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Augmented and Virtual Reality in Operations

A guide for investment

Introduction

Augmented Reality and Virtual Reality (AR/VR) are not new, but recent advances in computational power, storage, graphics processing, and high-resolution displays have helped overcome some of the constraints that have stood in the way of the widespread use of these immersive technologies. Global spending on AR/VR is now expected to reach $17.8 billion in 2018, an increase of nearly 95% over the $9.1 billion estimate for 2017.[1]

Given this impetus, we wanted to understand more about the current state of play with AR/VR in the enterprise. We surveyed executives at 700+ companies, including 600 companies who are either experimenting with or implementing AR/VR; spoke with AR/VR-focused leadership at global companies, start-ups, and vendors; and analyzed over 35 use cases, with a particular focus on:

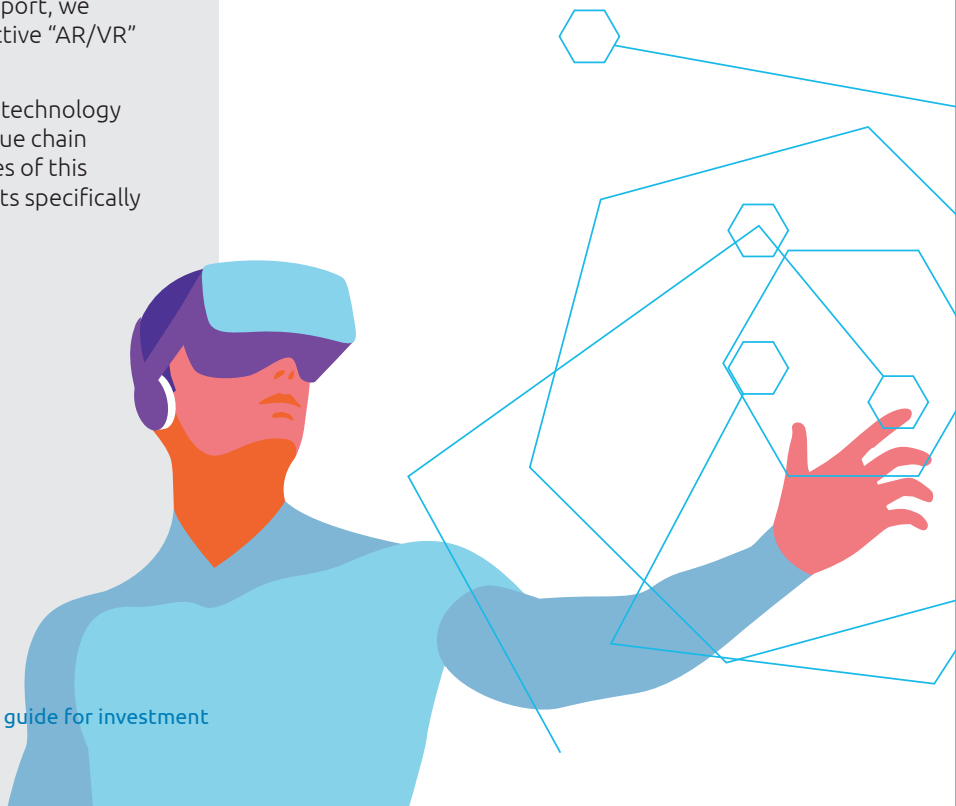
- The use of AR/VR for internal industrial company operations, including, but not limited to, design, engineering, and field services
- The automotive, utility, and discrete manufacturing sectors.

This research focuses on organizations that have initiated their AR/VR journey, whether by experimentation or implementation, and aims to answer a number of questions:

- How is AR/VR being used today?
- Where should organizations invest – what are the use cases that generate the most value?
- How can companies either begin or evolve their initiatives?

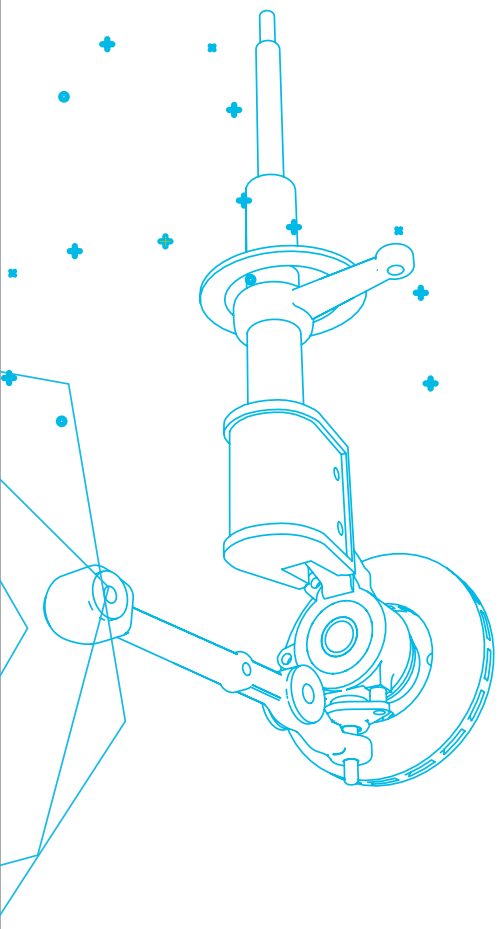
Outside of this report, terms you will commonly find when reading about AR/VR are mixed reality, hybrid reality, or merged reality in which both the physical and the virtual or digital realities coexist or even merge. In this report, we distinguish between AR and VR and use the collective "AR/VR" interchangeably with "immersive technology."

