from TAM. Include industry-specific systems that have network connections and software. Use existing tooling to create the baseline and supplement with OT-specific technologies as needed.
- Work with IT and OT procurement leaders as well as software asset management staff and sourcing teams to rectify any license compliance issues before attempting to focus on consolidation and cost reduction.
- Use TAM to enhance, not replace, existing OT practices where they exist. Leverage lessons from both TAM (particularly for software licensing) and OT practices for physical assets.

Sample Vendors

Axonius; Cyberbit; Flexera; Open iT; OpenLM; RAY • ALLEN, Inc. (RAI); Raynet; ServiceNow; Verve Industrial Protection

Gartner Recommended Reading

How IT Standards Can Be Applied to OT

Establish Successful Executive Security Governance in an Integrated IT/OT Environment

As IT and OT Converge, IT and Engineers Should Learn From Each Other

OT Security Best Practices

IoT Services

Analysis By: Eric Goodness

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Mature mainstream

Definition:

IoT services encompass support, maintenance and professional services to provide a range of business and technical expertise in support of initiatives where IoT is used to enable targeted outcomes. Various frameworks, methodologies and assets are within scope for IoT services. IoT services must be viewed within the broader remit of "digital services." The core outcomes of IoT services lie in the enablement of data acquisition and data contribution to broader digital business strategies.

Why This Is Important

There is a lack of internal resources skilled in IoT technologies and how to operationalize the integration of IT, OT and IoT. Demand for IoT services continues to show strong growth across all enterprise sectors. The availability of a broad and deep pool of providers that can balance technical expertise with sector-specific acumen is key to accelerating the adoption of IoT for digital business impact.

Business Impact

Buyers seek IoT services to:

- Improve the processes related to strategy development and vendor due diligence relating to IoT technologies and business design patterns.
- Accelerate the time to solution to recognize internal (operations, processes) and external (market, customers) benefits from digital optimization and digital transformation.

- Reduce noncore resources and mitigate the risks of deployment, integration and support.

Drivers

The drivers that lead enterprises to consider IoT services from external providers include:

- The use of external service providers to offer the skills and expertise not found in most enterprises. The emerging market for IoT solutions has created a unique market landscape for IoT services. The most common service providers for IoT HW and SW are OEMs and ISVs. In fact, ISVs are responsible for integrating at least 60% of the IoT platforms in the market.
- The use of ESPs offers enterprises a way to derisk the deployment, integration and implementation of IoT-centric products in the enterprise. Users are able to hold providers to various SLAs to ensure proper functionality and outcomes from the IoT solutions. Risk mitigation is also extended to cost control for project deployment.

A fast-growing market of suppliers of IoT services that spans industrial equipment OEMs, traditional IT ISVs, IT and OT system integrators, and niche IoT providers (hardware and software) offering a catalog of IoT services that span design, build and run services. Most importantly, the growing pool of providers is not only able to address technology challenges, but also increasingly able to factor in business acumen relating to sector-specific and regulatory requirements of customers.

Obstacles

The obstacles that deter enterprises from considering IoT services from external providers include:

- Determining the suitability of providers is challenging for many users. The market for providers is fragmented and expertise is distributed unevenly, usually by technology segments, IoT devices, middleware and applications.
- The market leaders for IoT strategy tend to reside with larger system integrators and consultancies. However, users continue to use the IoT platform vendors, no matter how small, as the main pool of ESPs for development and integration services for IoT solutions.

- The market has yet to see a broad pool of third-party maintainers for IoT products. This means maintenance and support services are mostly awarded to device OEMs and middleware vendors. Most of these providers are immature or small, and customer service is often not at the same level that users experience with larger IT companies.

User Recommendations

Users must act now to optimize the IoT service provider selection process:

- Engage service providers early to accelerate successful IoT adoption by clearly defining the activities and success metrics to support the transition of IoT POCs to field trials and into production systems and services. Service fees charged ahead of the acceptance of production systems and services may be returned/credited back to the user organization.
- Create a plan to identify where your business will provide services, augment partnered services or source services entirely to external providers by auditing and aligning internal resources to IoT project phases and success requirements.
- Ensure access to the best resources across the service life cycle by abandoning legacy vendor management approaches. Vendor size and legacy have little to do with successful design, build and run IoT solutions. The IoT market is fueled by nontraditional service providers and models, such as revenue sharing for connected products.

Sample Vendors

Accenture; Atos; Cognizant; Hitachi; Insight Enterprises; KORE; Vodafone

Gartner Recommended Reading

Tech Providers 2025: MSPs Must Lead the Adoption of Emerging Tech Services for Digital Businesses

Service Provider Insight: IoT Market Size by Sector

3 Areas to Drive IoT Differentiation Beyond Functions and Features

Light Cargo Delivery Drones

Analysis By: Bill Ray

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Light cargo delivery drones are flying, autonomous things used to deliver small packages of food, medical supplies or other suitably sized goods. Autonomy may be supplemented by remote operation when needed. Deployment use cases are limited by local and national legislation, which may restrict autonomous flight to specific areas, as well as the cargo capacity and flight time of the drone.

Why This Is Important

High-profile companies, including Alphabet, Amazon and JD.com, have invested in development of delivery drones. In many cases, these services are waiting for local legislation to catch up with technical capabilities. Consumer deliveries are the ultimate aim, to create scale and reduce costs. However, early use cases are focused on public services (such as medical and relief deliveries) and B2B services, where small-scale deployments can be profitable and legislation is less restrictive.

Business Impact

The initial impact will be on post and courier services, and the vehicles they use. However, delivering products anywhere, at low cost, will have a more significant impact on public buying behavior:

- Instant deliveries reduce the need for consumers to maintain local stocks — the "weekly shop" ceases to exist, impacting road transportation and parking requirements.
- Delivering to a person, rather than to an address, creates new business opportunities in just-in-time products and services.

Drivers

- Delivering directly to a mobile phone creates mobile customers who can order (and receive) goods from anywhere. Emergency equipment, such as a defibrillator, can be delivered directly to the point of demand, while businesses will be interested in delivering food into the hands of mobile consumers.
- Drones offer (largely) consistent delivery times, bypassing traffic and other impediments to ground transportation. This is generally faster, but (perhaps more importantly) it's predictable and forecastable.
- Business and administrative sites can reduce costs by negating the need for regional stocks and services. Delivery drones running between hospitals can reduce the need for replicated laboratory services (as samples can be quickly, and reliably, transported) and negate the need for local stocks of rarely used medication (such as obscure anti-venoms, which aren't often used, but can be needed urgently).
- Drones can be highly valuable in delivering products to locations, or across terrains, which lack traditional infrastructures such as tarmacked roads. Fixed-wing drones can travel hundreds of kilometers, delivering products (such as medical supplies or emergency communications equipment) through parachute drop or landing (where a short runway is available).
- The cost of using humans to deliver products is increasing. The use of "gig economy" workers to deliver goods is already attracting regulatory attention in many countries, resulting in increased cost of service as operating companies are obliged to treat delivery drivers as employees.

Of these driving forces the cost of consumer delivery will be the most important, in the long term, but more immediately we will see governmental and B2B delivery services emerging.

Obstacles

- Concerns over physical safety, citizen privacy and noise represent further legislative and regulatory hurdles, especially in urban environments.
- Legislation forbidding the use of drones beyond visual line of sight (BVLOS) makes it impossible to deploy light cargo drones in the biggest markets. In most countries a qualified pilot must be able to see the drone at all times, making delivery services impossible outside very limited trials and tests.
- Consumer delivery services still suffer from a lack of infrastructure, as drones need somewhere to drop their cargo. Solutions exist where customers have large gardens, or driveways, but drones remain incapable of delivering to flats or apartments.
- Drone flight times and lift capacity are still limited. Fixed wings offer greater range and speed, but require landing facilities unless vertical takeoff and landing is (also) supported.

User Recommendations

- Create an expert group within the organization, which can advise on the legal restrictions locally — including regional and national legislation (and which will take priority).
- Leverage (or create) local “flight test zones” where BVLOS may be permitted for companies or government groups, which wish to test technologies and services. These zones may cover wide areas, and will often serve as a core from which operations can be expanded over the coming years.
- Identify opportunities for deliveries across private campuses, government sites, or in regions where BVLOS is permitted.

Sample Vendors

Alphabet; Amazon; Flytrex; JD.com; Matternet; Skycart; Manna; Zipline

Gartner Recommended Reading

Market Trends: 4 Technologies That Will Revolutionize Drones and Robots

Why Autonomous Flying Drones Must Be on the Radar of Mobility Sector CIOs

Market Trends: Understand the Drone Opportunity in Retail

Sliding into the Trough

Machine Learning

Analysis By: Farhan Choudhary, Carlie Idoine, Shubhangi Vashisth

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Machine learning is an AI discipline that solves business problems by utilizing statistical models to extract knowledge and patterns from data. There are three major approaches that relate to the types of observation provided. These are supervised learning, where observations contain input/output pairs (also known as “labeled data”); unsupervised learning (where labels are omitted); and reinforcement learning (where evaluations are given of how good or bad a situation is).

