QUALITY 4.0: THE QUALITY INNOVATION FOUNDRY

Use Cases Continue to Emerge as Market Matures

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Section 1

Executive Summary and Demographics

Industrials Ask: What are Use Case Priorities as Quality 4.0 Becomes Mainstream?

It's been several years since the early wave of innovators began investing in digital technologies to improve operations generally and quality specifically. The ranks of digital, IT, operations, product development, and quality leaders focusing their digital energies and resources on quality improvement is growing quickly. Today's most common questions are:

1. Descriptive (similar to metrics)
2. Diagnostic

To answer these questions, LNS Research conducted a global survey in February 2019 around the use cases associated with Quality 4.0. We found that 55% of companies have implemented, are currently implementing, or plan to implement a Quality 4.0 initiative(s) within their Industrial Transformation (IX) program. This report provides details on the exact status of Quality 4.0 and puts Quality 4.0 initiatives in the context of the larger, overarching Industrial Transformation programs more generally.

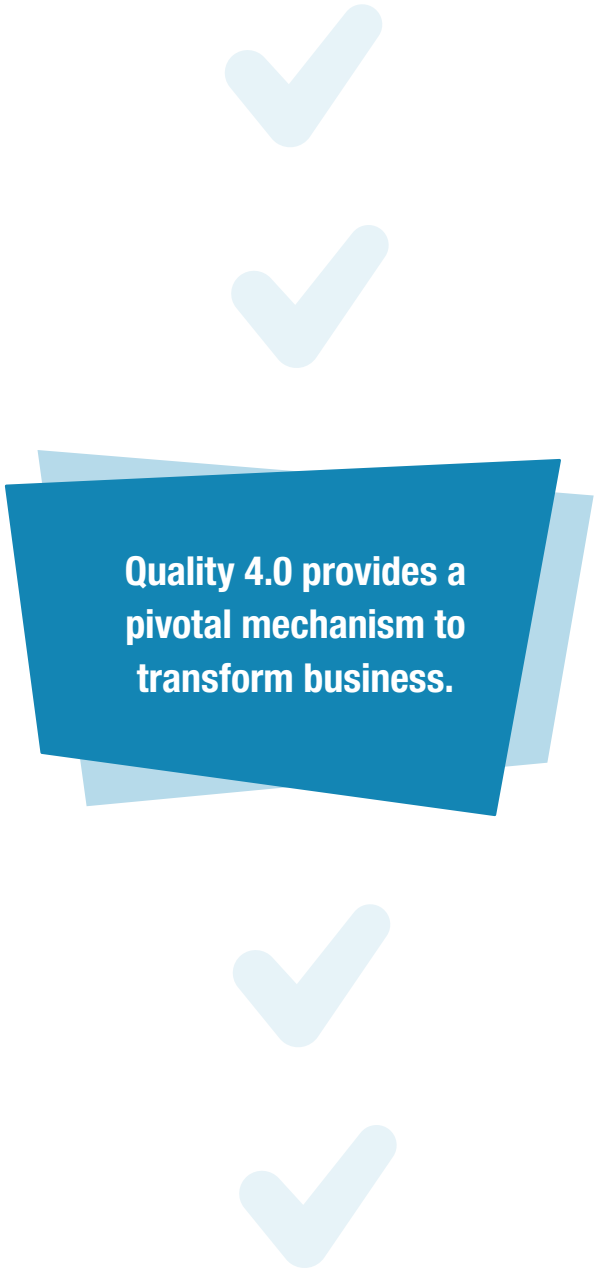
In our analysis, we evaluated the state of IX and Quality 4.0 in the real-world and then drilled into the specific use cases that are making a positive contribution to industrials' top and/or bottom lines. LNS Research has classified 33 Quality 4.0 use cases that the market is adopting and against which vendors are developing new technology offerings. Our analysis categorizes and defines these use cases, and provides findings on the level of industrial deployment, impact, and effort. We also examine the big picture to highlight the transformational potential of Quality 4.0.

Industrials Ask: What are Use Case Priorities as Quality 4.0 Becomes Mainstream? *(Cont.)*

The survey results are clear: Quality 4.0 pioneers are having a positive impact and are operating differently. Among numerous other differences, leaders in Quality 4.0:

- Achieve 90th percentile performance in quality and manufacturing metrics
- Seven times more likely to have high support for quality from the IT organization
- Three times more likely to implement any given quality process with technology
- Have aggressively adopted use cases within quality but also those that extend the quality focus outside the quality function and organization
- Are significantly more likely to adopt voice of the customer use cases, which represents a monumental change for quality and dramatically impacts their organization
- Focus on 8 of 33 use cases that deliver the most improvement for the least cost/effort

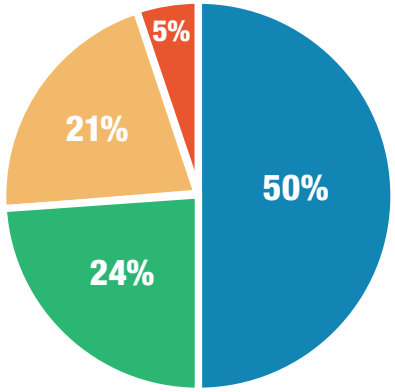
The survey data clearly shows that IX is progressing rapidly, Quality 4.0 is a cornerstone of IX more generally, and Quality 4.0 transformation initiatives are working. Quality 4.0 provides a pivotal mechanism to transform business, pushing us towards a more interconnected, seamless, and empowered organization. It's one in which the quality group has a pervasive role across the enterprise and embedded within functions such as new product development. Now is the time to pursue such programs aggressively.



Demographics

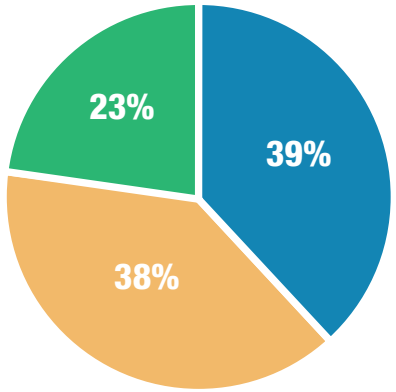
LNS Research executed global surveys on the state of Industrial Transformation (IX) programs in December 2018 and on Quality 4.0 maturity in February 2019. We surveyed executives and management across a wide range of organizational roles, industries, and geographies. At the time of publication, there were 302 respondents to the "IX readiness" survey, and 251 completed "Quality 4.0 maturity" surveys.

The demographics of the two surveys were similar, and the charts reflect the Quality 4.0 results specifically. LNS Research conducts its surveys in English, German, and French. Respondents indicate they work for corporations across a wide range of corporate revenues, with 39% of companies over $1 billion and 38% less than $250 million in 2017.



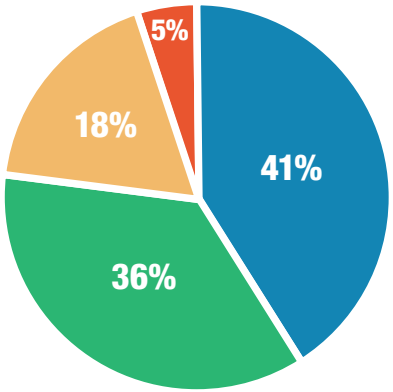
INDUSTRY
COLOR BY MANUFACTURING

- Discrete Manufacturing
- Batch Manufacturing
- Process Manufacturing
- All Others



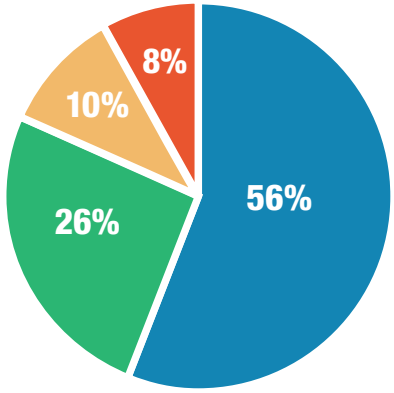
COMPANY SIZE
COLOR BY COMPANY REVENUE

- Large: $1B+
- Medium: $250M - $1B
- Small: >$250M



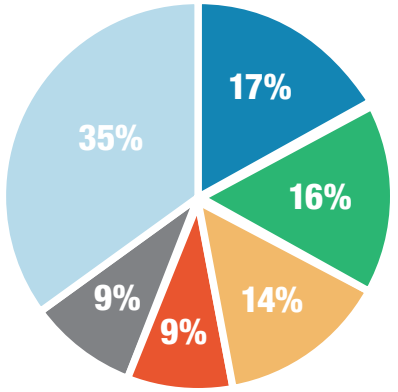
GEOGRAPHY
COLOR BY HQ LOCATION

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



JOB TITLE
COLOR BY ROLE

- Manager
- Director
- Vice president
- President or CxO



JOB FUNCTION
COLOR BY AREA OF RESPONSIBLITY

- Information technology
- Operations
- Quality
- Finance
- Engineering
- All Others

Section 2

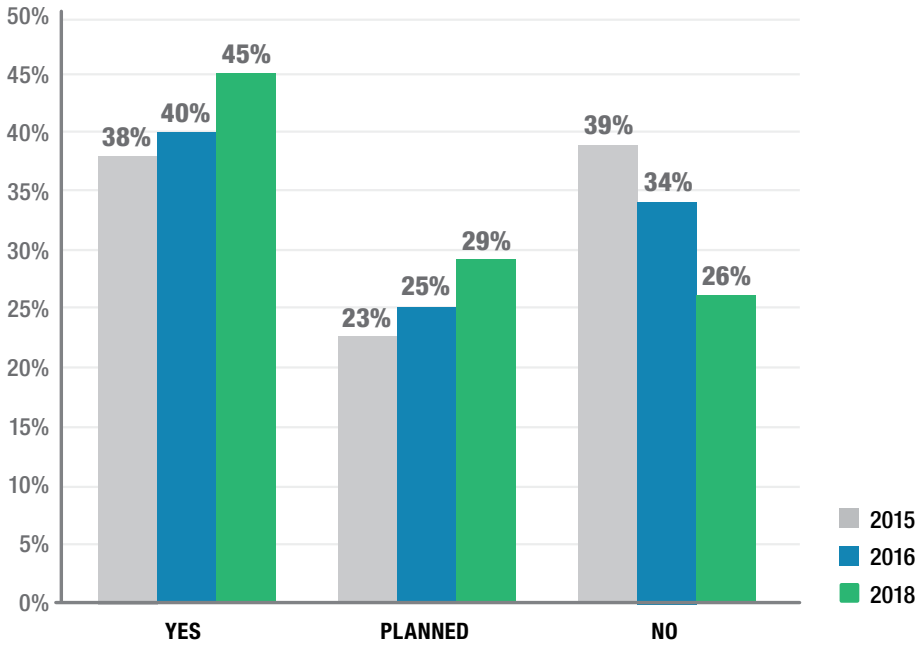
Quality 4.0 in Context of Industrial Transformation (IX)

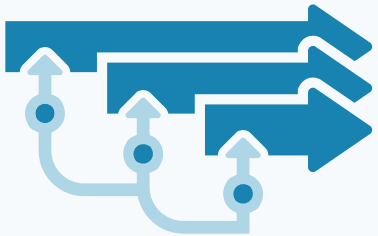
Building A Successful IX Strategy

Industrial Transformation goes by a range of names: Digital Transformation, Industrie 4.0, and smart manufacturing, among others. Regardless of what it's called, two-thirds of companies have implemented, are implementing, or plan to launch an IX program.

LNS Research has confirmed the power and potential of IX. While the numbers are small so far, many industrials are achieving the desired step-change improvements in the form of incremental revenue and cost savings. Eight percent of companies already report the IX program is "a real success," both in terms of business benefit and speed of the program's impact, and it's having a "dramatic impact" on the corporation. Another 20% of companies with an IX program have "made progress, and the corporation is seeing value." The technologies and market are maturing. Therefore, LNS now believes that even the most risk-averse companies should be planning for and embarking on an Industrial Transformation journey.

COMPANY HAS IX OR IIoT INITIATIVE





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.

