Industrial Transformation is Changing How We Run Our Factories

THE FACTORY OF THE FUTURE

**Industrial Transformation is
Changing How We Run Our Factories**

THE FACTORY OF THE FUTURE

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**ACRONYM
QUICK REFERENCE**
VIEW ON BLOG

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Section 1

Executive Summary

The Role of Data

The Factory of the Future (FoF) is not a checklist of emerging technologies to implement, nor is it a single point in the evolution of manufacturing. Rather, FoF is the embodiment and realization of Industrial Transformation (IX), encompassing a journey into new technologies and modes of operation that will affect plants globally for decades to come. FoF also does not stand alone. Its focus is inside the four walls of the factory, but its value is in creating a competitive advantage by flexibly and more cost effectively manufacturing smart and connected products that better meet the needs of consumers.

This research studies some of the technologies available today and in the near future that will drive the goals of IX. These include Digital Lean, Digital Twins, manufacturing simulation, and optimization of processes and the supply chain. A theme that is all pervasive in a FoF is data and information, driven by business process execution. We discuss the role of data – from many sources, traditional and new – changing the way we run our factories.
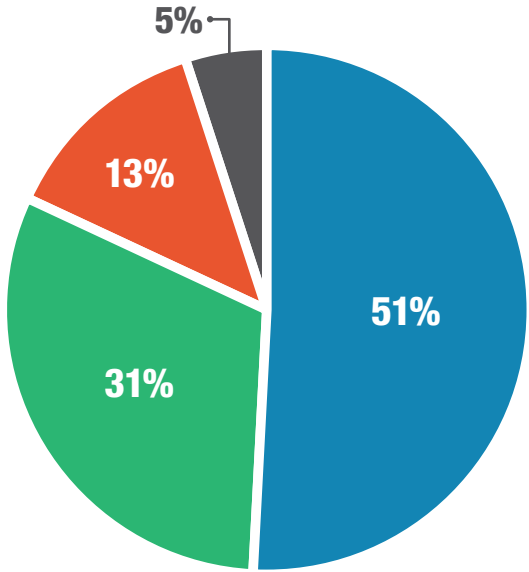
Section 2

Research Demographics
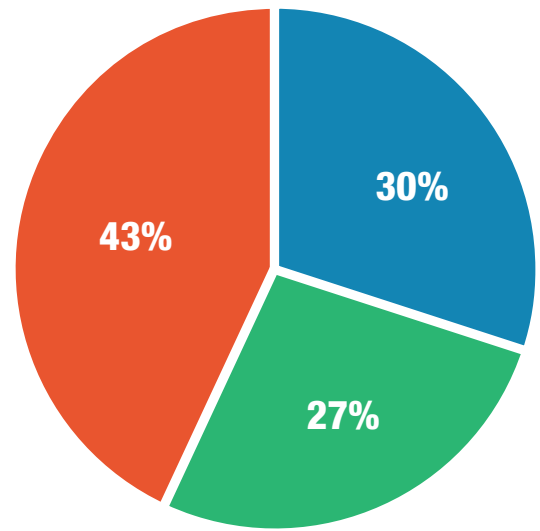
Research Demographics

GEOGRAPHY

- North America
- Europe
- Asia/Pacific
- Rest of World

51%
31%
13%
5%
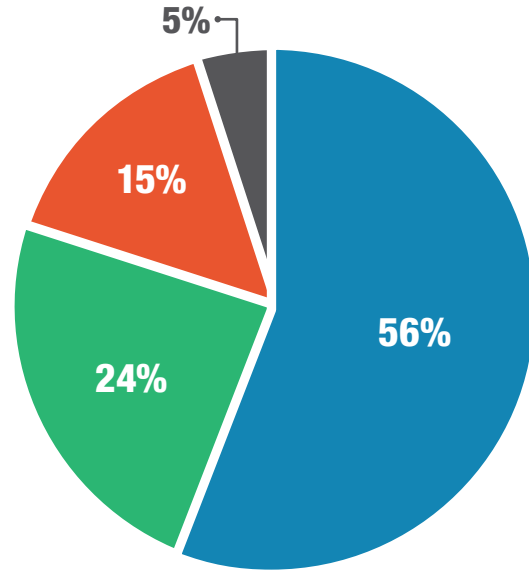
INDUSTRY

- Discrete Manufacturing
- Process and Infrastructure
- Batch Manufacturing
- Other

56%
24%
15%
5%

COMPANY SIZE

- Small: Less than $250MM
- Medium: $250MM - $1B
- Large: More than $1B

30%
27%
43%

Who Benefits from this Research?

This research is aimed at executives – CIO, COO, VP of manufacturing – to guide them as they manage the factory-centric parts of Industrial Transformation (IX) and to enable teams to extend them into the supply chain. It is essential that the sponsoring executive team is balanced between IT and OT responsibility so that the culture of sharing information and involving everyone is a fundamental part of the move to the factory of the future.

Involvement must be universal. Many large manufacturers want to implement FoF concepts and technologies to drive down costs – in other words, to remove people from the shop floor. While this is an unavoidable consequence of many IX programs, and especially those programs focused on plant level changes, eliminating people is not the goal. The goal should be to eliminate dirty and dangerous jobs with high turnover rates and low job satisfaction, which will naturally result in higher quality jobs with a more engaged and productive workforce. The World Economic Forum predicts in its 2018 Future of Jobs report that as tedious jobs are automated, more new jobs will be created, with a net gain in jobs and a much bigger gain in productivity.

Manufacturers must ensure that training, awareness, and opportunities are well defined for those who will take on the challenging task of getting the most out of each FoF. While the wider IX program may not have a laser focus on plant-based employees, it is imperative that the future state of upskilling industrial employment is understood by all – fear of redundancy and a feeling of no future would not be a good starting point. The FoF infrastructure is also critical in ensuring that the new workers can do their jobs as well as possible.

Solving the workforce issue is a key indicator of future success of any Industrial Transformation program. It can only be solved by top management and it needs to be addressed now.
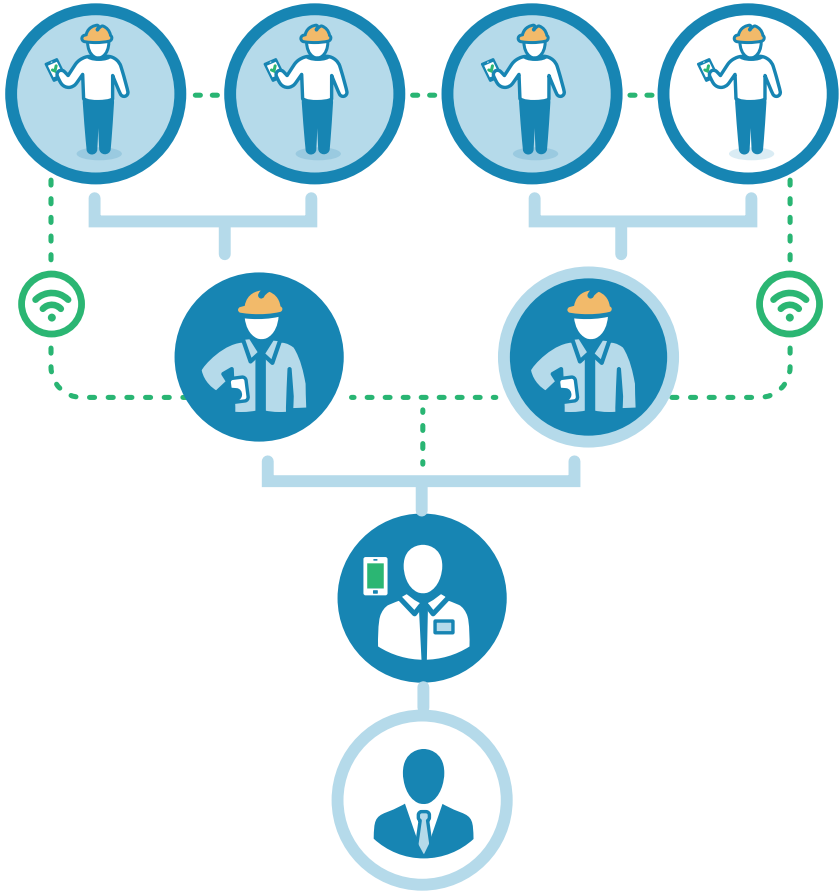
The Factory of the Future Today and Beyond

Driving Agility

The factory of the future is all about transformation – Industrial Transformation (IX). FoF technologies, processes, and people will be the driving force of change that will implement IX business strategies at the plant level. However, we need to ensure that change does not run out of control. Manufacturers must define fundamental milestones for plant transformation – various factories of the futures.
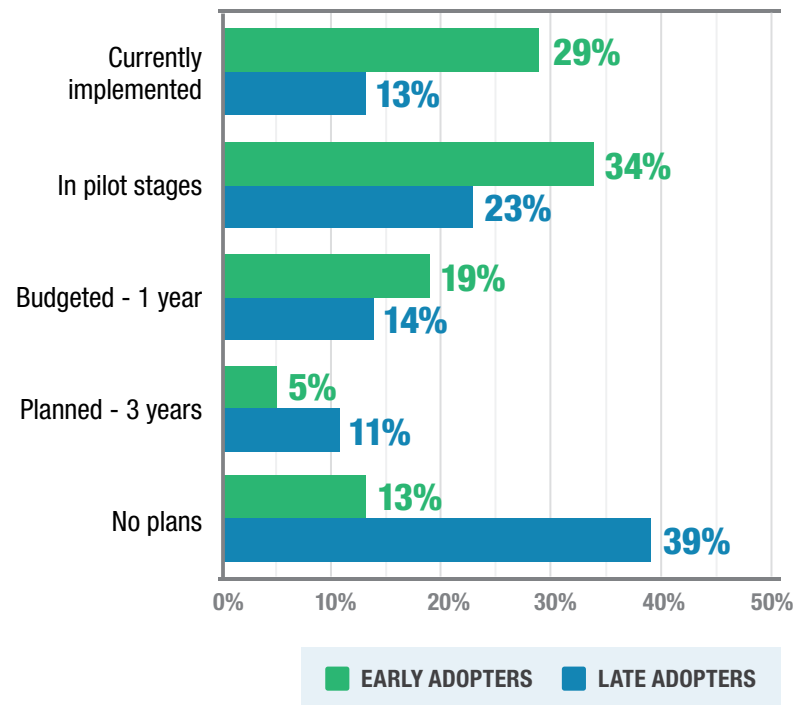
The FoF requires specific technologies to run a transformed business. Some will be essential from the beginning and some technologies that will be used later are not yet available. Technologies fall into three main bundles:

- Communication and data management

- Intelligence, real and artificial

- Manufacturing technologies and automation

The necessity or urgency of each of the three technology bundles depends on your starting point. In our recent FoF survey, we address a reasonably sophisticated audience, with 42% as "early adopters," those who are always and usually first to take on new technologies. The percentage of IX leaders has increased from 28% to 33% in the recent survey.