Additionally, although applications for immersive technology are relevant in other parts of an organization's value chain (sales, customer experience, etc.), for the purposes of this research, we focus on the applications and benefits specifically in business operations and field services.



Immersive technology has arrived, with AR the more widely practiced

Boeing's use of augmented reality for technicians has increased productivity by 40% and reduced wiring production time by 25%.



Boeing has used augmented reality to provide technicians with instructions for airplane wiring schematics in their field of view, allowing them to be hands-free. This reduces wiring production time by 25%, increases productivity by 40%, and eliminates error rates.[2]

Ford, on the other hand, uses virtual reality to increase human productivity and safety on the assembly line. Virtual reality identifies human movement captured through body motion sensors during equipment assembly with the goal of re-engineering movement to decrease risk of injury and increase productivity. This has resulted in a 70% drop in employee injuries and 90% reduction in ergonomic issues.[3]

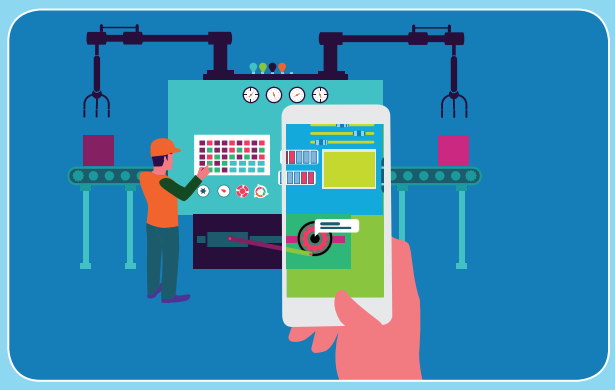
Fieldworkers at Toms River Municipal Utilities Authority (TRMUA), a New Jersey utility, use virtual and augmented reality to see concealed utilities such as water, gas, electric, and sanitary and storm water sewer utility features. This concept of "seeing through the ground" is possible through an application that processes data from the geographic information system (GIS) that the Microsoft HoloLens ultimately turns into a holographic projection of underground utility features based on the user's location and orientation. This innovation increases the productivity of the field workforce on a daily basis and more so under emergency situations such as fire or flooding.[4]

These examples illustrate how organizations are moving beyond the hypothetical to pragmatic use. In previous years, organizations focused primarily on educating themselves about the technology. Just three years ago, "Companies were wondering 'what can AR/VR do?' and 'where can it be used?'" says Dr. John Ahmet Erkoyunco from Cranfield University in the UK. The technology has since come a long way. Per our conversations with AR/VR software providers, the concerns today are more about ROI and the rate at which software can be developed.

What is Augmented Reality and Virtual Reality?

To start with, it is important to distinguish between the two technologies:

Augmented Reality (AR)



A digital layer is superimposed on the physical world, integrating the physical, real environment with virtual details to enhance or "augment" the real-world experience. Experienced with: Smartphones, tablets, smart glasses and other head-mounted displays.

Virtual Reality (VR)

Creates an interactive, completely digital environment that provides a fully enclosed, synthetic experience incorporating auditory and visual feedback, experienced often through the use of a head-mounted device (HMD).

Boeing's technicians use AR instructions for airplane wiring schematics in their field of view, allowing them to be hands-free.

Benefits:

Reduced wiring production time by **25%**

Increased productivity by **40%**

Fieldworkers at Toms River Municipal Utilities Authority (TRMUA), a New Jersey Utility, use AR and VR glasses to see concealed utilities lines under the streets in real-time.

Benefits:

Increased productivity

Improved collaboration

At Ford, VR is used to capture human movement during equipment assembly through motion sensors to re-engineer movement to decrease risk of injury and increase productivity.

