Manufacturing in the
Age of AI
Progress and Expectations

Julie Fraser, Vice President

Speeding the Loop from Data to Effective Action

Subtitle

Despite challenging supply chain situations, manufacturers are making progress toward Industry 4.0. Most understand that artificial intelligence (AI) and improved analytics can lead to better decisions and, thus, business benefits. However, creating the data management structure for success is something many are still learning. This research shows how Top Performing companies are making more significant strides than others. In short, they understand, invest in, and make the most of many aspects of people, process, and technology. Together, they enable capabilities that close the loop from data to information to insights to decisions and to profitable, timely action.

Tech-Clarity

Table of Contents

Progress on Industry 4.0

Industry 4.0 Vision

The future of manufacturing is more flexible, agile, and responsive based on AI and intelligent automation. This is the vision of Industry 4.0, which goes by many other names. While the concept encompasses the entire enterprise and supply chain, the manufacturing area often poses the most significant challenges and opportunities for gaining substantial benefits.

Three Years of Progress

When manufacturers embark on an Industry 4.0 initiative, they typically know it will be a multi-year journey. What we see is that most companies are now well on their way. There has been clear progress since our survey, The Manufacturing Data Management Challenge,[1] in 2020. A much more significant percentage of respondents' companies have made tremendous progress toward Industry 4.0 and gained benefits already.

INDUSTRY 4.0 PROGRESS 2020 VS. 2023

	2023	2020
Signifcant Progress and Results	24%	15%
Many Initiatives Underway	27%	23%
Several Projects	27%	26%
One Project	8%	11%
Planning, Not Yet Executing	10%	12%
No Strategy Yet	4%	13%

Tech-Clarity

Difficult Environment

TOP SUPPLY CHAIN CHALLENGES IMPACTING MANUFACTURING

- Materials shortages — **59%**
- Wide fluctuations in demand patterns — **46%**
- Extra pressure on due dates — **41%**
- New materials / suppliers need extra testing — **33%**
- New materials with new processing specs — **30%**
- Constant flow of new materials and product changes — **28%**
- Possibility of plant closures — **14%**
- None of the above — **3%**

Up to three selected
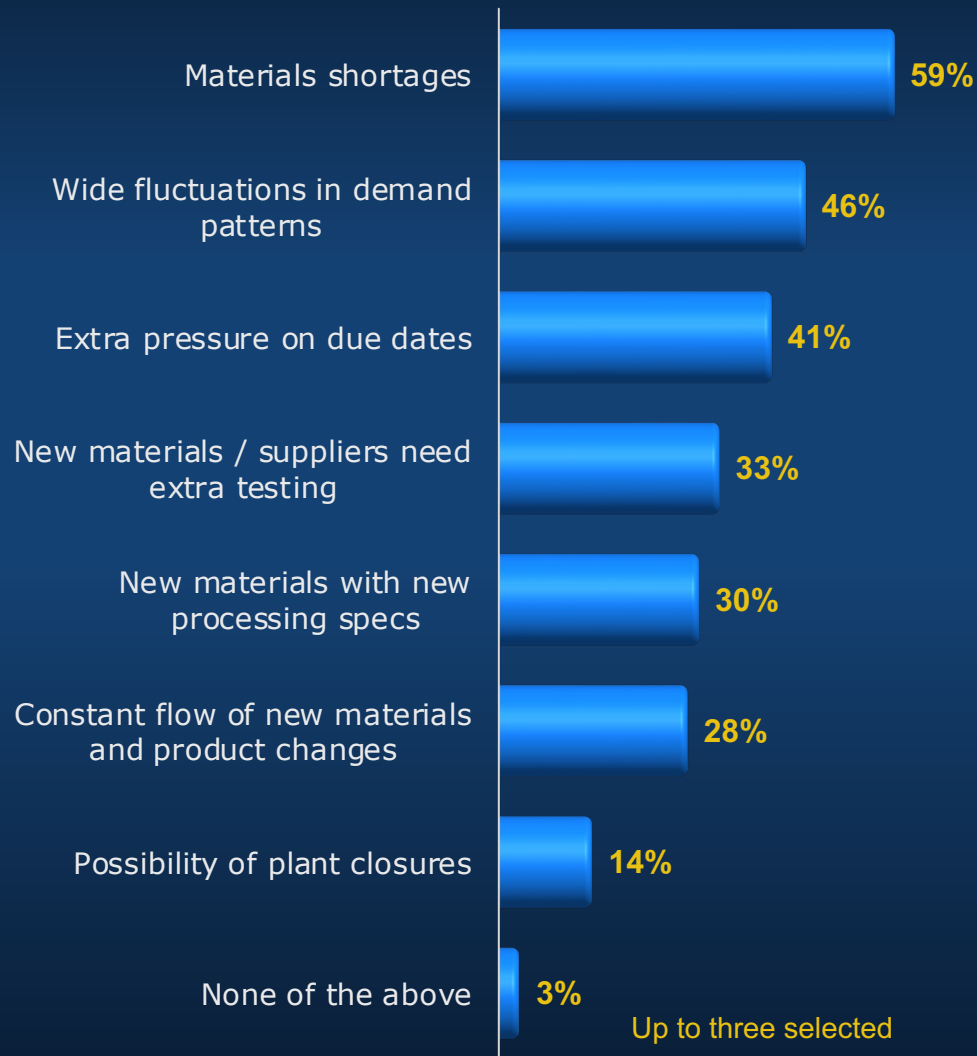
Time of Disruptions

The previous study was conducted just as the COVID-19 pandemic was taking hold. This one launched as it is finally easing. The materials shortages that most manufacturers experienced have not vanished in most cases. Geopolitical pressures are leading many companies to switch suppliers in onshoring, nearshoring, or friendshoring approaches.

Manufacturing Under Pressure

Both external supply chain circumstances and internal efforts to cope create additional challenges for manufacturing operations. As a supplier, many manufacturers see increased pressure on due dates and new customer expectations. As a customer, materials suppliers change, prices and availability fluctuate, and ensuring quality can be challenging.

Action in the Face of Ongoing Uncertainty

It is now apparent that supply chain volatility will not likely ease significantly. Given that demand patterns fluctuate widely and supply is uncertain, companies must ensure their operations are ready to respond. This includes the ability to change product mix, accommodate new materials, and overcome quality problems quickly and effectively. It's not enough to have data or even information. Companies must gain insights, make decisions, and act to preserve margins, quality, and customer confidence.

MANUFACTURING IN THE AGE OF AI: PROGRESS AND EXPECTATIONS

Tech-Clarity

Keys to Success

Data Management

When asked how important various types of manufacturing data management capabilities and technologies are to Industry 4.0 success, most manufacturers agree they are critical or important. Topping the most commonly viewed as essential is consistent data management. With the wide variety of types and sources for data in manufacturing, this is more difficult than it sounds – and more critical to success. The more detailed concept of putting OT data into context with plant IT data was also high on the list.
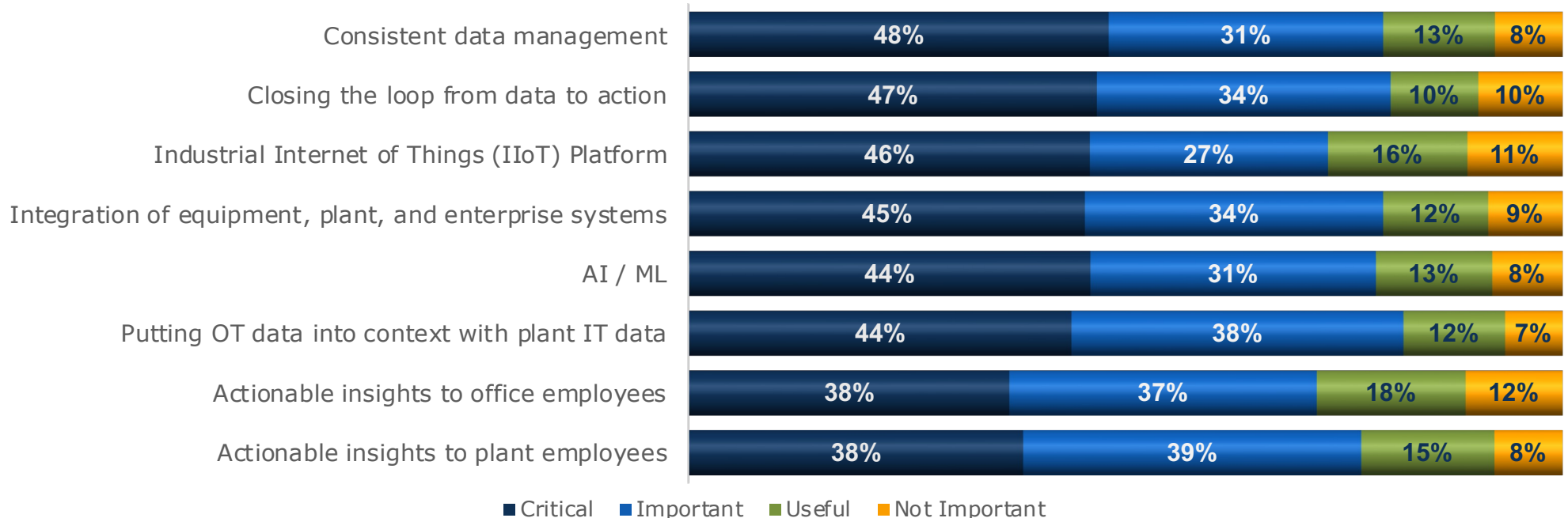
Intelligence and Analytics

One key process benefit from good data management is closing the loop from data to information to insights to decisions to action. Four of five survey respondents agree that this is critical or important to their Industry 4.0 success. Two specific aspects of this, delivering actionable insights to employees in the plant and offices, did not score quite as high, but it's still a resounding majority.

Integrated Technology for Effective Action

Most manufacturers plan to use technologies to close the loop efficiently, reliably, and quickly. The industrial internet of things (IIoT) can support gathering machine data. Integrating equipment, plant, and enterprise systems has been a goal for decades and continues to be a foundation for Industry 4.0 success. Artificial intelligence (AI) and machine learning (ML) enable analytics across the many diverse data sets relevant to manufacturing outcomes. These, too, score high.

