Connected Worker

ENABLE OPERATIONAL AGILITY WITH A DIGITALLY CONNECTED WORKFORCE

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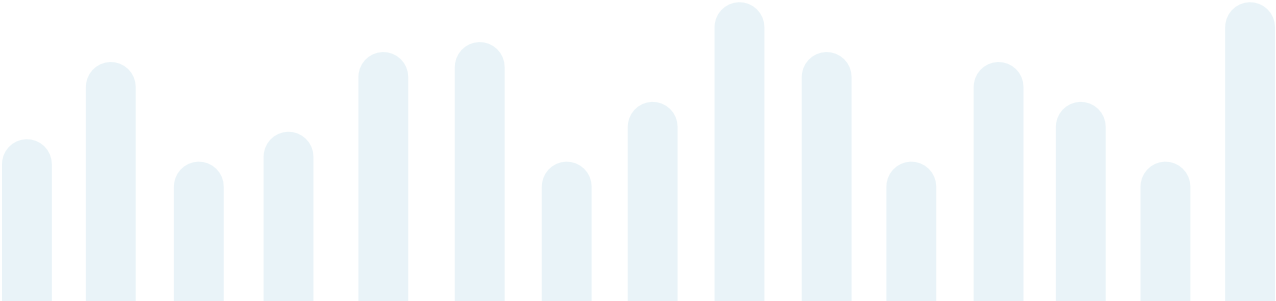# ENABLE OPERATIONAL AGILITY WITH A DIGITALLY CONNECTED WORKFORCE

TABLE OF CONTENTS

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Section 1

Executive Summary

Executive Summary

For industrial organizations, operating in the world before the COVID-19 crisis was no walk in the park. Complexity, change, and uncertainty were the order of the day, presenting a continually evolving risk environment to be dealt with. In response, companies embraced Industrial Transformation (IX)- the digital transformation of industrial operations – as the strategic framework to drive step-change performance improvement and competitive advantage. The main effect of disruption in global operations and supply chains caused by the pandemic has been not so much to change the nature of the extant business drivers, trends, and initiatives but rather to intensify and accelerate them.

This research focuses on how industrial organizations are implementing Connected Worker initiatives as a core pillar of their IX programs, and how the COVID-19 crisis has accelerated these investments. Frontline workforce issues are among the top strategic priorities in industrial operations, specifically addressing a severe talent shortage, and improvement of safety and EHS performance. The research presented herein shows that Connected Worker digital initiatives are increasingly being used to enable the operational agility needed to address these business problems through a competent, safe, and engaged workforce; and that the pandemic has preferentially accelerated these initiatives.

New frameworks are presented showing how Connected Worker initiatives are a key component of Operational Strategy; the synergy of EHS and Connected Worker projects in driving safety, quality, and productivity improvements; and a solution architecture model for achieving the important goal of alignment with current and future IX initiatives. We also present research data on the business value of such investments, including positive impact on IX success, profitability, and operational performance metrics such as Overall Equipment Effectiveness (OEE). Actionable recommendations are provided to help guide industrial organizations in building an agile, adaptable workforce ready for today's challenges and those of tomorrow, whatever they may be.
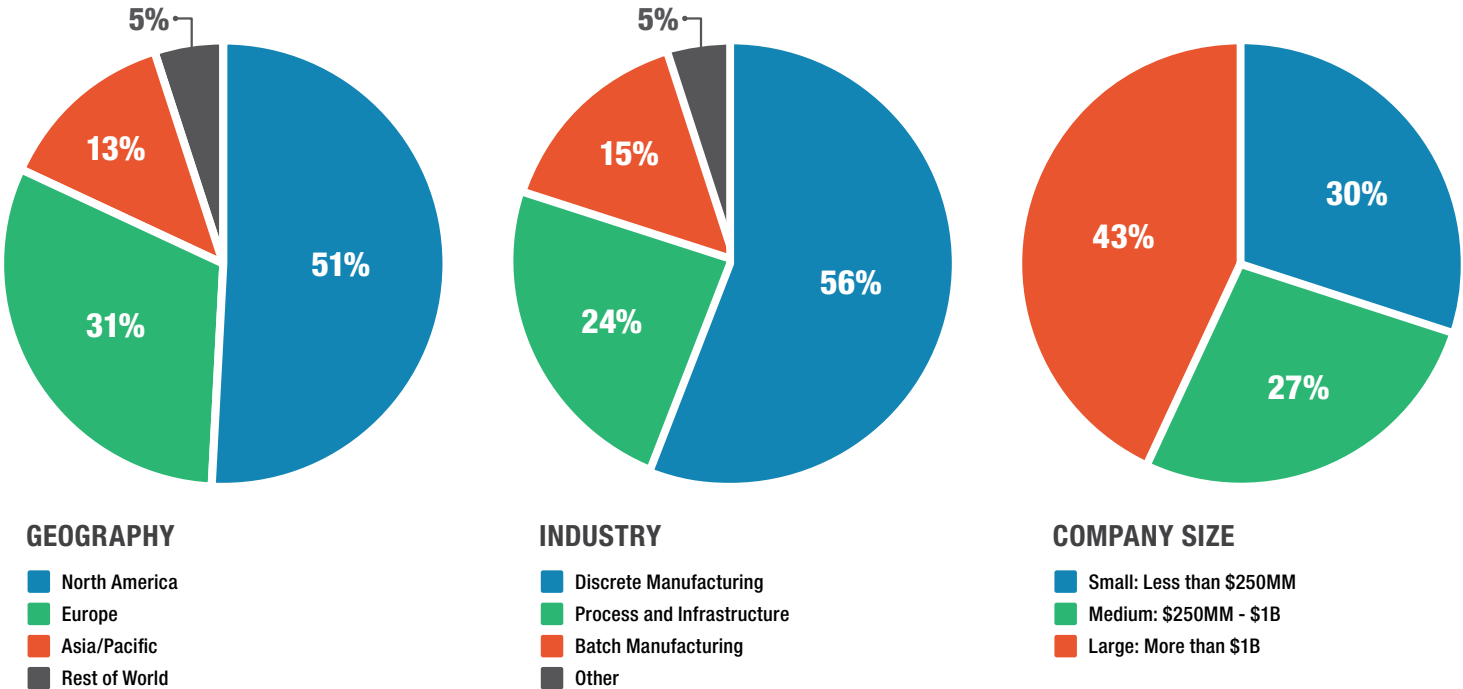
COMPLEXITY

UNCERTAINTY

CHANGE

RISK

Section 2

Research Demographics

Research Demographics

The main source of the research data presented in this eBook is a global survey executed by LNS Research in 2019 on the topic of "Manufacturing Operations Management". We obtained valid survey responses from 300 executive, management, and operations personnel in industrial organizations. The respondent pool was well-diversified by geographic region, industry, and company size. The survey gathered data on the status of manufacturing programs including strategic initiatives, deployment of enabling digital technologies, and factors impacting operational and financial performance. Selected data from other LNS Research surveys with similar demographic profiles are included, specifically "Impact of COVID-19 on Sustaining Operations" (June 2020) and "Analytics that Matter" with MESA International (2020).

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

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

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

Section 3

Drivers, Objectives, and Challenges
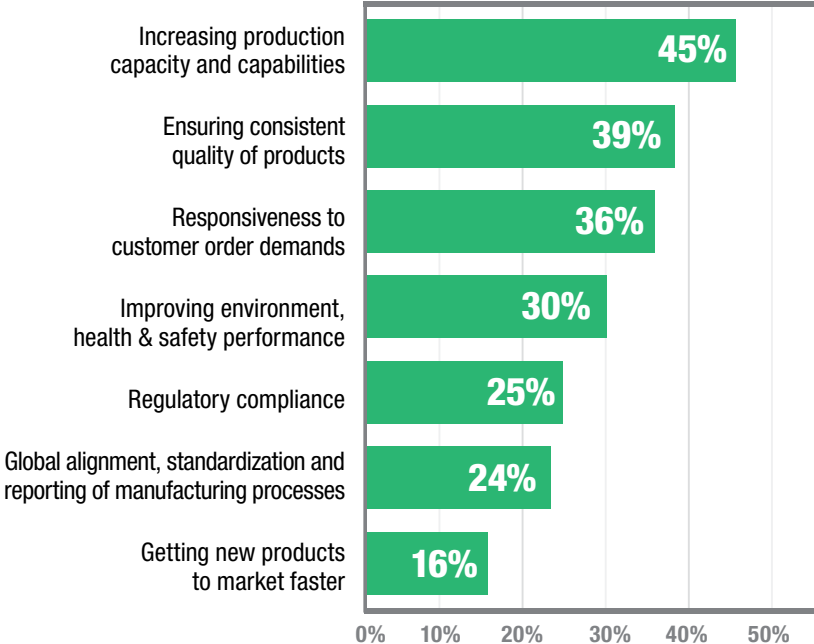
Intense Focus on Operational Excellence

Even as industrial organizations have launched IX initiatives in recent years, they have remained squarely focused on improving basic building blocks of Operational Excellence. Our research based on survey data collected in 2019 shows that the top strategic objective for operations is increasing production capacity and capabilities. As could be expected, the main goal is to build competencies that improve core value chain operations, namely manufacturing and production.

After improving core production capacity and capabilities, the top operational objectives are competencies and business functions that support that core:

- Ensuring consistent product quality
- Responsiveness to customer order demands
- Improving Environment, Health, and Safety (EHS) performance
- Regulatory compliance

These objectives span workforce, product, customer, and supply chain competencies across the value chain. It's interesting to note that improving EHS performance is prominent on the list; effective management of operational risk including the risk of non-compliance underpin Operational Excellence. This indicates that the value of integrating EHS into business strategy and core operations is recognized as key to safe, compliant, profitable operations.

