The merging of IT (Information Technology) and OT (Operational Technology) in the smart factory, often referred to as IT/OT convergence, is a fundamental aspect of Industry 4.0. It signifies the integration of traditional business-focused IT systems with the real-time, physical-process-focused OT systems that control and monitor industrial operations. This convergence is crucial for creating the interconnected, data-driven, and automated environment of a smart factory.

Here's a detailed explanation:

**Understanding IT and OT:**

- **OT (Operational Technology):**
  - Focuses on directly controlling and monitoring physical processes.
  - Involves systems like SCADA, PLCs, HMIs, and sensors.
  - Prioritizes real-time performance, reliability, and safety.
  - Historically, OT systems were isolated and proprietary.
- **IT (Information Technology):**
  - Focuses on managing and processing information for business operations.
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  - Prioritizes data integrity, security, and scalability.
  - Historically, IT systems were more open and standardized.

**The Need for Convergence:**

- **Data-Driven Decisions:**
  - Smart factories generate massive amounts of data from OT systems. IT systems provide the tools to analyze this data and extract valuable insights for optimizing production, maintenance, and supply chain management.
- **Real-Time Visibility:**
  - IT/OT convergence enables real-time visibility into all aspects of the production process, from raw materials to finished goods. This allows for faster response to changes and improved decision-making.
- **Automation and Optimization:**
  - Integrating IT and OT systems allows for greater automation of processes and optimization of production schedules. For example, ERP systems can send

production orders directly to MES systems, which can then control PLCs and robots on the shop floor.

- **Predictive Maintenance:**
  - Combining sensor data from OT systems with analytics tools from IT systems enables predictive maintenance, reducing downtime and improving equipment reliability.
- **Enhanced Security:**
  - While OT systems were historically isolated, now that they are connected to networks they are also vulnerable to cyberattacks. IT security best practices can be applied to OT systems to improve overall security.
- **Flexibility and Agility:**
  - IT/OT convergence enables greater flexibility and agility in manufacturing operations, allowing companies to quickly adapt to changing market demands and customer needs.

**Key Aspects of IT/OT Convergence:**

- **Network Integration:**
  - Connecting OT networks to IT networks using standard protocols (e.g., Ethernet, TCP/IP).
- **Data Integration:**
  - Sharing data between OT and IT systems using APIs, data lakes, and other integration technologies.
- **Security Integration:**
  - Implementing unified security policies and procedures across IT and OT environments.
- **Platform Integration:**
  - Using cloud platforms and other integration platforms to connect and manage IT and OT systems.
- **Organizational Alignment:**
  - Breaking down silos between IT and OT teams and fostering collaboration.

**Challenges of IT/OT Convergence:**

- **Security Risks:**
  - Connecting OT systems to IT networks increases the risk of cyberattacks.

- **Legacy Systems:**
  - Integrating legacy OT systems with modern IT systems can be challenging.
- **Skills Gap:**
  - Requires a workforce with skills in both IT and OT.
- **Cultural Differences:**
  - IT and OT teams often have different cultures and priorities.
- **Reliability vs. Security:**
  - OT prioritizes uptime, and IT prioritizes security, sometimes these two goals conflict.

**In summary:**

The merging of IT and OT is a critical enabler of the smart factory. It allows for the creation of a data-driven, interconnected, and automated environment that can optimize production, improve efficiency, and enhance competitiveness. However, it also presents challenges that must be addressed to ensure security, reliability, and successful implementation.

| Feature | IT (Information Technology) | OT (Operational Technology) |
|---|---|---|
| Primary Focus | Data processing, storage, and communication; Information management | Monitoring and control of physical processes; Automation |
| Data Type | Structured data (databases, spreadsheets, etc.); Information | Unstructured data (sensor readings, machine data, logs); Real-time data |
| Data Volume | Often large volumes, but less real-time critical | High volume, often real-time critical; Time-series data |
| Data Latency | Tolerance for some latency; Batch processing acceptable | Low or no latency tolerance; Real-time crucial for control |
| Connectivity | Primarily networked (Ethernet, Wi-Fi, Cloud) | Often uses industrial protocols (Modbus, Profibus, etc.); Fieldbus networks;<br>Legacy systems |
| Security | Focus on data confidentiality and integrity; Protection from data breaches | Focus on safety, availability, and real-time performance; Prevention of process disruption and physical damage |
| Environment | Controlled, office or data center environment | Harsh, industrial environments (factories, power plants, etc.) |
| Hardware | General-purpose computers, servers, network devices | Specialized hardware (PLCs, RTUs, HMIs, industrial PCs) |
| Software | Operating systems, applications, databases, middleware | Specialized control software (SCADA, DCS, historians, embedded systems) |
| Users | Office workers, IT professionals, data scientists | Engineers, operators, technicians, process control specialists |
| Maintenance | Scheduled maintenance, software | Reactive and preventative maintenance, often on-site; Long |