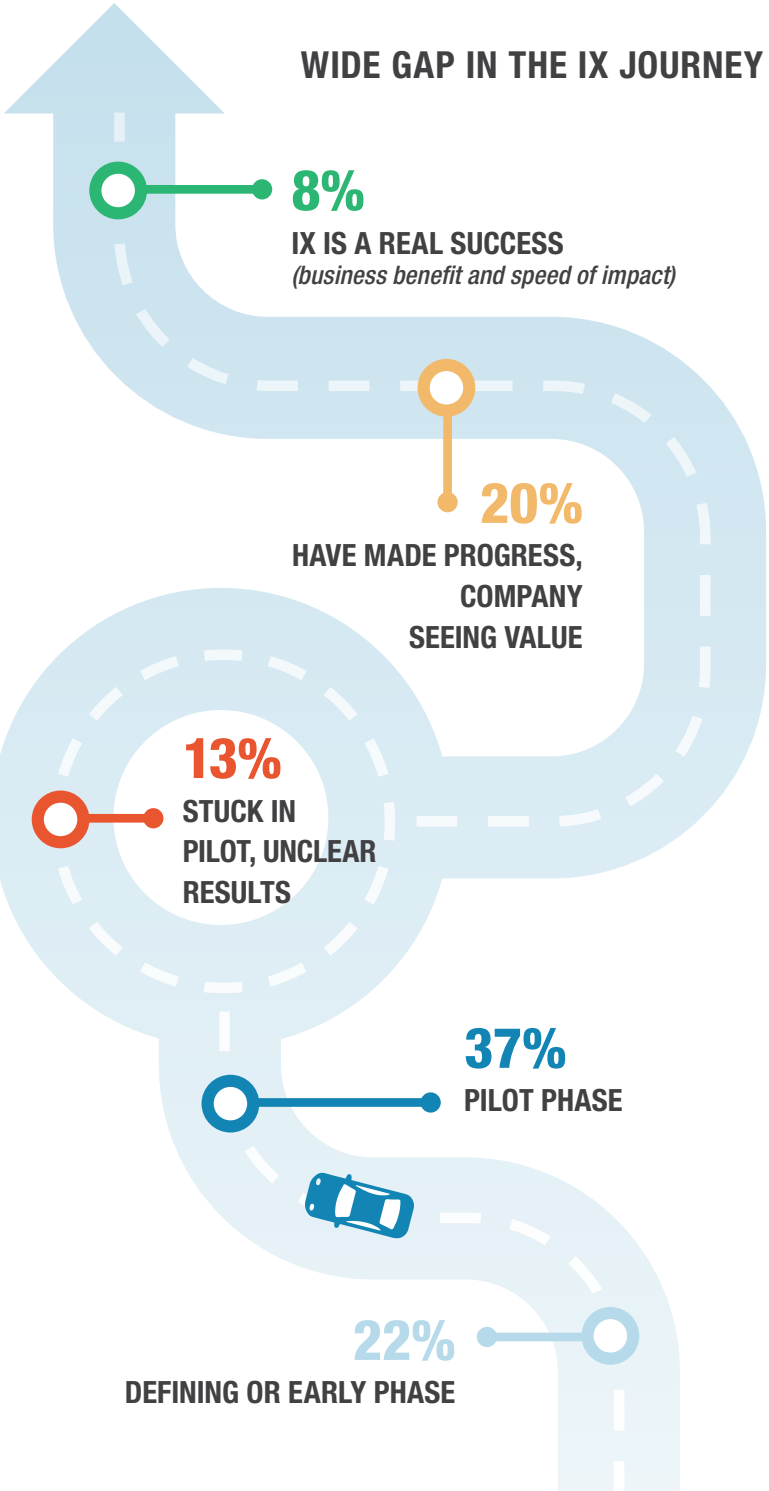
Click to learn more about the **Industrial Transformation Framework**

Building A Successful IX Strategy *(Cont.)*

The average IX program has ten distinct initiatives/projects with the largest organizations having just slightly more. What do these initiatives have in common? First, it's all about data. Data is the currency of Industrial Transformation, and applying Quality 4.0 is no exception. An effective Quality 4.0 initiative starts with data, which the organization gathers from people, processes, machines, online marketplaces, and third parties. Quality is a corporate-wide responsibility, and by extension quality processes and quality data connect with many IT systems.

Second, it is about connecting IT and operational technology (OT). The data required for transformation typically exists, but is fragmented across any number of automation, manufacturing, test, lab, business, warranty, quality, customer service and marketing systems, databases, and reports. Forty percent of IX leaders are also deploying Industrial Internet of Things (IIoT) platforms or analytics technology as part of the IX program. Ultimately, it is, in fact, about connecting IT, OT, and IIoT data sources (what we call an Operational Architecture).

Data is the currency of Industrial Transformation, and applying Quality 4.0 is no exception.

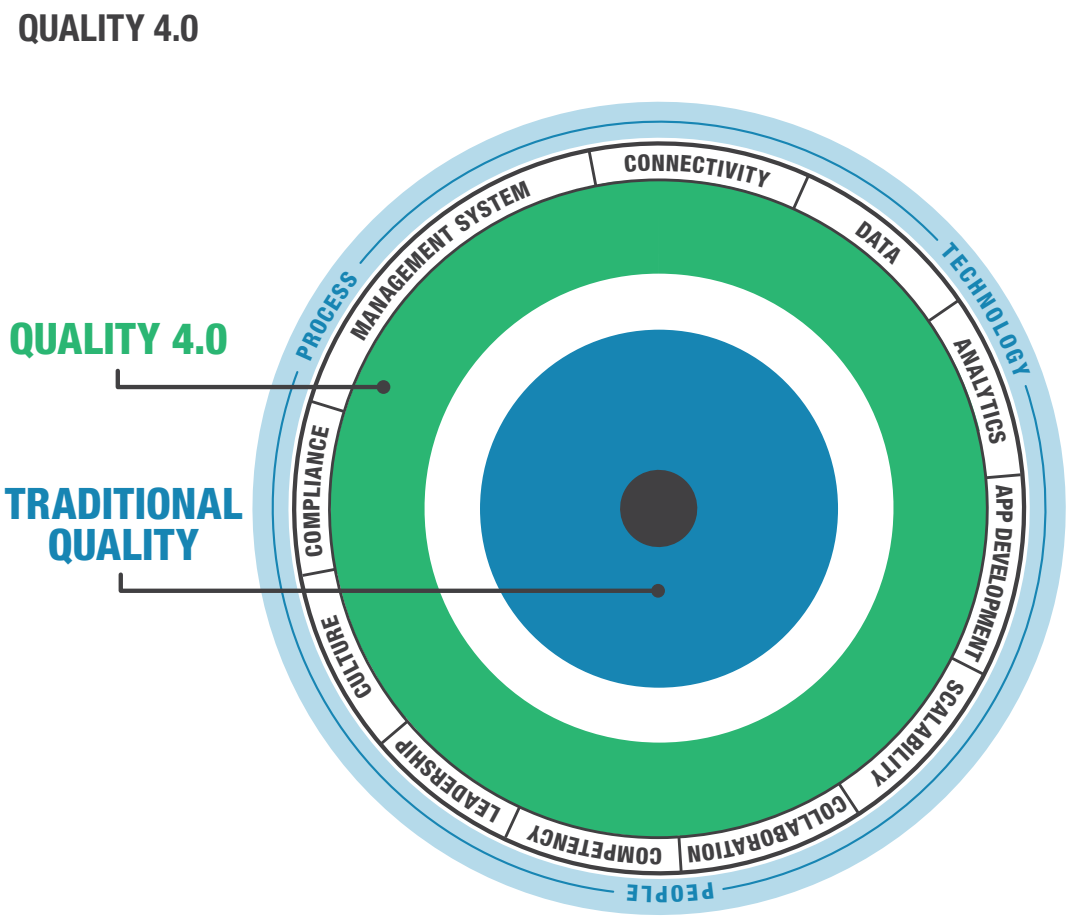


Transforming Quality

One or more of the IX initiatives companies weave into and overlay across many of those ten distinct initiatives is Quality 4.0 — the digitalization of quality management and the impact of digitalization on people, processes, and product. Quality 4.0 does not replace conventional quality methods, but instead builds on and improves them. Companies digitalize quality management by applying traditional and Industry 4.0 technologies (IIoT, advanced industrial analytics, cloud, digital twins, etc.) to improve quality monitoring and outcomes. At its core, Quality 4.0 is quality data enhanced with other data sources such as manufacturing, machine sensors, supplier management, and product lifecycle data, to derive new analytical insights to be used across the entire enterprise.

QUALITY 4.0 by LNS Research describes how manufacturers use modern technologies such as advanced analytics and digital connectivity to transform traditional quality and improve operational excellence; enabling enterprise efficiencies, innovation, performance, or strategic objectives.

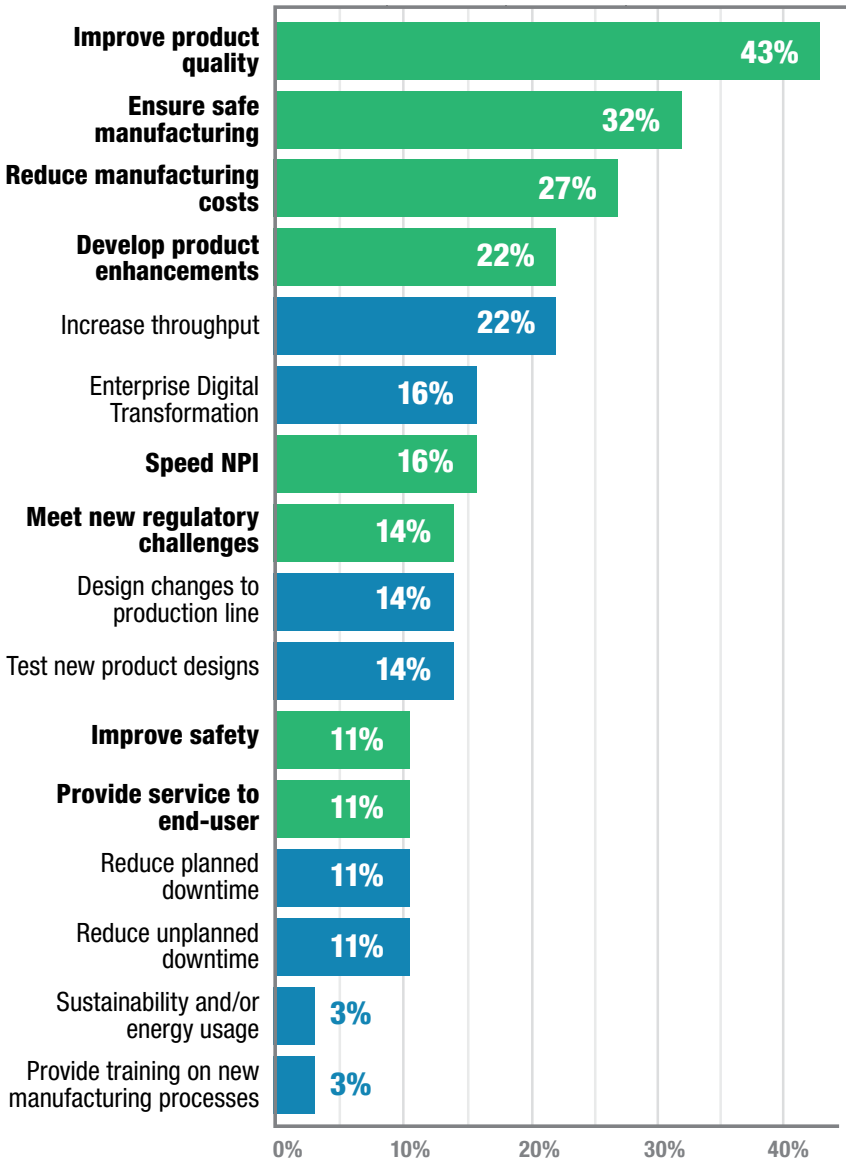
Click to learn more about the **Quality 4.0 Framework**



Transforming Quality *(Cont.)*

Overall, 23% of IX initiatives focus on quality, making quality improvements and quality monitoring the most common use case within IX. Why is quality at the top of the IX food chain? All the challenges in and around quality are driving Quality 4.0 initiatives. For example, improving product quality is explicitly the most important driver behind technology investments in the process industries. It is also critical to another seven business objectives and probably a factor in all other objectives.

