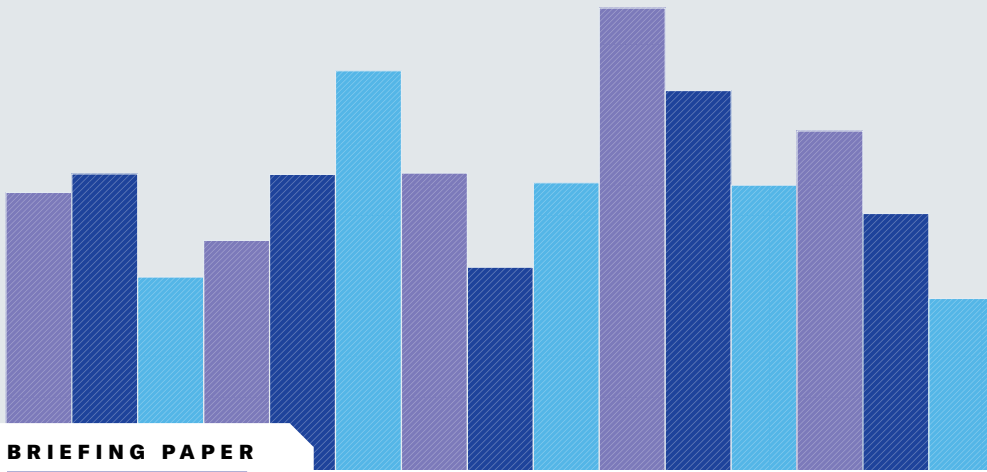


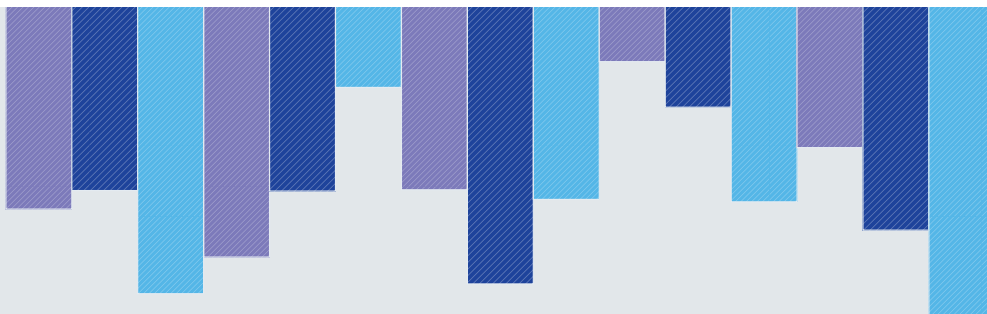


**Harvard
Business
Review**

ANALYTIC SERVICES



IT and Operational Technology Data Management in the Cloud



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Empowering the Future of Manufacturing with IT-OT Data Convergence

In today's hyper-connected world, data is the foundation of transformative decision making. As industries harness the potential of big data and artificial intelligence, the challenge lies not only in capturing this wealth of information but also in leveraging it for real-time insights and actionable results. For manufacturers, this journey has been more complex due to the historically fragmented landscapes of IT and operational technology (OT) data.

At Hitachi, we are committed to driving innovation and enabling manufacturing firms to realize the full potential of data convergence. The integration of IT and OT data is no longer a distant vision—it is a present-day opportunity to foster efficiency, enhance safety, optimize resources to drive sustainability, and develop groundbreaking products. However, achieving this requires more than technology; it demands a rethinking of culture, strategy, and collaboration.

We are excited to be in association with Harvard Business Review Analytics Services to bring insightful and engaging perspectives that delve into the critical juncture where IT-OT convergence meets cloud innovation. This briefing paper explores how foundational technologies and maturing processes are reshaping the \$2.9 trillion manufacturing sector, empowering businesses to seamlessly connect edge and cloud data systems. Whether it's predictive maintenance, optimizing supply chains, or building a workforce equipped for the challenges of tomorrow, the insights presented here underscore the power of a data-driven approach to industrial transformation.

As you read this paper, we encourage you to envision a future where manufacturers are equipped not just to survive but to thrive amidst rapid change. Together, we can embrace the promise of digital transformation and build smarter, more resilient operations.



Ganesh Bukka
Vice President and Global Head,
Industry 4.0
Hitachi Digital Services

IT and Operational Technology Data Management in the Cloud



The age of data-driven decision making requires an ever-expanding place to capture, store, and analyze information. In this era of artificial intelligence (AI) and big data analytics, many large companies will invest up to millions of dollars to mine all forms of data for difference-making insights.