| | | |
|---|---|---|
| | updates, patching | maintenance windows |
| Lifespan | Relatively short (3-5 years) | Long lifespan (10-20 years or more); Obsolescence a challenge |
| Scalability | Designed for scaling up and out; Cloud-native solutions | Scalability can be limited by physical constraints and legacy systems |
| Priority | Data and information availability; Business continuity | Process uptime and safety; Real-time control and reliability |
| Change Management | Controlled and documented changes; Agile methodologies | Highly regulated change management processes; Strict validation and testing |
| Cybersecurity | Focus on data breaches, malware, ransomware; Compliance regulations | Focus on preventing disruption of physical processes, safety incidents, and environmental damage; Operational resilience |
| Examples | Email, CRM systems, ERP systems, cloud platforms | SCADA systems controlling manufacturing equipment, PLCs in a power plant, smart grid systems |
| Key Metrics | System uptime, data throughput, application performance | Process efficiency, production output, safety incidents, equipment availability |

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## Top 15 Smart Factory KPIs

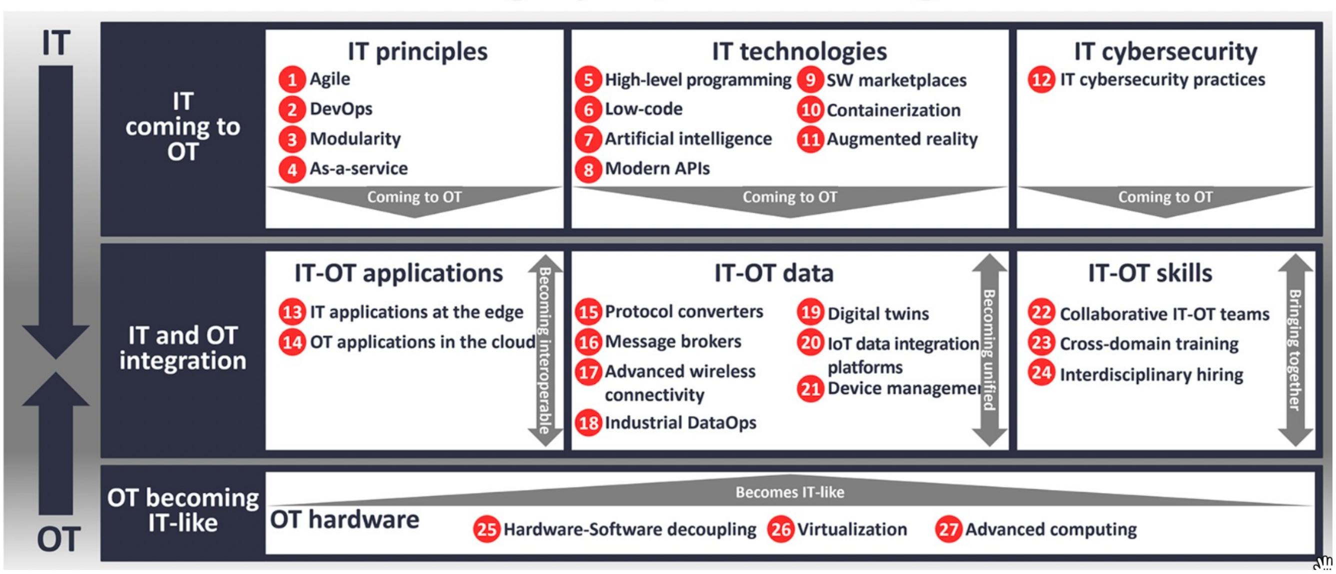
| Rank | KPI | Group | Importance[1] | Ambition[2] |
|---|---|---|---|---|
| 1 | Increase in overall equipment effectiveness (OEE) | Operational | 86% | ★★★ |
| 2 | Increase in labor efficiency | Operational | 79% | ★★★ |
| 3 | Increase in output | Operational | 78% | ★★ |
| 4 | Decrease in costs | Operational | 77% | ★ |
| 5 | Increase in quality | Operational | 76% | ★★★ |
| 6 | Increase in supply chain resiliency | Supply Chain | 73% | ★★★ |
| 7 | Increase in revenue | Marketing & Sales | 69% | ★★ |
| 8 | Increase in on-time delivery | Operational | 69% | ★★ |
| 9 | Decrease in reported safety incidents | Safety | 67% | ★★★★ |
| 10 | Increase in operational resiliency | Operational | 64% | ★★ |
| 11 | Increase in customer satisfaction | Marketing & Sales | 63% | ★★★★ |
| 12 | Decrease of waste | Sustainability | 63% | ★★★★ |
| 13 | Increase in ROE/ROCE | Finance | 63% | ★ |
| 14 | Increase in market share / market penetration | Marketing & Sales | 59% | ★ |
| 15 | Decrease in inventory levels | Finance | 57% | ★★ |