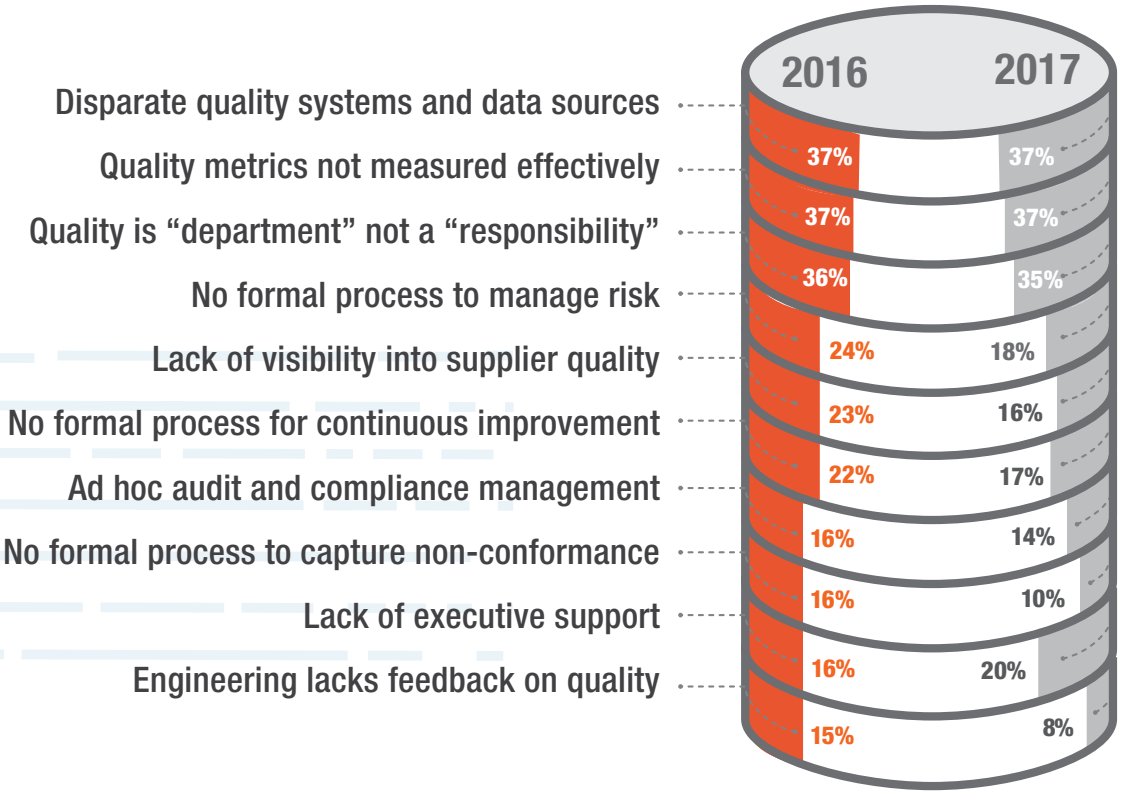
MANY OVERLAPPING BUSINESS OBJECTIVES FOR TECHNOLOGY (process industries)



Transforming Quality *(Cont.)*

LNS Research has been tracking the challenges in quality for the last seven years; we have found them to be myriad and continuing. However, IX generally and Quality 4.0 specifically must focus on data. Poor quality data is the leading cause of manufacturers failing to meet quality objectives. Companies have disparate data, lack metrics to benchmark, lack supplier data, and don't get data into engineering's hands. The lack of formal processes is the second largest category of challenges associated with quality, and companies also widely report organizational challenges. Digital technologies are powerful tools, and when used correctly, they connect so much more than IT systems — they connect assets, people, and products.

CHALLENGES TO ACHIEVING QUALITY OBJECTIVES *(n=1882)*



Lack of IT Support Generally

Accentuating all the challenges associated with quality is the lack of IT support, which emerges in at least two ways. First, we see a lack of engagement by the IT department in quality activities. Dedicated quality IT personnel are in short supply — only 22% of firms have a designated quality-IT liaison, and only 26% of companies report sufficient IT support for quality technology. Inadequate IT support is particularly risky, given that quality organizations often have little experience in deploying technology.

IT SUPPORT FOR QUALITY

Quality team manages or builds own tech systems

IT proactively includes quality in IT initiatives related to quality

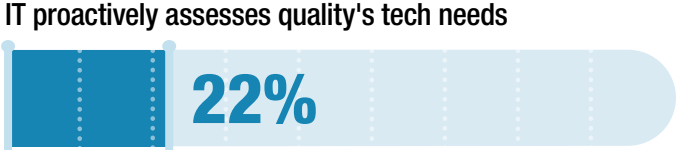
Quality actively circumvents IT

Quality receives adequate tech support and funding from IT

At least one permanent IT person assigned to work quality

IT works with quality to establish and update a quality tech roadmap

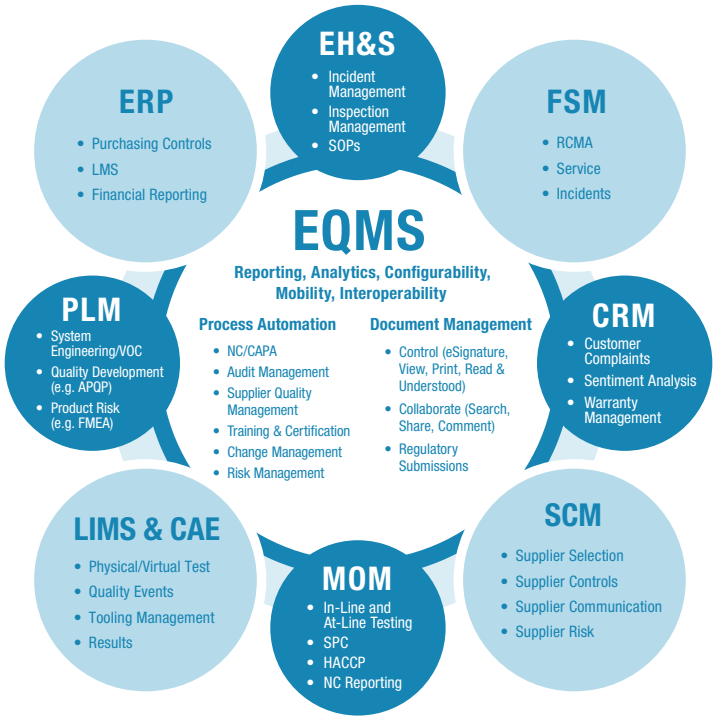
IT proactively assesses quality's tech needs



None of the above or don't know

Lack of IT Support Generally *(Cont.)*

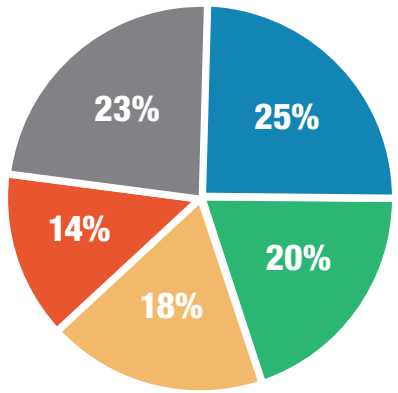
Second, enterprise quality management systems (EQMS) are still relatively rare. An advanced EQMS plays a critical role in Quality 4.0. Advanced EQMS captures quality information as data versus documents. It captures the context for quality data, where context is an explorable association between the quality data and information such as lots, parts suppliers, and failure modes. Advanced EQMS centralizes the data, permitting global comparisons and oversight. Yet, only 25% of companies have implemented these critical systems. Even worse, only 16% of manufacturers have integrated EQMS with the manufacturing operations management (MOM) system. This disconnect prevents knowledge transfer between teams, sites, functions, and corporate.



Industrial companies should not undervalue the potential impact of providing "adequate IT support" to quality. Firms with "adequate IT support" (those with a dedicated quality IT person, IT proactively assessing and engaging, or IT funding and supporting quality tech) are more capable across the board:

- >2x as likely to have an IX initiative
- 7x more likely to have implemented a Quality 4.0 program
- 3x more likely to have automated any given quality process with technology
- 2x as many supplier quality management (SQM) capabilities
- 3x as many risk avoidance capabilities

Quality has been generally underserved by technology and IT. Industrial companies that exceed the norm have made significantly more progress and thereby have better business results overall.

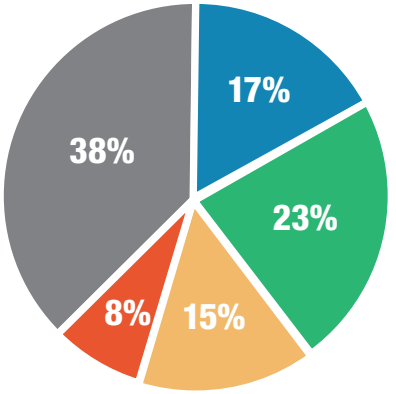


EQMS ADOPTION

Implemented
Planned within 3 years
Piloted
No plans
Budgeted within 1 year

State of Quality 4.0 Initiatives Today

Quality 4.0 is a leading-edge initiative within Industrial Transformation. Manufacturers with a Quality 4.0 initiative reap real value: improved quality, costs, efficiency, market share, and brand recognition. Quality 4.0 use cases enable new approaches and answers to traditional organizational and value chain quality challenges.



QUALITY 4.0 ADOPTION

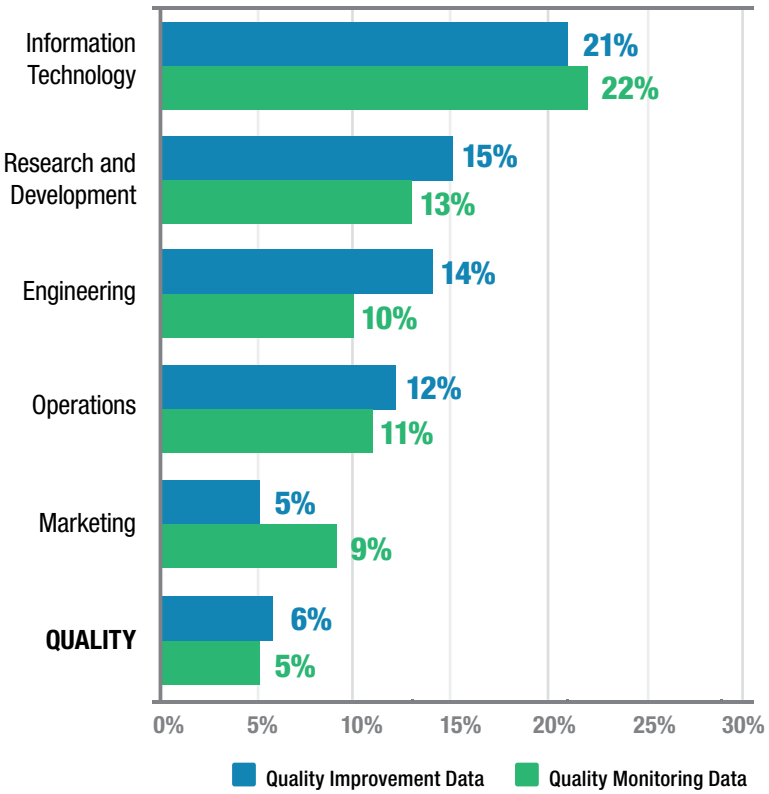
- Implemented
- Piloted
- Budgeted within 1 year
- Planned within 3 years
- No plans

Quality 4.0: Who, How, and Why

One of the key findings in the Quality 4.0 data is around the quality organization. Quality 4.0 is almost always one of the top initiatives in an IX program and, yes, quality engagement in IX has increased. However, the quality function is still less aware of broader Industrial Transformation than other functional teams. A comparison with IT is illustrative. Fifty-five percent of quality respondents were either unaware or were unsure if their company has an IX program or Quality 4.0 initiative underway. Conversely, only 19% of IT respondents said the same. Furthermore, only 15% of quality respondents are actively engaged in the IX or Quality 4.0 program or initiative, compared to 47% of IT respondents. In other words, many other roles and organizations are leveraging digital technology to deliver quality improvement with only limited engagement from the quality team. Given the priority of Quality 4.0 use cases by companies and the functional teams throughout the organization, it's imperative for those in the quality function to engage.

Quality 4.0 is almost always one of the top initiatives in an IX program, yet many other roles leverage digital technology to deliver quality improvement, with only limited engagement from the quality team.

