Digital Transformation in Process Industries

A Journey Towards Autonomous Operations

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Foreword

To business leaders and heads of operations, engineering, and IT functions in process industries: you are in a world of accelerating change driven by market and technology conditions. It is causing drastic change in the business environment. Your future will be decided by your ability to respond to market conditions using technology. Fortunately, a once-in-a-lifetime opportunity to transform your organizations is upon you. It is called Digital Transformation.

This eBook aims to deconstruct digital transformation in process industries into a clear understanding of challenges, best practices and enablers to guide you on your journey towards digital transformation and autonomous operations.

Introduction

Digital Transformation: Why Now?

Historically, manufacturers have taken a cautious and incremental approach to change in order to minimize risk and deliver mission critical levels of availability, safety, and security. For decades, technology has improved plant efficiency by automating and improving existing procersses.

Today, meteoric increases in computing power, memory capacity, and sensing are fueling revolutionary improvements in Robotics, AI, Data analytics, Big Data, and, are causing significant disruptions across markets, rearranging industries, companies, departments, and societies

As the worlds of Information (IT) and Operational Technology (OT) converge, operations and manufacturing are forced to improve flexibility, efficiency, quality and assurance, and agility while maximizing ROI to ensure sustainable profitability in order to stay relevant.

1.1   DRIVERS FOR DIGITAL TRANSFORMATION

The process industries are under pressure from fluctuating commodity prices, decreased capital expenditures, more stringent environmental regulations, aging workforce, and increased competition. A new generation of tech-savvy yet less experienced workers are moving into roles previously held by industry and plant veterans. At the same time, consumers technologies and customer experiences are raising the bar for industrial customers' expectations. On top of it all, we are facing a generational, worldwide energy transition towards sustainability.

MARKET AND TECHNOLOGY DRIVERS FOR DX

MARKET DRIVERS

WORKFORCE DYNAMICS
A new, tech-savvy generation and the loss of experience due to retirement are creating opportunities and challenges.

COMMODITY PRICE FLUCTUATION
Fluctuating commodity prices can have a tremendous impact on the earnings of process manufacturers and, by extension, the markets.

CAPEX OPTIMIZATION
In an environment with long asset lifecycles and constraints to new CAPEX, digital can extend return on existing investments.

SAFETY, QUALITY, AND ENVIRONMENTAL REGULATIONS
Digital technologies are set to transform the global energy system in the coming decades, making it more connected, reliable, and sustainable.

SPEED IS IMPORTANT
Avoid becoming digital prey: "It is no longer the big beating the small, but the fast beating the slow." (Eric Pearson, CIO of the InterContinental Hotel Group).

TECHNOLOGY DRIVERS

CLOUD
Data and its applications all come together in the cloud. DX includes the expanded use of elastic cloud computing.

BIG DATA GOES CROSS-ENTERPRISE.
Predictive modeling techniques from data science are being used across the enterprise to empower DX and better operational processes.

AI IS FRONT AND CENTER
If you do not have an AI strategy, you are going to struggle in the coming world.

IT AND OT CONVERGENCE
IT-OT business alignment becomes a two-way street.

CONSUMER TECHNOLOGIES
Consumer experiences and technologies raise customer expectations.

CUSTOMER INSIGHTS
Front office technologies provide real-time customer insights and forecasts to drive operations.

COVID-19 ACCELERATED COMPANIES' DIGITAL COMMUNICATIONS STRATEGY BY A GLOBAL AVERAGE OF 6 YEARS. 96% OF ENTERPRISE DECISION MAKERS BELIEVE THE PANDEMIC SPED UP THEIR COMPANY'S DIGITAL TRANSFORMATION, AND OF THESE 66% SAID IT DID SO 'A GREAT DEAL'.

Source: Key findings of the COVID-19 Digital Engagement Report, Twilio

1.2   BENEFITS OF DIGITAL TRANSFORMATION

Digital transformation offers compelling benefits to be enjoyed by organizations and leaders who act first.

BENEFITS OF DX

AGILE RESPONSE TO MARKET CHANGES
A clear view to financial, asset, and production data across the value chain speeds up decision making and time to benefit.

REMOTE AND AUTONOMOUS OPERATIONS
Empower your facility to run, learn, adapt and thrive in tomorrow's environment.

INCREASED CUSTOMER LOYALTY
A 360-degree, seamless customer experience and journey contributes to increased customer conversions and loyalty.

A CULTURE OF INNOVATION
Digital transformation generates enthusiasm and inspires product and service development. Employees feel empowered through education.

INCREASED INTERNAL COLLABORATION
Collaboration improves between business functions to unlock greater business value and efficiency.

SUSTAINABLE ECONOMIC EXCELLENCE
In a survival of the fittest, businesses that adapt and lead in digital transformation enjoy a lasting competitive advantage.

1.3   A JOURNEY TOWARDS AUTONOMOUS OPERATIONS

With the constant evolution of digital technologies, new opportunities are arising for those who are actively embracing and participating in DX. Everyone must examine their unique organizational contributions, knowledge, and skills and then connect those strengths to the DX process.

Even though, at the highest levels of many organizations, DX is no longer viewed as a matter of investigation and experimentation, but a strategic imperative linked to company survival, the idea of undertaking their own DX endeavor is often considered daunting.

FROM INDUSTRIAL AUTOMATION
TO INDUSTRIAL AUTONOMY (IA2IA)

INDUSTRIAL AUTONOMY

AUTONOMOUS OPERATIONS

AUTONOMOUS ORCHESTRATION

SEMI AUTONOMOUS

AUTOMATED

MANUAL / SEMI AUTOMATED

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

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.

DX Applied to Production and Manufacturing **SMART MANUFACTURING**

THE FUTURE OF DIGITAL TRANSFORMATION IS AUTONOMOUS

In process industries, DX is a journey towards an autonomous future. New technologies such as autonomous robots, additive manufacturing, artificial intelligence, augmented reality and 5G will allow for increased levels of automation, remote and unmanned operations. Putting humans out of harm's way, a facility might entirely automate operations, maintenance, and incident management.

Yokogawa believes for many end users, to achieve their smart manufacturing goals, autonomous operations is the destination. Autonomous Operations can be defined as assets and operations that have human like learning and adaptive capabilities that allow it to respond without operator interaction to situations within a secure bounded domain that were not pre-programmed or anticipated in the design and is responsible for all safety-critical functions. IA2IA is what Yokogawa foresees as the transition from Industrial Automation to Industrial Autonomy.

An autonomous future will require sensing and digital infrastructure that spans the entire operation and integrates data, smart devices at the edge, bulletproof hardware and software to deliver the required level of flexibility, adaptability, and resilience.

IA2IA™
Industrial Automation to Industrial Autonomy

YOKOGAWA ◆
Co-innovating tomorrow™
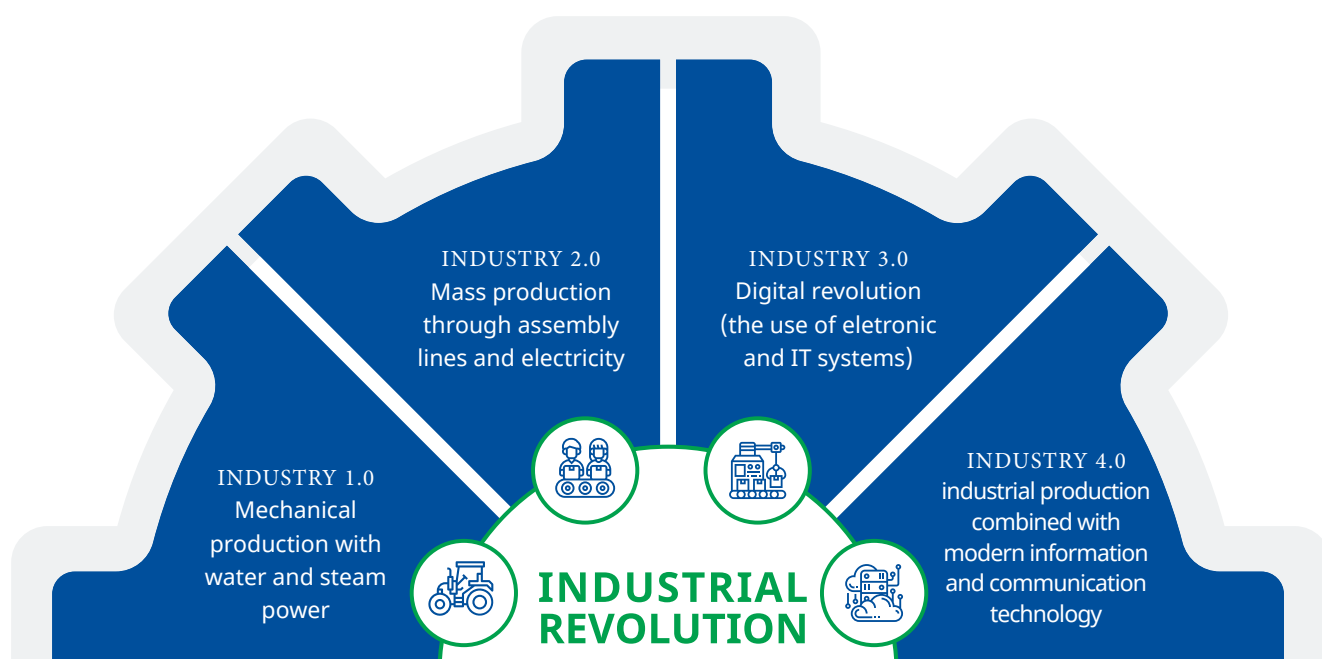
What is Digital Transformation (DX)?

DX is a journey towards autonomous operations

While Digital Transformation (DX) means different things to different people, its concept can become a mantra for earning relevance and establishing leadership in a digital economy. Rather than react to change or be disrupted by it, forward-looking companies are investing in DX to adapt and outperform peers.

DX is the novel use of digital technology to accelerate your company's business strategy, not technology for technology's sake. Whereas digitization is the act of converting information into a digital format, digitalization and DX involve business and workflow changes, enterprise operations and business transformation. DX is all about reorienting the business performance of an enterprise, by appropriate use of digital technologies.

2.1   DIGITALIZATION ISN'T NEW

Process industry veterans may observe that the concept of applying digital technologies to improve operational excellence isn't new. Since the 80's, process industries have embraced digital technology to better understand and manage resources, improve safety, and increase efficiencies. In fact, the field of Industrial Automation (IA) has given rise to this third industrial revolution for nearly half a century.

INDUSTRY 1.0
Mechanical production with water and steam power

INDUSTRY 2.0
Mass production through assembly lines and electricity

INDUSTRY 3.0
Digital revolution (the use of eletronic and IT systems)

INDUSTRY 4.0
industrial production combined with modern information and communication technology

INDUSTRIAL REVOLUTION

2.2   SOME THINGS ARE NEW

It is a strange and remarkable phenomenon that, in our personal lives, we are now deeply connected to physical and virtual worlds that are both global and intimate. The experience is undoubtedly human, allowing us to find friends, share ideas, conduct commerce, and delight in moments of genuine engagement. The future is already here, enabled by technological transformations in how we communicate, connect, and decide. From shopping, banking, and real estate to entertainment, travel, and mobility, our personal lives and customer experiences have been completely transformed through the application of IT.

IT mega trends have driven massive growth in computing power, storage, bandwidth, and information. In this environment, the network effect—a phenomenon whereby a product, service, or platform gains additional value as more people use it—has enabled the open sharing of ideas and development tools and an agile approach to exponentially accelerate the effects of software development, algorithms, and new business models. Indeed, 7 of the 10 largest companies in the world today, based on market capitalization, are fundamentally IT companies.

IT MEGA TRENDS

Cloud

User Experience

Analytics and AI

Open Architecture
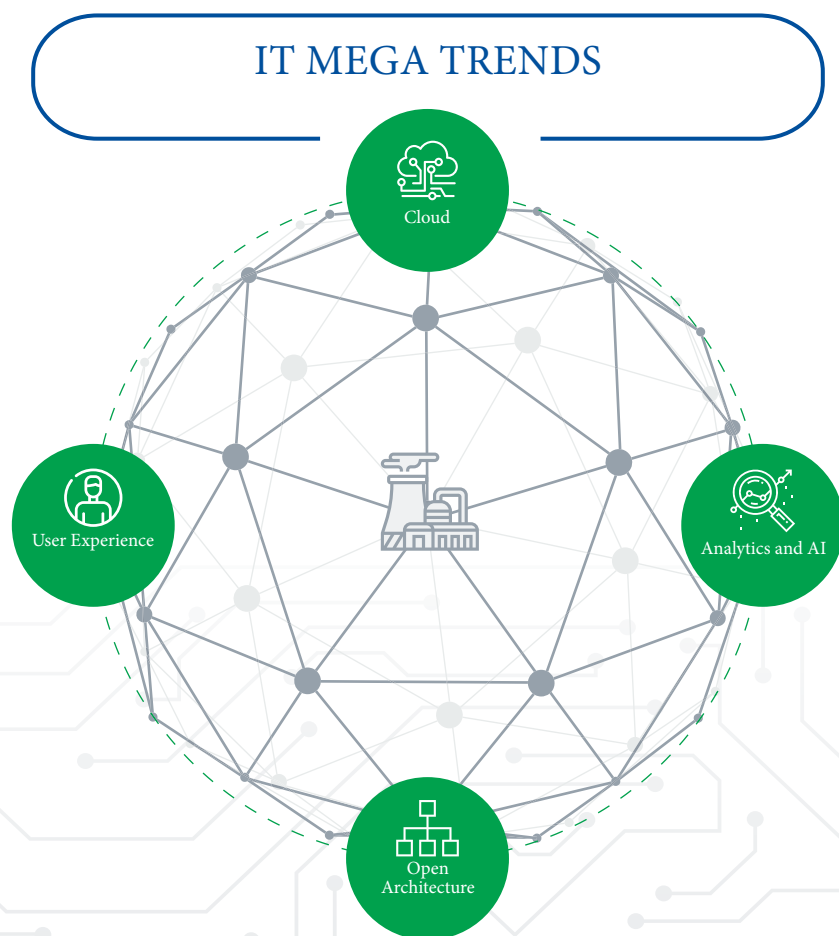
2.2.1   Cloud

The cloud is at the heart of IT transformation. It has practically eliminated the need for on-premise IT data centers, server co-location, and traditional in-house IT resources. The cloud has achieved this through virtual provisioning and access to computing infrastructure—computing power, storage, and bandwidth. Software-configured servers, storage, networking, and middleware have enabled companies to focus on the application layer, where domain knowledge and core competencies are implemented into code.

In a cloud environment, large amounts of data are ingested across multiple sources and are available to support insightful decision making and application interoperability. The industrial automation architecture is evolving its technology stack towards a model that resembles IoT while retaining the needs of industrial operations. Delivering new levels of connectivity without compromising safety requires a domain-aware approach to equipment, assets, data, and application integration.

The cloud is already the infrastructure of choice for most business applications, especially outside the energy and chemical sector. However, it remains unexploited for most operational applications. The reason is that most valuable operational applications rely on a continuous feed of plant data which means they can never be isolated from the plant in a way that say an HR performance management system or capital budgeting system can. This is partially addressed with 'edge devices' living in the 'fog' between the real world of the plant and the virtual world of the cloud to bridge the gap, but there is still a potential pathway for a 'bad actor' to reach the plant even through an edge device.

> The term cloud is a generic reference to accessing data and applications over the internet instead of on your local machine, and includes infrastructure providers such as such as Microsoft Azure, Amazon Web Services (AWS), or Google Cloud Provider (GCP)

> " Cloud computing represents the catalyst and the enabler of the important technological shift that was already well underway before COVID-19 "

Doreen Bogdan-Martin, Director, ITU BDT.

> " I don't need a hard disk in my computer if I can get to the server faster... carrying around these non-connected computers is byzantine by comparison "

Steve Jobs, late chairman of Apple (1997)

2.2.2   Analytics and Artificial Intelligence

Along with exponential increases in connectivity and devices, there has been a corresponding increase in data volume. IDC predicts that the collective sum of the world's data will grow from 33 zettabytes in 2018 to a 175ZB by 2025, an increased annual growth rate of 61 percent.

According to Gartner, fewer than 50% of documented corporate strategies mention data and analytics as fundamental components of enterprise value delivery. But at the same time, data and analytics are the key in an organization's digitization and transformation efforts.

New tools and mechanisms have been created to analyze, visualize, and interpret this enormous volume of data. New data management and analysis methods have emerged for storing, searching, and accessing structured and unstructured data. The computational power associated with advances in analytics has accelerated the changes in most industries, and early adopters include search engines, social media, and retail.

PROVIDING NEW ANSWERS AND INSIGHTS

Many manufacturers have some big data analytics applications in place. However, they are often only providing old answers to old questions, such as how to reduce downtime by 4% to decrease costs by 2%. True DX with big data analytics will create new answers to new questions. For example, plant managers can use massive volumes of data to address business problems that they would not have been able to tackle before, and of which they might not even have been aware.

