Organizations are using the internet of things and a constellation of smart devices to drive business change — a shift that will ultimately have larger, worldwide implications.

The promise of the fourth industrial revolution

New technologies can optimize the way people work. When implemented thoughtfully, such innovations can improve overall business processes. Those changes are accepted as part of progress.

But when a technology changes how and where people live and their relationships to one another and upends economies, it merits the term "revolution." Because it changes everything.

The technology behind the First Industrial Revolution was water and steam power, which mechanized textile production. The innovation made factories commonplace, which brought more people to cities and caused social upheaval. In the second, electric power made mass production possible. The third was based on semiconductors, which facilitated the data processing that automated production and spawned the digital age. Now a fourth industrial revolution is taking shape. The technology behind it is the internet of things — networks of connected devices such as sensors, robots, and wearables. The data these devices produce across so many in-depth connections is the fuel for powerful digital applications, from weather prediction systems to smart buildings that regulate their own climates to self-driving cars navigating city streets.

"It's a fusion of technologies," says Landry Signé, professor and founding co-director of the Fourth Industrial Revolution and Globalization 4.0 Initiative at Arizona State University's Thunderbird School of Global Management. "The fourth industrial revolution blurs the line between the physical, the digital, and the biological."

This revolution isn't particularly about the things that collect data. As with the other technological underpinnings in previous upheavals, it's what we do with them. By using artificial intelligence (AI) and machine learning to analyze data collections, says Andrew Dugan, chief technology officer at enterprise technology company Lumen, people can solve harder problems. For example, smart cities can use many types of sensors and other data technologies, with the goal of lowering emissions, reducing traffic, and doing better urban

Key takeaways

1 The internet of things, a massive network of connected smart devices, is ushering in the fourth industrial revolution, a transition to data-driven processes and technologies that can help organizations solve difficult business problems and ultimately make the world a safer, fairer, and better place to live.

2 Organizations using data to innovate are beginning to see business benefits, such as improved worker productivity and safety, better customer experience and service, and higher-quality products and services.

3 Data-driven technological innovation involves a number of challenges — integrating new and old systems, for example, and getting leadership buy-in. Organizations should start small, to show early returns, and invest in data science and outside expertise.

"The fourth industrial revolution blurs the line between the physical, the digital, and the biological."

Landry Signé, Professor and Founding Co-Director, Fourth Industrial Revolution and Globalization 4.0 Initiative, Thunderbird School of Global Management

planning. "Just the data that will be available for cities to help manage what's going on will be a big uplift," Dugan explains.

This is more than a data-munching exercise. The newfangled hardware and the data it generates are the beginning of the innovation process, not the end result. By building applications that use sensors and other connected technologies as a foundation, organizations can derive real-world value from data and find new, creative ways to make the world better.

To determine how this is taking shape, MIT Technology Review Insights canvassed dozens of organizations that are using the internet of things to do things that weren't possible before. What follows is a series of the best, most innovative examples. Some of these applications may inspire organizations to rethink how they collect, analyze, and act on data — all of them contribute to a better or at least more efficient planet.