Benefits:

70% Drop in employee injuries

90% Reduction in ergonomic issues

Source: Company websites and media articles

Adoption Rate: 29%

Superimpose step by step instructions

Boeing technicians work with AR instructions for airplane wiring schematics in their field of view allowing technician to be hands-free. This cuts wiring production time by 25% and reduced error rates to zero.

Adoption Rate: 27%

Early design of concept fully created in VR

BMW engineers and designers use VR to test how various components of a car look when assembled without physical prototyping. This brings down the cost of the engineering process significantly.

Adoption Rate: 22%

Virtual walk through of the site

At **Pacific Gas and Electric (PG&E)**, VR and plant data is used to provide a quicker and safer way for workers to inspect equipment, lowering the risk of technicians getting hurt.

Adoption Rate: 27%

Visualize equipment in production environment to see final product

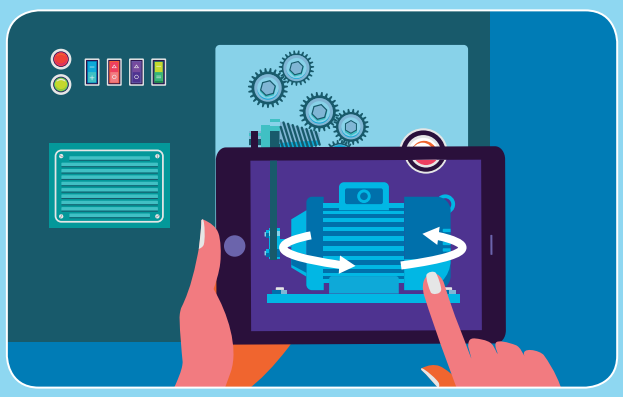
VR is used at **Airbus** to integrate digital mock-ups into production environments, giving assembly workers access to complete 3D models of the aircraft under production, reducing time required to inspect by 86%.

Adoption Rate: 27%

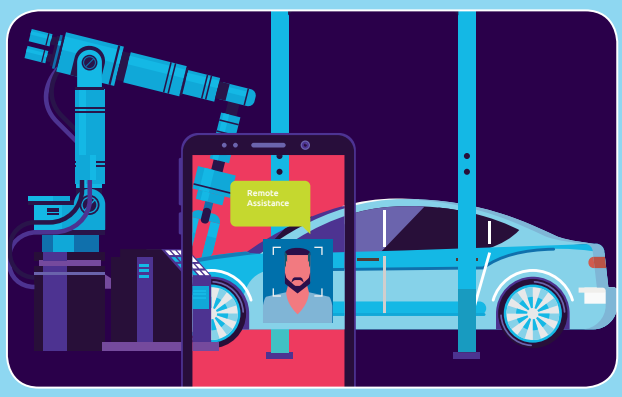
Remote collaboration

Designers at **Ford** collaborate with each other across vast geographic distances to virtually tour a new vehicle with the engineering team. This avoids incurring travel costs.

Augmented Reality (AR)

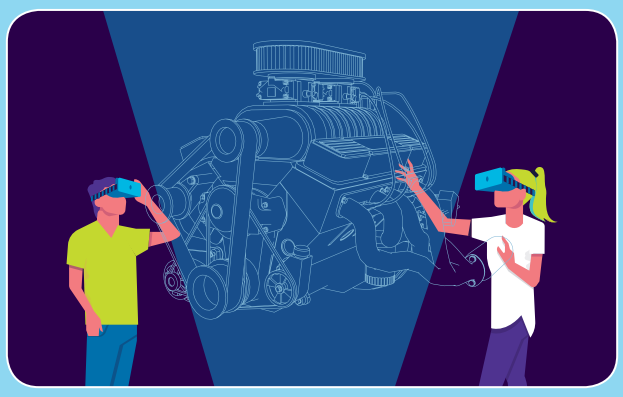


Step-by-step instructions while performing a manual task

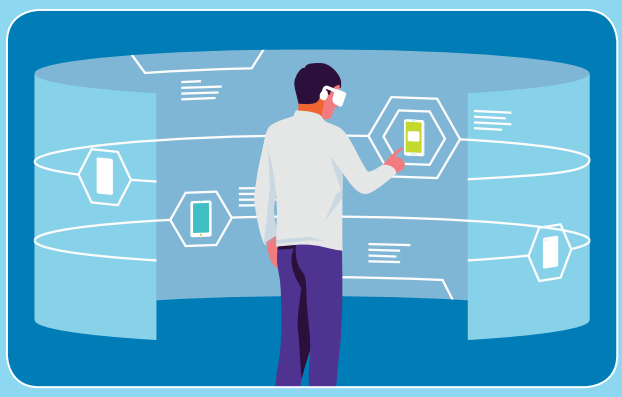


Remote assistance for support and guidance

Virtual Reality (VR)