If you are an early adopter, you may have already defined a data architecture to cover the enterprise, but most manufacturers have a disparate set of databases and data sources dotted around their enterprise.

Prevalence of a common data model/data architecture across IT and OT data

Category	Early Adopters	Late Adopters
Currently implemented	29%	13%
In pilot stages	34%	23%
Budgeted - 1 year	19%	14%
Planned - 3 years	5%	11%
No plans	13%	39%

EARLY ADOPTERS **LATE ADOPTERS**
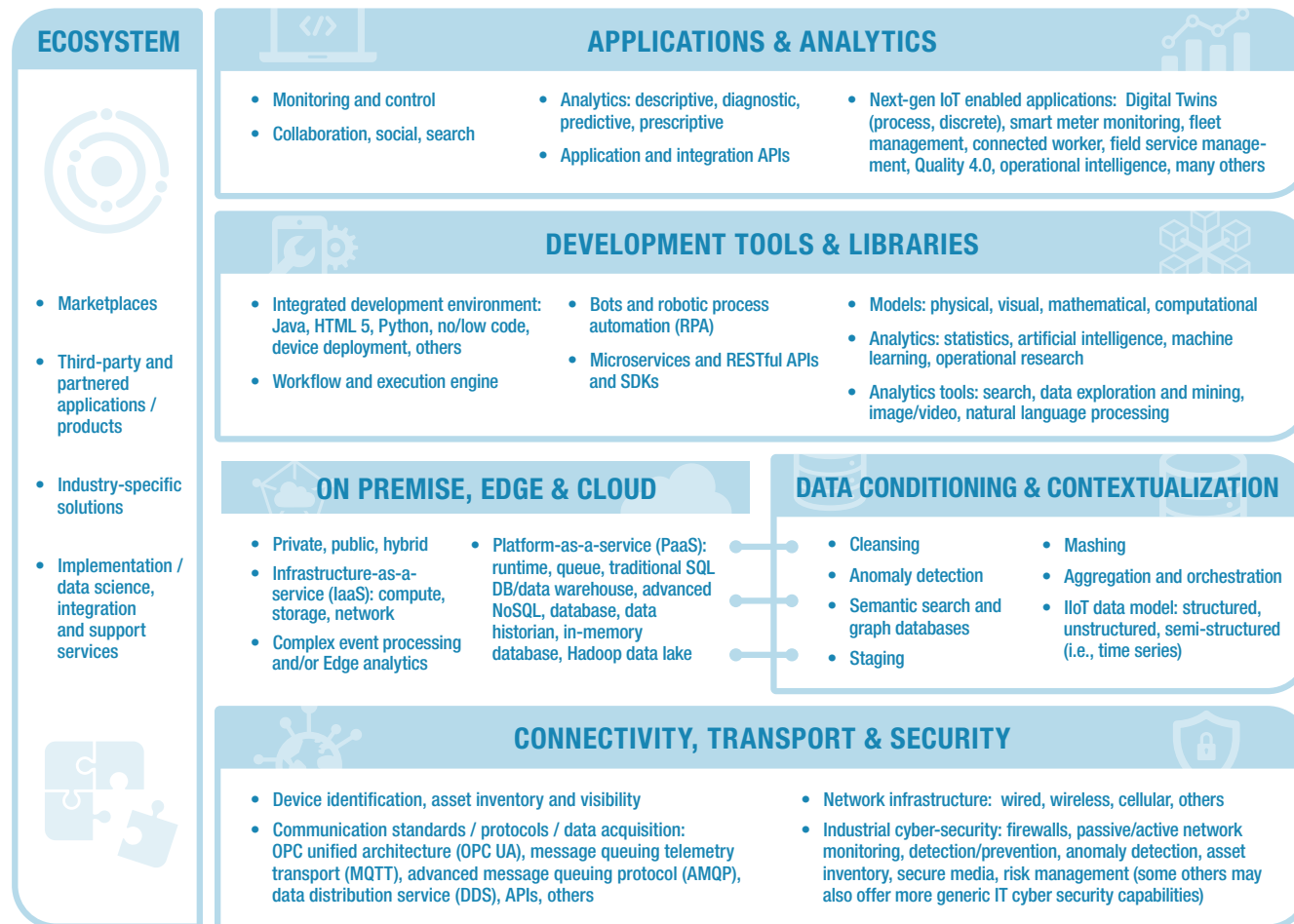
Section 4

Architecture

Industrial Transformation Architecture

A comprehensive Industrial transformation reference architecture depicts what is needed to integrate the parts of an IX program. What it does not attempt to do is to force a manufacturer into a specific architecture; it defines some technologies that need to be addressed but does not offer canned solutions – every scenario is different.

As we move into a transformed manufacturing world, we must not forget the world of manufacturing in which we currently live. Much of the existing technology will fit into our future factory. Of particular value are manufacturing operations management (MOM) systems and the business process management that they support. It can be a great starting point for data management as well as business processes that go beyond the plant.

INDUSTRIAL TRANSFORMATION (IX) REFERENCE ARCHITECTURE

ECOSYSTEM

- Marketplaces
- Third-party and partnered applications / products
- Industry-specific solutions
- Implementation / data science, integration and support services

APPLICATIONS & ANALYTICS

- Monitoring and control
- Collaboration, social, search
- Analytics: descriptive, diagnostic, predictive, prescriptive
- Application and integration APIs
- Next-gen IoT enabled applications: Digital Twins (process, discrete), smart meter monitoring, fleet management, connected worker, field service management, Quality 4.0, operational intelligence, many others

DEVELOPMENT TOOLS & LIBRARIES

- Integrated development environment: Java, HTML 5, Python, no/low code, device deployment, others
- Workflow and execution engine
- Bots and robotic process automation (RPA)
- Microservices and RESTful APIs and SDKs
- Models: physical, visual, mathematical, computational
- Analytics: statistics, artificial intelligence, machine learning, operational research
- Analytics tools: search, data exploration and mining, image/video, natural language processing

ON PREMISE, EDGE & CLOUD

- Private, public, hybrid
- Infrastructure-as-a-service (IaaS): compute, storage, network
- Complex event processing and/or Edge analytics
- Platform-as-a-service (PaaS): runtime, queue, traditional SQL DB/data warehouse, advanced NoSQL, database, data historian, in-memory database, Hadoop data lake

DATA CONDITIONING & CONTEXTUALIZATION

- Cleansing
- Anomaly detection
- Semantic search and graph databases
- Staging
- Mashing
- Aggregation and orchestration
- IIoT data model: structured, unstructured, semi-structured (i.e., time series)