Why This Is Important

According to Gartner’s 2019 AI in Organizations survey, machine learning (ML) is the AI initiative for which more POCs and production systems are conducted. Over the past few years, ML has gained a lot of traction because it helps organizations to make better decisions at scale with the data they have. ML aims to eliminate traditional trial-and-error approaches based on static analysis of data, which is often inaccurate and unreliable, by generalizing knowledge from data.

Business Impact

Machine learning drives improvements and new solutions to business problems across a vast array of business, consumer and social scenarios like:

- Automation
- Price optimization
- Customer engagement
- Supply chain optimization
- Predictive maintenance

- Fraud detection

Machine learning impacts can be explicit or implicit. Explicit impacts result from machine learning initiatives. Implicit impacts result from products and solutions that you use without realizing they contain machine learning.

Drivers

- As organizations continue to adopt these technologies, we recently see focus on aspects that relate to ML explainability and operationalization. Augmentation and automation (of parts) of the ML development process improve productivity of data scientists and enable citizen data scientists in making ML pervasive across the enterprise.
- In addition, pretrained ML models are increasingly available through cloud service APIs, often focused on specific domains or industries.
- Data science and machine learning education is becoming a standard at many academic institutions, therefore fueling the supply of newer talent eager to venture into this space.
- There's always active research in the area of machine learning in different industries — manufacturing, healthcare, corporate legal, defense and intelligence. Thus, its applicability is far and wide.
- Newer learning techniques such as zero, one, few or end shot learning are emerging that take away the burden of having high volumes of quality training data for ML initiatives. This lowers the barrier to entry and experimentation for organizations.
- New frontiers are being explored in synthetic data, new algorithms (e.g., deep learning variations) and new types of learning. These include federated/collaborative, generative adversarial, transfer, adaptive and self-supervised learning, all aiming to broaden ML adoption.

Obstacles

- The triggers of its massive growth and adoption have been growing volumes of data, advancements in compute infrastructure and the complexities that conventional engineering approaches are unable to handle.

- Even though ML is one of the particularly popular AI initiatives in the last few years, it is not the only one. Organizations also tend to rely on other AI techniques such as rule-based engines, optimization techniques, physical models to achieve decision augmentation or automation.
- A significant portion of ML models at an organization doesn't make it into production, therefore adding to technical debt and risks mistrust in the initiative, often delaying value realization from ML at organizations.
- The application of ML is often oversimplified as just model development but it's not so. Several dependencies which are overlooked, such as data quality, security, legal compliance, ethical and fair use of data, serving infrastructure, and so forth, have to be considered in ML initiatives.

User Recommendations

- Build up and extend descriptive analysis toward predictive and prescriptive insights, which can be excellent candidates for machine learning.
- Assemble a (virtual) team that prioritizes machine learning use cases, and establish a governance process to progress the most valuable use cases through to production.
- Utilize packaged applications if you find one that suits your use case requirements. These often can provide superb cost-time-risk trade-offs and significantly lower the skills barrier.
- Explicitly manage MLOps and ModelOps for deploying, integrating and monitoring analytical, ML and AI models.
- Adjust your data management and information governance strategies to enable your ML team. Data is your unique competitive differentiator, and adequate data quality, such as the representativeness of historical data for current market conditions, is critical for the success of ML.

Sample Vendors

Amazon Web Services (AWS); Databricks; Dataiku; DataRobot; Domino; Google Cloud Vertex AI; H2O.ai; Microsoft Azure; SAS; TIBCO Software

Gartner Recommended Reading

Magic Quadrant for Data Science and Machine Learning Platforms

Critical Capabilities for Data Science and Machine Learning Platforms

Toolkit: RFP for Data Science and Machine Learning Platforms

3 Types of Machine Learning for the Enterprise

Understanding MLOps to Operationalize Machine Learning Projects

Digital Twin

Analysis By: Alfonso Velosa, Marc Halpern, Benoit Lheureux

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

A digital twin is a virtual representation of an entity such as an asset, person, organization or process. The three types of digital twins are discrete, composite and organizational. Digital twin elements include the model, data, unique one-to-one association and monitorability. Digital twins are created in enabling platforms, such as analytics or simulation solutions, IoT platforms, or CRM applications.

Why This Is Important

Enterprises are using digital twins to create virtual representations of previously opaque entities or activities for process, cost or other business improvements. For instance, improved patient outcomes due to visibility of the entire patient across the siloed systems, or reductions in unplanned outages by monitoring the equipment state are now possible. Technology providers see digital twins and associated information products and services driving new customer outcomes and revenue streams.

Business Impact

- Digital twins enable business to enrich decisions — for example, to lower maintenance costs, increase asset uptime and improve performance.
- For OEMs, digital twins contribute to differentiation, new service models and obtaining customer data.
- Digital twins of people contribute to improved health monitoring, employee safety and customer transactions.
- Digital twins will help drive new business models, such as product as a service, as well as 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, have leveraged lessons from their extensive digital history toward 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 system engineering from the national ministries or departments of defense.
- Leading-edge enterprises are implementing digital twins to model IT organizations, financial exchanges, and processes such as purchase order approvals and fulfillment — for cost optimization and process improvement purposes.
- Consortia such as the Digital Twin Consortium and the National Digital Twin Programme at the Centre for Digital Built Britain contribute to digital twin visibility and business cases.
- 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.
- Improvements in models of all types employ analytics, visualization and simulation capabilities to understand, predict and automate business actions.

Obstacles

- Enterprises lack clear business objectives for digital twins. They lack consensus on the scope, structure, process or teams to start developing business-focused digital twins.
- Few enterprises have the fusion teams of skilled business, finance, and technology people and the collaboration between these people.
- These fusion teams must conceive, create and maintain the core 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.
- While consortium and standards bodies are emerging, they are all generally immature, with many vendors pushing proprietary formats. We lack standards for a broad range of digital twin integration, evolution and other technical issues.
- Few vendors have a viable 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 outcomes 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 resources and undermine adoption.
- Identify IT gaps and build a roadmap to drive IT organization learning opportunities, its investment plan for internal skills, and partner selection strategy.
- Build an IT digital twins technology roadmap to mitigate the hype around proprietary vendor approaches. Incorporate best practices for software asset development and management, security and privacy, and integration.
- Assess the use cases and architectural and technical implications of composite and organizational digital twins.
- Develop a long-term governance strategy.

Sample Vendors

Amazon; AVEVA; Cognite; Cosmo Tech; GE Digital; Microsoft; Thynkli; Voovio; XMPro

Gartner Recommended Reading

Use 4 Building Blocks for Successful Digital Twin Design

What Should I Do to Ensure Digital Twin Success?

What Data and Analytics Leaders Need to Know and Do About Digital Twins

Essential Product Management Practices to Monetize Data and Analytics Assets

IoT Platform

Analysis By: Alfonso Velosa, Eric Goodness

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

An Internet of things (IoT) platform enables the connection and capture of data from IoT-enabled assets or endpoints to develop, deploy, and manage business solutions that improve operations such as monitoring remote assets or optimizing maintenance. Capabilities include device management, integration data management, analytics, application enablement and management, and security. It may be delivered as edge or on-premises software, or cloud IoT platform as a service, or a hybrid combination.

Why This Is Important

Enterprises continue adding IoT capabilities to assets and products, seeking benefits such as cost optimization, process optimization, improved customer experience, and new opportunities such as product as a service. The sophistication, scale and business value of these interactions call for specialized technology resources, most often implemented as an IoT platform. While all verticals are deploying IoT, spend is highest in asset intensive industries such as manufacturing or oil and gas.

Business Impact

IoT platforms are usually required to implement IoT-enabled assets in order to make better business decisions from the data and information generated by connected products. Goals include:

- Differentiated smart products
- Cost optimization strategies centered on improved maintenance
- Process improvement by using assets at their best state
- Opportunities to sell new services and data products

Drivers

- Proliferation of IoT projects since IoT is widely proven across many industries to improve business outcomes — see Survey Analysis: Focus on Practical Outcomes for IoT Projects.
- IoT platforms are fit-for-purpose PaaS and on-premises software offerings that specifically help software teams to accelerate and improve the quality of IoT products while consolidating and structuring the data.
- Enterprises leverage their IoT assets to drive differentiation, lower costs, improve processes and enhance worker safety.
- Technology providers are driving marketing and sales efforts to engage their customers with IoT platforms. In parallel they invested in improved ecosystems and channel partners to make it easier for companies developing IoT enabled solutions to achieve business value.
- In parallel, technology providers continue to invest in their IoT platform technology to ensure they can deliver business solutions at scale for their customers.