The future is closer than it appears

There are some underlying trends in the following vignettes. The internet of things and related technologies are in early use in smart cities and other infrastructure applications, such as monitoring warehouses, or components of them, such as elevators. These projects show clear returns on investment and benefits. For instance, smart streetlights can make residents' lives better by improving public safety, optimizing the flow of traffic on city streets, and enhancing energy efficiency. Such outcomes are accompanied with data that's measurable, even if the social changes are not — such as reducing workers' frustration from spending less time waiting for an office elevator.
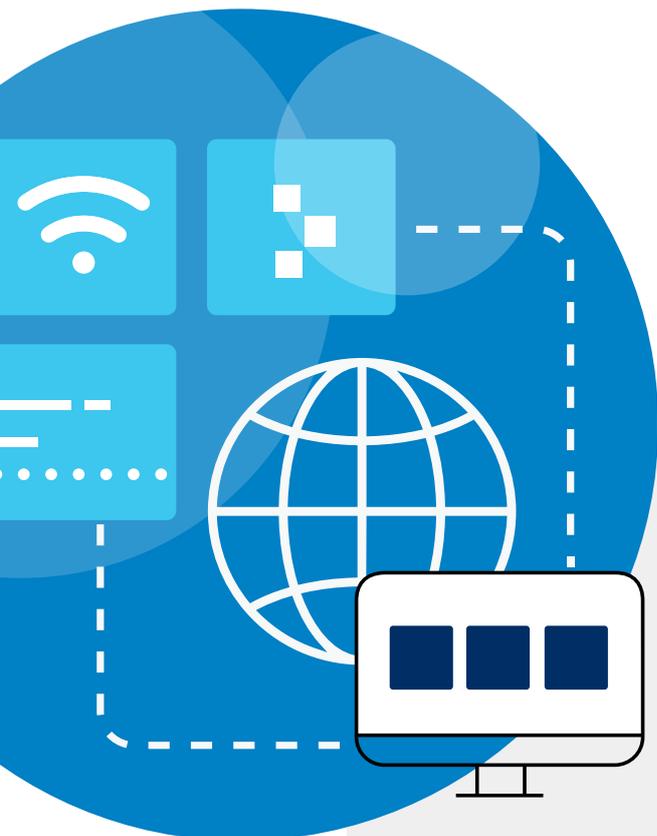
$3.7 trillion
4IR

Value creation potential of the fourth industrial revolution in 2025

Source: McKinsey & Company's "Industry 4.0: Capturing value at scale in discrete manufacturing"

Early adoption is also found in uses in which the harder technical or social problems are secondary, or, at least, the challenges make fewer people nervous. While cybersecurity and data privacy remain important for systems that control water treatment plants, for example, such applications don't spook people with concerns about personal surveillance.

Each example has a strong connectivity component, too. None of the results come from "one sensor reported this"— it's all about connecting the dots. Whether they've been built for in-house use or sold by a technology vendor, these custom applications rely on input from multiple data sources.

Finally, these applications are being built through partnerships. Not every company has the right expertise in-house, so it's common to develop alliances, work together, and use tools that aid in these projects. "Infrastructure and application platforms resolve some of the complexity and choices organizations are facing," Dugan explains.

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Andrew Dugan, Chief Technology Officer, Lumen
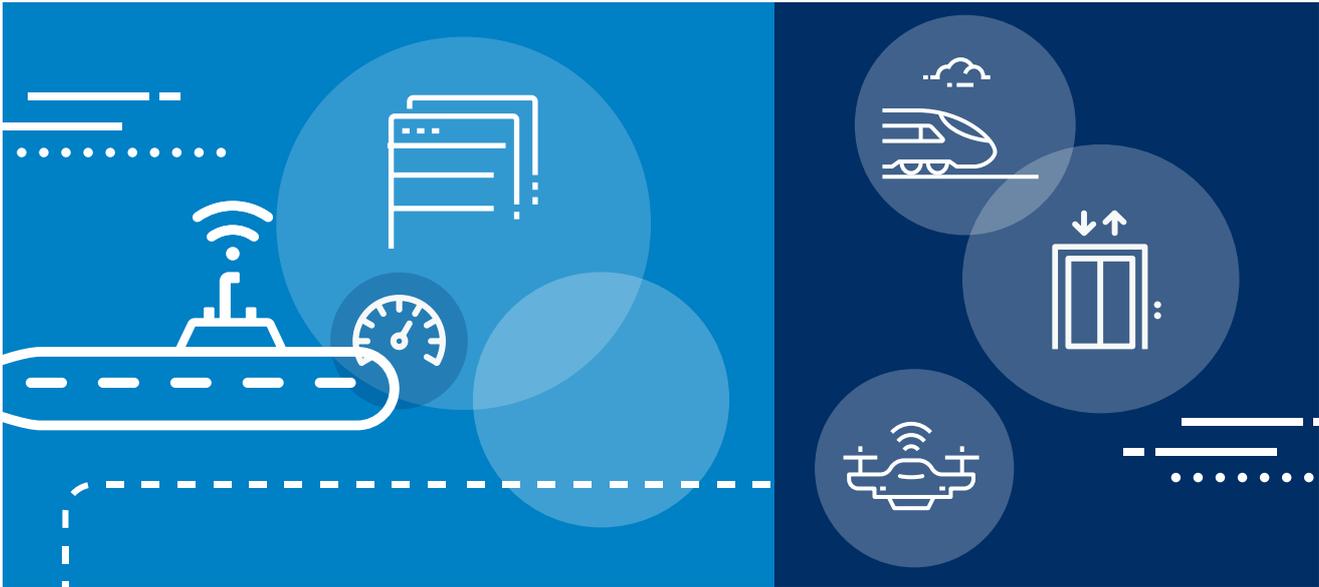
Organizations should join the fourth industrial revolution with their eyes open. These technologies can be complicated, requiring integration between new hardware and established IT systems.

