Harvard Business Review
ANALYTIC SERVICES

MIXED REALITY: A NEW DIMENSION OF WORK

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In the span of a few short decades, we've seen the very nature of what it means to work change. Just as the agricultural revolution led to rapid increases in efficiency and the industrial revolution ushered in new means of production, the digital revolution has again redefined what it means to work. Today, information is everywhere, transforming the way we communicate, collaborate, and create. Nowhere has this been more apparent than in the modern workplace. No matter where we work or what we do, the ubiquity of information has given rise to a new culture of work—one that is increasingly open, global, and multigenerational, driven by a greater sense of purpose, ingenuity, and teamwork than ever before.

But while information seems to be everywhere, it's often not in the hands of workers when and where they need it most. For 80% of the workforce—Firstline Workers who are the people serving customers behind the counter, in the clinics, and on the phone, or pioneering new products and processes on the factory floor—work requires information to be in context—not just on a screen, but in the physical space of their work. And for all employees, the global workplace demands that information be easily accessible and exchanged—across barriers of time and place, between geographically and culturally disparate teams.

At Microsoft, we are on a mission to empower every person and organization on the planet to achieve more. Central to this mission is our aim to build tools for the modern workplace, tools that will close the gap between workers and the information they need to do their best in the work, from the C-suite to the Firstline.

Mixed reality is one of the most powerful of these tools. From virtual reality simulations to augmented reality and data in the context of the real world, mixed reality has already begun to change the way we work, learn, and communicate. Whether in remote assistance, space planning, training, teamwork, or IoT-based spatial analytics, mixed reality has enormous potential to help businesses and their employees work smarter, faster, and better. By bringing information into our world, when and where we need it most, mixed reality adds a new dimension of creativity, teamwork, and security to the modern workplace.

We partnered with Harvard Business Review Analytic Services to examine the unique role and importance of mixed reality within the context of the modern workplace across a range of industries, from manufacturing, engineering, and construction to retail, defense, and education. This report will explore the opportunity organizations have to create more intuitive, immersive, and empowering experiences for their employees, in order to better serve their customers in this increasingly digital age.

LORRAINE BARDEEN

GENERAL MANAGER, MIXED REALITY

MICROSOFT

MIXED REALITY: A NEW DIMENSION OF WORK

Mixed reality—an umbrella term for technology ranging from virtual reality to augmented reality that blends the physical and digital worlds—is quickly becoming a key part of enterprise digital transformation initiatives. It is emerging as an important tool to improve employee productivity, training, and customer service, according to a recent Harvard Business Review Analytic Services study.

More than two-thirds (68%) of respondents believe mixed reality is important to achieving their companies' strategic goals in the next 18 months. FIGURE 1 And they're moving quickly: about a third of respondents said mixed reality systems will be in production at their companies within the year.

At the same time, respondents reported that mixed reality has been more difficult to implement than other enterprise applications. Most senior executives don't have a good grasp of the technology and are not articulating a clear vision for it, even though they see it as critical to their success.

Harvard Business Review Analytic Services surveyed 394 executives at companies in diverse industries and with 250 or more employees. The survey results, along with interviews with analysts and users, ratify that mixed reality is poised to reshape the way employees work and make them more productive by enabling them to work across physical and digital boundaries and to interact with digital content in new ways.

"Every 10 or 15 years, there's an impactful shift in the way people use and interact with technology and data," said Allan Cook, managing director for Deloitte Consulting. After the PC, the internet, and the mobile revolution, "mixed reality is going to be the fourth shift, and it will be as big as each one of those earlier shifts."

Ready for Action

Enterprises are rapidly adopting mixed reality. Forty-nine percent of respondents reported that their companies are piloting or implementing the technology in their workplace, and 38% are exploring use cases. FIGURE 2

Mercedes-Benz, the German automobile manufacturer, is one of these early adopters. In 2014, the carmaker began experimenting with mixed reality to train service technicians. The goal was to have the technicians use holographic images to visualize and understand the cars' complicated machinery faster and better.

The technology wasn't ready for such demanding, intricate uses at the time. "It was unusable," said Walter Bauch, a project manager at the Mercedes-Benz Global Training Center. "The heat given off was tremendous, and it had no battery life."