Obstacles

- IoT platforms require extensive customization to achieve business outcomes for large-scale deployments, driving up cost and schedule.
- Many enterprises approach IoT projects as technology projects, instead of as business projects that use IoT platforms to achieve business outcomes.
- Many enterprises operate in siloed fashions, adopting different IoT platforms for each use case, limiting their ability to scale, and adding complexity.
- Projects that use IoT platforms drive greater volumes of data, complicating existing processes and overwhelming employees and other stakeholders. They often lack training or process changes to absorb this new data — leading existing systems and people to reject the output of the IoT platform.
- IoT technical complexity, security and integration challenges remain barriers to scale at enterprises.
- Technology providers have yet to develop a clear value proposition and sales strategy that helps their customers leverage their platforms on scaled up levels.

User Recommendations

- Start with smaller IoT projects that help the business unit and IT organization acquire implementation lessons, identify IoT platform strengths and weaknesses, and verify alignment to business and finance KPI requirements.
- Identify the range of IoT projects for your enterprise, and segment them by their focus (internal vs. external), complexity and business objectives. Use these insights to establish a distributed deployment and a platform of platforms architecture.
- Use a skills gap for IoT projects and IoT platforms to build a plan to improve the IT organization's capabilities such as integration or digital twin model development.
- Prioritize vendors you already work with for their IoT platform. Evaluate candidate vendors on their fit-to-your-business objectives and technology. Key evaluation criteria include: proofs of value projects (for tech and business), the ability to drive operational-scale deployments, vertical market expertise and a partner ecosystem.

Sample Vendors

Alibaba Cloud; Amazon Web Services; AVEVA; ClearBlade; COVACSIS Technologies; Detechtion Technologies; Knowledge Lens; Microsoft; Siemens

Gartner Recommended Reading

Magic Quadrant for Industrial IoT Platforms

Critical Capabilities for Industrial IoT Platforms

Use the IoT Platform Solution Reference Model to Help Design Your End-to-End IoT Business Solutions

Use 4 Building Blocks for Successful Digital Twin Design

3D Printing of Industrial Parts

Analysis By: Arjun Boparai, Marc Halpern

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

3D printing (3DP) of industrial parts refers to the use of 3DP to produce a finished item, subassembly or intermediate product. It can also be used to print tools, jigs, fixtures, dies and molds that would be used during the production of finished goods. This applies to OEMs and their suppliers, which can produce items on an assembly line or in a machining, casting or forming line using 3DP.

Why This Is Important

Manufacturers continue to use 3DP, given the perceived cost and time advantages, to produce customized complex products just in time and simplify supply chain logistics and manufacturing operations. CIOs must become familiar with 3DP because it is an operational technology (OT) enabled by engineering technology (ET), but depends on IT to operate efficiently and effectively.

Business Impact

3DP for industrial parts is being leveraged to eliminate bottlenecks in manufacturing and supply chain operations. It reduces the inventory required for spare parts and tools and can produce customized products with new material combinations and complex geometries. It transforms manufacturing operations and service with its ability to produce industrial parts just in time instead of purchasing them.

Drivers

- 3DP directly uses 3D data from geometric design models, either created from scratch or scanned from existing products. 3DP eliminates additional work needed to translate 3D data into execution instructions for mainstream manufacturing operations.
- 3DP offers design and structural freedom, leading to development of in-house capabilities such as prototyping and design verification. Since it is an additive procedure, expensive raw material and resources are not wasted.
- The technology advances the ability to increase energy efficiency and durability of products, especially across the aerospace, defense and automotive industries. It can produce products with complex shapes and high strength and weight resistance, which cannot be produced with traditional manufacturing techniques.
- Consumers increasingly demand personalized products, which can be delivered more rapidly through 3DP. Additionally, these individualized products are more scalable and less costly than other manufacturing approaches, where the major cost arises from the molding process for low volume products.
- 3DP is part of a technology convergence trend that stimulates innovation where there are advances in material science and the ability to embed technologies (e.g., sensors, actuators, computer chips, with the potential to be created through nano 3DP) in larger 3D printed parts.
- 3DP advances the popular goal of lean manufacturing, with shorter lead time, since inventories of spare parts can be reduced and supply chain operations can be streamlined.
- 3DP helps in improved cost position, higher design reuse, faster product launch and introduction, and better aftermarket services resulting in improved competitive value.

Obstacles

- The investment cost of equipment and production time continue to be a major challenge for the technology to produce industrial parts.
- Multiple parties are involved in the 3DP process, which results in the technology's siloed adoption. This has led to the lack of integration between 3D printers and designing software (OT and ET component) and workflow software such as MES, ERP and SCM (IT component).
- Owing to limited materials available for the production of industrial parts, there are concerns around the reliability and performance of these products, especially under adverse environmental conditions of high temperature, resistance and chemical exposure.
- Insufficient training, education and awareness to use any 3DP technologies and materials efficiently is decreasing the uptake of the technology.
- IP related to industrial products' ideas and design must be safeguarded, or it would be subject to financial losses and lost growth opportunities.

User Recommendations

- Partner with the decision-making teams in the organization, such as finance, engineering and operations teams, to validate the viability of 3DP technologies by building an investment case.
- Align the involved parties to create a connected workflow to create an IT-ET-OT alignment.
- Audit and invest in IT components needed to connect 3D printers with workflow and design applications such as CAD, PDM, ERP and MES that capture content needed for 3DP operation.
- Augment the production of tools and fixtures by encouraging the use of 3DP. This would result in shorter lead time and pay for the initial cost and time investment.
- Work with supply chain leaders to assess the potential impact of 3DP on your extended supply chain across activities such as sourcing of parts, maintenance, overhaul and repair.
- Monitor the advances in 3DP and materials technology and discuss with decision makers to evaluate the benefits to manufacturing and supply chain operations.

Sample Vendors

3D Systems; EOS; GE Additive; Markforged; Materialise; Stratasys

Gartner Recommended Reading

The Manufacturing CIO's Role in Adopting and Scaling 3D Printing

Top 10 Strategic Technology Trends for Manufacturing Industries: 3D Printing

The IT Impact of 3D Printing on Business Models

IoT

Analysis By: Alfonso Velosa, Benoit Lheureux

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Internet of Things (IoT) is a core building block for modern business. IoT connected assets and equipment improve enterprise situational awareness and thus decision making. Technically, IoT is a network of products or assets with embedded technology to communicate and sense/interact with their internal states and/or the external environment. IoT comprises an ecosystem that includes assets, communication protocols, applications, data and analytics.

Why This Is Important

IoT is a foundation for, and contributes to, many digital and composable business initiatives. Most enterprises lack information about their assets or products, which is important to their customers. For operators of assets such as hotels or oil companies, adding IoT capabilities enables them to gain new understanding of the asset to operate it at the optimal level. IoT also enables OEMs to know how their products are used and how they should be improved.

Business Impact

IoT will impact most enterprises' internal operations, customer engagement, competitive position and product strategies by enabling:

- Optimization of a range of business processes: This covers the spectrum from costs to operations, while improving the use of assets and conserving resources.
- New revenue strategies: This includes generating revenue via improved products, services and data monetization.
- Safety focus: This includes meeting regulatory certification and driving employee safety.

Drivers

- Enterprises, on a global basis, have shifted from implementing IoT technology solutions toward implementing business solutions leveraging IoT capabilities.
- Since the 2020 economic downturn, traditional, IoT-enabled use cases have seen increased adoption to improve enterprise operations. For example, cost savings from asset optimization, differentiated smart product development, employee safety monitoring solutions or compliance reporting.
- A few, leading-edge enterprises are driving transformative strategies. For example, product as a service or guaranteed asset uptime.
- Prior to the 2020 economic downturn, many enterprises set average payback targets of three years. Modern financial payback targets are much shorter, with typical clients focused on six- to 18-month paybacks on clearly defined business projects.
- Technology and service providers have realigned their go-to-market strategy to express clearer value propositions to their enterprise customers.

Obstacles

- Many enterprise leaders do not understand that they have to support IoT-enabled business projects as culture change projects that require significant engagement with the business and frontline workers.
- Business leaders often fail to set clear business objectives for, and communicate the importance of, IoT projects.
- Lack of central teams to develop best practices and share them with the organization, or to allocate budgets, personnel and resources appropriately.
- Lack of standards that inhibit scaling for complicated solutions that involve multiple vendors, from sensors, gateways and communications, to implementation and analysis.
- Difficulty of integrating elements of an end-to-end IoT solution from assets and other data sources to the business applications.

