DATA-DRIVEN WORK SPACES

IoT and AI Expand the Promise of Smart Buildings

Sponsored by

Microsoft

BERT VAN HOOF

**PARTNER, GROUP
PROGRAM MANAGER
AZURE IOT**

MICROSOFT

The term "smart building" was coined in the 1980s after networking and connectivity changed what could be done in the built environment. Today that term is taking on new meaning, driven by growing possibilities for a new, more elevated idea of "smart." The internet of things (IoT) and artificial intelligence (AI) have great potential to help building owners, operators, and occupants manage and dwell in buildings with greater efficiency—saving costs and energy, and organizing space in a way that best fits a company's culture and goals. These benefits apply to a variety of spaces. For instance, hospitals, stadiums, and factories can all be smarter, and the same applies to the electrical grids that connect them and the cities that contain them.

At Microsoft we have shared our vision for ambient intelligence in the modern workplace, which includes the convergence of AI, IoT, and productivity tools that help organizations create a more productive and collaborative workplace. But with changing workplace trends, new lease accounting rules, and increased pressure to minimize costs and operate more sustainably, there has also been expanding interest in applying IoT and AI to transform the ways we experience and manage real estate.

We partnered with Harvard Business Review Analytic Services to examine the status of the smart spaces context and to analyze what decision makers think about when considering adopting smart spaces technology. This report explores the opportunity organizations have to enhance their spaces to better address people's needs. It confirms that technology is not the driver for the introduction of intelligence in spaces, but an important enabler. Traditionally, decisions about how to enhance physical spaces were driven by tangible operational and energy efficiency gains. But business decision makers have growing awareness of and interest in the new benefits of spatial modernization, such as sustainability, space optimization, occupant experience, and employee productivity.

The research completed also shows that organizations still see the introduction of intelligence into spaces as a complex and lengthy process with benefits that are difficult to quantify. At Microsoft, we are challenged every day to empower every person and organization to achieve more, and the next priorities for the dissemination of smart spaces,are to simplify their creation and rapidly bring their benefits to fruition.

Microsoft announced earlier in 2018 that it is investing $5 billion in IoT over the next four years. Our goal is to simplify the journey in IoT so any customer, no matter where they are starting from, can create trusted, next-generation IoT solutions. These are solutions that go beyond connecting and managing devices; but include modeling the relationships and interactions between people, places, and devices.

Microsoft's new Azure Digital Twins service enables such modeling to take connected devices a step further in the world of IoT. Twin object models (ontologies)—predefined domain-specific concept definitions, categories, and semantics—make it faster and easier to model and build domain-specific solutions for specific industry verticals. Combined with contextualized sensor processing, we create the ability to query data in the context of a space, rather than from disparate sensors. This sets our partners up to build repeatable and scalable spatially aware solutions. For example, in an office environment, spatial intelligence can enable better management of heating, cooling, and room-booking systems based on how the space is actually used. With built-in support for multi- tenants or nested tenants and role-based access control, our partners can focus on innovation at the application level instead of building from scratch. With Azure Digital Twins, partners will be able to create, scale, manage, and secure solutions that take advantage of spatial intelligence.

We'll start to see new AI experiences that are uniquely relevant because of the ability to correlate data from across the digital and physical worlds, thereby unlocking new opportunities to improve consumer experiences, create new efficiencies, and improve the spaces in which we work, live, and play.

This will pave the way for a range of new applications that bring the next level of smart to life.

DATA-DRIVEN WORK SPACES
IoT and AI Expand the Promise of Smart Buildings

New technology is helping owners, managers, and occupants extend the reach—and benefits—of smart buildings

It's no secret that smart buildings have taken hold throughout the world. The desire to better manage energy consumption helped launch smart-building strategies, which use scores of data-gathering sensors and sophisticated analytics to optimize facilities management. In fact, 66% of global organizations identify energy management as the prime business driver for smart buildings, according to a global survey of 405 commercial real estate developers, owners, and occupants conducted by Harvard Business Review Analytic Services.