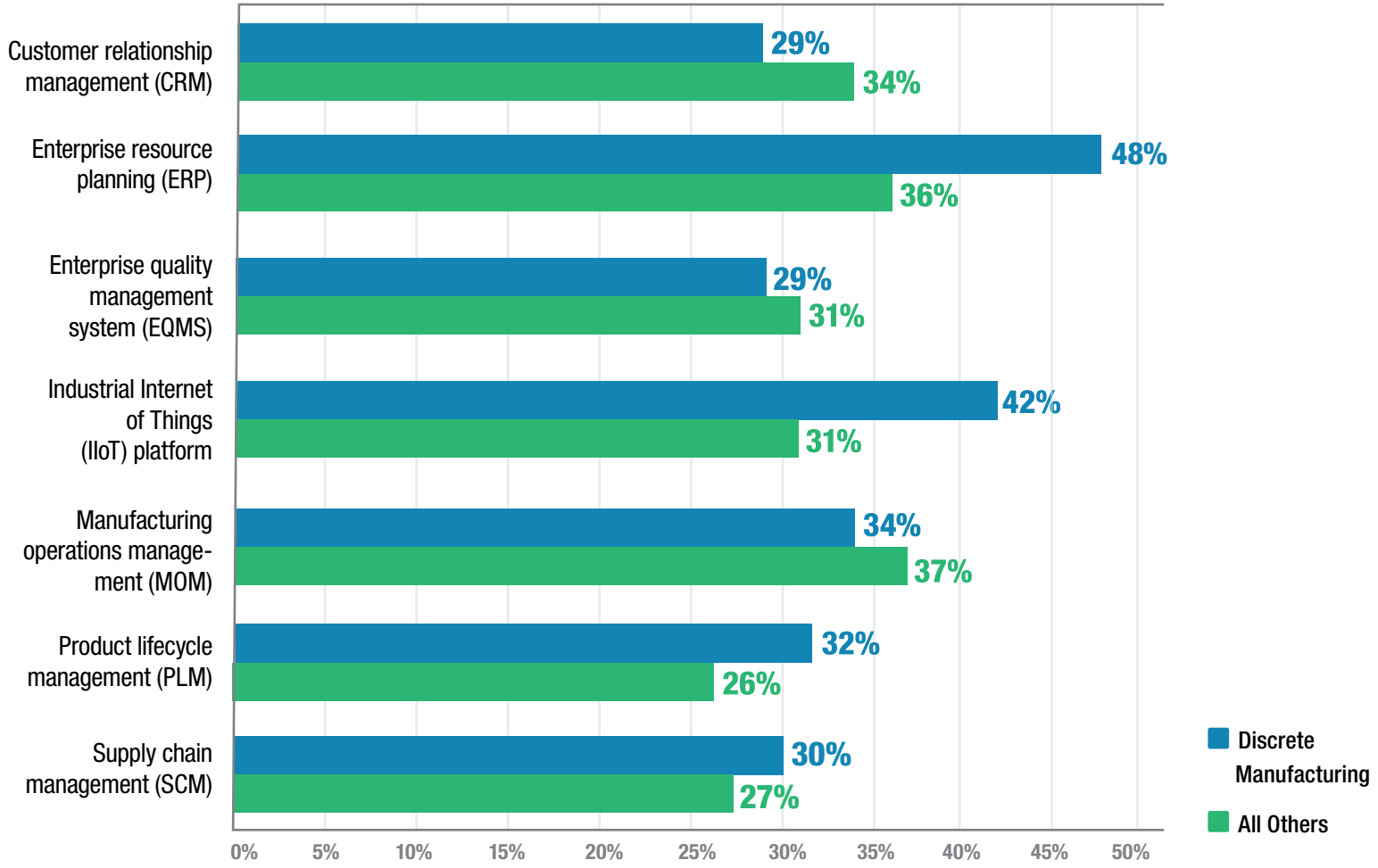
ROLES PLANNING TO USE IIoT TO MONITOR AND IMPROVE QUALITY



Quality 4.0: Who, How, and Why *(Cont.)*

Another key insight is how industrials are going about Quality 4.0 — Which systems are the foundation for quality transformation initiative(s)? The majority of companies are building onto "monument systems" — those that they have invested so much in that they cannot effectively change or replace — rather than a "rip and replace" strategy. A vast majority of companies are leveraging enterprise resource planning (ERP), MOM, customer relationship management (CRM), product lifecycle management (PLM), and other monument systems as the foundation for Quality 4.0. New generation solutions in the form of Industrial Internet of Things (IIoT) systems are the core in 37% of the cases. This is one of the areas we see interesting variation by industry: discrete manufacturers are significantly more likely to build on their ERP, IIoT, and PLM systems.

FOUNDATIONAL SYSTEM FOR QUALITY 4.0



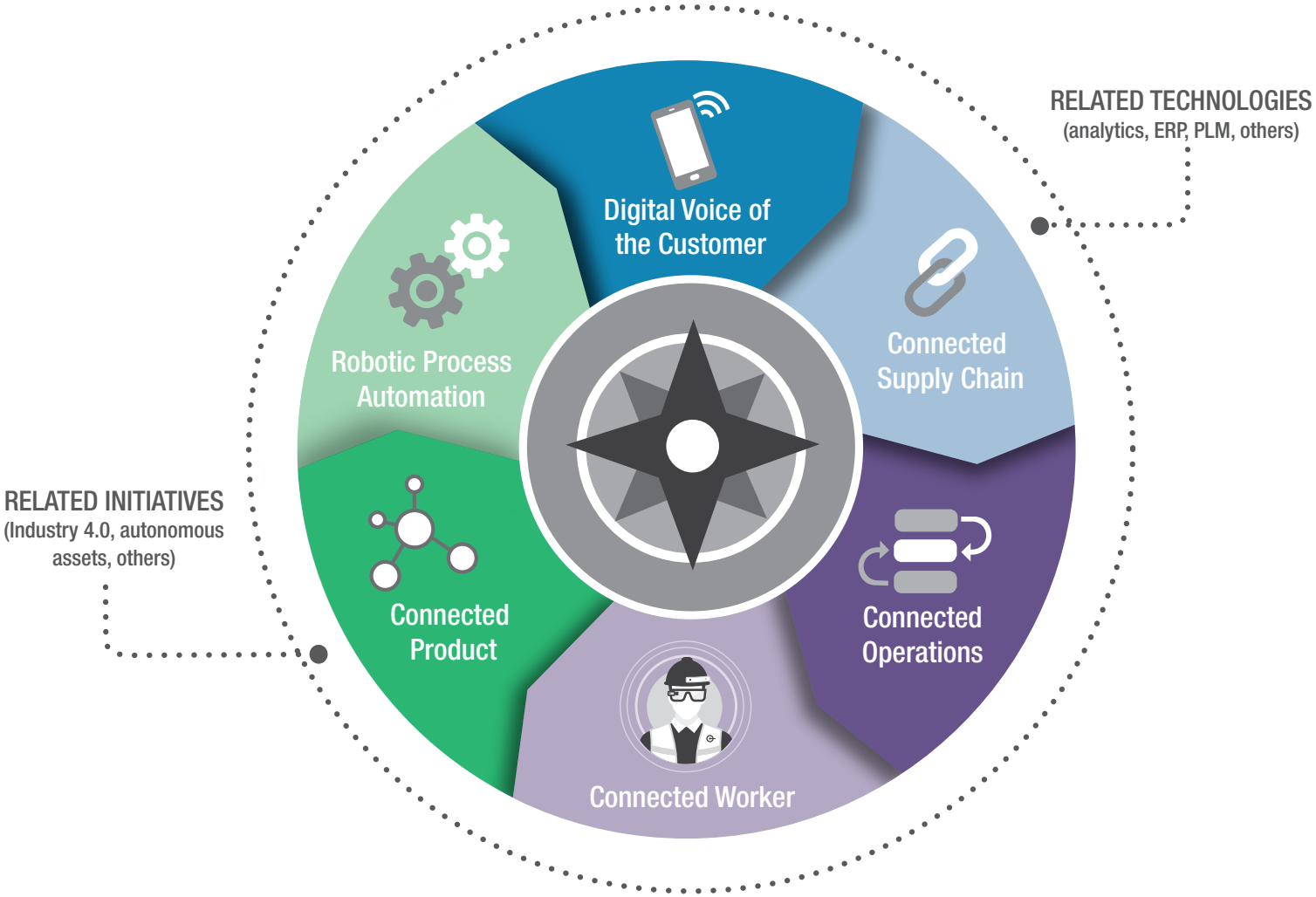
Section 3

A Methodology to Evaluate and Prioritize Quality 4.0 Use Cases

What's Working Today: 33 Quality 4.0 Use Cases

LNS Research currently tracks 33 Quality 4.0 use cases. We categorize them into six areas where quality intertwines with other departments and functions, as illustrated in the LNS Research Quality 4.0 Use Case Navigator.

QUALITY 4.0 USE CASE NAVIGATOR



Chicken or Egg?

Earlier we said: "One or more of those IX initiatives companies weave into and overlay across many of those ten distinct initiatives is Quality 4.0." What do we mean by "weave into and overlay?" Let's examine one example; many companies are developing remote operations centers to centralize hard-to-come-by resources and make them widely accessible across all or many sites. Here, we categorize this as a mobile/connected worker use case. Certainly, quality can benefit from centralizing scarce resources, as can many other departments. For some companies, quality may be the driving force behind these centers, but for others, operations or maintenance may lead the way. Which came first? Hence the "weave into and overlay" concept. We know that the average IX program has ten distinct initiatives. We also know that some initiatives are explicitly quality-focused but also benefit other functions, while other initiatives also support Quality 4.0 goals, though the company originally started them to help other functions.

The Impact/Effort Index: A Methodology to Evaluate Use Cases

For each use case, we must determine its impact on quality objectives specifically, and on manufacturing metrics more generally. To that end, we asked companies if they track specific manufacturing and quality metrics. For any given metric a company tracks, we further asked it to rate performance and recent improvements for that measure. We analyzed the impact of each use case first on the average score, and second on improvement.

Finally, LNS Research hears regularly from manufacturers that they are under intense pressure to deliver value quickly and without massive investment. To help industrials find solutions that meet those criteria we set as our end goal to rate each use case within a category relative to its impact/value and the level of effort required to achieve those goals. This means we look beyond just value; we examine the level of effort associated with implementation and rollout for each use case. We evaluate effort based on workload, time, and technical complexity. Ultimately, this allows us to understand "bang for the buck" associated with each use case. This analysis is industry-wide and of course many use cases have more impact in specific industries. Industry-specific analysis for your sector may be available; your company should contact its LNS Research account manager to determine availability.

The Impact/Effort Index: A Methodology to Evaluate Use Cases *(Cont.)*

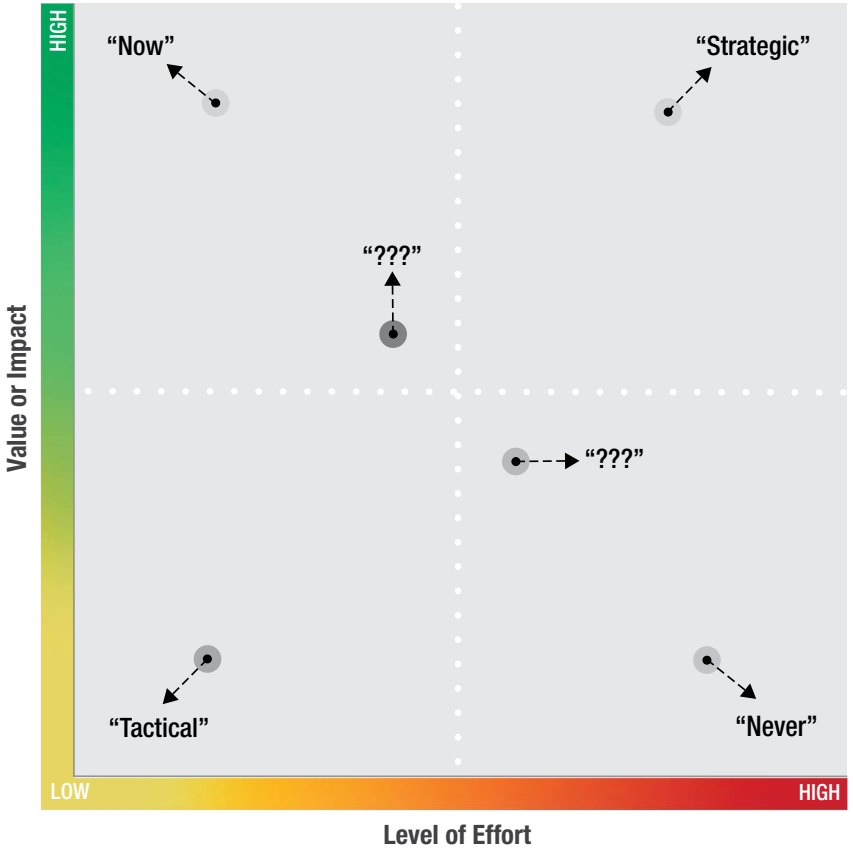
	IMPACT SCORE	EFFORT SCORE	% OF MARKET IMPLEMENTED
DIGITAL VOICE OF THE CUSTOMER			
Online marketplaces: five-star data analysis and product benchmarking	4.29	3.5	22%
Online marketplaces: semantic analysis to characterize reviews	3.16	4.7	27%
Social media: sentiment analysis	1.90	4.7	23%
Warranty data: statistical predictions	3.48	4.7	24%
Warranty data: machine learning pattern assessment	3.57	6.2	22%
Customer complaints: statistical predictions	3.23	4.0	31%
Customer complaints: machine learning/ artificial intelligence (ML/AI) pattern assessment	3.72	7.0	22%
CONNECTED SUPPLY CHAIN			
Real-time supplier operations visibility	3.94	6.8	24%
Predictive supplied good variance reduction	2.64	6.2	27%
Inspection optimization	2.65	4.8	26%
Multi-tiered supply chain traceability	2.87	7.8	34%
Prescriptive edge analytics	3.22	7.7	21%
Predictive critical parameter optimization	3.58	8.3	20%
CONNECTED OPERATIONS			
Predictive asset maintenance	3.20	6.1	32%
Predictive in-process variance reduction	3.09	6.3	19%
Predictive end-product variance reduction	3.38	7.4	22%
Predictive in-service performance	3.05	7.3	27%
Predictive customer experience	3.61	6.7	28%
Inspection optimization	3.12	4.7	25%

	IMPACT SCORE	EFFORT SCORE	% OF MARKET IMPLEMENTED
CONNECTED WORKER			
Mobile/augmented reality customer complaint capture	2.44	6.8	27%
Mobile/augmented reality audits	3.70	6.0	18%
Remote operations centers	2.41	8.3	15%
Engagement and retention apps	2.82	5.5	22%
Connected SOPs	2.52	5.8	24%
Connected training	3.32	5.7	19%
CONNECTED PRODUCT			
Performance monitoring	2.37	6.1	30%
Predictive maintenance	1.50	7.1	25%
Early failure detection/recall	2.07	6.7	20%
Remote diagnostics	2.07	6.4	13%
Prescriptive service	2.95	7.6	11%
ROBOTIC PROCESS AUTOMATION			
Audit data extraction	1.96	5.2	31%
Root cause suggestion	2.93	6.0	20%
Predictive routing	3.49	5.8	27%

The Impact/Effort Index: A Methodology to Evaluate Use Cases *(Cont.)*

We wanted to identify companies with the best performance in quality and manufacturing metrics. To do so, we averaged the responses against four different quality metrics (to address industry differences) and examined at companies with results in the 90th percentile. The four quality metrics examined are first pass yield, product in compliance, online marketplace five-star rating, and Net Promoter Score® (NPS®). We also identified highest performers by averaging three manufacturing metrics, again the 95th percentile, across the average of overall equipment effectiveness (OEE), successful new product introduction (NPI), and on-time delivery (OTD).