By 2016, however, advancements had made mixed reality viable. Mercedes-Benz identified 10 use cases, and settled on four to pilot: training, sales, safety, and service advisory. The new trial was so successful that demonstrating Mercedes-Benz's mixed reality capabilities became a popular road show at conferences the following year.

At the influential Hannover Messe show in Hannover, Germany, Mercedes-Benz demonstrated how technicians wearing mixed reality headsets could repair brakes more efficiently by consulting holographic images of the car parts instead of manuals or videos. At the International Motor Show in 2017, a crowd-pleasing demo offered a preview of how the technology could be used to improve the customer experience. After putting on a mixed reality headset, conference goers could view virtual bags being placed in a virtual roof box mounted on a real sedan. Ralf Krieger, a Mercedes-Benz executive who worked on the project, recalled their delight at seeing things, which did not really exist, placed in a "roof rack"—both of which were holograms but seemed so real.

"In my 30 years as a Daimler AG employee, I have never had an experience where I handed a technical solution to someone and it created such a happy experience, where they were smiling and fascinated," Krieger said. "There is something magical in the device."

New Benefits for Businesses

The "magic" of mixed reality is expected to translate into significant business advantages. Over the next few years, Mercedes-Benz anticipates deploying mixed reality to its network of 6,000 dealers, who will use it to explain repairs to customers. Executives envision the technology will improve relationships with customers, unlock employee productivity, and create new products and service offerings.

Automakers have been among the first industries to embrace mixed reality, and Cook sees other potential opportunities for the technology. Mixed reality could enable car salespeople to show models and options that are not on site, for example. "In countries where there are not a lot of high-end dealerships, a salesperson could bring the mixed reality technology to a prospective buyer's home and let him 'see' what the automobile would look like in his driveway," Cook said. "Based on that, they could decide it might make sense to bring an actual automobile to the buyer, or have him make a trip to the showroom."

Companies have identified numerous use cases for mixed reality technology, according to the survey. Training and educating employees tops the list, cited by 54% of respondents, followed by visualizing and analyzing data (49%). For example, mixed reality offers ways to train workers for situations that are too dangerous or costly to replicate live. Oil and gas companies are using mixed reality to train employees who maintain remote offshore facilities, letting them become familiar with the complex operations before they set foot on a rig.

Other areas where mixed reality technology has potential include:

Remote Assistance: Similar to how Mercedes-Benz plans to use mixed reality for repairs, technicians at any site can call an expert about any complicated issue rather than log on to a desktop or go back to their truck or office to find the information they need. "The classic way for an engineer to repair an aircraft engine is to consult manual after manual," said Ramon Llamas, a research director at IDC. "Mixed reality leaves your hands free to work, and you don't have to go back to the office."
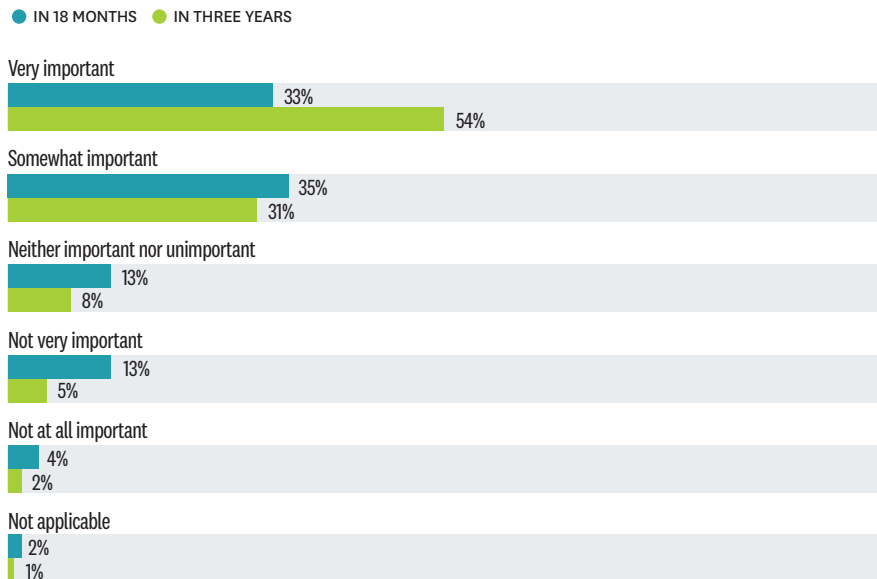
Customer Engagement: Mixed reality enables companies to engage with and learn more about customers in ways they never could before. For example, retailers can have customers

FIGURE 1

THE IMPORTANCE OF MIXED REALITY

Enterprises view mixed reality as imperative for business success.