But now, a significant group of executives is seeing energy management as just the beginning—they also see a more strategic role for smart-building technology. Early adopters are doing this by dynamically allocating space to meet the changing needs of their employees and to increase utilization percentages. In turn, building owners and occupants can leverage data to build new applications and services that increase collaboration and productivity of workers as part of a growing movement known as occupant experience. Just as important, these forward thinkers are finding the tools to meet these goals. Cloud services tailored for the internet of things (IoT), plus advanced analytics using artificial intelligence (AI) and machine learning, are redefining "smart" and supporting new use cases.

"[Smart-building] capabilities are helping people become more comfortable and productive at work, thanks to real-time data about air quality, lighting, noise levels, and other environmental factors," says Erik Ubels, chief technology officer at Edge Technologies, a technology real estate company headquartered in Amsterdam that specializes in a new generation of smart buildings. "Workers then are given convenient ways to find the workspace they need for the task at hand, whether that's a quiet place to focus on and review a complex spreadsheet or an open area to reconnect with colleagues about a new project."

New opportunities for smart buildings exist, but unfortunately, so do additional hurdles. Thirty percent of the respondents say their organization can't measure the ROI of their spending for smart-building applications. Twenty-nine percent of the respondents struggle with retrofitting legacy infrastructure and technology with sensors, IoT, and analytics. In addition, 23% say cultural and change-management issues are holding back progress.

However, a small but significant segment of the overall sample demonstrates a high level of smart-building maturity and skills for addressing today's challenges. This segement also provides important lessons for how less-mature organizations can advance their strategies.

KEY TAKEAWAYS

- 66% of global organizations identify energy management as the prime business driver for smart buildings

- 72% of executives say their prime business goals for smart buildings are reducing facilities and operations costs and improving profitability

- 46% strongly believe that a smart-building strategy will become a competitive differentiator in the commercial real estate market

- 30% of respondents say their organization can't measure smart-building ROIs

- 32% say the ROI time frame is more than 12 months

- 39% will invest in cloud services tailored for the internet of things

- 39% plan to earmark funding for cloud-based AI platforms

- 24% expect to add technology for digital twins for real-time analysis of facilities

New Opportunities

This report defines smart-building initiatives as those that use data-gathering sensors and analytics to better manage facilities costs, energy consumption, infrastructure maintenance, and use of physical space. Global executives who participated in the research are well acquainted with the more operations-oriented use cases in our definition, namely those relating to costs and energy. For example, 72% of the executives say their prime business goals for smart buildings are reducing facilities and operations costs and improving profitability. FIGURE 1 Similarly, 66% cite energy management as the prime incentive.

These nuts-and-bolts business drivers have sustained the sensor-based approach since its inception, and there are no signs that will change in the near future. Reducing spending on energy is something that can be metered and easily quantified, which provides credibility for smart-building projects. "We also believe there's a direct correlation between energy performance and occupant comfort," says Perry England, vice president, building performance, for MacDonald-Miller Facility Solutions, Inc., a Seattle-based full-service provider for the commercial real estate industry.

Smart technology is even being implemented in the early phases of a building's life. PCL Construction developed an application that uses sensors and analytics during the construction process for quality control. For example, to complete drywall installations, crews tape over seams and apply joint compound. These materials may deteriorate if environmental conditions become extreme, so PCL installs temporary sensors that send alerts when risks arise. "Monitoring and quickly remediating issues during construction, and before they become a problem, prevents potential damage, reduces re-work, and eliminates future client warranty claims," says Chris Palmer, manager, advanced technology services for PCL Construction, Edmonton, Alberta. "In addition to increasing build quality and client satisfaction, it also reduces costs, where eliminating re-work in just one room can save up to $30,000."
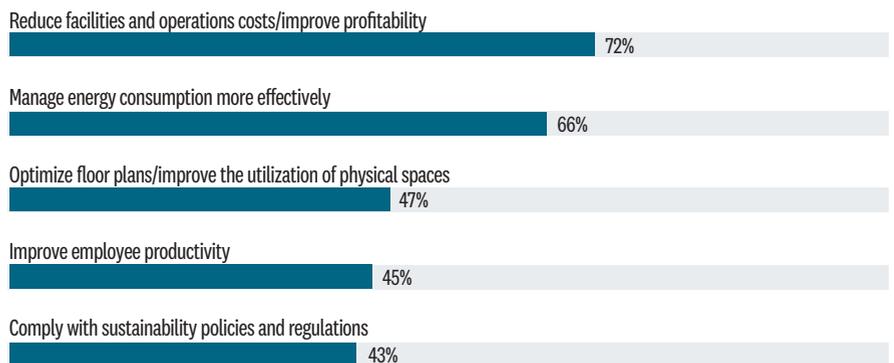
With that solid, bottom line–oriented foundation in place, many executives are ready to expand the reach of smart buildings in ways that don't just support internal operations. Tenant experience is a natural outgrowth of energy management and offers an insight into future developments. For example, an eight-person meeting room that is automatically set to