THE IMPACT/EFFORT INDEX



Overall Use Case Findings

Research on the 33 use cases resulted in three major findings.

FINDING #1 Implementation of these use cases shows a positive correlation with more than just quality; it has an impact across the entire organization. Virtually all 33 use cases meaningfully improve both quality and manufacturing performance. This corroborates a fundamental contention of Quality 4.0 — that quality is the responsibility of the entire organization and has an impact across the enterprise.

FINDING #2 The more use cases a company adopts, the more KPIs it adopts and the better it performs in manufacturing and quality.

% USE CASES ADOPTED	# MANUFACTURING KPIs	# QUALITY KPIs
>10	88	70
6-10	74	57
≤ 5	73	51

FINDING #3 In terms of "bang for the buck," we see that expanding the traditional view of quality to include voice of the customer through customer experience use cases provides the greatest return. These use cases deliver the greatest improvement and correlate the highest with quality and manufacturing leaders: they deliver the most value for the effort.

IMPACT/EFFORT INDEX: QUALITY 4.0 USE CASE CATEGORIES

Section 4

Use Case Categories Up Close

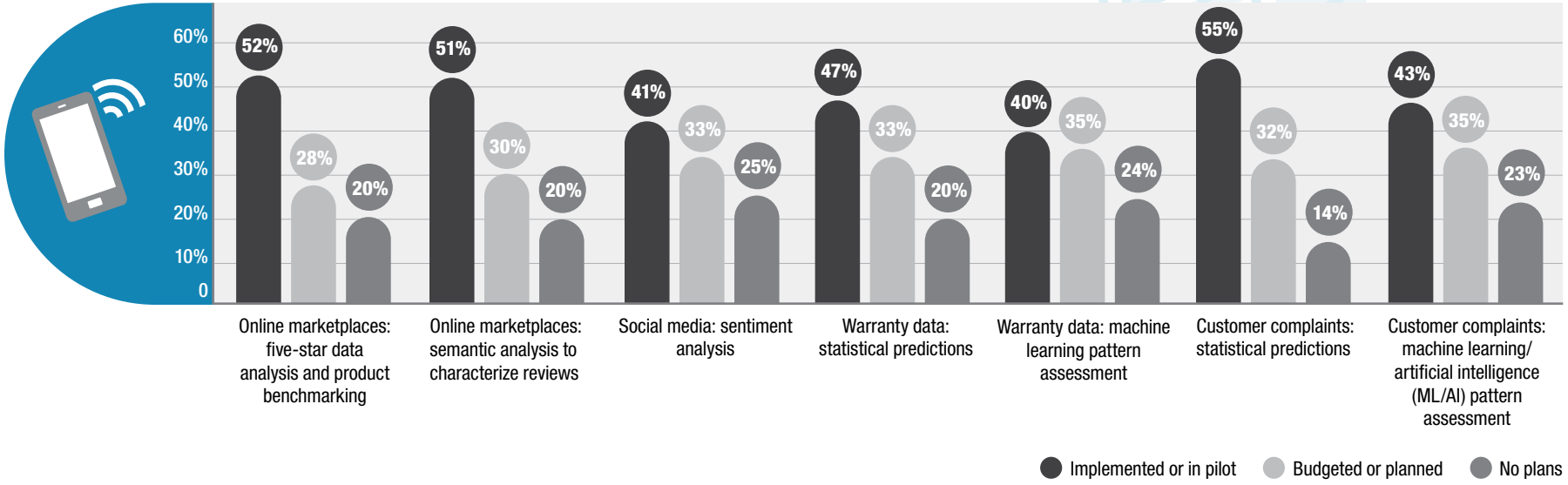
Use Cases | Digital Voice of the Customer

We begin by examining customer experience (the customer always comes first!). This category is a monumental change in how many companies have or do view the quality organization. Quality 4.0 leaders are increasingly engaging in work around digital voice of the customer to understand customers' perception of products and quality. Seven use cases are increasingly prevalent across industry:

- Online marketplace benchmarking
- Online marketplace semantic analysis
- Social media sentiment analysis
- Statistical warranty analytics
- ML/AI warranty analytics
- Statistical customer complaint analysis
- ML/AI customer complaint signal detection

Unsurprisingly customer complaints is the most commonly deployed use case even when pushed to the level of Quality 4.0: statistical prediction. Online marketplace five-star analysis is one of the most actively piloted use cases across all 33 potential use cases, and we would expect industry to deploy this use case widely soon.

QUALITY 4.0 USE CASES: DIGITAL VOICE OF THE CUSTOMER



Use Cases | Digital Voice of the Customer *(Cont.)*

The data clearly shows the positive impact of making customer experience a critical metric in quality. Overall, this category of use cases correlates most to leaders in quality and manufacturing. Moreover, the single most impactful use case identified across all 33 is "online marketplaces: five-star data analysis and product benchmarking." For industries with online user assessment—generally more consumer-oriented industries but not exclusively—the single use case most correlated to both quality and manufacturing leaders is the five-star analysis. Implementing this use case also leads to the most improvement in quality metrics independent of where a company was in maturity metrics before starting implementation.

We found that six of the seven customer experience use cases have a positive impact on the business. The sole exception was "social media: sentiment analysis," which does not lead to improvement in metrics and does not correlate to manufacturing metrics leadership. Other use cases that are particularly associated with leaders in quality and manufacturing metrics are statistical predictions of customer complaints and machine learning pattern assessment for warranty data (though they show uneven maturity levels in adoption).

Use Cases | Digital Voice of the Customer *(Cont.)*

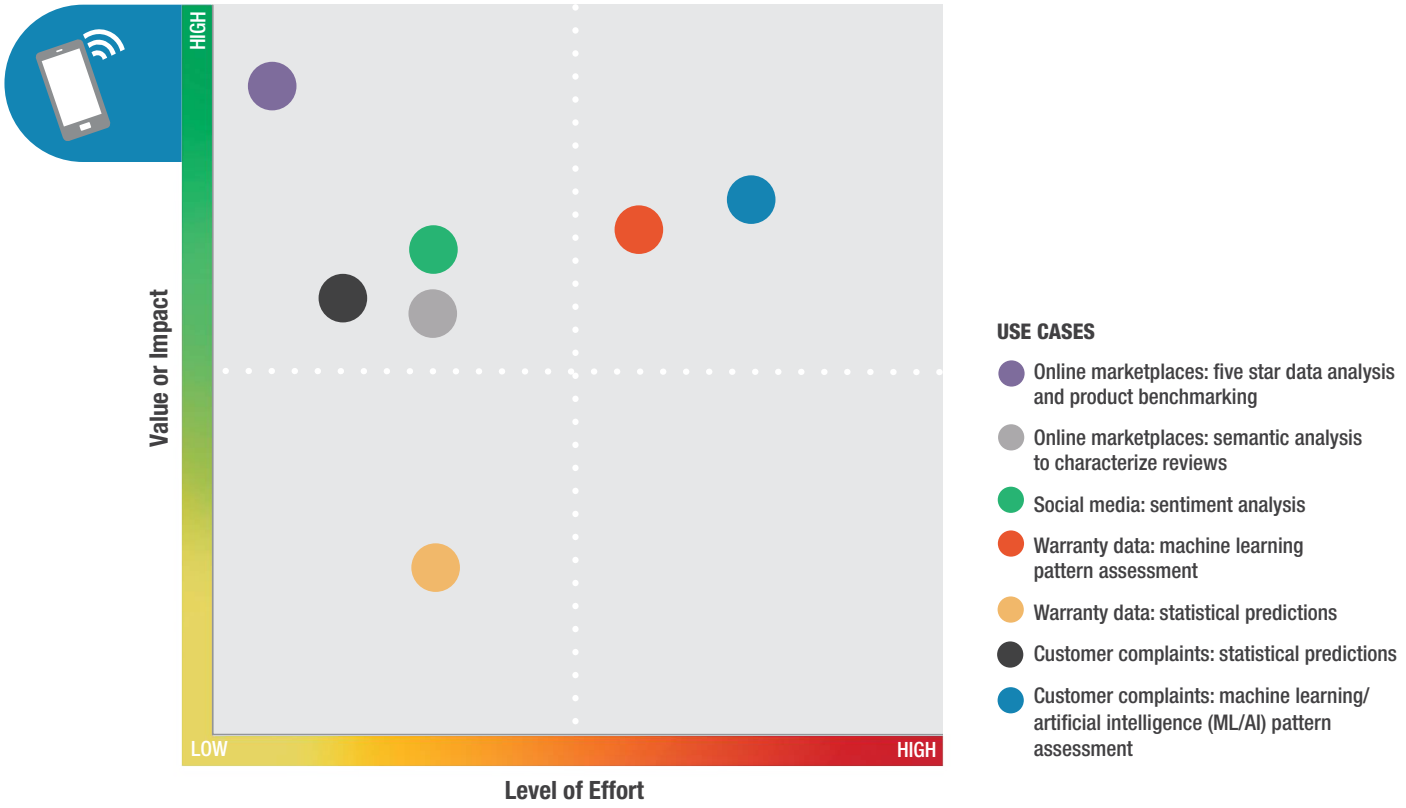
On the impact/effort index, the following customer experience use cases stand out in terms of "bang for the buck:"

- Online marketplace benchmarking
- Online marketplace semantic analysis
- Statistical warranty analytics
- Statistical customer complaint analysis

Overall, the five-star analysis delivered the most benefit in terms of improvements and is associated with both the 90th percentile of quality and the 90th percentile of manufacturing metrics. In fact, we believe it's the easiest of all use cases to implement, and it delivers the greatest return compared to effort. Clearly, the industrial organization should let customers define quality, so get to know your customers!

We recommend that most manufacturers evaluate the potential of these specific customer experience use cases in their business quickly.

IMPACT/EFFORT INDEX: DIGITAL VOICE OF THE CUSTOMER USE CASES



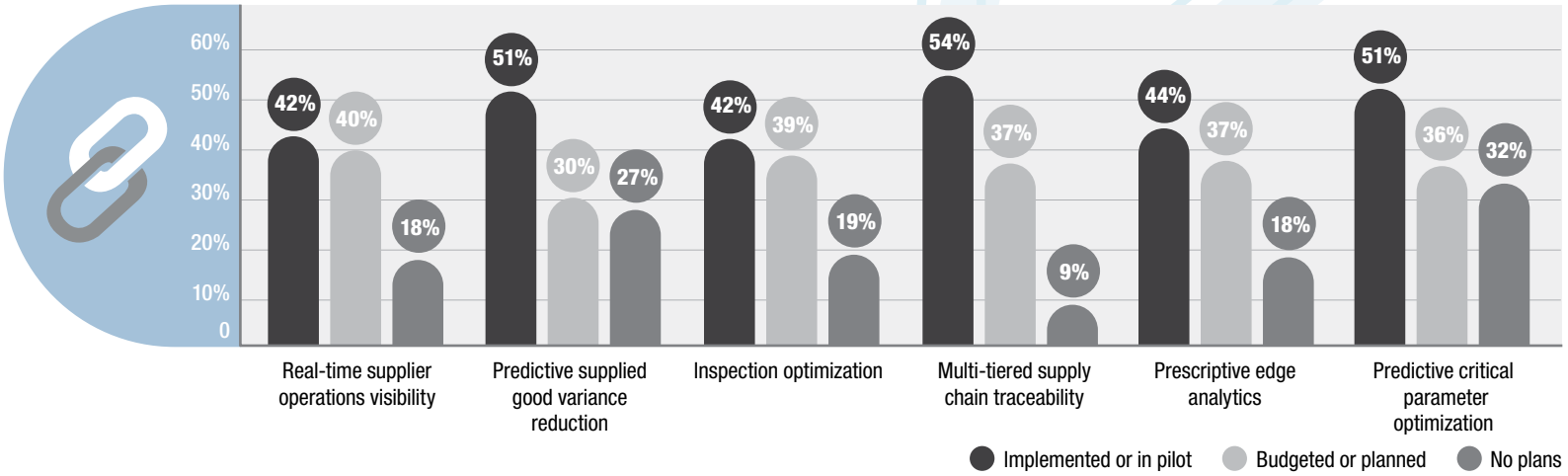
Use Cases | Connected Supply Chain

The next stop on the Quality 4.0 Use Case Navigator is connected supply chain. In a previous study LNS Research found that of all the quality capabilities we track, supplier quality management has the greatest impact on operational metrics such as overall equipment effectiveness (OEE), first pass yield (FPY), and on-time delivery (OTD). We find six use cases established in manufacturing:

- Real-time supplier operations visibility
- Predictive supplied good variance reduction
- Inspection optimization
- Multi-tiered supply chain traceability
- Prescriptive edge analytics
- Predictive critical parameter optimization

Twenty-one to thirty-four percent of companies have already implemented each of these use cases. Roughly another 45% are actively piloting or budgeting for each one. Surprisingly, we find full supply chain traceability to be the most widely implemented supply chain use case and one of the most widely deployed among all 33 use cases. It also represents the single use case with the most attention by manufacturers across almost all 33 use cases in that only 9% of companies have no plans to implement ever.