Analyzing information derived from products, assets, places, and operations is a central tenet of the emerging data-driven enterprise. Building the analytical capabilities to analyze this data requires a deep and ongoing investment in data science skills and infrastructure, including escalating stacks of data storage. For these reasons, among others, such as available talent and capital outlays for data infrastructure, the cloud is replacing on-premises data lakes and data warehouses for organizations concerned about investing long-term capital in these rapidly evolving and expensive capabilities. Accordingly, the cloud houses 60% of corporate data, reports Zippia Research.¹ The data explosion has been well documented and shows no signs of diminution. According to a February 2024 study by Markets and Markets, the cloud storage market is expanding at an 18.8% compound annual growth rate, a boost the researchers attribute “to the expanding realms of IoT [internet of things] and big data.”²

In most industries, cloud adoption has always seemed inevitable. Yet the manufacturing sector chose a divergent course, conducting most of its data analysis on premises or at the industrial “edge.” Implementing that policy has meant that, until recently, the vast stores of operational technology (OT) data gathered by manufacturing equipment, industrial controls, building management systems, and sensors known as the industrial internet of things (IIoT) not only eschewed the cloud but were also kept strictly segregated from IT data generated by customer interactions and financial and accounting systems. Although IT teams across most industries have shifted increasing amounts

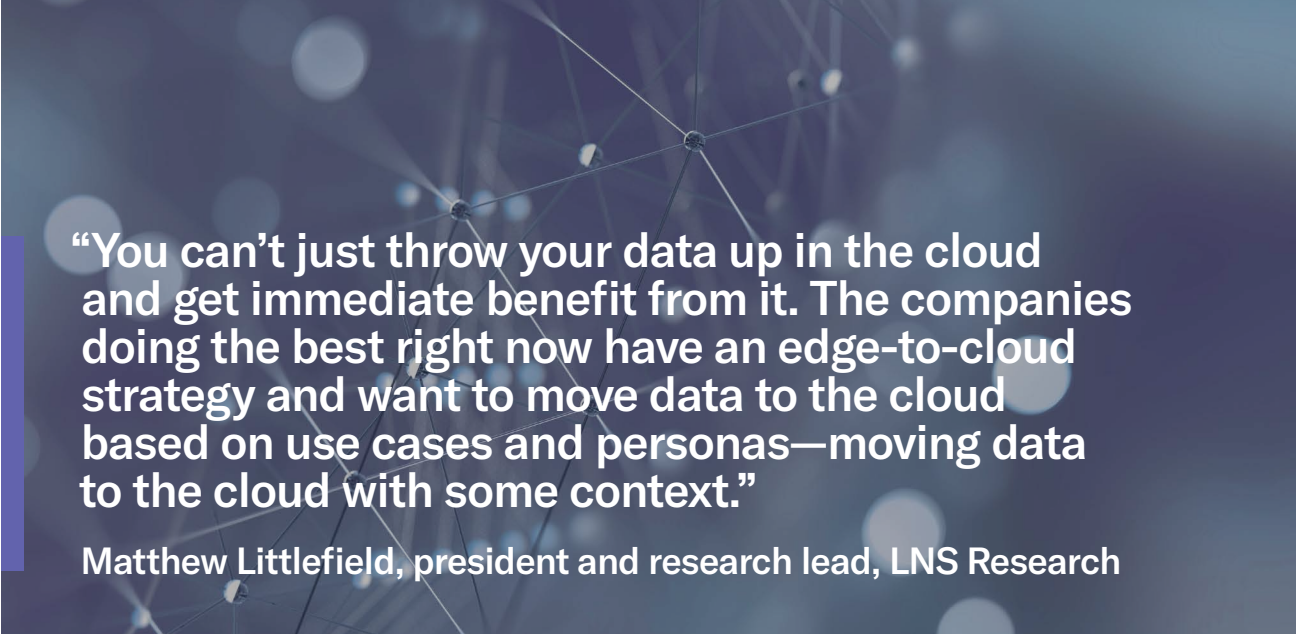
HIGHLIGHTS

Although IT teams across most industries have shifted increasing amounts of data storage and analytics to the cloud—empowering their digital transformation initiatives—**the cloud has yet to transform the \$2.9 trillion manufacturing sector.**

Getting to the point of better, faster, and cost-effective decision making **requires agility in business planning and technology architecture.**

The long-awaited IT-operational technology data convergence arrives at a time when **manufacturing is at an inflection point in its application of artificial intelligence-driven insights.**





“You can’t just throw your data up in the cloud and get immediate benefit from it. The companies doing the best right now have an edge-to-cloud strategy and want to move data to the cloud based on use cases and personas—moving data to the cloud with some context.”