Equipment design discussion in the virtual world



Employee using headsets for virtual training

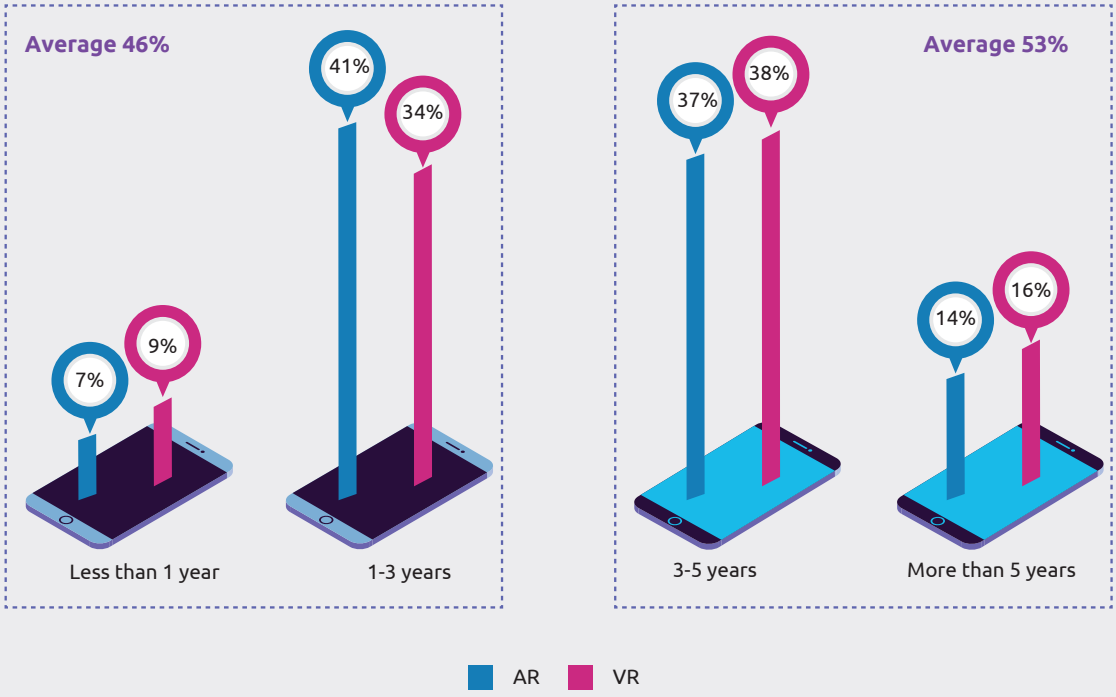
When will AR/VR become mainstream in your organization?

Companies are split on when the technology will become mainstream:

- **46% within the next three years**
- **53% after three years (see Figure 1).**

"The impact will not only improve in the next one to three years, but it will also become standard in the automotive business," says Frantisek Zapletal, Volkswagen IT.

Figure 1. **When will AR/VR become mainstream in your organization?**



Source: Capgemini Research Institute, Augmented and Virtual Reality Survey; May-June 2018, N=603 organizations that are exploring and implementing Augmented Reality and Virtual Reality

AR seen as more relevant and widely implemented compared to VR

Even though the use of VR in applications such as collaborative product design can be highly impactful, we found that 66% of organizations believe AR to be more applicable to them than VR. This could reflect the fact that while AR can alter our day-to-day interactions with digital machines and systems, VR enhances individual immersive experience by isolating the user from the real world. Paul Travers, the CEO of Vuzix, a multinational firm that sells AR/VR wearable technology, agrees. He says that although VR will be big, there are limitations to what you can do when isolated from the real world.[5]