IMPORTANCE OF VARIOUS ELEMENTS TO INDUSTRY 4.0 SUCCESS

Element	Critical	Important	Useful	Not Important
Consistent data management	48%	31%	13%	8%
Closing the loop from data to action	47%	34%	10%	10%
Industrial Internet of Things (IIoT) Platform	46%	27%	16%	11%
Integration of equipment, plant, and enterprise systems	45%	34%	12%	9%
AI / ML	44%	31%	13%	8%
Putting OT data into context with plant IT data	44%	38%	12%	7%
Actionable insights to office employees	38%	37%	18%	12%
Actionable insights to plant employees	38%	39%	15%	8%

■ Critical ■ Important ■ Useful ■ Not Important

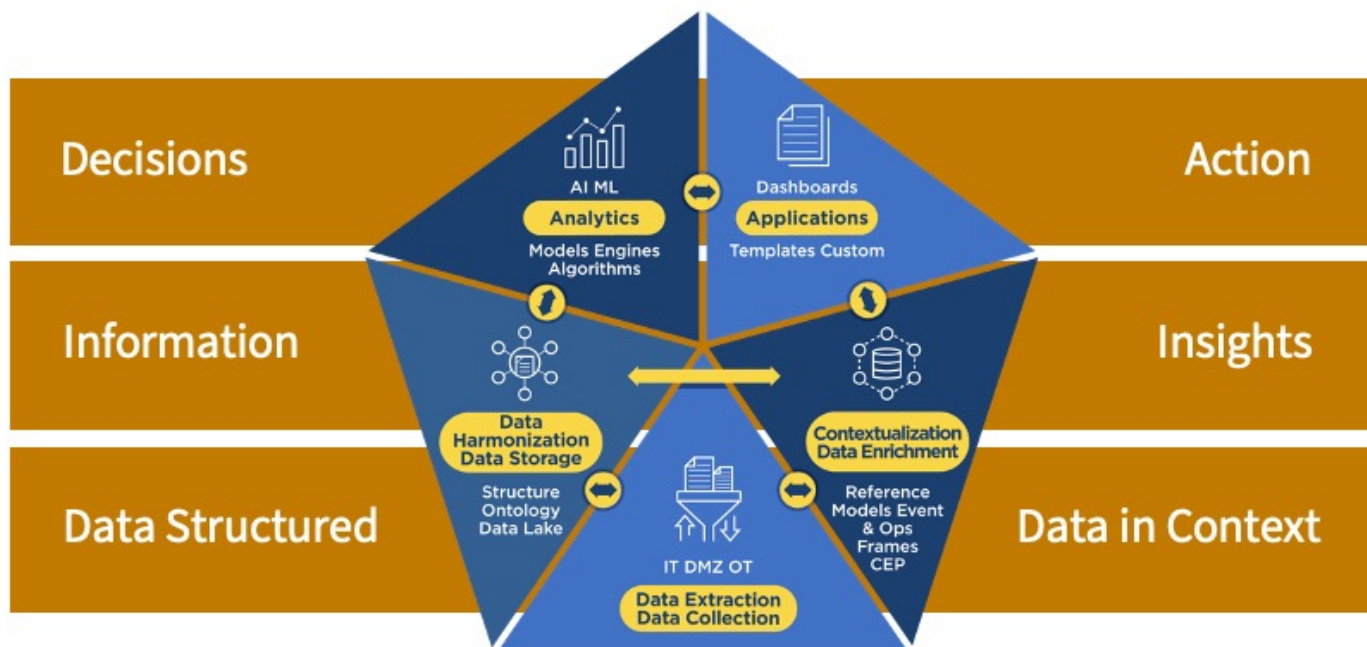Tech-Clarity

Closing the Loop from Data to Action

Data Management: A Conceptual View

For those who have yet to become versed in the challenges and nuances of manufacturing data management, we will provide a visual about data management for closing the loop. It explains the elements of a consistent manufacturing data management system at a conceptual level.

- At the bottom center of this diagram lies data collection and extraction. Whether from IT or OT, this is foundational – and where IIoT, sensors, and many applications where employees record actuals come into play.

- This data needs to be structured, harmonized, and stored to be useful. This process is complex, considering the vast array of machine and application data formats that change regularly.

- To the bottom right are data contextualization and enrichment. For example, take a machine data reading of 10; only with added context can you ascertain whether this was within the expected range.

- If not in range, additional context, such as the operator, lot of material, and ambient conditions, might deliver helpful information to paint a fuller picture of the situation. For example, the operator of that machine may know what to adjust or who to call.

- When analyzed, it might become an insight to help determine the root cause of a problem. This insight would then be more readily available.

- Insights enable better decisions. For example, will you hold all jobs using that lot of material or re-train an operator?

- The final aspect is ensuring effective action. Tying decisions to the triggers for action in the relevant manufacturing applications enables the agile, effective action that matters to profitability.
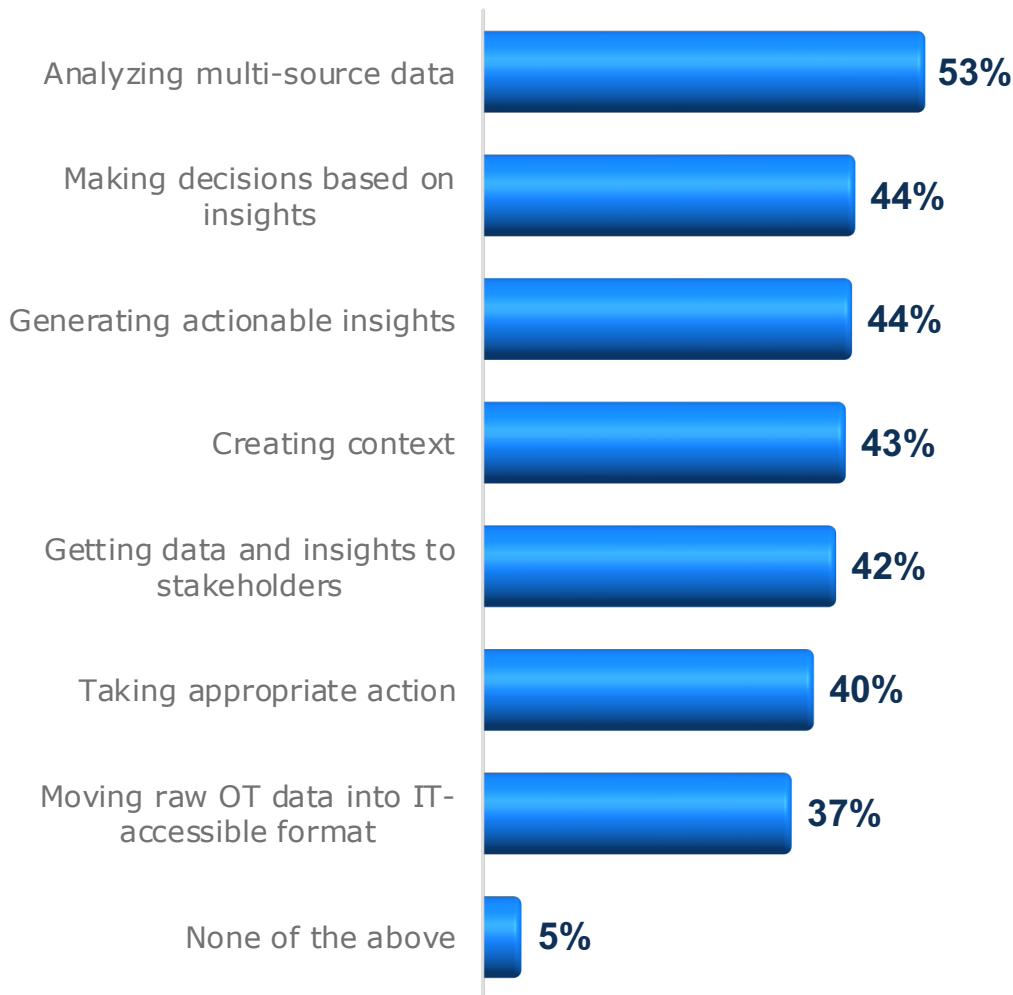
CONCEPTUAL VIEW OF MANUFACTURING DATA STRUCTURES AND ACTIVITIES

Tech-Clarity

Multiple Aspects to Master

GAPS IN THE DATA FLOW

Category	Percentage
Analyzing multi-source data	53%
Making decisions based on insights	44%
Generating actionable insights	44%
Creating context	43%
Getting data and insights to stakeholders	42%
Taking appropriate action	40%
Moving raw OT data into IT-accessible format	37%
None of the above	5%

The Goal: Closing the Loop

As the graphic on the previous page suggests, establishing consistent and complete manufacturing data management is multi-faceted. Ideally, information flows from its origin to storage, harmonization, enrichment, through analysis for decision-making, and into applications for action. We call this closing the loop from data to action – but it is genuinely complex.
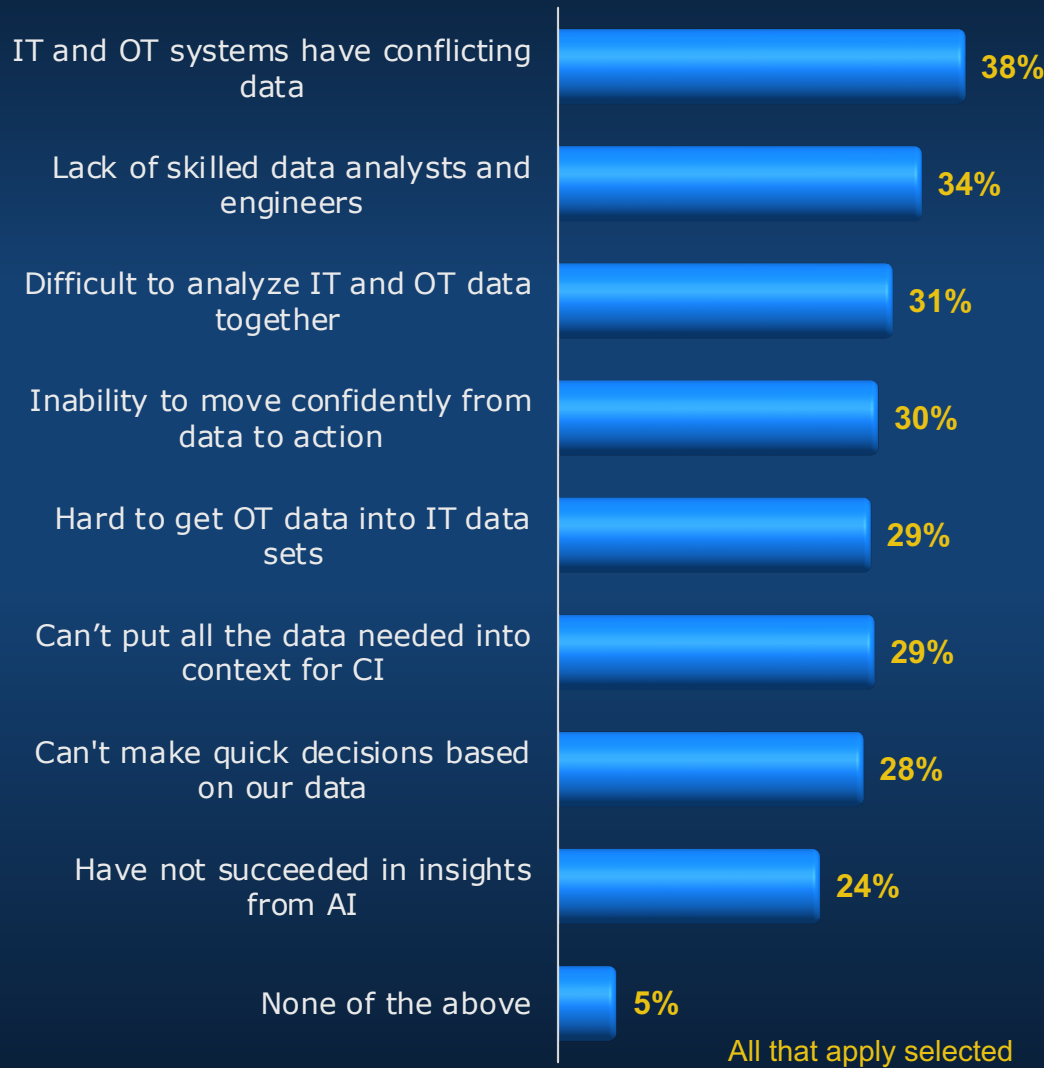
The Reality: Gaps in Data Flow

In reality, most companies have gaps in their data flow. In our survey responses, only 5% report not having manual handoffs at any of the seven points we listed. More than half of the manufacturers in this sample report a gap in the data flow at analyzing data from various sources. This may be top of mind as companies embark on advanced analytics and big data projects. Gaps exist for many at every stage, from moving OT data into a format for IT use to creating context, generating insights, making decisions, and taking appropriate action.