FIGURE 1

CLEAR INCENTIVES FOR GETTING 'SMART'

What business goals are most important when making smart-building investments?

[MULTIPLE REPLIES PERMITTED; TOP FIVE SELECTIONS SHOWN]

Reduce facilities and operations costs/improve profitability
72%

Manage energy consumption more effectively
66%

Optimize floor plans/improve the utilization of physical spaces
47%

Improve employee productivity
45%

Comply with sustainability policies and regulations
43%

SOURCE: HARVARD BUSINESS REVIEW ANALYTIC SERVICES SURVEY. JULY 2018

cool for full capacity is uncomfortably cold when there are only three or four people inside.

"A system that knows how many people are in the room at a given time can make the space more comfortable and at the same time reduce overall energy consumption," England says.

Helping commercial real estate companies improve their competitiveness is one reason why organizations are looking to capitalize further on smart-building strategies. In fact, nearly half (46%) of the building owners, managers, or occupants "strongly agree" that a successful smart-building strategy will become a competitive differentiator in their respective market. As a result, executives have a clear idea about the business drivers that will justify new smart-building investments over the next three years. More than half (51%) see new opportunities for improving employee productivity and the efficiency of building operations. FIGURE 2
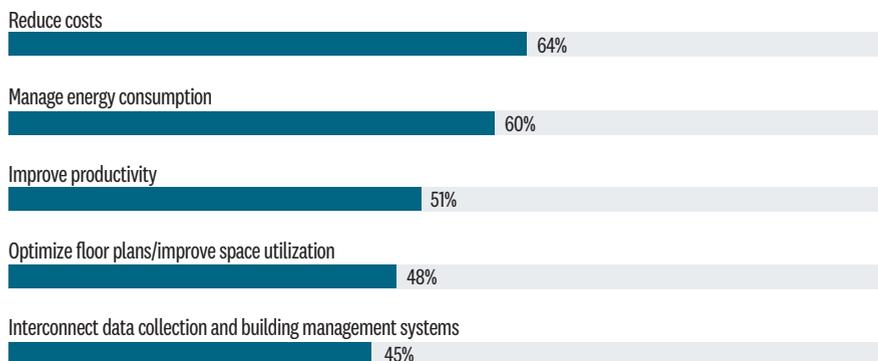
The productivity of occupants plays into an industry-wide benchmark known as the 3/30/300 model, first coined by the consulting firm JLL. In essence, it says that for each square foot in a building, owners typically spend about $3 for utilities, $30 for rent, and $300 for employee-related expenses each year. According to the model, investments for occupants (enabling them to become more productive, for example) yield greater relative returns than utilities savings, the more traditional and quantifiable use case for smart buildings. While industry veterans may debate whether the model's specific values are correct, many accept that the relative financial impact of the three is on target. "The industry's efforts have been very focused on operations, the '3,'" says Joshua Ridley, chief executive officer for Willow, Inc., a creator of digital twins for smart-building solutions based in Sydney, Australia. "I'm not saying that it shouldn't be. But we should also have a conversation about what the '300' represents—the first wave of occupant experience and how can we create a better place for our employees by getting them more connected, active, and productive."

WHAT'S DRIVING INVESTMENTS?

What business drivers will prompt new smart-building investments?