IIoT ANALYTICS

Big Data	NEW Answers to OLD Questions	NEW Answers to NEW Questions
Data	OLD Answers to OLD Questions	OLD answers to NEW Questions

VOLUME

ALGORITHMIC COMPLEXITY
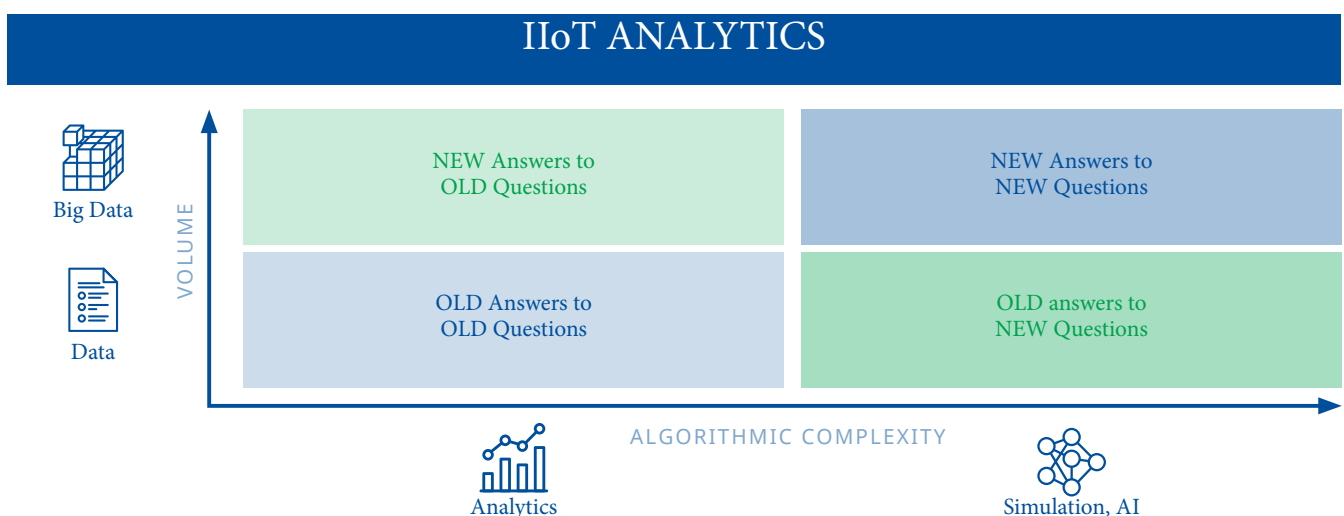
Analytics   Simulation, AI

Figure: LNS Research - Big Data and Analytics vs. Machine Learning Analytics.

2.2.3   User Experience (UX)

Successful DX leverages technologies to meet user expectations and beyond by creating and designing meaningful experiences. UX is designed around the way people interact with digital products or platforms, including websites, digital systems, and apps. Its main goal is optimizing the overall ease of use of all websites and digital platforms. In our quest to capitalize on technologies, design is our tool for simplifying and humanizing technology.

DX and UX design share a common goal of creating digital experiences to make processes as easy as possible for the end user. DX is heavily impacted by how users adopt technology and how UX systems are delivered to them. Creating an enjoyable, easy to use, digital experience is one of the main goals of DX and UX design.

> UX is the sum of the effects caused by a person using a digital solution. UX efforts concentrate on the experiences that people have when interacting with a specific product or solution (*Gartner*).

“

As the enabling technology matures and becomes seamless, differentiation is achieved through user experience. The ones to capitalize on the technology will be those that own [the] experience, those are [the] best at designing the experience “

Tzachi Toledo, Strategy Consultant

“

UX and agility are the two things that lines of business expect most from central IT. IT organizations are now measured more by adoption, or how much the software they provide is actually used. UX is not a nice-to-have feature anymore “

Sam Yen, the San Francisco-based chief design officer at SAP

The Internet and the cloud have significantly changed how application developers approach projects, collaborate on them, and architect their software. It also spawned the rise of DevOps (a set of practices that combines software development (Dev) and IT operations (Ops) to shorten the systems development life cycle and provide continuous delivery with high software quality) and processes to deploy, manage, and terminate those software applications through their lifecycle.

Leading application development frameworks are no longer created only by proprietary, monolithic vendors but through online global communities of open source developers and tools. Open source frameworks, such as Linux, JavaScript, and Python, have been accelerated by the network effect and the innovative benefits of a globally connected talent pool. This has particularly propelled the web, media, mobile, and gaming industries.

Connectivity and integration

Achieving new connectivity levels in the process industry also requires automation suppliers and end users to challenge the conventional approach of proprietary technologies and project delivery models. This shift is evident through open industry initiatives, such as Industry 4.0, NAMUR Open Architecture (NOA), and the Open Process Automation Forum (OPAF).

A new architecture allows for flexible, open connectivity, and deep integration among layers to achieve an interconnected and integrated outcome. A converged IT/OT approach is also referred to as IIoT, Industry 4.0, or Smart Manufacturing.

Digital Transformation Reference IT/OT Architecture

An IT/OT architecture enables data collection and integration, along with advanced analytics solutions for deriving value from the data, to solve your problems within and beyond plants and enterprises.

SEE APPENDIX 1
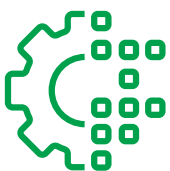
2.3   DIGITAL TRANSFORMATION AS A JOURNEY

Digital transformation is not something that can be accomplished overnight. MIT Sloan Management Review sees it as a journey, a progression comprised of three phases.

The first phase—where most companies make errors that greatly impede their efforts—is the fundamental change from analog to digital, or "digitization." Many organizations fall prey to the temptation to quickly acquire and incorporate new technologies, viewing them as panaceas and not as essential elements in a long-term strategy. The truth is that the process is much more complex and layered, and it requires careful planning.

DIGITIZATION
The process of making information available and accessible in a digital format.

DIGITALIZATION
The act of making processes more automated through the use of digital

DIGITAL TRANSFORMATION
The process of devising new business applications that integrate all the digitized data and digitalized applications.

The next phase is the digitalization of industries: the act of making processes more automated through the use of digital.

The final phase in this framework is digital transformation, which occurs when new digital business models and processes restructure economies. Societies also evolve as people integrate the technologies into their lives and habits. Digital transformation is a systems-level transition that alters behaviors on a large scale.

DEFINITION OF DIGITAL TRANSFORMATION BY YOKOGAWA

Digital Transformation (DX) is the novel use of digital technology to accelerate business strategy. It is about the application of digital technologies to empower people, optimize processes and to automate systems of the organization to achieve a step-change in business performance.

With DX, technology is evaluated as an integrated set in combination with the business strategy, people, processes, data, and assets. DX is often viewed as a program with prioritized digital initiatives oriented around business processes, rather than point solutions or Proof of Concept - POCs.

Business Model and Strategy

Operational Excellence, Product Leadership, and Customer Intimacy

Even though the main DX drivers are technology and market-oriented, like any IT project, you cannot lead with technology alone. It would just be an expensive exercise, 'an investment in toys', without a clear purpose or ROI that would be difficult to justify and fund.

If your company is serious about improving safety, environment and profitability, and start a DX journey, you need a business plan mapping and prioritizing the identified digital initiative and quantifying the financial benefits. Usually, those digital initiatives relate to the improvement and automation of business processes. For instance, a global CRM program roll-out is a digital initiative to better serve customers to improve loyalty and sales effectiveness. Without explaining how technology will in this case maybe reduce maintenance costs, justifying the investments you need for a state-of-the-art cloud-based AI & digital analytics platform is meaningless. A digital initiative should always be linked to a business process, and your company's business strategy should define how it delivers value to customers and through what distinctive competence or discipline. In short: an understanding of your company's business objectives and strategy is needed to frame the approach.

> " Arguing that you need a new cloud-based AI & digital analytics platform is meaningless unless you explain what you are trying to do "

ORGANIZATIONS NEED TO UNDERSTAND THEIR COMPANY'S BUSINESS OBJECTIVES AND STRATEGY IN ORDER TO FRAME THE RIGHT APPROACH TO DX.

3.1 THREE COMMON BUSINESS STRATEGIES

In their book, The Discipline of Market Leaders, Treacy and Wiersema argue that, nowadays companies cannot succeed by trying to be all things to all people. Instead, each firm must find a unique value that it alone can deliver to a chosen market. If a company tries to pursue all of these business strategies, it will likely end up offering mediocre products for mediocre prices. Instead, Treacy and Wiersema suggest three value disciplines that can shape every plan and decision: operational excellence, product leadership, and customer intimacy.
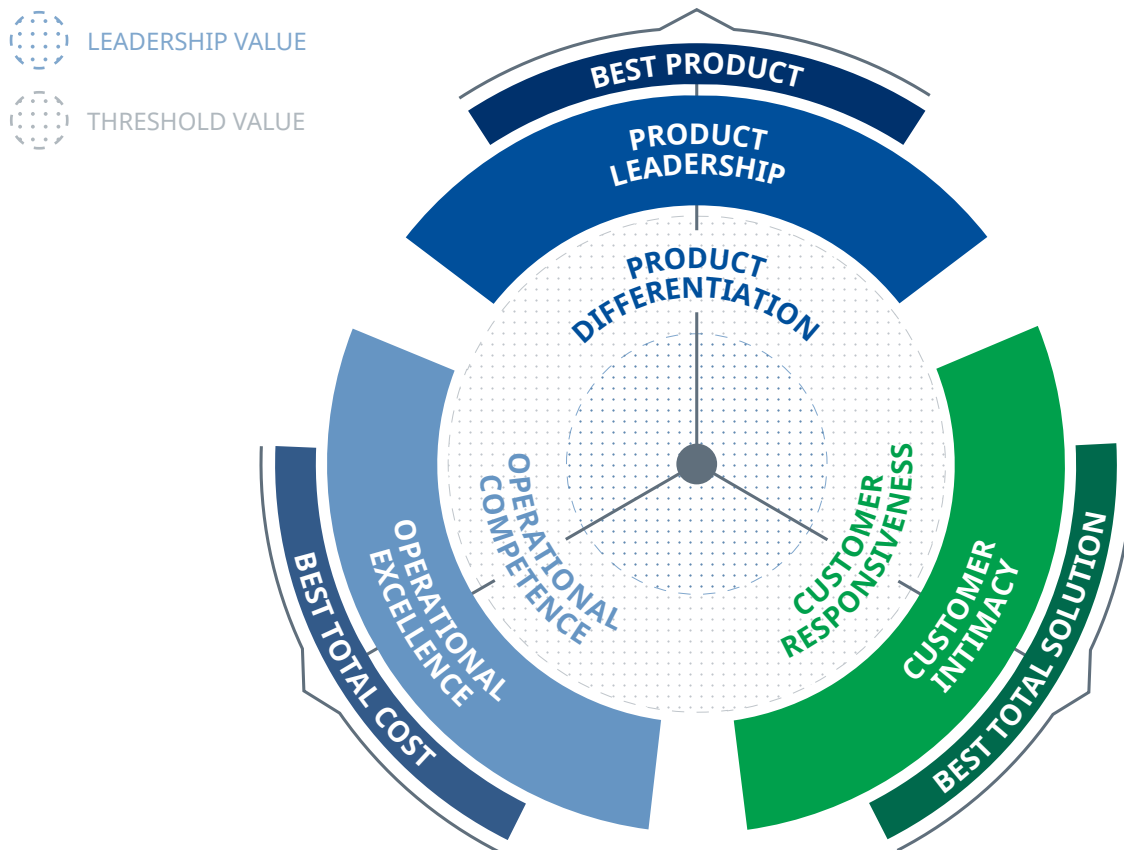
Value Disciplines Model (*source: Treacy M. and Wiersema F. (1995). The Discipline of Market Leaders*)

Companies, such as Walmart, Amazon, and Toyota, employ an operational excellence strategy to focus on price, throughput, production, and efficiency. Meanwhile, companies, such as Home Depot, Nordstrom, and Lexus, practice customer intimacy focused on flexibility and knowledge of customers. Finally, companies, such as Apple, Tesla, and Google, use a third business strategy that emphasizes speed and innovation to support product leadership.

People, Processes, and Technology

Digital transformation can be used to accelerate any of these approaches. However, it can only occur when people, processes, and technology are considered as an integrated set, aligned to the corporate vision and business model.

People by themselves have to do work. For now, people are still required for governing the output of machines. The future will be more autonomous?

Processes help people define and standardize work, preventing people from reinventing the wheel.

Technology help people work faster, more innovative – especially today in the age of artificial intelligence.

Operational Excellence

In the operational excellence value discipline, companies are highly asset intensive and have made large capital investments to support operations. They are characterized by high volume, low margin business models. Hence, production is viewed as the primary constraint to growth or profitability. An operational excellence strategy aims to drive down costs and risks while achieving maximum productivity and operating flexibility.

Fundamentally, 80%–90% of process industry companies are driven by operational excellence. Where capital is constrained, market volatility is high, and significant plant overhauls are not a viable option. Achieving a competitive advantage requires agile decision making and disciplined execution. This is increasingly facilitated by technology, allowing operators with strong competencies and robust business processes to leverage digital insights to deliver business benefits.

IN A YOKOGAWA SURVEY OF MORE THAN 100 OPERATIONS LEADERS IN PETROCHEMICALS AND OIL & GAS, OVER

79%

WERE VERY CONFIDENT THAT AN OPERATIONALLY EXCELLENT MINDSET WOULD RESULT IN A SAFER, MORE RELIABLE, AND MORE PROFITABLE OPERATION.

A company's approach to operational excellence can vary widely depending on its industry, company size, and digital maturity. Just as there are many different chemical, electrical, and mechanical processes across different industries, so too are there many different operational challenges and approaches associated with process excellence. There is no one size fits all approach to operational excellence or DX.

While a small plant may view operational excellence in terms of consistently generating export quality products, expanding plant capacity, or expanding regional and global business, a digitally innovative company may consider operational excellence to involve taking steps toward remote, unmanned, or even fully autonomous operations.

OPERATIONAL EXCELLENCE FOCUS AREAS ACROSS INDUSTRY VERTICALS

CHEMICALS

- Lack of clear strategy relating to digital
- Cyber security challenges
- Unscheduled downtime
- Outdated data communications

POWER

- Regulatory framework issues for adopting digitalization
- Cyber security challenges
- System reliability issues
- Resistance to adopt digital solutions
- Low energy efficiency

MINING

- Demands for high-level of safety standards
- Under-utilized sensor data
- Machine uptime
- Lack of skilled manpower
- Fragmented digital landscape: mining companies are looking for holistic solutions.

UPSTREAM

- Extended lead times
- Retrofit digital of brownfield projects
- Lack of data standards to enable condition-based monitoring & diagnostics
- Process safety augmentation challenges
- Efficiency improvement issues due process inconsistency

MIDSTREAM

- Aging infrastructure
- Cyber security challenges
- Limited sensing capabilities
- Inefficient response strategy during incidents

DOWNSTREAM

- Time-consuming inspections
- Inefficient energy management
- Increasing plant reliability issues
- Data security concerns
- Lack of agility to react & optimize due to market dynamics.

Product Leadership

Product leadership is about consistently striving to provide customers with leading-edge products or useful new applications of existing products or services. Some process industries, such as specialty chemicals and pharmaceuticals, focus on a product leadership strategy in which Research & Development (R&D) and a rigorous product management approach can reduce time to market and command a price premium for innovative products and services.

> " We focus on making people understand that digital is not a thing in itself, but it is a means to contribute to our vision of feeding an ever-growing world population and fostering health. "
>
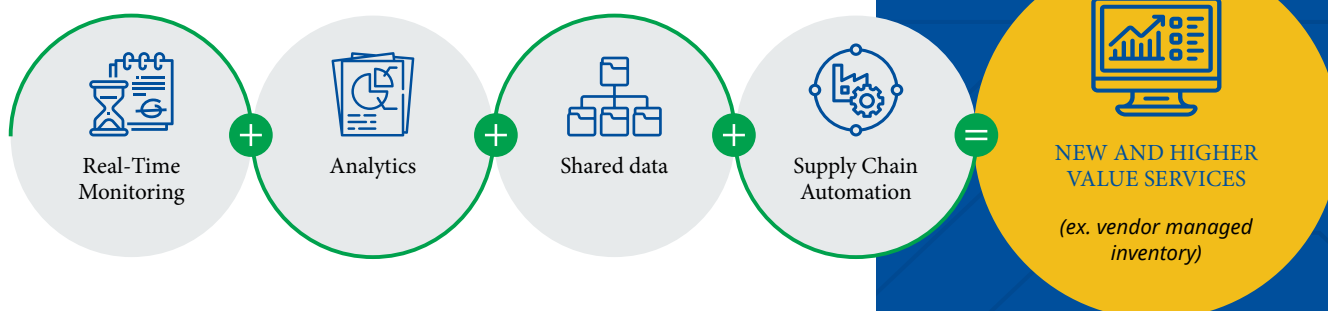> *Saskia Steinacker, Global head for digital transformation, Bayer*

Customer intimacy

Meanwhile, a company that delivers value via customer intimacy builds bonds with customers that are like those between good neighbors. Such companies do not deliver what the market wants but what a specific customer wants. In energy and chemicals, a company's operations may exist largely to serve the next step in the value chain. However, some energy, feedstock, and specialty chemical companies are increasingly exploring how to increase their customer intimacy and product leadership, leveraging deep integration and insights across customer data and the value chain.

Developing a deeper connection to your customer's consumption patterns and needs can create a competitive advantage in terms of your ability to deliver the right products in the right ways.

In some industries, such as air gas delivery, turbines, and compressors, vendor-managed inventory is already a reality, and real-time monitoring, analytics, shared data, and supply chain automation enable new and higher value services.

This value discipline can apply to nearly all process industries. For instance, a catalyst supplier to refineries might leverage cloud-based applications and services to improve catalyst yield, run-length, and selectivity. A shared data historian and process simulator based on first principles could provide model-centric technical support, troubleshooting, and optimization at the right time, delivering superior scheduling, planning, end-use performance, and differentiation through customer intimacy. Similarly, a specialty chemical company that supplies chemicals to the pulp and paper industry could dynamically adjust their batch process to prevent foaming.