... of 27 measured KPIs in total

Very important / Important

| Status quo | Future paradigm | Importance | What it will mean |
|---|---|---|---|
| Many manual processes | Scalable | ★★★★★ | Expand as demand grows, replicate across sites |
| Unique and restricted local setup | Automated | ★★★★★ | Autonomous processes with little human interaction |
| System/machine service dependent on few individuals | Serviceable | ★★★★★ | Ease of maintenance, troubleshooting, support |
| Limited access | Accessible | ★★★★★ | Providing intuitive / low-code interfaces and tools to use workflows and applications |
| Rigid and monolithic systems | Modular / Flexible | ★★★★½ | Separate, self-contained units |
| Proprietary and isolated systems | Interoperable | ★★★★½ | Seamless communication between tech components |


## The 27 themes making up IT/OT convergence




**Scalability –** 72% of respondents want a seamless ability to expand and scale down in response to market demand.

**Automation –** 70% of respondents want technology to perform tasks previously done manually.

**Serviceability –** 67% of respondents want ease with which factory equipment and systems could be maintained and repaired to help overcome skill labor gaps.

**Accessibility –** 62% of respondents want to provide easy access to factory data and controls using user-friendly interfaces and tools.

**Modularity and flexibility –** 58% of respondents want processes and systems to be designed for easy reconfiguration and adaptation to new products or processes.

**Interoperability –** 58% of respondents want differing systems, devices, and applications to work seamlessly, from the factory floor to the cloud.

**For industrial software vendors**: As manufacturers adopt modern edge computing, cloud integration, and software-defined automation, vendors must support modular architectures, real-time data processing, and API-driven interoperability to stay competitive.