User Recommendations

- Contribute to an IoT center of excellence composed of IT, operational (line of business) and business personnel. Use it to drive enterprisewide best practices and establish budget and people priorities.
- Build relationships across business units as IoT is really about business transformation. Invest time and effort on culture change, such as incentives to encourage cross-organizational collaboration around desired IoT-enabled business outcomes.
- Ensure the teams focus on both the IT and operational architectures to address key technology complexity, security and integration challenges.
- Manage a multivendor approach for IoT platforms, analytics and applications.
- Establish accountability, participation, predictability and transparency policies for IoT to address sponsorship, budgets, digital ethics, data ownership and rights to monetize IoT data.

Sample Vendors

AVEVA; Cognizant; Microsoft; NTT DATA; Toshiba

Gartner Recommended Reading

Tool: 50-Plus Digital Twin and IoT Cost Optimization Examples

Survey Analysis: Focus on Practical Outcomes for IoT Projects

Toolkit: Enterprise Internet of Things Maturity

Magic Quadrant for Industrial IoT Platforms

OT Security

Analysis By: Katell Thielemann, Ruggero Contu

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Operational technology (OT) security is the practice of protecting critical production and operational systems and services in asset-centric enterprises. OT security addresses industrial control systems and use cases where physical state changes depend upon secure, safe and reliable function. As digital transformation efforts increasingly target operational and mission-critical environments, OT security is evolving into cyber-physical systems security, with security disciplines converging.

Why This Is Important

Once disconnected from IT networks, the convergence of OT and IT systems driven by business needs has created new security risks. They are compounded by remote connections from original equipment manufacturers (OEMs). Because operational systems are the centers of value creation, OT security is of major relevance to asset-centric organizations, such as those considered to be part of national critical infrastructure, and to any other industrial verticals with operations-centric environments.

Business Impact

Whether nation states targeting critical infrastructure (e.g., the 2015 attack on Ukraine) and intellectual property (manufacturing is often targeted for cyber espionage), or financially motivated hackers deploying ransomware, the number of attacks on OT systems has steadily increased over the past five years. The impact of operational disruption can range from mere annoyance to hundreds of millions of dollars, as well as reliability and safety impacts.

Drivers

- Whether because of attacks or an overall heightened awareness of the increased risks they face, asset-centric organizations are increasingly focusing their attention on the security risks they face outside of enterprise IT. At the same time, a growing number of vendors are offering specialized security platforms to help enhance situational awareness of assets, network topology and vulnerabilities, as well as to help with threat detection and mitigation.
- International standards, such as IEC 62443, European NIS and NIST 800 series, are also emerging to provide guidance; and in some industry verticals, security mandates such as NERC-CIP are already in place. Given the close relationship between critical infrastructure and national security, and the growing concerns of targeted attacks, government-led efforts are also likely to increase, adding to the growing list of existing national legislations.
- A converged cyber-physical systems (CPS) security discipline is emerging, driven by organizations paying more attention to the basics of OT security (e.g., firewalls, network segmentation), while adding “greenfield” new robotics or IIoT systems with modern technologies that introduce new risks across a cyber-physical continuum of threats.

Obstacles

- Because of their history of OT deployments disconnected from IT systems, organizations working on expanding their security and risk efforts outside of enterprise IT often face cultural, governance and security control challenges that prevent a one-size-fits-all approach to security. For instance, operations often run 24/7 and cannot be stopped at will.
- OEMs often contractually connect remotely into OT systems to maintain and update them. If not done securely with consistent policies, this creates additional risks. In some cases, OEMs also control the deployment of any updates, which hampers security efforts.
- Most OT systems have important safety and reliability requirements that prevent deploying security controls at will.
- Organizations also continue to face acute and growing shortages of OT security skills to foster and support IT/OT integration, and securely support digital transformation efforts.

User Recommendations

- Initiate risk discussions between IT security and OT teams, and determine the current extent of OT security efforts.
- Deploy OT asset discovery, inventory and network mapping security platforms.
- Determine immediate gaps, such as flat OT networks, lack of firewalls, open ports, vulnerable and unpatched operating systems, shared password, etc.
- Accelerate security awareness and skills training for converging IT and OT infrastructures.
- Focus on organizational and cultural trust challenges between IT and OT personnel.
- Collaborate with your procurement team to demand OEMs of OT systems ensure that their (future) systems are secure by design.
- Prepare for a future where CPS security emerges as a centralizing discipline for securing converging IT, OT, and IoT systems and bringing together asset-centric cybersecurity, physical security and supply chain security best practices.

Sample Vendors

Barracuda; Claroty; Dragos; Nozomi Networks; SCADAfence; Verve Industrial

Gartner Recommended Reading

Market Guide for Operational Technology Security

Establish Successful Executive Security Governance in an Integrated IT/OT Environment

OT Security Best Practices

Emerging Technologies and Trends Impact Radar: Security in Manufacturing

Climbing the Slope

Industrial Operational Intelligence

Analysis By: Nicole Foust, Zarko Sumic

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Industrial operational intelligence (OI) combines capabilities formerly found within other operations systems. Capabilities include the ability to capture, store and visualize time series data (from historian software); model assets and processes for business user context; provide situational awareness and initiate field actions; provide operations-focused analytics; and offer support for asset management.

Why This Is Important

Industrial OI is a critical platform to monitor and add context to large volumes of multistructured data and information from diverse OT and IT data sources. It enables utilities to manage operational performance with a broader business context than individual SCADA systems, energy management systems, data historians, or other plant and control center applications could. In a sense, industrial OI combines capabilities from these more mature applications into a new decision support application .

Business Impact

Industrial OI supports operational decision making in plant management, transmission and distribution network operations. A key capability is the ability to define and maintain persistent functional and operational models (or relationships) that create understandable business context for users.

Example benefits include:

- Dynamic grid
- More efficient and effective operations
- Better optimization of asset investments

Drivers

- The role of industrial OI in industries such as utilities has recently been elevated by AI, which dictates a new focus on analytics and managing big data. The development of industrial OI in utilities is occurring in parallel with other industrial sectors, resulting in vendors advancing product capabilities across multiple sectors. The size of the market opportunity has attracted the interest of more-generic OI platform vendors.
- Industrial OI can dynamically manage operational performance in the context of multiple constraints and a changing business environment. Industrial OI can help mitigate operational risk.
- More-timely management of data streams coming from historians and real-time production systems, combined with advanced and augmented analytics, will help utilities to uncover potential problems and begin developing better predictive capabilities. It will support real-time situational awareness, predictive “what if” capabilities and event-driven collaboration.

Obstacles

- Broader adoption still faces a number of barriers, including the limitations of existing solutions, poor integration and alignment of IT and OT, and cultural resistance to information sharing.
- Stand-alone legacy systems have not moved as quickly regarding the requirement to create and manage multiple data models, use data mining and discovery tools, and leverage advanced analytics.

User Recommendations

- Implement governance as deploying industrial OI has OT and IT impacts. It should be undertaken as part of a broader initiative that converges and aligns IT and OT.
- Create more value from OT data by investing in industrial OI solutions. In some instances, your existing vendors are building out the necessary capabilities. However, keep in mind the limitations of legacy architectures, and don’t rule out using more-generic OI platforms. To justify your OI investments, focus on specific benefit opportunities, and identify suitable use cases for your industry.
- Start small and expand over time to leverage both OT and IT data sources, and to provide a closed loop that links operational and business performance to deliver operational improvements.

- Identify which users need what information and when to support advanced decision making. Ensure that your industrial OI supports information usage, value and dissemination that match the speed of operations and support just-in-time decision making.

Sample Vendors

AVEVA; Dassault Systèmes; Hitachi ABB Power Grids; PTC; SAP; Schneider Electric

Gartner Recommended Reading

How Utility CIOs Can Use Intelligent Operations to Achieve Resilience During the Energy Transition

Market Guide for Enterprise Asset Management Software

Top Practices for Utility CIOs Evaluating Enterprise Asset Management Software

Market Guide for Asset Performance Management Software

Implement a Design Authority to Deliver Improved Asset Value Supported by an Asset Management System

IT/OT Communications

Analysis By: Tim Zimmerman

Benefit Rating: Moderate

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Operational technology (OT) continues to incorporate IT standards-based technology for line-of-business processes. The need to address deterministic performance, latency-sensitive application requirements and the move from proprietary communications protocols to IT standards such as IEEE 802.3 and 802.11 are part of every OT to IT communication migration strategy.

Why This Is Important

Communications must be resilient and reliable to meet mission-critical demands in markets as diverse as manufacturing, utilities and smart cities. OT, specifically, supports activities in which downtime or failure can not only impact productivity, but also threaten worker safety. Industry-standard technologies continue to make improvements that allow these technologies to be integrated into solutions which historically would have required proprietary solutions and separate networks.