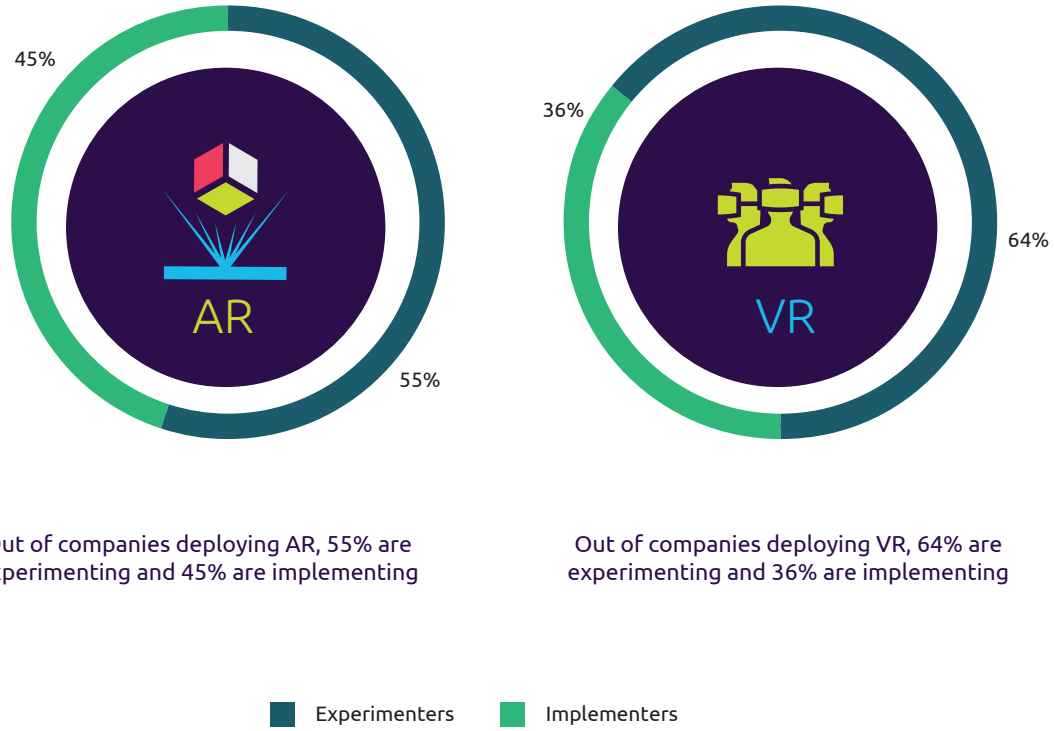
By connecting the digital world to the real world, AR supports a number of breakthrough use cases.[6] These involve delivering text- and image-based content to workers performing manual tasks and access to real-time remote help from experts on a wearable or handheld device. As a result, as Figure 2 shows, more organizations are implementing AR (45%) than VR (36%).

Commenting on the applicability of VR relative to AR, " VR isn't too relevant for us, although we could use it to train people who go to the substations, though there are less complicated means," says Antti Aarnio, head of Digital Services at Fingrid, a Finnish electricity transmission grid operator. "Especially in our industry, once it passes safety standards, AR could provide added value for our employees in high-risk situations – for example, being able to tell if a piece of equipment is under high voltage or high temperature."

Companies in the US, China, and France currently lead the implementation race

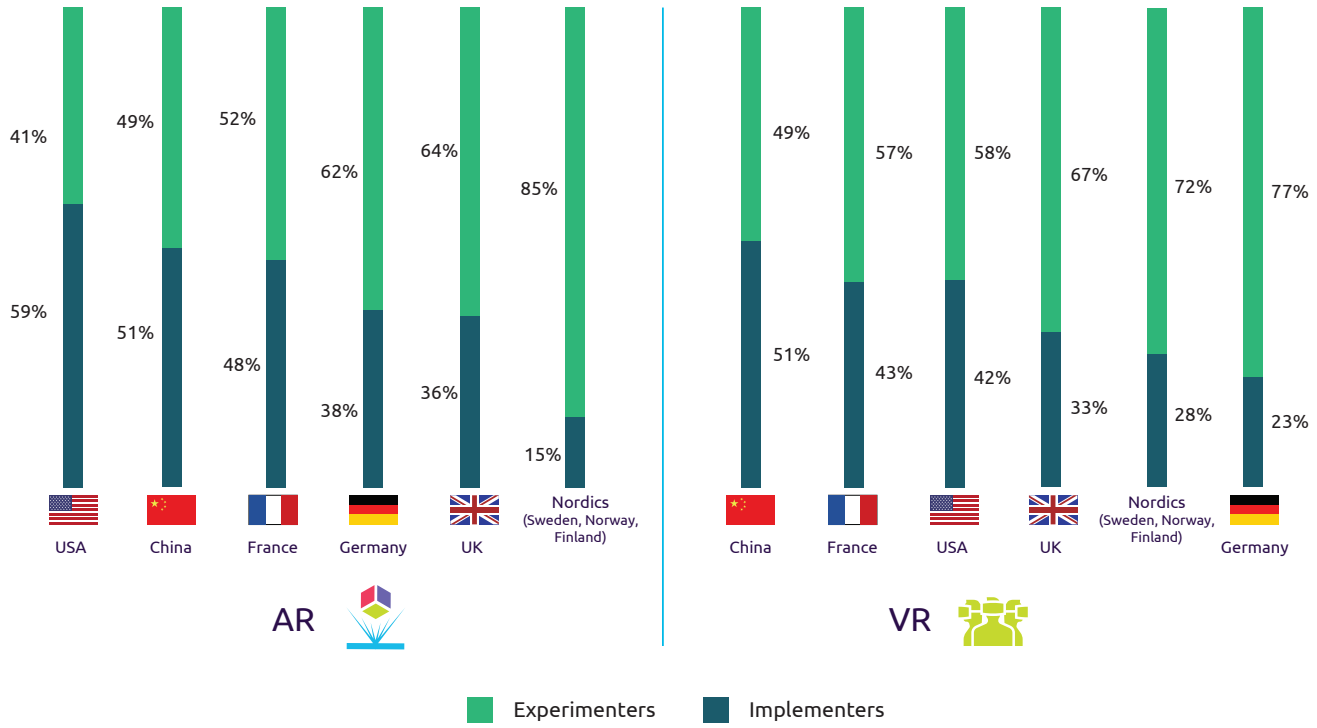
The US, in addition to having the most AR implementers (59%), is also expected to be the largest AR/VR spender in 2018, at $6.4 billion (see Figure 3).[7] Alternatively, the Chinese government and Chinese companies have launched concerted efforts to become leaders in virtual and augmented reality through focused research and development efforts, direct investment, and building human capital.[8] France's market position in this space is illustrated by its leadership in VR development across continental Europe, according to the Venture Reality Fund, a Silicon Valley-based venture capital firm focused on early state investments in AR/VR.[9]