Suboptimal Results

Every time there is a manual handoff of data or information, the process slows down and is open to the risk of errors. Decision and action delays often mean lost time, material, and profit. In today's competitive markets, manufacturers can ill afford any of those.

Tech-Clarity

Challenges in Manufacturing Data Management

CHALLENGES IN MANUFACTURING DATA MANAGEMENT

Challenge	Percentage
IT and OT systems have conflicting data	38%
Lack of skilled data analysts and engineers	34%
Difficult to analyze IT and OT data together	31%
Inability to move confidently from data to action	30%
Hard to get OT data into IT data sets	29%
Can't put all the data needed into context for CI	29%
Can't make quick decisions based on our data	28%
Have not succeeded in insights from AI	24%
None of the above	5%

All that apply selected

Data Issues

Manufacturers face various challenges with manufacturing data management and closing the loop from data to action. The most commonly selected issue was that IT and OT systems have conflicting data. Lacking a way to harmonize can lead to frustration for all involved. Respondents also wrote in: lack of data collection in real-time for analytics; data inconsistencies.

Staffing

The second most common challenge is part of the broader manufacturing skills shortage: a lack of skilled data analysts and engineers.[2] The combination of data skills and an understanding of the specific needs for data and analysis in manufacturing is currently rare. One of the respondents who chose 'Other' wrote: "Staffing at all levels."

Processes

The extensive set of processes presents many issues. Challenges start with getting OT data into IT data sets. Others include adding context, analyzing IT and OT data together, gaining insights from AI, and confidently moving from data to action. One respondent wrote: "Difficult to merge data from many different locations for an overall global perspective analysis." Only 5% report not having any of those challenges.

Technology

Some additional responses in the Other field for this question include old systems that are difficult to migrate to new ones. Fragmented systems, upgrading systems, and the cost of implementing new systems.

Tech-Clarity

Integration Still Obstructs Progress

Helping Data Flow

Gaps and challenges suggest a need for integration between manufacturing systems. Unfortunately, most companies still expend tremendous effort creating and maintaining that integration. When systems are not fully integrated, manual processing gaps are inevitable. There are also challenges such as conflicting data from various systems.
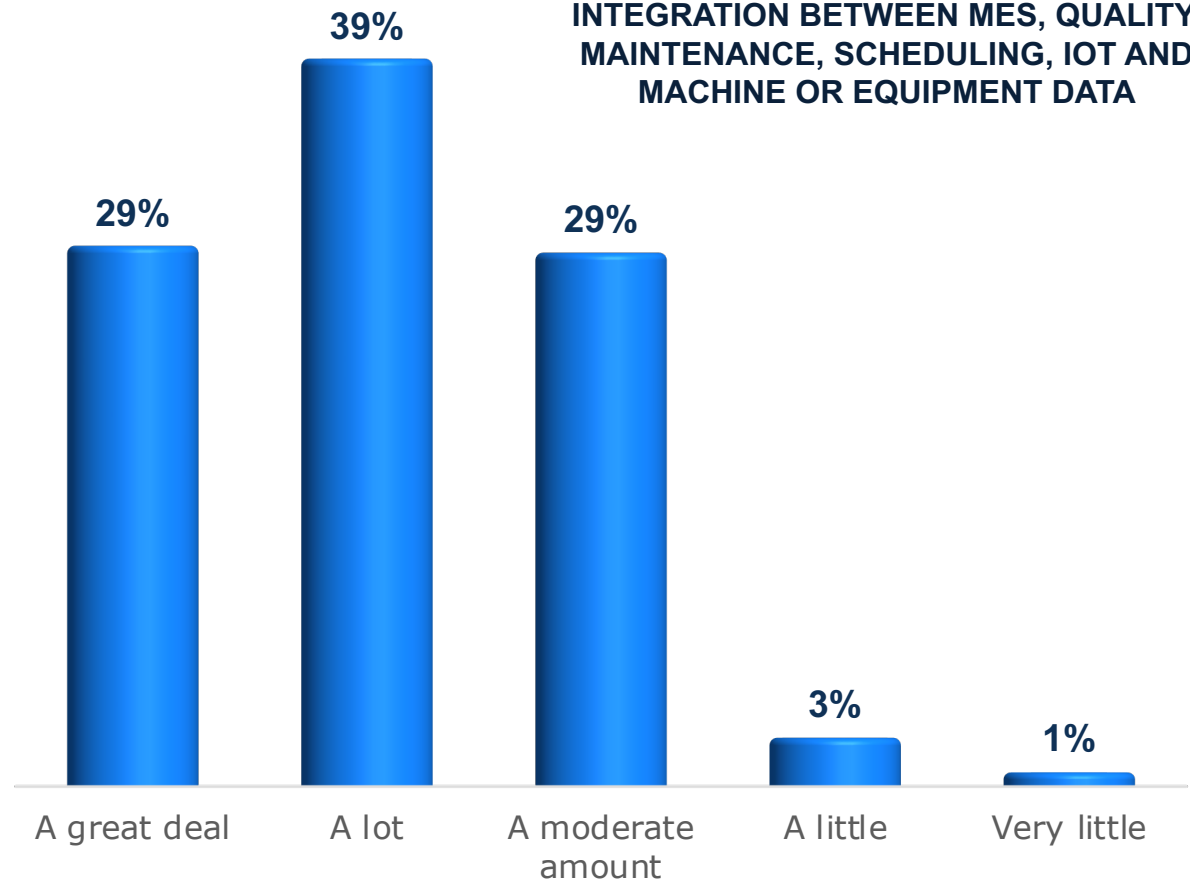
Not Improving from 2020

Though companies are making strides toward Industry 4.0, it's not because they have resolved the integration issue. This response base is more likely to say integration is a lot of work than the previous study's group. We suspect that this is because Industry 4.0 projects are pushing them to integrate more fully, raising awareness about the amount of time and effort companies are spending.

Possible Fix

Part of the challenge is that many companies have separate systems for tracking, operator guidance or work instructions, quality,

maintenance, scheduling, IoT, and equipment data collection. More comprehensive manufacturing software suites might include more of those. If a single system inherently handles those, integration challenges should diminish noticeably.

AMOUNT OF TIME, EFFORT, AND EXPERTISE REQUIRED TO INTEGRATE AND MAINTAIN INTEGRATION BETWEEN MES, QUALITY, MAINTENANCE, SCHEDULING, IOT AND MACHINE OR EQUIPMENT DATA

Bar chart:

Category	Value
A great deal	29%
A lot	39%
A moderate amount	29%
A little	3%
Very little	1%

MANUFACTURING IN THE AGE OF AI: PROGRESS AND EXPECTATIONS

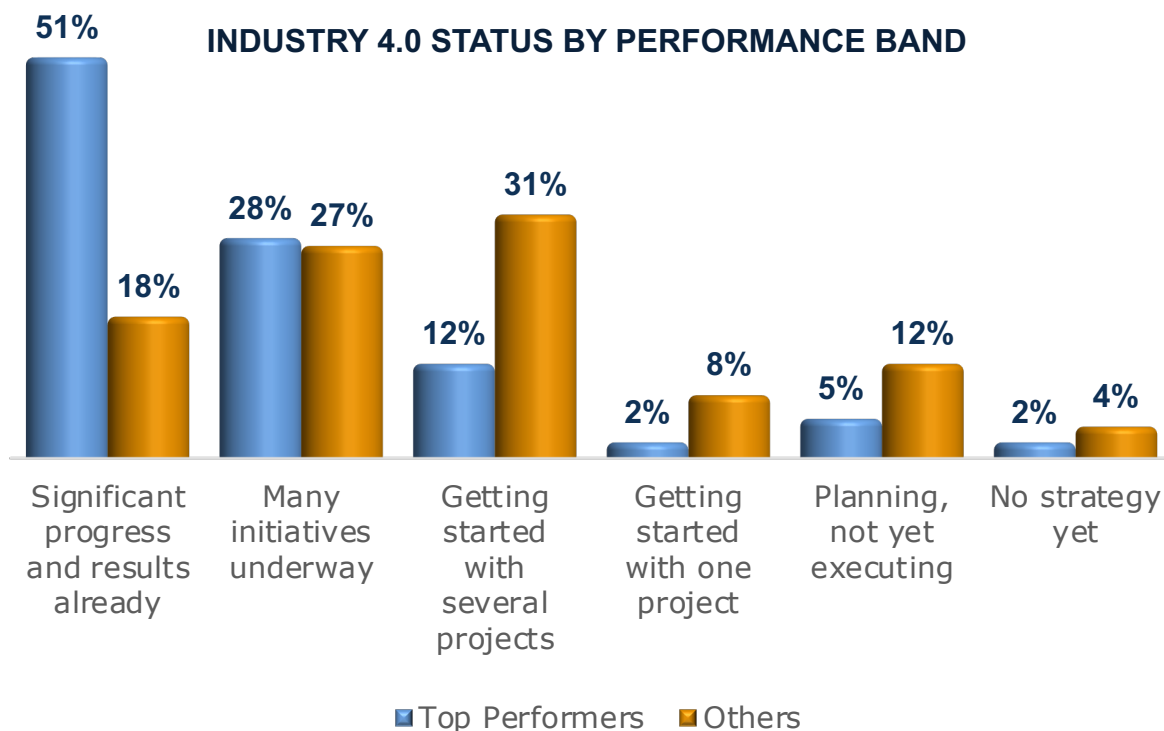Tech-Clarity

Improvement is Possible: Top Performers

Top Performers Show the Way

So far, we've focused on challenges and obstacles to success. However, some companies are having outstanding success and making rapid progress. The sidebar defines these Top Performers.
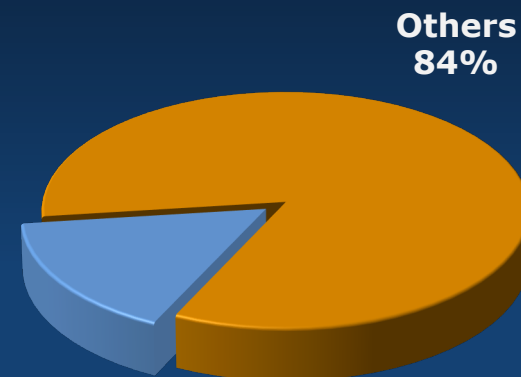
Progress on Industry 4.0 and Data Management

Over half of the Top Performers have made significant progress on Industry 4.0 and are already seeing results. They have many other characteristics that distinguish them from Others in this study. The following several sections will focus on what is different, so everyone can consider how to do some of that in their companies.