Business Impact

- IT/OT communications will enable companies to overcome the common objection and hurdle for IT/OT integration — namely, the belief that networks need to be separated. This opens up more opportunities to integrate IT and OT systems and thus directly draw on OT data. There also is the opportunity for efficiency.
- An IT strategy that includes OT may reduce the staff which historically managed multiple different networks, technologies and applications.

Drivers

- Elimination of proprietary technology saves initial procurement costs as well as service and maintenance.
- The ability of IT networks to address latency with time-sensitive networking functionality, and isolated with virtual segmentation means that many operations can be upgraded.

Obstacles

- Security risk continues to be the biggest obstacle. Devices on OT networks are often vulnerable to security issues when exposed to traditional IT environments (because they are on old OS releases or are unpatched) and may require specialized security approaches since they may not support 802.1X or other security policy requirements.
- Awareness of the ability to address latency on IT networks, OT networks have been designed to address specific issues that “best effort” IT network architectures must address prior to any migration.
- Long refresh cycles for OT equipment may prevent the evaluation of IT equivalent functionality.
- Organizations will need to drive cultural change and integrate IT and OT teams so that they work together and develop trust.

User Recommendations

- Document and incorporate technical requirements mandated for use in the associated business process. This will help enterprises that use proprietary OT communications solutions without proper information management governance, such as security or communication policies.
- Review requirements and risk against the existing implementation by having IT and OT work together. Enterprises will then be able to know if switching to standards-based components is viable from risk, performance, latency, migration, environmental (for example, temperature, humidity and vibration) and cybersecurity viewpoints.
- Start with noncritical workflows and equipment as they may already be able to take advantage of networking IT solutions without compromising the business outcome while providing cost optimization opportunities.
- Test all upgrades to ensure compliance with existing IT and OT requirements.

Sample Vendors

ABB; Cisco; Emerson; Rockwell Automation; Schneider Electric; Siemens

Gartner Recommended Reading

Emerging Technology Analysis: Time-Sensitive Networking

Magic Quadrant for Industrial IoT Platforms

When Does a CIO Need to Be Involved in OT?

2020 Strategic Roadmap for IT/OT Alignment

How IT Standards Can Be Applied to OT

Asset Performance Management

Analysis By: Nicole Foust, Kristian Steenstrup

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

APM are business applications for optimizing reliability and availability of operational assets (such as plant, equipment and infrastructure) essential to the operation of an enterprise. It uses data capture, integration, visualization and analytics to improve asset maintenance activities. APM includes capabilities and functionality to support asset strategy, risk management, predictive maintenance, reliability-centered maintenance, and financially optimized maintenance activities.

Why This Is Important

APM has become an important core competency for asset-intensive and asset-centric organizations. Organizations invest in APM tools and technologies to reduce unplanned repair work, improve asset availability and safety, minimize maintenance costs, and reduce the risk of failure for critical assets. Realizing the business can move beyond the key use case of equipment reliability, organizations are leveraging APM to improve overall business operations.

Business Impact

- APM is an important investment area for asset-intensive industries, including manufacturing, mining, oil and gas, transportation, telco, and utilities.
- Successful APM deployments can deliver measurable improvements in availability, as well as reduce maintenance and inventory carrying costs.
- Benefits such as improved uptime and cost savings can be substantial, typically delivering benefits measured in millions of dollars per year.

Drivers

- Organizations need better solutions to deliver enhanced asset insights.
- Those that depend significantly on availability of their assets, such as manufacturing, utilities and natural resources industries, tend to be further along in their asset management capabilities and strategy, and invest more heavily in APM.
- Innovation in enabling technologies such as cloud, IoT and AI/ML are widening the scope and decreasing the deployment cost, aiding more awareness and use of APM.
- As operations take advantage of newer sensors (e.g., acoustic), drones and bots, APM has access to increased data volumes of better quality and granularity (or reduced latency) and accuracy yield richer use cases and more robust capabilities.
- Business processes supported by APM software are becoming an important core business capability for asset-intensive organizations. CIOs are increasingly realizing benefits which aid the market transition beyond the use of APM focused on equipment reliability to increasingly leveraging APM to also help improve overall business operations.
- Most APM projects are executed on the premise that data-driven decisions will improve equipment reliability and, therefore, reduce operational risk.
- The potential of reduced maintenance cost and downtime, coupled with higher levels of operational reliability is attracting other industries, however, all are progressing at a varied pace.

Obstacles

- Limited availability of good-quality and consistent asset data to support a more advanced maintenance capability.
- Limited adoption of asset management standardization such as ISO 55000.
- Digital business immaturity constrains organizational ability to support advanced asset maintenance capabilities.
- Market confusion from conflicting vendor claims overlaps with complementary products. These comprise Industrial Internet of Things (IIoT) platforms, EAM systems that also provide CbM and beyond, APM included as a part of digital twins, and OEMs including predictive analysis support.
- Whether the vendor and product have proven capabilities for your desired asset maintenance activities and classes of assets within your industry, and if they align with your asset management strategy.
- Importance of EAM in APM success: (1) there must be an interface to your EAM to be able to execute APM recommendations directly in the transactional EAM system; (2) your EAM systems must have good quality data; (3) some EAM vendors also have APM capabilities which may require significant customizations or may limit use with only their offered EAM product.

User Recommendations

- Assess the maturity of your EAM system and have a sustainable integration plan with your APM before investing in APM. Although newer EAM products include APM capabilities, CIOs should not expect to get all APM capabilities from the EAM vendors themselves.
- Identify a combination of asset maintenance capabilities to support a variety of asset types and situations across the business through a toolbox approach. Most vendors do not offer all levels of APM maintenance capabilities, across all industries and asset types. Thus organizations may need more than one APM product, depending on the complexity of their businesses, the types of assets and their asset maintenance goals.
- Ensure IoT and operational technology (OT) systems compatibility with the technical and process needs of reliability systems by getting involved in the planning of IoT monitoring of plants and equipment.
- Source good data — that is, historical service and operational data — organizations looking to invest in APM should also expect to make investments in information management infrastructure to capture operational data where it doesn't exist today.

Sample Vendors

AspenTech; AVEVA; Bentley Systems; GE Digital; Hitachi ABB Power Grids; IBM; SAP; SAS; Uptake

Gartner Recommended Reading

Market Guide for Enterprise Asset Management Software

Top Practices for Utility CIOs Evaluating Enterprise Asset Management Software

Market Guide for Asset Performance Management Software

Optimize Utility Capital Expenditures With Asset Investment Planning Solutions

Mapping a Route to Asset Management and Reliability

IT/OT Integration

Analysis By: Kristian Steenstrup

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

IT/OT integration is the end state sought by organizations (most commonly, asset-intensive organizations) where, instead of a separation of IT and OT as technology areas with different areas of authority and responsibility, there is integrated process and information flow. Integration includes infrastructure, software, and potentially resources.

Why This Is Important

Few organizations have a mature, systemic approach to IT/OT resource integration. For most, IT and OT are managed by separate groups with different approaches to technology and different vendors in use. Integration can be initiated by IT departments; however, operational business units may also seek integration when trying to solve other challenges such as dealing with cybersecurity, rising support costs, safety concerns, disaster recovery or software administration.

Business Impact

Opportunities and benefits from transparency and an integrated value chain based on data come from integrating the systems. As IT and OT platforms and technologies converge (become more alike) through increasing use of IT products within OT, a successful digital business manages both IT and OT together. There is shared responsibility, even though direct reporting lines may not shift. Data can be shared, and process flows become continuous and coherent, with minimal interruptions.

Drivers

The benefits of IT/OT integration for asset-intensive digital businesses will be organizations much more capable of managing, securing and exploiting data, information and processes.

- IT/OT integration results in integrated systems, processes and teams of people as technology domains with different areas of authority and responsibility come together.
- A common driver is for better reliability and maintenance strategies through more direct access to condition and use data for plants and equipment.

- Integrated operational intelligence will provide better production management, quality control, responses to events in the supply chain and more efficient production processes. The result will be a more agile and responsive organization.
- The data from OT systems will be the fuel for better decision making in areas such as operations (adjusting and responding to production events), energy consumption, material consumption, and product quality, safety and reliability.

Obstacles

- Historically, IT and OT had little contact as they have different reporting lines. Without incentives, this will not change.
- Completely integrated approaches to IT and OT are difficult to achieve because of the deeply rooted tradition in many businesses, where engineers and operations staff have been the “exclusive owners and operators” of OT.
- Many companies have disparate standards of technology in IT and OT, and even different standards for documenting the technologies, making initial planning difficult.
- An integrated data model spanning IT and OT rarely exists.

