The Journey Towards Remote and Autonomous Operations

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Agenda

1. IA2IA Background
2. End-User Focus Areas
3. Use Cases
4. IA2IA Building Blocks
5. Path to Autonomous Operations
6. Summary

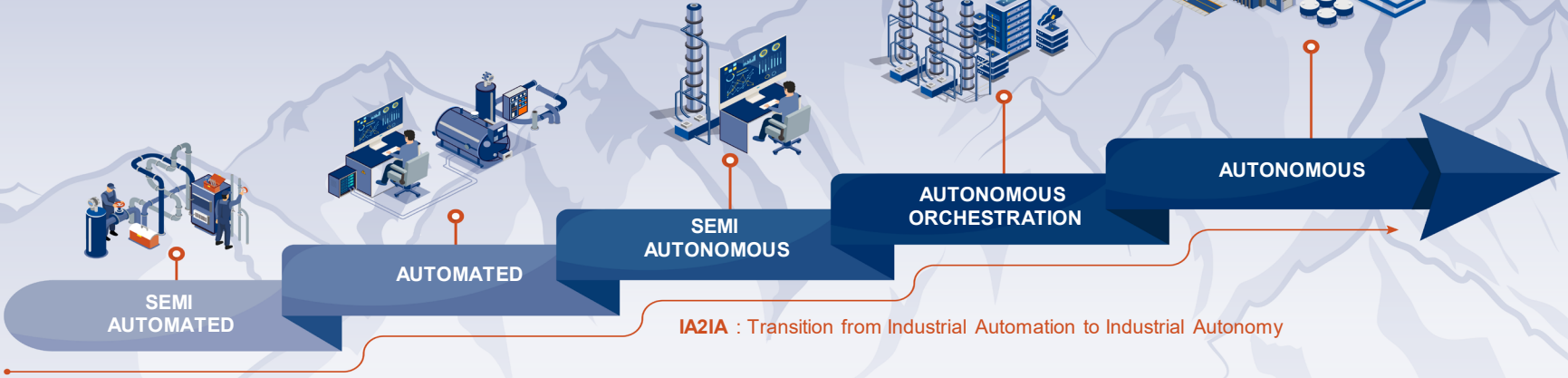
AUTONOMOUS OPERATIONS:

The vision from Yokogawa on Smart Manufacturing

OpreX™

With its **OpreX** products, services, and other solutions, Yokogawa is helping its customers with a way forward for the creation of value that leads to industrial autonomy

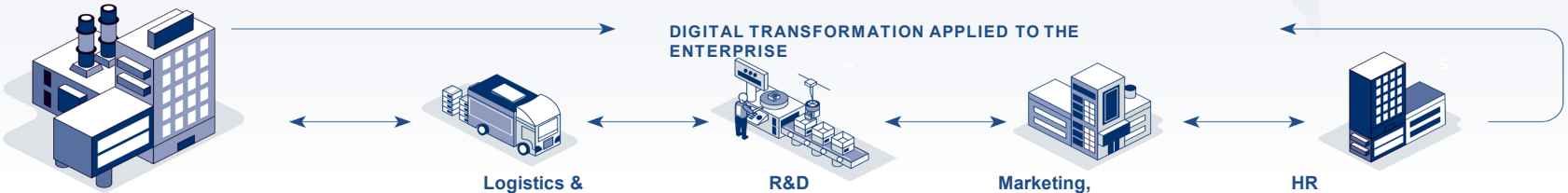
Through co-**innovation**, Yokogawa creates new value with our clients for a brighter future.



IA2IA : Transition from Industrial Automation to Industrial Autonomy

SMART MANUFACTURING

Digital transformation applied to Production & Manufacturing



Industrial Autonomy Maturity Model

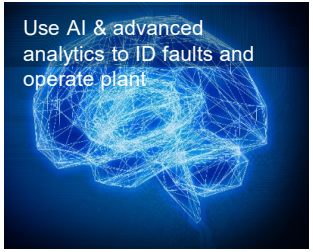
IA2IA

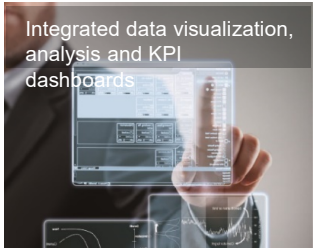
	Autonomy Level	Stage	Attribute
Industrial autonomy	5	Autonomous Operations	The facility is completely autonomous including process operations, supply chain, etc. System of systems
	4	Autonomous Orchestration	The facility operates autonomously, synchronized to optimize manufacturing and safety under most circumstances. Autonomous systems
	3	Semi-Autonomous	A mixture of autonomous and automated assets with human orchestration. Autonomous components
Industrial automation 	2	Automated	Humans are responsible for safe operations, assisted by traditional automation systems
	1	Semi-Automated	Humans and automation systems share the workload, with humans responsible for safe operations.
	0	Manual	Humans control the facility at all times.