RESPONDENTS BY PERFORMANCE BAND

Others 84%

Top Performers 16%

INDUSTRY 4.0 STATUS BY PERFORMANCE BAND

Category	Top Performers	Others
Significant progress and results already	51%	18%
Many initiatives underway	28%	27%
Getting started with several projects	12%	31%
Getting started with one project	2%	8%
Planning, not yet executing	5%	12%
No strategy yet	2%	4%

■ Top Performers   ■ Others

Defining Top Performers

Those who have both excellent agility and continuous improvement are Top Performers (scoring 5 out of 5 on both of these capabilities). They make up **16%** of the total responses.

Agility: Ability to adapt quickly to change (and support targeted product mix while maintaining good plant efficiency and quality)

Continuous improvement: Speed and effectiveness of identifying issues and making beneficial decisions and changes

Tech-Clarity

Understand All the Issues Matter

MANUFACTURING DATA MANAGEMENT ISSUES RATED AS 'CRITICAL TO INDUSTRY 4.0 SUCCESS' BY PERFORMANCE BAND

Industrial Internet of Things (IIoT) platform
- Top Performers: 74%
- Others: 41%

Closing the loop from data to info, insight, decision, action
- Top Performers: 69%
- Others: 43%

Advanced analytics AI/ML
- Top Performers: 68%
- Others: 40%

Consistent data management across OT and IT
- Top Performers: 67%
- Others: 45%

Integration of equipment, plant, and enterprise systems
- Top Performers: 62%
- Others: 43%

Actionable insights to plant employees
- Top Performers: 55%
- Others: 35%

Putting OT data into context with plant IT data
- Top Performers: 55%
- Others: 42%

Actionable insights to office employees
- Top Performers: 45%
- Others: 32%

■ Top Performers
■ Others

Knowledge Foundation

Industry 4.0 is a vision – and most of these Top Performers have committed to that. To get to the point of having made progress, they most likely have had to delve into many aspects of what Industry 4.0 requires. Education and understanding are vital jumping-off points for manufacturing data management at the heart of Industry 4.0.

Not Over-Simplifying

As the chart shows, most Top Performers believe that nearly all issues we mention about manufacturing data management are crucial to their success with Industry 4.0. This more consistent understanding shows that they are not trying to focus on just one aspect or angle, but know they will need to cover many bases.

Tech-Clarity

Launch Initiatives to Address the Issues

Acting on Convictions

It is one thing to understand what might lead to success, but another entirely to take action to address those facets. Top Performers also are more likely to have initiatives to address the facets they believe will lead to Industry 4.0 success. There is always a lag between understanding and action, so the slightly lower numbers are not surprising.
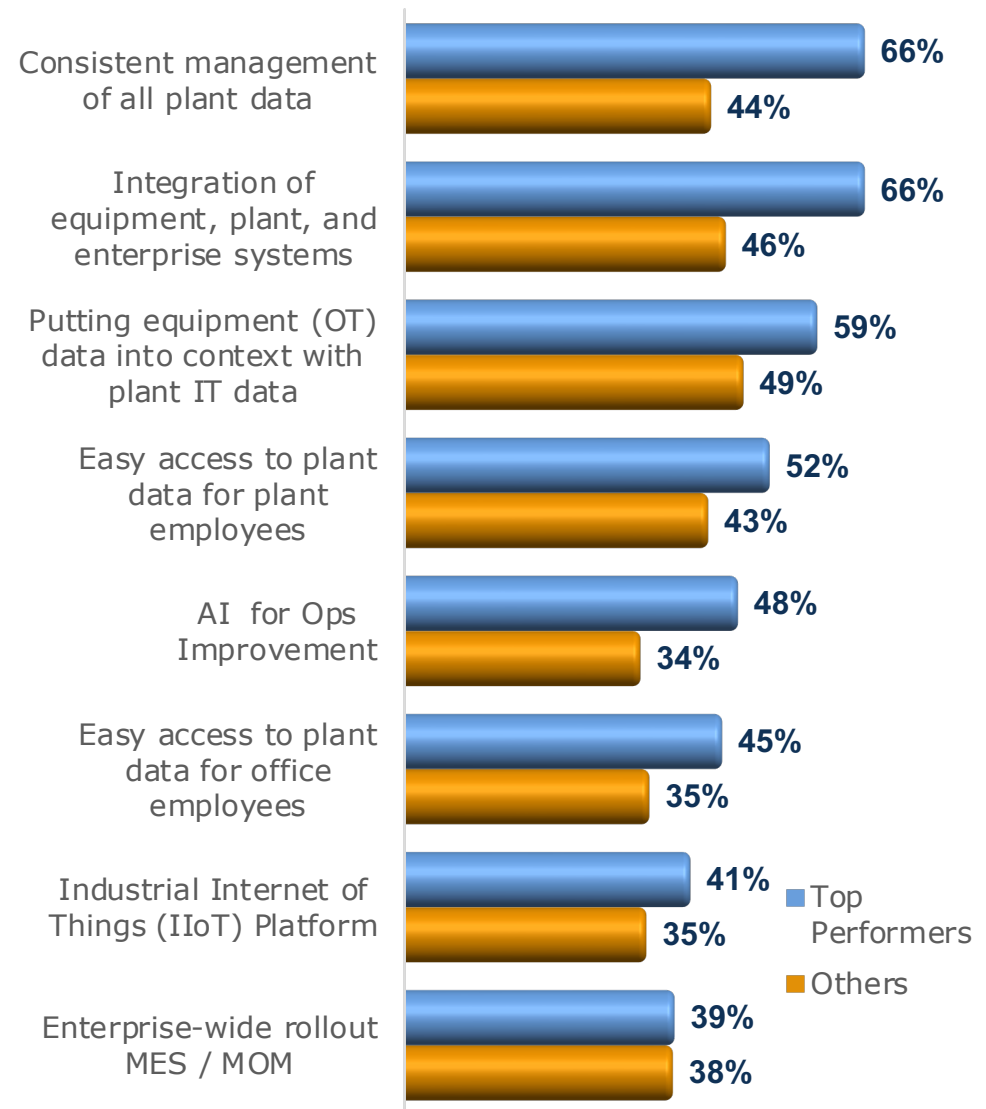
Outcomes Focused

The top four most common initiatives are focused on capabilities and integration. Consistent manufacturing data management, integration, and data access projects can deliver a foundation for success with Industry 4.0. Putting OT data into context with plant IT data is a crucial and challenging aspect of data management. These focus on reversing the IT/OT divide.

Key Technology Initiatives

Initiatives for specific technologies such as AI for operations improvement, IIoT platform, and MES/MOM rollouts are also common. These can support data management capabilities and employee access to needed data.

MANUFACTURING DATA MANAGEMENT PROJECTS OR INITIATIVES BY PERFORMANCE BAND

Initiative	Top Performers	Others
Consistent management of all plant data	66%	44%
Integration of equipment, plant, and enterprise systems	66%	46%
Putting equipment (OT) data into context with plant IT data	59%	49%
Easy access to plant data for plant employees	52%	43%
AI for Ops Improvement	48%	34%
Easy access to plant data for office employees	45%	35%
Industrial Internet of Things (IIoT) Platform	41%	35%
Enterprise-wide rollout MES / MOM	39%	38%

■ Top Performers
■ Others

Tech-Clarity

Improve Organizational Structure
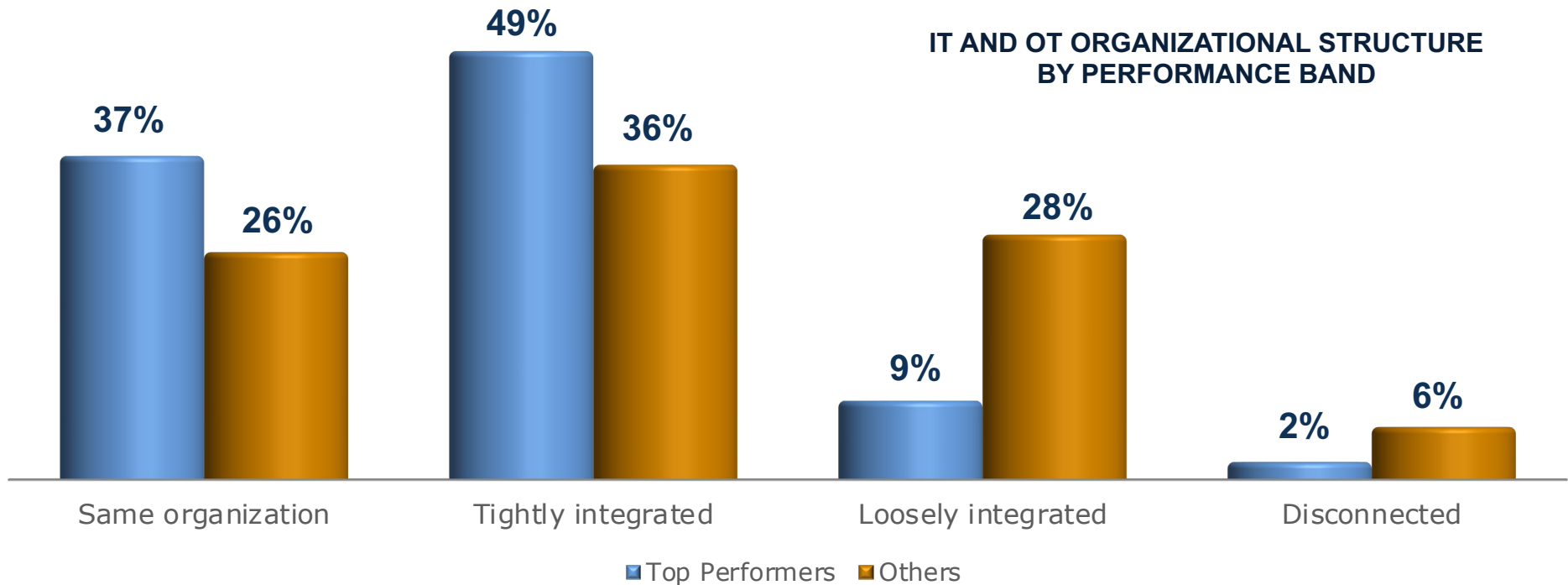
Integration of IT and OT

Historically, automation or operations technology (OT) focused on keeping the production process running as efficiently and effectively as possible, while IT focused on standardizing, upgrading, and security issues for the technology itself. The differences in priority and understanding have created rifts over the decades where many companies' OT team intentionally kept their IT team out of the plant. This is no longer viable.

Combined Data Management

When the people who own the IT and OT data and processes work for the same boss or are tightly integrated, it is much more likely that they will begin to understand each others' needs and succeed in combining IT and OT data and managing it consistently and intelligently.

Improving over Time

The portion of companies who have combined IT and OT into one organization has increased dramatically since 2020 (37% vs. 20% of top performers and 26% vs. 14% of Others). Everyone has been learning and moving toward Industry 4.0, so this is not entirely surprising. Expectations for intelligent operations with minimal on-site staff during the pandemic may have also driven some of this progress.