Matthew Littlefield, president and research lead, LNS Research

of data storage and analytics to the cloud—empowering their digital transformation initiatives—the cloud has yet to transform the \$2.9 trillion manufacturing sector.³ According to ARC Advisory Group, only 15% of manufacturing data is stored in the cloud (one-quarter of the corporate average reported by Zippia).⁴

Yet manufacturing firms finally appear ready to tap the cloud to manage and analyze OT and IoT data to deepen their understanding and perception of their physical environments, products, business metrics, services, and supply lines. What’s changed? The emergence and maturation of several foundational technologies have set the stage for IT and OT data convergence. Matthew Littlefield, president and research lead at LNS Research in Boston, explains that in the manufacturing field, “10 years ago you had the rise of connected devices but most of the data remained trapped at the machine layer. Today manufacturers have connected assets, connected process, and connected frontline workforces, coupled with an industrial-focused set of cloud, cybersecurity, and AI technologies. Overall, there’s been a tremendous increase in IT-OT convergence maturity.”

This paper examines how companies can become more data-driven and gain a real-time understanding of people, places, and things to achieve greater efficiency and business insight—blending IT and OT data and data teams—in unprecedented ways, from the edge to multi-cloud. The paper will describe the opportunities and challenges organizations face in moving their converged IT and OT data workloads to the cloud to generate efficiencies of scale and maximize operational excellence to produce breakthrough products and services.

“I think manufacturing data is messy,” explains Littlefield. “You can’t just throw your data up in the cloud and get immediate benefit from it. The companies doing the best right now have an edge-to-cloud strategy and want to move data to the cloud based on use cases and personas—moving data to the cloud with some context.”

Emerging Industrial Use Cases

No matter the location, on premises or in the cloud, only some, if any, companies blend IT and OT data without a compelling use case. The manufacturing sector’s quest for cost-saving maintenance efficiencies provides one clear objective. Yet while an operations team understands the ins and outs of its facility equipment, it may lack insights spanning the entire company, complicating decision making with that objective in mind.

Consider, for example, an oil conglomerate that operates refineries worldwide and runs production operations in multiple countries.

“The value in a manufacturing environment is they want to look across the enterprise,” says Janice Abel, principal consultant at ARC Advisory Group in Boston. “Let’s say the company has a [faulty] pump or a distillation tower and they want to know if the same issue is popping up [elsewhere]. Could it be the brand of the pump or flow meter, or machine, or could it be the way they’re using it or the process limits?” Actions such as rolling up their operational field data to a centralized cloud database “might help them identify problems and not use certain types of equipment in certain situations or modify processes to be more efficient.”

Armed with enterprise data, operations teams can make cost-effective data-based actions. The desired insights may also extend to areas such as safety and energy management. From a sustainability perspective, the data can help companies determine where they are losing energy or assist them in “eliminating waste in manufacturing materials,” Abel says. Of course, you need a lot of data and processing to fuel this analysis. “A major refinery told me they’re probably not collecting enough data,” she says. “They could collect 90% more data and be better at improving efficiencies and optimizing operations.”

LNS Research’s Littlefield views the IT-OT convergence as part of an industrial transformation. He believes many manufacturers have run pilots and established several use cases for mining data to transform manufacturing operations. The main focus, he explains, is improving employee efficiency. “But only a few have figured out how to scale and embed this across the enterprise.”

One way to improve employee performance is to apply ingested OT and IIoT data to predictive maintenance models. “You want to take learnings from across the company, centralize that data, and then build models to understand the personas, use cases, and decisions being analyzed,” explains Littlefield. Some models will run at the industrial edge, while others will use the cloud. Employing this approach, he says, “I can get the best of both worlds, where I can optimize that decision making based on all my learning across the enterprise, but I can still make decisions at the edge.”

Building a Data-Driven Workforce Culture

As manufacturers embrace data-driven decision making, they may leverage operational data to help improve worker productivity, safety, and efficiency. However, the industry may have an even more urgent need to apply data insights to help solve the consequences of prolonged labor shortages, including assisting young workers who lack industry expertise or haven’t made a long-term commitment to the field.

Nearly three in four manufacturers (72%) say that their top challenge is “attracting and retaining a quality workforce,” according to a National Association of Manufacturers study.⁵ Littlefield believes workforce concerns have hardened since the outset of the pandemic. “You have a manufacturing labor shortage and then a tremendous amount of turnover,” he says, leading to a “dramatic loss of experience and knowledge.”