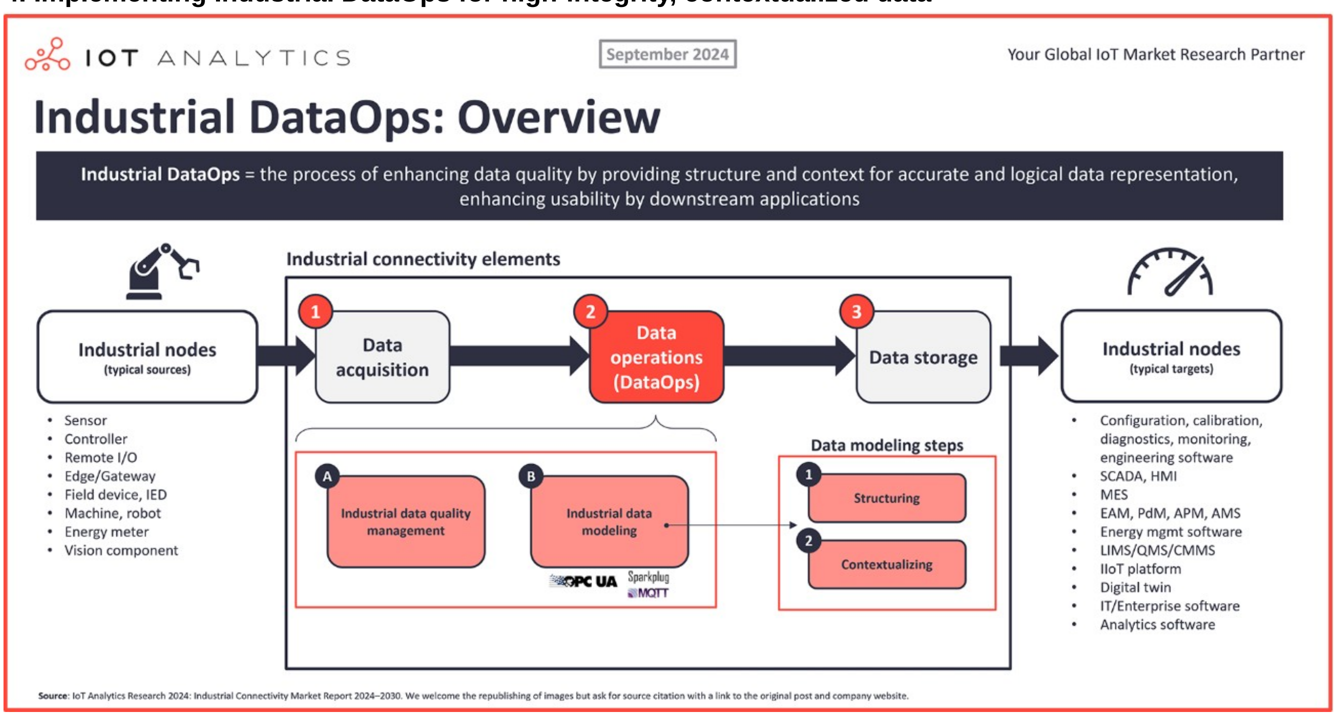
**For manufacturers**: To stay competitive, **manufacturers should adopt software-defined solutions** that seamlessly connect IT and OT. Virtual PLCs, industrial DataOps, and lightweight communication protocols increase flexibility, reduce downtime, and improve data-driven decision-making.

**1. Breaking down IT/OT silos with modern integration strategies**

**2. Extending ISA-95 for software-driven, real-time manufacturing**

**3. Deploying edge AI to enable real-time intelligence at the OT layer**

**4. Implementing Industrial DataOps for high-integrity, contextualized data**



**5. Scaling industrial connectivity with lightweight communication protocols**

**6. Modernizing industrial software through cloud and edge advancements**

**7. Advancing virtual PLCs for flexible, software-defined industrial control**

**8. Enhancing cybersecurity with embedded, software-driven protection**

### Analyst takeaway

The shift toward software-defined manufacturing is accelerating as manufacturers prioritize automation, scalability, and interoperability in their tech stacks. IT/OT convergence, industrial DataOps, cloud-edge architectures, and virtual controllers are fundamentally reshaping industrial automation, driving a move away from rigid, hardware-dependent systems.

**For industrial software vendors**, success will require fully embracing API-driven, containerized, and modular architectures that enable real-time data processing and seamless interoperability across IT and OT environments. The shift is not just about selling software—it is about building open, scalable ecosystems that manufacturers can integrate with their existing operations. OT vendors should take inspiration from IT platforms like **Salesforce**, **ServiceNow**, and **Databricks**, which have built API-first, data-centric ecosystems that seamlessly connect multiple enterprise applications. A similar approach in industrial automation would unlock greater flexibility, faster deployment cycles, and improved data contextualization.

**For manufacturers,** investing in software-defined automation is no longer optional—it is a competitive necessity. Those that fail to modernize their control architectures, connectivity strategies, and data pipelines risk being left behind in an era where agility and intelligence define industrial success. Companies in the automotive sector—particularly EV-first players like **Tesla**—are at the forefront, using software-defined MES, edge-driven analytics, and AI-powered quality control to increase production agility. Similarly, **Foxconn** has set the benchmark for IT-OT integration at scale, leveraging cloud-driven MES, software-defined robotics, and digital twins to reconfigure factories based on shifting market demands.

**The lesson is clear:** Industrial automation can no longer be hardware-first. The future belongs to software-defined, real-time, and adaptive manufacturing ecosystems that mirror the success of IT in building flexible, API-driven architectures.