Figure 2. Out of companies deploying AR/VR, implementation levels by organization category



Source: Capgemini Research Institute, Augmented and Virtual Reality Survey; May-June 2018, N=603 organizations that are exploring and implementing Augmented Reality and Virtual Reality. Implementers: companies with small or large-scale implementations; Experimenters: companies with proof of concepts or pilots.

Figure 3. Out of companies deploying AR/VR, implementation levels by country



Source: Capgemini Research Institute, Augmented and Virtual Reality Survey; May-June 2018, N=603 organizations that are exploring and implementing Augmented Reality and Virtual Reality. Implementers: companies with small or large-scale implementations; Experimenters: companies with proof of concepts or pilots.

Immersive technology delivers better efficiency, productivity, and safety

AR drives higher productivity and efficiency. Many companies use AR to streamline workflows by providing hands-free access to immersive step-by-step instructions while performing a manual task. With AR, employees can also remotely collaborate with experts for any troubleshooting guidance.

Dr. Gunter Beitinger, VP of Manufacturing at Siemens, describes how the technology can help in performing quality control for printed circuit boards. "Employees have to continuously look between a physical circuit board and a screen to compare, validate, and test acceptable quality," he explains. "AR enables those same employees to inspect circuit boards by augmenting their view and calling attention to various elements they could have missed." Using this method, Gunter states, "has resulted in an improvement in quality on the scale of 20–25%."

In another example, John Reece, CIO of GE Transportation's Global Services group, outlines how a recent pilot focuses on workers' maintenance efficiency. "By using AR to view maintenance instructions and sign off on tasks without having to go back to their computer, workers performing maintenance on locomotives were able to increase the number of maintenance tasks per hour by 59%," he explains. John Reece said his group will run a broader pilot in 2018 with a larger technical scope including adding contextual information to maintenance records through dictation.

