LNS
Research

Leverage Tech Like a Pro: Lessons from Industrial Transformation Leaders

# Executive Summary

The data is clear. More and more companies are engaging in Industrial Transformation (IX) and a select few are finding very real benefit in the form of increased revenues, lowered Cost of Goods Sold (COGS), and increased operating margins. People, Process, and Technology all must be aligned to deliver transformation success. This Research Spotlight builds on earlier Spotlights covering **people** and **process** to focus on key technology trends and best practices in Industrial Transformation (IX).

The select few Industrial Transformation Leaders (IX Leaders) are realizing significant benefits from their IX programs, while most programs have not yet delivered any value. IX Leaders are:

- Delivering significant improvement in key operational metrics, including improving Overall Equipment Effectiveness (OEE) by 20%, New Product Introduction (NPI) by 17%, and reducing defects per million by 67% on average.

- Realizing dramatic improvements to the financial performance of the company as they are 72% more likely to have grown revenues by more than 10%, and 57% more likely to have reduced Cost of Goods Sold (COGS) by more than 10% because of their IX program.
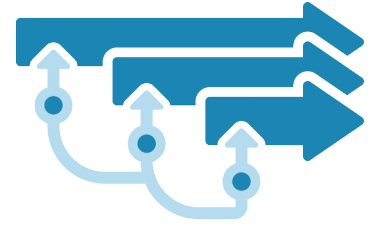
INDUSTRIAL TRANSFORMATION (IX) IS A PROACTIVE
and coordinated approach to leverage digital technologies to create step-change improvement in industrial operations. Industrial Transformation is a critical and often the largest subset of a Digital Transformation program that includes initiatives outside of the industrial space, such as redefining customer relationships.

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INDUSTRIAL TRANSFORMATION FRAMEWORK

Success is partially tied to deploying technology more effectively. IX Leaders are:

- Deploying 150% more digital technologies than their peers

- TWICE as likely to have implemented an Operational Data Hub

- 83% more likely to be focusing on data infrastructure as a core enabler to their program

- FIVE times more likely to have implemented an operational data model when compared to Followers

- 41% more likely to have focused on business, and 60% less likely to have made "evaluating/testing…technologies" a core strategy of their program

The survey data clearly shows that Industrial Transformation is working and that technology best practices are among the keys to that success.

This Research Spotlight derives findings from LNS Research-conducted global surveys and our experiences advising manufacturers to specifically cover:

- The definition of, and benefits from, IX

- Key technology trends across IX

- Seven IX Best Practices across technology

- Recommendations for industrials

IX Leaders are
5X
more likely than Followers to have implemented an operational data model.

Defining Industrial Transformation and IX Leaders

Industrial Transformation (IX) is the proactive and coordinated approach in leveraging digital technologies to create **step change** improvement across the value chain. IX has become a very real phenomena across industrial operations with more than two-thirds of companies committed to an Industrial Transformation program. But only a small percentage of companies are realizing any value from IX – the Industrial Transformation Leaders (IX Leaders). Global survey data powerfully demonstrates that IX is delivering for manufacturers and ROI is being realized widely across IX Leaders. In fact, 80%+ of IX Leaders were able to reduce COGS and/or improve operating margins and/or grow revenues by at least 3% because of their IX program.

| IX Leaders are		more likely to			by		as a result of their IX program
	72%		Increase	Revenue		10%	
	57%		Reduce	COGS		10%	
	43%		Increase	Operating Margin		5%	

FIGURE 1 - Likelihood of Positive Results Among Industrial Transformation Leaders

Let's drill into how IX Leaders are differentiating themselves in deploying IX technology and the core technology trends across transformation.

Technology of IX Leaders

We would like to detail the specific technologies that IX Leaders are using. But we can't meaningfully as they vary significantly by industry, manufacturing model, and level of automation (reach out to the LNS Research team if you would like to receive industry-specific data). For example, Remote Operations Centers and/or Asset Performance Management systems are valuable to asset-intensive industries but significantly less so to material-intensive industries. Digital Twins of products are almost exclusively valuable to discrete manufacturers.

What we can do is highlight three technology trends core to success in IX and seven best practices.

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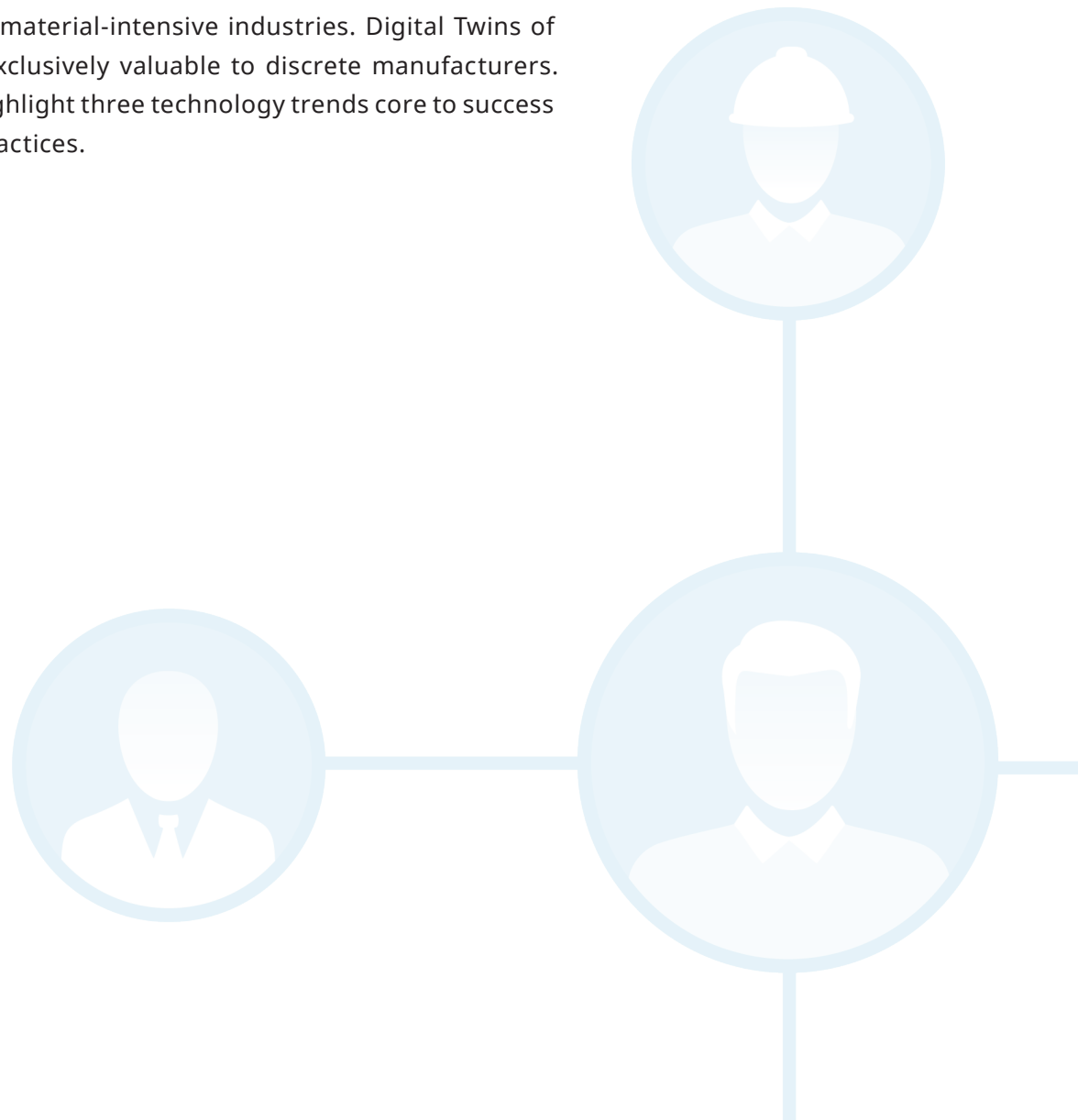
[1] This Research Spotlight builds on more general reports on IX Readiness published in **April** and **August 2021.** Additionally, LNS Research has related reports on **People,** the **Transformation Chasm,** and the **Transformation Pivot** in our library. All five reports derive findings from a LNS Research conducted global survey in the winter of 2021 and our experiences advising manufacturers. Demographics of the survey can be found in the Appendix.