[MULTIPLE REPLIES PERMITTED; TOP FIVE SELECTIONS SHOWN]

Reduce costs
64%

Manage energy consumption
60%

Improve productivity
51%

Optimize floor plans/improve space utilization
48%

Interconnect data collection and building management systems
45%

SOURCE: HARVARD BUSINESS REVIEW ANALYTIC SERVICES SURVEY. JULY 2018

Occupant experience isn't the only opportunity that forward-leaning executives are contemplating. Leaders in the smart-buildings space—those who are developing or already have an enterprise approach in place—also see a chance to embrace new markets. A commanding majority—82%—of leaders say the technology will see significant adoption beyond offices and residential facilities into manufacturing plants, hospitals, retail stores, sports stadiums, schools, and other types of organizations. For example, greater use of sensors and sophisticated analytics can alert manufacturers to emerging problems in production lines before quality-control or reliability problems arise. Similarly, hospitals, retailers, and sports teams can send highly personalized information and offers to patients and patrons who opt in to these services. Demand for smart buildings will also grow over the next three years as underutilized and inefficient work spaces become harder to justify financially, according to the 56% of the full sample of respondents who "strongly agree" with that statement.

This demand will be fueled in part by a reaction against the costly vacancies that currently plague the industry: a quarter of all respondents say 26% or more of their clients' office or factory spaces are vacant at any given time.

DEMAND FOR SMART BUILDINGS WILL GROW OVER THE NEXT THREE YEARS AS UNDERUTILIZED AND INEFFICIENT WORK SPACES BECOME HARDER TO JUSTIFY FINANCIALLY

"Many of our clients have realized that delivering smart next-generation workplace experiences **are critical to attract and retain the right talent** and meet their expectations of a modern digitized workplace," says Sandeep Davé, chief digital and technology officer at CBRE.

Roadblocks to Success

But while the smart-buildings market is poised for growth, success isn't guaranteed. Executives must overcome a host of challenges. For example, quantifying the business case for new investments is still difficult, with 30% of the respondents saying their organization can't measure the ROI of their spending for these applications. FIGURE 3 However, having mature smart-building operations clearly has advantages: only 14% of the segment of companies with an enterprise strategy face similar struggles trying to quantify investment returns, while 26% of the leaders say they can accurately measure most or all components of ROI. The timing of investment paybacks is another ROI hurdle. Nearly a third (32%) overall say the typical time frame for returns is 13-24 months, while a similar number (31%) say it's

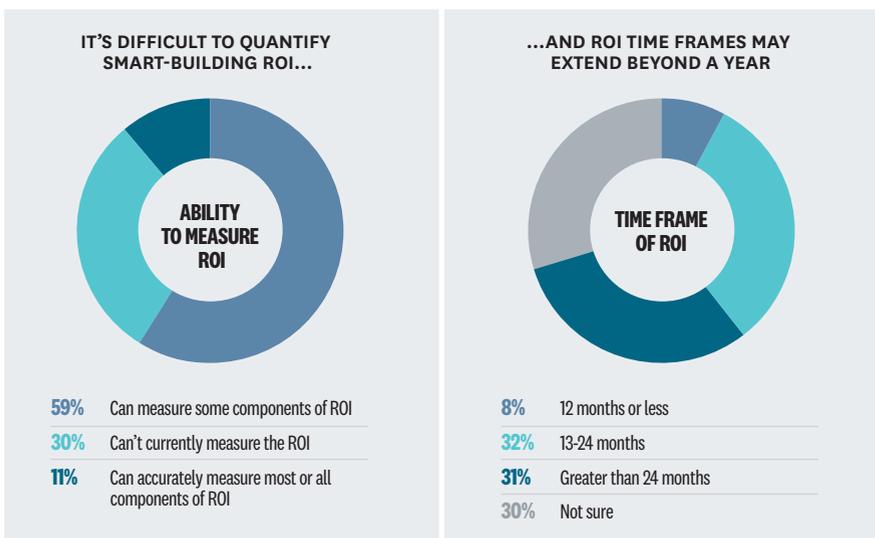greater than 24 months. A similar number (30%) aren't even sure how long returns are taking.