Real-Time Monitoring **+** Analytics **+** Shared data **+** Supply Chain Automation **=** NEW AND HIGHER VALUE SERVICES *(ex. vendor managed inventory)*

3.2 SUSTAINABILITY

Digital technologies are not only transforming markets and creating new paradigms of doing business, but are also providing organizations with solutions to sustainability challenges. Therefore, sustainability is an overarching value discipline or business model.
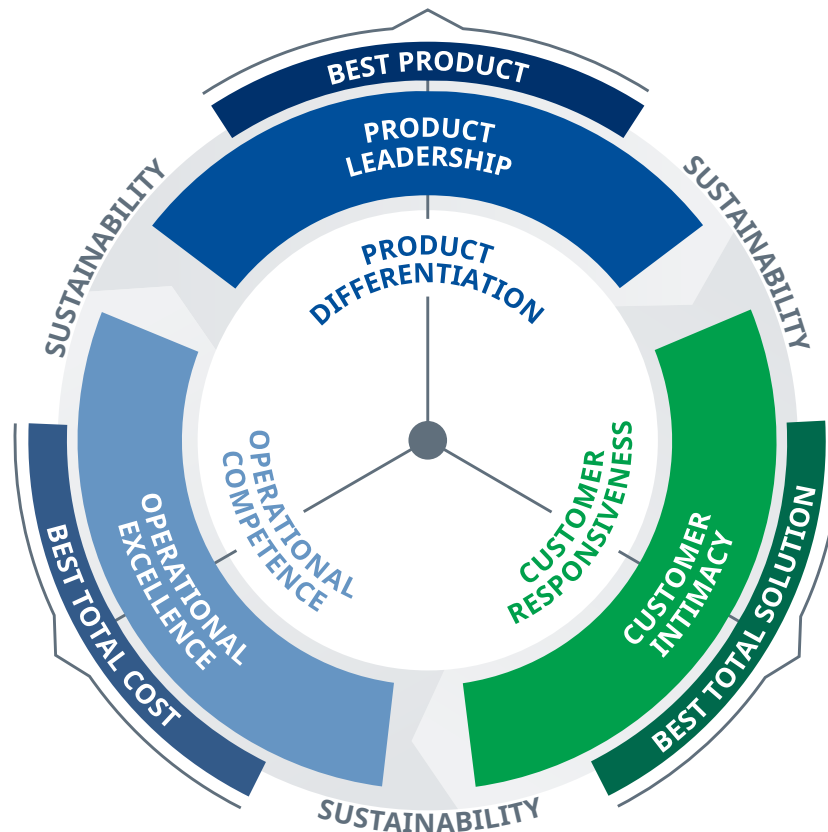
Many companies are actively integrating sustainability principles into their businesses decisions. They are pursuing goals that go far beyond delivering economic value and the reputation management- concerns they may have had in the past. There is an increased focus on broad, long-term goals of saving energy, developing green products, and retaining and motivating employees, which help them capture value through growth and return on capital.

Operating companies view DX as a means of supporting a business strategy focused on navigating the global energy transition. Digital data is not only faster, more precise and available to anyone with the right access rights, it also saves resources and helps us reduce our carbon footprint. Besides energy conservation, resource conservation, and greenhouse gas reduction, these companies recognize the social and economic advantages of shifting from compliance to social responsibility and stewardship and the synonymous relationship between safe and sustainable operations.

THREE GOALS AND MID-TERM TARGETS TO BE ACHIEVED BY 2030

	Stopping climate change	Quality life for all	Improving the circulation of resources and efficiency
VISION TOWARD 2050 (Three Goals)	**net-zero emissions**	**well-being**	**circular economy**

	Avoiding CO$_2$ emissions	Creating safety and health value	Improving resource efficiency
MID-TERM TARGETS to be achieved by **2030**	**Target: 1 billion tons** *(cumulative from FY2018 to FY2030)*	**Target: 1 trillion yen** *(by FY2030)*	**Target: 1 trillion yen** *(by FY2030)*
Business focus areas and overview of value creation stories	**Renewable and low-carbon energy** — Help avoid CO$_2$ emissions by offering renewable energy and LNG solutions	**Life innovation and safety** — Support people's health and prosperity by providing life-innovation solutions and ensuring safe, comfortable workplaces	**Saving energy and resources** — Contribute to sustainability and economic growth by ensuring stable, efficient operation and resource circulation
Related SDGs	[SDG 7, 13]	[SDG 2, 3, 8]	[SDG 6, 7, 9, 12]

BY SETTING SUSTAINABILITY TARGETS FOR ITSELF, YOKOGAWA AIMS TO HELP ITS CUSTOMERS TRANSITION TO A CIRCULAR ECONOMY, ENSURING THE WELL-BEING OF FUTURE GENERATIONS.

AT THE 2019 WORLD ECONOMIC FORUM IN DAVOS, YOKOGAWA WAS RANKED IN THE PRESTIGIOUS GLOBAL 100 MOST SUSTAINABLE CORPORATIONS BASED ON A RIGOROUS ANALYSIS OF MORE THAN 7,500 COMPANIES WITH US$1B+ IN REVENUES.

YOKOGAWA HAS SUBSCRIBED AND COMMITTED TO GUIDE ITS MID-TERM BUSINESS TARGETS BY THE UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS (SDGS) – A BLUEPRINT TO ACHIEVE A BETTER AND MORE SUSTAINABLE FUTURE FOR ALL.

IT/OT Convergence

From the Automation Pyramid to the IIoT Technology Stack

A key pillar of digitalization and digital transformation lies in your ability to infuse information technology (IT) into your company's operations and operational technology (OT), and the integration of your business and production environments.

In the past, IT and OT could function independently. OT kept the plant running, and IT managed business applications from the front office. OT systems were standalone or used a proprietary platform and communications. Gradually, OT sustems migrated to running on common IT operation systems. Nowadays, thanks to the 4th industrial revolution —including the new IT trends described in chapter 2—the previously separate domains of OT and IT are increasingly merging. Analysts have called this the IT/OT convergence.

Successfully adopting IT enablers— such as cloud computing; open architcture; advanced analytics, including artificial intelligence (AI); and user centric agile design— requires a cloud-based platform that consolidates OT and IT data securely through an edge, leveraging data from on-premise, from mission critical or existing systems, and from cloud-based It systems.

OT

Supervision systems

Control systems

Process equipment

IT

Storage systems

Computing technology

Business applications

Data analysis
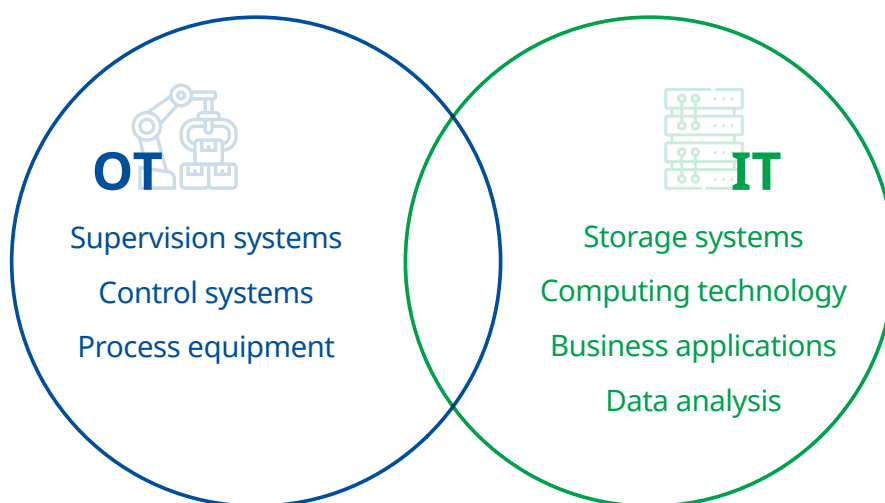
4.1   IT/OT IN MANUFACTURING

IT and OT have different backgrounds, but their conjoined applicability arises from the Industrial Internet of Things (IIoT).

OT in manufacturing includes the hardware and software systems, such as DCS, SIS, PLCs, SCADA, and MES that safeguard and control processes in a plant environment.

Manufacturing has been quick to embrace production technologies, and OT systems can be extremely sophisticated. However, OT systems are not always networked or incorporated into a broader enterprise system for reasons related to safety.

In contrast, IT in manufacturing refers to the informational infrastructure in a given operation, encompassing the network architecture and all of the hardware and software components necessary for processing and storing information. IT includes hardware, such as laptops and servers; software, including enterprise software, such as ERPs; office productivity programs; and other business-related tools.

In the process industry, IT/OT convergence reduce the distance between the systems that control manufacturing processes and those that control data storage, communications, and computing.

> "
> As more companies work toward IT/OT alignment, the CIO and the IT organization will be at the forefront of fostering relationships and changing the culture of the organization "
>
> *Kristian Steenstrup, analyst and Gartner Fellow*

IT/OT CONVERGENCE CHALLENGES

ORGANIZATIONAL SILOS
Given the breadth of OT in manufacturing, the machines, devices, and control mechanisms of modern factories often operate in relative isolation and communicate using a variety of niche protocols. This creates silos, communication difficulties, and blind spots in processes.

IT AND OT SKILLS
IT/OT convergence is changing the way manufacturers work and the skills that workers need. Increasingly, engineers need to perform work that is traditionally done by software developers, systems integrators, and network specialists.

CYBER SECURITY
The presence of IP-connected devices, cloud platforms and open and agile provisioning in OT networks introduces new vulnerabilities and will contribute to an increase in number and variety of cyber threats targeting OT systems.

LEGACY SYSTEMS
There's no 'one-size-fits-all' approach to legacy system modernization. Are problems caused by technology, architecture or the functionality of the application?

Even though IT/OT convergence introduces new challenges for manufacturing companies, it is far outweighed by the DX benefits of potential new business models and digital services, such as Everything-as-a-Service (XaaS). Examples of XaaS include the "all-you-can-eat" music and video streaming models, ridesharing services, redefining the tools and services in Fin(ance)Tech, Mar(keting)Tech, and H(uman)R(esources)Tech.

The IT/OT convergence also offers out-of-the-box integration solutions for plant automation, asset management, and manufacturing execution systems (MES). This is a game-changer for business, since it can potentially enable new levels of autonomy and subscription and outcome-oriented business models. Furthermore, companies who act first often enjoy a significant market share advantage as their value rises in proportion to the user base and speed of adoption.

Convergence matters because it is—gradually but surely—changing the nature of manufacturing, creating opportunities for innovative improvements to manufacturing processes for those willing to act.

THE CLOUD ENVIRONMENT IS CATEGORIZED INTO THE FOLLOWING SERVICE MODELS:

SOFTWARE AS A SERVICE (SaaS)
Delivers an application and its UX to the end-user over the web.
Common uses: CRM, HR applications, business dashboards.

PLATFORM AS A SERVICE (PaaS)
Offers a combination of middleware and application development tools, enabling efficient and agile deployment.

Common use: cloud application development

INFRASTRUCTURE AS A SERVICE (IaaS)
Combines hardware and software to provide cloud services.
Common use: Outsourcing computing infrastructure to an on-demand cloud service

4.2 MAKING IT/OT CONVERGENCE WORK

COMBINED APPROACHES AND INTEGRATION

Successful OT applications are built on a deep understanding of how your operational processes and technology deliver value to users and customers and the work processes and algorithms you use. Combining new IT approaches with your domain knowledge and existing applications requires wrapping or migrating your automation, operations, or value chain related software.

THE DIGITAL TRANSFORMATION (DX) INDUSTRY ARBITRAGE APPROACH

In the DX industry arbitrage approach, we look to early adopter industries for IT and organizational best practices while keeping the focus on what you know best: your business. Hence, this approach involves a partner who understands your operational processes, is fluent in IT and OT, and works with you to innovate in the areas you identify.

CONVERGING AND SECURING OT-IT

Learn how Hyogo Pulp Industries (Japan) introduced a virtual network infrastructure using SDN (Software-Defined Networking) technology. The aim of this initiative was to strengthen cyber security measures in plant networks, and create a safer and more efficient network infrastructure anticipating the introduction of IIoT (Industrial IoT) solutions.

READ MORE

As IT/OT convergence makes its way across all corporate functions, companies envision a digital enterprise in which digitalization and automation empower every human at every level in the organization with situational awareness to view the right information at the right time and support decision making.

DIGITAL ENTERPRISE

INDUSTRIAL CLOUD SOLUTIONS

Manufacturing & Supply Chain

EMPLOYEE CLOUD SOLUTIONS

HR | Employee systems

Finance

Spend Management

ERP CLOUD SOLUTIONS

Marketing

Sales

Service & Support

FRONT OFFICE CLOUD SOLUTIONS
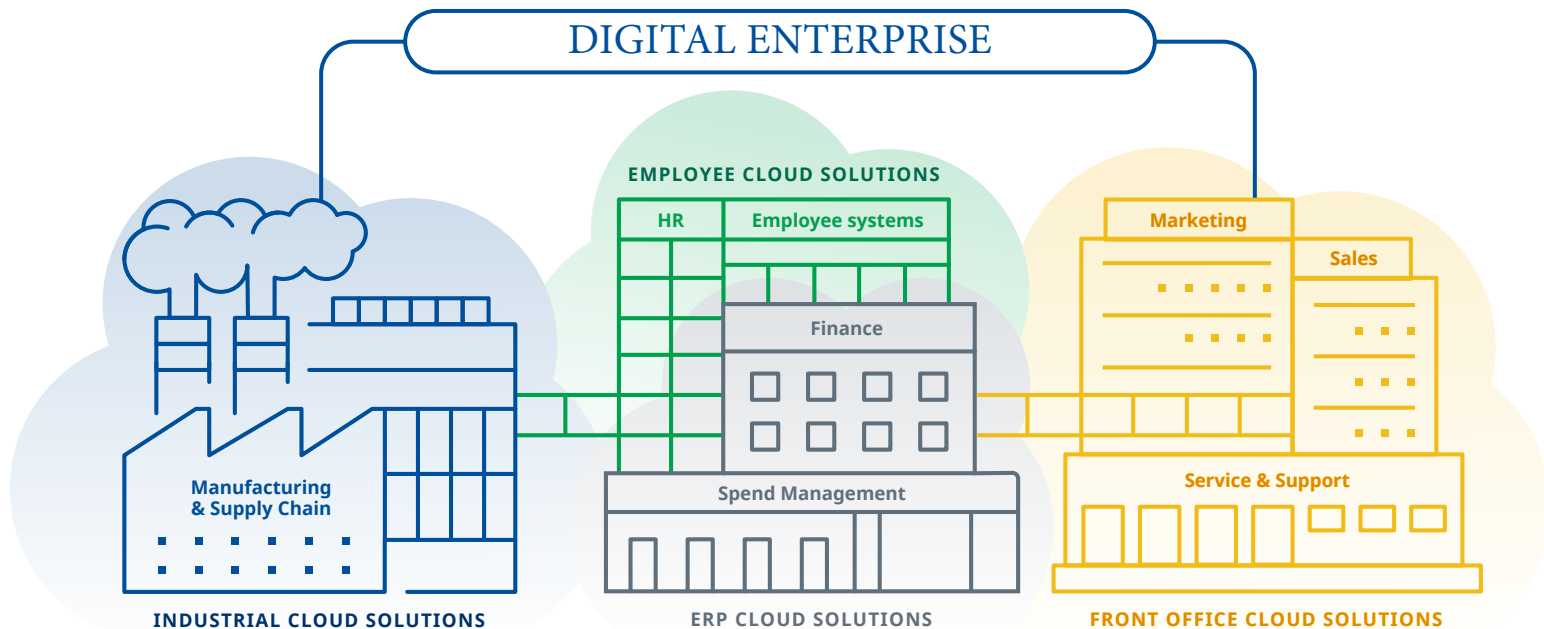
INCORPORATION OF AN IIoT TECHNOLOGY STACK

The companies behind consumer IoT applications that combine smart devices with cloud-based apps have often successfully incorporated an IoT technology stack. This pillared and open but interconnected architecture is used in the design of IoT products, such as smart speakers, smart appliances, health and wellness devices, and thermostats. Key amongst other factors that define the success of digital transformation, is the digital enterprise architecture that captures the techology stack and its interplay with existing systems and business processes.

THE IIoT TECHNOLOGY STACK

Device Hardware

Device Software

Communications

Cloud Platform

Cloud Applications
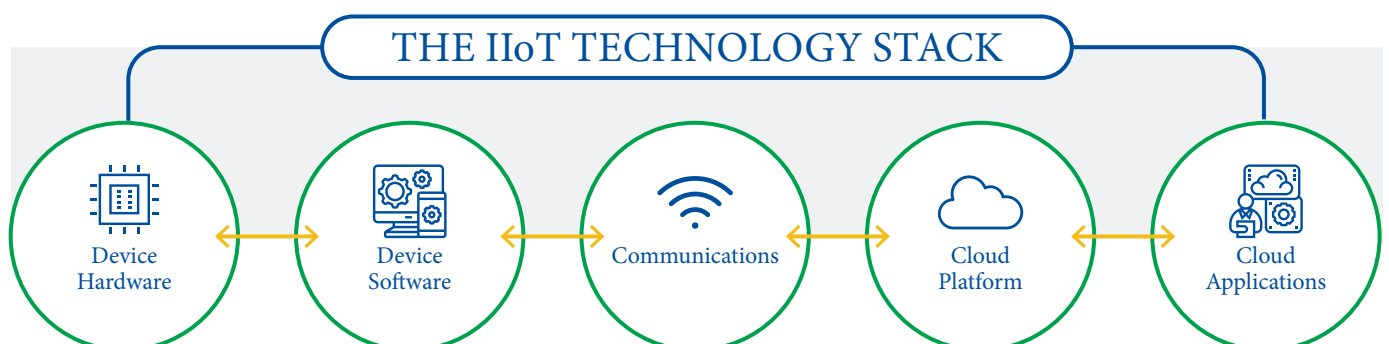
Making Industrial Automation Smart

The impact of DX on operational technologies

The world of industrial automation (IA) has always centered on cost reduction, improved productivity, safety, efficiency, and uptime. These elements are now being driven and accelerated by DX. The global process industry is becoming more connected, networked, and integrated. For IA this has led to a shift from the traditional ISA-95 automation Purdue model to a cloud-based digital platform, or the IIoT technology stack. The ISA-95 model, or automation pyramid, is a layered approach in which one layer is integrated with the next. It is designed with on-premise production (on a private local area network), operations, and software in mind. The tip of the pyramid, representing enterprise software integration, was often aspirational.

Virtualization technologies are now blurring the distinctions between the top three levels and enabling the migration, engineering and development of software applications in the cloud. New applications for real-time optimization, edge analytics, machine learning (ML), AI, and new sensors create opportunities for innovation and automation across the layers. But it also puts new requirements on integration architecture.