An Emerging Transformation Architecture

We all know that data is at the heart of Industrial Transformation (IX). The twist and the driver for new emerging technologies is the breadth of data being leveraged. Manufacturers have historically relied primarily on structured enterprise data (typically captured in a SQL database.) ERP, Supply Chain, and Quality systems all manage and store their data in a structured format. The emerging challenge is to merge that IT data with OT data from operations. IX Leaders are more than TWICE as likely to implement that convergence. What makes this a challenge is that much of the OT data is not highly structured. Many manufacturers also have semi-structured data in the form of time series data from their data historian(s). And increasingly unstructured data from social media or vision systems are critical to operational improvement. The focus of leading transformation programs is to bring all that data together to provide a more comprehensive view of operations.

Has your company created a common data model or data architecture for IT & OT Data?

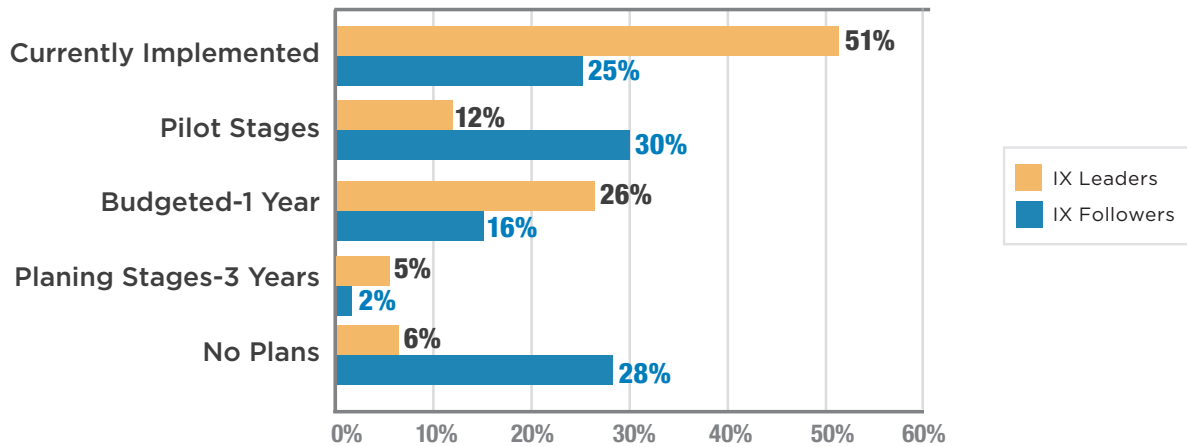| Category	IX Leaders	IX Followers
Currently Implemented	51%	25%
Pilot Stages	12%	30%
Budgeted-1 Year	26%	16%
Planing Stages-3 Years	5%	2%
No Plans	6%	28%

FIGURE 2 - Creation of Common Data Model or Data architecture for IT and OT Data

The challenge with unstructured data is that it starts off like that drawer in the kitchen where you put all the things you don't know what to do with and it ends up as a large, off-site self-storage unit. Unstructured data is incredibly easy to store, and equally difficult to retrieve and use in any meaningful way. Unlike the classic suburban household with a storage unit, large corporations have large amounts of data that could (and likely should) be stored but it is not. The problem is not that the data is not valuable; the problem is that it is unlikely to be usable unless context is added to the data. For the industrial data hub, context and structure are synonymous.

While it is possible to add structure to data stored in unstructured data stores, the "modern" unstructured tools themselves lack the ability to do so. Modern NoSQL data stores pride themselves on being unstructured and promote the idea of schema on read. While OT data is not always structured, it is important to use the knowledge about the data to add structure early in the data retention process. This does not mean that all the data must be structured but it means that enough structure and context must be added to the data to make it usable for a client and other systems. Some examples:

- Time series data should be stored with the context of the tag (sensor or other source) and time. The tag can be placed in the context of an equipment model or production analysis. The tag should also be given other context such as measurement unit and quantity kind. The equipment model should be decorated with type and capability information. The way the time series data is retrieved should be standardized so that the user does not have to understand how the data is stored in order to retrieve it. This does, however, not mean that all the time series data from one machine shall be stored in the same table with a structure that matches the machine type.

- An operator logbook may be stored as clear text that can be searched but is not inherently understandable by a machine. The log entry should be stored in the context of the person writing it, the time when it was created, and the location, physical assets, and production run that the entry relates to. Further analysis can be done using Natural Language Processing (NLP) if this is desired.

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>
> **- Tom Comstock**
> *Research Fellow*

- A truck with bulk materials may carry a document that describes the content of its tanks. If you are lucky, this document is in a machine-readable format such as JavaScript Object Notation (JSON) or Extensible Markup Language (XML). Some of the data may be known to the receiving plant, such as the name of the materials in the tank and the license plate of the truck, whereas other information does not have a home. In this case, the known context should be stored in a structured way, whereas the unknown data can be stored close to its raw format, such as a JSON document or a picture of the scanned bill of lading. This makes it possible to find the unstructured data when it is needed to verify or extend the structure data.

- A video feed showing the state of the receiving yard is unstructured data, but the information about the camera and what it is looking at belongs to the asset structure of the plant. Similarly, image processing can extract features from that video that can provide additional data that can provide both context (such as the license plate of the truck) and measurements (such as the wait time in the yard).

It is a common misconception that new database technologies must be used to effectively store unstructured data. The reality is that most major database systems already support structured, semi-structured, and unstructured data. The major database systems from Oracle, Microsoft SQL Server, PostgreSQL, and MySQL all support JSON, XML, and Binary Large Objects (BLOB); some support it better than others. Many of them also support large-scale, full-text-search, which makes it possible to search for the things when you don't "understand the structure" or have misplaced an item. Therefore, the best solution is rarely to rip-and-replace the existing data-hub architecture, or to bolt on a NoSQL database on the side, but more likely to extend the existing data store with the unstructured features that are needed. Some high-density data sources, such as video streams and time-series-sensor data, may require their own stores but we are even seeing convergence in these areas.

Lack of structure and context is the major reason that some companies describe their data lake as a data swamp. They can get the data in, but they cannot get the data out.

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LNS Research captured and documented the **LNS Research Industrial Transformation (IX) Reference Architecture** for effectively leveraging the value of structured, unstructured and semi-structured data. This **Reference Architecture** pictured in Figure 3 highlights the key role data has in transformation. The focus of the Reference Architecture is the gathering, ingesting, moving, contextualizing, aggregating, evaluating, and leveraging of data to create actionable insights to drive better decisions. Further, the Reference Architecture envisions the need for tools to build workflows around the data and data governance processes.

LNS Research sees six main buckets of capabilities that are critical in enabling manufacturers to capture the true value of new digital technologies and transform their industrial operations. Fundamental to the IX Reference Architecture is an operational data model. LNS Research has found 66% of transformation Leaders have implemented a common data model across IT and OT. Leaders are FIVE times more likely to have implemented an operational data model when compared to Followers.

> IX Leaders are
> **5X**
> more likely to have implemented an operational data model when compared to Followers.