User Recommendations

- Evaluate the IT/OT integration challenges and benefits in your specific company.
- Achieve consensus across groups and with senior management, and create an alignment activity first to manage governance and standards. Sustainable integration needs well-planned IT/OT alignment.
- Add a more integrated approach to technology progressively. This integration should extend at least to data exchange and platform maintenance, with particular attention paid to communications, cybersecurity and enterprise architecture. In some companies, that commonality will lead to an organization no longer delineated between IT and OT.
- Initiate IT/OT alignment discussions to arrive at common standards for platforms, security and architecture.

Sample Vendors

Accenture; Cisco; Eurotech; NTT DATA; PTC; Rockwell Automation

Gartner Recommended Reading

The Importance of OT Integration for Industrie 4.0

Magic Quadrant for Industrial IoT Platforms

2020 Strategic Roadmap for IT/OT Alignment

Event Stream Processing

Analysis By: W. Roy Schulte, Pieter den Hamer

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Event stream processing (ESP) is computing that is performed on streaming data (sequences of event objects) for the purpose of stream analytics or stream data integration. ESP is typically applied to data as it arrives (data "in motion"). It enables situation awareness and near-real-time responses to threats and opportunities as they emerge, or it stores data streams for use in subsequent applications.

Why This Is Important

ESP is a key enabler of continuous intelligence and related real-time aspects of digital business. ESP's data-in-motion architecture is a radical departure from conventional data-at-rest approaches that historically dominated computing. ESP products have progressed from niche innovation to proven technology and now reach into the early majority of users. ESP will reach the Plateau of Productivity within several years and eventually be adopted by multiple departments within every large company.

Business Impact

ESP transformed financial markets and became essential to telecommunication networks, smart electrical grids and some IoT, supply chain, fleet management, and other transportation operations. Most of the growth in ESP during the next 10 years will come from areas where it is already established, especially IoT and customer experience management. Stream analytics from ESP platforms provides situation awareness through dashboards and alerts, and detects anomalies and other significant patterns.

Drivers

Five factors are driving ESP growth:

- Companies have ever-increasing amounts of streaming data from sensors, meters, digital control systems, corporate websites, transactional applications, social computing platforms, news and weather feeds, data brokers, government agencies and business partners.
- Business is demanding more real-time, continuous intelligence for better situation awareness and faster, more-precise and nuanced decisions.
- ESP products have become widely available, in part because open-source ESP technology has made it less expensive for more vendors to offer ESP. More than 40 ESP platforms or cloud ESP services are available. All software megavendors offer at least one ESP product and numerous small-to-midsize specialists also compete in this market.
- ESP products have matured into stable, well-rounded products with many thousands of applications (overall) in reliable production.
- Vendors are adding expressive, easy-to-use development interfaces that enable faster application development. Power users can build some kinds of ESP applications through the use of low-code techniques and off-the-shelf templates.

Obstacles

- ESP platforms are overkill for most applications that process low or moderate volumes of streaming data (e.g., under 1000 events per second), or do not require fast response times (e.g., less than a minute).
- Many ESP products required low-level programming in Java, Scala or proprietary event processing languages until fairly recently. The spread of SQL as a popular ESP development language has ameliorated this concern for some applications, although SQL has limitations. A new generation of low-code development paradigms has emerged to further enhance developer productivity but is still limited to a minority of ESP products.
- Many architects and software engineers are still unfamiliar with the design techniques and products that enable ESP on data in motion. They are more familiar with processing data at rest in databases and other data stores, so they use those techniques by default unless business requirements force them to use ESP.

User Recommendations

- Use ESP platforms when conventional data-at-rest architectures cannot process high-volume event streams fast enough to meet business requirements.
- Acquire ESP functionality by using a SaaS offering, IoT platform or an off-the-shelf application that has embedded CEP logic if a product that targets their specific business requirements is available.
- Use vendor-supported closed-source platforms or open-core products that mix open-source with value-added closed-source extensions for mainstream applications that require enterprise-level support and a full set of features. Use free, community-supported, open-source ESP platforms if their developers are familiar with open-source software and license fees are more important than staff costs.
- Use ESP products that are optimized for stream data integration to ingest, filter, enrich, transform and store event streams in a file or database for later use.

Sample Vendors

Amazon; Confluent; Google; IBM; Informatica; Microsoft; Oracle; SAS; Software AG; TIBCO Software

Gartner Recommended Reading

Market Guide for Event Stream Processing

Adopt Stream Data Integration to Meet Your Real-Time Data Integration and Analytics Requirements

Market Share Analysis: Event Stream Processing (ESP) Platforms, Worldwide, 2020

Managed IoT Connectivity

Analysis By: Pablo Arriandiaga

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Managed connectivity for IoT or machine-to-machine (M2M) services encompass connectivity hardware, software, and network and IT services that are generally bundled and managed by a third-party provider. These services enable enterprises to connect, monitor and control business assets and processes over a fixed or wireless connection. These services are key to informing and integrating purpose-built and stand-alone telematics systems, IoT platforms or legacy back-end IT and OT systems.

Why This Is Important

The market for cellular-based-managed IoT connectivity services, field-area networks (FANs) and satellite is mature, but enterprises are demanding a number of capabilities that are still quite nascent in this market:

- NB-IoT and LTE-M
- eSIM and iSIM
- 5G technology and its role in mobile edge computing
- Integration with hyperscalers
- Consumer or industrial connected products as most of managed connections are for connected commercial products such as automotive
- Bring-your-own connectivity scenarios

Business Impact

- Critical role in IoT solutions to support managing the complexity of endpoints and connectivity types, even though managed connectivity services are a small component of the end-to-end IoT solution
- Support broader IoT initiatives by ensuring use of appropriate and rightsized solution components, including edge devices and gateways, connectivity to the cloud, flexibility to encompass a variety of connectivity providers in a seamless way through technologies such as eSIM

Drivers

- NB-IoT and LTE-M: Expected adoption of NB-IoT and LTE-M has reduced dramatically the cost of the IoT connectivity and modules continue to accelerate due to national deployments in big countries such as China with NB-IoT or the U.S. with both networks. Roaming agreements, mainly for LTE-M, have grown significantly during this last year. Enterprises look for guarantees in terms of standard and broadly adopted connectivity for devices and sensors that could have a lifetime of 10 years versus proprietary technologies such as Sigfox or LoRa WAN.

- Platform of platforms: Multinational companies where IoT connectivity is a critical element of their strategy for connecting their products and assets in a secure way. As IoT connectivity commoditizes, managed IoT connectivity services and platforms increase relevance to be connectivity agnostic and provide flexibility to multinationals. This can be achieved with a sustainable managed IoT connectivity platform strategy that can be integrated with the rest of the IoT infrastructure without the risk of changing the connectivity provider. This is what Gartner calls the platform of platforms.

- Connected industrial products are starting to emerge with the convergence of IT/OT, and most of the vendors on the market are shifting priorities to serve the manufacturing industry beyond their traditional play in connected vehicles. Apart from traditional industry verticals in the managed IoT connectivity services market like transportation or utilities, other industry verticals like healthcare, insurance or retail that were underserved by this market are getting relevance as they are accelerating their digital transformation.

- Edge compute, 5G and private mobile networks in IoT will accelerate the adoption of managed IoT connectivity services as enterprises and providers are increasing the number of use cases being tested across different industry verticals for their digital transformation initiatives.

Obstacles

- Lack of understanding of the benefits of 3GPP and non-3GPP LPWA networks by enterprises and its availability, where many times it is confused with 5G. 3GPP and non-3GPP LPWA networks provide low revenue for connectivity to vendors that have a lack of end-to-end skills in industry verticals where these technologies could scale and don't promote it.
- 3GPP LPWAN global deployments needing roaming and interoperability that will need at least one year to mature.
- eSIM: MNOs are still reluctant to deploy eSIM for IoT and open their networks to third parties, allowing enterprises better mechanisms to bring-your-own-connectivity scenarios.
- Integration with hyperscalers and IoT platform providers is in very early stages, so enterprises can't access a seamless management of connectivity and devices under a single pane of glass. This splits the purchasing process of managed IoT connectivity services as a separate part of the IoT solution.

User Recommendations

Companies that are considering managed IoT connectivity services should consider the following recommendations:

- Identify vendors that could add more value on top of connectivity. Assess whether bundled solutions can be more cost-effective when including point solutions. Verticals that are well-served in this market are automotive, transportation and logistics, utilities or smart cities but increasingly manufacturing, retail and healthcare, as well.
- Evaluate cellular and 3GPP LPWAN capabilities by requesting specific agreements with local providers, global points of presence to avoid latency and flexibility through multi-IMSI, eSIM and iSIM to add third-party connectivity into vendors' managed IoT connectivity platforms (platform of platforms).
- Assess the evolution of the vendors' roadmaps and ecosystem by ensuring they include edge and cloud integration, APIs availability natively integrated with hyperscalers, and roadmap for 5G and private mobile networks.