Therefore, a new paradigm is needed.
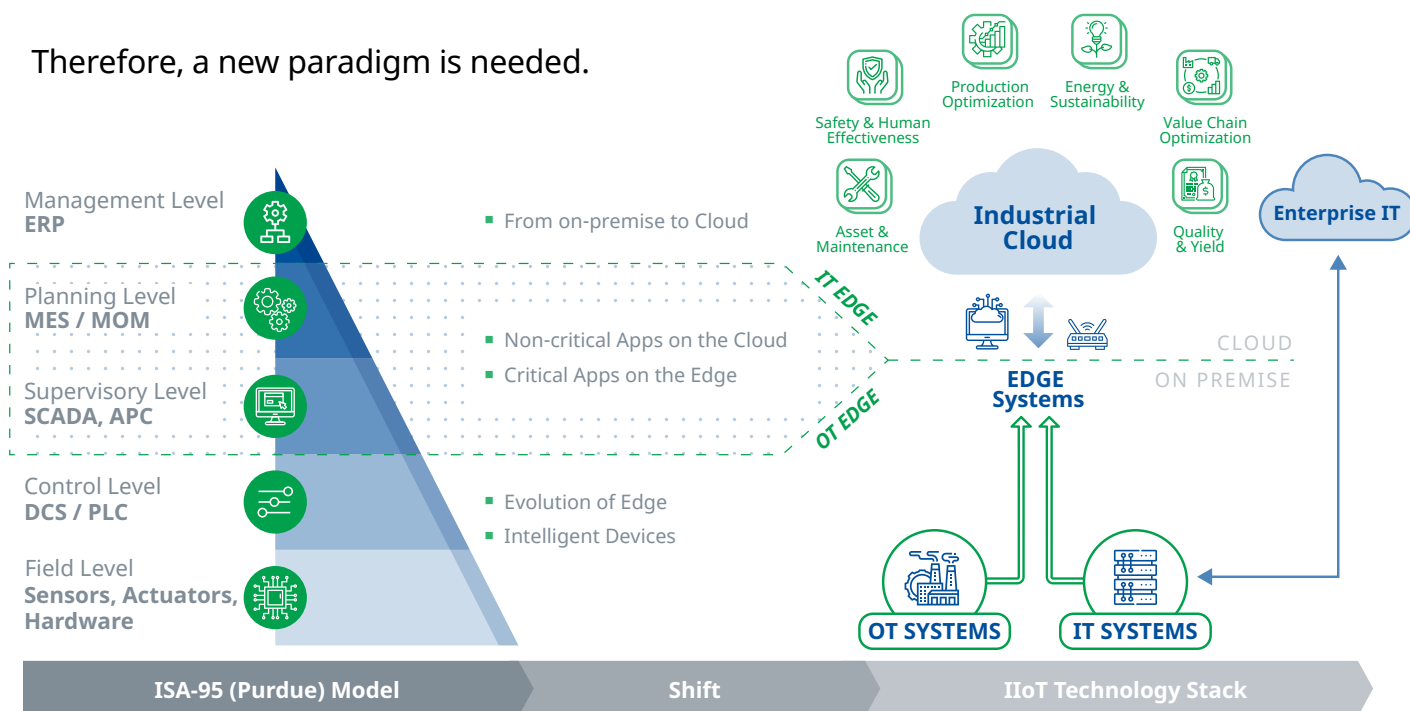
Figure: The shift from the ISA-95 (Purdue) model to an IIoT technology stack model

5.1   SENSORS

IIoT and Industry 4.0 are driving the growth of wireless sensors being deployed to digitize field data. There is great innovation in this space, driven by technology convergences and advances in miniaturization. Today, a wealth of sensing technologies are being used to measure, analyze, or regulate process liquids and gases, temperature, pressure, flow, level, and electrical parameters. They all have become big sources of IIoT data.

Sensing devices are the foundation of an IT/OT platform and reflect a plant operation's vital signs because sensor data is used to inform and drive plant operational performance. A successful digital journey rests on the quality and reliability of measured data, making suppliers with high instrument accuracy and stability well suited to IIoT applications.
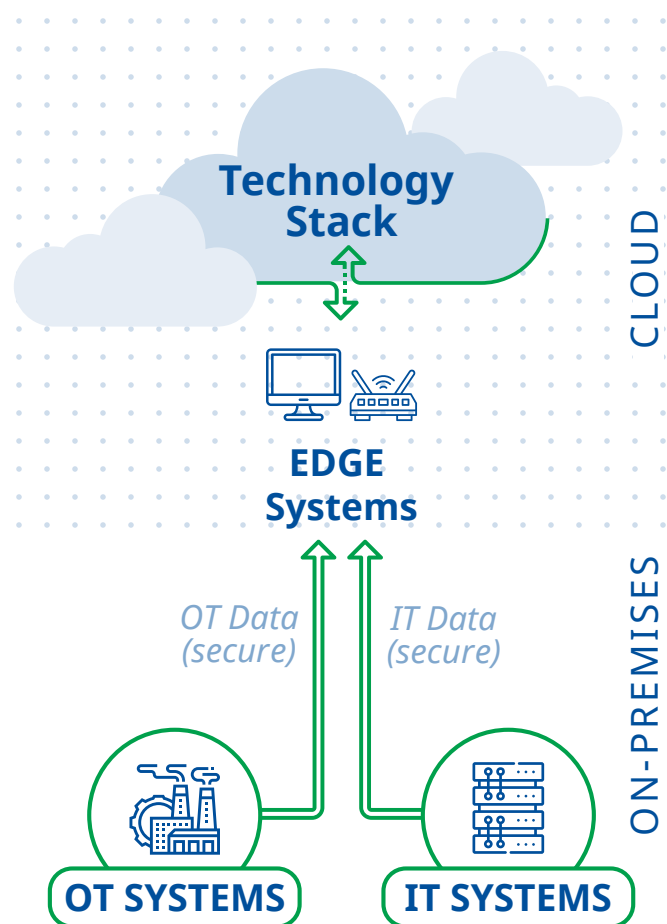
Figure: Wireless sensors measure and transmit the information either to the edge equipment or directly to the sensor cloud using various protocols like ISA100, LoRa, Sigfox and other wireless protocols.

WITH CURRENT FINDINGS INDICATING THAT

LESS THAN 5%

OF A MANUFACTURING PLANT'S GENERATED DATA IS PUT TO GOOD USE, THERE IS A HUGE OPPORTUNITY FOR FIRMS TO REAP NEW REWARDS THROUGH DIGITIZED SENSORS.

5.2   AUTOMATION NETWORKS

When a facility is automated, an automation network should offer smart, secure wireless connectivity. Eliminating costly cabling enables the easy reconfiguration of production lines for an agile factory. This flexible approach to manufacturing helps meet customer demand for a variety of products. It has the benefits of cellular security for data and device integrity and an open platform for applications and services for factory developers, device manufacturers, and original equipment manufacturers (OEMs).

Automation and Industrial Control Networks

Fieldbuses, or industrial control networks, are dedicated networks designed for mission-critical control and sensing functions. Originating from analog 4-20mA, fieldbuses have been superseded by digital protocols such as HART, Profibus, FOUNDATION Fieldbus, ISA100, and Wireless HART. The choice of automation network depends on the engineering trade-offs between design, implementation, and maintenance.

Unlike consumer IoT applications, there is a considerable case for maintaining the role of the automation network for process industries. Given the need to protect human life, plant assets, and the environment, automation networks provide a critical layer of protection from IT systems and enterprise applications. Today's integrated solutions deploy gateways, firewalls, and other devices that connect disparate networks and translate communications protocols and data types.

Network Edge

For less critical applications, the IIoT concept of the network edge is challenging the concept of an automation network.

Edge computing is done at or near the data source instead of relying on the cloud/data center to do all the work. The edge controller is often the secure end point for all plant floor systems. It places emphasis on bringing computation and data storage closer to the sensor with a subset of the data sent to the cloud for centralized analysis. Like digital fieldbuses, IIoT can be used for remote diagnostics, asset management, predictive maintenance, and safety monitoring.

Technology Stack
with Cloud Applications

Data   *Instructions*

NETWORK EDGE

LOCAL CONTROL

Inputs   *Outputs*

Operations Technology (OT)
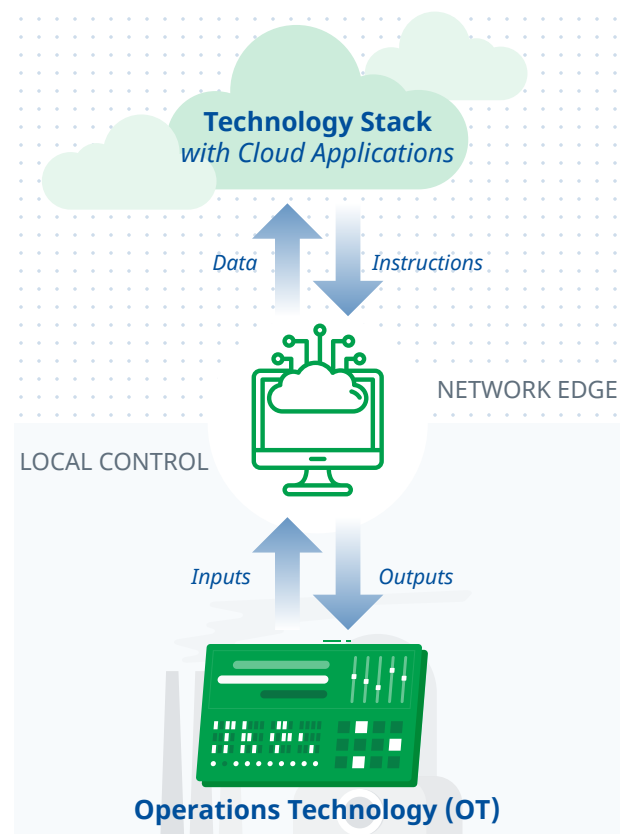
5.3 CONTROL AND AUTOMATION

Decades of reliable operations

For decades, industrial control systems have played an important role in industrial automation, allowing process manufacturers to collect, process, and act on data from the production floor. But DX promises to bring a new era in industrial automation. In this era, machines will be able to execute complex control functions with self-learning capabilities and minimal operator interventions. This will allow process manufacturers to reduce accidents and production downtime tied to human error and achieve optimal plant operation.

DX-driven need for greater system openness, connectivity, and security are likely to continue shaping future DCS and SCADA developments. SCADA systems already play a critical role in ensuring the efficient operation of all automation components. They take information from the plant floor and make it actionable across the digital enterprise. They also power the IIoT, helping ensure the proper communication of digital information. This enables the information to do its work in a digitalized industrial organization. And by providing powerful visualization, SCADA systems work hand in glove with other manufacturing applications to provide transparency, increase productivity, and achieve digitalization. Consequently, a SCADA system is a core component in realizing the digital journey to Industry 4.0.

With greater system connectivity, integrated operations centers (IOCs), and dynamic operator guidance made possible with high-quality alarm systems, process manufacturers will be able to achieve new levels of system optimization and safety.

MANUFACTURING EXECUTION SYSTEMS (MES)

MES applications track the transformation of raw materials into physical goods during the production process and track how physical properties get converted into dollars and cents. Traditionally, MES resides in the ISA95 automation pyramid between the enterprise resource planning (ERP) and process control levels. But new technology enabling direct connectivity from applications, such as MES, to sensor and enterprise data in the organization. New algorithms and protocols are improving real-time data flows on the plant floor and optimizing the production process. These improvements can most easily be made when these applications are based in the cloud allowing data and application interoperability. Integrated analysis of information and the application of AI including the use of graph databases and knowledge graphs and blockchain can unlock further value.

Consolidating the traditional control hierarchy

Today, IIoT and Industry 4.0 offer tremendous promise in consolidating the traditional control hierarchy while applying large-scale cloud-based computing to industrial processes. The vision of application integration from the control room to the boardroom is brought dramatically closer to reality with DX. As part of DX, DCS and SCADA systems should also support web services, IIoT and cloud-based connectivity such as Open Platform Communications United Architecture (OPC UA) or Message Queuing Telemetry Transport (MQTT), and IT connectivity like Simple Network Management Protocol (SNMP) or Internet Control Message Protocol (ICMP) to monitor IT assets.

TRADITIONAL SYSTEM ARCHITECTURE

Figure: Example of an Integrated Production Control System (DCS/PLC/SCADA) Architecture

INDUSTRY 4.0 MODEL

Figure: In an Industrial Cloud paradigm, the Edge represents processing and computing close to the data source and is regarded as the confluence of OT & IT.
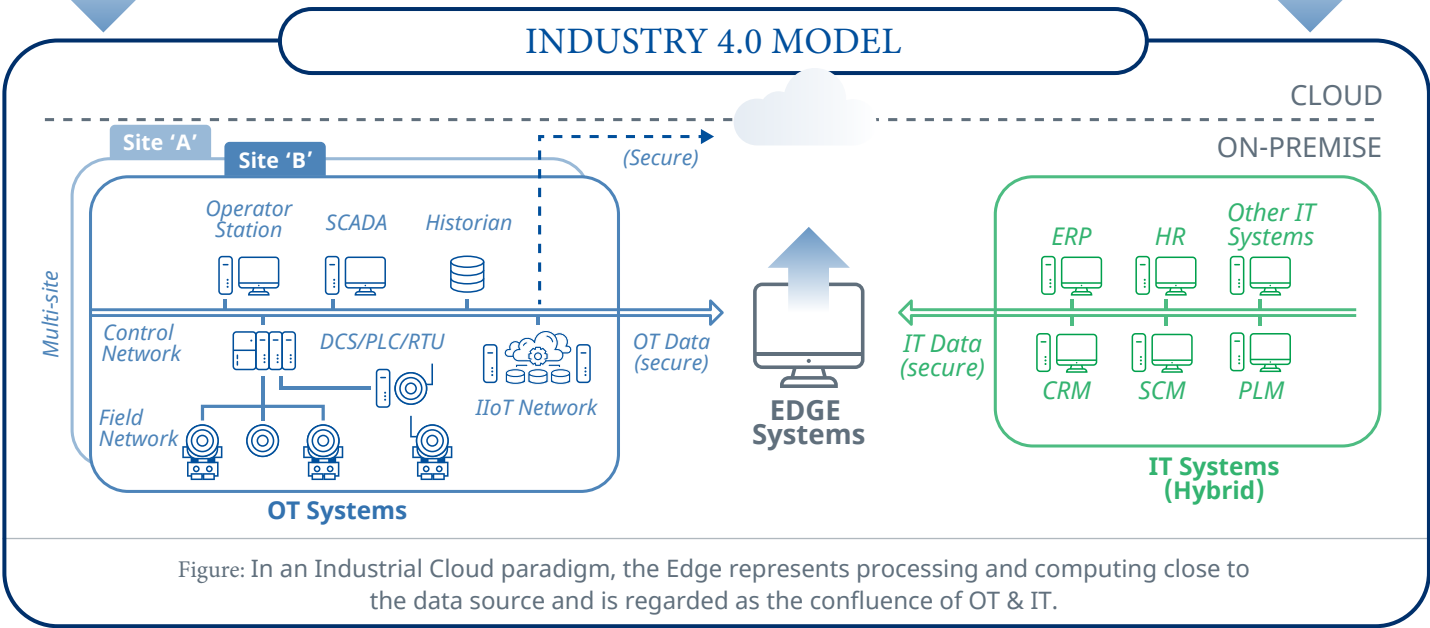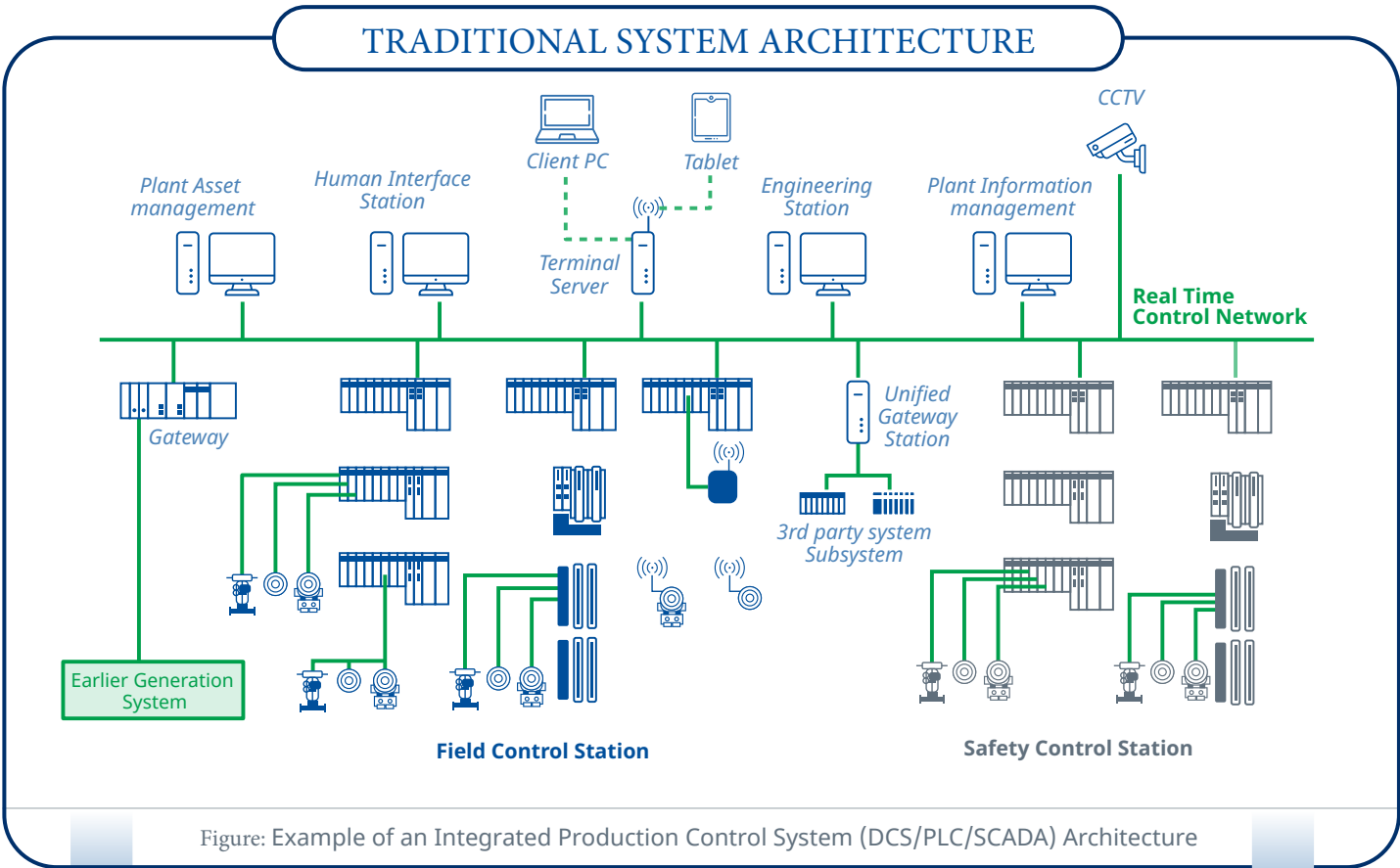
5.4 PROCESS AND ASSET DATA