IT AND OT ORGANIZATIONAL STRUCTURE BY PERFORMANCE BAND

	Same organization	Tightly integrated	Loosely integrated	Disconnected
Top Performers	37%	49%	9%	2%
Others	26%	36%	28%	6%

■ Top Performers   ■ Others

Tech-Clarity

Succeed in Staffing

Building Out the Industry 4.0 Team

Industry 4.0 is often called digital transformation –it's also a transformation of what personnel a manufacturer needs to succeed. If the objective is to have smooth-flowing data, put it in context, and analyze it with AI or ML, there are new players who might not have been considered previously.

ROLE	TOP PERFORMERS FULLY STAFFED	TOP PERFORMERS EXPANDING STAFF	OTHERS FULLY STAFFED	OTHERS EXPANDING STAFF
Data Scientists	38%	45%	18%	35%
Data Engineers	48%	38%	26%	32%
MES Specialists	38%	45%	19%	37%
Production Experts	48%	33%	26%	31%
Liaison IT/OT	46%	41%	25%	30%
CDO/I4.0 Lead	50%	40%	24%	26%
Change Management	46%	39%	24%	33%

MANUFACTURING IN THE AGE OF AI: PROGRESS AND EXPECTATIONS

Tech-Clarity

Overcoming Skills Shortages

Top Performers Better Staffed

We asked about staffing for some specific roles. Top Performers are radically more likely to be fully staffed or expanding staff for these roles. By having extraordinary capabilities and understanding all the facets needed to succeed with Industry 4.0, these companies are attracting talent more successfully than others.

IT Roles

Earlier on page 9, we saw that the #2 challenge is a lack of skilled data scientists and engineers. Both roles are critical to success, and far more Top Performers are fully staffed than Others. MES Specialists are a familiar category but are in very short supply worldwide. A liaison between IT and OT can support teams that are not already integrated – or even those that are.

Other Skills

At the top is a Chief Digital Officer or Industry 4.0 lead to keep the vision of Industry 4.0 moving prioritize activities and investments. Half of the Top Performers are fully staffed in this area, twice the proportion of Others at 24%. Many manufacturers have attempted to progress on Industry 4.0 as an IT project with limited success; they now know production experts are essential to success. Change management is another scarce skill that many Top Performers have found to support their transformation.
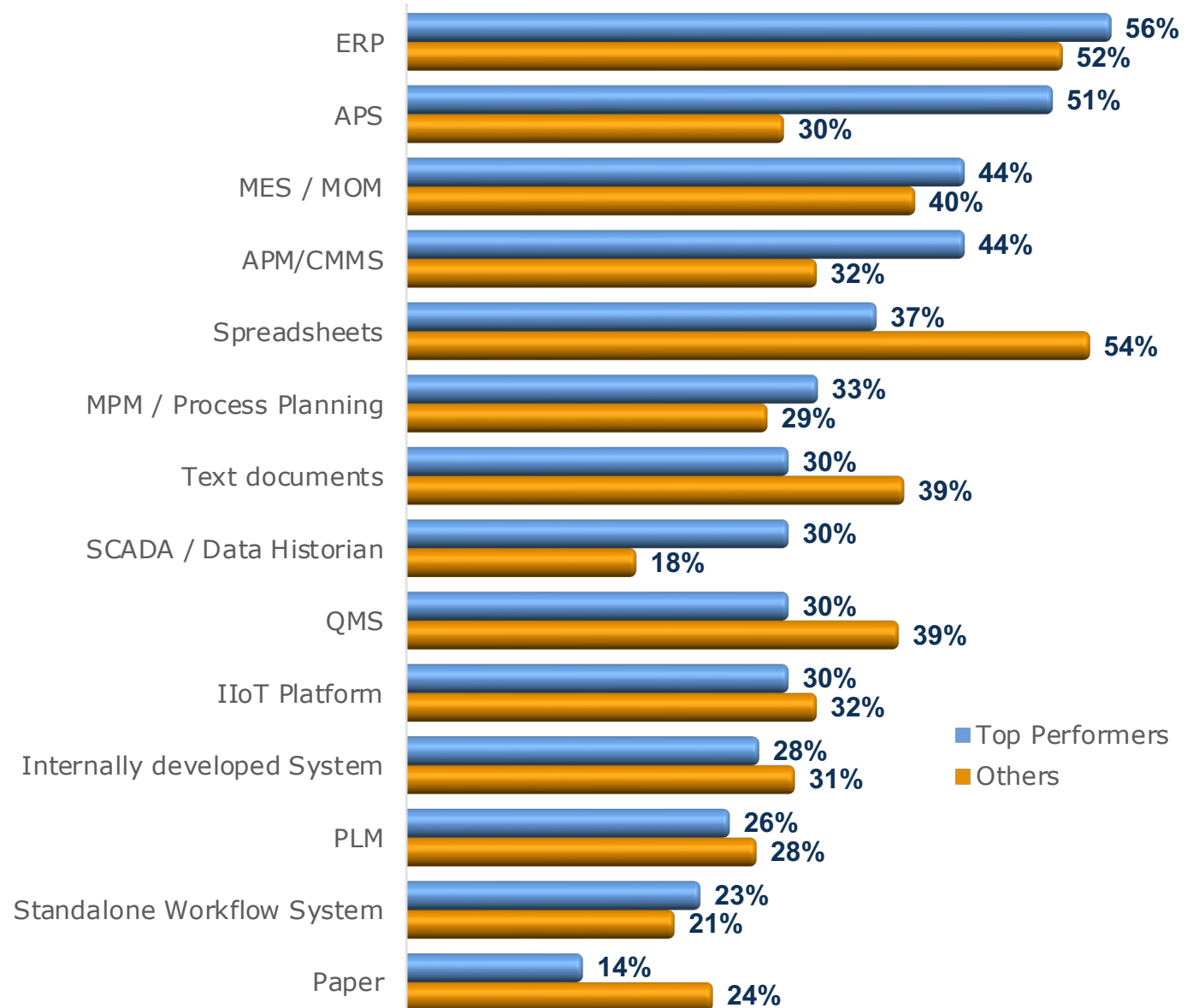
Tech-Clarity

Leverage Commercial Applications

Software Support

While the transformation of Industry 4.0 requires organizational, people, and process change, these are enabled by technology. Sustaining processes and initiatives is far easier when application software designed for best practice ways of working is in place. It works even better when it's flexible enough to support ongoing continuous improvement.

Paperless and More

Top Performers are leveraging a wide array of applications to manage their manufacturing operations. Top Performers are also less likely than Others to use paper, text documents, spreadsheets, or homegrown systems. They are also less likely to use document-centered systems such as traditional quality management systems (QMS).
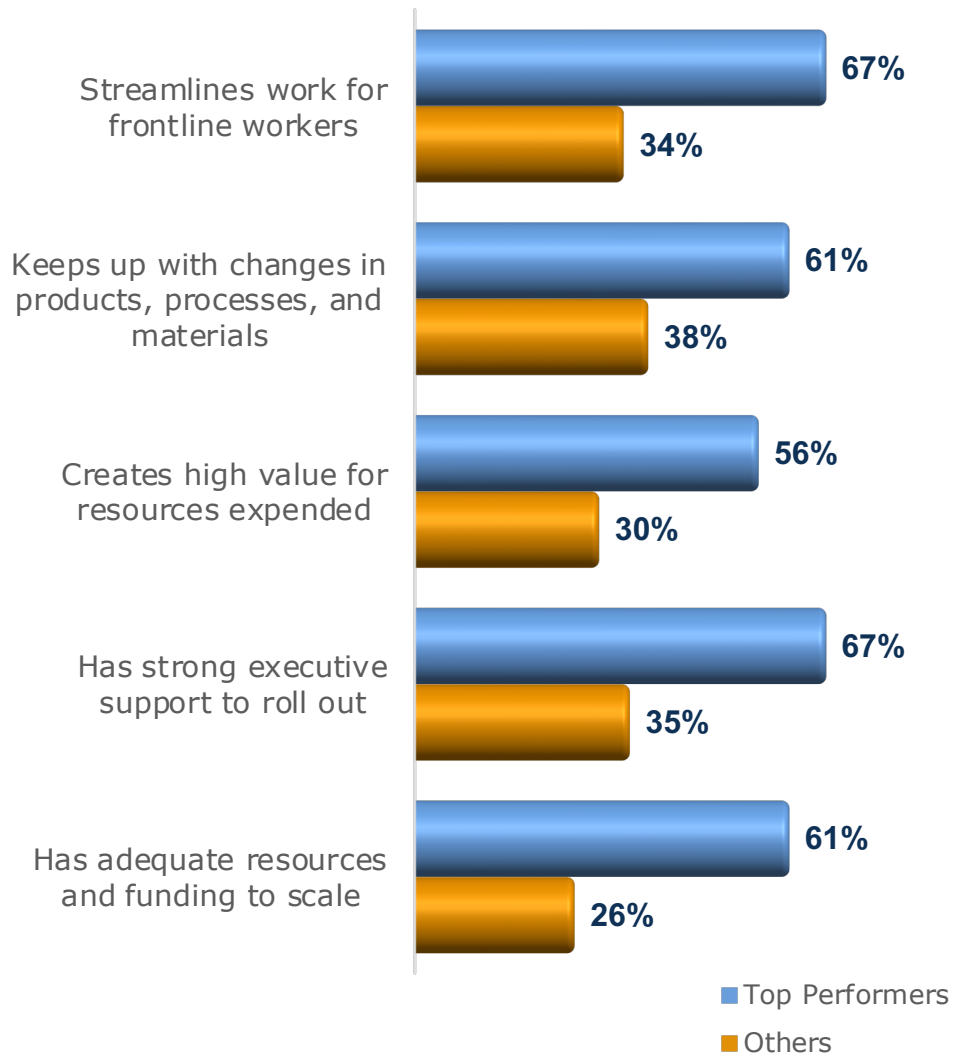
PRIMARY SYSTEM FOR MANAGING PRODUCTION OPERATIONS

	Top Performers	Others
ERP	56%	52%
APS	51%	30%
MES / MOM	44%	40%
APM/CMMS	44%	32%
Spreadsheets	37%	54%
MPM / Process Planning	33%	29%
Text documents	30%	39%
SCADA / Data Historian	30%	18%
QMS	30%	39%
IIoT Platform	30%	32%
Internally developed System	28%	31%
PLM	26%	28%
Standalone Workflow System	23%	21%
Paper	14%	24%

■ Top Performers
■ Others

All that apply selected

MANUFACTURING IN THE AGE OF AI: PROGRESS AND EXPECTATIONS

Tech-Clarity

Have Better Experience with MES

STRONGLY AGREE MES IS PERCEIVED AND BACKED WELL BY PERFORMANCE BAND

Streamlines work for frontline workers
- Top Performers: 67%
- Others: 34%

Keeps up with changes in products, processes, and materials
- Top Performers: 61%
- Others: 38%