STRATEGIC OBJECTIVES FOR OPERATIONS

Objective	Percentage
Increasing production capacity and capabilities	45%
Ensuring consistent quality of products	39%
Responsiveness to customer order demands	36%
Improving environment, health & safety performance	30%
Regulatory compliance	25%
Global alignment, standardization and reporting of manufacturing processes	24%
Getting new products to market faster	16%

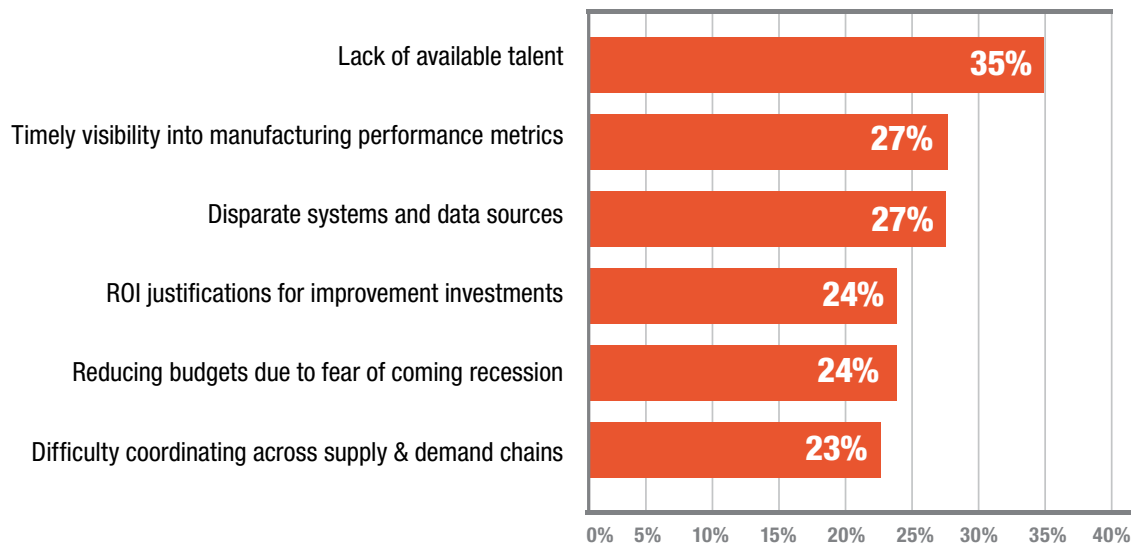## Top Challenge: Attracting and Retaining a Quality Workforce

For industrial organizations, the barriers to achieving strategic objectives for operations center primarily on people and technology limitations. Reflecting ongoing demographic trends, the top challenge is difficulty in fielding a workforce with the right talent, skills, and competencies. Given all the attention paid to digital technologies and process optimization, it's noteworthy that the toughest challenge is finding and retaining the right people to implement and run those technologies and processes.

The importance of people and workforce competence is further highlighted by drilling down on the data based on profitability. High margin plants are 47% less likely to cite lack of talent as a challenge than low margin plants, indicating that they have better adapted to the labor environment and found ways to recruit, train and retain a workforce with the right competency profile.

Inadequate enabling technologies also have a major impact, with fragmented systems and siloed data sources hindering operational visibility, collaboration, process execution, and continuous improvement.

HIGH MARGIN PLANTS:
are **47%** less likely than low margin plants to cite lack of talent as an operational challenge

TOP CHALLENGES TO ACHIEVING OPERATIONAL OBJECTIVES

Challenge	Percentage
Lack of available talent	35%
Timely visibility into manufacturing performance metrics	27%
Disparate systems and data sources	27%
ROI justifications for improvement investments	24%
Reducing budgets due to fear of coming recession	24%
Difficulty coordinating across supply & demand chains	23%

0% 5% 10% 15% 20% 25% 30% 35% 40%

Frontline Workforce Challenges

Our previous research has highlighted two major workforce challenges faced by industrial organizations: the industrial skills gap, and workplace safety and health risks. These challenges are closely related and create twin imperatives for companies to implement robust frontline workforce recruitment and training programs, along with effective safety and risk management programs.

The Industrial Skills Gap

Industry has been grappling with labor shortages and skills gaps for years, making it challenging for industrial organizations to find, hire, train, retain, and upskill a qualified workforce with the right competency profile. A pre-pandemic survey of U.S. manufacturers in February, 2020 found that the inability to attract and retain a quality workforce was their primary business concern (noted by 67.1% of respondents as a top issue) as it had been in every quarterly survey over the previous two and a half years. (Source: Manufacturer's Outlook Survey: First Quarter 2020, National Association of Manufacturers).

The major force at work here is an aging industrial workforce that is rapidly retiring, with valuable skills, experience, and institutional knowledge being lost. And the widespread implementation of IX programs is introducing a wide array of new digital technologies into industrial operations, such as IIoT platforms, automation systems, and robotics, among many others. This trend changes the competencies needed to effectively deploy technology and processes, and provide the operational agility required in dynamic production environments.

67%

of manufacturers cite skilled worker shortages as a top challenge.

WORKFORCE CHALLENGES
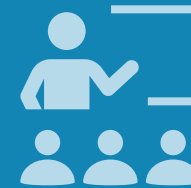
- Recruit, train and retain people to address skills gap
- Enable organizational learning and knowledge transfer
- Engage and empower frontline workforce
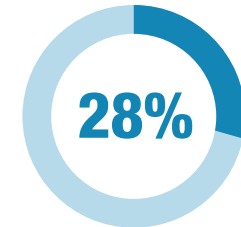- Drive productivity, safety and quality improvements

Effective Safety and Risk Programs

As noted, improvement of safety and environmental performance is one of the top strategic goals of industrial operations. This is as it should be: workplace safety is a pre-requisite to smooth-running, profitable operations. Conversely, unsafe operations are prone to costly injuries and property damage, unplanned downtime and lost productivity. A key benefit of a strategic approach to safety management is the potential for positive impacts on workforce recruitment and retention. A company with safety as a true core value, effective programs and a proactive safety and risk culture are more likely to be viewed as an employer of choice, and have higher levels of employee engagement and ultimately lower turnover rates.
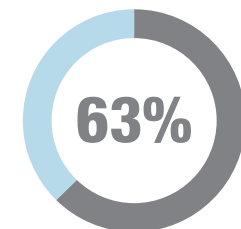
For these reasons, many companies view effective management of operational risks as an essential part of their overall approach to enterprise risk management, and as key to addressing their industrial skills gap challenges. However, when it comes to safety and risk management on the frontlines, there's a gap between strategy and execution. Our research shows that current capabilities for safety and risk programs and processes are generally deficient. Most respondents (63%) report they don't have capabilities in place to effectively manage risk and safety. And little over a quarter (28%) report using a life-cycle approach to risk management with closed-loop processes to identify, assess, control, and monitor operational risk.

28%

ONLY 28% of
industrial organizations
use a lifecycle approach
to risk management.

Operational Risks Among the Top 10 High Impact Enterprise Risks	
Risk Description	**% Respondents Indicating Risk is High Impact**
Impact of regulatory change and scrutiny on operational resilience, products, and services	70%
Insufficient operations infrastructure/legacy IT systems	67%
Cyber security threat to core operations	66%
Inability to identify and escalate risks in timely manner	61%
Lack of skills to adopt digital technologies	56%

Source: Enterprise Risk Management Institute, "Executive Perspectives on Top Risks in 2020" (NC State University, 2020)

63%

63% of manufacturers
say they lack the capability
to manage safety and risk
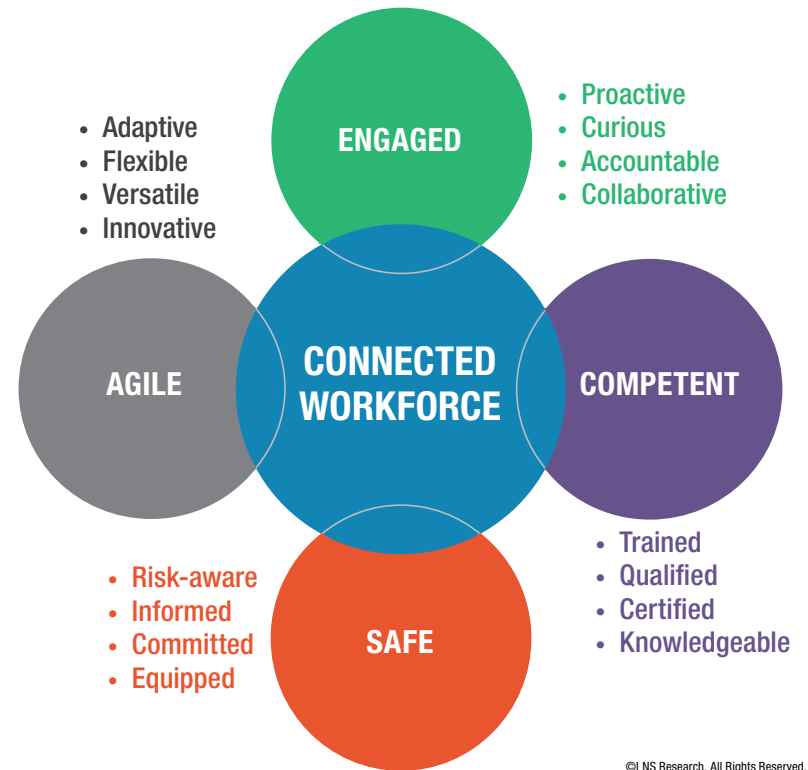effectively.

Enter the Digitally Connected Workforce

The initial waves of IX investment focused on using asset-related data from smart connected assets to improve core operational areas like asset reliability, overall equipment effectiveness (OEE), energy management, and product quality. We've observed that IX initiatives are expanding to a more holistic view of connected operations that recognizes the critical importance of digitally connecting people with each other and the overall operational system–the Connected Workforce. Our most recent IX survey data shows that over a third (34%) of industrial organizations have already implemented Connected Worker technologies. This is greater than or equal to adoption rates for projects focused on Connected Operations, Assets, and Products. Among those organizations not yet underway with Connected Worker initiatives, 68% are well into pilot deployments or have budgeted projects to start within 12 months.

These initiatives leverage both proven and emerging digital technologies such as mobile devices, robotics, augmented reality, sensor-equipped wearables, and IIoT systems. These and other technologies serve to better connect frontline workers with each other and their work environment, facilitating the multi-directional flow of data, information, insights and actions to improve processes and overall operational performance. Connected Worker technologies help address critical workforce challenges by augmenting human capabilities. The goal is a frontline workforce that's more engaged, proactive, and empowered with data-driven insights to make faster, better decisions.