Collecting data: Winning through connectivity

Connecting data makes automation easier. Data can be collected across devices, networks, and the cloud, including in situations in which the information otherwise would be inaccessible.

- Sensors are helping explore the ocean. Access to the internet of things and digital tools gives Triton Submarines new ways to control, measure, document, and learn from each exploration.

- Olea Edge Analytics deploys internet-of-things sensors that help cities fix broken commercial water meters. That also gives municipal water departments financial returns — a boon for tightened budgets.

Analyzing data: Asking better questions

Several technologies can work together to collect data from disparate locations and then do smart things.

- New Jersey Transit, the largest statewide public transit system in the United States, turned to Iota Communications, a wireless network carrier and software service company, to use energy and weather data to optimize energy efficiency.

- The secret to safer elevators and, in turn, buildings lies with data and changing work culture, says Chris Smith, vice president of product strategy at Otis. His team is using connected elevator technologies to perform unique virtual simulations for customers. For instance, staggering employee starting-work times can help minimize bottlenecks by reducing the number of people waiting for an elevator at a given time.

- Drones collect data, too. Kespry, an aerial intelligence and perception analytics company, has an industrial sensor network to improve worker productivity, safety, and well-being in the mining, aggregates, insurance, and oil and gas sectors. Instead of having people climb on roofs to collect on-site data, the company automates the entire process via a sensor network using drones based on AI, machine learning, analytics, and the internet of things, explains George Mathew, Kespry's CEO.

Acting with the data: What does it enable?

Not every system is based on data directly gathered from a sensor. Sometimes, the value is generated indirectly from a variety of sources, taking usage into account in combination with, say, location. And that can make a huge difference in customer experience.

- Sensor technology is saving lives. Last year, nearly 40,000 organ transplants were performed in the United States, and more than 112,000 people are on the national transplant waitlist. When an organ becomes available, there's a race against time. Transplantation requires coordinating an abundance of complexity and communicating with organ procurement organizations, transplant centers, surgeons, hospitals, couriers, and patients. MediGO, which serves the organ transplantation industry, tracks organs in real time, communicates, and analyzes data about organ quality.

- Weather-related applications are among the fundamental uses for consumer smart devices, whether they're speakers, cars, or even refrigerators. But the sheer volume of data creates a huge problem, says Stephen Savitski, senior director of IT enterprise monitoring at forecaster AccuWeather. Billions of devices make trillions of calls on the company's weather application programming interface, or API, every month — and the applications accessing weather data make important decisions.

Innovating with the data: Get smarter

These technologies let organizations do one-of-a-kind things or make better decisions. At the very least, additional data helps organizations improve profitability.

- Predicting fuel usage has financial benefits. Affordable, connected tank monitors can optimize fuel delivery efficiency and increase customer satisfaction. Remote monitoring company Anova transmits daily tank level and usage data to its fuel delivery customers' back-office software, allowing them to optimize delivery routes, increase fuel delivery volume, and reduce overall operating costs.

- Warehouses have a lot of physical space to monitor, which means they need to track data for energy use and cost savings. For instance, tech platform company Enlighted helped Veeco discover problems in the lighting fixtures in its 615,000 square-foot warehouse. The capital equipment supplier's internet-of-things system lets personnel adjust settings according to environmental and occupancy changes. After one year, Veeco reduced its lighting energy load by 59%, achieving a reduced energy bill, with $14,000 saved on annual lighting maintenance.