It's notable that while leaders are better able than their peers to measure returns, they haven't found a way to shorten the time frames. One reason may be that while it's easy to quantify paybacks in traditional areas—hard data can be obtained regarding reduced operating and energy costs—the benefits of newer, more strategic applications, such as competitiveness and occupant productivity, are more difficult to measure. That's not stopping some organizations from moving forward. "Many of our clients have realized that delivering smart next-generation workplace experiences are critical to attract and retain the right talent and meet their expectations of a modern digitized workplace," says Sandeep Davé, chief digital and technology officer, Global Workplace Solutions at CBRE, a global commercial real estate service provider headquartered in Los Angeles.

Steelcase, a supplier of office furniture that has formed a new business unit for smart-office capabilities, worked with a growing company that was feeling pinched for space. Executives were hearing complaints about a lack of available conference rooms or spaces that offered specialized technology, such as telepresence or video-conferencing systems. "They were on the cusp of launching an expensive expansion project," says Sara Armbruster, vice president for strategies, research, and digital transformation at Steelcase.

But before doing that, the firm installed sensors that captured real-time information about room occupancy levels and traffic patterns. Analyses

FIGURE 3

INVESTORS MUST BE PATIENT

IT'S DIFFICULT TO QUANTIFY SMART-BUILDING ROI...

ABILITY TO MEASURE ROI

...AND ROI TIME FRAMES MAY EXTEND BEYOND A YEAR

TIME FRAME OF ROI

59%	Can measure some components of ROI
30%	Can't currently measure the ROI
11%	Can accurately measure most or all components of ROI

8%	12 months or less
32%	13-24 months
31%	Greater than 24 months
30%	Not sure

SOURCE: HARVARD BUSINESS REVIEW ANALYTIC SERVICES SURVEY, JULY 2018

of the data yielded a surprising result—the utilization level across the entire workspace was only about 35%. While the total square footage was more than enough to accommodate the current staffing levels, "the data showed that employees were struggling to find space, not because it wasn't available, but because it may have been in a different part of the building and they just weren't aware of it," Armbruster says.

Drawing from the sensory data and analytics, the company reconfigured the space it already had. Some large conference rooms were reconfigured into smaller meeting areas and enclaves.

Then the company rolled out a mobile app to let people find and book available space that offered the right size and the right resources, such as a whiteboard or video-conferencing system. These moves increased the overall utilization rate from 35% to 51% so far, while better suiting their employees' needs, Armbruster says.

Other roadblocks to smart-building implementations include challenges associated with retrofitting legacy infrastructure and technology, a problem cited by 29% of the entire sample. FIGURE 4 In addition, 23% identify corporate-cultural and change-management issues. It is notable that the inadequate funding

for smart-building projects is further down the list of challenges. Apparently, C-suites and boards are ready to approve sufficient resources if they're presented with a solid business case.

The survey also pinpointed one of the prime reasons for cultural and change-management problems. Only 10% of the overall survey respondents "strongly agree" that smart-building initiatives can be easily and quickly implemented using existing IT staff and skill sets. Similar percentages of building owners and occupants share this assessment. Both groups can address shortcomings by engaging with real estate management companies with smart-building expertise and solutions. In addition to training or hiring talent with the necessary expertise, companies should address change issues with a solid communications strategy. "The key is how well organizations engage employees throughout the process of adding smart-building capabilities," Armbruster says. "Have regular conversations about why the company is moving to a new type of work environment, installing sensors, or reconfiguring existing spaces. It's critical to give employees a voice in that process from the beginning to the end."

ADDRESS PRIVACY CONCERNS HEAD-ON

Privacy will likely be one of the biggest concerns for employees as smart-building implementations grow. Sensors that record where people work and congregate, or when they enter or leave the building, may quickly conjure images of an intrusive work environment. "It is important to strike a balance between collecting rich data that can provide meaningful insights on the one hand and at the same time ensure that we are not intruding on the privacy of individuals," says Sara Armbruster, vice president for strategies, research, and digital transformation at Steelcase.