Gartner Recommended Reading

Magic Quadrant for Managed IoT Connectivity Services, Worldwide

Critical Capabilities for Managed IoT Connectivity Services, Worldwide

Tech Providers 2025: Edge Ecosystems Will Challenge CSPs' Dominance in Managed IoT Connectivity Services

Building Information Modeling

Analysis By: Marc Halpern, Bettina Tratz-Ryan

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Building information modeling (BIM) is the discipline supported by software to capture, organize and manage information needed to design, create, evolve and operate facilities from earliest conception to demolition.

Why This Is Important

Organizations in many industry sectors including construction, government, manufacturing and retail need better means of organizing and accessing content about their facilities to streamline facilities design, construction, management, operations, modernization and demolition. Increases in regulations governing facilities design, construction, operations and maintenance compounded by the number of roles involved in these activities require better means of managing and accessing information.

Business Impact

BIM delivers the following benefits:

- Reduces lost time and unnecessary costs associated with using wrong or out-of-date content throughout the life cycles of facilities
- Improves ability to find and access content to support any activity such as facilities design, construction, operation, upgrade, maintenance and demolition of facilities
- Improves collaboration across many roles responsible for the life cycles of facilities
- Enhances sustainability and circularity over the life cycles of facilities

Drivers

- As the costs of constructing and operating facilities continue to rise, facilities owners, construction firms and operators seek means to make life cycle activities more efficient, reducing cost and time.
- 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.
- Technology advances and growing experience with BIM encourages more companies to adopt it.
- Prevalence of SaaS for other business software encourages cloud-native BIM.
- Manufacturers, utilities and architectural engineering and construction firms seek better means of complying to a growing number of regulations that they believe BIM will support more efficiently.
- Stakeholders in facilities seek to reduce costly mistakes with BIM by enabling better access to more timely and accurate information.
- BIM enables improved collaboration across roles participating in life cycle activities from remote locations.

Obstacles

- Manufacturers are deeply invested in their current culture and processes, making it difficult to adapt to new ways of working that BIM requires.
- Reaching consensus on BIM priorities and architecture proves challenging given the number of roles both inside and outside an enterprise involved.
- BIM champions struggle to make compelling business cases for the investment.
- Building BIM content in proprietary design software formats will decrease its utility over time, cause vendor lock-in and increase the cost to maintain BIM.
- BIM projects will fail if scope creep creates higher-than-expected costs and lower-than-expected ROI. Insufficient supplier, partner and customer participation in BIM initiatives can lead to gaps in key content. Inflexible or incorrect BIM model design undermines future usefulness or possibly makes them obsolete before the end of a facility's service life.

User Recommendations

- Reduce the risk of failed BIM implementations by phasing the implementations into smaller, focused projects that build upon each other.
- Structure BIM initiative using governance or maturity models (see How to Achieve Better Business Model Strategies With Industry Data Governance). Use both the BSI Levels 0 through Level 4, and incorporate 2D BIM to 7D BIM categories of data as the company moves from one level of BIM maturity to the next.
- Address BIM data architecture challenges by assigning IT architects to work with key BIM stakeholders.
- Encourage BIM adoption by redefining job performance metrics that encourage potential users to adopt BIM.
- Assign a BIM lead to run a project defining corporate standards for creating and modifying BIM models, and establish a training program to educate the user community.

Sample Vendors

Autodesk; Bentley Systems; Hexagon (Intergraph); Nemetschek Group; RIB Group

Gartner Recommended Reading

Innovation Insight for Model-Based System Engineering

Predicts 2021: Manufacturing Digitalization Roadmap for Agility and Revenue Generation

How to Achieve Better Business Model Strategies With Industry Data Governance

IoT Integration

Analysis By: Benoit Lheureux

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

IoT integration refers to the integration strategies and technologies needed to assemble end-to-end IoT-enabled business solutions. IoT-specific integration challenges include integrating IoT devices, operational technology (OT), digital twins and multiple IoT platforms. More traditional IoT project integration challenges include integrating IoT applications and digital twins with enterprise applications, data, business processes, SaaS applications, B2B ecosystem partners and mobile apps.

Why This Is Important

Every IoT project requires significant integration work — some unique to IoT projects — to enable IoT devices, IoT applications and various existing business applications to work well together. In a recent survey, a majority (71%) of companies reported that they made moderate to major investments in their integration strategy to support IoT projects (see Survey Analysis: Companies Recognize Integration as a Key Competency for Internet of Things Projects).

Business Impact

- IoT integration is an essential functional requirement for all IoT projects.
- All software engineering leaders (SWELs) and application leaders responsible for IoT projects must address IoT integration, and to successfully deliver IoT products, they will either have to train or hire software engineers with unique-to-IoT integration skills.
- Special integration skills and tools are often needed for IoT projects (e.g., for OT integration).

Drivers

- Extraordinary IoT project technology heterogeneity — e.g., multiple types and OEMs offering IoT devices, brand-new and decades-old products and equipment, diverse IoT device data heterogeneity, and diverse applications systems to be integrated.
- A proliferating desire to ingest and analyze IoT data to support data-driven business decisions.
- Proliferation of IoT projects (for which IoT integration is always required).
- IoT integration is a key challenge for IoT projects. A Gartner survey found that companies can't rely on a "one-size-fits-all" approach to IoT device integration, and had to integrate their IoT projects with many different types of IT endpoints (see Survey Analysis: Companies Recognize Integration as a Key Competency for Internet of Things Projects).
- To fully realize the benefits of IoT, companies will eventually need to integrate new IoT technologies with legacy (i.e., pre-IoT) business applications and software using new, enhanced workflow (see How Can Organizations Integrate IoT Digital Twins and Enterprise Applications?).
- Complex, distributed IoT projects often involve a mix of IoT devices, IoT platforms, business applications, mobile apps, cloud services and (often) external business partners. Such complex IT projects are needed to enable new IoT-enabled outcomes — e.g., self-diagnosing and self-repairing assets and equipment, "lights-out-manufacturing," or product-as-a-service.
- The need for owner-operators in heavy-asset industries (e.g., manufacturing, utilities, oil and gas production) to integrate IoT-connected devices and digital twins hosted on multiple IoT platforms.
- A growing need to align time-series data generated by various IoT-connected assets and equipment with traditional EAM master data (e.g., BOM) for the same assets and equipment.
- Performance and scalability — that is, potentially large numbers of IoT devices, products and equipment with high API throughputs and large volumes of time series data must be integrated.

Obstacles

- SWELs tend to focus on building software engineering teams for IoT projects with skills in IoT data, applications and analytics — rather than skills in IoT integration.
- Few engineers have IoT software development skills, and even fewer have IoT integration skills.
- TSPs investing in IoT products (e.g., IoT platforms) tend to focus more on IoT data, applications and analytics, rather than on integration, which creates integration functionality gaps.
- A function gap among many general-purpose integration tools (e.g., ESB, iPaaS) for many of the IoT-specific integration needs of IoT projects (e.g., IoT devices, OT equipment or LOB applications such as MES). While many integration tools support modern IoT device protocols (e.g., APIs, MQTT and OPC-UA), most cannot connect to older, "brownfield" OT equipment.
- IoT integration products focused on OT integration (e.g., OSIsoft, Skkynet) may be needed and must be licensed separately.
- Perceived high cost of IoT-specific integration tools or services.

User Recommendations

SWELs for IoT projects should:

- Clearly identify what IoT integration functionality is needed for IoT projects (see Survey Analysis: Companies Recognize Integration as a Key Competency for Internet of Things Projects).
- Avoid simplistic approaches to IoT integration (e.g., "APIs = integration") that cannot, alone, address all your needs (e.g., does not also address functionality such as IoT data translation, OT integration).
- Hire and/or train software engineers with IoT integration skills.
- Confirm the availability of required IoT integration capabilities for any IoT product or service (see Critical Capabilities for Industrial IoT Platforms).
- Modernize your B2B integration strategy (either via EDI or APIs — see Use APIs to Modernize EDI for B2B Ecosystem Integration) to enable IoT project integration with business partners.

- Align your IoT integration skills with your company's overall integration strategy (see How to Deliver a Truly Hybrid Integration Platform in Steps).

Sample Vendors

Alleantia; Dell Boomi; Informatica; Microsoft; Reekoh; Salesforce (MuleSoft); Sky Republic; SnapLogic; Software AG; Solace

Gartner Recommended Reading

Survey Analysis: Companies Recognize Integration as a Key Competency for Internet of Things Projects,

What Should I Do To Ensure Digital Twin Success?