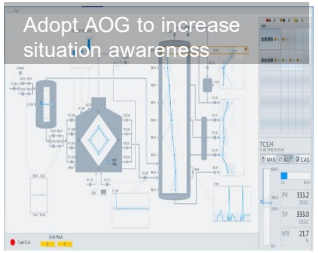
Unattended Ops

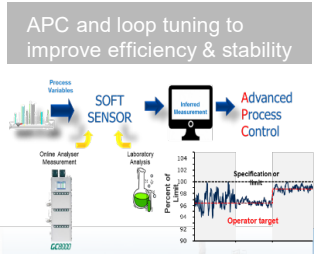
Remote Ops

Remote Operations

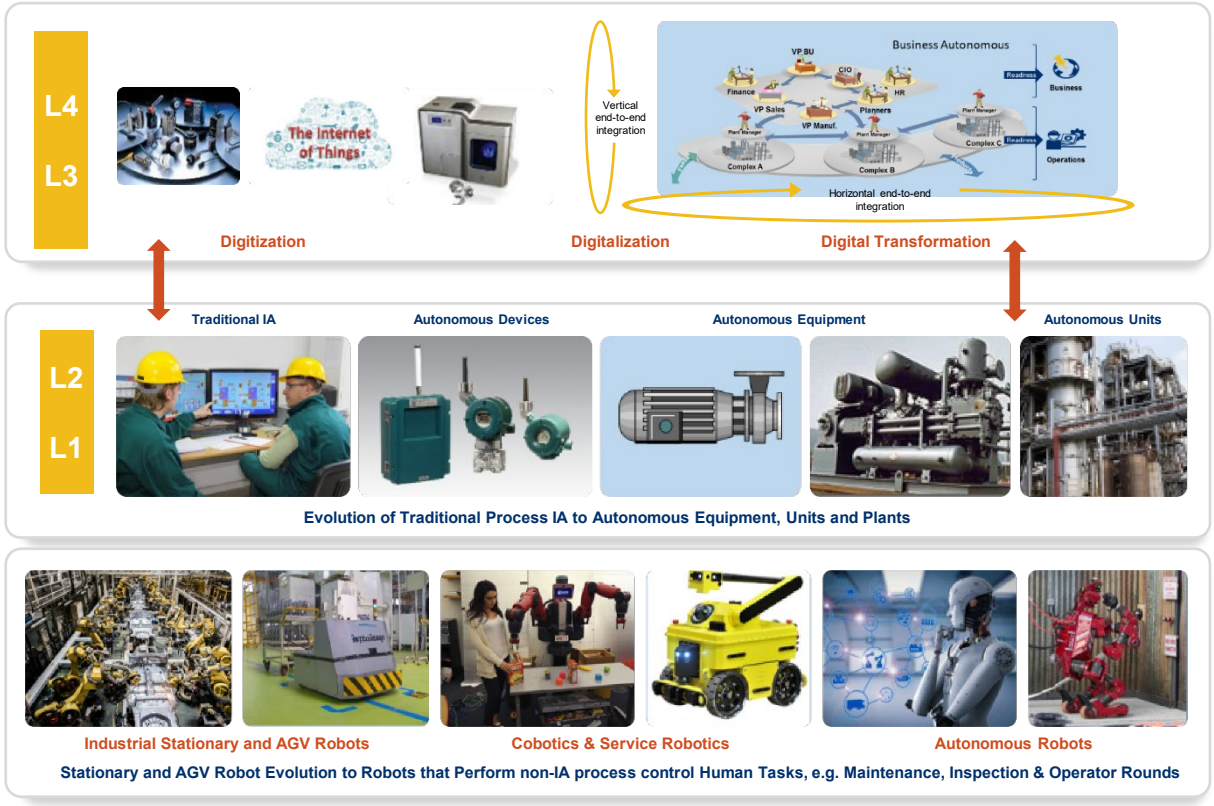








Autonomous Operations Vision



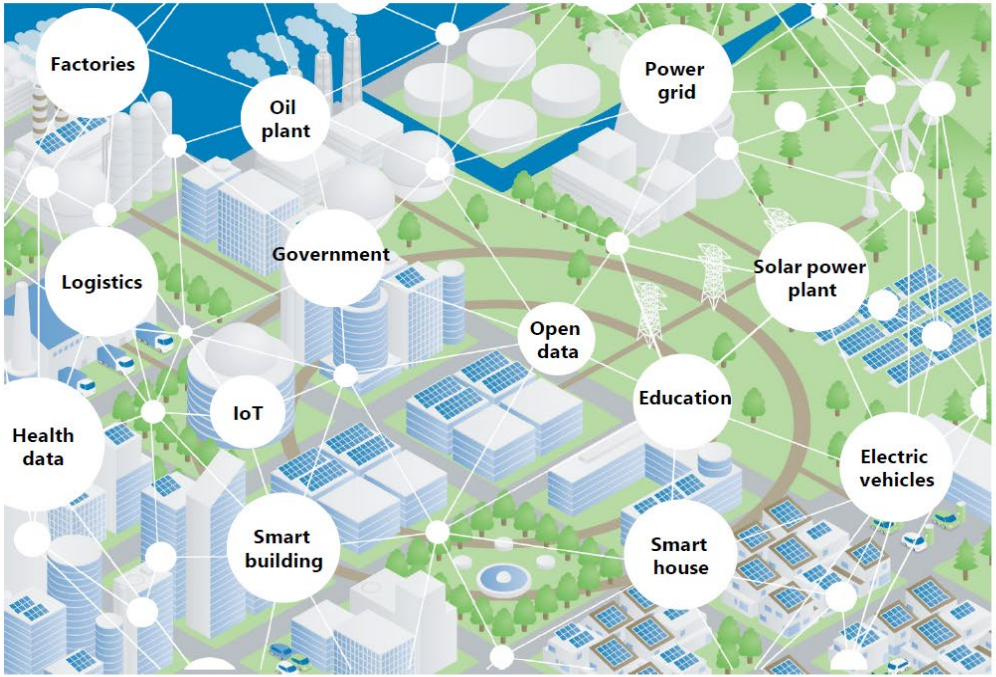
Autonomous Plants

- **IA2IA**
  - Enhances capabilities in multiple areas
  - Enhances worker productivity
- **Autonomy in multiple domains:**
  - Production optimization
  - Asset management and reliability
  - Prescriptive maintenance
  - Self-diagnosis and self-healing