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
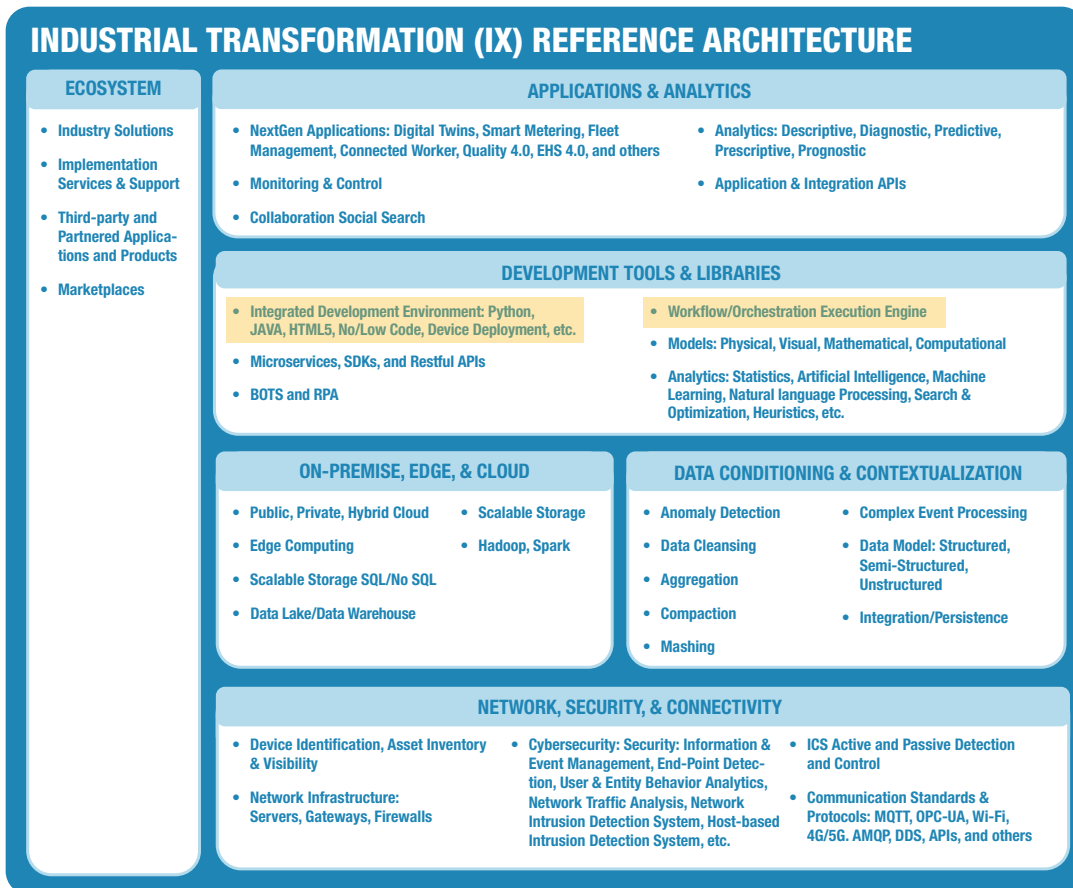
FIGURE 3 - LNS Research IX Reference Architecture

From Data Lakes to Operational Data Hubs

The emerging solution to instantiate this architecture is a data hub approach. **LNS Research had detailed data hubs before.** This emerging concept involves connecting multiple data sources across the plant and enterprise to a central hub after several layers of DataOps processes to ensure data quality and context. This data hub approach enables companies to maintain a single source of the truth across IT and OT data, avoid custom integrations, and overcome several other existing challenges in traditional data management. IX Leaders are more than TWICE as likely to be using data lakes as a core integration mechanism (in addition to application-to-application integration that often mimics the ISA-95 model) compared to Followers.

Current Integration Methods

Direct application-to-application integration: IX Leaders 64%, IX Followers 56%
Using a data lake to enable bidirectional data flow, supported by a data contextualization layer: IX Leaders 57%, IX Followers 27%
Using APIs and Microservices: IX Leaders 32%, IX Followers 7%
Manual integration: IX Leaders 19%, IX Followers 34%
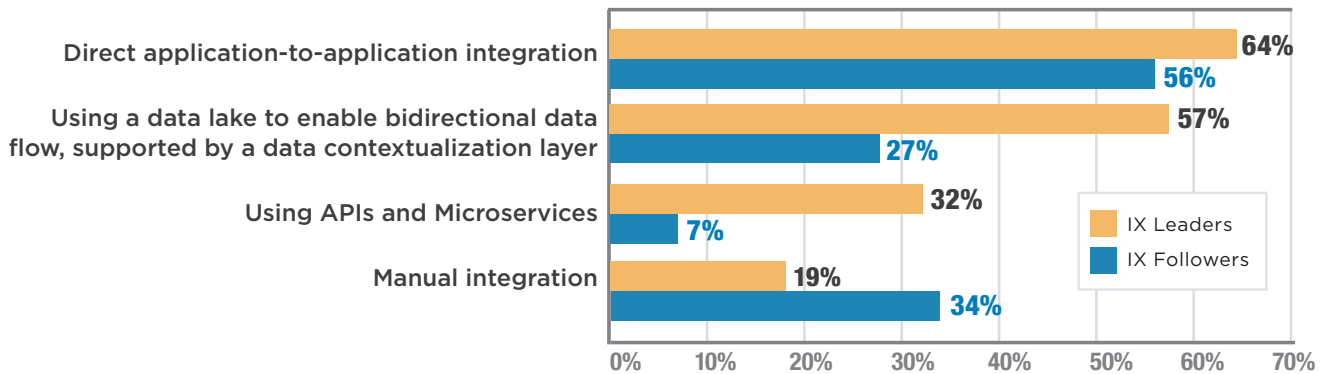
FIGURE 4 - Integration Methods

The data hub is both a concept and, increasingly, an actual physical instance. All in all, Leaders are almost THREE TIMES more likely to be managing their operational data through a data lake, data hub, or other storage repository system than Followers.

In fact, the data hub concept is leading to a bifurcation of the IX Reference Architecture in implementations and vendor strategies. Increasingly more IX savvy manufacturers are segmenting analytics from the data infrastructure. In that way, incremental, specialized analytics packages can be readily added to the IX tech stack. This reduces the costs and time associated with adding specialized analytics capabilities.

Vendors are also increasingly segmenting themselves into infrastructure and analytics but confusion still reigns around the development environment as both sets of vendors are offering those environments. The Industrial Transformation Reference Architecture in Figure 3 shows the battle lines as Advanced Industrial Analytics, IX Infrastructure, and IX Platform vendors are all offering IDEs and "platforms" that overlap confusingly with each other. LNS Research fully expects to see vendors more consciously align to our data hub architecture as more and more manufacturers are implementing the bifurcated architecture.

Leaders are almost 3X more likely to be managing their operational data through a data lake, data hub, or other storage repository system than Followers.