Creates high value for resources expended
- Top Performers: 56%
- Others: 30%

Has strong executive support to roll out
- Top Performers: 67%
- Others: 35%

Has adequate resources and funding to scale
- Top Performers: 61%
- Others: 26%

■ Top Performers
■ Others

Quality of MES

The quantity of Top Performers who use MES (44%) is similar to Others (40%). And yet, the quality is another story. Top Performers' companies' perceptions of MES are very different. It seems MES is more likely to be a respected Enterprise application in Top Performers.
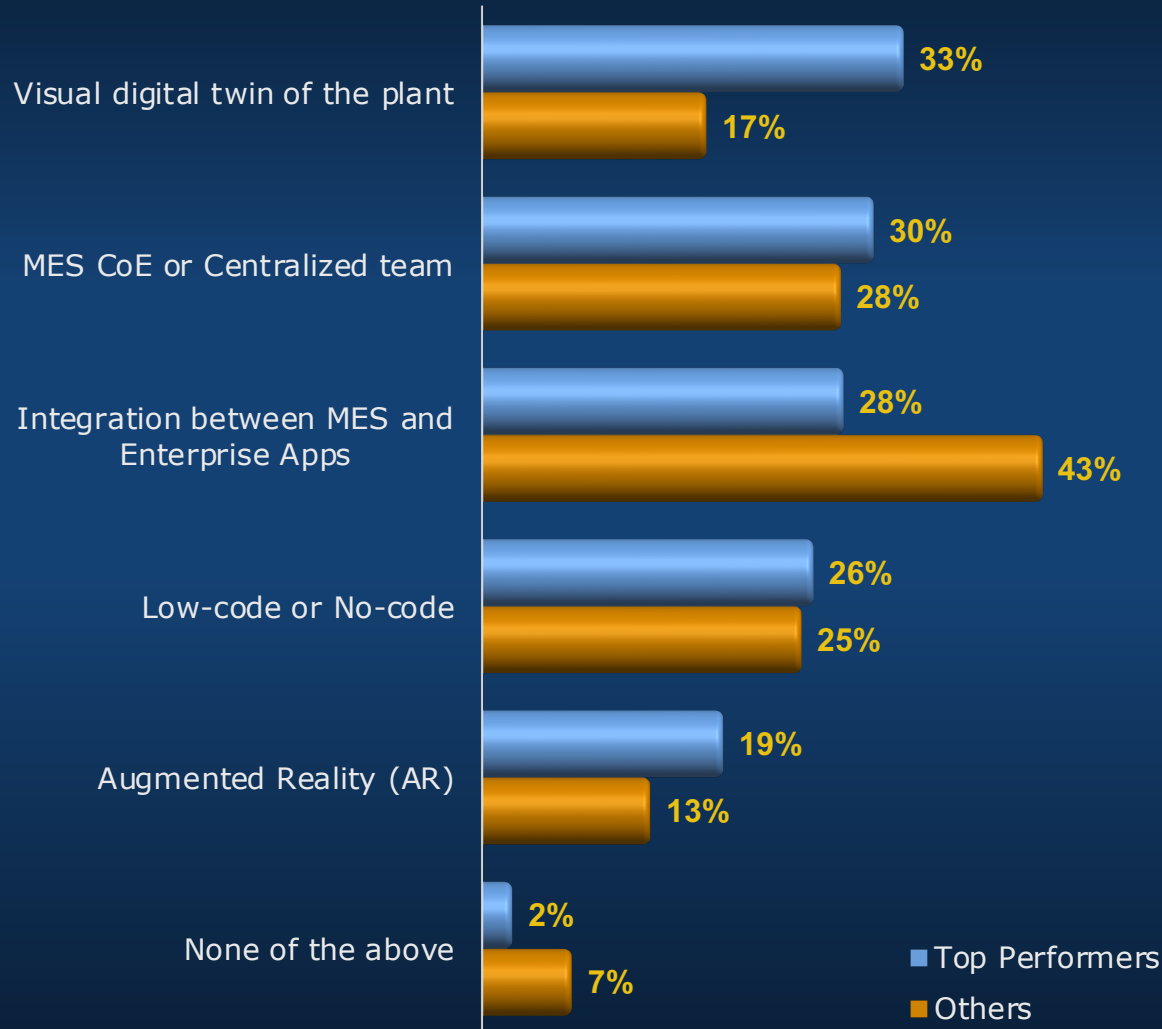
Support for MES

Over two-thirds of top performers feel their MES has strong executive support to roll out. And over 60% feel MES has adequate resources and funding to scale. With this backing, the Top Performers are far more likely to succeed in their scale-up and roll-out.

MES Benefits

The support is natural because most feel it streamlines work for frontline workers and delivers high value. In the face of the manufacturing skills shortage, MES must ensure that both plant and IT human resources are used effectively. The other clear trend since 2020 is that disruption and change are not diminishing but growing. So, MES that keeps up with changes is also critical to success.

Tech-Clarity

Explore Advanced Technologies

USE OF ADVANCED TECHNOLOGIES BY PERFORMANCE BAND

Visual digital twin of the plant
- Top Performers: 33%
- Others: 17%

MES CoE or Centralized team
- Top Performers: 30%
- Others: 28%

Integration between MES and Enterprise Apps
- Top Performers: 28%
- Others: 43%

Low-code or No-code
- Top Performers: 26%
- Others: 25%

Augmented Reality (AR)
- Top Performers: 19%
- Others: 13%

None of the above
- Top Performers: 2%
- Others: 7%

■ Top Performers
■ Others

Automation, Analytics, and More

From our list of "advanced technologies," most Top Performers use three. Intelligent instrumented automation – the OT data sources for manufacturing data management top the list. Advanced analytics such as AI and ML can deliver better decisions by analyzing diverse data in more automated ways. Integrated plant data stores can support consistent IT and OT data management across one or many sites.

Not Necessarily Separate Systems

Note that this question asked about the use of advanced technologies and approaches. Some of these may be part of the same system or other systems not named. For example, more applications now include dashboards and advanced analytics. The IIoT platform may be built into MES, and some applications also have low-code or no-code elements.

Is Integration Advanced?

The only item in our list of 10 approaches that more Others than Top Performers use is Integration between MES and enterprise applications. This may be because integration to ERP – and even PLM, Supply Chain, and other applications – is a given in more modern MES implementations.

Gain Business Capabilities

Gaining from Doing

Top Performers are gaining solid capabilities. This is likely a result of their initiatives, staffing, and technology investments. As with their positive results from MES, it appears they are getting value from their wide variety of activities.
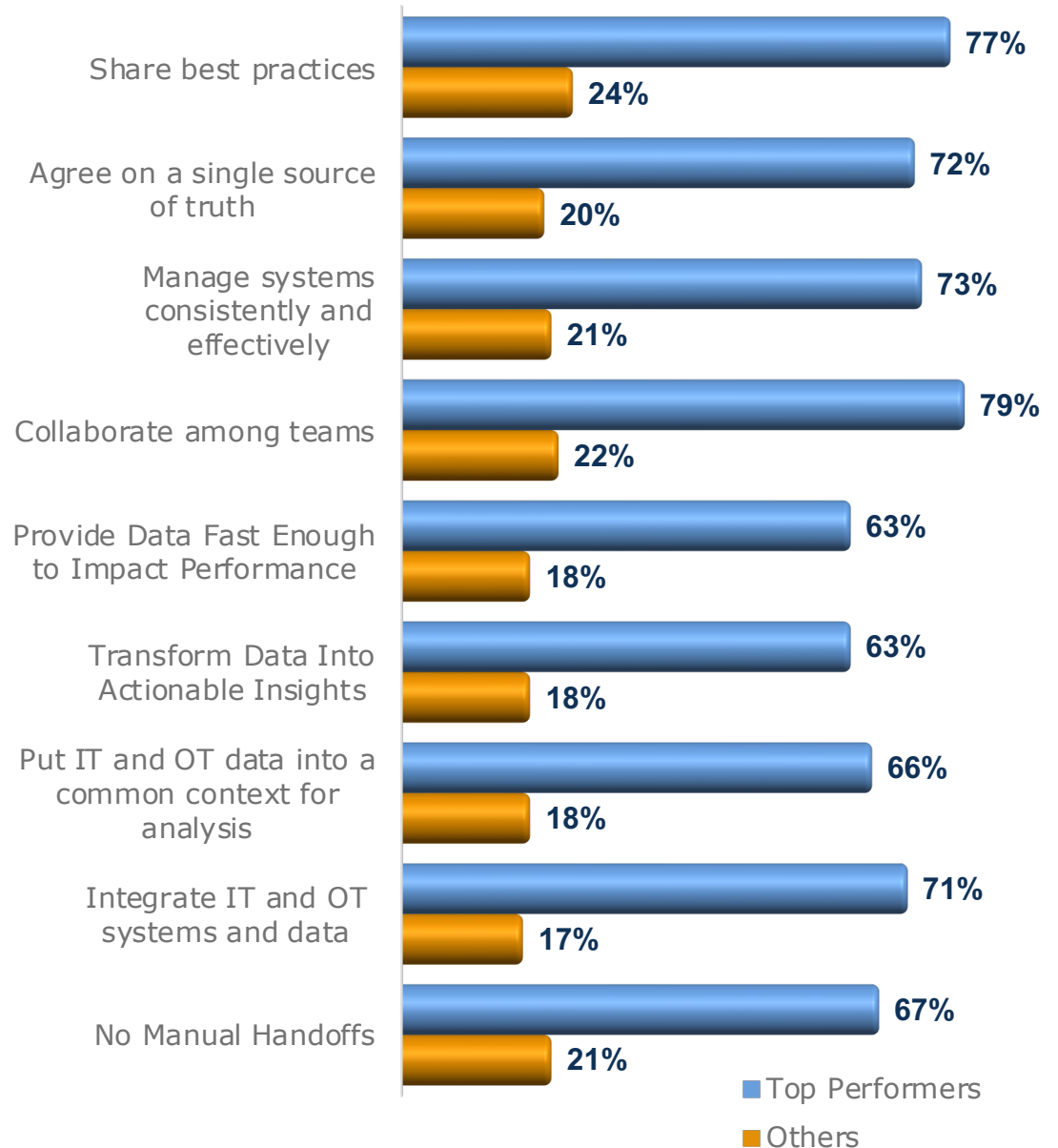
Capable for Today's Needs

As we explained, being ready to use AI and advanced analytics to close the loop between data and action is multi-faceted. It requires capability to capture, agree on, and structure data rapidly enough to impact production performance. Analysis is what transforms data and information into insights. Getting to action may require collaboration and sharing best practices as well as integrating this into applications suited for the tasks.