Please rate how important mixed reality technologies are, or will be, in helping your organization achieve its strategic business goals in the next 18 months/three years.

● IN 18 MONTHS ● IN THREE YEARS

Very important
- 33%
- 54%

Somewhat important
- 35%
- 31%

Neither important nor unimportant
- 13%
- 8%

Not very important
- 13%
- 5%

Not at all important
- 4%
- 2%

Not applicable
- 2%
- 1%

SOURCE: HARVARD BUSINESS REVIEW ANALYTIC SERVICES SURVEY, MARCH 2018

COMPANIES ENVISION THE CONVERGENCE OF PHYSICAL AND DIGITAL EXPERIENCES BECOMING A DEFINING FEATURE OF THE MODERN WORKPLACE.

FIGURE 2

BUSINESSES ARE READY FOR MIXED REALITY

To the extent that your organization is using or thinking about using mixed reality, how soon will any applications be in production?

87% currently exploring, piloting, or deploying mixed reality

- 67% currently exploring use cases or piloting MR
- 20% currently in production or deploying MR

We are actively exploring use cases for the technology but have not begun testing
- 38%

We are currently testing or piloting the technology
- 29%

We have expanded our testing into production with the technology
- 5%

We are using the technology in one or more functional areas
- 15%

We have no need for this technology
- 13%

SOURCE: HARVARD BUSINESS REVIEW ANALYTIC SERVICES SURVEY, MARCH 2018

FIGURE 3

UNTAPPED POTENTIAL

Companies have identified a range of mixed reality use cases.

Which of the following use cases for mixed reality technologies have been identified by your organization? Which of the following aspects of work have the greatest potential to be improved?
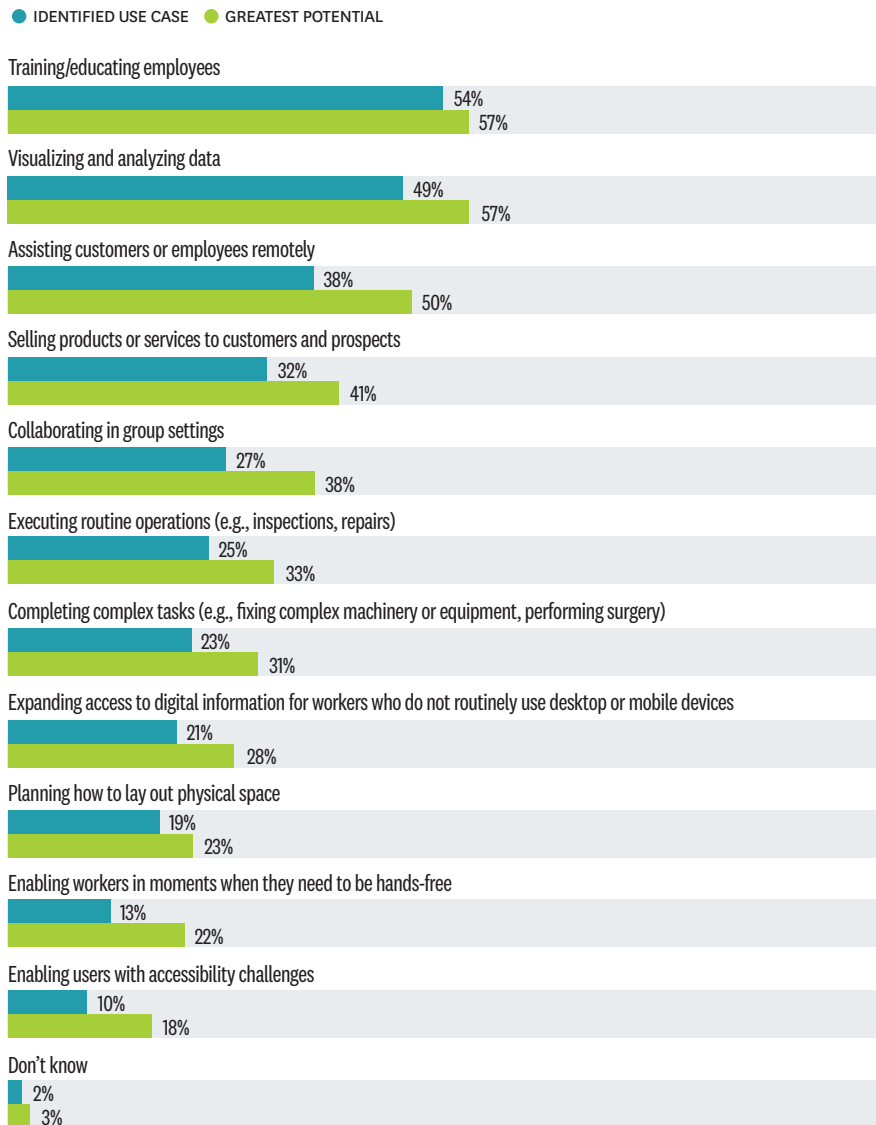
● IDENTIFIED USE CASE ● GREATEST POTENTIAL