Critical Capabilities for Industrial IoT Platforms

Use APIs to Modernize EDI for B2B Ecosystem Integration

How to Deliver a Truly Hybrid Integration Platform in Steps

Use the IoT Platform Solution Reference Model to Help Design Your End-to-End IoT Business Solutions

Entering the Plateau

Smart Lighting

Analysis By: Nick Jones

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Definition:

Smart lighting is a lighting system connected to a network that can be monitored and controlled from a centralized point or via the cloud. These systems typically include controls, connectivity, analytics and intelligence. They usually exploit LED technology for energy efficiency. Advanced smart lighting systems can also integrate Bluetooth beacons, support location tracking, provide sensor information to other systems and (in a few cases) deliver networking using Li-Fi.

Why This Is Important

Smart lighting provides substantial energy savings compared to “dumb” lighting by combining energy-efficient LEDs with dynamic control systems. Some smart lighting systems include features such as spectrum control for visual effects or circadian lighting. Also, the light fittings, networks and control systems for smart lighting can support a range of sensing and wireless communications technologies for smart building or smart city applications.

Business Impact

- Energy-efficient dynamic lighting to improve citizen safety and quality of life
- High-quality indoor lighting that can be integrated with building management systems to optimise smart building energy usage
- Customisable or circadian lighting to improve the working environment
- Spectrum-controlled lighting for decorative indoor and outdoor effects
- Reduced maintenance costs by networked monitoring

Drivers

- Sustainability demands, which require more efficient use of energy, with up to 70% less energy consumption with the usage of smart lighting
- Need for operational cost reduction in managing and maintaining indoor and outdoor lighting systems
- Need to improve quality of life in indoor offices or outdoor public spaces
- A desire for potential health and well-being benefits from circadian lighting
- A need for sensing and communications to deliver new capabilities such as utilisation sensing, workplace analytics and indoor navigation
- Opportunity to use the control network as a backbone network for smart city sensing
- A desire to improve occupant satisfaction and convenience, by providing personal and dynamic control over lighting levels and effects
- Financial savings from innovative “light as a service” business models that reduce the capital cost of deployment or retro fitting into existing buildings
- Ability of smart lighting to provide data networking services in a few cases using Li-Fi, although this is rather niche

Obstacles

- High capital cost to replace existing indoor or outdoor lighting systems
- Li-Fi integrated with smart lighting being niche because it provides limited value
- The need to adopt new strategies for using and controlling lighting and the spaces it supports, to gain the maximum benefits
- Challenges of cost-justifying intangible benefits in the areas of working conditions and well-being
- Use of proprietary communications and control protocols by many smart lighting systems, limiting interoperability and creating large integration costs with other systems such as building management

User Recommendations

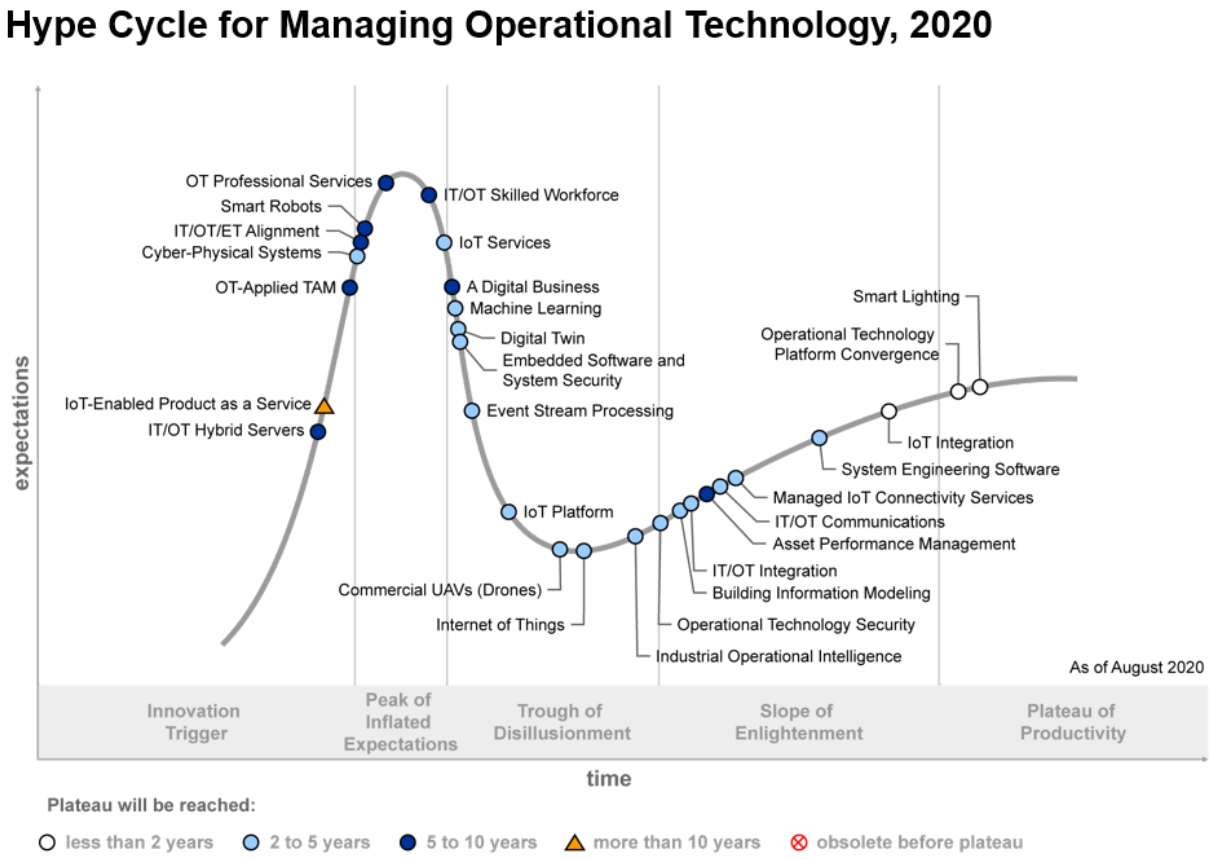
- Replace legacy street lighting with smart lighting systems to reduce operational costs, achieve sustainability goals and improve citizen experiences. (Recommended for city administrators.)
- Replace indoor lighting systems with smart lighting in offices and factories to improve the working environment and save money. Look for vendors that can provide business models that reduce the capital cost. (Recommended for facilities managers.)
- Ensure there is a business and technology solution to obtain sensor and operational data from new smart lighting system deployments to support goals such as integration with space booking and workplace space optimisation systems. (Recommended for CIOs.)

Sample Vendors

Acuity Brands; OSRAM; Signify; Telensa

Appendixes

Figure 2: Hype Cycle for Managing Operational Technology, 2020



Source: Gartner
ID: 450227

Gartner

Source: Gartner (August 2020)

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 (July 2021)

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 (July 2021)

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 (July 2021)

Evidence

[1] 2021 Gartner CIO Survey.

Document Revision History

Hype Cycle for Managing Operational Technology, 2020 - 13 August 2020

Hype Cycle for Managing Operational Technology, 2019 - 31 July 2019

Hype Cycle for Managing Operational Technology, 2018 - 26 July 2018

Hype Cycle for Managing Operational Technology, 2017 - 25 July 2017

Hype Cycle for Managing Operational Technology, 2016 - 20 July 2016

Hype Cycle for Managing Operational Technology, 2015 - 3 August 2015

Hype Cycle for Operational Technology, 2014 - 23 July 2014

Hype Cycle for Operational Technology, 2013 - 31 July 2013

Hype Cycle for Operational Technology, 2012 - 30 July 2012

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

Market Guide for Operational Technology Security

OT Security Best Practices

Alternative Organizational Models for IT/OT Alignment

Manufacturing Insight: How to Position Hybrid IT/OT Offerings

2020 Strategic Roadmap for IT/OT Alignment

The Importance of OT Integration for Industrie 4.0

How IT Standards Can Be Applied to OT

When Does a CIO Need to Be Involved in OT?

Predicts 2021: Manufacturing Digitalization Roadmap for Agility and Revenue Generation

Table 1: Priority Matrix for Managing Operational Technology, 2021

Benefit ↓	*Years to Mainstream Adoption*			
	Less Than 2 Years ↓	***2 - 5 Years*** ↓	***5 - 10 Years*** ↓	***More Than 10 Years*** ↓
Transformational		Cyber-Physical Systems Digital Twin Event Stream Processing IoT Machine Learning		IoT-Enabled Product as a Service
High	IoT Integration Smart Lighting	Building Information Modeling Industrial Operational Intelligence IoT Platform IoT Services IT/OT Integration Managed IoT Connectivity OT Security	Asset Performance Management IT/OT/ET Alignment IT/OT Hybrid Servers Light Cargo Delivery Drones OT Professional Services Smart Robots	
Moderate		3D Printing of Industrial Parts IT/OT Communications	OT-Applied TAM	
Low				

Gartner (July 2021)

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