73% of industrial organizations have started Connected Worker initiatives

CONNECTED WORKFORCE CHARACTERISTICS

- Adaptive
- Flexible
- Versatile
- Innovative

ENGAGED

- Proactive
- Curious
- Accountable
- Collaborative

AGILE

CONNECTED WORKFORCE

COMPETENT

- Risk-aware
- Informed
- Committed
- Equipped

SAFE

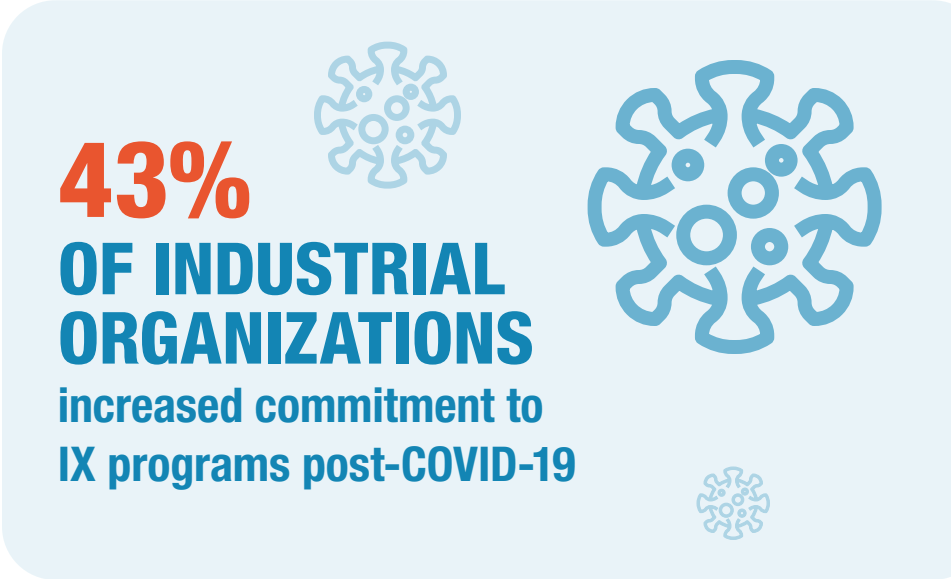- Trained
- Qualified
- Certified
- Knowledgeable

Section 4

Impact of the COVID-19 Crisis

Greater Focus on Industrial Transformation

Now let's turn to the COVID-19 pandemic and its impact on industrial organization plans, priorities, and actions. Over the past several years industrials have increasingly relied on IX initiatives as their strategic framework to improve and optimize operations for competitive advantage. Our research shows that not only aren't companies pulling back on their IX programs but are in fact increasing focus.

About a third of responding companies reported maintaining their focus on IX initiatives, while 43% are increasing focus. Only 18% report pairing back existing IX initiatives, most of those modestly. The COVID-19 crisis has served as a catalyst for industrial organizations to strengthen IX efforts as part of their strategic response.

43%
OF INDUSTRIAL ORGANIZATIONS
increased commitment to IX programs post-COVID-19

IMPACT OF COVID-19 ON IX PROGRAM

Response	Percentage
Our focus has stayed about the same	35%
We have modestly increased our strategic focus on industrial transformation	25%
We don't have an Industrial Transformation program implemented or planned	18%
We have dramatically increased our strategic focus on Industrial Transformation	18%
We have modestly pared back our strategic focus on Industrial Transformation	15%
We have dramatically decreased our strategic focus on Industrial Transformation	3%

IX Efforts Intensified in Core Operations

In response to the pandemic, industrial organizations have increased efforts to transform core operational and support functions within manufacturing and production facilities. That Environment, Health, and Safety (EHS) 4.0 is reported to have gained the most traction isn't surprising, given that the pandemic manifested itself in terms of risk to worker health and safety, and a threat to operational continuity. Other support functions cited as receiving significantly increased focus are Quality 4.0 and Asset Performance Management 4.0, both of which are complementary to EHS 4.0 and targeted at improving core operational performance across productivity, quality, and safety.
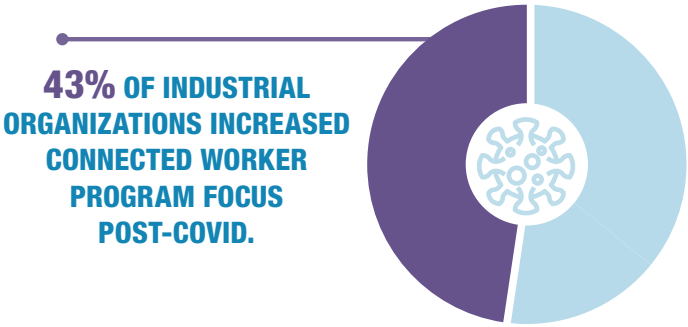
Respondents also reported an increased focus on "Factory of the Future" transformation via digitalization and automation. This is in keeping with new challenges and requirements faced by industrial operations such as increased employee absenteeism, new requirements for physical distancing, modification of production processes and workflows, and increased remote work. The Smart Factory is more important than ever.

Connected Worker and Remote Operations Center initiatives were also cited as receiving increased focus. Given that remote operations capabilities enable a more collaborative, connected workforce, altogether 43% of respondents increased focus on Connected Worker programs. Clearly the COVID-19 crisis has accelerated previously existing trends driving IX investments, with Connected Worker, safety and risk standing out.
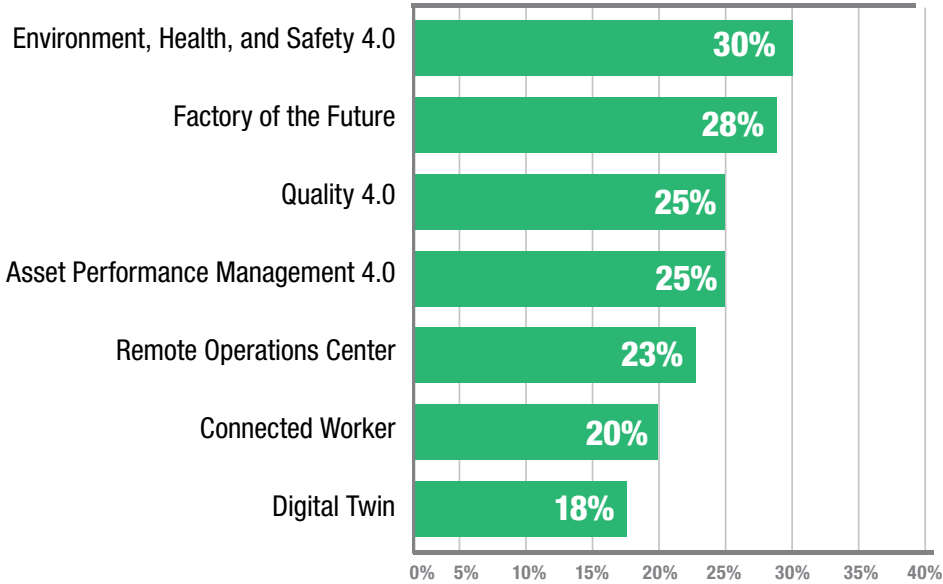
43% OF INDUSTRIAL ORGANIZATIONS INCREASED CONNECTED WORKER PROGRAM FOCUS POST-COVID.

IX PROGRAMS WITH INCREASED FOCUS

| Program	Percentage
Environment, Health, and Safety 4.0	30%
Factory of the Future	28%
Quality 4.0	25%
Asset Performance Management 4.0	25%
Remote Operations Center	23%
Connected Worker	20%
Digital Twin	18%

Response: Enable an Agile Connected Workforce

What types of actions did industrial organizations take to mitigate COVID-19 safety and operational risk? We conducted surveys on response actions at two points in time: March 2020 in the early phases of the pandemic, and three months later. The accompanying chart shows the adoption of various responses, and how these actions shifted over time.

Several key observations based on this data are:

- The most common response was updating Personal Protective Equipment (PPE) requirements for the frontline workforce. Depending on industry and job task, this most often resulted in new requirements for wearing respiratory protection, face coverings, and face shields. Such use of PPE is often the first line of defense, especially for an airborne hazard.

- Administrative controls such as staggering shift start and stop times, and implementing rotating shifts were used heavily, especially in the early phases.

- As the crisis unfolded, much greater emphasis was placed on more permanent engineering and operational controls such as re-configuring production process flows to improve physical distancing of personnel.

- Focus on the use of Connected Worker and related digital technologies gained traction over time, including tools for remote expert access, better use of already-available collaboration tools, rapid development of new apps, vision systems, cobots, AGVs, and specialized Connected Worker tech such as smart wearables to help maintain distancing.

- The importance of knowledge capture and rapid training systems to on-board and re-train workers increased during the period.
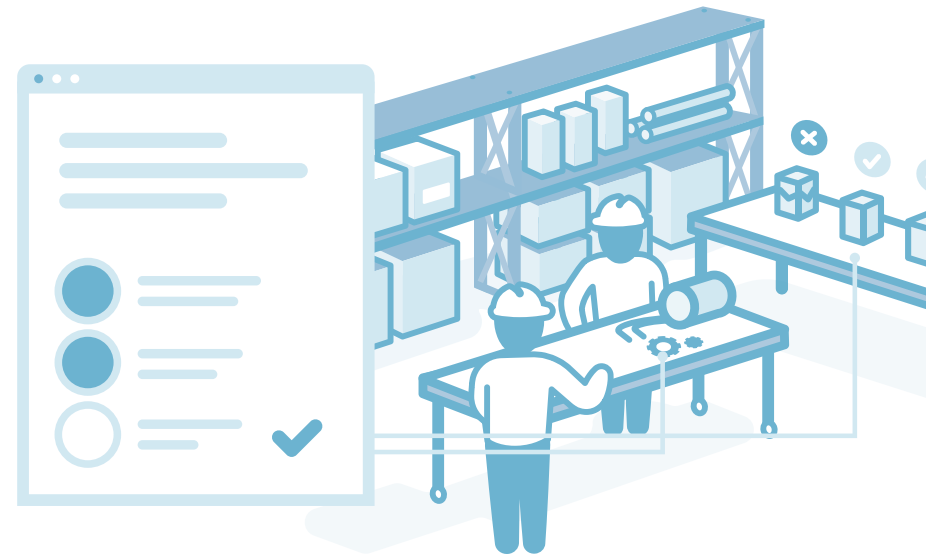
Response: Enable a Connected Workforce *(Cont.)*

While PPE requirements and administrative controls were emphasized early on, technology-enabled engineering and operational changes gained traction over time, including Connected Worker use cases such as remote expert access and in-context training.