Training/educating employees
54%
57%

Visualizing and analyzing data
49%
57%

Assisting customers or employees remotely
38%
50%

Selling products or services to customers and prospects
32%
41%

Collaborating in group settings
27%
38%

Executing routine operations (e.g., inspections, repairs)
25%
33%

Completing complex tasks (e.g., fixing complex machinery or equipment, performing surgery)
23%
31%

Expanding access to digital information for workers who do not routinely use desktop or mobile devices
21%
28%

Planning how to lay out physical space
19%
23%

Enabling workers in moments when they need to be hands-free
13%
22%

Enabling users with accessibility challenges
10%
18%

Don't know
2%
3%

SOURCE: HARVARD BUSINESS REVIEW ANALYTIC SERVICES SURVEY, MARCH 2018

walk through virtual aisles, track their vision to determine the most appealing configurations of goods, and try out new layouts instantly, instead of moving physical items around.

Space Planning: Space planners and design engineers can overlay holographic floor plans on top of physical sites. Using mixed reality, they can experience and iterate on designs before they're even built, saving time and enabling stakeholders to review and move forward with plans with a greater degree of confidence.

Teamwork: Geographically disparate teams will be able to collaborate as if they were in the same locale, using 3D models of products and holographic images to help them make more informed decisions and avoid potential misunderstandings.

While the variety of use cases companies have identified is impressive, many organizations are still exploring mixed reality, said Llamas. "They are still gaining an understanding of the difference between virtual reality and augmented reality before they address the next question of defining specific use cases and benefits."

The survey findings reflect Llamas' view. Respondents see more potential for the technology than their current exploration of it suggests. For example, while only 38% of respondents have identified a case for using mixed reality to assist customers or employees remotely, 50% saw this area of work as having the greatest potential to be improved by merging digital and physical environments. FIGURE 3

Overall, seven in 10 respondents agreed that "mixed reality offers a measurably better way of doing things than we currently have."

While still early in its technology life cycle, the potential payback from mixed reality is starting to emerge. Cook analyzed a stack of mixed reality use cases for the field services unit of a large telecommunications firm and determined that spending $10 million on mixed reality technology would likely result in $50 million to $90

million in costs avoided. The potential paybacks included savings from having to send out fewer repair trucks.

According to the survey, improved customer satisfaction, cited by 62% of respondents, tops the list of expected benefits from mixed reality. Others include efficient work processes (55%), competitive advantage (52%), improved productivity (49%), improved customer service (47%), and reduced costs (37%).

Dealing with Challenges

While mixed reality has the potential to empower employees, transform operations, and better serve customers, it also brings challenges, among them finding the ideal way to create and present an immersive experience. Six in 10 of respondents said developing mixed reality applications is more difficult than developing most other types of enterprise applications.