CONNECTIVITY, TRANSPORT & SECURITY

- Device identification, asset inventory and visibility
- Communication standards / protocols / data acquisition: OPC unified architecture (OPC UA), message queuing telemetry transport (MQTT), advanced message queuing protocol (AMQP), data distribution service (DDS), APIs, others
- Network infrastructure: wired, wireless, cellular, others
- Industrial cyber-security: firewalls, passive/active network monitoring, detection/prevention, anomaly detection, asset inventory, secure media, risk management (some others may also offer more generic IT cyber security capabilities)
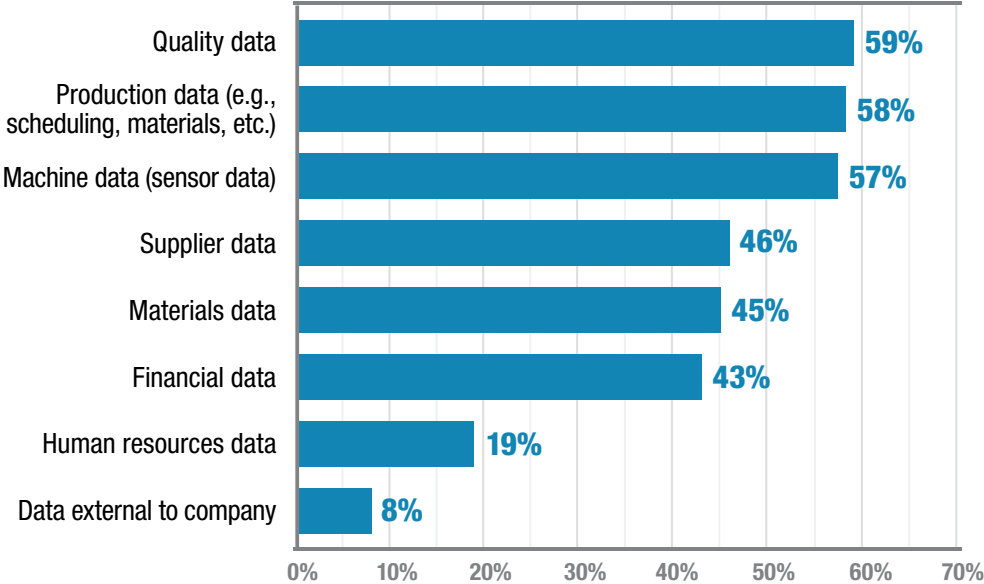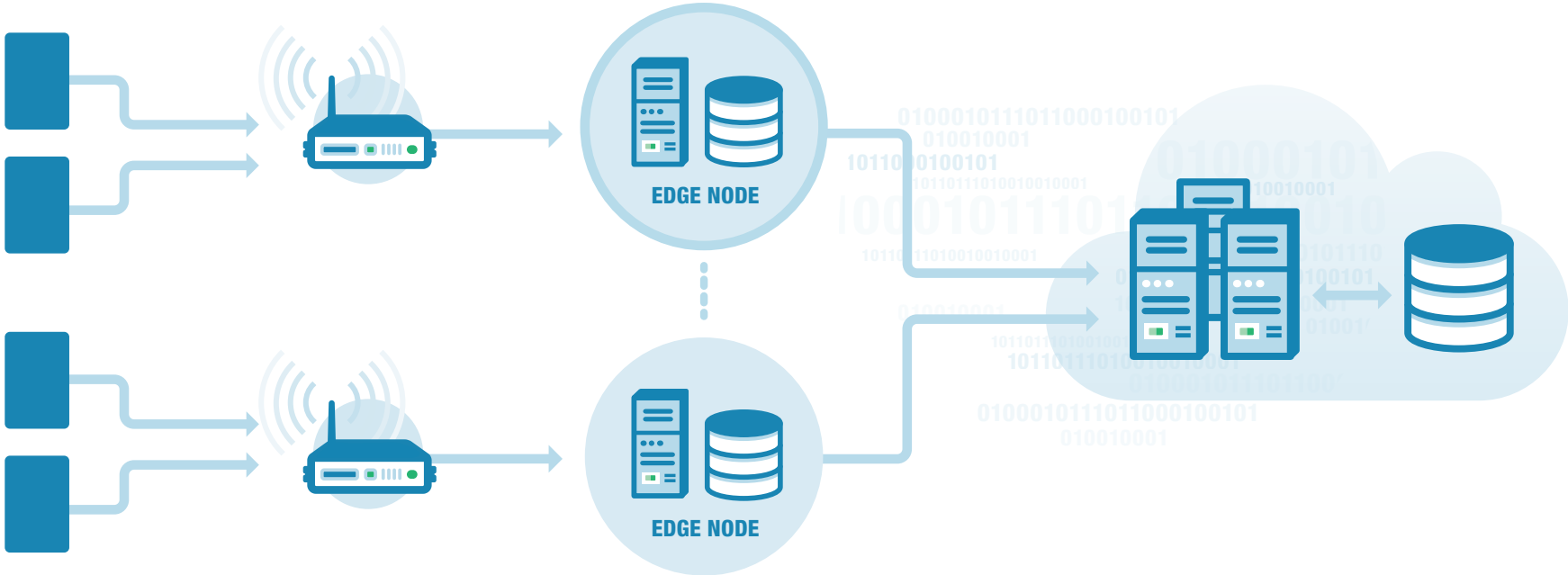
Edge Computing – And Data

In the FoF, apps and analytical tools will use data from many different sources – sensors, control systems, ERP, customers, video – the list is endless. The uses of such data are also endless and, unlike in the past, they are becoming geographically distributed.

In the simplest terms we define edge computing to be that which bridges the gap between control and Cloud (or even data center). It is much easier to see it in a picture.

Sources of data included in data models

Source	Percentage
Quality data	59%
Production data (e.g., scheduling, materials, etc.)	58%
Machine data (sensor data)	57%
Supplier data	46%
Materials data	45%
Financial data	43%
Human resources data	19%
Data external to company	8%

CLOUD AND EDGE ARCHITECTURE

EDGE NODE

EDGE NODE

Edge Computing – And Data *(Cont.)*

Where Edge starts and plant control and computing ends is very much dependent on the viewpoint you take. A valve manufacturer might see the valve as the plant and the control system above it as the Edge. At the other extreme, an ERP vendor would see everything below business systems as plant and might have a plant data center as the Edge. Neither is right or wrong: it is just a viewpoint of a multi-level data hierarchy.
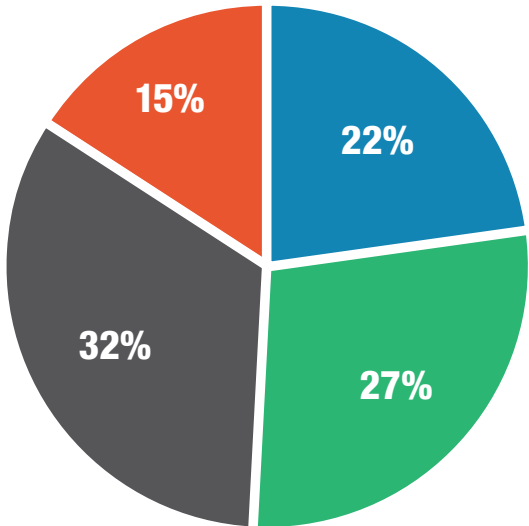
What is important is that the architecture is well defined and agreed between all. Although information technology people (IT) and operations (OT) see things from a different perspective, they must agree and stick to the overall data architecture.

Defining Edge Computing

ENGINEERING/OPERATIONS

13%
27%
27%
30%
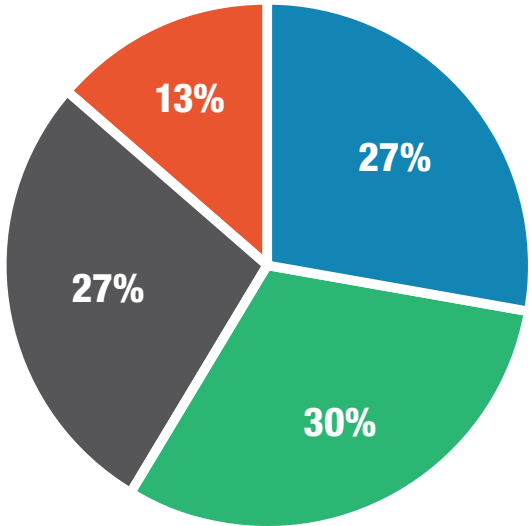
SUPPLY CHAIN SERVICES

15%
22%
32%
27%

- ■ Outside of the IT center, nearer the data source
- ■ At, on, or integral to the field device or equipment (tank, pump, pipe, vessel)
- ■ Both
- ■ Neither

Toward Enterprise Architecture

One of the biggest changes to many plants as IX architecture takes hold is the advent of IoT devices that allow a direct connection among sensors, other plant equipment, and the IX data store, whatever that might be. Ultimately, the best approach for an enterprise-wide solution would be to have a single data platform that serves all levels of the enterprise data architecture. As IX programs evolve, we are starting to see different consolidated architectures where master data is stored centrally and can be used everywhere. A couple of examples include:

- Put everything into a data lake after the necessary cleansing and consolidation. Apps and analytics can then use any data from across the value network.

- Choose a commercial platform and toolset from a single vendor that is sufficiently open to data from disparate sources and use that platform for connectivity, apps and analytics.

ENTERPRISE PLATFORMS
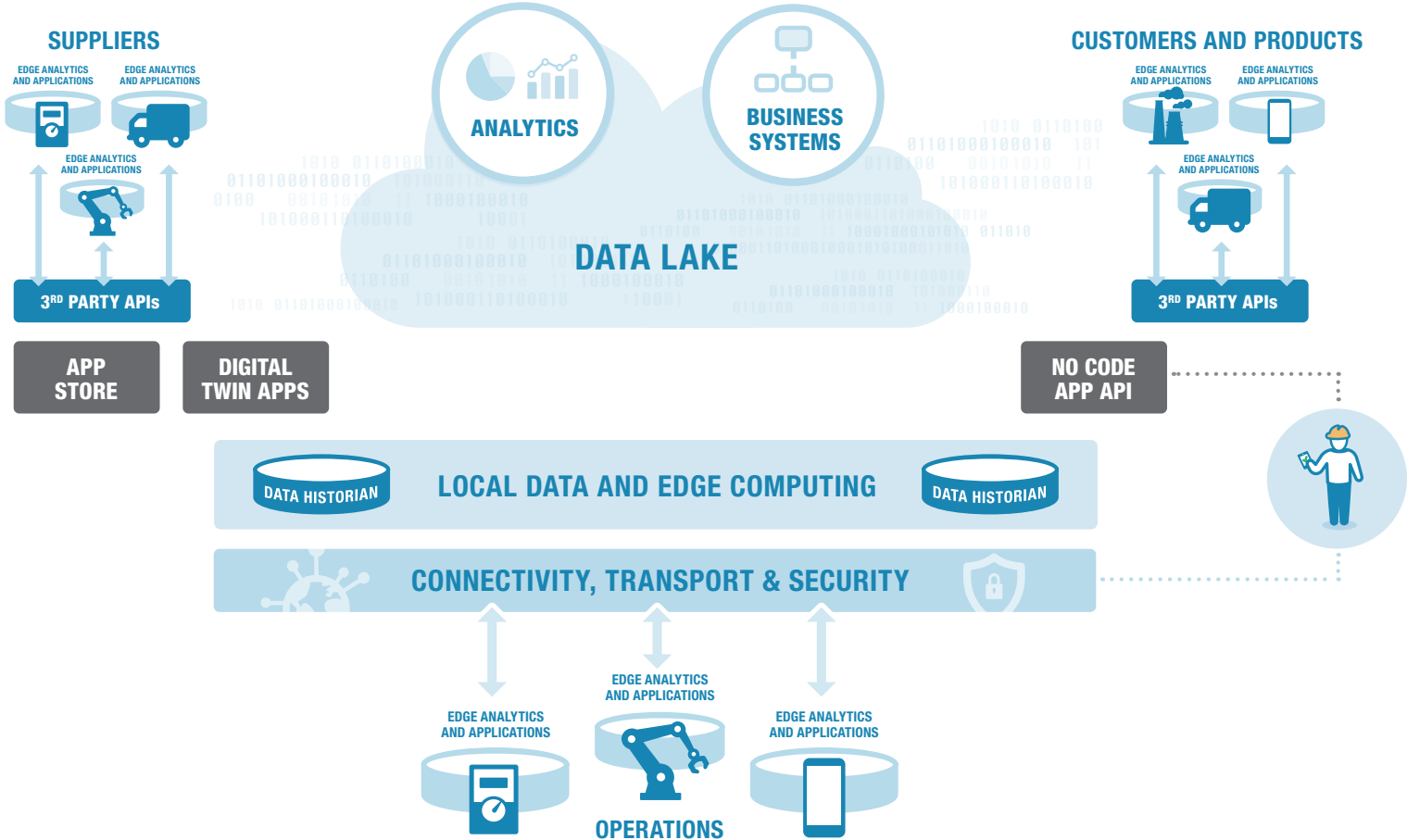
Toward Enterprise Architecture *(Cont.)*