- Sensors can track location and other attributes. For instance, in a museum that houses some of the most expensive artifacts in the world, every artifact is tagged using a smart device. The devices, from Everbridge, which sells emergency-notification systems, capture the artifacts' geospatial location, ambient temperature, and humidity level. The data connectivity and intelligence allow the priceless assets to be protected from small temperature or humidity changes that could cause rapid deterioration — on top of the added security that confirms, "Yes, the painting is still right where it's supposed to be."

'Industries without smokestacks'

Organizations should join the fourth industrial revolution with their eyes open. These technologies can be complicated, requiring integration between new-to-the-business hardware and established IT systems. And there are other technical challenges, such as network choices and security. For instance, does it make more sense to analyze data close to the point of origin, in the sensor at the traffic light, or in a centralized data center, with more computing horsepower?

Any organization that adopts internet-of-things technologies wants an early success, with easily identified and measured signposts, if only to demonstrate that a project is worth the investment. "Pick the ones where you think you've got the highest probability of actually producing a return," says Lumen CTO Dugan. Wandering around looking for value for too long is a sure way to wear out organizational patience.
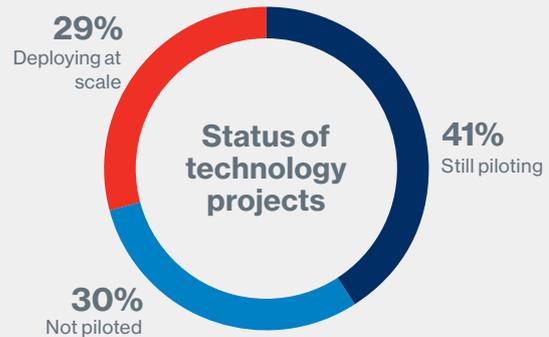
Organizations should begin with the data they have in-house and invest in data science and outside expertise, says Dugan. That might mean hiring data scientists and getting the tools that help them extract value from data. But any true revolution has an influence on society – and it behooves all people to consider the effects of their choices, says Arizona State University's Signé. As a result, matters such as governance and ethics need to be examined by more than technologists: corporations, citizens, nongovernmental organizations, and others have to get involved. "It cannot be exclusively a top-down process. It really requires a certain level of engagement with a broad variety of players," says Signé.

He cites Zipline, which uses drones for blood delivery in Africa and gets essential medical products to remote rural areas. The company is successful because the governments there are willing partners, seeing an incredible opportunity to overcome the region's limited infrastructure. It's just one instance of what Signé sees as "industries without smokestacks," which create new systems of production and help bolster economies around the world.
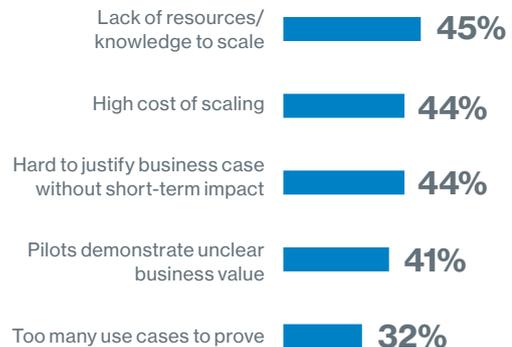
The collection and analysis powered by these new devices will make possible things we can't necessarily envision yet, Dugan says. "It is going to be the next thing we look back at and say, 'Data transformed the world.'"

A revolution in the making

The fourth industrial revolution, also known as "industry 4.0," is gaining a foothold, with more than two-thirds of manufacturers reporting that adopting related technology is a top priority. But far fewer are actually rolling out projects, and obstacles remain.

Importance to strategic agendas

- 68% Top priority
- 22% Average
- 10% Low priority

Status of technology projects

- 41% Still piloting
- 30% Not piloted
- 29% Deploying at scale

What's keeping organizations from joining the revolution?

Lack of resources/knowledge to scale	45%
High cost of scaling	44%
Hard to justify business case without short-term impact	44%
Pilots demonstrate unclear business value	41%
Too many use cases to prove	32%

Source: McKinsey & Company's "Industry 4.0: Capturing value at scale in discrete manufacturing"

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