The diagram also conveys another subtle trend. IX Leaders are creating operational-specific data hubs/lakes. Progressively more companies are finding that enterprise-level data lakes, with all the information from across the corporation, are too cumbersome to be valuable. Nor are function-specific (quality, manufacturing, procurement) strategies broad enough to yield meaningful incremental insights. There are no absolute answers yet on the precise level of focus, but data hubs that are focused across manufacturing, the supply chain, quality, and design consistently achieve the right balance for impact.
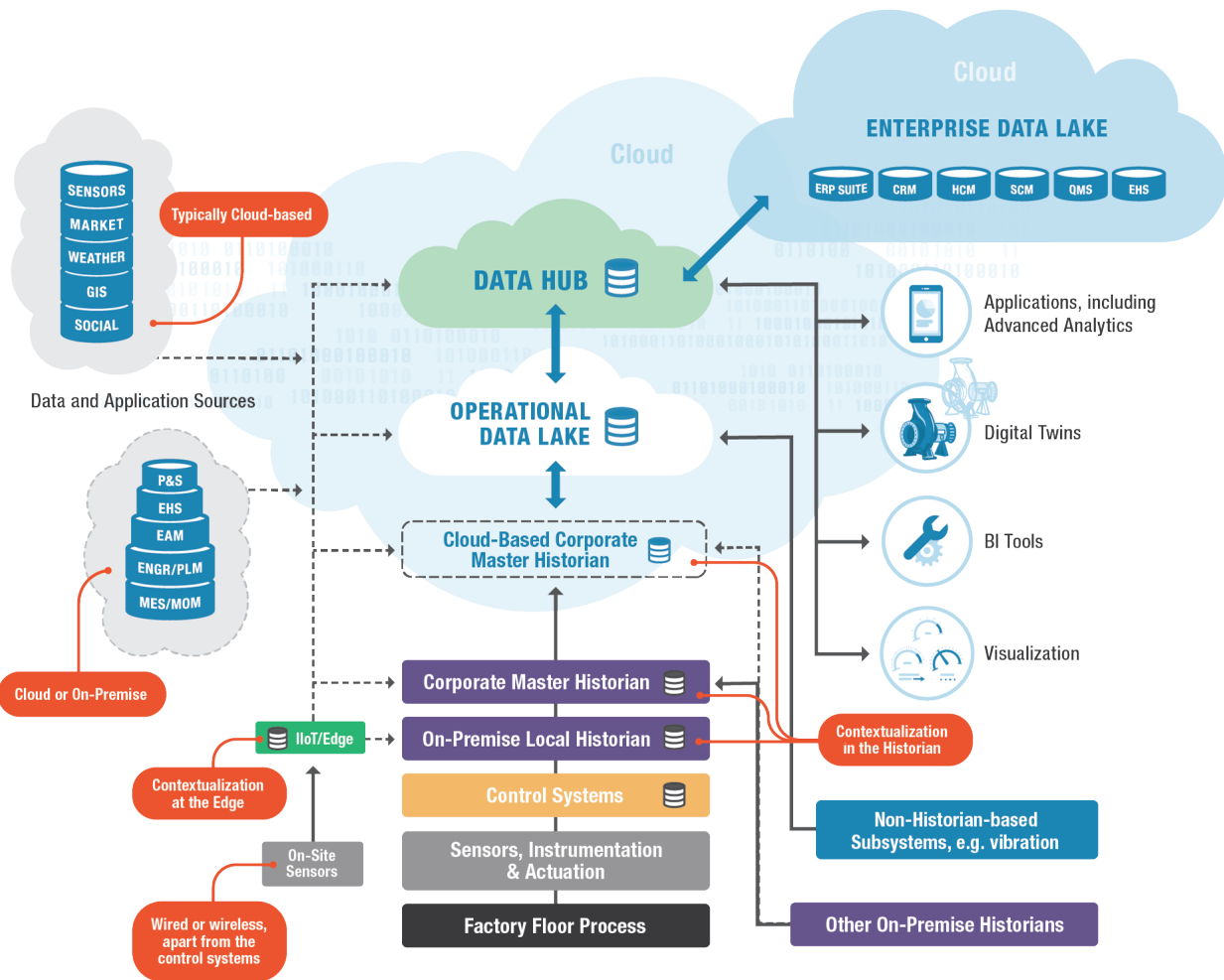
FIGURE 5 - Data Lake

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[2] Given employee retention challenges manufacturers face, "incremental" insights may be a higher bar than necessary. Many organizations are attempting to use systems to replace the deep operational knowledge of experienced workers that are no longer part of the organization rather than gain further insights. Retaining what they have is increasingly the focus rather than expanding their insights.

Analytics is the Goal but not the Focus of the Work

The data hub conceptualization separates the data management and operations from analytics. LNS Research has consistently found a differentiated focus between IX Leaders and Followers. IX Followers tend to only focus on the analytics and not on the data infrastructure required for analytical impact, leaving their programs behind. One critical point to remember is that it will be very hard to perform effective analytics on the data if the data is missing context and structure.

Followers are failing to invest in the data infrastructure that ensures the right data is available to the right personnel at the right time, in the right format and in the right context. In fact, IX Leaders are doing the hard work of data management across any number of dimensions.
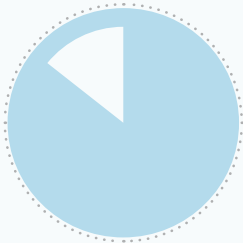
83%
More Likely

Why aren't companies investing in their data infrastructure?

It seems obvious enough. To make data the "new oil," one must be able to get to it, transport it to where it's needed, put it into context, and package it for effective consumption. The problem is there is no direct payback for that work. "Data plumbing" does not provide value, only the insights that come from that plumbing. In fact, business value is derived only from the actions taken from those insights.

At some point, Industrial Transformation (IX) programs must focus on the data infrastructure. LNS Research believes there is a crucial Pivot required to deliver real and sustainable business benefit. IX Leaders are 83% more likely than Followers to be investing in "infrastructure (data acquisition, cleansing, contextualization, etc.) without direct and immediate payback."

Seven Technology Best Practices

LNS Research has identified seven "clusters" of best practices in Industrial Transformation. We use the phrase "clusters" to reflect the fact that each best practice has a People, Process, and Technology dimension to it. Let's define the "7 Best Practices in Industrial Transformation" and the drill into the Technology dimension of each (previous research drilled into the **People** and **Process** dimensions).

1. The Power of More™

The single most powerful finding of all the LNS Research work on IX programs is that Leaders are doing more in every direction. IX Leaders are:

- executing a more expansive functional scope and strategy

- encompassing greater breadth on their IX program teams

- reaching out to both customers and suppliers

- getting data from more sources and making it available to more roles across the corporation

- jointly funding more initiatives/solutions

This trend most definitely continues in technology. IX Leaders are deploying 170% more technologies when compared to Followers. We asked industrials about their engagement with 25+ different emerging and IX technologies and found only 30-40% of the IX Leaders were engaged in any specific

What Emerging Technologies Has Your Company Implemented Or Planned To Implement?

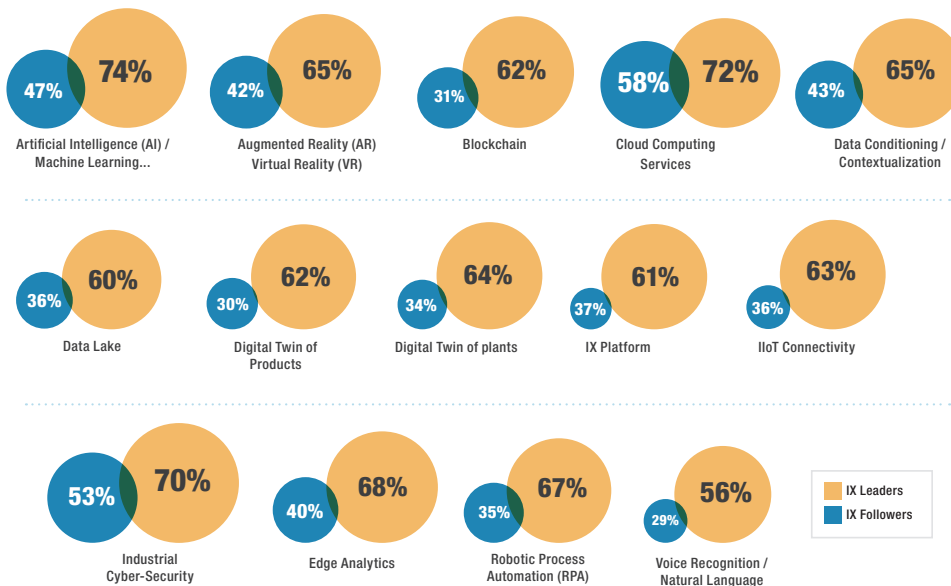| Technology	IX Followers	IX Leaders
Artificial Intelligence (AI) / Machine Learning...	47%	74%
Augmented Reality (AR) Virtual Reality (VR)	42%	65%
Blockchain	31%	62%
Cloud Computing Services	58%	72%
Data Conditioning / Contextualization	43%	65%
Data Lake	36%	60%
Digital Twin of Products	30%	62%
Digital Twin of plants	34%	64%
IX Platform	37%	61%
IIoT Connectivity	36%	63%
Industrial Cyber-Security	53%	70%
Edge Analytics	40%	68%
Robotic Process Automation (RPA)	35%	67%
Voice Recognition / Natural Language	29%	56%