The fears can be partially addressed by ensuring that only anonymized data is being recorded. So while the smart-building platform may track how many people are in a meeting room or at a desk in a work cluster, it is more difficult to pinpoint which individuals are there. But that alone may not be enough. Companies should also communicate early and often with employees so they know what information is being collected and why. Companies should also explain why some staff members may want to opt in to provide personal information to smart-building systems. For example, when sensors can identify the individual who is occupying a work space, the environmental conditions in the immediate surroundings can be adjusted to that person's specific tastes. Any initiatives that provide these types of opt in options should also include the right to be forgotten, meaning that personal information is deleted if the individual no longer wants to be identified by the system.
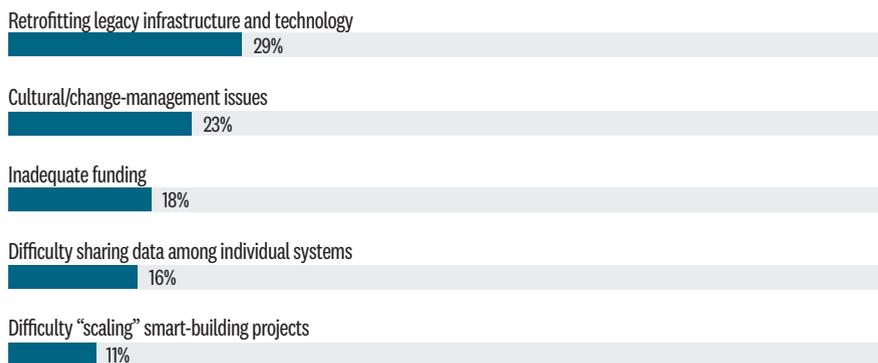
Some in the real estate industry draw comparisons to ride-sharing services. "They know where we're traveling to and where we like to shop, but we're willing to offer them that information because of the value they provide," says Davé.

FIGURE 4

WHAT'S HOLDING BACK SMART-BUILDING PROJECTS?

The biggest challenges organizations encounter with smart-building initiatives
[MULTIPLE REPLIES PERMITTED]

Retrofitting legacy infrastructure and technology
29%

Cultural/change-management issues
23%

Inadequate funding
18%

Difficulty sharing data among individual systems
16%

Difficulty "scaling" smart-building projects
11%

SOURCE: HARVARD BUSINESS REVIEW ANALYTIC SERVICES SURVEY. JULY 2018

By running **IoT and AI capabilities in the cloud**, building owners and managers avoid having to create and maintain the necessary hardware and software.

Cloud Supports Innovation

While challenges exist, global executives are looking to emerging technologies to help overcome hurdles. When asked what technologies they expect to add over the next three years, the top response (at 42%) among the overall sample was analytics for predictive maintenance, which represents the logical step forward for companies that have already bought

into the value of optimizing operations and energy management with smart-building capabilities. But there also are signs of the approach's more strategic direction: 39% expect to add cloud services tailored for IoT, while the same percentage will earmark cloud-based AI platforms, two highly complementary service offerings. The subgroup of leaders was even more enthusiastic about AI: 50% put investments in this area at the top of the list. By running IoT and AI capabilities in the cloud, building owners and managers avoid having to create and maintain the necessary hardware and software. They can also contract for additional processing and analytical services if a smart-building implementation expands with additional sensors or supports new business models.

Executives have clear reasons for committing to cloud IoT and AI. More than a third (34%) of the entire sample, and 46% of the leaders group, expect to see significant increases in revenues and business opportunities thanks to these solutions. Specifically, 59% of the overall sample plan to use IoT and AI technologies to better allocate space utilization. The group of leaders will double down in this area: 71% see the benefits of IoT and AI for optimizing work spaces.