COVID-19 RESPONSE MEASURES

Measure	March 2020	June 2020
Change PPE requirements	70%	65%
Change manufacturing process flows	30%	55%
Use existing collaboration tools	55%	53%
Change shift start and stop times	43%	43%
Establish remote assistance	34%	35%
Develop new digital apps	14%	23%
Develop knowledge capture/rapid training system	11%	23%
Implement new automation technologies	5%	20%
Implement rotating shifts	36%	20%
Implement specialized Connected Worker technologies	11%	18%
Hire additional workers	5%	8%

Digital Priorities: Enabling a Safe, Connected Workforce

The COVID-19 pandemic hasn't changed trends in industrial operations as much as it's accelerated preexistent trends. Before the crisis, improvement of EHS performance was already a top strategic priority for many organizations. Now, transformation and digitalization projects focused on EHS not only haven't been reduced or slowed, but have been emphasized and sped up. The same applies to transformation pilots of digital tech including Connected Worker and advanced data analytics.

COVID-19 TRANSFORMATION PROJECTS

MARCH 2020

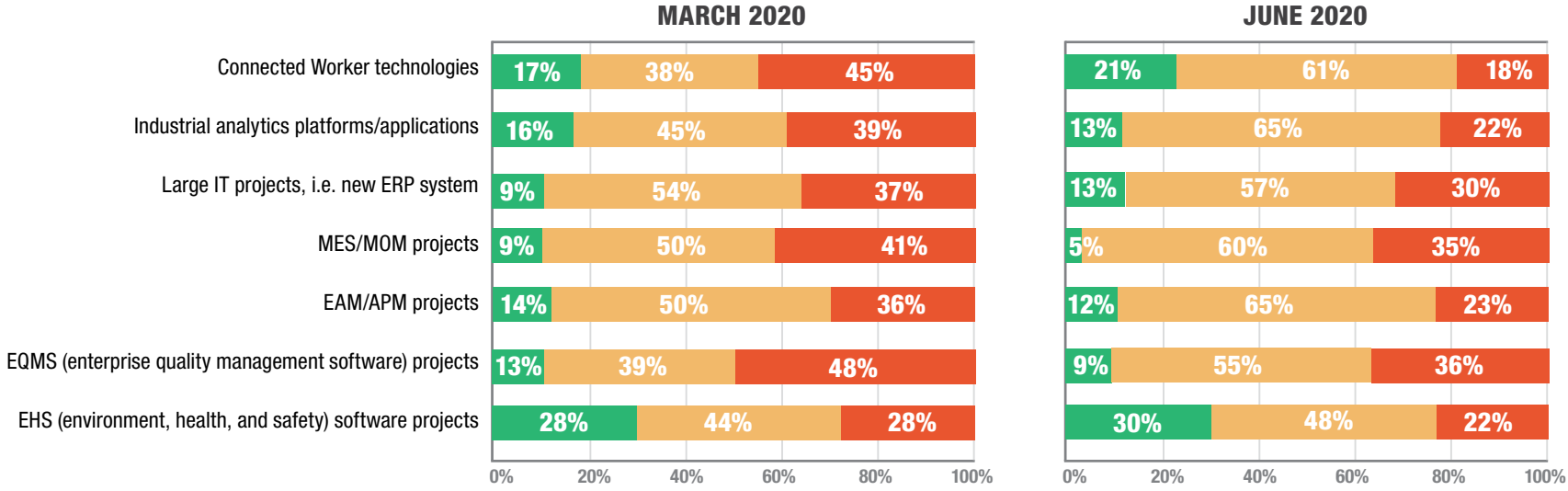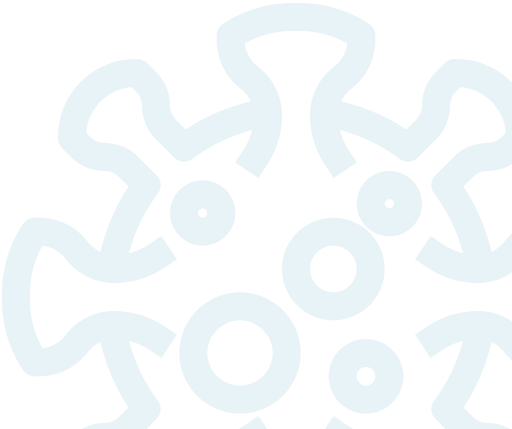|	Speeding Up	Staying on Schedule	On Hold
Connected Worker technologies	17%	38%	45%
Industrial analytics platforms/applications	16%	45%	39%
Large IT projects, i.e. new ERP system	9%	54%	37%
MES/MOM projects	9%	50%	41%
EAM/APM projects	14%	50%	36%
EQMS (enterprise quality management software) projects	13%	39%	48%
EHS (environment, health, and safety) software projects	28%	44%	28%

JUNE 2020

	Speeding Up	Staying on Schedule	On Hold
Connected Worker technologies	21%	61%	18%
Industrial analytics platforms/applications	13%	65%	22%
Large IT projects, i.e. new ERP system	13%	57%	30%
MES/MOM projects	5%	60%	35%
EAM/APM projects	12%	65%	23%
EQMS (enterprise quality management software) projects	9%	55%	36%
EHS (environment, health, and safety) software projects	30%	48%	22%

* Traditional statistics include data collection, descriptive and inferential.

Legend:
- Speeding Up
- Staying on Schedule
- On Hold
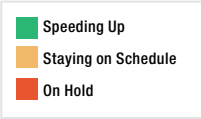
Digital Priorities: Enabling a Safe, Connected Workforce *(Cont.)*

In a COVID-19 world, tech-enabled transformation initiatives to improve the safety and productivity of the frontline workforce have been elevated. Likewise, this is borne out by data on what digital technologies have been prioritized for implementation considering COVID-19.

NEW DIGITAL TECHNOLOGIES PRIORITIZED FOR RAPID DEVELOPMENT AFTER COVID-19

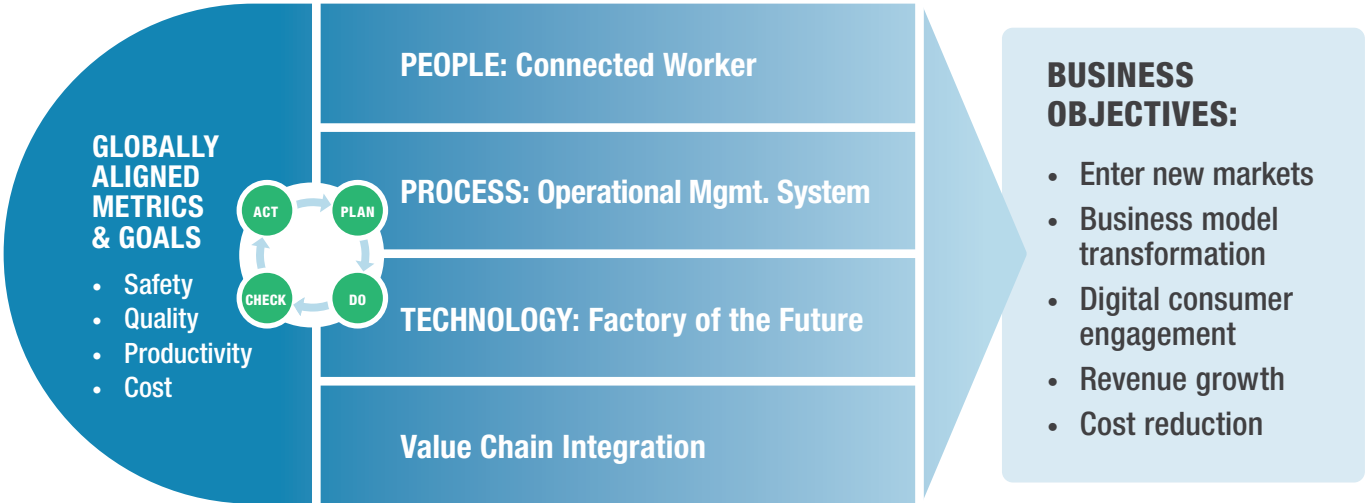| Technology	%
Updating/upgrading existing systems	30%
Mobile devices (Smart phones and tablets)	28%
Networking solutions (Wi-Fi, Bluetooth, cellular radio, etc.)	25%
Device connectivity and incremental sensors	25%
Machine Learning/Artificial Intelligence (ML/AI)	23%
Industrial IoT platform	23%
Big data analytics - Predictive & Prescriptive analytics	20%
Autonomous vehicles, robots or cobots in production	18%
Vision systems	13%
Digital Twins of plants and operations	10%
Smart wearables (smart glasses, head-mounted displays...)	8%
No-code/Low-code applications	5%
Augmented Reality/Virtual Reality (AR/VR)	5%
Proximity beacons	3%
Blockchain	3%
Drones	0%

Section 5

Connected Worker Solutions

Connected Worker Initiatives are Integral to Operations Strategy

When a company undertakes an IX program, the first consideration should be its enterprise business objectives, and the underlying operational strategy designed to meet them. IX initiatives should directly support key elements of the operations strategy to enable continuous improvement of performance as measured by globally aligned metrics and goals. These goals should drive safety, quality, productivity, and cost results required to achieve the organization's Operational Excellence objectives, and ultimately competitive differentiation.