IX Leaders
IX Followers

FIGURE 7 - Implemented or Planned Emerging Technologies

technology but were, on average, 78% more likely to be engaged than Followers. Interestingly, this trend held across bleeding edge technologies like Blockchain and more mundane things like updating OT technology. Leaders were at least TWICE as likely to have already engaged in all of the following: Converging OT and IT; Autonomous vehicles, robots or cobots in production; 3D printing/additive manufacturing; Blockchain; updating IT business systems; and updating operational technology. IX Leaders were deploying five sets of technology to two sets for Followers.

A key indicator of Industrial Transformation (IX) maturity is the capability to pursue multiple technologies simultaneously.

IX Leaders were also more deeply engaging in the technologies they deployed. Very specifically, they developed internal skills around those technologies (which is a sign of the maturity of their program). Leaders were two to three times more likely to have the expertise within the company across ALL the technologies we queried.

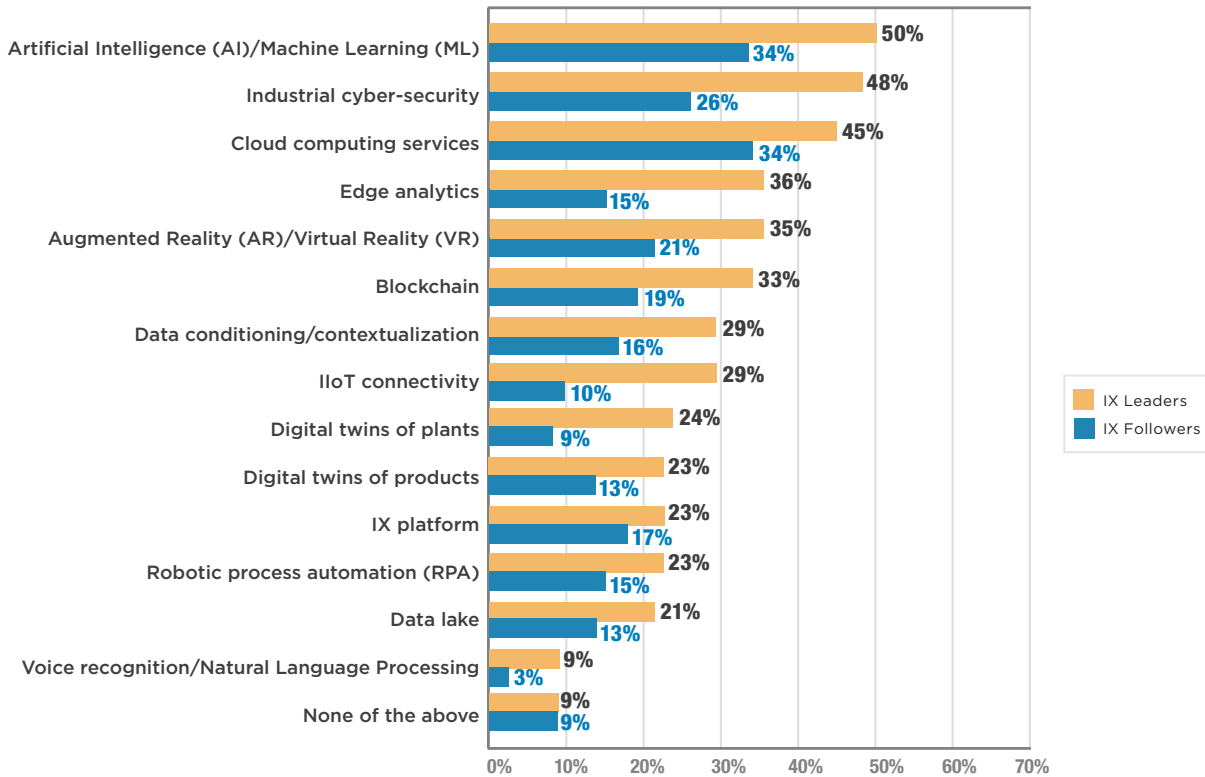## Does your company have expertise in these technologies?

FIGURE 8 - Technology Expertise: Leaders vs. Followers

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[3] Not all technologies were applicable to all industrials, so it is not surprising to find only 30-40% of IX Leaders are implementing any one specific technology. For example, Digital Twins of Plants tends to be deployed in the process and infrastructure industries and Digital Twins of Products typically in discrete industries.

2. Top-Down

IX is a high-profile project across industrial enterprises globally. Industrial Transformation programs require engagement from large swaths of company personnel, rearchitecting of business processes, and convergence of several business functions and existing programs. In other words, transformation is hard and is not for the faint of heart. Therefore, executive engagement is critical to get the program going, funded, and a high profile internally.

One key mechanism to ensure on going executive support for the transformation program is align the program to executives' goals and corporate strategy. Executing the program according to the **LNS Research Transformation Framework** supports an "all in" perspective by aligning the IX program to the corporate strategy.

One of the most common problems we see in IX programs is that companies often start with Solution Selection (wow...technologists want to start by digging into the technology; who would have thought it?). Focusing too early on solution selection leads to a "technology push" rather than "pull" and puts the program at risk of diverting from corporate priorities.

In addition, LNS Research regularly sees significant disconnects between the technologists and the business. We often see IX programs focused on reducing costs when growing revenues is the strategic imperative. Few IX programs have reoriented yet to address the Manufacturing Labor Crisis that animates so many manufacturing executives. Plant management is often looking for core analytics (OEE) and the IX program is focused on more esoteric forms of analytics, like machine learning and artificial intelligence.
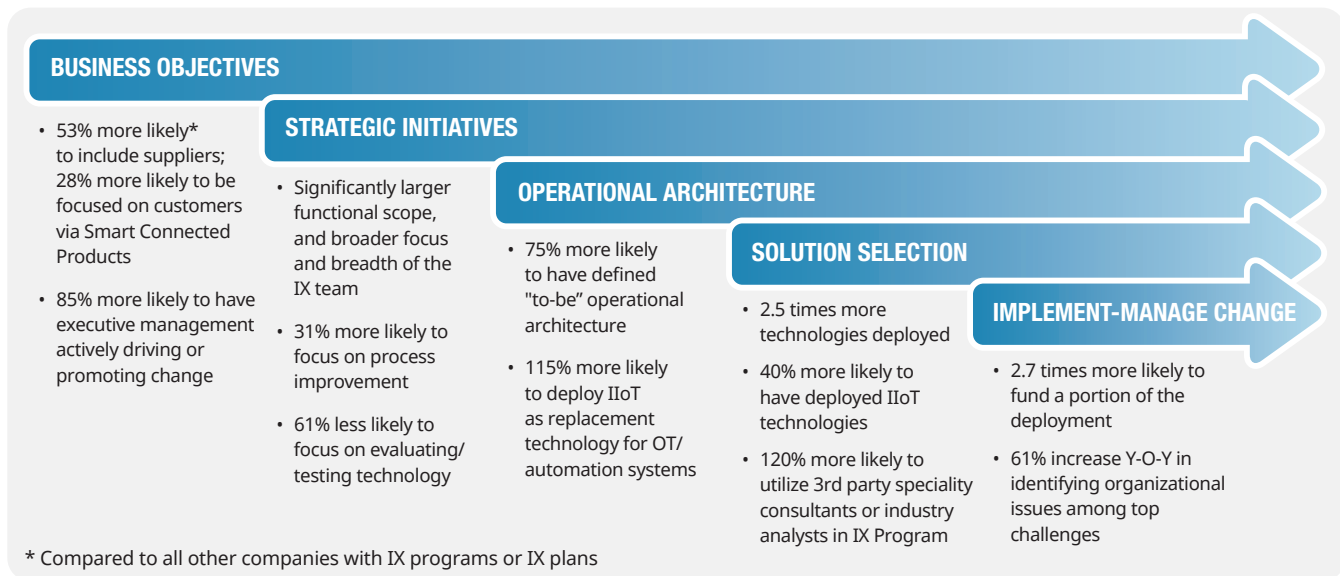