In addition, cloud services let providers of smart-building solutions focus on their core business rather than maintaining on-premises software development tools. For example, Ridley, the CEO at Willow, says the cloud platform his company uses provides tools for rapid software development, as well as preconfigured interfaces for relevant third-party applications.
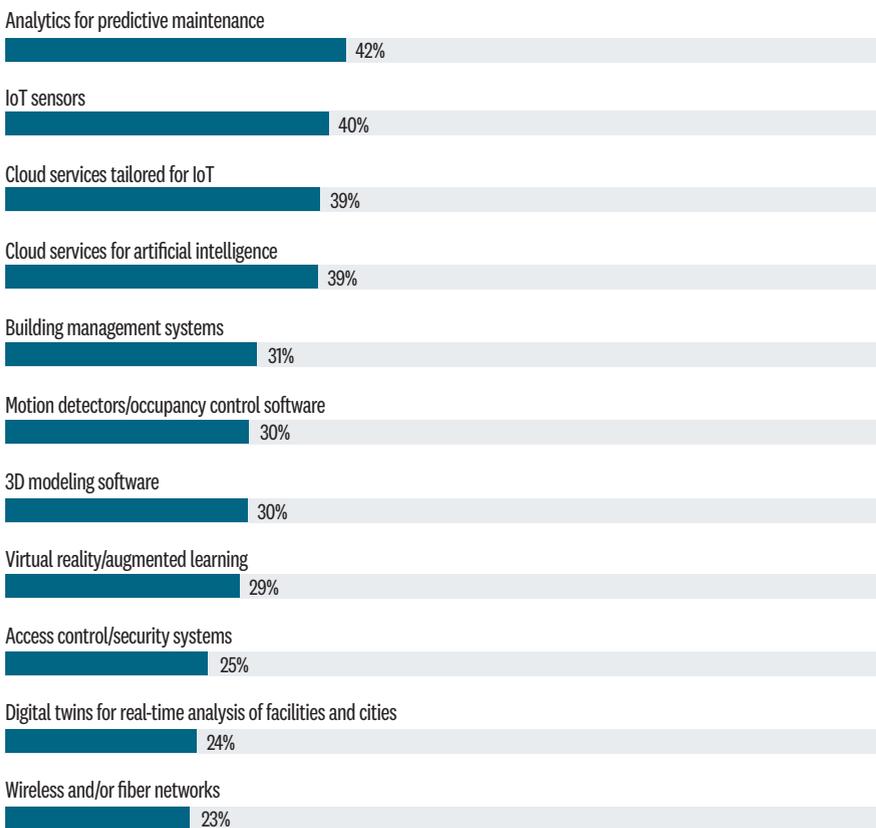
Another important technology area will be the use of digital twins for real-time visualization and analysis of facilities and cities. These digital, 3D replicas of

FIGURE 5

TECHNOLOGY ROADMAPS TAKE SHAPE

The technologies companies plan to add over the next three years for smart buildings

[MULTIPLE REPLIES PERMITTED; TOP 10 SELECTIONS SHOWN]

Analytics for predictive maintenance
42%

IoT sensors
40%

Cloud services tailored for IoT
39%

Cloud services for artificial intelligence
39%

Building management systems
31%

Motion detectors/occupancy control software
30%

3D modeling software
30%

Virtual reality/augmented learning
29%

Access control/security systems
25%

Digital twins for real-time analysis of facilities and cities
24%

Wireless and/or fiber networks
23%

SOURCE: HARVARD BUSINESS REVIEW ANALYTIC SERVICES SURVEY, JULY 2018

work spaces and building equipment use sensory data to show lighting conditions, temperatures, the layout of elevators and security systems, and other elements of the physical world. By understanding how people are interacting with work spaces, digital twins can recommend ways to optimized the environment. "Digital twins for the built environment, which identify actionable insights from data, IoT, and AI, are needed to deliver revolutionary innovation in smart buildings," Ridley says. Twenty-four percent overall expect to add technology for digital twins for real-time analysis of facilities and cities by 2021. FIGURE 5

The reason? By providing all this information within a clear visual format, digital twins help managers see how spaces are being used and where inefficiencies arise in floor plans and equipment. In fact, 78% of the leaders say the real-time representations can deliver significant improvements in facilities management. For example, the software in a digital twin may be programmed to alert facilities managers when local regulations require them to inspect fire dampers. The twin can maintain ongoing records of inspections, including who performed them and when to provide an audit trail.