  - Value chain optimization
  - Safety
  - Environmental compliance
  - Inventory management
  - Quality assurance
  - Energy management
  - Business and profit optimization

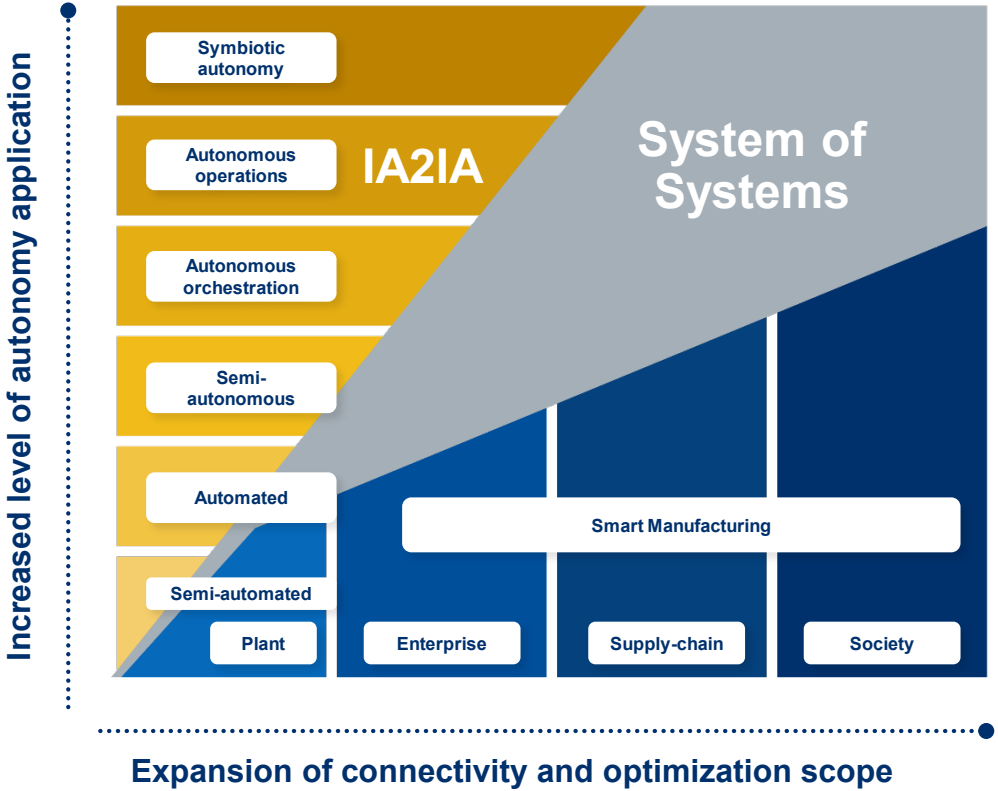
The Global Trend toward System of Systems

System of Systems

Everything is inter-connected in complicated ways, and the components function as independently operated and managed systems that work together to achieve a purpose that cannot be achieved by any single system.