BUSINESS OBJECTIVES

- 53% more likely* to include suppliers; 28% more likely to be focused on customers via Smart Connected Products
- 85% more likely to have executive management actively driving or promoting change

STRATEGIC INITIATIVES

- Significantly larger functional scope, and broader focus and breadth of the IX team
- 31% more likely to focus on process improvement
- 61% less likely to focus on evaluating/testing technology

OPERATIONAL ARCHITECTURE

- 75% more likely to have defined "to-be" operational architecture
- 115% more likely to deploy IIoT as replacement technology for OT/automation systems

SOLUTION SELECTION

- 2.5 times more technologies deployed
- 40% more likely to have deployed IIoT technologies
- 120% more likely to utilize 3rd party speciality consultants or industry analysts in IX Program

IMPLEMENT-MANAGE CHANGE

- 2.7 times more likely to fund a portion of the deployment
- 61% increase Y-O-Y in identifying organizational issues among top challenges

* Compared to all other companies with IX programs or IX plans

FIGURE 8 - LNS Research's IX Framework

3. Morph to Bottom-Up (Engage Business/Operations)

Top-Down commitment is necessary but not sufficient for success. Subject matter expertise from the plants, plant management, and specialized contractors is highly correlated to success. Further, given that 60% of corporations are requiring plants to individually fund the roll out of IX solutions, engagement early and often is critical to successfully scaling IX over time. The program must morph from Top-Down to also be Plant-Out with significant engagement from across business and operations. Remember IX should <u>not</u> be something you are doing TO plant personnel. It should be something you are doing WITH plant personnel.

A core mechanism to ensure engagement is to have a business-led, not technology-led IX program. IX Leaders are 60% less likely to use "evaluating and testing...technologies" as a core strategy in their IX program, and 31% more likely to use business improvement strategies to organize the program. Transformation does not come from technology but from process changes empowered by collaborative technologies. Understanding the power of technology to enable change is important but cannot be the organizing principle of the IX program.

IT-led IX programs seldom are business-led. If you (or your IT team) are asking Manufacturing management to help you gain buy-in for your solutions from the plants, you have likely failed to morph your program to Plant-Out.

> " Understanding the power of **technology to enable change is important** but cannot be the organizing principle of the IX program.
>
> **- Tom Comstock**
> *Research Fellow*

IX Program Strategy Focus

Strategy	IX Leaders	IX Followers
Greatest inefficiencies in operations	52%	41%
Develop opportunities for new competitive advantages	48%	30%
Identify most inefficient business processes to re-architect those first	43%	38%
Fix existing holes in IT and OT architecture	39%	38%
Seek new ways to deliver value to customers	29%	30%
Evaluate/test IIoT and other technologies (i.e., APM, AR/VR, etc.)	25%	40%
Address shifting market demographics & economics	16%	6%

4. Bring along the whole manufacturing network

Even the most advanced companies have a range of maturity across their manufacturing plants from technically advanced to still paper-based. It is easy for IX programs to focus on the most advanced plants with their supportive and technically inclined management. It is common to see IX programs chase the diminishing returns in making the best plants even better. This is one of the core reasons that a **Lighthouse implementation strategy typically stalls.**

Industrial Transformation Leaders know that they must seek to improve operations in all high value operations (those that are contributing the most to profits or losses) independent of their technical capability today. IX Leaders phase use cases strategically. They leverage early successes with the "technologically willing" to engage the rest of the organization.

IX programs must eventually address the bulk of the plants which are often significantly less automated and often have disjointed IT and OT systems. LNS Research has found two important insights about "legacy" systems:

1. IX Leaders are starting from a notably stronger position with their IT, OT, and Design systems.

2. And yet, they are more likely to be upgrading/rearchitecting those systems.

IX Leaders are more than TWICE as likely to be updating/rearchitecting both Information Technology, like ERP systems, and Operational Technology, like automation and MES/MOM. Leaders were 40% more likely to be upgrading/rearchitecting design systems. It may be counterintuitive, but long-term IX success is just as dependent on legacy as digital technologies.

A focus on data does not mean an exclusive focus on software:

It is not uncommon for us to hear that IX programs are exclusively focused on software, especially those led by the IT organizations and/or those focused primarily on Lighthouse plants. Focusing exclusively on software misses the fact that less than **43%** of machines/assets on plant floors on average are digitally connected today. As we like to say, it is hard to apply artificial intelligence to paper.

In addition, vision systems are having a notable impact as they generate another data stream (typically unstructured). Oil and Gas companies are effectively using vision systems to monitor refinery plumes. Food and Beverage and other manufacturers are deploying vision systems for quality checks to great benefit. IX Leaders are **160%** more likely to be deploying vision systems.

5. IT-OT Convergence

IT-OT Convergence is all over the automation and IT media. It means everything from replacing closed, proprietary process control systems with new software running on standardized computers to an integrated team organizationally. LNS Research has written about the IT OT convergence extensively.

IX Leaders are converging methodically. IX Leaders have created strategies to link changes in their legacy systems and new digital technologies. LNS Research has found that IX Leaders are THREE TIMES more likely to have formally developed an Operational Architecture for how IT, OT, and IX technologies will work together. Leaders are 60% more likely to have created their Operational Architecture than in 2019. And if they don't have it already, they are working on it as only 3% of IX Leaders put this out of scope of their IX program. Clearly, defining a detailed architectural plan accelerates and empowers IT-OT convergence.

IX Leaders are
3X
have formally developed an Operational Architecture for how IT, OT, and IX technologies will work together.

6. Balance short and long-term

Quick wins are highly critical to getting an IX program off the ground. The challenge is that for long-term success, the program must also tackle data connectivity, transport, and contextualization challenges, which are difficult and have limited direct payoff.

Therefore, LNS Research advocates a blended view of use case prioritization. Quick wins are critical to gain program momentum but may not always build the transformative capabilities needed for step change improvement. Manufacturers need to be thinking about all the hard work behind real transformation instead of focusing exclusively on the low-hanging fruit. More specifically, manufacturers must build a data infrastructure from sensor to data lake, including data connectivity, transport, and contextualization.

In fact, as the program matures and crosses the Transformation Chasm, there is typically an increasing focus on big problems and solutions. The focus on data infrastructure and hubs above is a key but there are others.