J. P. Gownder, vice president and principal at Forrester Research, said that mixed reality raises issues such as security for connected devices and new skill sets that IT departments will require. "You are building a semi-cinematic experience, so you might need a cinematographer and grip to capture real-world video," he said. "Those are not traditional developer skills." Companies have to ponder the user experience: what is the optimal amount of time to wear a headset? Should it be controlled by hand gestures or by voice?
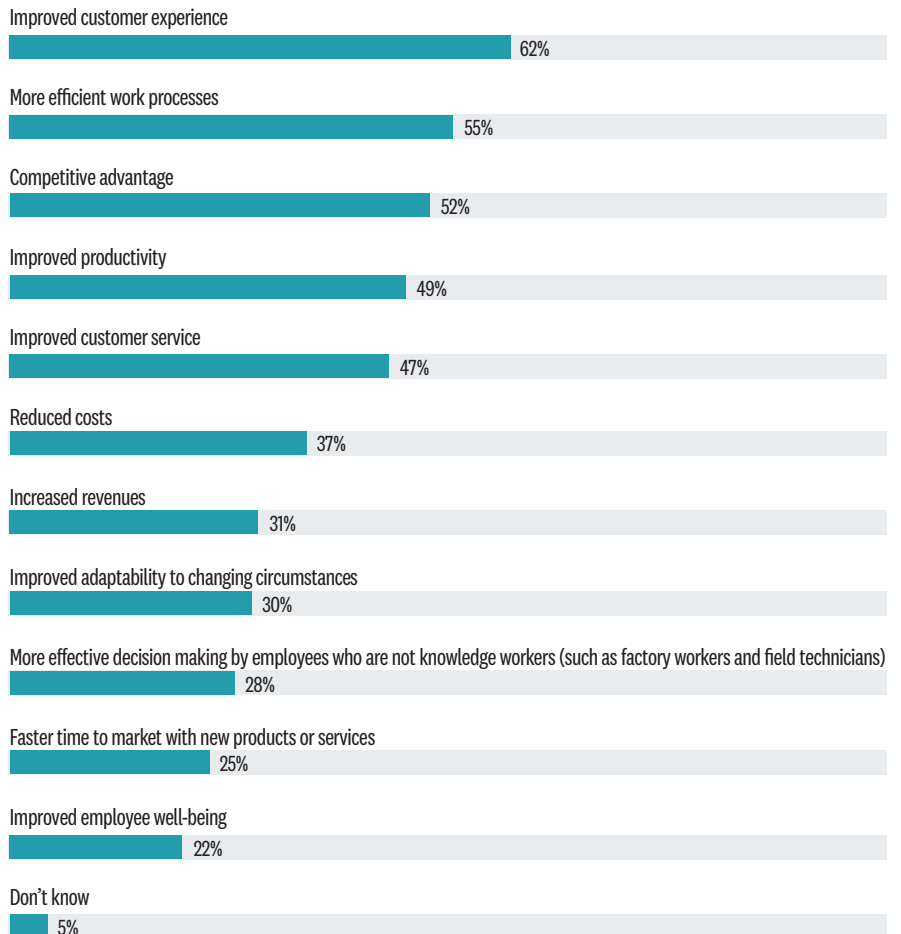
The form factor has significant implications as well. For example, in the government and defense sectors, where mixed reality has become an increasingly important tool for military training, the form factor carries certain limitations. Mike Wikan, creative director at the consultancy Booz Allen Hamilton, who has worked with the military on these use cases, observed that a mixed reality headset that prevents a soldier from taking the butt of a rifle up to his cheek can be a significant impediment to using the system for training purposes. "A soldier doesn't want

A RANGE OF BENEFITS
Companies expect mixed reality to improve productivity and customer satisfaction.

Thinking of your ideas or plans to use mixed reality, which of the following business benefits do you anticipate from your investment?

Benefit	%
Improved customer experience	62%
More efficient work processes	55%
Competitive advantage	52%
Improved productivity	49%
Improved customer service	47%
Reduced costs	37%
Increased revenues	31%
Improved adaptability to changing circumstances	30%
More effective decision making by employees who are not knowledge workers (such as factory workers and field technicians)	28%
Faster time to market with new products or services	25%
Improved employee well-being	22%
Don't know	5%

SOURCE: HARVARD BUSINESS REVIEW ANALYTIC SERVICES SURVEY, MARCH 2018

anything on their body for training purposes that they won't use in real life," said.