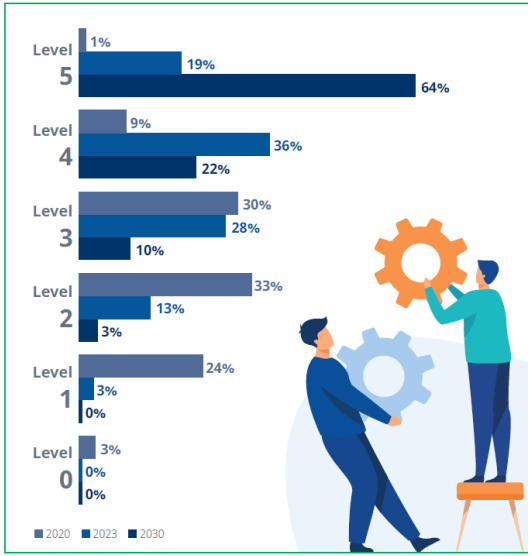


Extending Autonomous Functionality



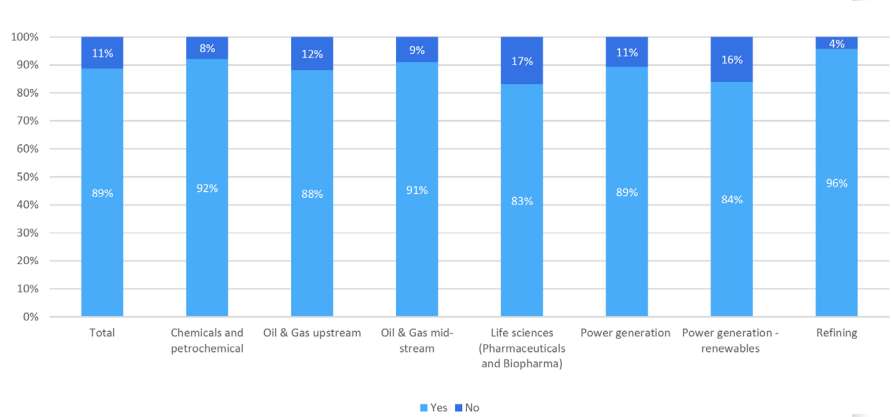
End-Users' Perspective

Levels of autonomy reached by end-users



Source: Omdia survey of more than 500 digital transformation leaders that was commissioned by Yokogawa