QUALITY 4.0 USE CASES: CONNECTED SUPPLY CHAIN



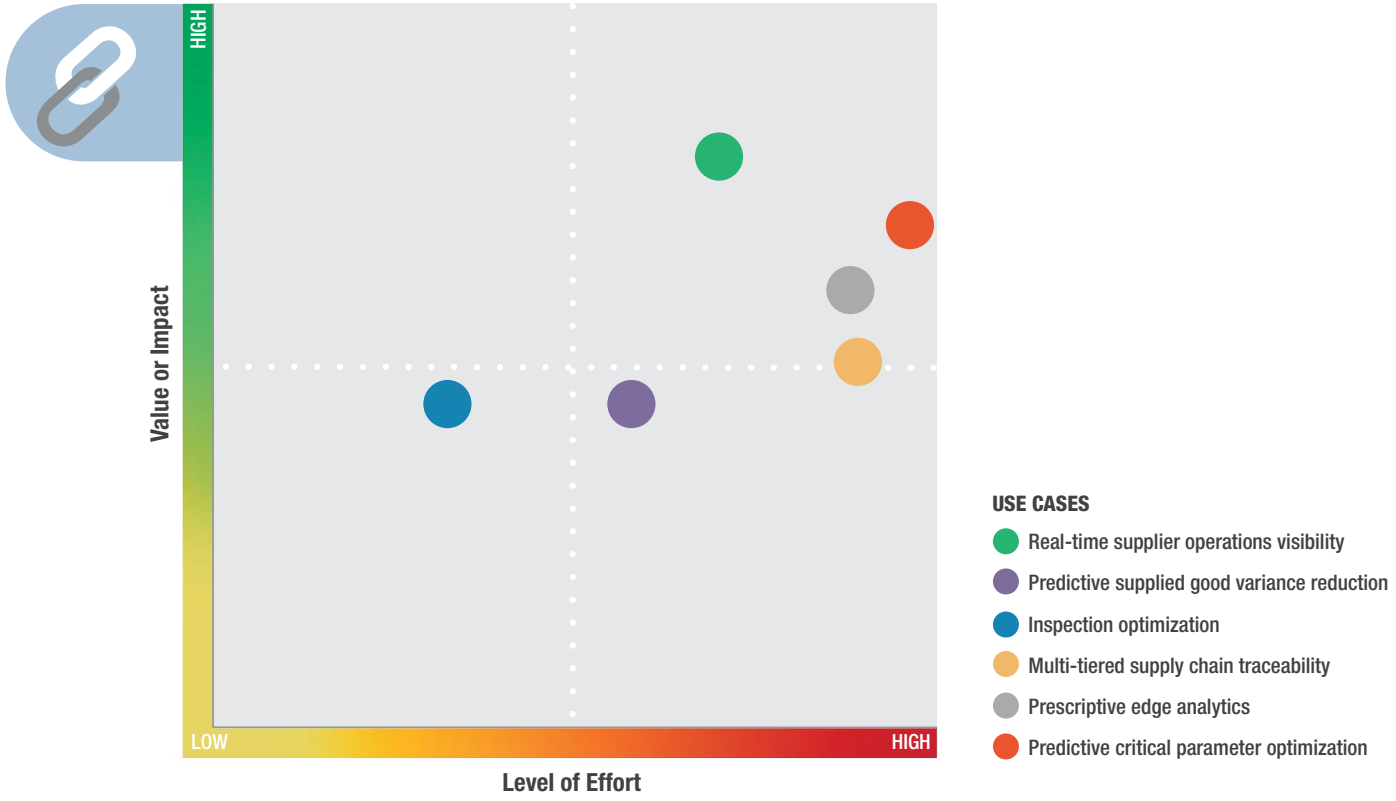
Use Cases I Connected Supply Chain *(Cont.)*

We expected to find a significant positive impact in deploying this category of use cases given our earlier findings. We were not disappointed. Overall, supplier quality use cases are second only to customer experience use cases in terms of delivering results overall in quality and manufacturing metrics. Each of the six use cases showed an average of 31% improvement on the quality and manufacturing metrics. Real-time supplier operations visibility was most closely associated with manufacturing metrics leadership results of all 33 use cases.

When we looked at these six use cases in terms of the impact/effort index, we see that they offer some of the most significant returns. However, we estimate that these are some of the hardest use cases to execute. Therefore we estimate "effort" as relatively high for many of them. Multi-tiered supply chain and predictive critical parameter optimization were particularly difficult and, therefore, likely to have concrete pay back only in quality/yield sensitive environments like semiconductor fabrication.

LNS Research believes the potential return on these use cases warrants manufacturers to carefully consider applying them only from a Quality 4.0 perspective (even though they have incremental value beyond Quality 4.0) and cautions companies to estimate the potential effort carefully. Other use cases may deliver equal benefit at less cost.

IMPACT/EFFORT INDEX: CONNECTED SUPPLY CHAIN USE CASES

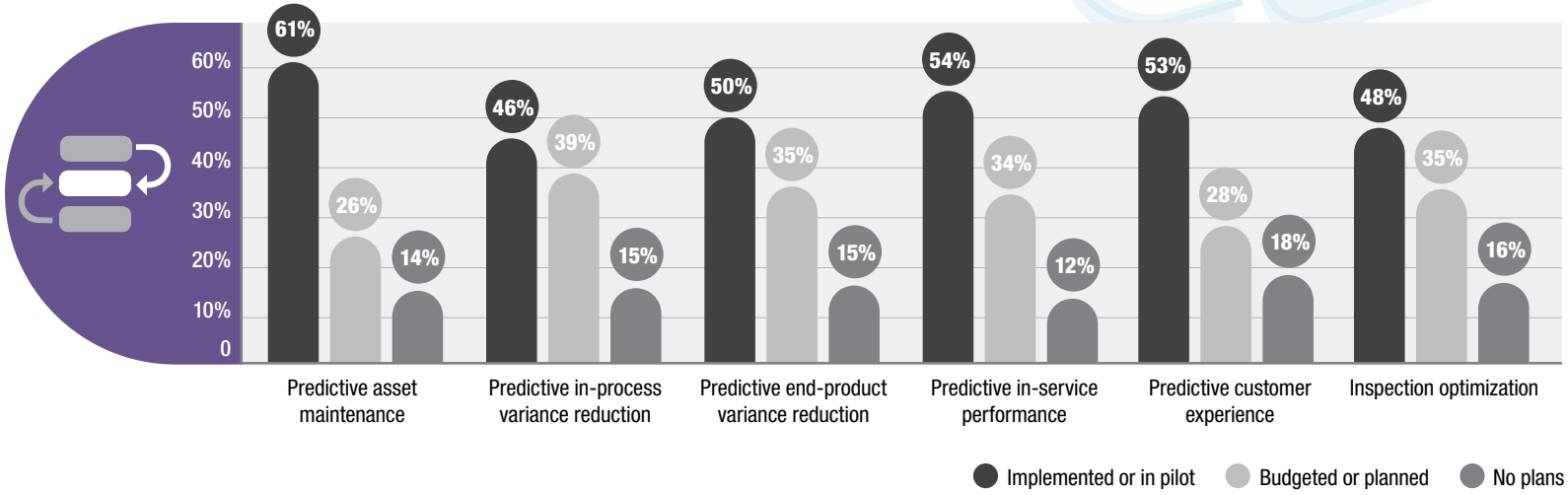


Use Cases | Connected Operations

LNS has identified six connected operations use cases as widely deployed in the market. Further, the data indicates that industry will likely widely implement all these within five years. The reason for the widespread adoption is value. On average, they deliver as much value as customer experience use cases (not surprisingly since they are focused so squarely on manufacturing). The challenge is that they are more effort intensive. So, while predictive customer experience and predictive end product variance reduction use cases deliver significant improvement in both quality and manufacturing metrics, only inspection optimization delivered good bang for the buck since less effort is required.

- Predictive asset maintenance
- Predictive in-process variance reduction
- Predictive end product variance reduction
- Predictive in-service performance
- Predictive customer experience
- Inspection optimization

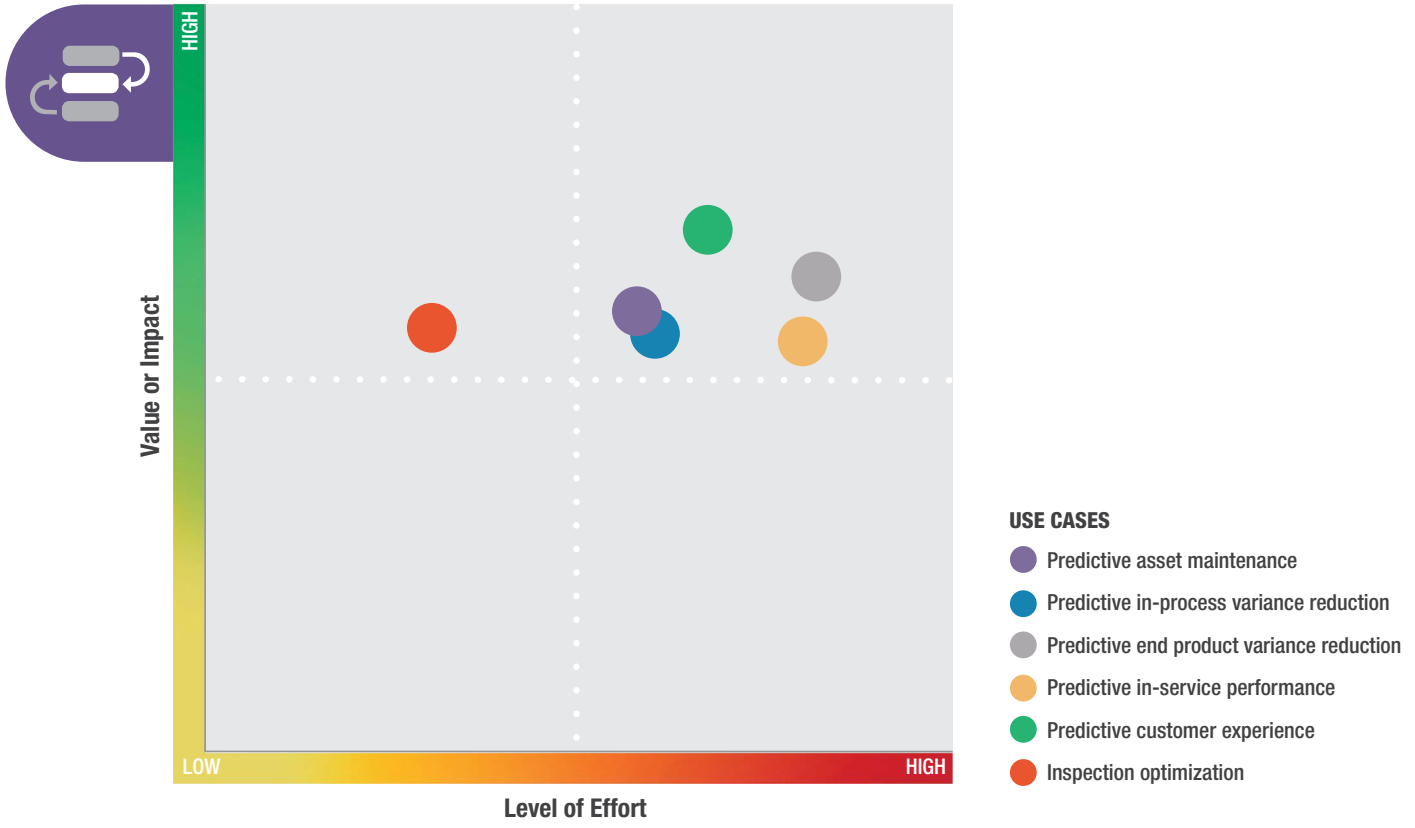
QUALITY 4.0 USE CASES: CONNECTED OPERATIONS



Use Cases I Connected Operations *(Cont.)*

Again, we believe the potential return on these use cases warrants manufacturers to carefully consider implementation from just a Quality 4.0 perspective (they have incremental value beyond Quality 4.0) but cautions companies to estimate the potential effort carefully. Other use cases may deliver equal benefit with less cost.