As mixed reality becomes more important to business processes, it's also critical to make sure all areas of the organization have a better grasp of the technology. According to the survey, mixed reality initiatives currently fall under the bailiwick of Information Technology and R&D departments. A little more than half (53%) of respondents said IT is
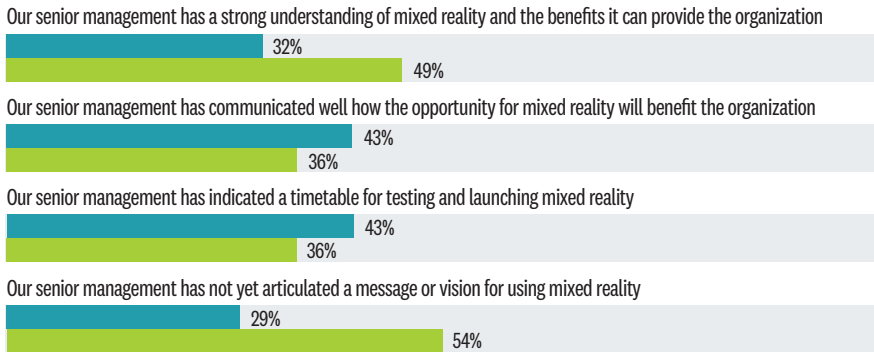
FIGURE 5

A NEED FOR LEADERSHIP

Senior managers have yet to articulate a strong vision for mixed reality.

Please rate your level of agreement with each of the following statements.

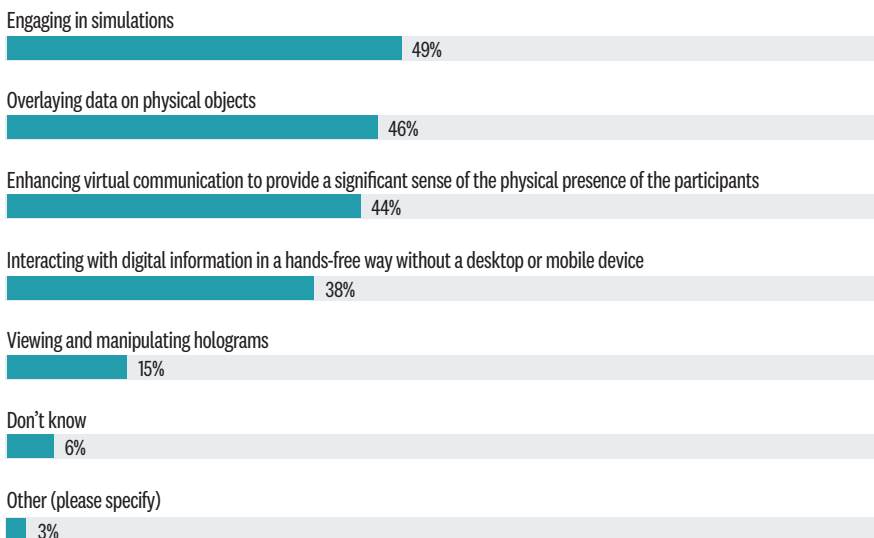● SOMEWHAT/STRONGLY DISAGREE   ● SOMEWHAT/STRONGLY AGREE

Our senior management has a strong understanding of mixed reality and the benefits it can provide the organization
32%
49%

Our senior management has communicated well how the opportunity for mixed reality will benefit the organization
43%
36%

Our senior management has indicated a timetable for testing and launching mixed reality
43%
36%

Our senior management has not yet articulated a message or vision for using mixed reality
29%
54%

SOURCE: HARVARD BUSINESS REVIEW ANALYTIC SERVICES SURVEY, MARCH 2018

FIGURE 6

NEW WAYS OF WORKING

Companies want to use mixed reality to simulate and enhance physical workflows.

Which of the following capabilities of mixed reality technology is your business most interested in pursuing?