Industry adoption of autonomy



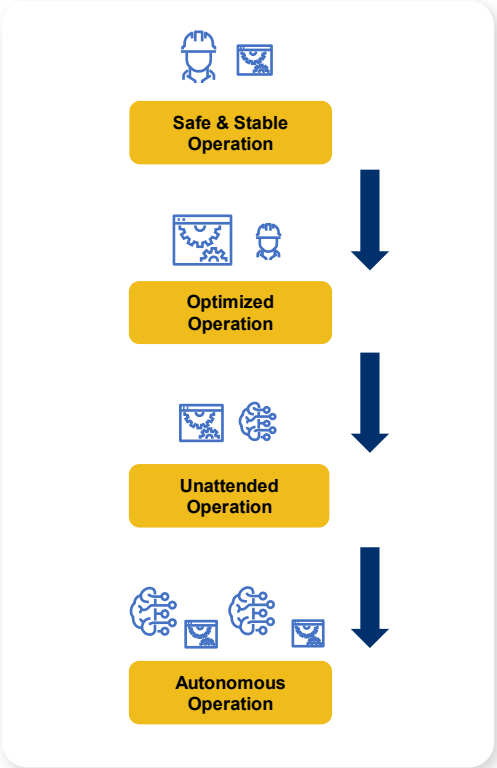
Some Common Elements

Goals

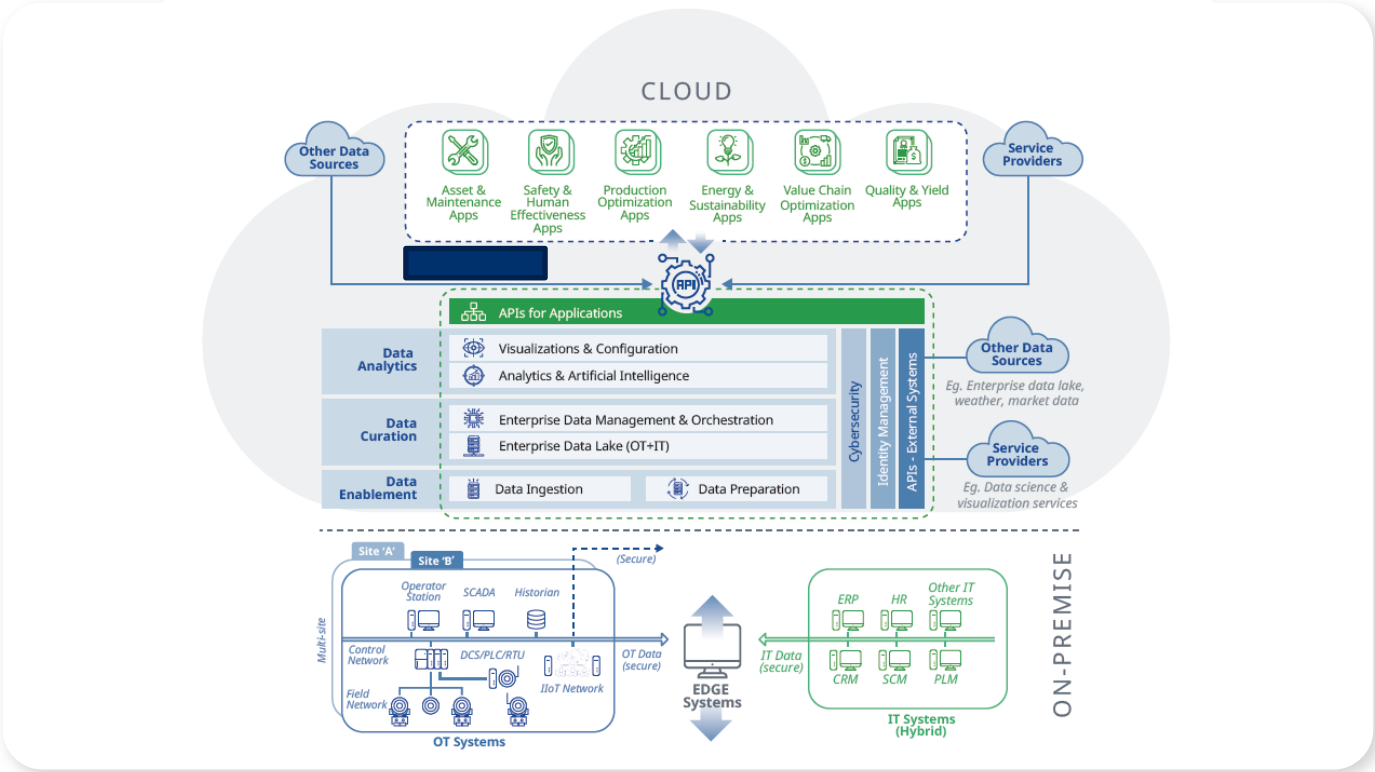
- Improve safety, increase efficiency, lower costs, improve asset availability, and achieve sustainability initiatives, ensure compliance

Approach

- Greenfield – design for NUF (one-year); “walk-to-work” facilities
- Brownfield – selective autonomy to reduce manpower, remove people from hazardous environments, improve decision making, etc.
- Improve reliability
  - Including process anomaly detection and equipment condition monitoring
- Standardize operations and maintenance (campaign and episodic)
- Increase collaboration
- Conduct remote operations and surveillance (IOCs)
- Use more intelligent sensors
- Leverage data utilizing AI, Cloud, and Edge Devices
  - Adopt platform approach to analyze data, build models, deploy solutions and scale quickly
- Conduct operator rounds and inspection with robots and drones
- Organizational & Capability redesign over time (Cultural shift)



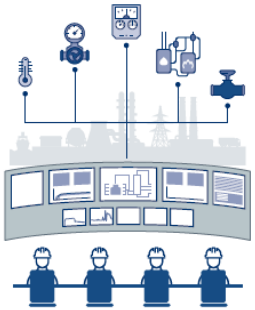
Cloud Architecture for Smart Manufacturing



Operations Management

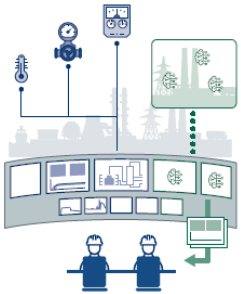
Manual
- Production process are executed manually
- Paper based instructions and data recording
- Equipment not connected

Semi-Automated
- Automated system play a limited role
- Significant human interactions
- Limited instrumented equipment – primarily for automation purposes



Automated
- Automated system perform majority of production
- Silos of information
- Operators share workload with automation system

Semi-Autonomous
- A mixture of autonomous components and automated assets
- Application specific autonomous functionality
- Decision and actions supported by advisory systems
- Operators monitor system's performance



Autonomous Orchestration
- A mixture of autonomous Systems and automated assets
- Cloud and data lakes enable MC orchestration
- Humans perform orchestration between functional domains
- Decisions and tasks guided by AI and digital twins

Autonomous Operations
- Futuristic state – fully autonomous facilities
- System of systems provides complete vertical and horizontal integration of domains
- Humans perform innovative tasks like designing new process