How would you characterize your strategy for picking Use Cases/Initiatives to target in your IX Program?
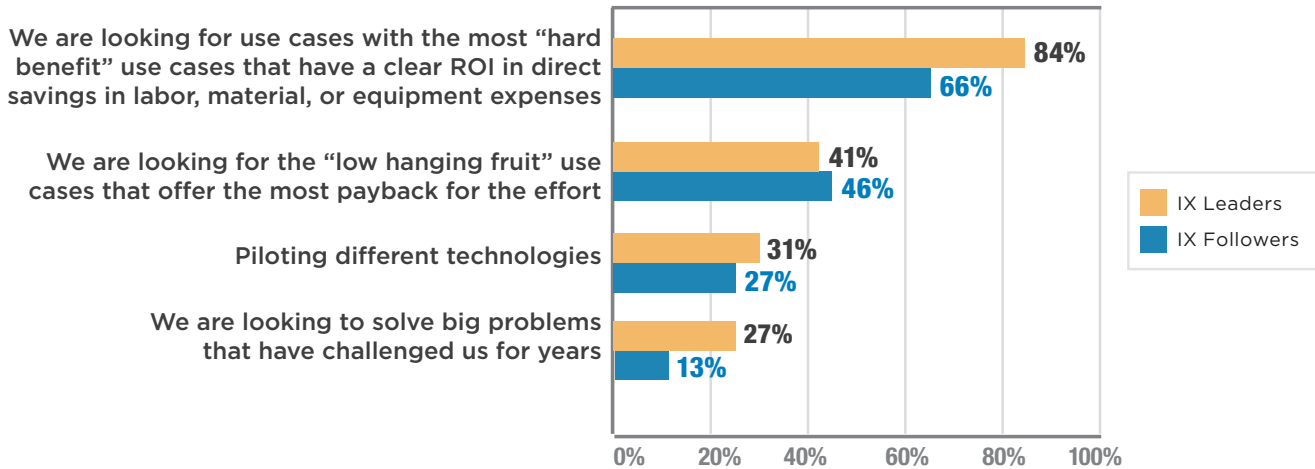
FIGURE 11 - Strategy Characterization of Picking Use Cases/Initiatives

In addition, LNS Research has found that it is critical for industrials to use an architectural and strategic approach to vendor selection. The technology landscape is confusing and messy. Multiple manufacturers are now regularly talking about the overwhelming plethora of Advanced Industrial Analytics vendors that are beating down their doors to offer specialized algorithms for specific optimizations (and often proclaiming them to be the best thing since sliced bread). And manufacturers are not helping themselves. Executing 12 different initiatives simultaneously often leads to engagement with multiple vendors with overlapping capabilities. LNS Research advocates a structured approach:

- Creating an Operational Architecture mapping the "to be" application of IT, OT, and IX technologies

- Consciously selecting an IX architectural approach. **We have written extensively about three alternative architectural paths available**

- Selecting vendors based on the overall corporate and IX strategy and architecture

7.   Data is the currency of IX

Data has been the primary focus of this report. Collecting it, understanding it, delivering it, and making decisions based on it are fundamental to transformation.

Key to transformation success is data democratization. Multiple LNS Research studies have found that giving timely access to operational data throughout the organization is critical:

- **Companies that are "stuck in pilot" in IX are making operational data available only to managers.**

- Followers and stuck companies limit data flow internally only, losing out on intelligence and automated processes that cross company boundaries.

- Leaders are significantly more likely to make the data available to every set of users we queried about. There must be a trend here.

Which roles have access to analyzed information from the plant within the time-frame necessary to make appropriate decisions?
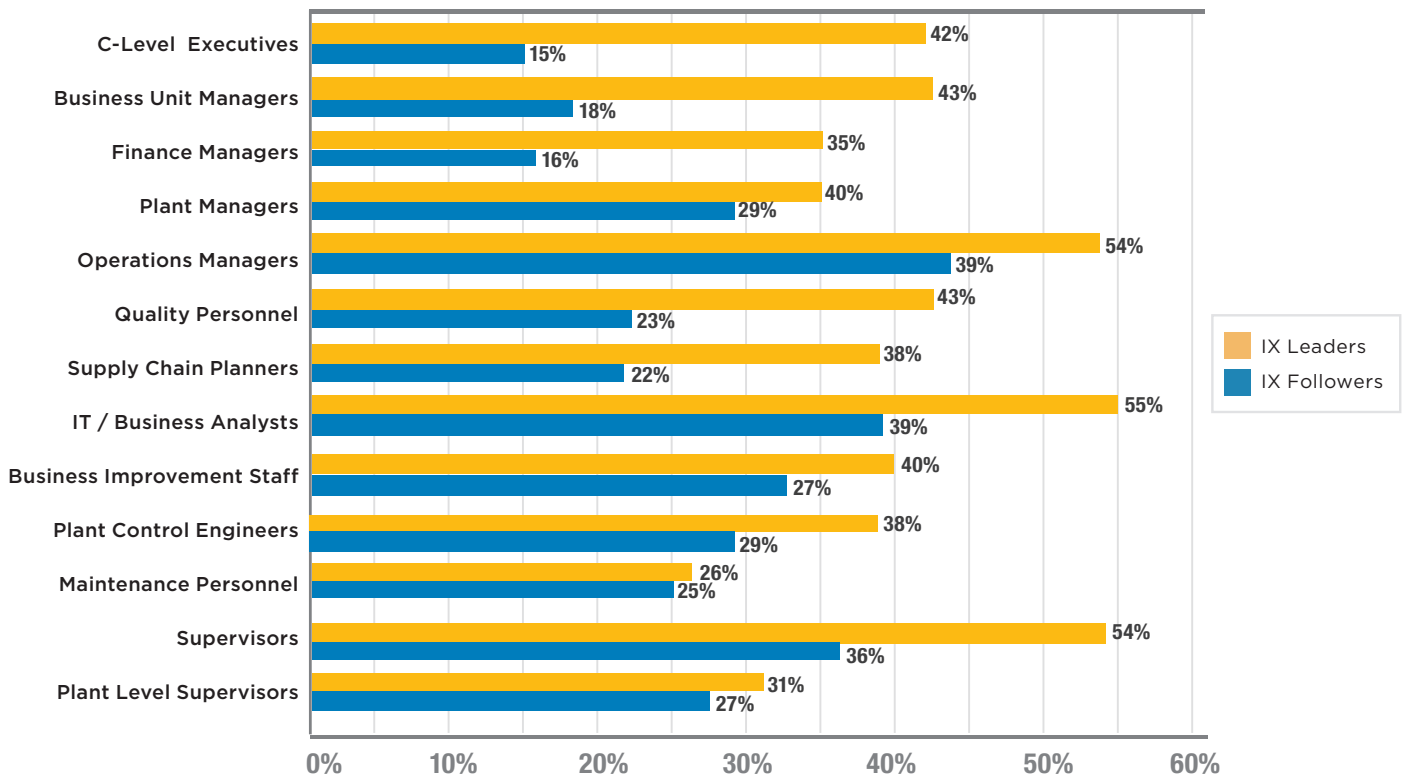
FIGURE 12 - Roles with Access to Analyzed Information from the Plant

One example of the significance of data democratization can be found in the Quality domain. LNS Research has found that giving plant data access to Quality personnel notably improves manufacturing, quality, and New Product Introduction (NPI) metrics. The flip side also improves those metrics: making Quality data available to the rest of the organization by including it in a holistic data model. The bottom line is that those companies that pursued Quality data democratization – that executed both sides of the Quality data equation – had the best performance across all these metrics.

Data Model	Quality Personnel (A) have access to plant data within the time frame to make appropriate decisions		Quality Data (B) included in holistic data model		Quality Personnel (A) and Quality Data (B)	
METRICS	**YES**	**NO**	**YES**	**NO**	**YES**	**NO**
On-time Delivery	85% ▲	84%	90% ▲	81%	90% ▲	84%
Overall Equipment Effectiveness	80% ▲	76%	86% ▲	71%	84% ▲	76%
Successful NPI	73% ▼	75%	82% ▲	70%	82% ▲	75%
Capacity Utilization	80% ▼	81%	84% ▲	78%	85% ▲	81%
First Pass Yield	81% ▲	79%	86% ▲	77%	86% ▲	79%
Defects Per Million Opportunities	4,000 ▼	6,000	4,000 ▼	6,000	2,000 ▼	6,000

* All metrics are median values

FIGURE 13 - Data Democratization

Best Practices and Associated Technology Recommendations

All in all, the chart below describes the best practices we found in the data and engagements with manufacturers with a drill down into the Technology dimension of those best practices.