Through a plant's operations, process and asset data are aggregated, cleaned, and enriched by a process historian. Most operations have accumulated years of time series data in various states of completeness; however, only a small portion is being used as a basis for operational decisions. By processing, interpreting, and applying business logic to the process and asset data, digital application and services are established.
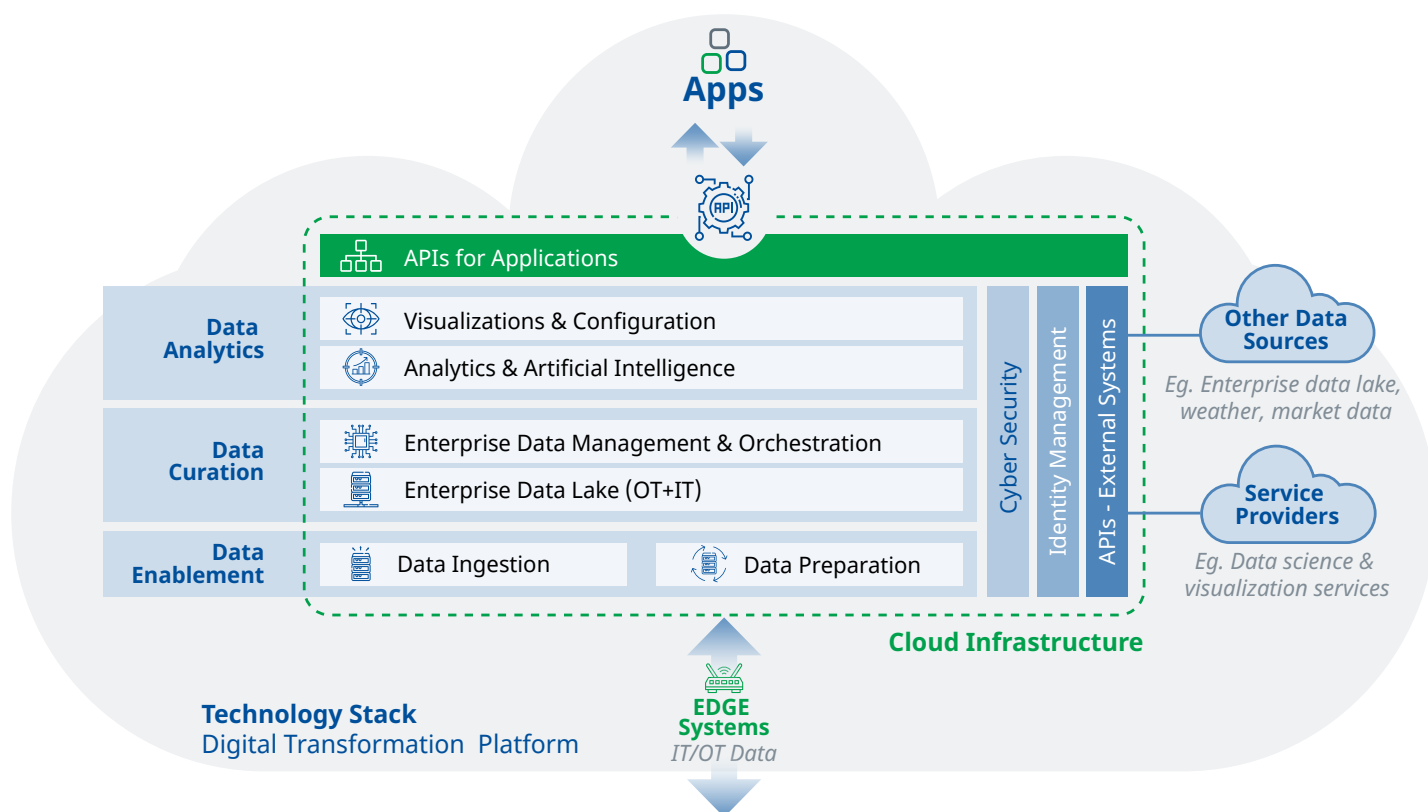
Historians and Data Lakes

Today's historians and data lakes are being used to store ever-increasing amounts of data originating from a much wider variety of sources, including control and monitoring, laboratory information management, and asset management systems. They have the potential to translate this into actionable insights to implement and improve equipment diagnostics, maintenance, safety, alarms, production, performance, and other process plant activities. However, if not managed well, most data lakes lack the essential features that prevent your data lake from turning into a data swamp.

Historians are the critical point of integration between IT and OT, acting as an OT data collector to distribute process and asset information throughout the enterprise in various formats as needed.

OT Data Foundation

What is possible with today's process and asset data? With the availability of application packages and open interfaces, virtually any kind of analysis of plant data is now possible. An OT data foundation is fundamental to your digitalization ambitions. Data reconciliation, field mapping, and normalization are prerequisites for the effective use of analytics software and applications, such as advanced process control, real-time optimization, simulation, and AI.
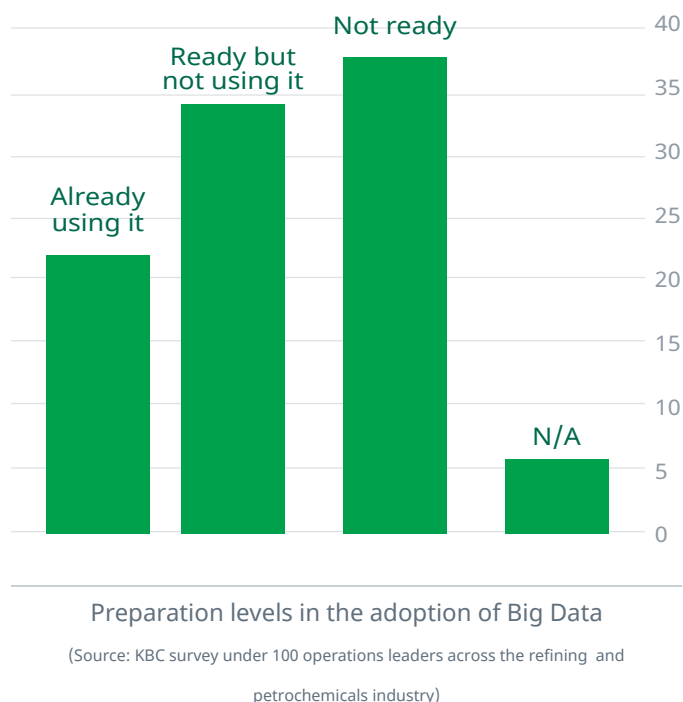
Preparation levels in the adoption of Big Data

(Source: KBC survey under 100 operations leaders across the refining and petrochemicals industry)

Digital Transformation Reference IT/OT Architecture

An IT/OT architecture enables data collection and integration, along with advanced analytics solutions for deriving value from the data, to solve your problems within and beyond plants and enterprises.

SEE APPENDIX 1

5.5   APPLICATIONS AND SERVICES

The application and service layer of a digital platform, as shown in the figure below, processes, interprets, and applies business logic to the underlying process and asset data. Automation vendors, historian suppliers, and system integrators have created a wide variety of specialized software applications ranging from analytics, simulation, alarm management, safety system monitoring, and asset management to mass balancing, off-site management, and power and energy optimization.
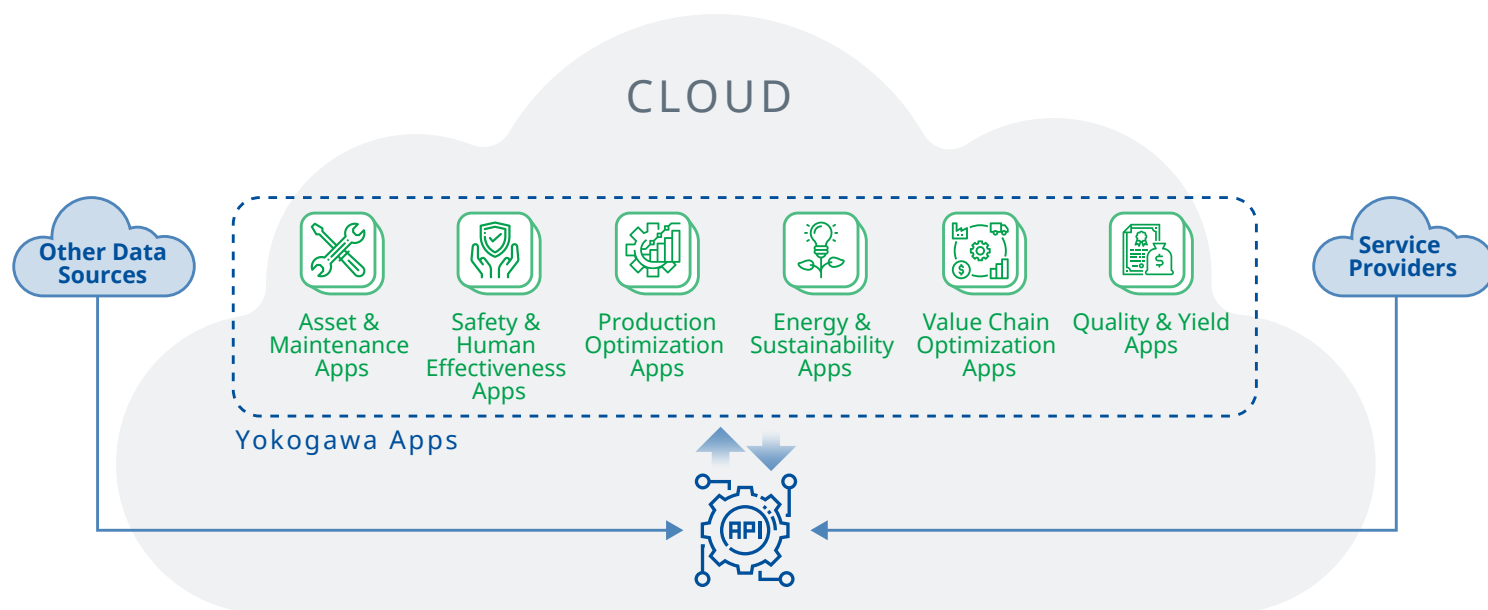
Apps or solutions are software programs that are built to solve specific business problems. For example, asset management, production optimization, health and safety, and other categories which appear in the layer above the apps of a technology stack or digital platform. Cloud applications are built using different services, such as the data, enterprise data management and orchestration, logic builder, and visualization available from the platform.

The plumbing on the platform encourages the different apps to connect with each other and securely exchange or reuse data as needed. Once available on the platform, data can be reused by other apps, thereby eliminating data duplication along the lifecycle. The standard apps are configured for deployment using the logic and graphic builder functions.

The apps enable the realization of the vision of DX. In many cases, these app packages are developed between a supplier and a user to solve specific problems and challenges and then made into a universal solution available to other users.

Today, in pursuit of user convenience, ubiquitous access, and other IT/OT convergence benefits, these software applications are being developed in and migrated to the cloud.

5.6   ENTERPRISE INTEGRATION

The full scope of a company's enterprise software extends beyond operations and manufacturing to supply chain, front office commercial systems, financial ERP systems, and human resources (HR) systems. Simply put, enterprise integration used to be the ERP layer of the ISA95 pyramid. Now, it can encompass all external integrations form the cloud to the DX platform.

Integrating all of the above-mentioned systems enables the journey toward a digital nirvana where companies can increasingly automate the supply chain, commercial operations, engineering, asset management, and financials.
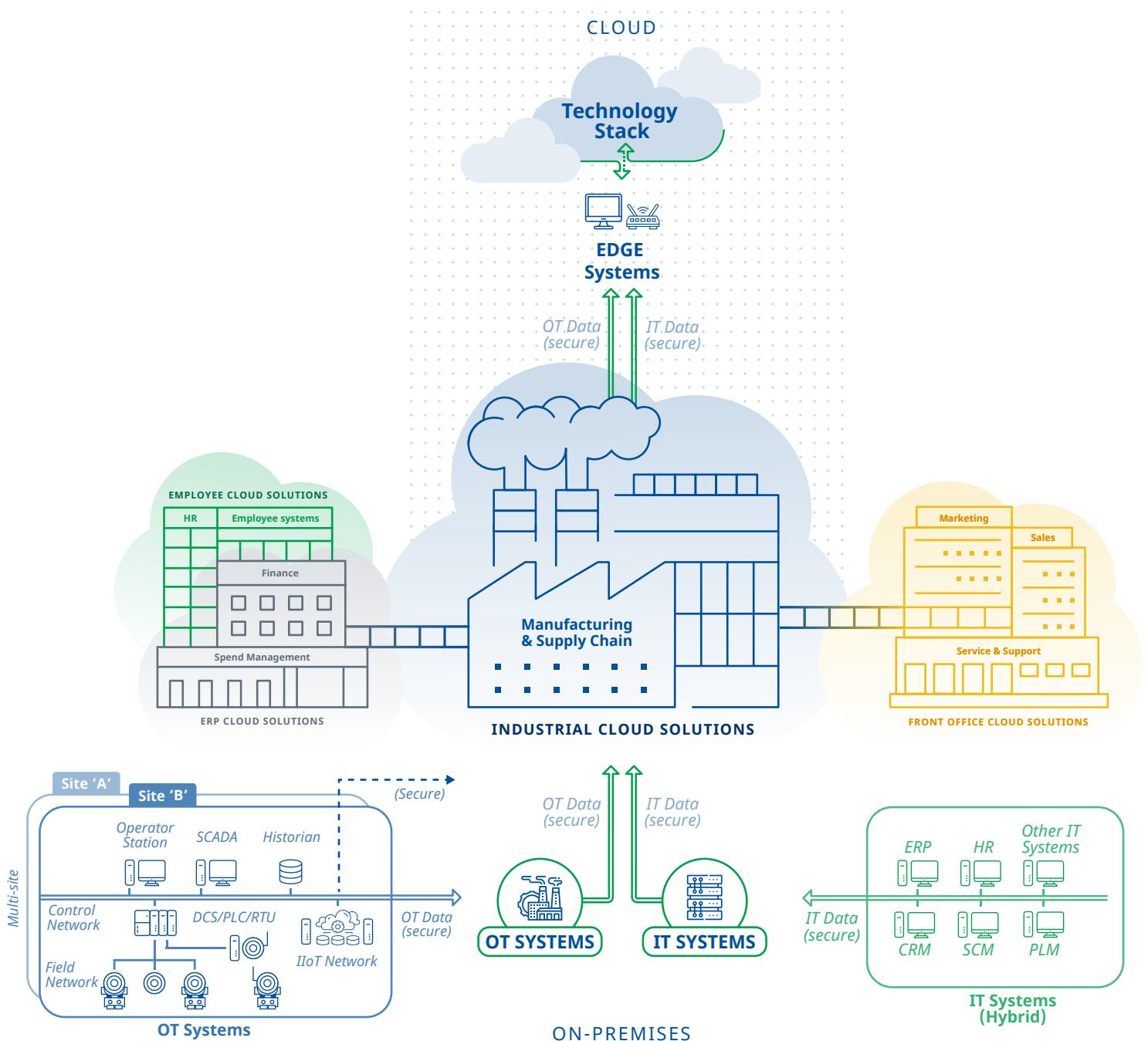
Digitalize Everywhere in Operations

The impact of DX on business processes

Your vision of the business should be one of an operational asset, or portfolio of assets, that exists in the context of their supply chains and surrounding business environment. To maximize revenue and margin while minimizing cost and risk, the whole asset together with the supply chain should continuously respond, in unison, to market signals and disturbances as quickly as possible.

An ideal set of operational processes and best practices would manage your asset through its lifecycle, production and manufacturing processes, in view of the value / supply chain and sustainable operating processes. DX in operations seeks to uncover these operational best practices, automate them and support decision making through technology.

Where to digitalize?

In this chapter, we introduce a high level view of business processes in operations and the component business processes of which they are comprised. These functional areas are frequently associated with departments, software applications, and data sets to be integrated. Taken together we call it: Smart Manufacturing Value Map.