Autonomous Components and AI

Past: Automated Operations
No use of AI, plant performance relies heavily on individual skill, slow-decision making process

Key: regulatory controllers, OTS, Shift Logs, Production Reports

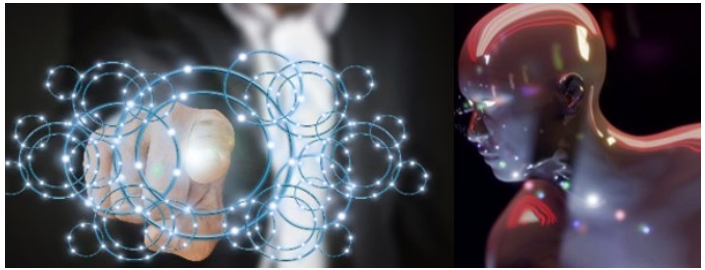
Present: Select Autonomy
Partial use of AI to realize Profit-Driven Operations (PDO), AI advisory dashboards support decision making

Key: High Fidelity "What If" Scenario Simulator
AI/Machine Learning Advisory Dashboards

Other Applications:
Asset anomaly predictive maintenance, process anomaly root cause analysis, product quality prediction and control, and process control

Plant of the Future:
- More plant data
- More powerful computing resources
- Demand tighter compliance with management KPI's
- Less available skilled human resources
- Less time available for decision-making

Future: AI-Driven Autonomous Optimization
AI optimizes plant, limited to no human intervention. Humans may be in remote locations since their immediate presence is not required

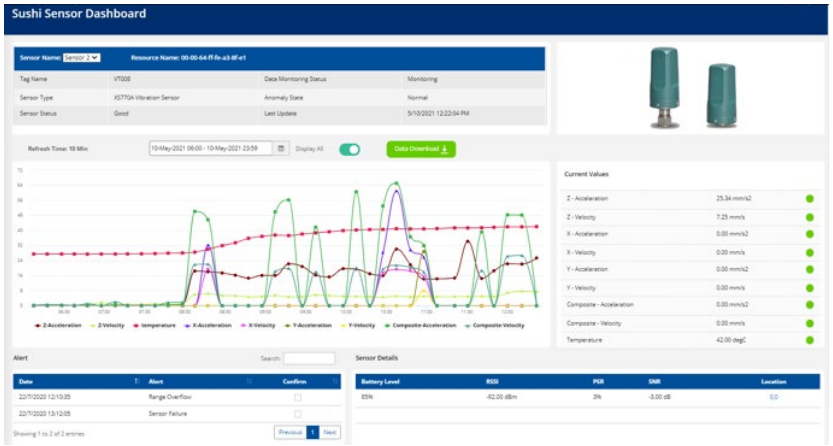


Maximize Management KPIs

Key: Auto ML, AI Algorithms, Combining Knowledge with ML (Numeric AI)