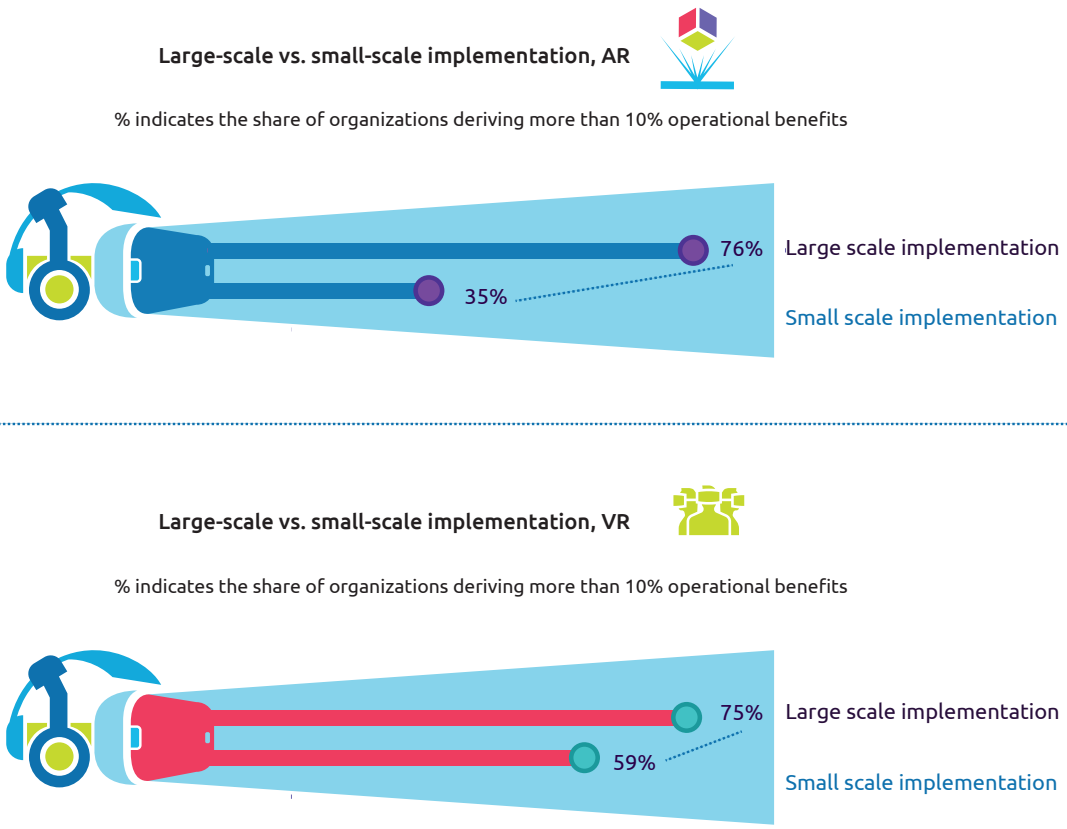
VR drives increased efficiency and safety performance. Collaborative product design in VR dramatically boosts efficiency. Imagine the case of automotive design – experts in vehicle safety, styling, durability, and noise, vibration, and harshness located all over the world can collaboratively resolve conflicts very quickly when simultaneously placed in a fully 3D, immersive design space allowing the interaction of design components. This ability is enabled by using 3D CAD (computer-aided design) data and a virtual reality platform. Without VR, it takes numerous iterations, emails, and meetings to arrive at a design agreed upon by all parties.

VR can also be used in an experience such as a training. Employees who would otherwise be subject to training in harsh, high-risk circumstances can learn and make decisions in a physically-safe environment through VR. The safety factor alone can be enough to justify investment in VR due to the cost of accidents both in training and on the job.[10]

A large share of companies yield over 10% operational benefit with AR/VR. On average, 82% of companies implementing AR/VR indicate that benefits yielded from their AR/VR initiatives meet or exceed their expectations. Figure 4 highlights the percentage of companies implementing AR/VR who are experiencing over 10% operational benefit in areas such as increased efficiency, productivity, and safety. At least 75% of companies with large-scale AR/VR implementations can attest to operational benefits over 10%.

75% Share of organizations with large-scale AR/VR implementations that realize over 10% operational benefits

Figure 4. Share of companies with implementations yielding over 10 percent operational benefits



Source: Capgemini Research Institute, Augmented and Virtual Reality Analysis; N=152 and 275 organizations implementing at-least two Augmented Reality use cases at large scale and small scale respectively, N=116 and 220 organizations implementing at-least two Virtual Reality use cases at large scale and small scale respectively.

Where do organizations find value with immersive technology?