SMART MANUFACTURING VALUE MAP

Reduce Cost/Risk   Smart Manufacturing   Increase Revenue & Margin

Integrated / Centralized Operations

Infrastructure Management ON SITE — CLOUD	Integrated IT / OT Data			Analytics & Simulation		
Asset Lifecycle	**Production/Manufacturing**			**Value Chain**		
	Safety & Human Effectiveness	Asset & Maintenance	Production Optimization	Quality & Yield	Materials & Logistics	Planning & Accounting	Energy & Sustainability
Process Design	Functional safety	Reliable control & safety	Revenue maximization	Skilled workforce	Feedstock sourcing	Planning	Emissions & Waste
Engineering & Construction	Physical and Cyber security	Instrumentation & analyzer maintenance	Capital expense management	Rigorous adherence to plans	Inbound logistics	Scheduling	Energy Transition
Upgrade / revamp	Regulatory compliance	Asset management	Operating cost containment		Outbound logistics	Accounting	Social License to Operate
Decommission		Data aggregation & quality	Agile response to market changes		Delivery		
			Culture of profitability				

6.1 ASSET/FACILITY LIFECYCLE

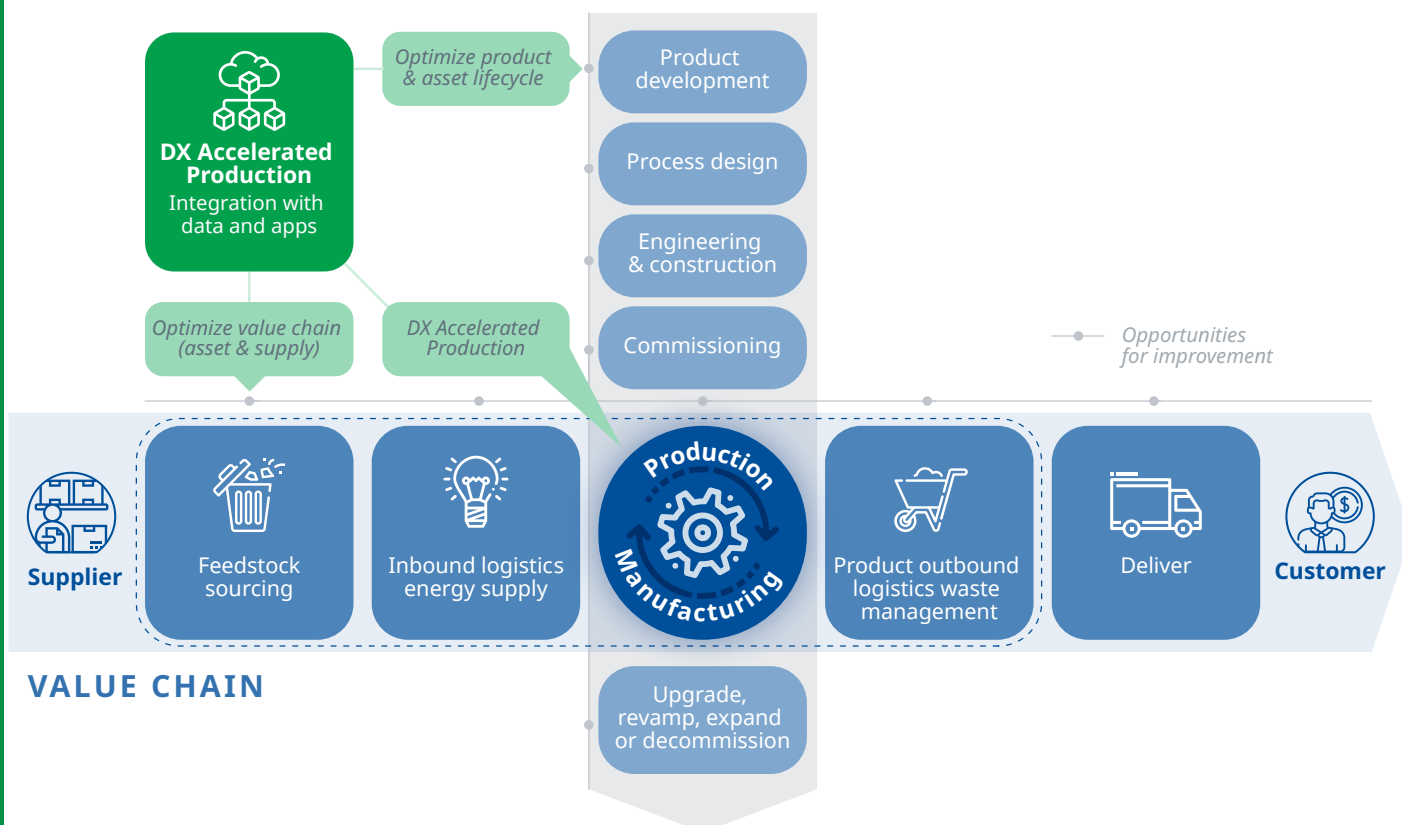The most capital and human resource intensive aspect of operations is production/manufacturing, including the plant or facility construction. Whether brownfield or greenfield, an asset undergoes years or decades of planning, design, engineering, operation, and maintenance.

Throughout the asset lifecycle, there are significant opportunities for IT/OT convergence and productivity improvements, ranging from education and maintenance to incident response, obsolescence management, and data management. Digital transformation starts at the beginning of the asset lifecycle with process simulation. Standard XML schemas, which conform to ISO 15926, can be used to establish an asset knowledge graph and asset knowledge management foundation. Ontologies, or data structures, can be used to convert 3D P&ID data and steady state simulations into a semantic model to create dynamic simulations, control and safety system configurations and logic, and, ultimately, the asset knowledge graph.

There are a broad range of services over an asset's lifecycle, ranging from education and maintenance to incident response, obsolescence management, and data management.

ASSET LIFECYCLE

DX Accelerated Production — Integration with data and apps

Optimize product & asset lifecycle

Optimize value chain (asset & supply)

DX Accelerated Production

- Product development
- Process design
- Engineering & construction
- Commissioning
- Upgrade, revamp, expand or decommission

Opportunities for improvement

VALUE CHAIN

Supplier · Feedstock sourcing · Inbound logistics energy supply · Production Manufacturing · Product outbound logistics waste management · Deliver · Customer

6.2   VALUE CHAIN

Management, automation, and value chain (asset and supply chain) optimization are central to all process industries. From raw material supply to product delivery and consumption, process manufacturers must respond quickly and efficiently to market changes and demand shifts. Digitalizing and integrating data and applications across the value chain enables optimization. Since data and applications are spread across organizational silos, an integrated supply chain approach typically requires an enterprise initiative to stimulate collaboration and information sharing. Today, value chain optimization is highly manual and dependent on skilled subject matter experts using simple linear models that may be poorly maintained. As enterprise-wide integration becomes a reality, companies can achieve automated value chain optimization with data-driven, automated models and work processes, enabled by the cloud and ML to deliver significant business agility and outcomes.

The decision cycle for investment planning, production planning, supply chain scheduling, production accounting, and process control can be accelerated through digitalization and IT/OT integration, resulting in greater certainty and impact. The holy grail of value chain optimization lies in the closed loop optimization of planning, scheduling, operations, and autonomy.
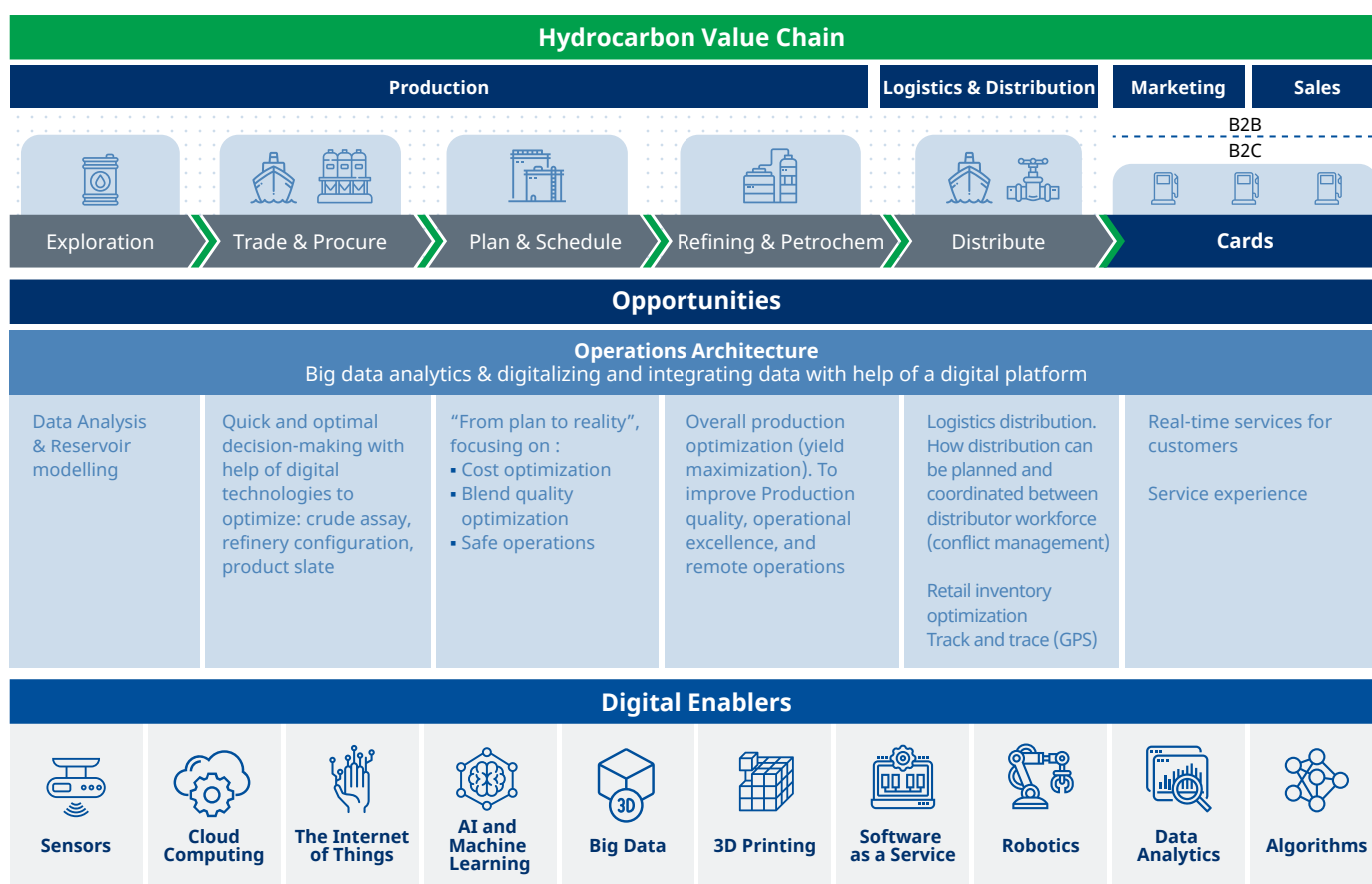
DIGITAL OPPORTUNITIES EXIST ACROSS EACH VALUE CHAIN

Figure: Example of a fully integrated value chain and workflows.

6.3 PRODUCTION AND MANUFACTURING

A DX journey towards further growth and improvement often encompasses the adoption of smart manufacturing in the areas of production and manufacturing.

While DX is often viewed as a program with prioritized digital initiatives oriented around business processes rather than point solutions, smart manufacturing is about applying digital enabling technologies to production and manufacturing to allow self-learning, self-adapting, autonomous operations.

Production/Manufacturing			
Safety & Human Effectiveness	**Asset & Maintenance**	**Production Optimization**	**Quality & Yield**
Functional safety	Reliable control & safety	Revenue maximization	Skilled workforce
Physical and Cyber security	Instrumentation & analyzer maintenance	Capital expense management	Rigorous adherence to plans
Regulatory compliance	Asset management	Operating cost containment	
Decision Support	Data aggregation & quality	Agile response to market changes	
		Culture of profitability	

The key element of a smart manufactruing is deriving real-time data, such as raw material availability and work-in- progress inventory, from the manufacturing process for decision making and problem solving. This entails obtaining process and asset data from individual manufacturing stages using devices and solution, such as (smart) sensors, control and automation, automation networks.

Digital transformation in the area of production and manufacturing leads to process improvements and makes it easier to adopt disruptive technologies that enable an enterprise to achieve a competitive edge.

RE-THINKING TRADITIONAL APPROACHES

Less than 5% of a manufacturing plant's generated data is put to good use—primarily due to improper data management strategies, limited application expertise, missing data, and a sheer lack of resource availability. However, this also creates a huge opportunity for firms to reap new rewards through digitized sensors.

Clearly, this market scenario requires the process industry to re-think traditional plant operational management methods. While process plant owners have installed sensors and digitized their plants for process control, the next prominent challenge will be to take action to digitalize plant operations in a way that leverages the plant's digitized sensor data.

6.4   HUMAN RELIABILITY AND DOMAIN KNOWLEDGE

Human reliability

Human reliability affects health, safety, security, and environment (HSSE); efficiency; and availability. In the airline industry, 90% to 95% of all accidents are caused by human factors. Studies show that process industries have similar characteristics, with the leading cause of unplanned downtime and accidents attributed to human errors.

HUMAN RELIABILITY REFERS TO HOW HUMANS PERFORM IN WORK-RELATED ENVIRONMENTS AND IS SHAPED BY THEIR SITUATIONAL AWARENESS AND PERCEPTION OF WHAT IS HAPPENING AROUND THEM.

Situational awareness, in turn, is affected by how clearly information is presented, along with other factors, such as state of mind, physical health, age, attitude, emotions, and fatigue. The exodus of the baby boomers from the workforce and the influx of a relatively inexperienced new generation of workers has created a need for new solutions.

Human reliability and predictability can drastically diminish in times of stress. Most incidents occur during stressful times, such as startups, shutdowns, transitions, and abnormal situations. The most common human errors are caused by not following standard operating procedures, unclear operating instructions, too many pressing actions to handle, inadequate safety and hazard assessments, poor communication, outdated procedures, inadequate training, and poor alarm management programs.

The following digital solutions can easily address these issues:

- Advanced decision support brings together advanced operator graphics, alarm management, and modular procedural automation. Advanced decision support helps reduce human errors by improving operator awareness during routine and abnormal situations.

- An operator training simulation is one of the best ways to prepare operators with realistic simulations of normal and critical situations.

NEWER DIGITAL TECHNOLOGIES ARE ALSO IMPROVING HUMAN RELIABILITY
Augmented reality and virtual reality are used to train and assist workers in following procedures and making better decisions.

Domain knowledge

As IT and OT converge, much of the domain knowledge will follow. For example, the sensor level has always been in the domain of process measurement technologies, such as pressure. Today, the expertise is evolving to include wireless networking, power consumption, data, and cyber security. The sensor domain will become IT-aware, while the domain will become sensor-aware.

IoT technologies and IT/OT convergence are also providing for the significantly improved management of domain knowledge. By digitalizing domain knowledge, today's enterprises no longer suffer from huge expertise losses when individuals retire. Digitalizing domain knowledge using media, such as video, makes it widely available to anyone in need. For example, it can allow a process pressure expert to expeditiously get up to speed on wireless networking and data transfer technologies.

6.5   HEALTH, SAFETY, SECURITY, AND ENVIRONMENT (HSSE) AND CYBER SECURITY

Together, safety and human reliability serve as a cornerstone of operations in the energy and chemical industries. Rigs, plants, ships, pipelines, terminals, and assets are constantly changing to meet new and evolving regulatory requirements, production targets, and operational objectives. Safely managing these changes is a daunting task that requires risk assessment, approvals, change management, and documentation. Many layers of protection are needed to ensure HSSE. Generally, these include design integrity, asset integrity, and operational integrity.

Safe operations

As the asset or operational objectives change, new procedures need to be established and operators need to be retrained. If an asset fails suddenly, it poses a safety risk. It must be shut down safely to avoid an incident that could damage the equipment or the environment or lead to loss of life.

Companies take great measures to ensure safe operations by conducting HAZOP studies and implementing alarm management and procedural automation solutions to keep each process in a safe operating window. Companies also use a multitude of systems and process analytical equipment to detect gas leaks and fugitive emissions, and they use safety instrumented systems (SIS) to safely shut down the process in case of an incident. These systems can be improved through the use of digital technologies.

> " We can use robotics, augmented reality, big data, the digital twins and other aspects of Industry 4.0 to help achieve Dow's 2025 sustainability goals and to continue to improve our safety performance. Safety, as well as cyber security, remain paramount as our industry continues to evolve. "
>
> *Billy B. Bardin. Global Operations Technology Director.*
> *The Dow Chemical Company. (Chemengonline.com)*

Mitigating risk

Since safety is paramount in process industries, IT/OT convergence implementation teams are working hard to raise security to the same level. Safety and security controls need to work together to mitigate risk and minimize the business impact of any incident. Security has become a part of corporate safety programs and is commensurate with safety in training programs.

Cyber security

Cyber security is a common denominator among all technologies. The cyber security strategy and implementation approach based on the Purdue Model now extends throughout the enterprise. A new standards-based approach has been designed to encompass IT and OT systems. While OT typically uses the NIST cyber security framework, IT requirements and interactions with third parties could involve additional standards, such as ISA/IEC 62443 and ISO 27001.

Unique to IIoT, IT/OT convergence implementation teams will continue making decisions regarding the segregation of OT networks from corporate networks, OT network isolation from the Internet, least privilege access controls at site and process levels, and cross-site communication restrictions. Meanwhile, cyber security domain expertise is evolving to encompass the formerly disparate OT and IT domains.

YOKOGAWA'S CYBER SECURITY PORTFOLIO

Assessment and Analysis	Design and Implementation		Operation Support			Validation Support
	Host Based Security	Network Security	Security Update	Situational Awareness	Respond and Recovery	
Security Assessment	Antivirus Implementation/ Management	Secure Network Design	Security Information Service	Virus Check Service	Software Backup Service	Audit
	OS Patch Management	Firewall	Antivirus Update	Network Healthiness Check Service	Security Incident Response	
	Malware Inactivated Service	Network Monitoring System	Application Whitelisting Update	Security Awareness Training	SOC (Managed Service)	
	OS hardening/ OS Port lock	Next Gen Firewall	OS Patch Update			
	User/PC Setting Management	IPS/IDS				
	Backup Recovery System	Unidirectional Gateway				

Comprehensive system and network security services for plant, manufacturing and operation environments

The role of leadership and business culture

The impact of DX on people

Technology is supposed to support and empower humans; it is supposed to capture and enable the spread of human knowledge and experience and offload mundane, repetitive, and dangerous tasks, freeing humans to innovate. In a digitalized plant, you are an implementer and a supervisor of strategy, supported by automated number-crunching and execution.