LNS RESEARCH IX BEST PRACTICE	TECHNOLOGY
The Power of More™	Engage in a wide array of technologies supporting multiple use cases
Top Down	Execute per the LNS IX Transformation Framework™ (Business and Use Cases prioritized by Corporate Strategy)
Morph to Bottom-Up	Business not technology led programs
Balance short & long-term	Balance quick wins with a focus on data infrastructure. Use an architecture and strategic approach to vendor selection
Bring along the manufacturing network	Upgrading/extending legacy OT, IT, and Design Systems can be most powerful transformative opportunity
IT/OT Integration	Develop an Operational Architecture
Data is the currency of IX	Democratize data: build an operational data lake by capturing data from a wide array of sources (inside and outside the company) Provide data via advance industrial analytics widely across and outside the company

FIGURE 14 - Best Practices via Technology

Recommendations: The Time Is Now

The research is compelling. Companies all over the globe are seeking to go beyond Continuous Improvement to find step change improvements in business. While the numbers are small so far, many industrials are finding those step change improvements in the form of incremental revenue opportunities and cost savings. Industrial Transformation (IX) is working.

For manufacturers to succeed in IX, they need to learn from the early adopters and transformation leaders. IX is no longer a mystery that requires process innovation. Best practices are clearly emergent. Here we covered Technology and have previously covered Process and People. IX increasingly requires the application of identified best practices to your specific environment and culture.

IX also requires a "real commitment." LNS Research has found that 84% of companies are increasing or maintaining their investments in IX in the face the economic uncertainties painfully surfacing globally. **LNS Research is on record** as noting this could be a watershed moment for corporations as IX is becoming a core mechanism of competitive differentiation and IX Leaders are delivering significantly better financial results.

At LNS Research, we are on a mission to empower industry leaders to transform their organizations. We are driving industrial organizations to be agile, autonomous, and sustainable. Expect LNS Research to expand our research on the activities of enterprises globally. Stay tuned.

IX NOW SIMPLY REQUIRES
the application of identified
best practices to your specific
**ENVIRONMENT &
CULTURE.**

Appendix: Demographics

The 2021 edition of the IX Readiness survey was taken by more than 300 business and IT decision-makers, including managers, directors, VPs, C-suite executives across several functions in manufacturing companies. We sought responses from across the discrete, batch, process, and infrastructure industries. Half of the companies were from Europe and the other half were from North America and the Asia/Pacific regions. We translated the survey to French, German, and Simplified Chinese to accommodate survey takers from Europe and Asia. The survey includes more than a hundred questions on a company's IX program's objectives and challenges, budget, scope, key metrics, organizational culture, and technology resources.

Other surveys (2018/2019 IX Readiness, 2020 Analytics that Matter, etc.) used for comparison purposes had generally similar demographics with some having slightly higher North American participation.
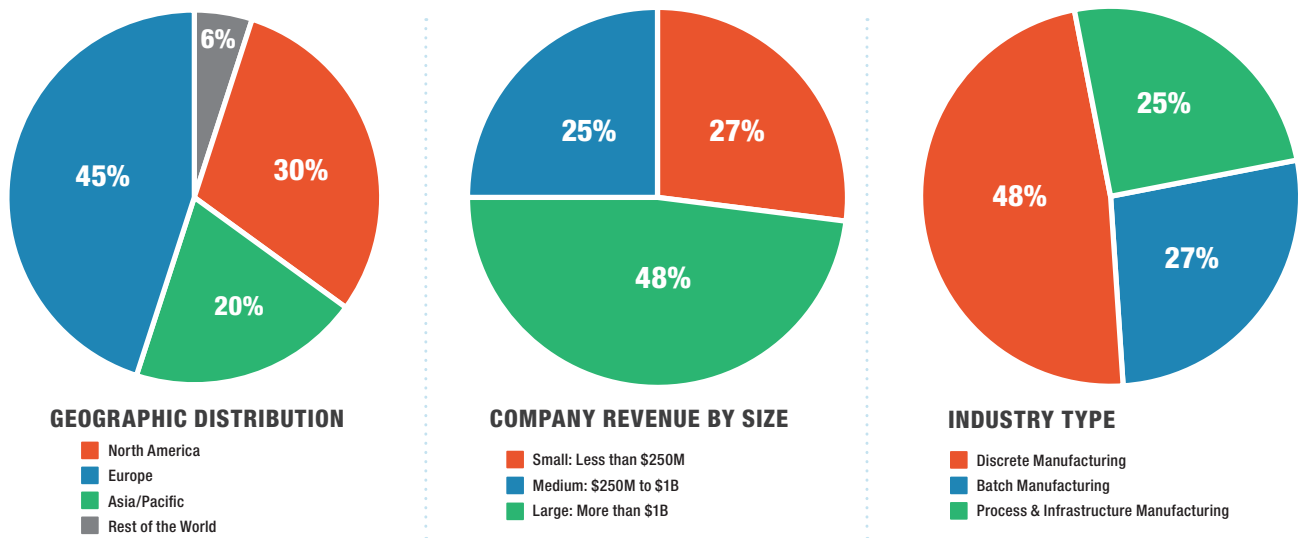

GEOGRAPHIC DISTRIBUTION
- North America
- Europe
- Asia/Pacific
- Rest of the World

COMPANY REVENUE BY SIZE
- Small: Less than $250M
- Medium: $250M to $1B
- Large: More than $1B

INDUSTRY TYPE
- Discrete Manufacturing
- Batch Manufacturing
- Process & Infrastructure Manufacturing

FIGURE 15 - Survey Demographics

RELATED RESEARCH ON INDUSTRIAL TRANSFORMATION (IX)

RESEARCH | Pivot to Value for Industrial Transformation Success ➜

RESEARCH | Advanced Industrial Analytics: Four Proven Strategies to Scale Transformation During Uncertain Times ➜

RESEARCH | People in Industrial Transformation (IX): Leadership, Culture, and Organizational Best Practices ➜

RESEARCH | Taking Control of Quality Transformation: Strategic & Cultural Imperatives for the Quality Executive ➜

RESEARCH | Next-Generation Sustainability: Risk, Opportunity, and Competitive Advantage ➜

RESEARCH | Connected Workforce: Enable a Competent, Agile Industrial Workforce ➜

RESEARCH | Driving Continuous Improvement Through Digital Lean Tools ➜

RESEARCH | Digital Continuous Improvement in an IX World ➜

EBOOK | Enable Operational Agility with a Digitally Connected Workforce ➜

BLOG | Introducing the Industrial Transformation (IX) Reference Architecture ➜

BLOG | Understanding Industrial Transformation: Definition and Framework for Success ➜

RESEARCH | Industrial Transformation: Architecture and Analytics Just the Beginning ➜

RESEARCH | IX Architectural Paths 1 of 3: Three Paths & Understanding IX Infrastructure ➜

RESEARCH | IX Architectural Paths 2 of 3: Evaluating IX Platforms and IX Applications & Analytics ➜

RESEARCH | IX Architectural Paths 3 of 3: Looking at IX Strategic Partners ➜

RESEARCH | Industrial Transformation Success: How to Secure Operations' Buy in to Create Effective Leadership ➜

RESEARCH | IX Digital Readiness ➜

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