There will be many more architectures. Successful ones will allow easy integration of new technology from the plant floor to the enterprise and beyond to clients and consumers. However, in the near term, many companies will stick with what they have and augment it to aid integration. Vendor platforms and mainstream cloud services will assist the integration effort.

Clearly, architecture decisions go far beyond the scope of FoF. Moreover, FoF components require complex architectural support.

It is difficult to explain the possibilities and complexities of a data architecture in just a few words. This brings us to an opportunity inside many manufacturers: data leadership. We have seen the difficulties that can occur with IT/OT convergence in areas such as manufacturing operations. Bringing together all the players in data integration is a task of a different magnitude to IT/OT convergence. It includes a vast array of users, influencers, and decision makers, all with their own agendas. IX leadership should look closely at the management of the major data repositories and appoint a Data Operations leader to manage the transition from a wide and disorganized set of data stores to a global data architecture, whether it is a corporate data lake, a native cloud solution, or a vendor specific global platform.
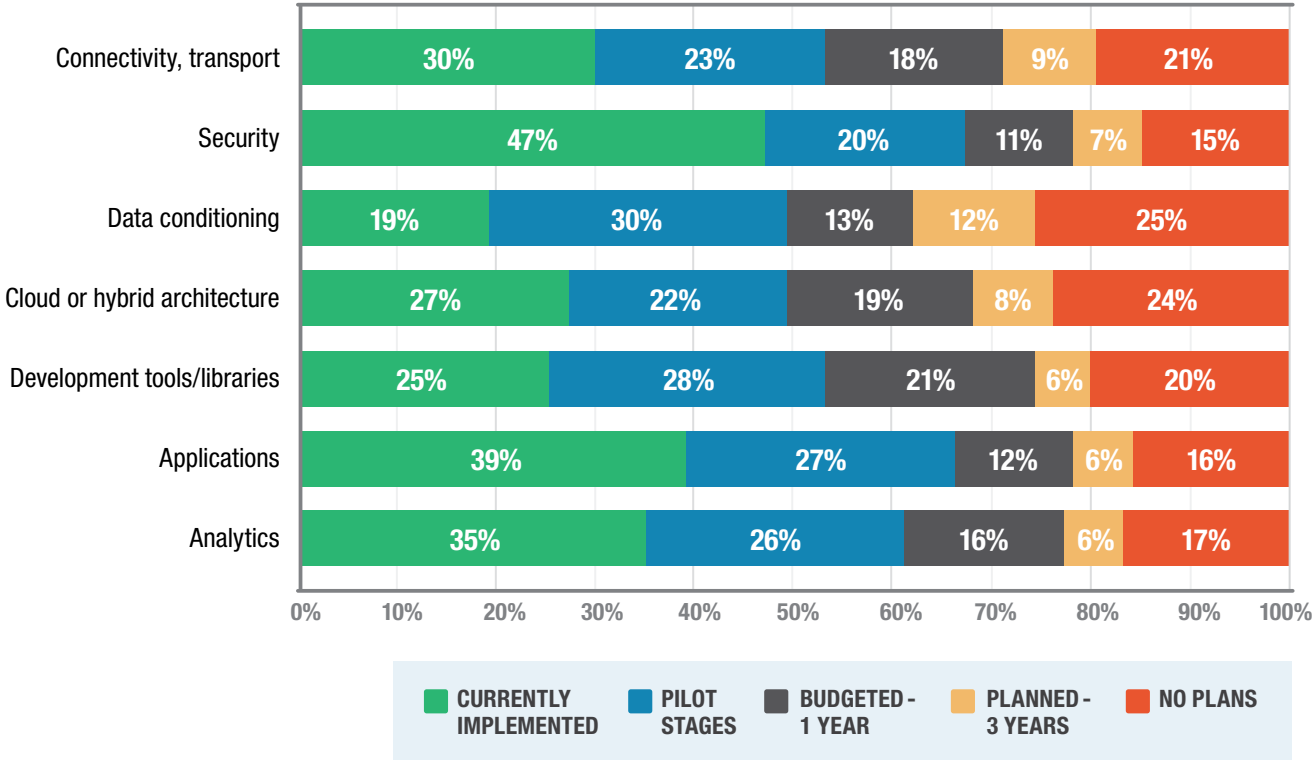
Toward Enterprise Architecture *(Cont.)*

It is important to consider Digital Twins when talking about FoF architecture since they are a principal part of many FoF programs with demanding data integration requirements. LNS has published research on Digital Twins in discrete and process industries. The discrete model addresses product Digital Twins as well as plant equipment. The research highlights the three dimensions of product data that need to come together to animate real Digital Twins.

The research highlights some of the complexity of handling data. There are other layers of complexity required to manage FoF data. Those who already have sophisticated manufacturing plants will be used to the requirements for handling data in a timely manner and having the ability to consolidate data to levels that are practical to use beyond the plant. Millisecond control and one-to-two-second reporting in a historian deliver quantities of data that are useful for operators and process engineers, but just fill up storage at the higher levels. The architecture may have to support the same data in different levels of consolidation and in a consistent structure – it is clear that the Data Conditioning and Contextualization box in our IX architecture is critical to the FoF.

IIoT reference architecture

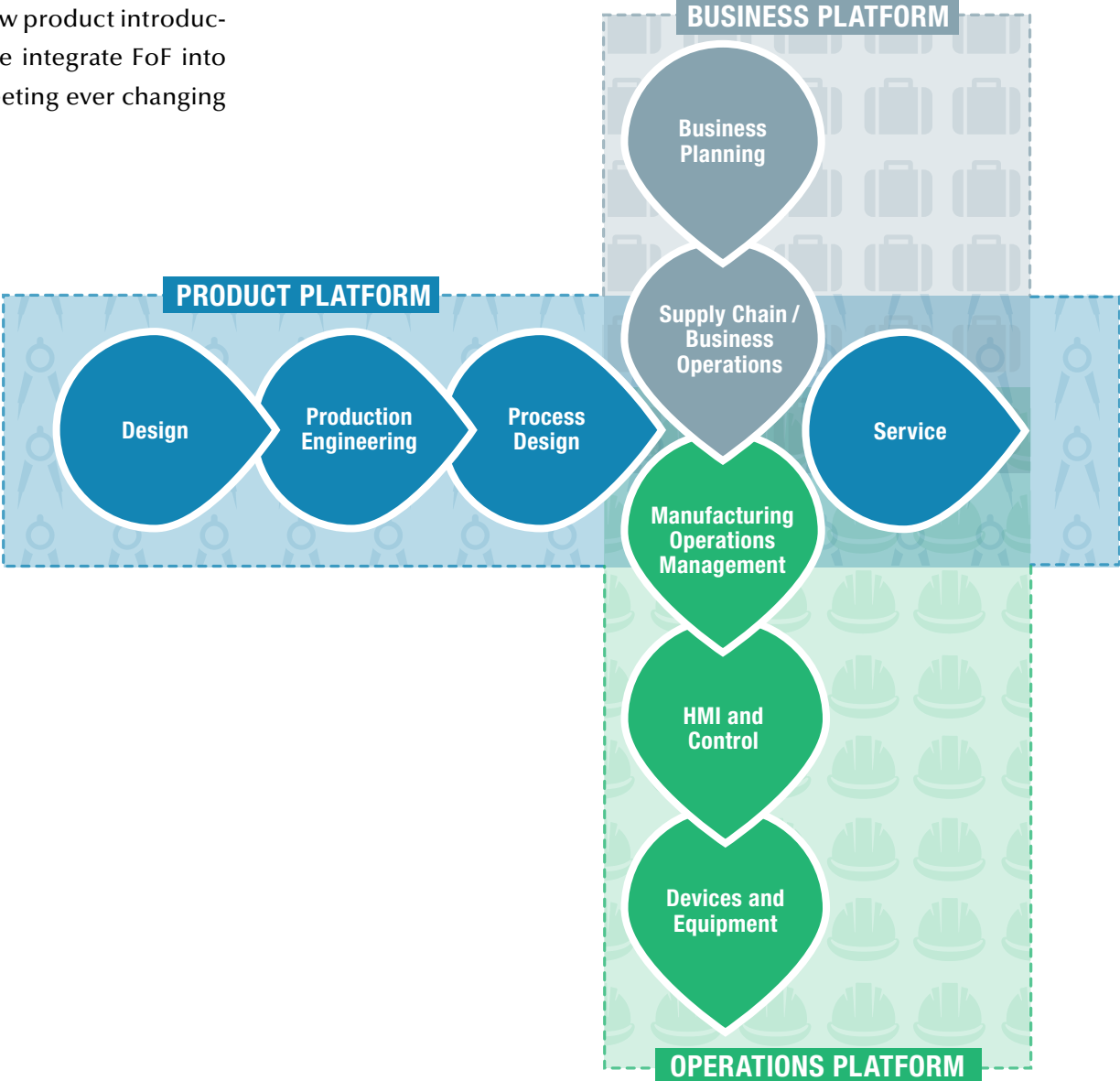|	CURRENTLY IMPLEMENTED	PILOT STAGES	BUDGETED - 1 YEAR	PLANNED - 3 YEARS	NO PLANS
Connectivity, transport	30%	23%	18%	9%	21%
Security	47%	20%	11%	7%	15%
Data conditioning	19%	30%	13%	12%	25%
Cloud or hybrid architecture	27%	22%	19%	8%	24%
Development tools/libraries	25%	28%	21%	6%	20%
Applications	39%	27%	12%	6%	16%
Analytics	35%	26%	16%	6%	17%