Engaging in simulations
49%

Overlaying data on physical objects
46%

Enhancing virtual communication to provide a significant sense of the physical presence of the participants
44%

Interacting with digital information in a hands-free way without a desktop or mobile device
38%

Viewing and manipulating holograms
15%

Don't know
6%

Other (please specify)
3%

SOURCE: HARVARD BUSINESS REVIEW ANALYTIC SERVICES SURVEY, MARCH 2018

leading the development and use of the technology, followed by R&D departments at 43% of companies.

However, across industries, senior leadership is still early in its journey toward taking decisive action in the mixed reality space. Only 32% of respondents think their senior management has a strong understanding of the technology and the benefits it brings to the organization. Fewer believe their top executives have articulated a message or vision for using it. FIGURE 5

While those numbers might seem modest, Munjeet Singh, a vice president at Booz Allen Hamilton, sees them as optimistic. "This is a radically new technology," he said. "It's not a linear equation like a faster computer. The fact that a third of senior managers already have a strong understanding of mixed reality makes me hopeful about aggressive experimentation and adoption."

Others think the impetus for mixed reality adoption is stronger when it comes from all parts of the company. "As senior managers, we want to tap into the potential and creativity of the global team," said Jürgen Sturm, the chief information officer of ZF Group, a German automotive supplier. "Top management doesn't need to issue a top-down statement about every new technology; it is much more important to generate a culture of innovation that empowers people to spontaneously try new things."

The ZF Group, which began experimenting with mixed reality two years ago, has taken such an approach. Like many early adopters of mixed reality, it was frustrated by early iterations. Initially, the headsets were too heavy and not robust enough to use on the shop floor. But Sturm saw a gradual improvement in the technology that turned into a wellspring of innovation.

With the rapid maturity of the technology, ZF Group has included augmented reality in its IT business service catalog for the past 18 months. While the company has not promoted its use extensively, employees within

the company have developed their own use cases. Technicians who need to perform predictive maintenance or repair complicated technology at the company's 230 locations around the globe collaborate with on-site workers using augmented reality rather than getting on a plane to see the equipment in person.

"People are already making use of this kind of technology in their private lives," Sturm said. "It makes a great difference when we can use this technology to work together globally during the day and still be at home with our kids at night."

In another case, production designers who wanted to add new equipment to a factory used mixed reality to see how it would fit into the space and affect workflow before it was actually installed. "In the ideal case, we will be able to optimize factories before they are even built," Sturm said. "The game-changing thing is you can immersively use the different pieces of information in one seamless experience."

What has struck Sturm is the bottom-up nature of the mixed reality initiatives. "Nobody told these guys to make use of mixed reality," he said. "It was a grassroots initiative that was an extension of our other collaboration tools, like instant messenger."

A New Dimension of Work
As the digital revolution extends across every aspect of enterprises and society itself, companies envision the convergence of physical and digital experiences becoming a defining feature of the modern workplace.

As they look to the future, companies are exploring a number of mixed reality capabilities that replicate and enhance real life. Respondents report that three capabilities have captured their interest the most: engaging in simulations (49%), overlaying data on physical objects (46%), and enhancing virtual communication (44%). FIGURE 6

These capabilities create the ability to work in more intuitive ways and to gain fresh perspectives that can dramatically change the way people

work and the insights and productivity they can enjoy. For example, Gownder related a conversation with a NASA scientist with whom he worked in 2014. The scientist showed him some images of space rocks and told him that when he looked at the images using mixed reality, he learned more about the rocks in a week than he had in six months of studying 2D images. "In that case, the technology created incredible value," Gownder said.

Another interesting development is the wide range of people for whom value is being created. To date, a lot of the benefits of digital business have accrued to information workers sitting in front of a laptop. Mixed reality continues the democratization of data by putting more and better information in the hands of people who don't use computers routinely, such as field technicians and customer-facing employees. For a workforce that will increasingly consist of employees who are accustomed to using smartphones constantly, mixed reality provides a more natural way of approaching tasks, with its intuitive gesture- and voice-driven interface and hands-free form factor.

The military, where many soldiers are Millennials, provides a case in point for how the technology aligns with modern ways of learning technology. "They aren't sure what to make of a 500-page manual, but being immersed in a simulation is something they've been doing their whole life," Singh said.