IMPACT/EFFORT INDEX: CONNECTED OPERATIONS USE CASES



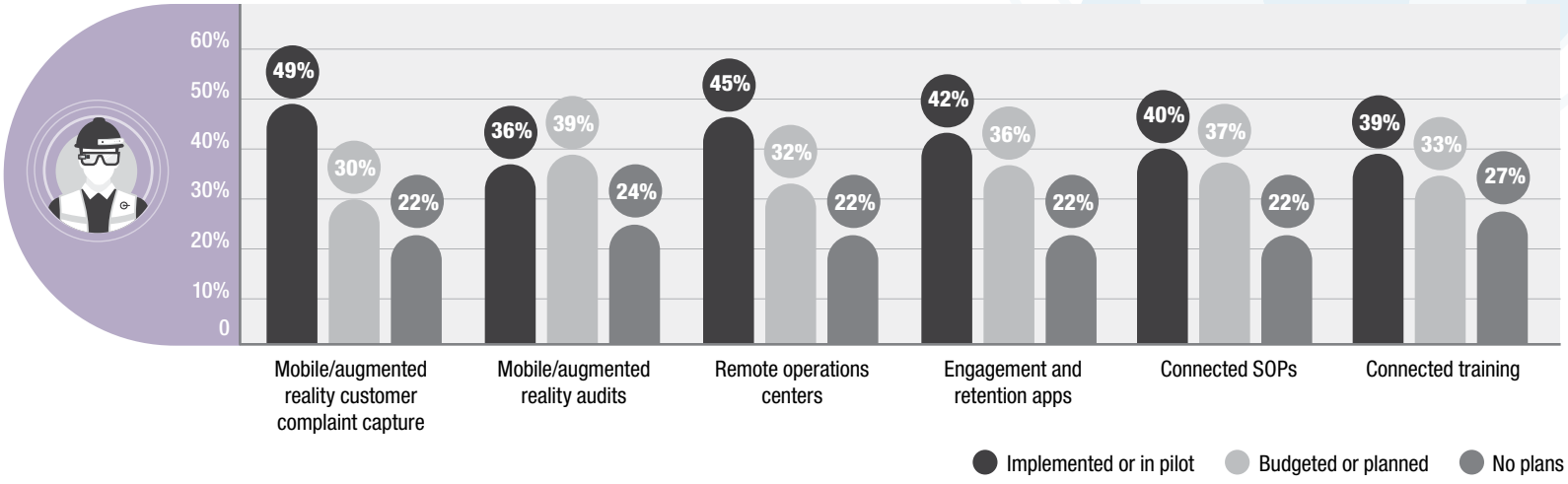
Use Cases | Connected Worker

When we consider Quality 4.0 or Industrial Transformation, assets and products usually come to mind first, even though connecting the workforce provides many opportunities and significant value. Connected worker use cases allow companies to improve worker competency and compliance, and accelerate the availability, accuracy, and effectiveness of the insights they receive and can act upon. Six connected worker use cases are notable today:

- Mobile/AR customer complaint capture
- Mobile/AR audits
- Remote operations centers
- Engagement and retention apps
- Connected SOPs via AR
- Connected training

Remote operations centers are not widely deployed yet but have the most active pilots of any of the 33 use cases. We will be following deployments closely as the cross-functional potential is significant in several sectors (mining and oil and gas are two of the most obvious). Compelling areas of investment also appear around mobile devices, virtual reality, and augmented reality.

QUALITY 4.0 USE CASES: CONNECTED WORKER

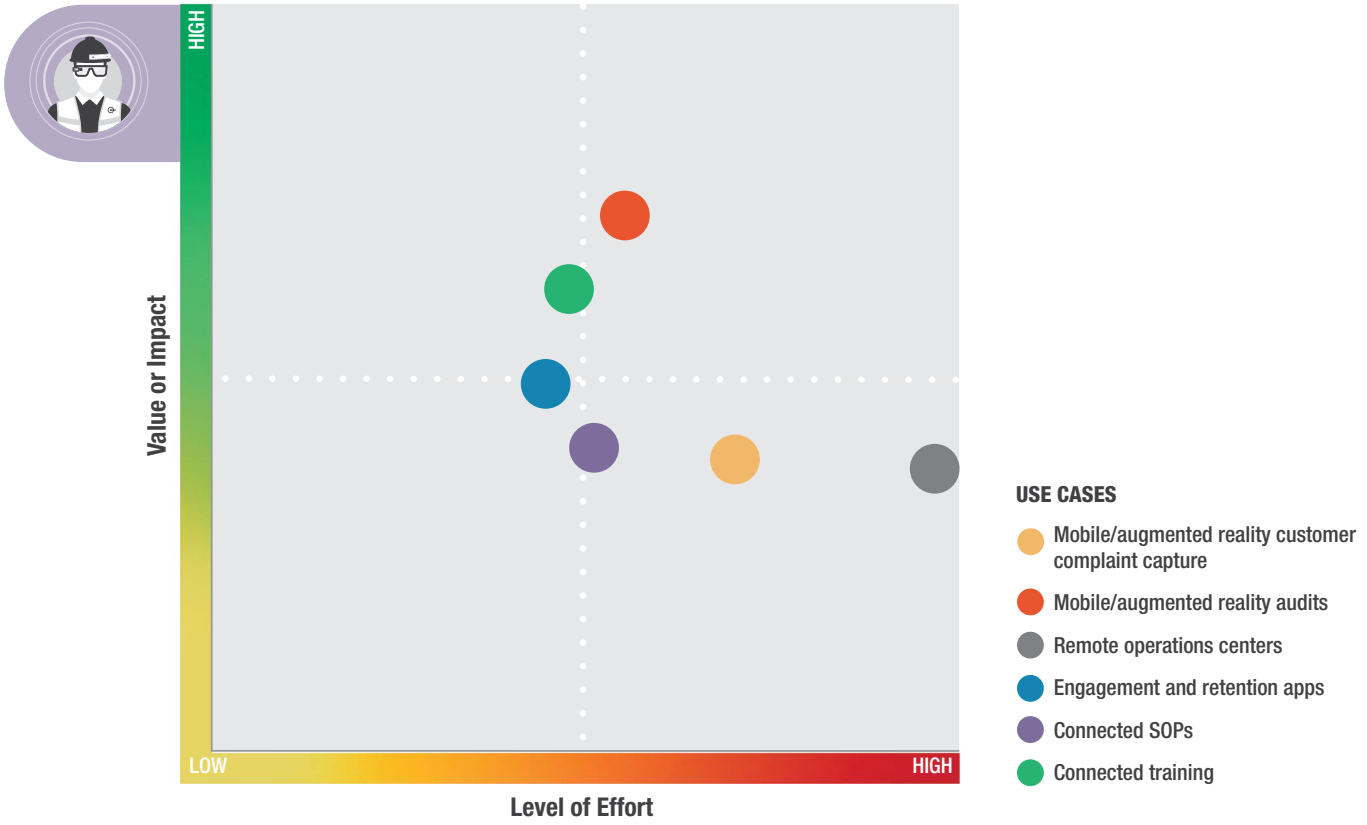


Use Cases | Connected Worker *(Cont.)*

When we examine overall payback across the category, we see that quality and manufacturing leaders have been less likely to implement connected worker use cases to date. We do see that connected worker use cases deliver above-average improvements in quality metrics (so they may be more correlated in the future). Remote operation centers delivers Quality 4.0 value we estimate it to be the biggest effort among all 33 use cases. Given technology vendors' investments around remote operations centers, we expect the cost to come down but suggest that Quality 4.0 benefits alone may be insufficient to justify these larger projects (which have other benefits as well).

Only a few connected worker use case scored particularly well on the impact/effort index. We will continue to watch these use cases carefully over the next few years. The significant investment by technology companies may change this equation over time.

IMPACT/EFFORT INDEX: CONNECTED WORKER USE CASES



Use Cases | Connected Product

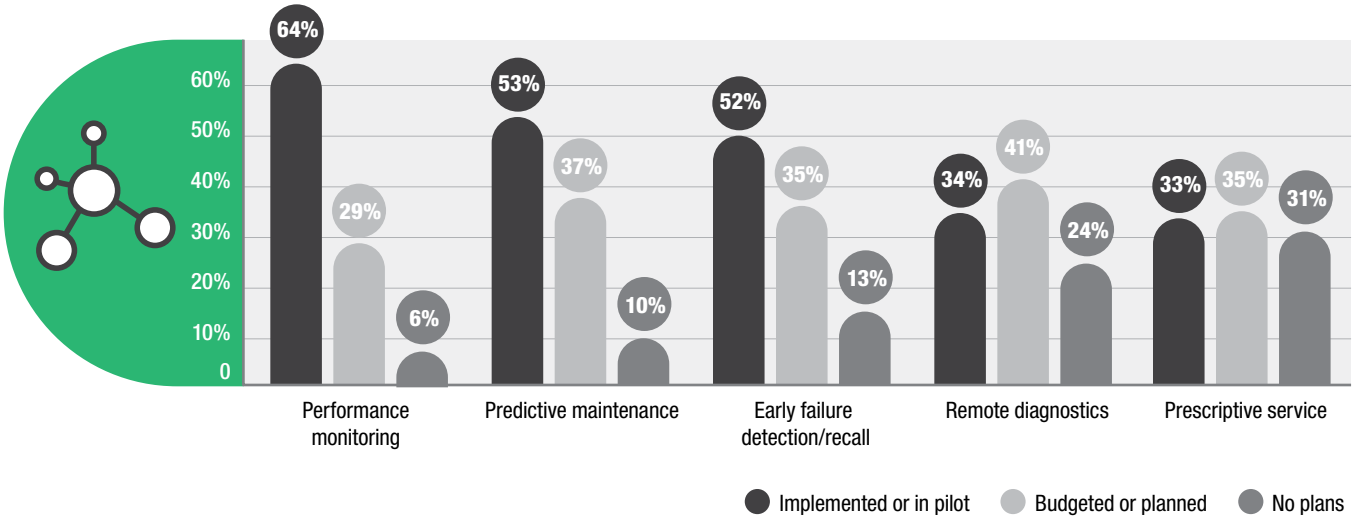
In many ways, the underlying vision of Industry 4.0 and the Internet of Things (IoT) is about connected products. The vision is simple: manufacturers will be increasingly connecting their products to the internet to provide insight about actual use and performance and to enable more proactive service. For many, the ultimate is the "servitization" of products which would require an understanding of product usage well beyond the level companies display today. We are currently tracking five connected product use cases:

- Performance monitoring
- Predictive maintenance
- Early failure detection/recall
- Remote diagnostics
- Prescriptive service

From a quality perspective, these five use cases are specifically and tightly tied to services and usage life of the product. Alignment to the overall vision of Industry 4.0 and IoT may account for widespread adoption. Performance monitoring is the most widely implemented of all the 33 use cases and has the greatest attention of manufacturers with the single lowest number, 6%, of companies with no plans to implement. Predictive maintenance and early failure detection are also among the very most widely deployed use cases.

LNS Research has been tracking Analytics that Matter in manufacturing with MESA for several years, and we have consistently seen that prescriptive analytics isn't for everyone. We see the same reflected again with the high level of "no plans." Digital Twins shows that it is still in an earlier adopter stage in the quality domain. The impact/effort index for connected product use cases indicates that quality may not be the focus of the effort.