According to ARC Advisory’s Abel, the manufacturing industry understands that data-driven digital transformation can help offset “the old way of doing things—tribal knowledge. Today, you are seeing an inexperienced workforce, and they don’t know what happens when this happens.” Abel remembers meeting a mid-level manufacturing manager who “grew up” assessing production data on



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spreadsheets—sometimes hundreds of them that he created from scratch. She recognizes that this outmoded approach wouldn’t fly today. “But you wouldn’t be able to determine how to do it like he did,” says Abel, “because he implemented it. And the new workers coming in today didn’t grow up on spreadsheets and implement the processes.”

Beyond shifting worker demographics, Abel and Littlefield believe that culture drives OT and IT convergence. Manufacturers hope that blending IT and OT data will bridge a long-standing cultural divide between OT and IT teams not known for being on the same page about much of anything. For example, IT teams often have computer science or software engineering training, while OT teams may come from electrical, mechanical, or chemical engineering disciplines. An IT outage could disrupt business operations. By contrast, an OT outage or failure could affect physical safety or cause production shutdowns.

“Just getting the people at these companies to work together—that’s probably the hardest” aspect of a successful convergence, notes Littlefield. He fears that IT and OT teams may feel “threatened, and there can be turf wars. It’s cultural in a lot of cases. And I think a lot of times it comes down to incentives or assumptions that aren’t immediately apparent.”

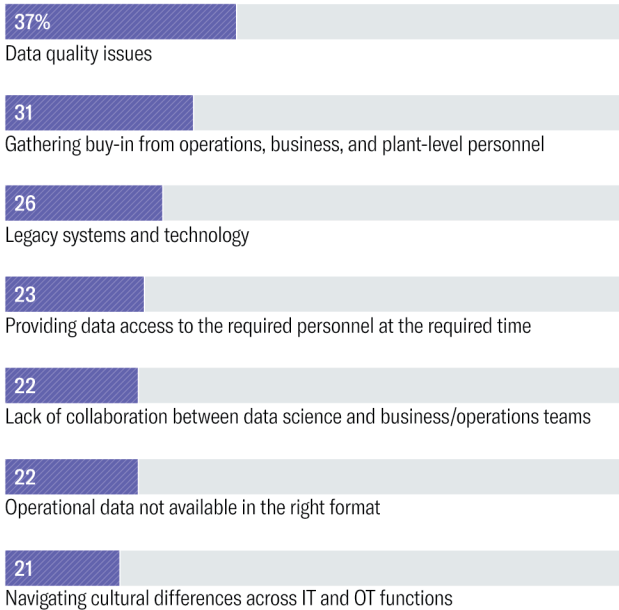
In an LNS Research study of manufacturing business and IT decision makers published in December 2022, one in five (21%) said navigating cultural differences across IT and OT functions was among their biggest challenges in achieving industrial transformation with advanced analytics.⁶ **FIGURE 1** Little surprise then that 22% of respondents reported a lack of cooperation between data science and business/operations teams.

The industry collectively responds to this challenge by investing in automation and arming workers with data-driven insights to succeed without extensive training. “You have to have a corporate culture that supports digital transformation initiatives,” adds Abel. “Today, workers have digital twins and [virtual reality] so they can see what the data means. They can physically see what the data is doing.” Utilizing all available

FIGURE 1

Top Industrial Analytics Challenges

What are the biggest challenges to implementing industrial analytics?



Source: LNS Research study, December 2022

data sources, including OT and IT, she says, manufacturers see the potential value of providing “data at the right time and to the right person.”

The Principles of Data Gravity

Manufacturers looking to complete an industrial transformation know they must improve their data. Acquiring data from closed or legacy shop-floor systems can be complex and expensive to engineer. Yet data sets are seldom static, and the bigger the data set, the harder it is to move. The cost of movement is one fundamental principle of data gravity. Another principle is latency. Accordingly, when operational teams must make business decisions in real time with the freshest possible data, it’s typically faster to process that data at the industrial edge (think factory floors or refining facilities) for on-site decisions. Shuttling large data sets to the cloud adds precious time, and so does processing them and transmitting the results back to on-site operations teams.

In manufacturing, placing data for analytical purposes isn’t strictly a binary decision. It’s not just a question of locating data in the cloud or on-premises. Some percentage of data moves from manufacturing or refining facilities to “edge” processing clusters, where it is quickly analyzed for

real-time operational decisions such as energy consumption, flow rates, and equipment status, which can impact areas such as efficiency, productivity, maintenance, safety, and energy management, says Abel. Regulators may require the manufacturer to store data in its data centers for several or more years.