The role of the frontline workforce has become well-recognized as a critical success factor as experience has been gained with IX. Although digitalization will automate some tasks and eliminate some jobs, it also raises the bar on the skills needed to implement and operate new technologies and processes in a more dynamic operating environment. In this environment, the demand for frontline workers who are engaged, curious, flexible, and skilled will be even greater. As Factory of the Future technology is implemented to optimize operations, Connected Worker initiatives are becoming an increasingly important part of operations strategy to help meet these challenges in a labor-constrained environment.

OPERATIONS STRATEGIC INITIATIVES EXAMPLES

GLOBALLY ALIGNED METRICS & GOALS
- Safety
- Quality
- Productivity
- Cost

ACT → PLAN → DO → CHECK

PEOPLE: Connected Worker

PROCESS: Operational Mgmt. System

TECHNOLOGY: Factory of the Future

Value Chain Integration

BUSINESS OBJECTIVES:
- Enter new markets
- Business model transformation
- Digital consumer engagement
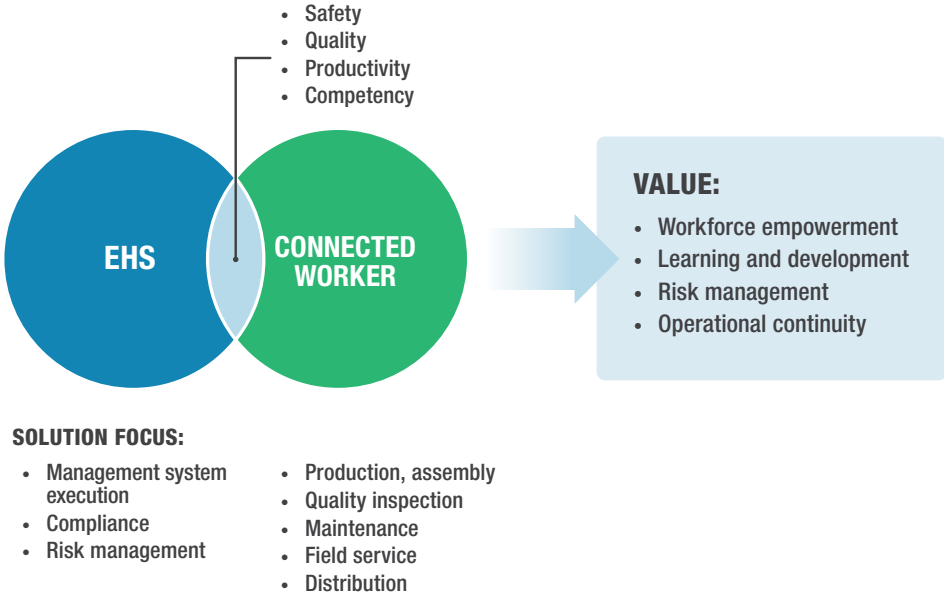- Revenue growth
- Cost reduction

Synergy of Connected Worker and EHS Solutions

As the implementation of Connected Worker technologies has gained traction, we've observed a strong synergy between these solutions and those for EHS. EHS solutions are often based on enterprise software that enables consistent execution of management systems and programs, including compliance and risk management processes. In most cases, these capabilities are available on mobile devices. EHS solutions are used operations-wide, and benefit frontline workers across departments and business functions.

Connected Worker solutions on the other hand tend to focus on a particular problem in specific vertical domains such as maintenance, quality, field service, etc. By combining this with the cross-functional EHS use case view, there are significant potential synergies across safety, quality, productivity, and competency management.

For example, implementation of EHS software on mobile devices with Bluetooth proximity beacons can deliver context-relevant safety procedures to any frontline worker, in production, maintenance, field service.   This not only improves safety, but also quality and productivity, and makes wide-scale deployment more cost-effective. On the other side of the coin, Connected Worker solutions deployed to solve a specific problem, e.g., use of augmented reality technologies for digital work instructions, can be designed to simultaneously implement safety requirements and reduce risk. The leverage created serves to help achieve higher-level business value beyond task optimization in the form of workforce engagement and empowerment, organizational learning and development, risk reduction, and protection of operational continuity.

CONNECTED WORKER AND EHS SOLUTION SYNERGY

- Safety
- Quality
- Productivity
- Competency

EHS

CONNECTED WORKER

VALUE:
- Workforce empowerment
- Learning and development
- Risk management
- Operational continuity

SOLUTION FOCUS:

- Management system execution
- Compliance
- Risk management

- Production, assembly
- Quality inspection
- Maintenance
- Field service
- Distribution

Connected Worker Solutions: More than Tech

Although there is no standard definition of what a Connected Worker solution is, there is one aspect everyone should be able to agree on: Connected Worker solutions involve much more than deploying some connected devices and cool tech. As with all IX initiatives, the name of the game is transformative change enabled by a well-orchestrated combination of people, process, and technology with a healthy dose of organizational change management. A narrow focus on evaluating and testing technology is a sure path to a pilot that goes nowhere.

The LNS Research point of view on Connected Worker is worker-centric and bottom-up. Although the greatest value comes from a Connected Workforce at the organizational level (team, site, business unit, enterprise), that value is created by changing how individuals interact with their work environment, and with the people and systems comprising the overall operational management system. The value of the solution is not in the technology, but rather in how technology enables new, faster interactions and feedback loops.

Our key criterion for a Connected Worker solution is that the application of technology increases the degree of connectivity or adds new modes of connectivity between the worker and one or more elements of the operational management system to facilitate the multi-directional flow of data, information, actionable insights, and autonomous actions.

Like other enterprise tech, Connected Worker solutions in most cases are comprised of a combination of software, content, hardware, infrastructure, and implementation services. Key technology categories include Applications, Analytics, Infrastructure, Wearable technology, Work area connected devices, and integration with OT systems. Solutions can range from simple (e.g., mobile apps on a smart phone) to more complex (e.g., an IIoT system with sensor equipped wearables and Big Data analytics) depending on the problem to be solved.
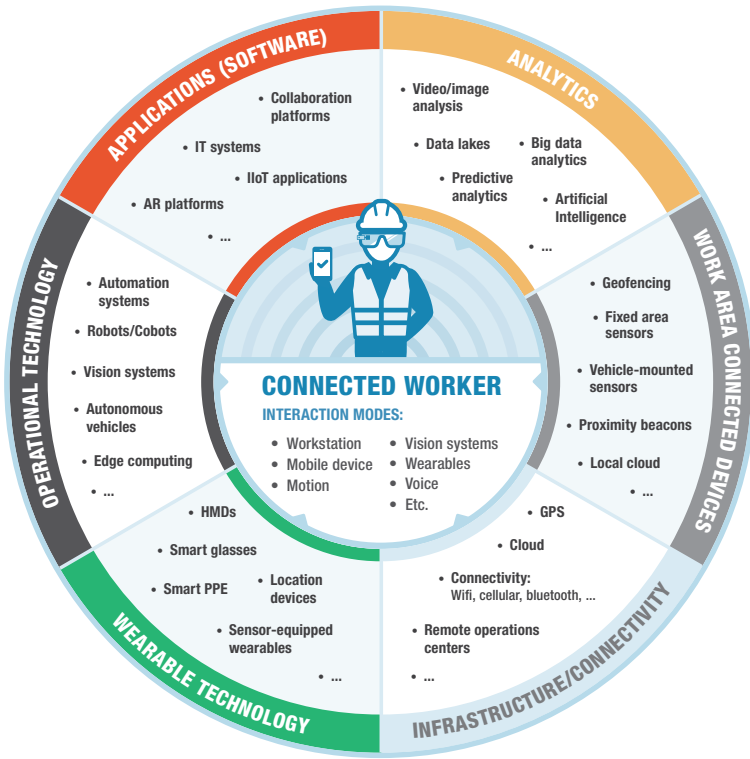
Solution Architecture

Most established industrial organizations have a fragmented, diverse landscape of legacy technology systems including operational technology such as automation systems and manufacturing execution systems, and IT systems such as ERP, HR, procurement, EHS, Quality, and supply chain management, among others. There is often limited interoperability and communication among these various systems, hindering collaboration, visibility, and performance improvement. The introduction of IX initiatives (including Connected Worker) and their enabling digital technologies can complicate an already complex situation.

Deployment of new digital technologies such as IIoT platforms, smart connected devices, Big Data, edge computing, and advanced analytics into the legacy technology environment creates risk of creating more silos of data, process, and teams. Capitalizing on the opportunities of IX requires an approach that brings together the data and capabilities from existing legacy systems with new digital technologies to provide the anticipated insights and business value.