Many people are finding digitalization uncomfortable. Why? Because it is revealing. It is eliminating places for underperformance to hide- whether that is individuals, departments, business units, business processes, or companies. Data proliferation and omni-directional communications are revealing activities that should perhaps be repurposed or improved. It does not allow silence to remain comfortable.

IT/OT collaboration issues — 21%

Lack of Corporate buy-in and investments — 21%

Culture and change management — 29%

Lack of a digital roadmap — 21%

Preserving legacy investments — 7%
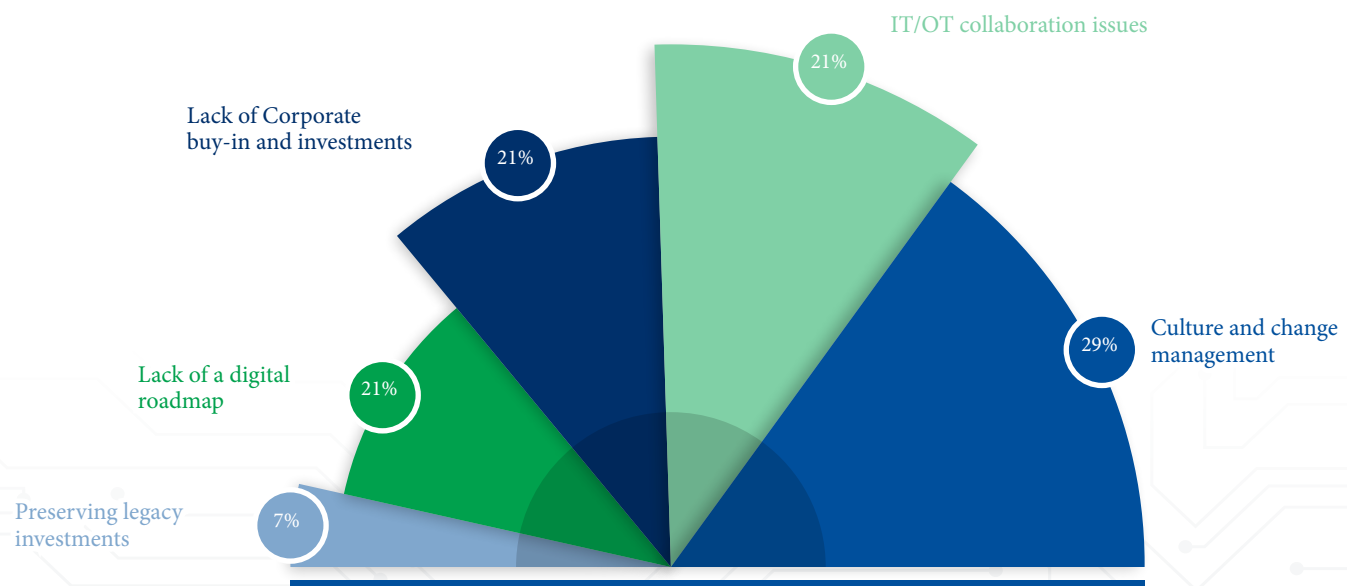
WHAT ARE THE TOP RESTRAINTS OF DIGITAL TRANSFORMATION?

7.1   CULTURE

Since DX is disruptive to current work practices, there can be considerable resistance to change. Some resistance comes from departments that do not want to share information and collaborate, and some resistance come from workers who do not understand how DX will affect their jobs.

DX requires introducing a culture that supports change while also enabling the company's overarching business strategy. It asks for informed leaders who acknowledge the existence of a "digital divide" between plant personnel who deeply understand OT and their counterparts who deeply understand IT. While OT expertise is typically gained through years or decades of real-world industrial experience or "tribal knowledge", the sudden and rapid explosion of IT has produced a new set of tools that are unfamiliar and overwhelming to industrial customers. An effective approach to DX recognizes that both skill sets are important, collaboration is necessary, and collaboration and skill sets must be addressed at all levels of an organization.

TACIT KNOWLEDGE represents one of the biggest sources of trapped value across the energy and chemical industry. We believe that institutionalizing tacit knowledge is one of the key success factors that enables aligning of the business operating model to business goals. We view tacit knowledge as the skills, ideas and experiences that people have gained over time but are not systematically codified in a way that makes them easily expressed or transferred.

7.2   LEADERSHIP

DX initiatives require changes in the culture and mindset of the organization, which typically reflect the communication and working style of the leadership. Leaders must recognize the need for change and the capacity constraints that make this difficult.

DX is simultaneously complex, ambiguous, strategic, and operational; therefore, leadership must identify key players and organizational connectors who possess the traits to tackle these challenges. Factors for assessing and identifying these players include core experience and perspective, mental and change agility, problem solving capacity, persistence, assertiveness, and tolerance of ambiguity.

'Digitally-wise' companies are incorporating HR programs to assess and develop technology, leadership, and change management skills. Often, a small but carefully curated team with cross-functional experience and a dedicated focus on DX is created at first. The primary areas of functional convergence in this team are between OT, IT, and business strategy. This enables a continuous thread from market understanding and customer experience through OT/IT execution, development, and innovation.

Due to the enterprise-wide impact of DX and its dependency on IT, the ideal champion of a company-wide DX tends to be the CEO, or increasingly, a CIO or Chief Digital Officer (CDO) who can champion and organize the resources and investments required.

DX provides a framework for aligning the leadership team, who can speak with one voice through this lens to reinforce the company's strategy and drive a new way of working. To mitigate anxiety and fear of change, digital leaders have a responsibility to create an environment where employee development and experimentation are encouraged.

7.3   NEW OPPORTUNITIES

There is a myriad of opportunities for those who actively embrace DX and participate. Everyone must examine their unique contributions to the organization and their knowledge and skills and then connect those strengths to the DX process—giving employees control over how the DX will unfold and framing new technologies as a way to become even better at what they were already good at doing.

Program management, team building, and sustainability from project inception through implementation into day-to-day workflows creates opportunities for those who wish to contribute.

Where Should We Start?

Practical steps to embark on your DX journey

As your company becomes increasingly aware of the external threats and opportunities of DX, there is a corresponding desire to act. Although strategies should be developed with an external context, the practical execution of DX begins internally, where your company can fully own its actions and outcomes. No one knows your problems and needs better than you.

THE FOLLOWING PRACTICAL STEPS ARE RECOMMENDED TO EMBARK ON YOUR DX JOURNEY:

STEP 1 — Align with corporate goals and strategy

STEP 2 — Assess readiness

STEP 3 — Maturity model

STEP 4 — Break organizational silos to collaborate

STEP 5 — Organize processes around customers

STEP 6 — Identify quick wins and estimate benefits

STEP 7 — Build a technology foundation

STEP 8 — Organize technology around data
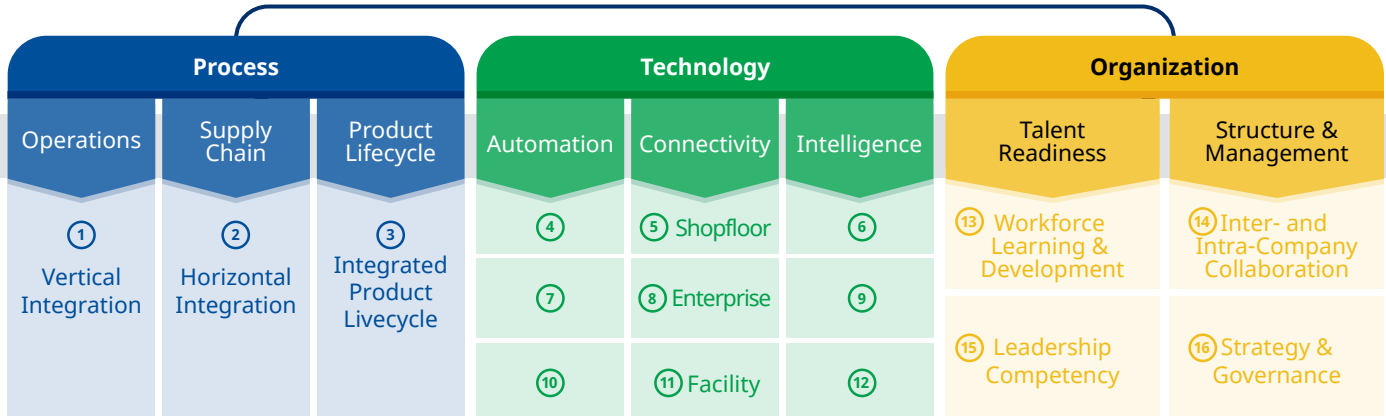
ALIGN WITH CORPORATE GOALS AND STRATEGY

To start with, you need an understanding of your company's business objectives and strategy to frame your DX approach. Digitalization efforts driven only by operations tend to result in limited impact across the enterprise and can lead to long cycles of technical discussions, limited C-level support, and IT involvement. Strategic investments can be difficult to justify with operations viewed as a cost center that is fundamentally charged with delivering maximum productivity at the lowest cost. A strategic approach therefore involves connecting with your company's business strategy and business processes. These business cases can be driven and supported by the C-level or proposed by the organization and endorsed by the leadership.

ASSESS READINESS

DX readiness should be considered as an integrated set of business strategy, people, processes, and technology. Your company should consider and evaluate its capabilities in each of these areas to reach a common organizational understanding of your as-is situation.

People readiness refers to your company's current levels of organizational collaboration, skill sets, and change readiness. In addition to routine HR performance management initiatives, DX requires the identification of team members who can act as organizational connectors and those who possess a combination of change agility, learning agility, technology, and leadership skills. In addition, mapping out the organization's communication pathways and frequency among departments and hierarchies will reveal how these human connections support or inhibit the desired business processes.

SMART INDUSTRY READINESS INDEX

Process			Technology			Organization	
Operations	Supply Chain	Product Lifecycle	Automation	Connectivity	Intelligence	Talent Readiness	Structure & Management
① Vertical Integration	② Horizontal Integration	③ Integrated Product Livecycle	④	⑤ Shopfloor	⑥	⑬ Workforce Learning & Development	⑭ Inter- and Intra-Company Collaboration
			⑦	⑧ Enterprise	⑨	⑮ Leadership Competency	⑯ Strategy & Governance
			⑩	⑪ Facility	⑫		

To help manufacturers take the first step on their transformation journey, the Singapore Economic Development Board ("EDB") launched the Smart Industry Readiness Index ("SIRI") and its accompanying Assessment Matrix in November 2017. SIRI identifies 3 fundamental building blocks of Industry 4.0: Technology, Process, and Organisation. All 3 building blocks must be considered to harness the full potential of Industry 4.0.

A company's readiness also relates to its current state and the completeness of defined business and work processes. While business process mapping is a well-established practice, these activities often address one business function or do not adequately represent manufacturing or operational processes.

Lastly, technology readiness in OT and IT domains should be considered across the integrated IIoT and enterprise views.

MATURITY MODEL

Every DX journey is unique and supported by enabling technologies and services. Along with maturity and operational assessments, your focus areas and desired outcomes will be used to guide you in determining your ideal approach for creating value.

Moreover, by combining Yokogawa's decades of know-how on achieving industry-specific operational excellence with DX best practices, we will lay out a clear maturity model assessment, roadmap, and guidance for your DX journey.

PROCESS INDUSTRIES DX MATURITY MODEL

TARGETED OUTCOMES	RISK MINIMIZATION	STABLE & REPEATABLE OPERATIONS	INDUSTRY LEADING EFFICIENCY	SUSTAINABLE & AUTONOMOUS
	VULNERABLE	OPERABLE	OPTIMAL	SUSTAINABLE
Business Strategy & Processes	Ad-hoc or absent	Siloed initiatives and visions	Integrated common vision	Active ecosystem integration
People & Culture	Disengaged and losing vital knowledge	Active knowledge transfer	Culture of learning & development	Leaders are digital innovators
IT / OT Collaboration	Siloed	Tolerant	Collaborating	Engaged & integrated
State of Data	Islands of information	Integrated plant data	Enterprise data lake	Value chain integration
State of Technology	Legacy	Current	Advanced	Innovative

BREAK ORGANIZATIONAL SILOS TO COLLABORATE

Every organization naturally develops organizational silos, since camaraderie and communications naturally form around day-to-day team structures, roles, and projects. While restructuring can address some of these issues, it is a lengthy and complex process. If not executed with adequate preparation, restructuring can create unintended consequences and new silos.

A more practical approach can be the employment of organizational network analysis and health index tools to identify the key trusted staff who others turn to when they have questions. Once the most influential people at key points across the organization are revealed, they can be invited to participate in a digital transformation task force, becoming a new cross-functional team organized around transformational objectives, relentlessly reinforcing messages, and delivering change on the ground.

Internal communications mechanisms are necessary so that everyone can stay informed, take notice, and act. These measures can involve internal campaigns, blogs, social media town hall meetings, etc.
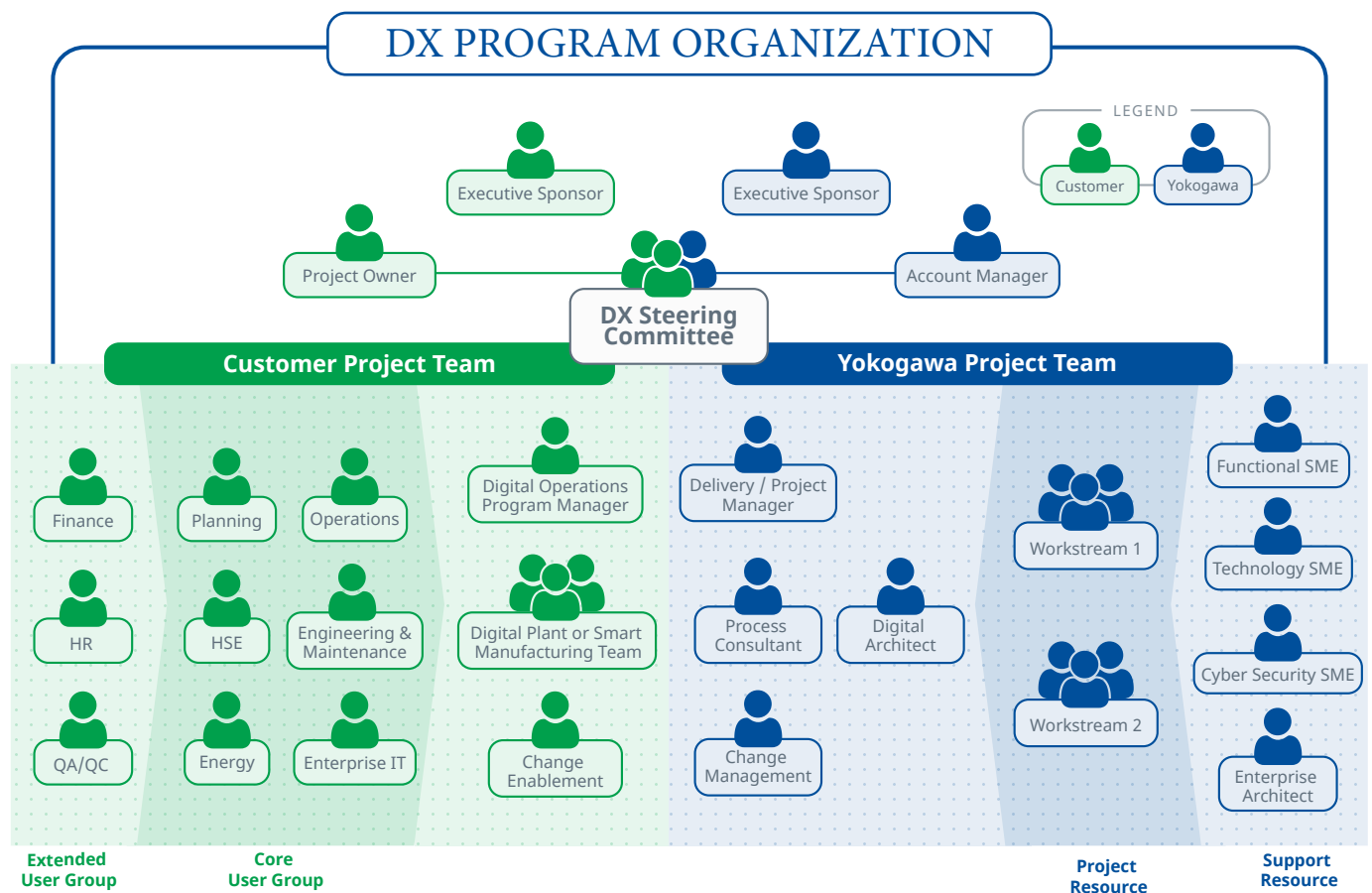

Figure: Example of a DX program organization outlined by Yokogawa. The customer project team is mirrored to the DX vendor project team (in this case, Yokogawa). This overview is part of a broader DX framework that will be discussed in Chapter 8.

ORGANIZE PROCESSES AROUND CUSTOMERS

Operationalizing a strategy involves understanding, implementing, or improving business processes. Increasingly, these business processes will be oriented around the customer experience and the customer journey.

DX requires a mindset and culture that places the market, customer value, and customer experience first. The company must adopt a perspective that prioritizes the needs of the market over the needs of its departments or leaders and promotes the necessary organizing principles, processes, portfolio, and operations to deliver those market needs.

A customer-oriented business process involves front office, operations, engineering, and business leaders when evaluating risks and prioritizing investments. Cross-functional project teams must also reach a shared use of common terminology and metrics. Successful case studies are characterized by holistic strategies for securing the IT/OT ecosystem and a standards-based, risk-aware approach.

IDENTIFY QUICK WINS AND ESTIMATE BENEFITS

Having a clear view of your customer-oriented business processes provides a clear connection to the value created for your customer and, therefore, your business. We recommend that all digitalization investments be associated with a business process.

In this way, the application of technology, automation, and other expenses can be linked to business process improvements and their associated value. The ROI model and projections can be clearly modeled around business processes, costs, and projected returns.