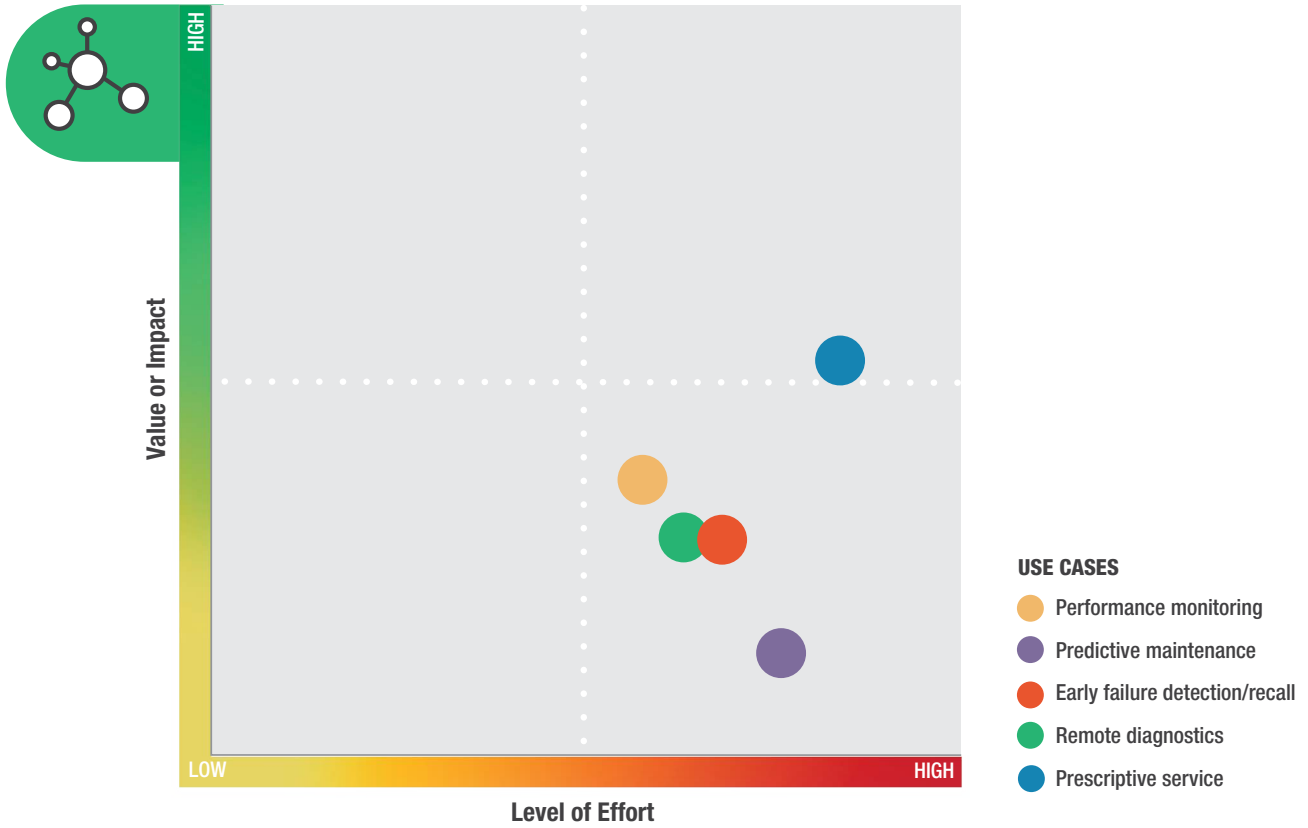
QUALITY 4.0 USE CASES: CONNECTED PRODUCT



Use Cases I Connected Product *(Cont.)*

Overall, connected product use cases leads to the least improvement in metrics, and this area is the lowest in terms of correlation to the 90th percentile in manufacturing metrics. Also, we estimate them to be among the most difficult to implement. There may be powerful business reasons to justify work around connected product (reduce services costs, increase revenue), but they are among the least efficient ways to improve quality and manufacturing metrics. (We have noticed that several IIoT vendors have recently deemphasized connected products in messaging. The current data may be a small piece of the puzzle to explain those messaging changes.)

IMPACT/EFFORT INDEX: CONNECTED PRODUCT USE CASES

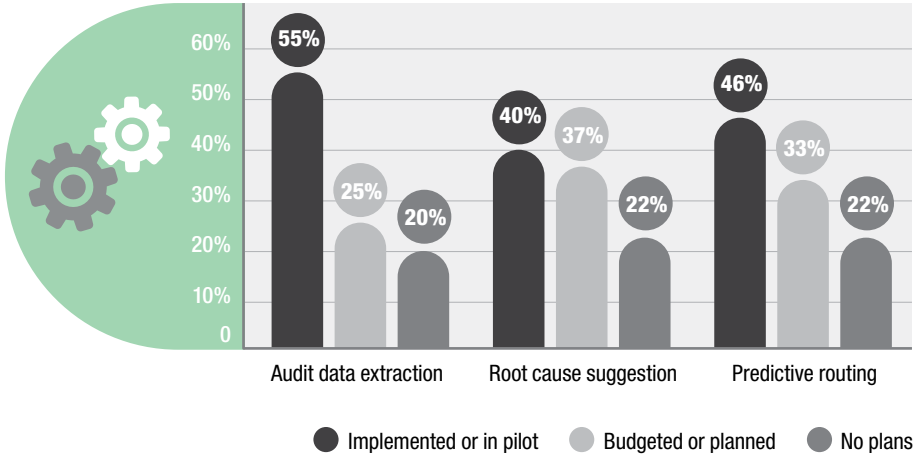


Use Cases | Robotic Process Automation

IX is about using digital technologies to reengineer business processes. Robotic process automation (RPA) is a core tool to enable that reengineering by providing connectivity, decision-making, and workflow within and across existing business, quality, and manufacturing systems. In Quality 4.0 companies are deploying RPA meaningfully in three ways:

- Audit data extraction
- Root cause suggestion
- Predictive routing

QUALITY 4.0 USE CASES: ROBOTIC PROCESS AUTOMATION

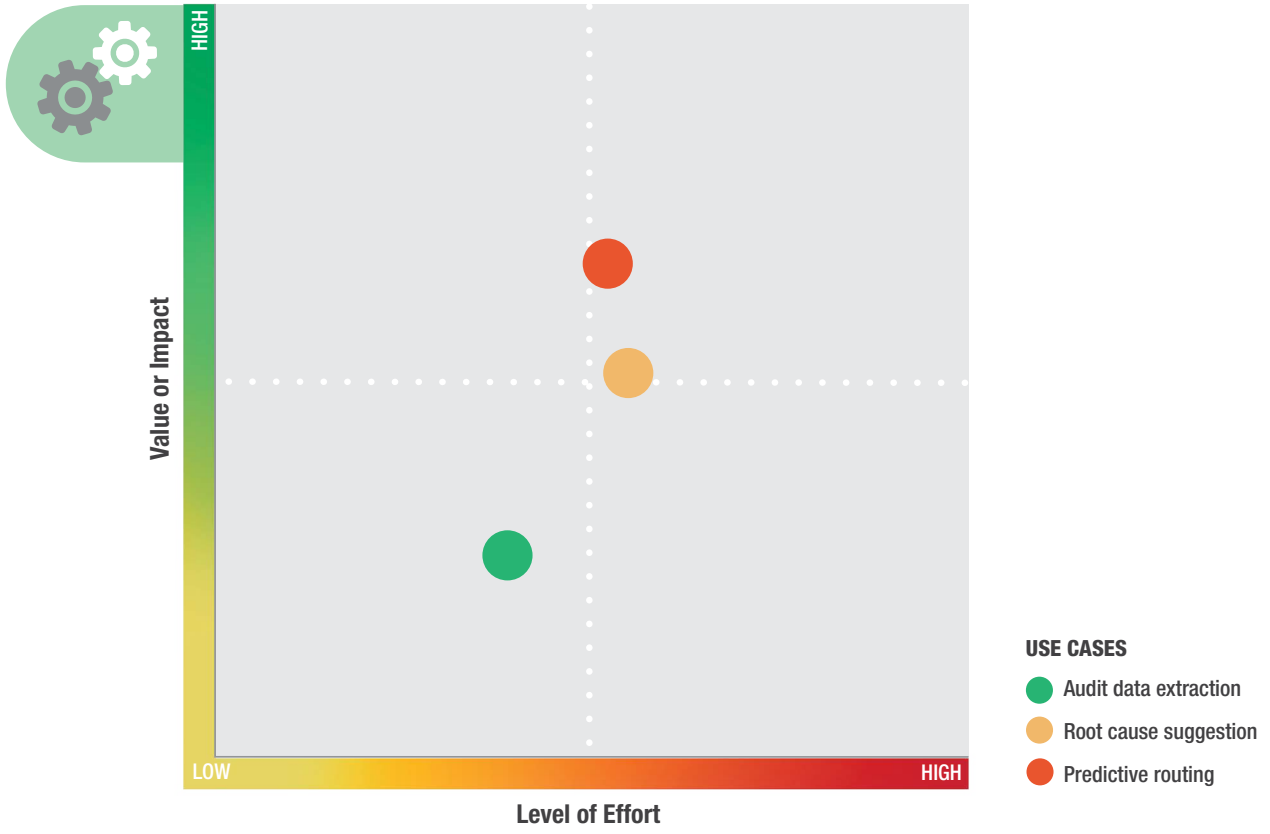


Use Cases | Robotic Process Automation *(Cont.)*

Audit data extraction is the use case with the greatest attention in this category by manufacturers, which is not surprising given the impact found in the survey data. In many industries, life sciences and automotive, for example, companies use audit data extraction to capture critical data from documents and reports; these are easily missed or delayed without automated tools to extract data. Predictive analysis routing is also a widely deployed and piloted use case.

The impact of audit data extraction appears mixed, even though industry has widely deployed it. Audit data extraction has not led to significantly higher quality or manufacturing metrics. The scale of effort is low, so companies should generally consider it a tactical choice. The other two RPA use cases each have higher impact and significantly more effort in implementation. LNS will watch RPA closely to see if it can live up to marketing hype or if it will be one more integrative workflow technology that has value only in specific use cases.

IMPACT/EFFORT INDEX: ROBOTIC PROCESS AUTOMATION USE CASES



Section 5

Recommendations and Resources

A View of the Forest Above the Trees: Quality 4.0 is Truly Transformative

Throughout this report, we discussed the impact and effort associated with 33 use cases and illustrated the impact/effort index across them. However, getting a sense of the big picture is just as important for leaders across industrial companies.

EVERY COMPANY MUST HAVE A VISION FOR THE FUTURE. Quality 4.0 and digitalization are foundations for a new business model — corporations that are interconnected, seamless, and empowered. Our research on IX readiness showed that transformation doesn't come from technology, but rather from process changes enabled by collaborative technologies. This report shows that it is equally true for Quality 4.0 specifically. The most fundamental process change is to move quality as a standalone process executed by a low-profile department to a core part of the corporation's fabric: core in traditional quality domains like compliance and also more widely across the enterprise in activities such as the product development process. Quality 4.0 will, over time, allow the quality organization to focus on real business improvement as it automates its role in collecting, aggregating, contextualizing and interpreting data. There is real and hard work to get there. The industrial company must capture and analyze data. It must also build data flows and models, and leverage and regularly improve intelligent algorithms. Despite the effort, the payoff is real. Ultimately, it will automatically and intelligently enforce quality control while quality assurance becomes proactive and the dominant focus of a tightly integrated department.

THE ROLE OF THE QUALITY ORGANIZATION MUST FUNDAMENTALLY SHIFT. Quality leaders have the opportunity and the responsibility to take a seat "at the grown ups' table." Companies and the people throughout them often view the quality function as a necessary evil or even an insurance program; even better if they are never seen. Quality 4.0 offers the quality department the chance to engage more directly in the business. Leveraging customer experience data makes the quality organization core to the business. Driving better business results by reducing costs and improving quality and the customer experience earns it a higher status within the organization. The quality team should use that customer data to become embedded in the product development process. However, with power comes responsibility. If you know how to improve the business, can you still accept only a seat at the kids' table? No. Quality leaders must leverage Quality 4.0 to drive greater responsibility in this new world order.

The most fundamental process change is to move quality as a standalone process executed by a low-profile department to a core part of the corporation's fabric.

Recommendations: Time is of the Essence

The research and findings are compelling: IX and quality transformation leaders are creating competitive advantage for their companies by aggressively pursuing transformation and digitalization. Every industrial organization should take IX steps now or risk losing ground to competitors.

ACOMMIT TO IX, NOW: A major takeaway from the research is that IX and Quality 4.0 early adopters have achieved dramatic results. They are improving the quality of products, better meeting customer needs, and improving business performance.

QUALITY MUST GET IN THE DRIVER'S SEAT. Quality teams must take an active leadership role in Quality 4.0 because while it is fueled by technology, the true transformation occurs in culture of quality, leadership, and quality processes. Quality 4.0 offers the quality leader the opportunity to embed more deeply and pervasively in the corporation's business and the responsibility to drive change.

LEVERAGE LESSONS LEARNED FROM EARLY ADOPTERS. LNS Research identified five clusters of best practices in its IX readiness study. The Quality 4.0 data here provides equally powerful insights for industrials. Quality's role must consistently expand to include the voice of the customer through customer experience use cases. The hard reality of customer assessment drives the most improvement in manufacturing and quality. Overall, LNS Research found the following Quality 4.0 use cases have the most impact for the level of effort required:

- Online marketplace: five-star data analysis and product benchmarking
- Online marketplace: semantic analysis to characterize reviews
- Warranty data: statistical predictions
- Customer complaints: statistical predictions
- Inspection optimization
- Engagement and retention apps
- Connected training
- Predictive routing

Reference the use cases to understand which ones are deployed repeatedly, and how to build from one use case to the next.

ACCEPT THAT IX AND QUALITY 4.0 ARE ABOUT BUSINESS TRANSFORMATION. Use Quality 4.0 as an opportunity to transform business outcomes, culture, leadership, competencies, processes, and collaboration.

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.)*

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
View Research →

INDUSTRY FOCUS

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

AUTOMOVTIVE AND A&D RESEARCH | Manufacturing Performance: Automotive and A&D Gaining Momentum with Analytics
View Research →

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

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

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

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

QUALITY 4.0: THE QUALITY INNOVATION FOUNDRY

Use Cases Continue to Emerge as Market Matures

Author:

Tom Comstock

Principal Analyst

tom.comstock@lns-global.com

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