Connected Worker solutions will likely be built from a combination of already deployed and new technologies from different vendors. The LNS Research IX Reference Architecture is a tool to help industrial organizations define and design IX solutions that will work best with the as-is and to-be technology landscape. It's a future-looking framework that defines six categories of technology capabilities needed to deliver the entire range of IX use cases in operations and across the value chain – to transform industrial operations. These capabilities encompass connectivity including security, data management, development tools, applications and analytics, and deployment architecture.
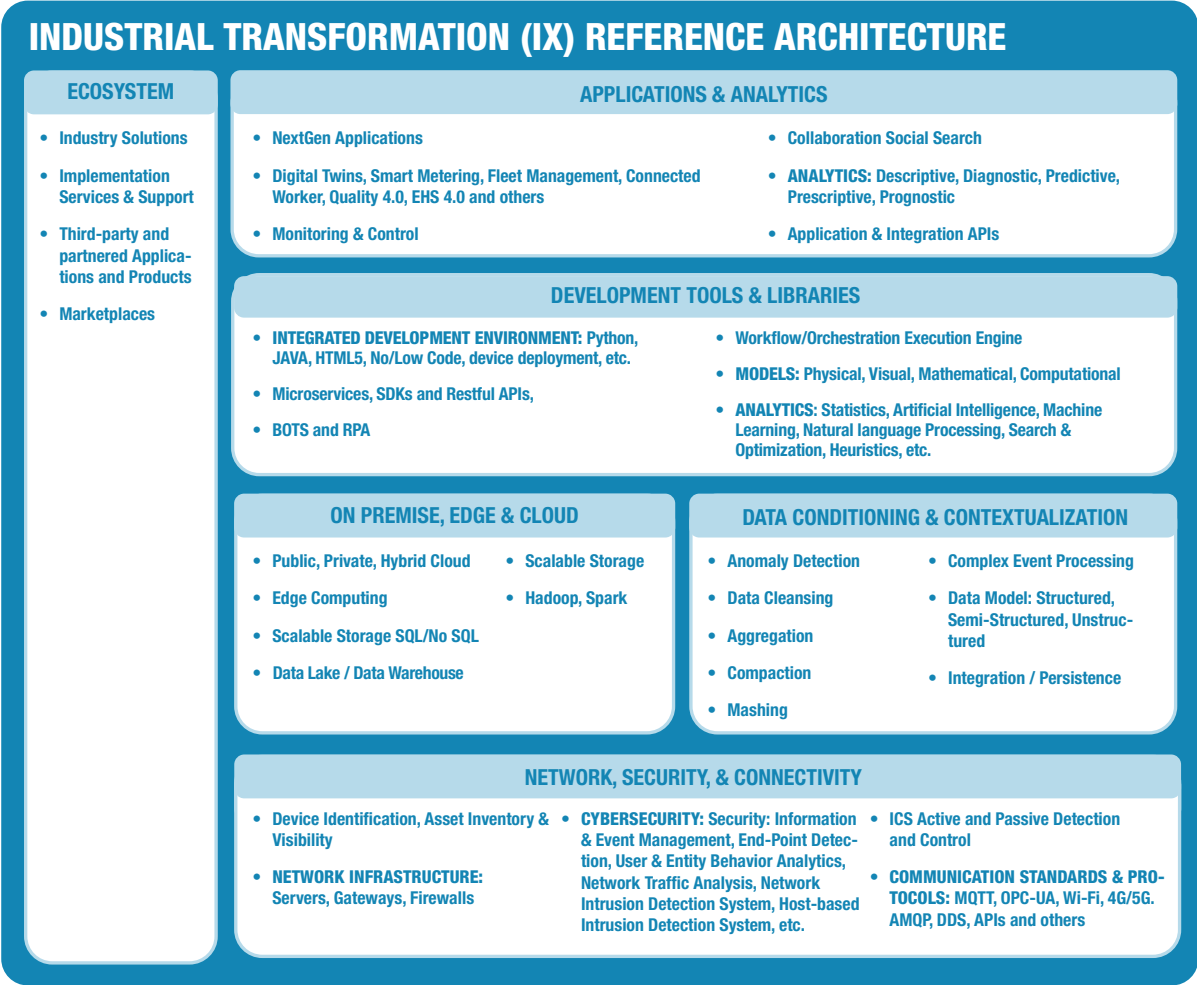
Solution Architecture *(Cont.)*

Key questions will arise in developing a Connected Worker solution strategy. Should we go with one of the many purpose-built Connected Worker point solutions that addresses a specific business problem? If so, how many do we need and can we scale and support? Or should we adopt a flexible and extensible no/low code Connected Worker platform that can handle a wide range of use cases? Or maybe it would be better to leverage the standard IIoT platform our company already has adopted to build applications and solutions, hoping the benefits of integration will offset higher initial development costs? All these approaches, and others, may be valid. The key is to develop a Connected Worker solution strategy that is best aligned to your organization's current and future IX architecture.

INDUSTRIAL TRANSFORMATION (IX) REFERENCE ARCHITECTURE

ECOSYSTEM

- Industry Solutions
- Implementation Services & Support
- Third-party and partnered Applications and Products
- Marketplaces

APPLICATIONS & ANALYTICS

- NextGen Applications
- Digital Twins, Smart Metering, Fleet Management, Connected Worker, Quality 4.0, EHS 4.0 and others
- Monitoring & Control
- Collaboration Social Search
- ANALYTICS: Descriptive, Diagnostic, Predictive, Prescriptive, Prognostic
- Application & Integration APIs

DEVELOPMENT TOOLS & LIBRARIES

- INTEGRATED DEVELOPMENT ENVIRONMENT: Python, JAVA, HTML5, No/Low Code, device deployment, etc.
- Microservices, SDKs and Restful APIs,
- BOTS and RPA
- Workflow/Orchestration Execution Engine
- MODELS: Physical, Visual, Mathematical, Computational
- ANALYTICS: Statistics, Artificial Intelligence, Machine Learning, Natural language Processing, Search & Optimization, Heuristics, etc.

ON PREMISE, EDGE & CLOUD

- Public, Private, Hybrid Cloud
- Edge Computing
- Scalable Storage SQL/No SQL
- Data Lake / Data Warehouse
- Scalable Storage
- Hadoop, Spark

DATA CONDITIONING & CONTEXTUALIZATION

- Anomaly Detection
- Data Cleansing
- Aggregation
- Compaction
- Mashing
- Complex Event Processing
- Data Model: Structured, Semi-Structured, Unstructured
- Integration / Persistence

NETWORK, SECURITY, & CONNECTIVITY

- Device Identification, Asset Inventory & Visibility
- NETWORK INFRASTRUCTURE: Servers, Gateways, Firewalls
- CYBERSECURITY: Security: Information & Event Management, End-Point Detection, User & Entity Behavior Analytics, Network Traffic Analysis, Network Intrusion Detection System, Host-based Intrusion Detection System, etc.
- ICS Active and Passive Detection and Control
- COMMUNICATION STANDARDS & PROTOCOLS: MQTT, OPC-UA, Wi-Fi, 4G/5G. AMQP, DDS, APIs and others

Section 6

Business Value

The Connected Worker Value Curve

What constitutes an effective Connected Worker solution is highly variable based on the problem at hand, the organization, how use cases are defined and prioritized, and available resources. Before addressing best practices for Connected Worker initiatives and use cases, it's useful to have a framework in mind to think about the sources of potential business value, and their relative magnitudes.

The LNS Research Connected Worker Value Curve compares six sources of value by the degree of workforce connectivity and potential business value. As the digital connectivity between people and their work environment increases, so too does the potential value to be gained. Going up the value curve, the scope and magnitude of benefits expands from individual and team, to site, to enterprise, even potentially to the industry level.
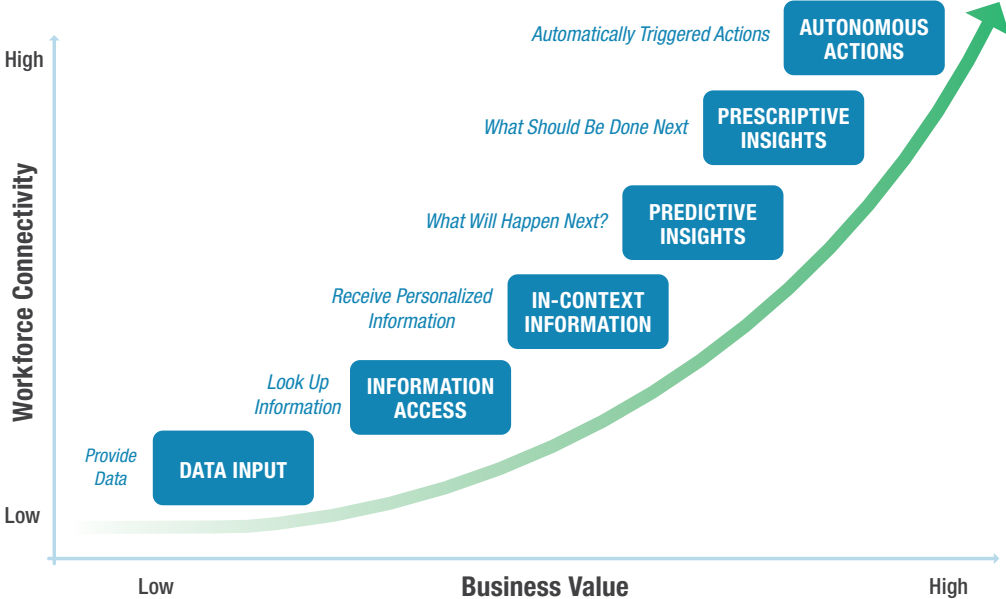
The Connected Worker Value Curve *(Cont.)*

This curve is explained by the larger volume and variety of multi-directional data flow available as the workforce is more digitally connected. This provides a stronger information foundation upon which to support risk-based decisions by the frontline workforce, trigger autonomous actions, and to extract actionable insights to improve safety, quality, and productivity. Below are examples of Connected Worker scenarios per the six value sources:

This value curve can also be viewed as a prototypical journey an organization might take in undertaking Connected Worker initiatives. The first step is often using simple mobile apps on phones and tablets to input data or access information on demand, with various levels of cost, complexity, and benefits possible from there.

- **Data Input:** Reporting a safety incident at a kiosk on plant floor

- **Information Access:** Maintenance work orders available on mobile devices

- **In-Context Information:** Use of an augmented reality software platform for in-context training via head-mounted display

- **Predictive:** Use of an IIoT platform to collect Big Data on worker-machine interactions and apply predictive analytics to identify impending safety risks

- **Prescriptive:** AI-enabled prescriptive maintenance to predict asset failure and provide outcome-focused maintenance recommendations

- **Autonomous:** Human-robot collision avoid-ance autonomously triggered by body-worn sensors

CONNECTED WORKER VALUE CURVE

Workforce Connectivity (High / Low) vs Business Value (Low / High)

- *Provide Data* — **DATA INPUT**
- *Look Up Information* — **INFORMATION ACCESS**
- *Receive Personalized Information* — **IN-CONTEXT INFORMATION**
- *What Will Happen Next?* — **PREDICTIVE INSIGHTS**
- *What Should Be Done Next* — **PRESCRIPTIVE INSIGHTS**
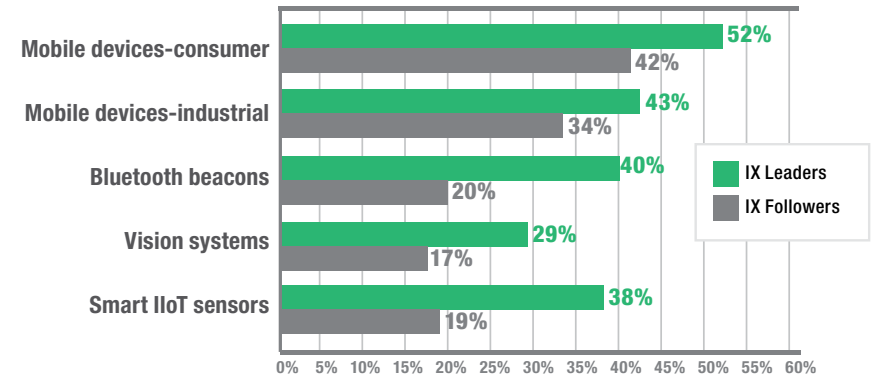- *Automatically Triggered Actions* — **AUTONOMOUS ACTIONS**