The Factory of the Future Operational Optimization

The FoF is about transformation. The factory must encapsulate the fundamental requirement for today's and tomorrow's factory: agility. Agility is all about being able to change when driven to do so. The ability to change covers everything from new product introduction to continuous quality improvement. As we integrate FoF into IX, plant level agility becomes the means of meeting ever changing business transformation.

Continuous operations optimization:

- Never stops
- Covers operations management in the plant and beyond
- Drives us to continue looking for a better solution

INTERSECTION OF PLATFORMS ENABLES DIGITAL TWIN

BUSINESS PLATFORM

Business Planning

Supply Chain / Business Operations

PRODUCT PLATFORM

Design

Production Engineering

Process Design

Service

Manufacturing Operations Management

HMI and Control

Devices and Equipment

OPERATIONS PLATFORM

The Factory of the Future Operational Optimization *(Cont.)*

The truly transformed business will be in a constant state of optimizing – like Capability Maturity Model Integration (CMMI) level 5 maturity for processes – with its agile factories ready to deliver the services and experiences needed to serve everyone touched by the business. This seems like a far-off dream, but there are many changes to technology, processes and people that can start the marathon needed to achieve optimizing agility. These include topics we discuss below, specifically digital twins, Digital Lean and, most important, people.

CHARACTERISTICS OF MATURITY LEVELS

OPTIMIZING
Focus on process improvement

L5

QUANTITATIVELY MANAGED
Processes measured and controlled

L4

DEFINED
Processes characterized for the organization
and is proactive. *(Projects tailor their processes
from organization's standards.)*

L3

MANAGED
Processes characterized for projects
and is often reactive

L2

INITIAL
Processes unpredictable,
poorly controlled and reactive

L1

Section 5

Digital Twins
and Digital Lean

The Digital Twin of the Factory – The New Beginning

We have already mentioned Digital Twins' need for complex data architecture, but what is a Digital Twin? It is one of the early examples of a factory of the future application that goes far beyond the factory.

While we see many definitions of "Digital Twin," LNS Research keeps it simple:

A Digital Twin is an
EXECUTABLE VIRTUAL MODEL
of a physical thing or system.

Here we see a depiction of the twin of a product, a faithful model of an airplane, that is "executable" through multi-science simulation at multiple levels and perhaps structurally modeled for some individual components. As we saw in our previous research, Digital Twins can be used for many applications and, simple Digital Twins, at least, should become a part of the FoF. Indeed, Digital Twins of the plant itself are the definition of the capabilities of the factory, a key goal when increasing production flexibility.
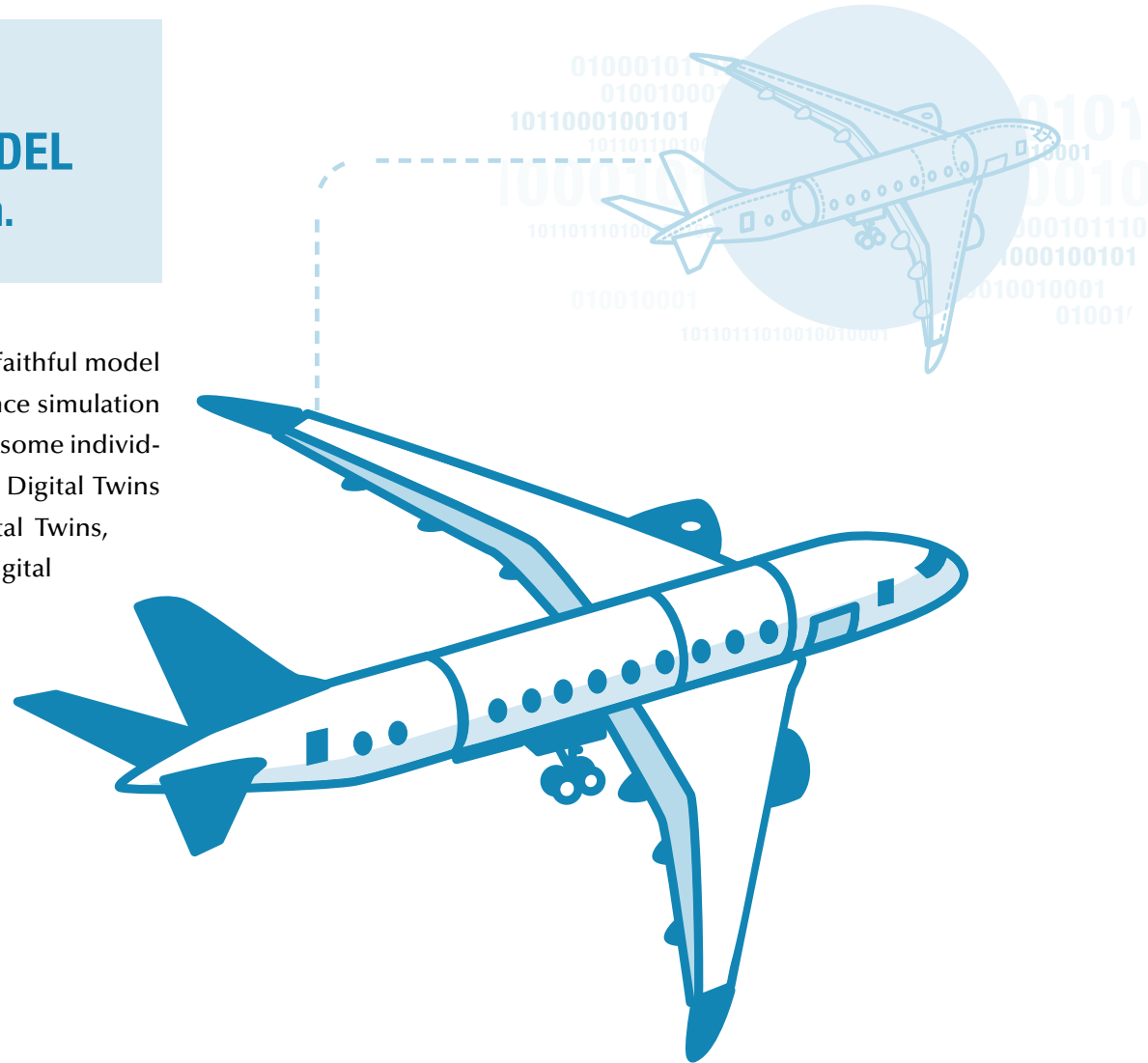
The Digital Twin of the Factory – The New Beginning *(Cont.)*

The definition of the factory, with a series of twins, will change factories forever. Agility comes from:

- ease of change

- the ability to run multiple products through multiple routes in one facility

- the capability of managing very small orders, down to the order of one delivering true personalization