Top Performers Excel

Across a wide array of data management capabilities and processes, most Top Performers rate their capabilities as Excellent. The percentages are dramatically different from Others. Top Performers are:

- 4X as likely to excel at integrating IT and OT data and systems
- >3X as likely to excel at all other aspects of manufacturing data management and operations excellence

EXCELLENT CAPABILITIES BY PERFORMANCE BAND

Share best practices
- 77%
- 24%

Agree on a single source of truth
- 72%
- 20%

Manage systems consistently and effectively
- 73%
- 21%

Collaborate among teams
- 79%
- 22%

Provide Data Fast Enough to Impact Performance
- 63%
- 18%

Transform Data Into Actionable Insights
- 63%
- 18%

Put IT and OT data into a common context for analysis
- 66%
- 18%

Integrate IT and OT systems and data
- 71%
- 17%

No Manual Handoffs
- 67%
- 21%

■ Top Performers
■ Others

MANUFACTURING IN THE AGE OF AI: PROGRESS AND EXPECTATIONS

Tech-Clarity

Accelerate Improvement

Getting Better All the Time

Continuous improvement is one of the factors we included in defining Top Performers, along with agility. So, it is no surprise that most of these companies reported that their manufacturing performance metrics have been improving. In the total survey response set, most companies report improving performance over the past three years on many of the key performance indicators (KPIs) we list.
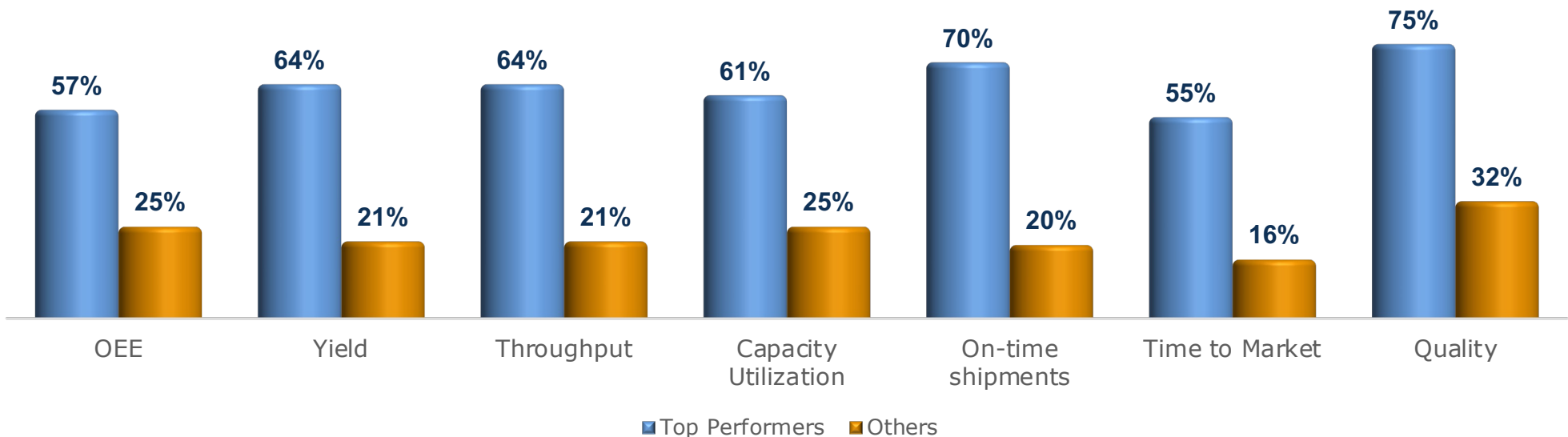
Significantly Better

The Top Performers differ in that most of them have improved significantly. (Other response options were Better, Slightly better, No change, or Worse.) This compares to a third or fewer of Others on every KPI we included in this question. Now improving significantly may vary based on the starting point. Since every production operation is different, all we can do is look for improvement – and significant improvement matches with the investments and capabilities these companies report.
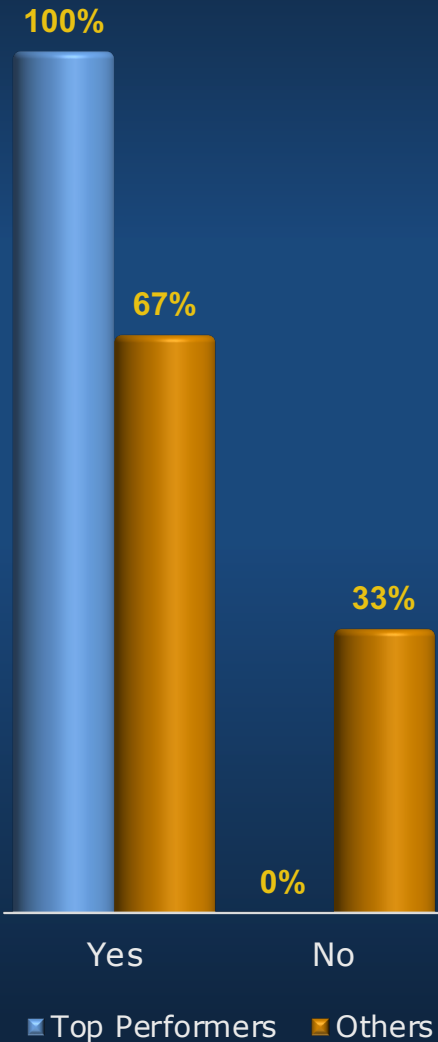
Against All Odds

Earlier, we pointed out that most of the companies in this study faced materials shortages, and many also had unexpected demand patterns and due date pressures. Given the global situation over the previous three years, with the COVID-19 Pandemic, geopolitical upheaval and conflicts, and frequent natural disasters making significant improvements on manufacturing KPIs may have spelled the difference between profitability and disaster.

SIGNIFICANTLY BETTER PERFORMANCE OVER THE PAST THREE YEARS BY PERFORMANCE BAND

	OEE	Yield	Throughput	Capacity Utilization	On-time shipments	Time to Market	Quality
Top Performers	57%	64%	64%	61%	70%	55%	75%
Others	25%	21%	21%	25%	20%	16%	32%

■ Top Performers ■ Others

MANUFACTURING IN THE AGE OF AI: PROGRESS AND EXPECTATIONS

Tech-Clarity

Meet Cost Targets

MET COST REDUCTION TARGETS BY PERFORMANCE BAND

- 100% — Top Performers, Yes
- 67% — Others, Yes
- 0% — Top Performers, No
- 33% — Others, No

Yes   No

■ Top Performers ■ Others

Profitability Rests on Costs

A primary goal of every manufacturer is profitability, and the side where most companies have more power is on cost than on pricing. Most companies set targets for product and production operating costs. Operations are constantly under pressure to meet or exceed cost targets, meaning reducing costs even below the target.

Cost Targets

In the volatile and supply-constricted world of the past several years, most companies struggled to keep costs under control. However, a quarter of Top Performers not only met but exceeded their cost targets. This compares with only 6% of others. The significant improvements on manufacturing KPIs likely allowed them to offset material and other costs with efficiencies.

Cost Reduction Targets

In addition to overall cost targets, many companies set cost reduction targets. Another aspect of continuous improvement is the ability to meet these cost-reduction targets. Nearly all Top Performers met cost reduction targets, compared to two-thirds of others (93% vs. 57%).

DEGREE TO WHICH MET COST TARGETS BY PERFORMANCE BAND

- No response / I don't know: Top Performers 11%, Others 10%
- Exceeded cost target: Top Performers 25%, Others 6%
- Large degree: 95-100% of cost target: Top Performers 16%, Others 16%
- 86-95% of cost target: Top Performers 27%, Others 27%
- 71-85% of cost target: Top Performers 18%, Others 28%
- Small degree: <70% of cost target: Top Performers 2%, Others 13%

■ Top Performers
■ Others

Tech-Clarity
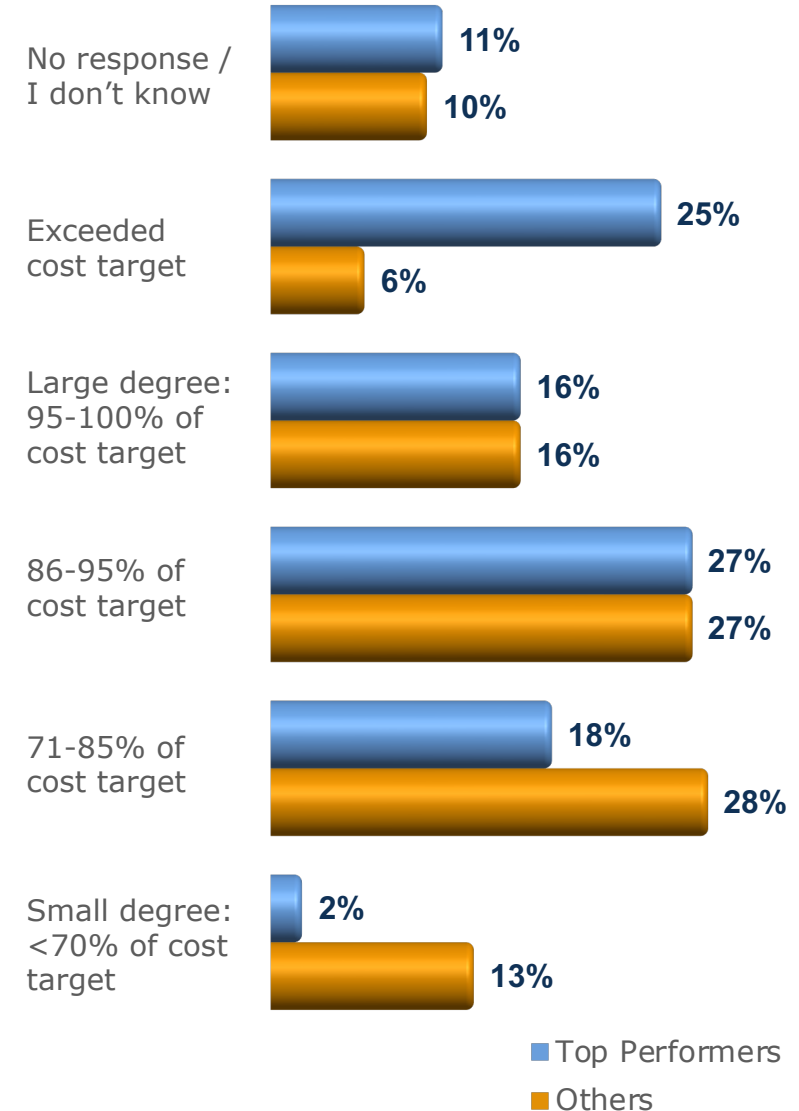
Why Manufacturing Data Management?