The survey results, as well as analyst observations and user experiences, provide some guidance on the best way to approach explorations of the technology:

Educate from within. Even if senior executives don't lead the charge for mixed reality, IT departments need to make sure they understand how it can impact the organization. "Mixed reality isn't a like a smartphone that everyone already has," Llamas said. "A lot of companies are still in the exploratory stages with this technology, and a lot of senior executives don't understand the difference between virtual reality and augmented reality."

EVEN IF SENIOR EXECUTIVES DON'T LEAD THE CHARGE FOR MIXED REALITY, I.T. DEPARTMENTS NEED TO MAKE SURE THEY UNDERSTAND HOW IT CAN IMPACT THE ORGANIZATION.

WHAT CONSTITUTES AN "INFORMATION WORKER" COULD CHANGE BECAUSE MIXED REALITY WILL ALLOW EVERYONE TO BE INVOLVED IN THE COLLECTION AND USE OF INFORMATION.

Start experimenting. Sturm said companies should have a "fail fast and succeed early" philosophy toward exploring the most promising use cases of mixed reality. "Think big and start small," he said. Since the technology is moving so quickly, companies should begin exploring now to make sure they aren't left behind while staying attuned to its continuing evolution. Partners can help to fill talent gaps as needed.

Expect new worker roles. What constitutes an "information worker" could change because mixed reality will allow everyone to be involved in the collection and use of information. Many more types of information will become available to any worker in a compelling, easy-to-understand way. Singh envisions a time when mixed reality technology will, for example, enable a farmer to easily gather information about crop yields or pest infestations and instantly package that information for a researcher in California to analyze and advise whether crop blight is developing. "People who are not normally involved in research can become an integral part of it and get the benefits," he said.

Leverage the best of both worlds. Evaluate the many ways that work processes can be reinvented by mixing and matching physical and digital components to bring together the best of both worlds. ZF Group expects that digital technology will play a role in the entire value chain, from ideation through design and development of new products, building up prototypes, and ramping up production.

"IT should always have the ambition of looking further out to see what technology can bring to the table," Sturm said. "Millions of consumers already use immersive technology in their homes, so it's only natural that we will see more and more mixed reality in our professional lives. This is exciting technology that can make our lives easier and better, so we need to be open to the possibilities and the value it can bring."

METHODOLOGY AND PARTICIPANT PROFILE

A total of 394 respondents drawn from the *Harvard Business Review* U.S.-based audience of readers (magazine/newsletter readers, customers, HBR.org users) completed the survey.

SIZE OF ORGANIZATION

ALL RESPONDENTS' ORGANIZATIONS HAD 250 EMPLOYEES OR MORE.

52%	**10%**	**37%**
10,000 OR MORE EMPLOYEES	5,000-9,999 EMPLOYEES	250-4,999 EMPLOYEES

SENIORITY

16%	**47%**	**28%**	**9%**
EXECUTIVE MANAGEMENT/ BOARD MEMBERS	SENIOR MANAGEMENT	MIDDLE MANAGEMENT	OTHER GRADES

KEY INDUSTRY SECTORS

20%	**13%**	**11%**	**10%**	**8%**	
TECHNOLOGY	BUSINESS/ PROFESSIONAL SERVICES/CONSULTING	MANUFACTURING	HEALTH CARE/ PHARMA/ LIFE SCIENCES	BANKING/FINANCIAL SERVICES AND EDUCATION	OTHER INDUSTRY SECTORS WERE REPRESENTED BY 6% OR LESS EACH

JOB FUNCTION

13%	**11%**	**11%**	**8%**	**7%**	
GENERAL/EXECUTIVE MANAGEMENT	IT	R&D/INNOVATION/ PRODUCT DEVELOPMENT	SALES/BUSINESS DEVELOPMENT/ CUSTOMER SERVICE	EACH ENGINEERING, HR/TRAINING, STRATEGIC PLANNING	OTHER FUNCTIONS WERE REPRESENTED BY 6% OR LESS EACH

REGIONS

47%	**30%**	**18%**	**5%**
NORTH AMERICA	EUROPE, THE MIDDLE EAST, AND AFRICA	ASIA/PACIFIC	REST OF WORLD

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