By building first principles, accurate and modular models of the plant equipment and the physical plant itself, we open a new world of factories of the future. The ability to run new products through a plant before the product design is complete is a primary enabler of the agile factory. As we move toward models of the broader product and supply chain, models of the environment, beyond the FoF, will influence the factory itself. As well as modeling the factory, we can look at it from the other side. Models of the supply chain can be used to analyze constraints in multiple factories to enable a value-chain-wide concept of Digital Twins and consider value chains of the future (VCoF)
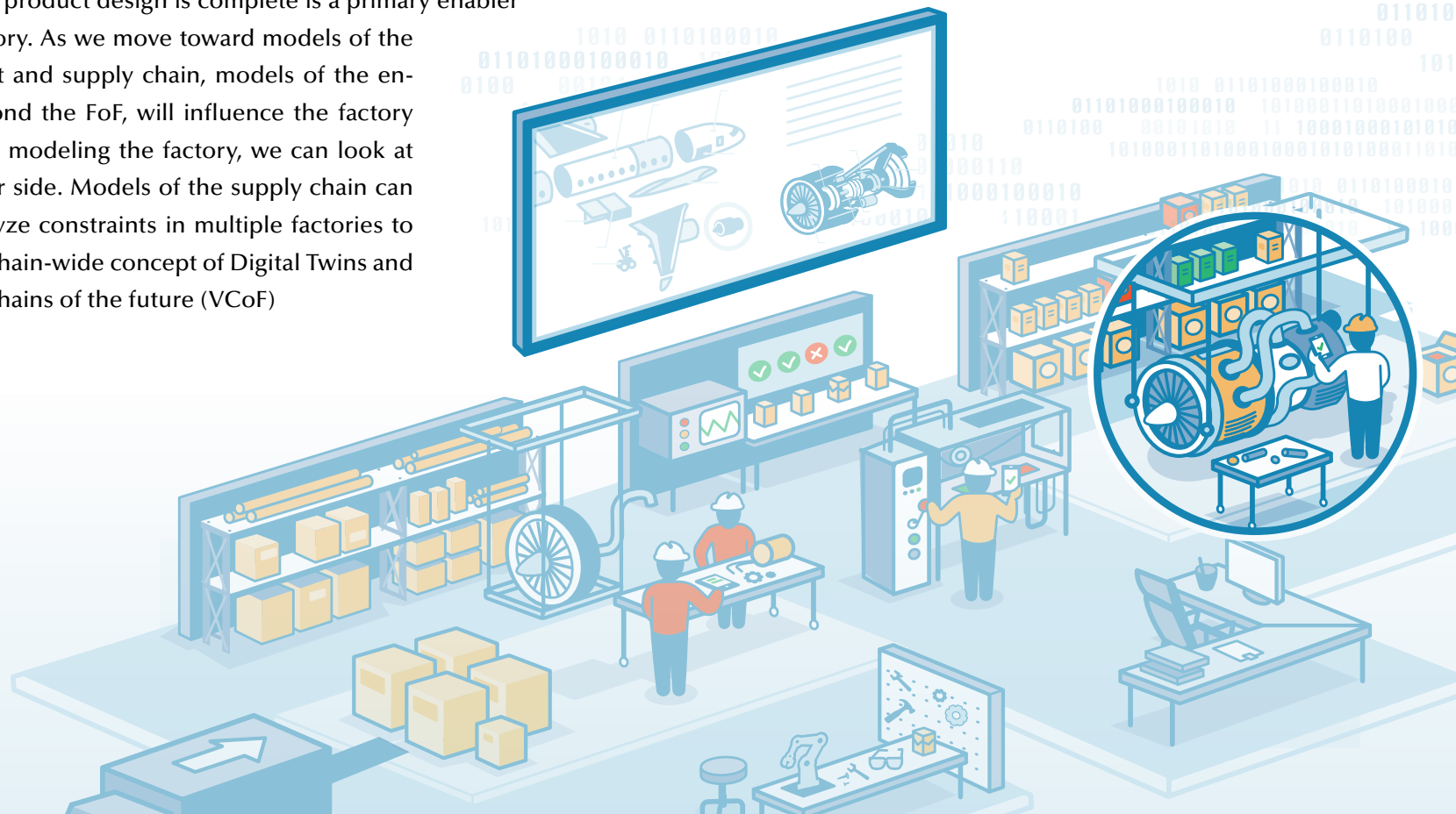
Digital Lean

Digital Twins are a high-tech solution that many feel will be in their somewhat distant future. However, many manufacturers will be active users of traditional Continuous Improvement (CI) tools such as Lean and 6 Sigma. LNS has studied the advent of digital techniques into traditional CI environments. Like much of the transformational impact of FoF on the enterprise, Digital Lean take-up is more common among Industrial Transformation (IX) leaders. On balance, our research shows that Lean is very popular but there is a resistance to Digital Lean.

When we correlate those that use Digital Lean with the more traditional manual users, there are some surprising and important results, shown here.

It is important that digital versions of lean processes augment rather than replace the old ways. Gemba walks are a good example: do not replace Gemba walks with remote monitoring but turn up on your GEMBA walks fully informed on your tablet of the state of play

and then everyone will be ready to have a more meaningful discussion; you will get straight to the issues as everyone is working from the same information and can see the areas needing addressing.

Impact of Digital Continuous Improvement (CI) on analytics sophistication

Predictive analytics	55% / 31%
Prescriptive analytics	36% / 13%

■ IX LEADERS   ■ IX FOLLOWERS
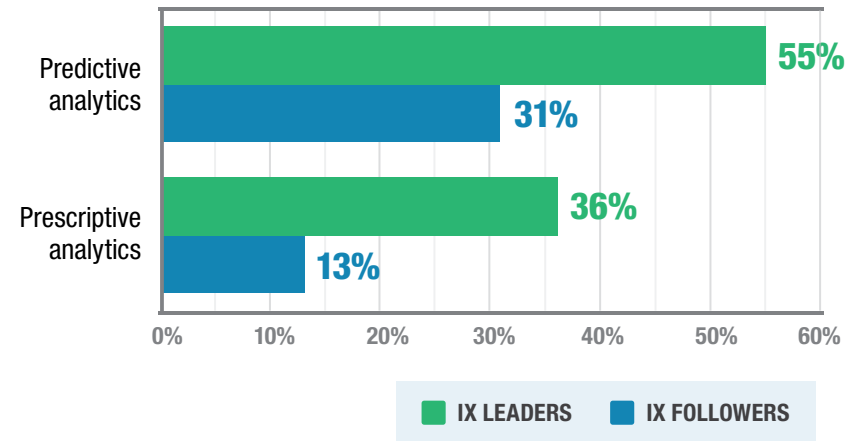
Median metric performance

|	WITH DIGITAL CI	WITHOUT DIGITAL CI
Successful new product introduction	78%	70%
Net profit margin	25%	20%
Improvement in manufacturing cycle time	30%	11%
Improvement in change over time	32%	14%
Improvement in throughput	29%	17%
Improvement in first pass yield	26%	10%
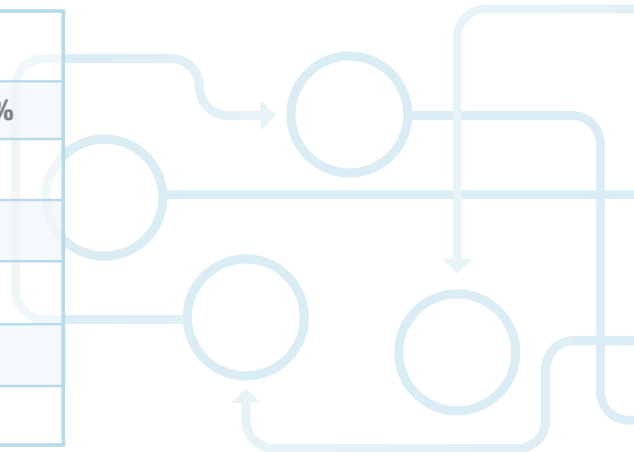
OEE Looking to the Future

Another commonly used measure is OEE, Overall Equipment Effectiveness. OEE is probably the most abused manufacturing measure we see. However, it has potential, especially if every machine across multiple plants is measured for OEE in the same or, at least, a consistent way.

We would like to see OEE replaced by a measure that reflects well on operators rather than badly on machines – a measure focused more on productivity and people would fit well in the changing role that people are playing in the factory. Indeed, as we move into a more sophisticated world of FoF with new roles in the plant, there is a need to revisit OEE and to define new KPIs and metrics.

Overall Equipment Effectiveness (OEE) =

AVAILABILITY% x PERFORMANCE% x QUALITY%
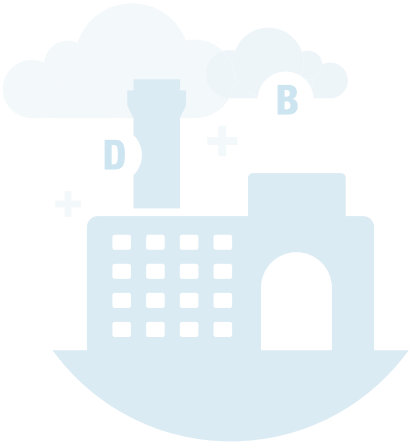
People: the Future of the Factory

Empower and Retain Plant-Level Workers

It is appropriate to continue our discussion from Lean to people – as CI techniques are so focused around the people in the plant and the teams that are made up by these people. Western manufacturing is constantly driven to reduce cost to compete with developing manufacturing strongholds. Just doing the same as before is not acceptable – we need to do two things with our staff, especially those who work in the plants:

- Empower them with tools and technology
- Retain them with interesting jobs

LNS Research survey data shows that plant engineers and operators that use digital CI tools are more likely to have cloud applications implemented, use more sophisticated analytics and have substantially better metrics improvement. In other words, they run their factories better. To maintain this, manufacturers need to ensure that they hire the right people and provide them with flexible tools such as no-code environments for building their own apps and dashboards.