Intelligent Investment

Companies are discovering that making progress on Industry 4.0 and gaining its benefits rests on mastering manufacturing data management. Getting beyond data to information, intelligence, and actionable insights requires all aspects of data management. Ideally, this is a unified, consistent approach that supports the manufacturing operation – and the business.
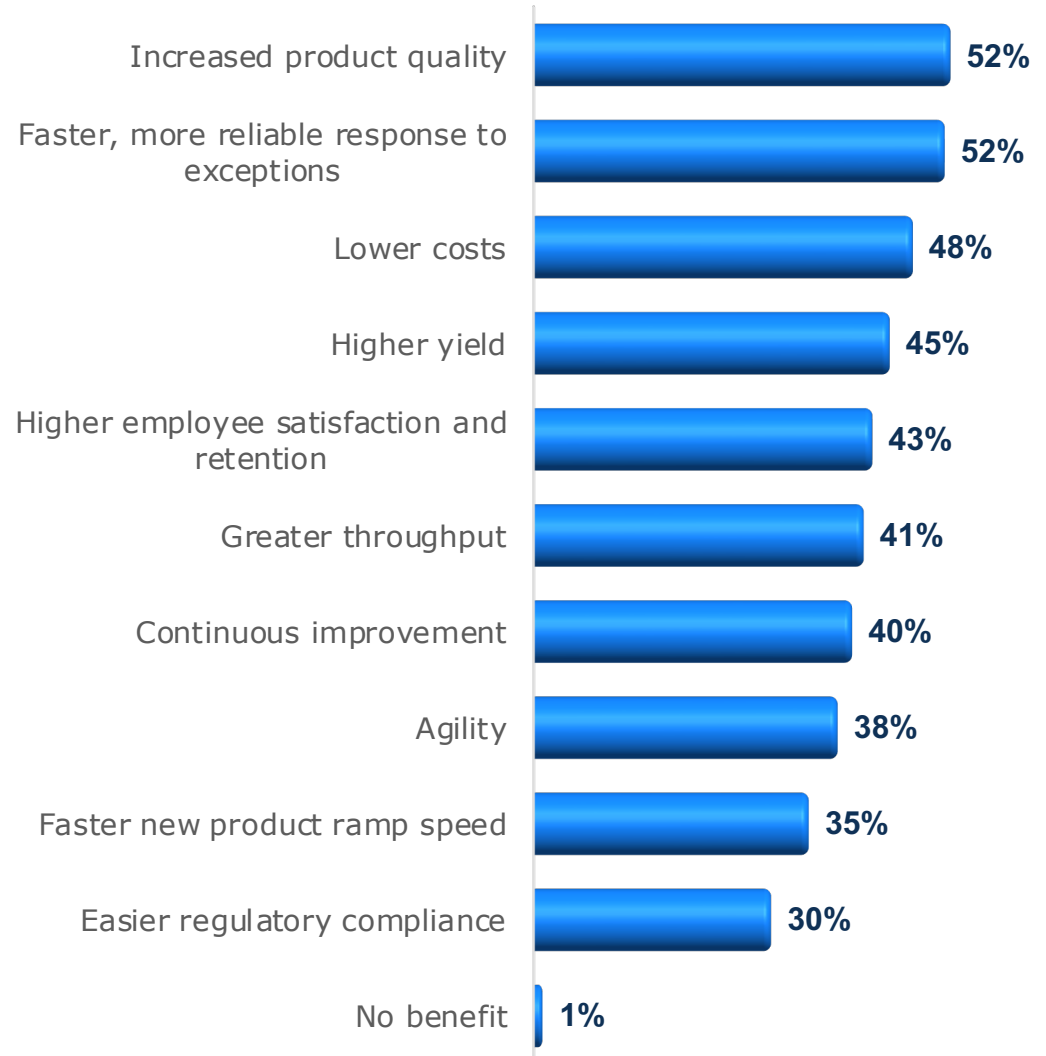
Broad Business Benefits

We asked to understand what benefits companies are getting or expecting from better and more unified manufacturing data management. The question was: "Which benefits do you see or would you expect from better and more unified plant data management that offers OT and IT data in context, ready to analyze and act on?" Respondents could select all that apply. Responses were divergent, with only two chosen by more than half of respondents: increased product quality and faster, more reliable response to exceptions.

Foundation for AI and Analytics

Anyone who has attempted an AI or advanced analytics project knows sound data management is a prerequisite. If any aspects of manufacturing data management are weak, it can limit the success of analytics and AI efforts. Analytics can be used to gain insights into any of the improvement areas listed.

BENEFITS OF UNIFIED DATA MANAGEMENT

Benefit	Percentage
Increased product quality	52%
Faster, more reliable response to exceptions	52%
Lower costs	48%
Higher yield	45%
Higher employee satisfaction and retention	43%
Greater throughput	41%
Continuous improvement	40%
Agility	38%
Faster new product ramp speed	35%
Easier regulatory compliance	30%
No benefit	1%

MANUFACTURING IN THE AGE OF AI: PROGRESS AND EXPECTATIONS

Tech-Clarity

Why Drive to AI?

Many Applications

This is the age of AI. Just as human intelligence can address many topics, so can artificial intelligence. We asked, "Where would your company anticipate benefits from using advanced analytics in the plant such as artificial intelligence (AI), machine learning (ML), predictive, or prescriptive analytics? (list all processes, areas, or disciplines). The responses varied widely, as the word cloud shows.

Top of Mind

The most common benefits these respondents see are in production: quality, productivity, efficiency, yield, maintenance, safety, costs, and control. They also cite error-proofing, speed, and efficiency. In addition, they see benefits across the business, including for management, training, supply chain, revenue, engineering change, marketing, fraud detection, and customer service.

Tech-Clarity

Quotes: Selected Benefits of Advanced Analytics

Expected Benefits

"

The benefits would be reducing the error when developing new products, the lead time from design to the market, and increasing the chance of success.

One of the primary reasons businesses use advanced analytics is to forecast future outcomes, to personalize the customer experience, and mitigate risk and handle setbacks.

AI would greatly improve speed and quality of data and output of analysis. It would lower the amount of effort required to reach the same quality of analysis.

Organizations that use advanced analytics can act quickly and with a greater degree of confidence about future outcomes.

We would expect benefits to be in almost all disciplines, including IT, Finance, HR, and Operations. It would help us better manage our processes and cut down on inefficiencies which affect our profits.

Reduction in human error, perform repetitive jobs, unbiased decisions, digital assistance, 24/7 availability, zero risk, etc.

Brings innovation and advancement in company's functioning.

Reduce the load of analysis, real-time non delay action.

Benefits Already Seen

My company is already engaged in artificial intelligence and machine learning with better results and experience.

Helps to analyze sensor data, predict breakdown and accidents, improve safety conduct inventory tracking.

Great results as an outcome by using these technologies.

We have a 37% increase in distribution and sales. The AI was a great implementation and improved and important to our company.

AI and ML helps to monitor environmental conditions and alert workers of potential health and safety risks.

Tech-Clarity

The Path Ahead

Next Steps:

The manufacturers in this survey, including the Top Performers, know they are on an ongoing journey. Every company must ask themselves what their next steps are. Depending on the state of your capabilities and processes, the answer will vary.

Recommendations

- Recognize that Industry 4.0 is a journey, and manufacturers can only expect to get benefits once they have made significant progress.
- In the face of complex and unpredictable external circumstances, invest in internal understanding, initiatives and projects, staff, and capability-building technologies.
- Be sure everyone - top floor to shop floor - understands Industry 4.0 has many keys to success, and one central element is manufacturing data management.
- Evaluate your data management weaknesses across all facets and set out to improve them.
- Prioritize projects not only by data flow gaps but also for the potential to make significant revenue and cost improvements across the company.
- Evaluate whether applications with broader functionality will reduce your integration resources and effort and still be deep enough to meet your needs.
- Educate your team on many aspects of data management and analytics to ensure they understand how projects fit into a larger vision.
- Start initiatives and projects that help you learn – progress requires action.
- Focus on creating an attractive workplace and staffing for an array of newer positions that support data management, AI, and transformation.
- Step up your evaluation of commercial technology that might replace homegrown systems, spreadsheets, and Excel.
- Focus on AI and analytics as benefits drivers, and focus programs on areas that matter to business success.

About the Research

Data Gathering

Tech-Clarity gathered and analyzed over 300 responses to a web-based survey on manufacturing. Survey responses were gathered by in early 2023 by direct e-mail, social media, and online postings by Tech-Clarity.

Industries

The respondents represent primarily discrete manufacturing industries. The top few in order are: 23% industrial equipment and machinery, 21% automotive and transportation, 18% electronics and high tech, 18% building products and fabrication, 14% medical devices and life science, 13% consumer packaged goods, and 11% consumer hard goods.*

Company Size

The respondents represent a bell curve of company sizes, including 11% from smaller companies (less than $100 million), 15% $100 to $250 million, 31% between $251 million and $1 billion, 25% between $1.1 billion and $5 billion, and 17% greater than $5billion. Company sizes were reported in US dollar equivalent.

Geographies

Responding companies report manufacturing in North America (58%), Western Europe (50%), Eastern Europe (22%),

Asia outside China and Southeast (20%), Southeast Asia (16%), Latin America (16%), China (11%), Australia (11%), Middle East (9%), and Africa (6%).*

Supply Chain Role

51% of are OEMs. 27% are contract manufacturers, 20% are suppliers of subassemblies or parts, and 2% listed other.

Role

The respondents were comprised of 35% Manager level, 24% Directors, 20% VP Level, 11% C-level executives, and 10% team leaders or individual contributors.
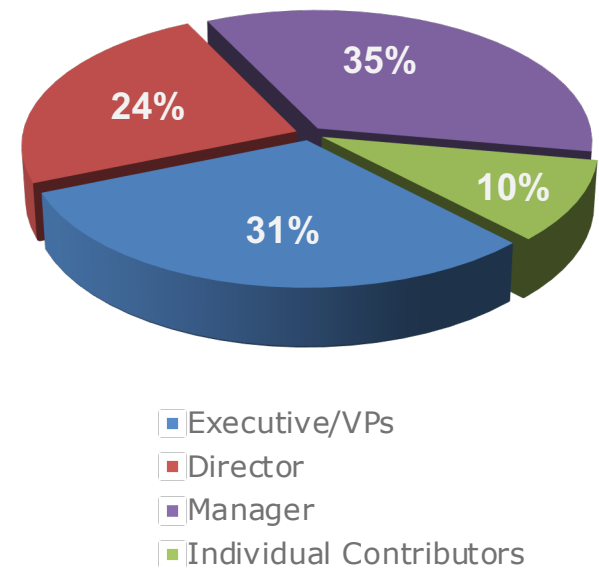
Organizational Function

Of the respondents, 15% are in Manufacturing roles; 15% in Information Technology (IT), 13% in Operational Technology (OT), 12% in General Management, and 12% in Manufacturing IT. The remainder were from a variety of organizations including Product Design, Plant Management, Program Management, Product Management, Data Science or Engineering, Quality, Facilities engineering, and Continuous Improvement.

* Note that the values may total greater than 100% because companies reported doing business in multiple industries and geographies.

The respondents represented a mix industries, company sizes, roles, disciplines, and geographies.

RESPONDENTS BY ROLE

- Executive/VPs
- Director
- Manager
- Individual Contributors

Tech-Clarity

Acknowledgments

About the Author

Julie Fraser joined Tech-Clarity in 2020 and has over 35 years of experience in the manufacturing software industry. She is an enthusiastic researcher, author, and speaker. She has a passion for manufacturing progress and performance gains through Industry 4.0 strategies and supporting software technology.

Julie is actively researching the impact of digital transformation and technology convergence in the manufacturing industries, with a focus on supply chain and plant floor and how to use manufacturing data in conjunction with data from offices, labs, and the ecosystem.

Tech-Clarity is an independent research firm dedicated to making the business value of technology clear. We analyze how companies improve innovation, product development, design, engineering, manufacturing, and service performance through the use of digital transformation, best practices, software technology, industrial automation, and IT services.

Julie Fraser
Vice President
Tech-Clarity, Inc.

Tech-Clarity.com

TechClarity.inc

@TechClarityInc

Tech-Clarity

References
1) Fraser, Julie, "The Manufacturing Data Challenge" ©2020 Tech-Clarity, Inc.
2) Definitions of Data Engineers and Analysts:
• A data engineer develops, constructs, tests, and maintains architectures, such as databases and large-scale processing systems.
• A data scientist cleans, massages, and organizes (big) data to gain insights.

Critical manufacturing
an ASMPT company

Tech-Clarity