Connected Worker Solutions: Evidence of Value

Impact on Profitability: Industrial organizations that adopt Connected Worker and related digital solutions as part of their enterprise solution portfolio tend to have more profitable plants than those that don't. We compared use of Connected Worker solutions in high margin vs. low margin operations. High margin operations are 59% more likely to have implemented Connected Worker solutions. A similar positive association with profitability is seen from before the adoption of workforce collaboration solutions and digital twin technologies.
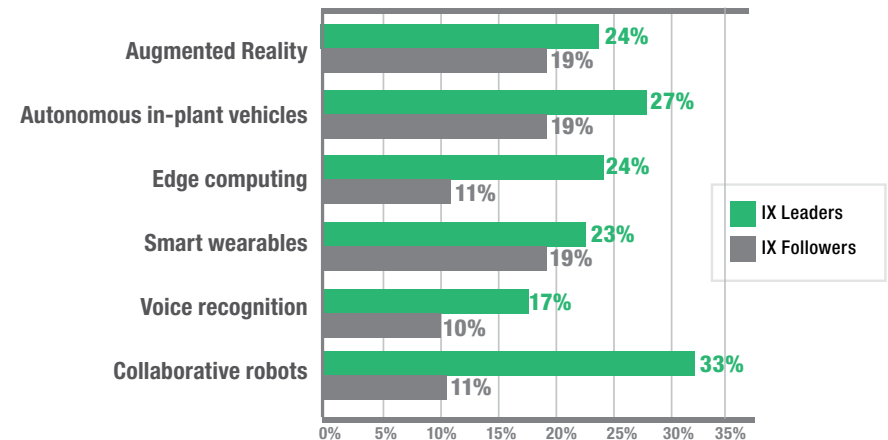
Adoption of Enterprise Solutions vs. Profitability

Solution Category	Enterprise Solution Adopted	
	High Margin Operations	Low Margin Operations
Connected Worker	35%	22%
Workforce Collaboration	52%	41%
Digital Twins	35%	6%

Impact on IX Success: IX Leaders are those organizations that have achieved real success and business value from their industrial transformation initiatives. Our research shows that IX Leaders are much more likely to have invested in developing and enabling a digitally connected frontline workforce. For example, IX Leaders are much more likely to have implemented connected devices that provide a Connected Worker solution infrastructure, such as hand-held mobile devices, proximity beacons, vision systems, and IIoT sensors capable of transmitting data. Likewise, IX Leaders more often deploy emerging technologies that enable a wide range of Connected Worker use cases, such as Augmented Reality, edge computing, smart wearables, and collaborative robots.

CONNECTED DEVICE TECHNOLOGIES DEPLOYED

	IX Leaders	IX Followers
Mobile devices-consumer	52%	42%
Mobile devices-industrial	43%	34%
Bluetooth beacons	40%	20%
Vision systems	29%	17%
Smart IIoT sensors	38%	19%

EMERGING DIGITAL TECHNOLOGIES DEPLOYED

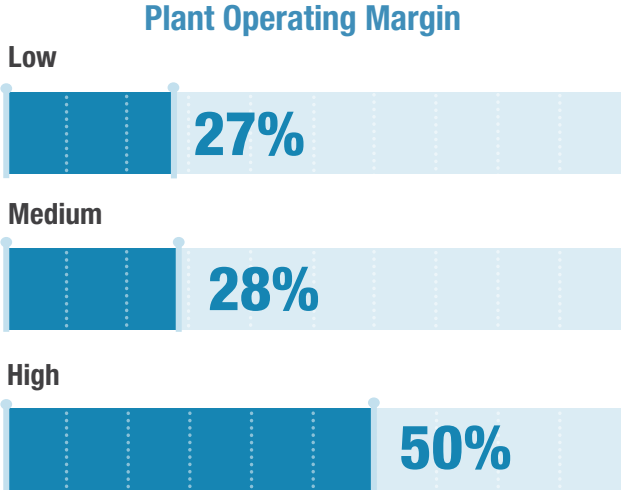|	IX Leaders	IX Followers
Augmented Reality	24%	19%
Autonomous in-plant vehicles	27%	19%
Edge computing	24%	11%
Smart wearables	23%	19%
Voice recognition	17%	10%
Collaborative robots	33%	11%

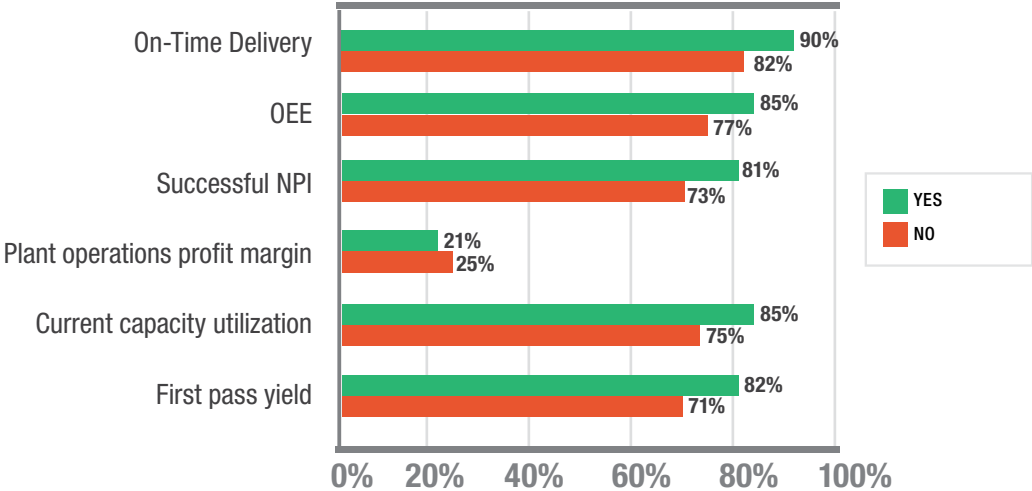# Impact of a Safe, Engaged Workforce on Operational Performance

Connected Worker solutions can deliver value by enabling a wide range of use cases across value chain operations, with expected benefits spanning safety, quality, and productivity. While improvement of EHS and safety performance has long been a goal of many industrial organizations, the COVID-19 crisis has re-enforced the value of effective EHS and operational risk management systems in building a safe, engaged workforce – a necessity in today's environment. As presented above, Connected Worker initiatives can be a key enabler to achieve this.

Our research indicates that organizations that possess effective EHS, safety, and risk management capabilities achieve better operational performance in terms of profitability, operational effectiveness and product quality. And organizations whose leaders are committed to EHS management as a top strategic priority tend to be more profitable than those in which this is not the case. The positive association between EHS capabilities and operational performance indicates that Connected Worker solutions can help drive this by enabling stronger EHS processes and execution.

PERCENTAGE OF RESPONDENTS WITH IMPROVING EHS PERFORMANCE AS A STRATEGIC OBJECTIVE FOR OPERATIONS

Plant Operating Margin

Low
27%

Medium
28%

High
50%

EFFECTIVE MANAGEMENT OF SAFETY AND RISK

	YES	NO
On-Time Delivery	90%	82%
OEE	85%	77%
Successful NPI	81%	73%
Plant operations profit margin	21%	25%
Current capacity utilization	85%	75%
First pass yield	82%	71%

0% 20% 40% 60% 80% 100%
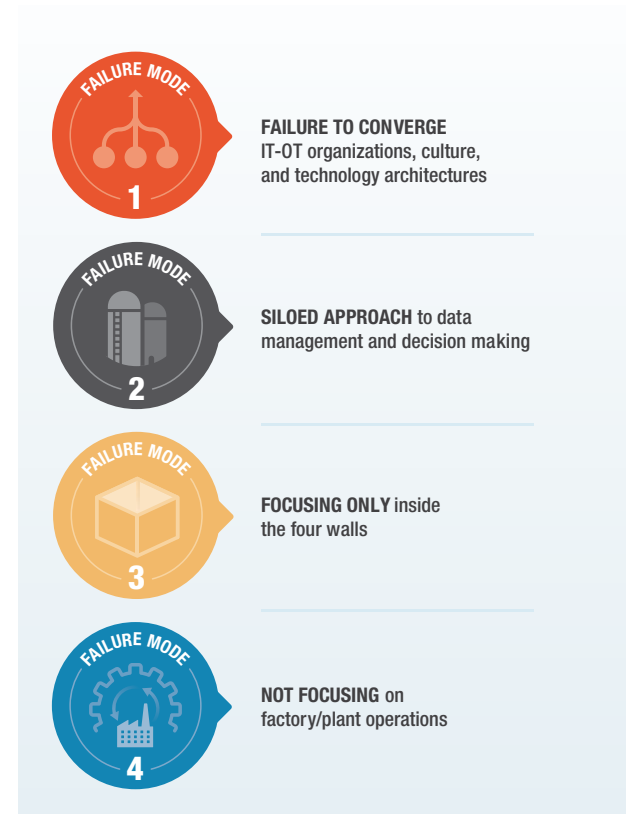
Critical Success Factors

LNS Research has published extensively on trends, challenges, strategies and solutions for achieving success with IX initiatives including Connected Worker. Our research on *"Avoiding Pilot Purgatory: How to Choose the Right Use Cases to Accelerate Industrial Transformation"* identified that a significant percentage of companies undertaking IX initiatives get stuck in "pilot purgatory" and have trouble scaling solutions across operations and capturing business value.