This does not mean they should jump at the first available no-code tools. Young workers expect to have appropriate tools at their disposal, and many are driving for change. They need to be involved in decision-making and should be consulted at every stage about which tools are needed during selection and deployment of modern tools. Some of the early no-code apps tend to slip between being too simplistic for IT and development engineers while being a bit over complex when used ad hoc on the shop floor.
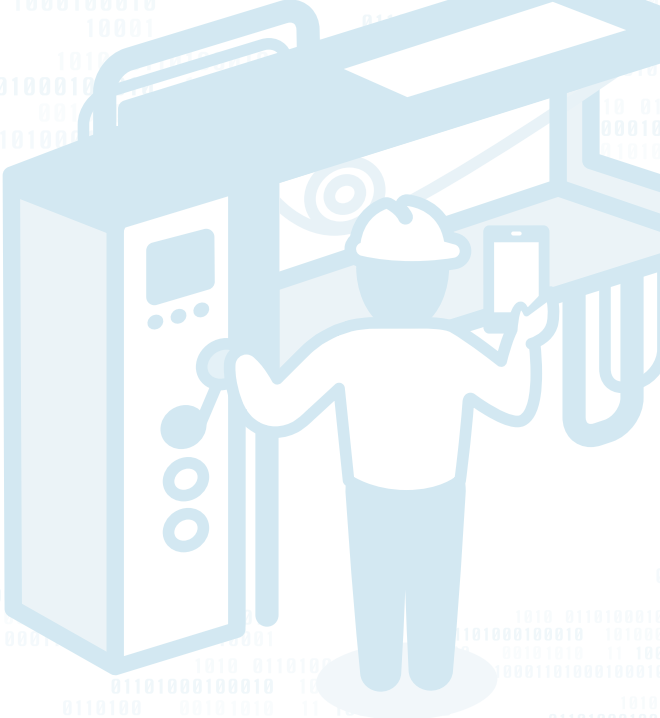
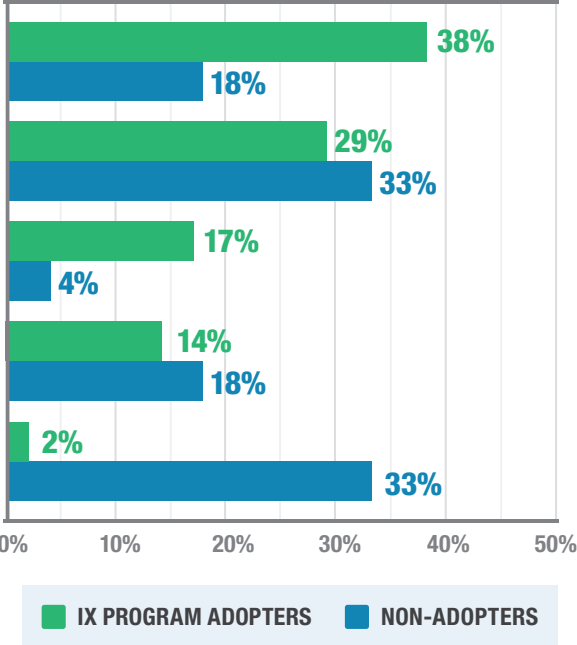## Feelings of plant level workers about digitally transformed operations

	IX Program Adopters	Non-Adopters
We have millennials/ young workers in our workforce that have expectations for newer systems and technology	38%	18%
Our workforce has been supportive of Industrial Transformation	29%	33%
Our plant floor workers are demanding new systems	17%	4%
Our workforce's acceptance of Industrial Transformation varies widely	14%	18%
Our workforce is resistant to change	2%	33%

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Changing How we Run our Factories:
THE FACTORY OF THE FUTURE

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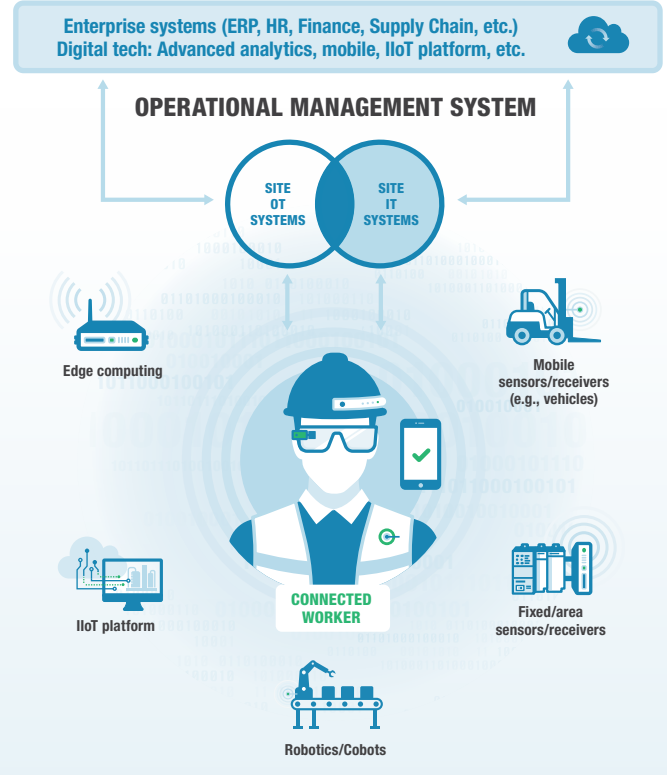CONTENTS

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Empower and Retain Plant-Level Workers *(Cont.)*

New no-code tools and others are essential to the FoF but there is much more. Connected workers will need to access information wherever they are on whichever device is available. Such devices should be able to deliver unasked-for information based on location, work order, role of the individual and so on. As the factory becomes more agile and technology improves, the tools for the upcoming generation of shop floor worker will be in constant flux. When we talk about the Factory of the Future, we really mean "futures" as the FoF continues to evolve. It is the same for tools and technologies that support the plant staff: Continuous Improvement applies also. we expect that Continuous Improvement will apply not only to the plant but also to the tools and devices used by shop floor staff.

The success of any FoF programs is most influenced by the shop floor workers. TRAINING, EMPOWERING, AND RETENTION will ensure that the workforce of tomorrow will be the "future of the factory."

Enterprise IT systems (ERP, HR, Finance, Supply Chain, etc.)

OPERATIONAL MANAGEMENT SYSTEM

Site OT systems

Site IT systems

Local point solutions
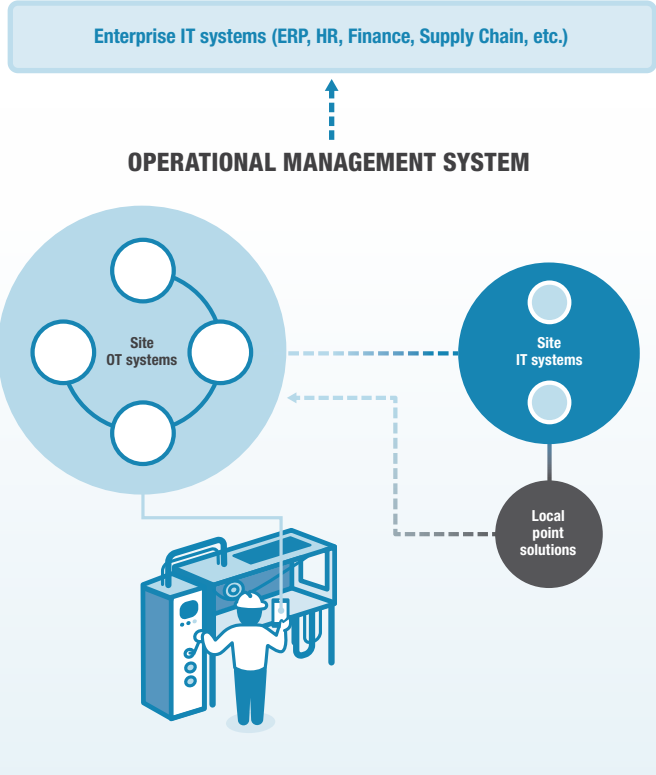
TRADITIONAL ARCHITECTURE

- OT-centric worker interaction
- Single point of interaction
- Limited visibility and control: reactive
- Perform tasks

Enterprise systems (ERP, HR, Finance, Supply Chain, etc.)
Digital tech: Advanced analytics, mobile, IIoT platform, etc.

OPERATIONAL MANAGEMENT SYSTEM

SITE OT SYSTEMS

SITE IT SYSTEMS

Edge computing

Mobile sensors/receivers (e.g., vehicles)

IIoT platform

CONNECTED WORKER

Fixed/area sensors/receivers

Robotics/Cobots

IX OPERATIONAL ARCHITECTURE
WORKER INTERACTION...

- Worker-centric
- Multiple points of interaction
- Transparency: proactive and predictive
- Insights and automated actions
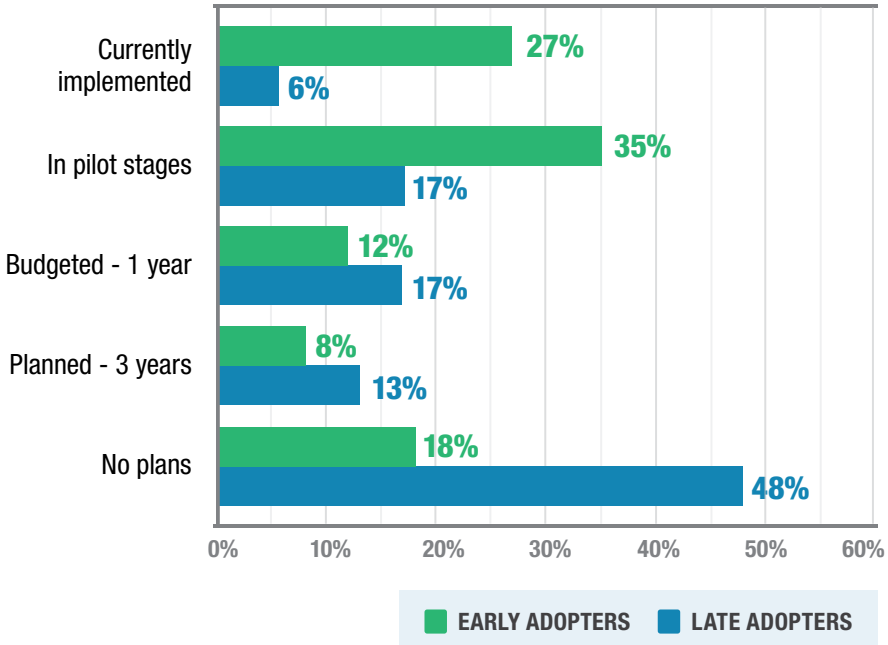
Intelligence, Real and Artificial

It is not our intention to dive deep into all the technologies that will be applied in the FoF. The list is almost endless and includes such interesting fields as robots and cobots, 3D printing, and autonomous intelligent vehicles. There is one critical technology that is touted as a major contributor to IX and FoF success: artificial intelligence (AI), and its lesser sibling, machine learning (ML).