BUILD A TECHNOLOGY FOUNDATION

Leading companies ensure a stable technology foundation before moving to cross-functional integration and acceleration. Case studies show that, in the early phases of digitalization, up to 80% of digitalization efforts may be spent on janitorial and data housekeeping activities. While tedious, a clean and stable data foundation is essential to support effective analysis, decision making, and automation through applications.

In process industries, business processes also include operational processes, such as plant startups and shutdowns and shift handovers. As these processes are mapped to the value chain and other enterprise operations, they unlock greater potential for value delivery.
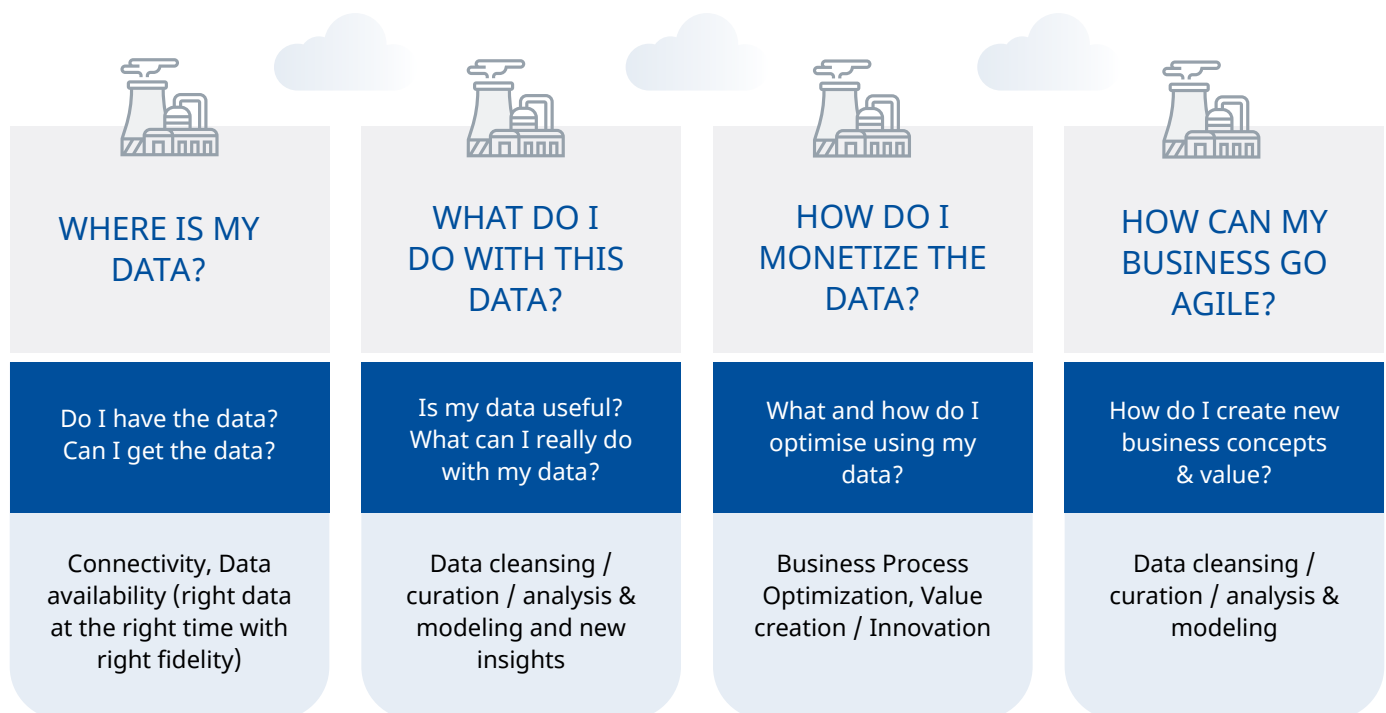
ORGANIZE TECHNOLOGY AROUND DATA

The quest for digital nirvana is enabled by technology and built upon a systematic approach to the aggregation and normalization of data.

In process industries, this means auditing your connectivity and access to all process and asset data with the aim of integrating all OT data in a single data lake and ensuring data fidelity and quality.

The importance of building this OT data foundation cannot be emphasized enough. Defining all current and desired data ingress sources will reveal some automated, manual, and non-existent areas where technology can be applied.

As the data is aggregated, a rigorous approach to data cleansing must be applied, which addresses duplicate data, enrichment, normalization, and data relationships. Only a data-centered approach to technology ensures a reliable foundation from which analytics, application logic, and interoperability can be applied.

WHERE IS MY DATA?	WHAT DO I DO WITH THIS DATA?	HOW DO I MONETIZE THE DATA?	HOW CAN MY BUSINESS GO AGILE?
Do I have the data? Can I get the data?	Is my data useful? What can I really do with my data?	What and how do I optimise using my data?	How do I create new business concepts & value?
Connectivity, Data availability (right data at the right time with right fidelity)	Data cleansing / curation / analysis & modeling and new insights	Business Process Optimization, Value creation / Innovation	Data cleansing / curation / analysis & modeling

Partner Up

Just as a company's business strategy realization is unique, so too is its desired approach to DX. Process industry companies need a business partner who starts by engaging and aligning with their goals, aspirations, and business strategies. Innovation is not just a one-time event or project.

Today, executive steering teams recognize that a co-innovation approach to a DX journey offers deep benefits, a broader perspective, and sustainability. Partnering with consultants, suppliers, and customers brings in the entire supply chain and allows implementation teams to best manage complexity, project execution, risk, and the full scope of domain expertise that is required.

Across the spectrum of process industries, Yokogawa partners with customers to support your journey, while enabling the use of industrial automation technologies, IT/OT services, and domain knowledge to support operations. We envision a DX that optimizes your operations through the enterprise value chain.

Yokogawa's mission, "Co-innovating Tomorrow," expresses this approach. We're designed to support our clients' DX journeys and help their operations take shape and excel.

Our engagement model starts with understanding your goal, identifying challenges, quantifying financial impact, and estimating the complexity of the change. These actions are followed by discovery stages to comprehensively understand as-is and desired business processes, human factors, and enabling technologies. Quick wins are designed to accelerate implementation and generate proof of value. Throughout this process, we continuously develop and tune the continuous delivery of value achieved through digitalization.

DISCOVER

Discover digital opportunities for organization and establish digital transformation blueprint.

Activities:
▸ Value Discovery
▸ Digital Maturity Assessment
▸ Key Stakeholder Interviews
▸ DX Blueprinting

Deliverables:
▸ Digital Transformation Blueprint
▸ DX Maturity Assessment Report
▸ Interim Action Plan

DESIGN

Develop a digital transformation business plan wich is ready for implementation.

Activities:
▸ Stakeholders Alignment Sessions
▸ Business Process Mapping
▸ Analyze and Design
▸ Business Case Challenge Sessions

Deliverables:
▸ Business Case
▸ DX Roadmap
▸ DX Governance Framework
▸ Digital Architecture Design
▸ Cyber Security Philosophy
▸ Application Framework Design
▸ User Requirement Specifications (URS)
▸ Proof of Value

DEVELOP

Deploy outcome-based digital transformation experience according to plan

Activities:
▸ Programme Governance
▸ Project & Change Management
▸ Build, Test and Production Release
▸ Agile Sprints & DevOps

Deliverables:
▸ Digital Products and Services
▸ Training Programme
▸ Documentation
▸ Sustainability Plan

Conclusion

As DX continues to disrupt, transform, and re-shape global business, the imperative to change is clear and very present in process industries. To make this change, you will need to shift your focus from reactive operations to proactive, predictive, and profit-optimizing operations.

Successful process industry companies see DX as a key strategy for deploying sustainable innovation across value chains through the judicious use of digital technologies, while structurally altering operational models, culture, and best practices that encompass new ways of working.

Companies cannot make the DX journey alone. They need to leapfrog innovation by partnering with experts fluent in both operational technology and IT.

Your partner must understand your existing operations, technology, and data. As complexity differs for each company, the imperative is to co-create solutions that fit your needs, requirements, and budgets. Many solution providers have piece-meal offerings, including consulting, IT, and OT technologies. Increasingly, the best fit DX approach requires a partner who will support you throughout this journey, is open and oriented to all possibilities, and takes responsibility in all aspects of the process from planning to performance-based results.
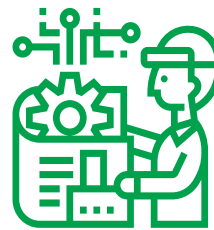
YOKOGAWA INTEGRATES ITS BUSINESS AND DOMAIN KNOWLEDGE WITH DIGITAL AUTOMATION TECHNOLOGIES AND CO-INNOVATES WITH CUSTOMERS TO DRIVE THEIR BUSINESS PROCESS TRANSFORMATION.

Digitalization is accelerating and disrupting the decision cycle. For the first time, a digital enterprise is within reach for the energy, chemical, and process manufacturing industries. It is time to go beyond Proof of Concept (PoC) to Proof of Value (PoV), rally your operations around this vision, and create lasting, sustainable business value.

Yokogawa co-creates value by connecting data, systems, and organizations to the value chain and business and domain knowledge. Our dedication to customer success puts you at the forefront of your DX, co-innovating with you throughout your journey to ensure that solutions are tailored to your exact needs.

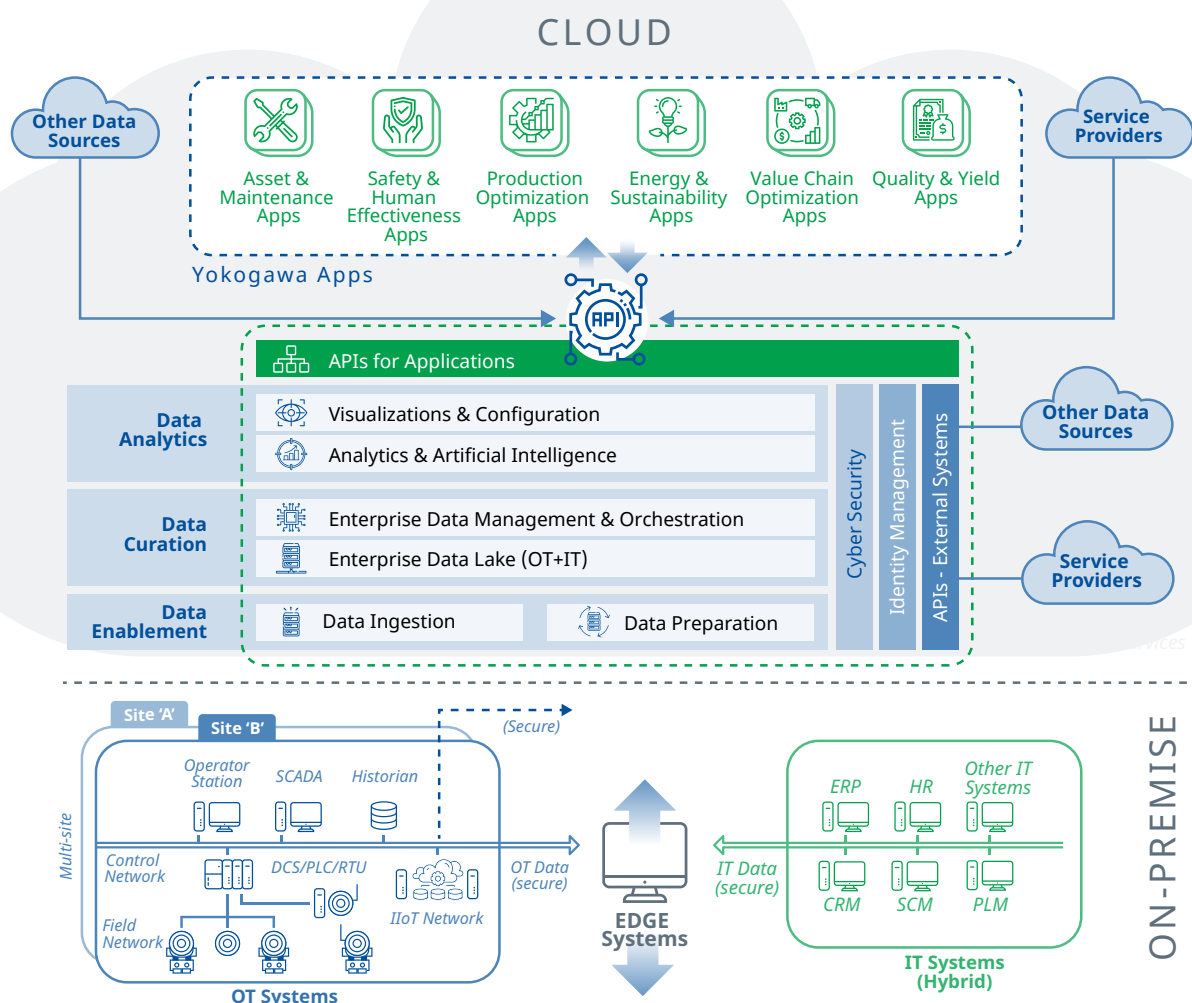# Appendix I

Digital Transformation Reference IT/OT Architecture

An integrated, context-aware IT/OT architecture is necessary to support digital transformation (DX) in process industries. Reorienting the business performance of operations involves the ingestion, processing, & curation of data from various sources, algorithms and integrated applications to empower humans to support insightful decision making.

For most companies, the transition to an IT/OT architecture presents an opportunity to optimize manufacturing or operational processes, unlock and enhance the value of legacy systems and data. An Industrial cloud solution architecture reflects the interplay of existing and desired systems, aligning assets and operational processes with the value chain in which they exist. An IT/OT architecture works backwards from market needs and customer experience, to applications and operational processes, to the hardware and data to which they securely connect.

Yokogawa helps customers realize this architecture with a broad set of services including consulting, applications engineering, system integration, deployment, training and ongoing maintenance.

CLOUD

Yokogawa Apps

Asset & Maintenance Apps

Safety & Human Effectiveness Apps

Production Optimization Apps

Energy & Sustainability Apps

Value Chain Optimization Apps

Quality & Yield Apps

Other Data Sources

Service Providers

APIs for Applications

Data Analytics	Visualizations & Configuration
	Analytics & Artificial Intelligence
Data Curation	Enterprise Data Management & Orchestration
	Enterprise Data Lake (OT+IT)
Data Enablement	Data Ingestion / Data Preparation

Cyber Security · Identity Management · APIs - External Systems

Other Data Sources

Service Providers

ON-PREMISE

Site 'A' · Site 'B' · (Secure)

Multi-site

Operator Station · SCADA · Historian

Control Network · DCS/PLC/RTU · IIoT Network · OT Data (secure)

Field Network

OT Systems

EDGE Systems

IT Data (secure)

ERP · HR · Other IT Systems

CRM · SCM · PLM

IT Systems (Hybrid)

CLOUD APPLICATIONS

Industrial apps are software programs or integrated solutions engineered to solve specific business problems. Cloud-based apps and solutions enable smart manufacturing and the digital transformation vision including integrated, remote operations with enterprise connectivity. While cloud applications consume common services provided by the underlying digital platform (regarded as the middleware) via RESTful APIs and other interfaces, they often bring additional logic, visualization & user interactions specific to the purpose. Applications are configured for the appropriate data sources and visualization preferences before use. Beyond the standard apps, a range of bespoke solutions can also be rapidly assembled by combining one or more apps, or using the standard functions provided by the platform.

Typical Applications and Solutions:

- Integrated Operations and Remote Operations
- Asset management, production optimization, quality, health and safety

CLOUD INFRASTRUCTURE

In an industrial environment, infrastructure is shifting from on-premise servers and private data centers towards colocation, hybrid and private and managed cloud infrastructure. An industrial platform is provisioned and managed on such cloud infrastructure to deliver solutions and applications. Edge systems provide secure OT data to a customer's choice of cloud infrastructure. While Yokogawa can provide the full spectrum of digital services including cloud infrastructure, our services are designed to be infrastructure agnostic, thereby allowing the customer to choose the best suited infrastructure.

Infrastructure Options:

- On-premise private cloud
- Customer's cloud infrastructure (Microsoft Azure, Amazon Web Services (AWS), Google Cloud, etc.)
- Managed cloud infrastructure

EDGE TECHNOLOGY

In an Industrial Cloud paradigm, the Edge represents real-time processing and computing close to the data source and is regarded as the confluence of OT & IT. The edge is characterized by both strong connectivity to the old world of OT equipment and the the new world of cloud and unstructured data. The edge controller is often the secure end point for plant floor systems and thus edge security is factored into the design. The edge optionally provides for buffering of data and local processing capability, including execution of AI/ML algorithms and application hosting. Yokogawa approaches each of these requirements by our 'edge gateway' and 'edge server' solutions.

Typical Edge Functionality:

- Safe and secure by design
- Real-time buffering and compute including AI/ML models
- Southside connectivity - industrial protocol support for assets on the plant floor (Modbus, OPC, legacy equipment, etc.)
- Northside connectivity (MQTT, CoAP, AMQP, Web sockets etc. Cameras & imaging systems)

ON-PREMISE TECHNOLOGY

The on-premise assets of an organization are a key part of the digital transformation fabric, because the overall Enterprise architecture must be built on top of the existing infrastructure. On-premise OT equipment primarily comprises systems on three types of networks - a control network, a plant information network, and industrial wireless networks. IT systems typically include ERP, CRM, PLM, HRMS, and other systems with most migrating to cloud at a faster pace than the OT systems. Most systems provide APIs based on standard industry protocols that facilitate data exchange between the systems.

Typical OT Components:

- Control network (DCS / PLC), remote terminal units (RTU), data acquisition systems, and field equipment, 4-20mA, HART, FF, ISA100, and Modbus networks
- Plant Information network - SCADA, plant historians, and other plant information management systems
- Industrial wireless networks - ISA100, LoRa, Sigfox, etc., wireless industrial sensors, transmitting information through edge systems or directly to cloud

OpreX™ Yokogawa achieves operational excellence by providing products, services, and solutions based on the OpreX comprehensive brand that cover everything from business management to operations.

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