We identified four critical IX failure modes and corresponding success factors that are instructive for planning and executing Connected Worker initiatives:

1. **Leverage IT-OT Convergence** - IX Leaders join the often-separate realms of Information Technology (IT) systems (e.g. ERP) and Operational Technology (OT) (e.g. plant automation systems) in terms of organization, data, and analytics. The greatest value of Connected Worker initiatives can come from insights gleaned from combining IT and OT views; initiative leaders should understand and leverage IT-OT convergence in their organization.

2. **Take a Cross-Functional Approach** - Lack of cross-functional collaboration is still common in many industrial organizations, as are technology-enabled functional silos. IX Leaders are much more inclusive in using functionally broad teams. Connected Worker initiatives tend to span multiple use cases across value chain operations; a cross functional approach will help scale technology deployments and maximize value.

3. **Cast a Broad Net for Data** - We have identified an "internally focused" mindset that can hamper success of IX programs, in which its assumed that internal data is all that's needed to solve internal problems. Rather, incorporating external data from other plants and business units, third party systems, suppliers, and customers may reveal new patterns and insights. For Connected Worker initiatives this could include external data sources such as weather, regulatory content, contractor data, etc.

4. **Focus on Core Operations** - Our research shows that IX leaders focus their IX initiatives on their core production operations, in the factory, plant, or mill. IX is about transforming industrial processes and operations. Although efforts aimed at transforming customer experience and supply chain are important, optimizing core production operations likely has priority; by definition Connected Worker initiatives support improving frontline operations.

FAILURE MODE 1 — FAILURE TO CONVERGE IT-OT organizations, culture, and technology architectures

FAILURE MODE 2 — SILOED APPROACH to data management and decision making

FAILURE MODE 3 — FOCUSING ONLY inside the four walls

FAILURE MODE 4 — NOT FOCUSING on factory/plant operations

Recommendations

Recommendations

The potential value possible from integrating Connected Worker initiatives into frontline operations represents a significant opportunity for industrial organizations. Much of this value comes from helping organizations deal with major challenges such as the industrial skills gap, and from making the organization more resilient to adverse events, as exemplified by the COVID-19 pandemic. Connected Worker solutions can help organizations recognize and mitigate potential risks, and to respond to events and adapt to change with greater operational agility. Below are six recommendations to achieve success with Connected Worker initiatives.

1. **Build capabilities for resilience.** The COVID-19 pandemic reminded us that not all adverse events can be predicted let alone prevented. However, the impact of such events on operations can be controlled through business continuity planning and organizational capabilities to assess and manage enterprise and operational risk, and adapt to change with agility and flexibility. Connected Worker initiatives can provide data-driven insights to help enable such foresight and resilience.

2. **Incorporate Connected Worker initiatives into Operational Strategy.** The automation that comes with Industrial Transformation won't eliminate the frontline workforce. Rather, it places increased demands on it for expanded skill sets, versatility, and decision-making. With on-going wide-scale employee turnover, industrial organizations must deal with the resulting industrial skills gap. This requires a strategic approach to attracting and retain a quality workforce with the right competency profile. Connected Worker initiatives should be a key pillar of Operational Strategy, directly contributing to the development of a safe, engaged, informed workforce, with the collaboration and agility needed to meet fast-changing requirements.

3. **Align with Operational Architecture.** Technology is key pillar of Operational Strategy with which Connected Worker initiatives should be aligned, if not integrated. Understand your organizations overall IX/Factory of the Future solution strategy and architecture, and leverage complimentary aspects across Operational Technology (OT), Information Technology (IT) and Industrial Internet of Things (IIoT). This will improve buy-in, function, speed and value. The LNS Research IX reference architecture assists solution selection and design by serving as a framework for evaluating and mapping the major categories of capabilities needed for Connected Worker projects in the context of the overall IX program.

4. **Emphasize agility over functionality in solution selection.** The main pre-requisite of a future-proof solution that enables resilience is adaptability to change. While functionality to meet today's business requirements is important, the flexibility to meet unknown future requirements will be key to supporting Industrial Transformation. Capabilities that provide operational agility such as configurability, extensibility, interoperability, and scalability should carry considerable weight in the selection process.

Recommendations *(Cont.)*

PAGE
34

ENABLE OPERATIONAL AGILITY WITH A
DIGITALLY CONNECTED WORKFORCE

TABLE OF
CONTENTS

SECTION

1 2 3
4 5 6
7

5. **Move up the Value Curve.** - In many cases, it makes sense to focus initial Connected Worker efforts on relatively simple solutions such as provision of digital procedures. Perhaps the greatest strategic value of the Connected Worker opportunity comes from applying advanced analytics including Artificial Intelligence (AI) to IIoT-generated Big Data on human-workplace interactions to glean actionable insights at the line, site, business unit, and enterprise levels. Such insights may be used to enable real-time response actions, including triggering autonomous ones, for short-term local improvement, and to identify major long-term improvement opportunities. This may or may not be part of phase one but harnessing the power of advanced analytics should be given priority in the Connected Worker road map.

6. **Scale success broadly by deploying winners across global operations.** - A best practice recommendation from our IX research is to first go broad rather than deep. Focus on solving specific problems and showing value in production at one or a few sites, then roll that success out across global operations to leverage investments across departments, sites, business units, and geographies. Connected Worker solutions can enable a diverse set of use cases throughout value chain operations, ranging from R&D to manufacturing to field service. IX leaders tend to have more commonality in IT and OT systems; standardizing on a limited number of Connected Worker solutions will reduce complexity and costs while improving results.

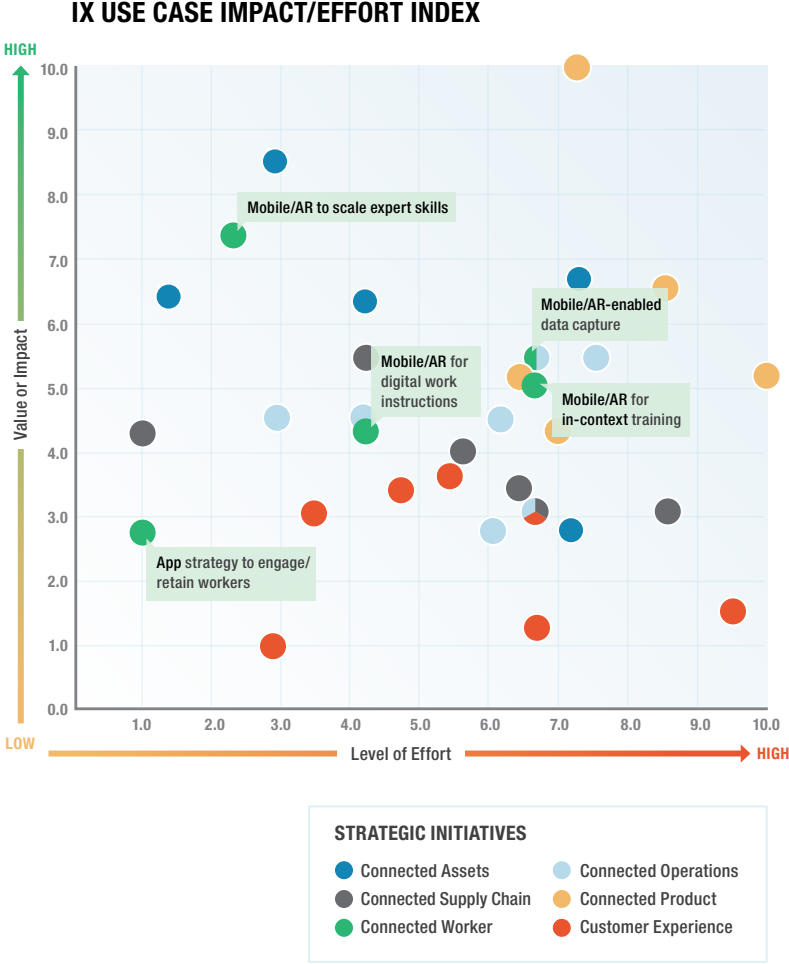# Appendix A

Connected Worker Use Case Selection

Selecting Connected Worker Use Cases

Selecting the right problems to solve is key to the success of IX initiatives. Many organizations struggle to identify which use cases to focus on and at what point along the IX journey. Our research assessed IX use cases based on expected impact on operational performance and resources needed to implement. Along with Connected Asset and Operations use cases, Connected Worker use cases feature prominently as having highly favorable effort-reward ratios. Not surprisingly, the Connected Worker use cases with the highest potential help address the critical workforce demographic and skill gap challenges faced in all industrial sectors:

- Implementing an application strategy to improve worker engagement/retention

- Scale rare/expert skills with mobile/AR technology (remote expert access)

- In-con¬text training mobile/AR technology (micro-training)

- Digital work instructions with mobile/AR technology

- Data capture enabled by mobile/AR technology

A key observation is that these high potential Connected Worker use cases are enabled by mobile and AR technology. This is not surprising given the significant cross-industry adoption rates of these technologies. It should also be noted that since Connected Worker use cases tend to be cross-functional, many of the use cases classified as Connected Assets or Operations could be enabled by Connected Worker technologies as well, e.g., asset maintenance, field service, etc.

The approach used to select Connected Worker use cases for implementation will vary by organization and depend on the status and capabilities of the IX initiative overall. Many organizations have met with success by initially focusing on relatively low effort, quick-win projects that solve a well-defined, important business problem. Candidate use cases should be quantitatively assessed by their impact, resources required, and cultural readiness.

IX USE CASE IMPACT/EFFORT INDEX

STRATEGIC INITIATIVES

- Connected Assets
- Connected Supply Chain
- Connected Worker
- Connected Operations
- Connected Product
- Customer Experience

PAGE
37

ENABLE OPERATIONAL AGILITY WITH A
DIGITALLY CONNECTED WORKFORCE

TABLE OF
CONTENTS

SECTION

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

View Research ➜

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

View Research ➜

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.)*

PAGE
38

ENABLE OPERATIONAL AGILITY WITH A
DIGITALLY CONNECTED WORKFORCE

TABLE OF
CONTENTS

SECTION

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

View Research ➜

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

View Research ➜

ENVIRONMENT, HEALTH, AND SAFETY

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

Watch Webcast ➜

RESEARCH | Unify EHS and Quality: Capture Synergies and Turn Policy into Action

View Research ➜

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

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