A MORE CONNECTED FUTURE

As the leading practitioners of smart buildings show, the technology offers a wide range of potential benefits for owners, managers, and tenants. But reaping those rewards isn't guaranteed. Companies must address some important challenges around legacy technology and change management. Senior leaders must also be willing to approve new investments without a full set of quantifiable data to justify every dollar, and then have the patience to wait perhaps a year or more to see a full return. But not all the gratification will necessarily be delayed. In addition to seeing near-term cost reductions in operating expenses, companies may see signs of more productive workforces as people learn to use connected technology to work more efficiently and comfortably.

NEXT-GENERATION 'SMARTS'

Technology innovations in the internet of things and artificial intelligence will offer new opportunities for expanding smart-building strategies beyond traditional use cases. Here's a sample of near-term possibilities.

AI and automation for productivity: Occupants will use voice recognition capabilities to adjust environmental conditions to their liking or say, "the video-conferencing system in this conference room isn't working." The AI assistant would be aware of which room has the problem, generate a work order, and quickly reply with an estimate of when the problem would be resolved. The assistant could also direct people to an alternative room with similar resources.

Automated room scheduling: Using a visual representation of the office space displayed on smartphones or laptops, employees can see what areas are currently free, how many people are using them, what resources are in each location, and reserve spaces.

Building access: Using combinations of QR codes, facial recognition, or software-based credentials on mobile devices, authorized employees and partners can gain entrance to main buildings or restricted areas without traditional common-access cards, which can be lost or stolen.

Connected campuses: Thanks to connections to their smartphone apps, people are directed to available parking spaces appropriate for the size and type of vehicles they drive. Once inside the building, individuals may choose an appropriate desk or workspace, and the building automatically adjusts the surrounding lighting and temperature to their preferences. When it's time to begin a video conference, the building can locate and log in the necessary participants wherever they are on campus or other facilities.

Public safety and emergency management: If a fire, intruder, or other crisis situation arises, sensor-based data and analytics can help officials direct people safely to exits or places to take cover.

And if the visions of some smart-building advocates are a guide, today's smart offices may soon spawn more interactive and collaborative communities and regions.

"We'll really be onto something big when buildings start connecting with other buildings and municipal services," England says, citing a local initiative that lets companies exchange information with an electric utility to manage electricity demand and take advantage of off-peak rates when possible. "There are examples of this across the country and the world. But it will take mass adoption of that approach for us to really see its potential."

Until then, forward-looking companies are preparing themselves and their employees for this future, one sensor at a time.

METHODOLOGY AND PARTICIPANT PROFILE

A total of 405 respondents were drawn from the *Harvard Business Review* audience of readers, including magazine/enewsletter readers, customers, and HBR.org users.

SIZE OF ORGANIZATION

52%
10,000 OR MORE

12%
5,000–9,999

22%
1,000–4,999

12%
500–999

SENIORITY

64%
EXECUTIVE/SENIOR MANAGEMENT

20%
MIDDLE MANAGERS

16%
OTHER

KEY INDUSTRY SECTORS

14%
TECHNOLOGY

12%
TELECOM/ENERGY/ UTILITIES

11%
BUSINESS/ PROFESSIONAL SERVICES

9%
EDUCATION

9%
MANUFACTURING

8%
HEALTH CARE/ PHARMA/ LIFE SCIENCES

7%
GOVERNMENT/ NONPROFIT

OTHER SECTORS WERE EACH REPRESENTED BY 5% OR LESS OF THE RESPONDENT BASE

JOB FUNCTION

20%
GENERAL/ EXECUTIVE MANAGEMENT

9%
SALES/BUSINESS DEVELOPMENT/ CUSTOMER SERVICE

8%
IT/SOFTWARE ENGINEERING

8%
ENGINEERING

OTHER FUNCTIONS WERE EACH REPRESENTED BY 7% OR LESS OF THE BASE

REGIONS

48%
NORTH AMERICA

25%
EUROPE

18%
ASIA/PACIFIC

5%
MIDDLE EAST/ AFRICA

4%
REST OF WORLD

Figures may not add up to 100% due to rounding.