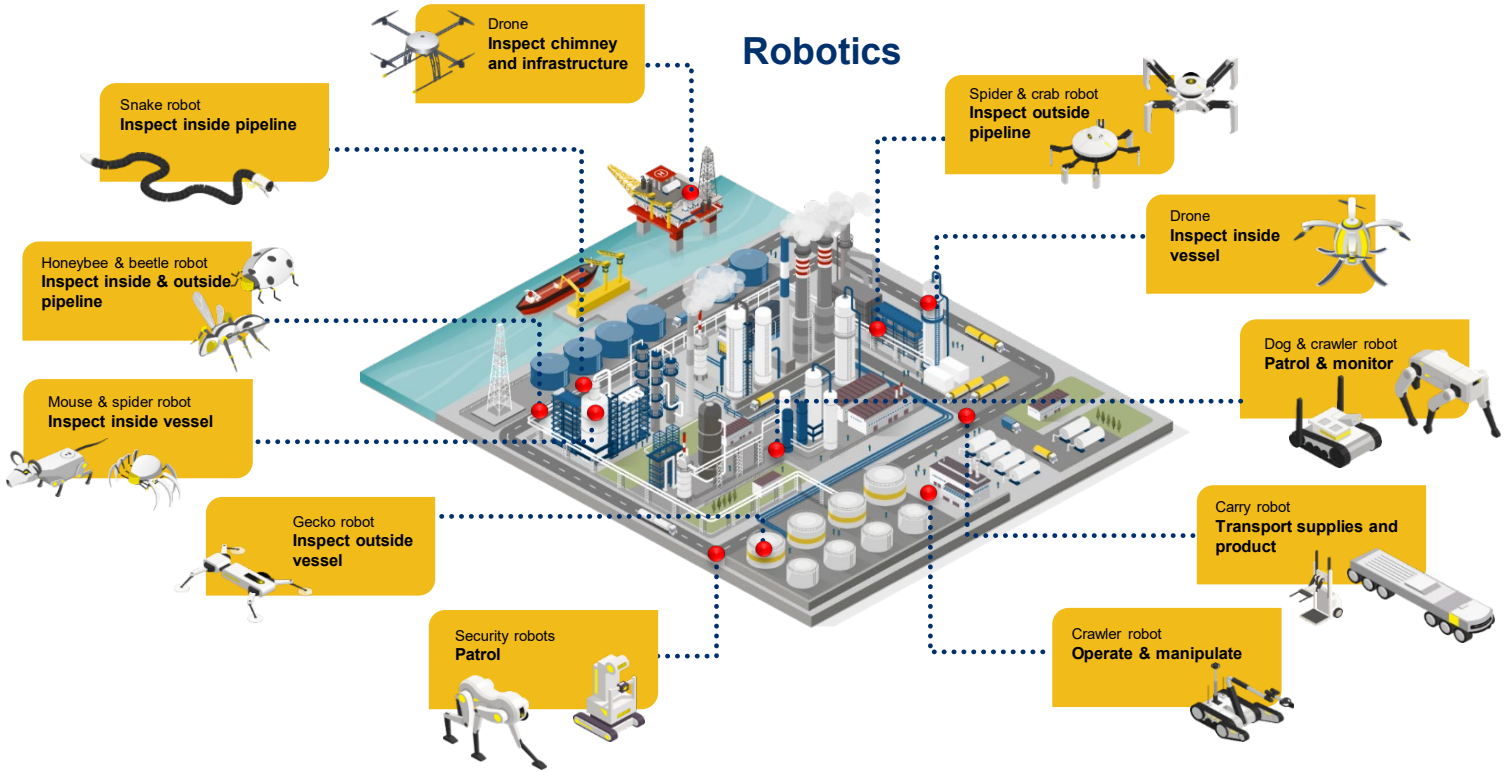
Vibration Monitoring with Sushi Sensors

Pump Vibration Monitoring with Sushi Sensors

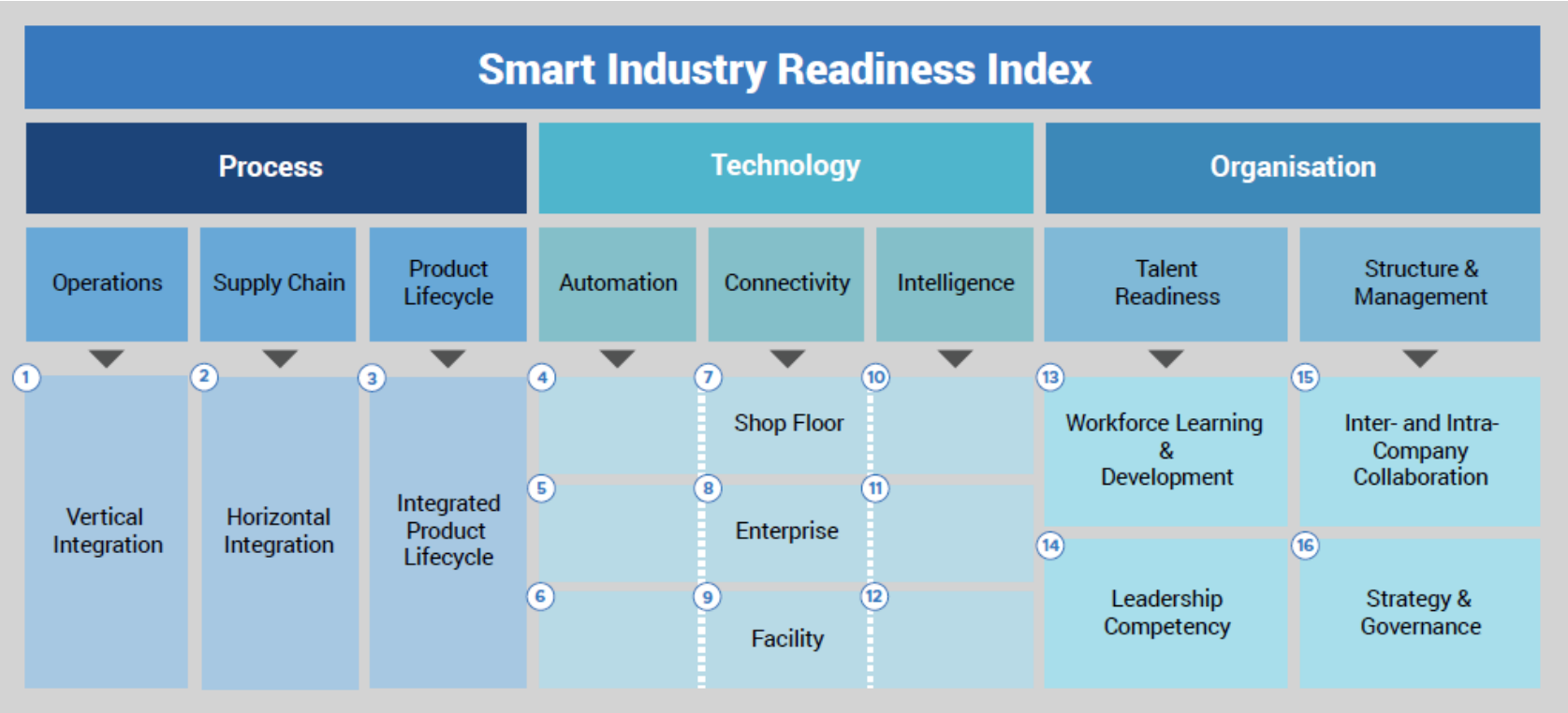


Live Monitoring Dashboard

Robotics

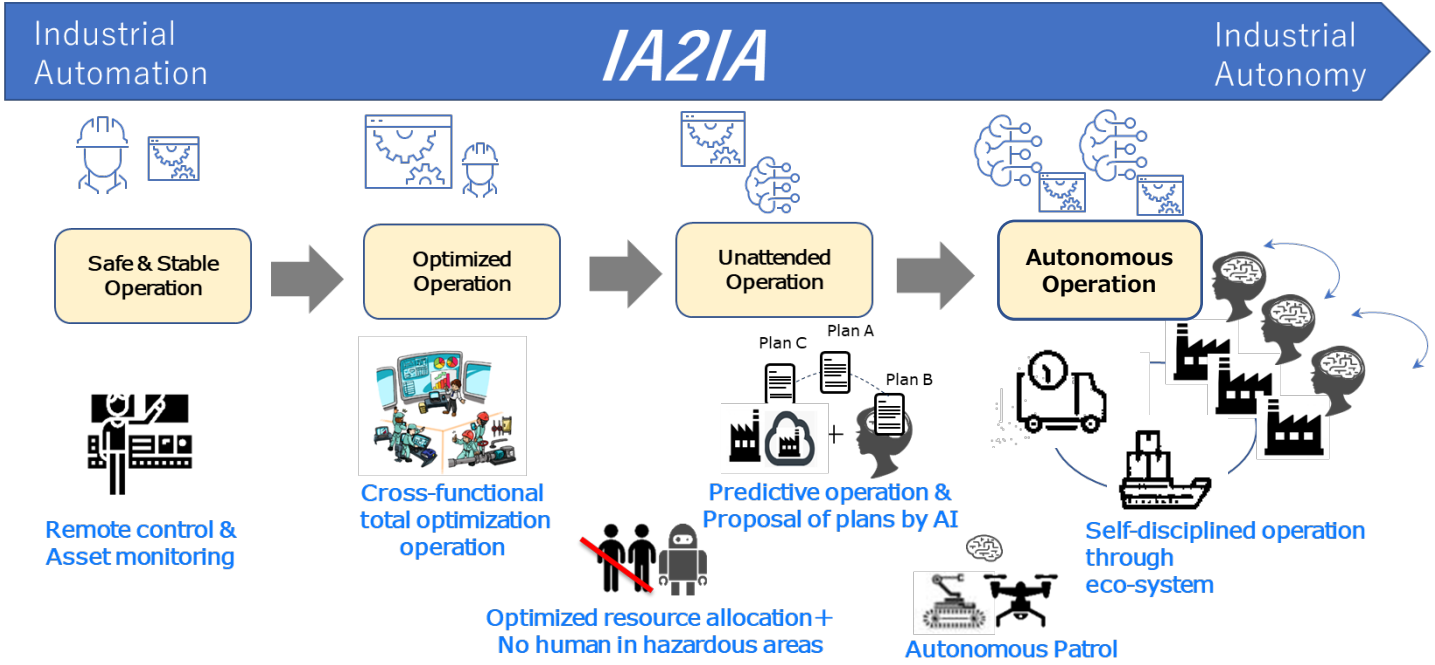


SIRI Assessment



Source: Singapore Economic Development Board

Roadmap



Summary

- Industrial autonomy is inevitable.
- Industrial autonomy enhances industrial automation by:
  - Adding layers of smart sensing and machine cognition
  - Anticipating and adapting to both known and unforeseen circumstances
  - Removing the need for human intervention for some functions or activities
- Industrial autonomy will penetrate all areas of operation:
  - Manipulating and controlling the process
  - Manufacturing operations management
  - Asset Management
  - Planning and Scheduling
  - Supply chain activities, etc.
- Autonomous building blocks are already available

Companies are saying they need industrial autonomy sooner rather than later

Co-innovating tomorrow™