Data gravity is often a matter of “brute economics,” contends Tony Baer, founding principal of dbInsight in New York. In practice, the data gravity prompts manufacturers to “bring intelligence close to where the data is” created. Baer explains that manufacturers do this because moving large data volumes “will kill networks, and most IoT data is pretty low value. You don’t want to spend large sums on transporting low-value data.”

He adds that if operational data readings indicate that “a malfunction is about to happen, you want decision making where it might happen. Latency in some places could kill you.” Legal concerns may also limit a manufacturer’s data movement choices. In certain European and Asian countries, for example, data sovereignty rules prohibit moving data outside the nation where it originated.

Moving Data Into and Out of the Cloud

Getting to the point of better, faster, and cost-effective decision making requires agility in business planning and technology architecture. Devising an edge-to-cloud decision-making strategy entails a command of storage and workload economics. While there are compelling reasons to process data at the industrial edge, many companies will later “take that data, downsample it, and put it in the cloud after the process is complete,” notes Baer.

Unfortunately, shuttling operational data to the cloud is a nontrivial exercise. “Moving data in general from on-premises to the cloud is quite a challenge,” says Abel. A large cloud service provider once brought a trailer carrying data storage directly to a customer site to avoid the high cost and time required to manage a cloud upload. It’s not just a matter of uploading data files, she cautions. The data must be checked because poor-quality data can lead to poor results. It may also need to be encrypted to prevent any cybersecurity issues.

“The majority of industrial data, I’d say 85 to 90% today, is what they call tag data, which is really time-based data, and it’s from machines (such as industrial control systems) and the internet of things,” adds Abel. The tags may record analog information, such as temperature and pressure; digital information, such as whether a machine is on or off; and calculations derived from other machine values. While tags sound innocuous, they may record valuable details about industrial processes. Storing the OT data in specialized industrial databases, called “historians,” complicates integration with typical IT databases. The OT data must be



37%

of respondents said data quality issues were among their biggest challenges in achieving industrial transformation with advanced analytics.



“The biggest thing is integrating and connecting that data—they can be done more effectively in the cloud than they can be done on-premises. Cybersecurity is often better in the cloud when it is managed by a third party.”

Janice Abel, principal consultant, ARC Advisory Group

“extracted” through various industrial protocols, often with relevant metadata about the process or assets.

Thinking about combining IT-OT data, Abel says, “You have different types of data, and you can’t just join temperature and flow rates” with IT data. “You can’t say PSIG [pounds per square inch gauge] and degrees (Centigrade or Fahrenheit) and add them together. You need to understand the relationship and context like the ideal gas law and the properties. It’s not simple to join complex data—making sense of it can be really hard.”

Once the data is adequately normalized and uploaded to the cloud, companies analyze operational data for insights that weren’t evident in real time. “You have, in some cases, workers literally operating a machine that has to make a decision in a split second,” says Littlefield. “And other workers might be planning which production line within the factory to change over—decisions they could make within a day. Or decisions are made at the enterprise level, where it might take two weeks to make the right decision.”

Abel expects manufacturers to apply “more AI in the future in preventative maintenance, operations, supply chain, and cybersecurity.” She believes that the primary justification for this spending will be increased operational efficiency, “but it’s mostly time savings or getting data faster to make better decisions.”

The catch is “you need a lot of data to use AI,” says Abel. Large volumes of data drawn from multiple sources, such as IT and OT data sets, is easier to organize in the cloud than at the edge. “The biggest thing is integrating and connecting that data—they can be done more effectively in the cloud

than they can be done on-premises.” She also notes that the data may be in a safer place. “Cybersecurity is often better in the cloud when it is managed by a third party.”

Conclusion

The long-awaited IT-OT data convergence arrives at a time when manufacturing is at an inflection point in its application of AI-driven insights. Many manufacturers have successfully implemented analytics at the edge but have not yet completed an edge-to-cloud strategy. Finding the right tools to address pressing workforce concerns may motivate manufacturers to fully embrace the cloud—which requires data.

Abel believes manufacturers’ investments lead to “a more autonomous environment, not necessarily people-less.” Implementing more efficient and autonomous operations will save costs by “eliminating human error, saving time, or assisting someone to do their job better.”

However, Abel cautions that manufacturing workers are wary of increased automation. Skilled workers don’t want to be replaced by autonomous factories, although they like the idea of being assisted by AI or robotics. Yet data-driven decision making is gaining momentum. “We’re at an inflection point where it’s going to go very rapidly,” says Abel. “I feel like the technology change is going to be fast-forwarded in the next few years.”



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Endnotes

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