AI has been around since the days of Turing tests and, in recent years, has become a practical technology, due to the availability of vast computing power and a renaissance in interest beyond winning at complex games such as chess and Go. Manufacturers and the FoF

should not consider AI as a standalone technology that you must implement to be a real tech leader. Rather, AI is an expanding set of techniques that solves complex problems, such as scheduling, predictive maintenance, optimization in logistics, operational problem solving, and many fields of analytics. Some AI techniques like speech recognition, computer vision, translation, and process optimization are already gaining acceptance in manufacturing. Manufacturers should be looking across the breadth of FoF opportunities for profitable uses of AI and ML to gain an advantage over the laggards.

Status of Artificial Intelligence Program
(Machine Learning, Deep Learning and Other AI)

| Status	Early Adopters	Late Adopters
Currently implemented	27%	6%
In pilot stages	35%	17%
Budgeted - 1 year	12%	17%
Planned - 3 years	8%	13%
No plans	18%	48%

■ EARLY ADOPTERS   ■ LATE ADOPTERS

Beyond the Factory, Into the Supply Chain

To conclude our look at FoF technologies and tools, let's look beyond the four walls of the factory onto one of the worlds beyond, the supply chain, which puts FoF into context as we consider plans for IX. Manufacturing uses raw materials that come from suppliers and operates to deliver goods from the plant to the client. We talk a great deal about optimization seen holistically through IX, supply chain, and FoF. The FoF needs reasons for existing and should not be considered on its own. FoF operational optimization is just a part of architecture, IX, and extension beyond the enterprise.

Although many changes can be made inside the plant independently of larger Industrial Transformation programs, it is imperative that they are inextricably linked at the planning and strategy level. A company might decide to install a Manufacturing Operations Management (MOM) system across many plants. This is a common starting point for IX and is much more likely to drive value if done in conjunction with more strategic intent.

Similarly, a manufacturer with already highly automated factories may choose to enhance planning and scheduling capabilities with a wider view than a single plant. This will directly affect the plants, as tighter supply chains will drive them. It will also encourage those leading FoF activities to look at how change inside the plant can improve the value chain. An example might be improved ability to run small orders. FoF should be a part of every IX program for manufacturers.

Finally, the main message you should take away is that Factory of the Future technologies, processes, and people will drive continuous operational optimization, the primary goal of the Chief Operating Officer (both COO).
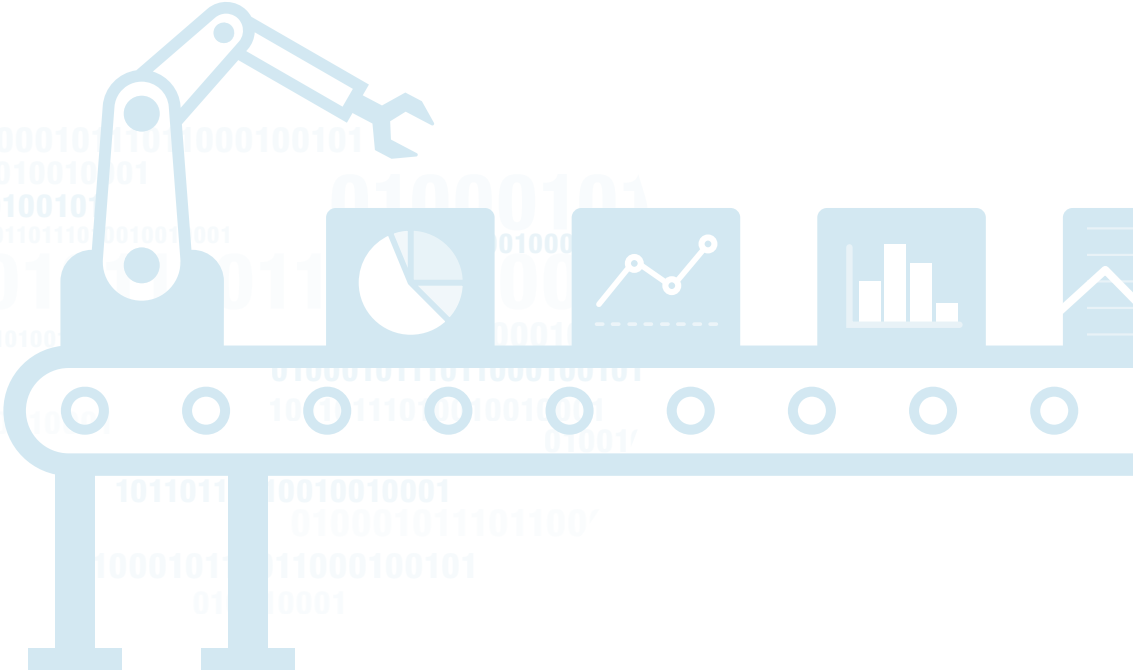
Section 7

Recommendations and Resources

Recommendations

FoF covers many topics and should be considered in conjunction with an IX program wherever possible. It is quite feasible to install some FoF technology on its own - AGVs as an example - but real benefits will accrue as transformation from process to enterprise is realized.

It is therefore difficult to give recommendations independently of a larger IX program as discussed in many of our research papers. However, there are key structural considerations that will help immensely:

- All IX programs should incorporate FoF technologies, processes and, vitally, people.

- We talk often of IT/OT convergence. In the factory, where OT reigns supreme, the acceptance of information technology is vital. Indeed as the factory installs ever newer software technologies, the need for IT skills increases

  ° Fields such as no code applications are understood by IT and they can hep immensely

  ° IT is required to manage data handling above the plant level and close cooperation is needed to ensure that everyone's requirements are met.

- Remember that FoF stands for Factory of the FUTURES, not one but many. Plan a staged approach as part of your ongoing IS program and involve as many plant personnel as possible during every stage.

Finally, define short term goals for improvement inside the factory walls. Deliver agreed ROI in the first stages will ensure that future stages actually take place.

Industrial Transformation Resource Guide

Companies use digital technology to drive transformation across the value chain. Use these resources to learn how to align the people, processes, and technologies required to achieve Operational Excellence in your organization.

INDUSTRIAL TRANSFORMATION

BLOG | Understanding Industrial Transformation: Definition and Framework for Success

View Blog ➜

RESEARCH | Industrial Transformation: Architecture and Analytics Just the Beginning

View Research ➜

RESEARCH | Industrial Control Systems and Edge Computing: Enabling an Operational Architecture for Applications and Analytics

View Research ➜

INDUSTRIAL ANALYTICS

RESEARCH | Build a Flexible Industrial Analytics Strategy for Today and Tomorrow: Why Business Leaders Should Adopt a Use Case Approach

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BLOG | How the Right Operational Architecture Powers the Analytics That Matter

View Blog ➜

RESEARCH | Analytics Really Do Matter: Driving Digital Transformation and the Smart Manufacturing Enterprise

View Research ➜

FACTORY OF THE FUTURE

RESEARCH | Improving Continuous Improvement: Reinvent Lean Today with Digital Technology

View Research ➜

RESEARCH | Forging the Digital Twin in Discrete Manufacturing: A Vision for Unity in the Virtual and Real Worlds

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RESEARCH | MOM and PLM in the IIoT Age: A Cross-Discipline Approach to Digital Transformation

View Research ➜

APM 4.0

Solution Selection Guide | Asset Performance Management (Platform Vendors), 2018 Edition

View Solution Selection Guide ➜

RESEARCH | APM 4.0: Prescription for Better Profitability in Operations

View Research ➜

RESEARCH | The Road to Digital Transformation Success: A Methodology to Modernize Operational Excellence

View Research ➜

Industrial Transformation Resource Guide *(Cont.)*

QUALITY, COMPLIANCE

RESEARCH | Quality 4.0 Impact and Strategy Handbook

View Blog ➜

RESEARCH | Driving Operational Performance with Digital Innovation: Connecting Risk, Quality and Safety for Superior Results

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RESEARCH | Roadmap to Supplier Status: Think Risk Performance, Not Compliance

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ENVIRONMENT, HEALTH AND SAFETY

WEBCAST | EHS 4.0: Using Technology to Reach New Levels of Safety and Environmental Performance

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RESEARCH | The Connected Worker: Mobilize and Empower People to Reduce Risk and Improve Safety

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AUTOMOTIVE RESEARCH | IATF 16949-2016: A Pivotal Opportunity in Automotive Quality Management

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AUTOMOTIVE AND A&D RESEARCH | Manufacturing Performance: Automotive and A&D Gaining Momentum with Analytics

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LIFE SCIENCES RESEARCH | Digitalized Quality in Life Sciences: Roadmap to Sustainable Growth and Speeding Profitable, High-Quality Products to Market

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LIFE SCIENCE RESEARCH | Quality 4.0 in Pharmaceutical: Use Cases and Advantage in a Digitally Maturing Market

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METALS AND MINING RESEARCH | Data for Balanced Scorecard: Driving Profits in Mining, Metals, and Materials Industries

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POWER GENERATION RESEARCH | Driving Better Decision Making with Big Data: A Roadmap for Digital Transformation in the Power Generation Industry

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Industrial Transformation is
Changing How we Run Our Factories:
THE FACTORY OF THE FUTURE

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