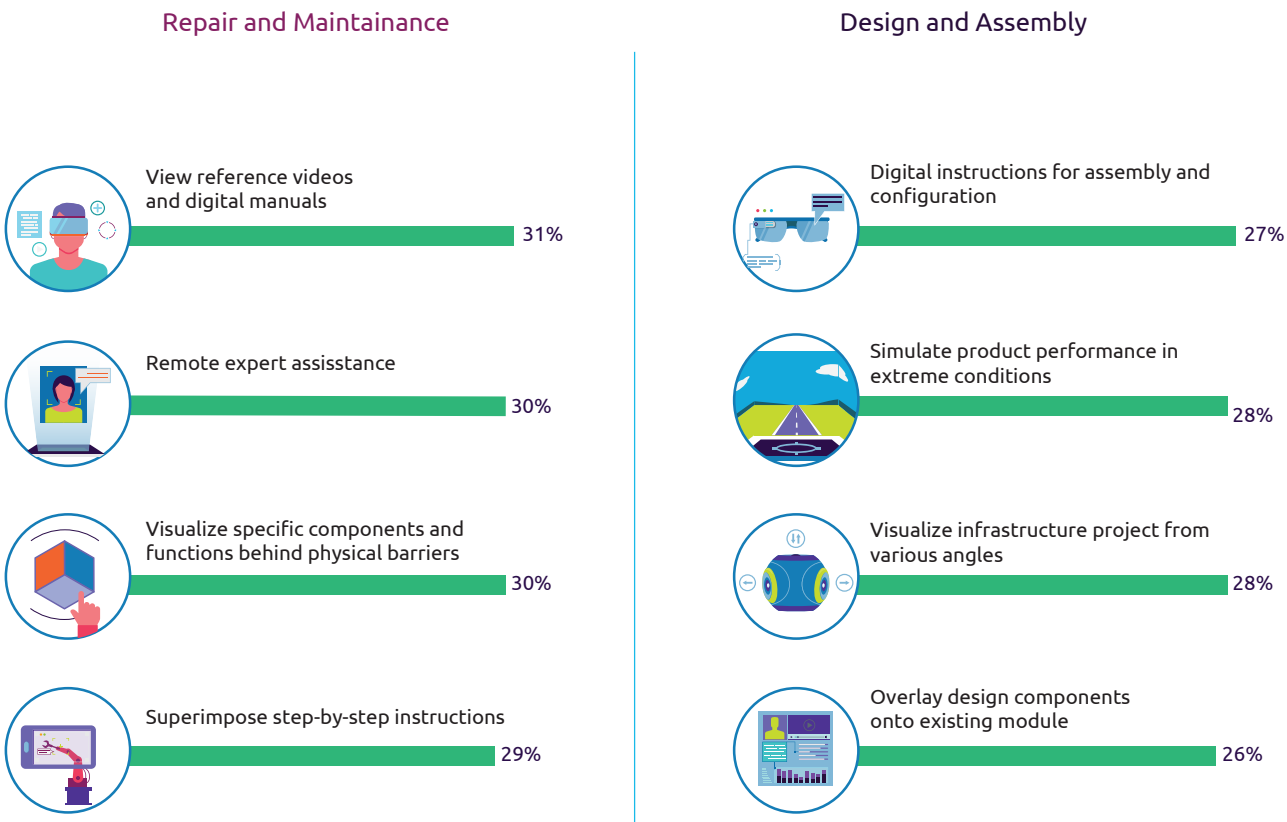
Repair and maintenance is the most popular focus of implementation efforts

AR/VR is poised to redefine current processes and transform the value chain. Industry is leveraging this technology across four areas:

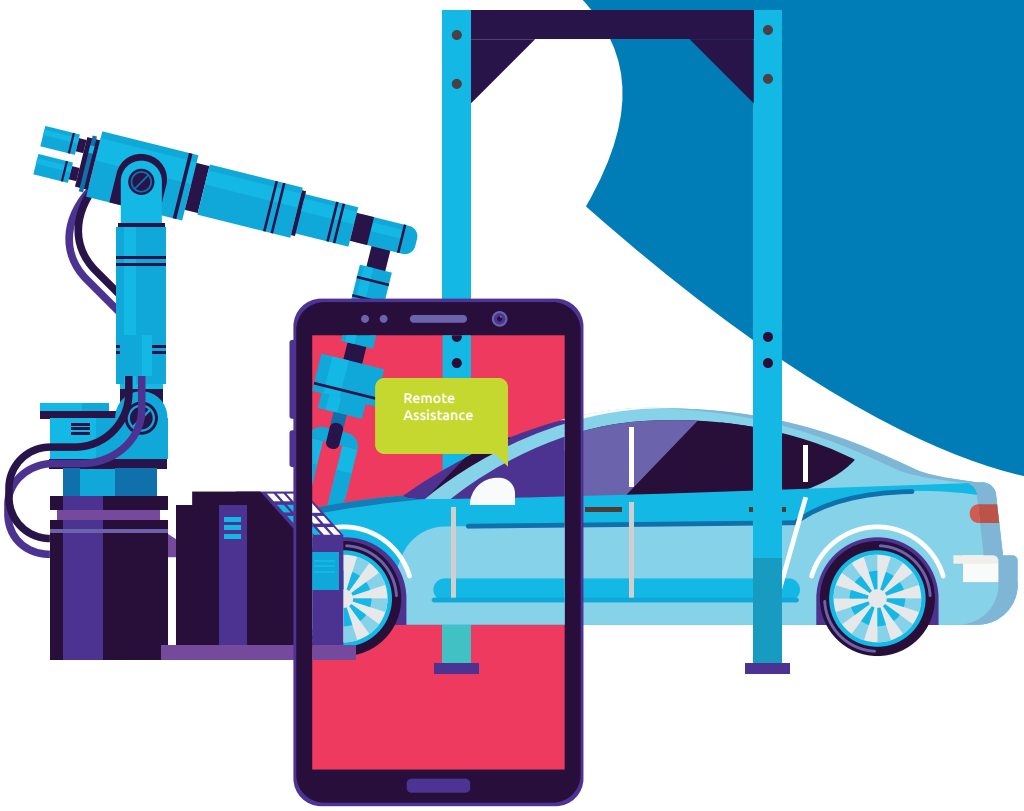
- **Design and Assembly:** Digitally experience an asset design and operation; test and model changes before completion
- **Immersive training:** Immerse an employee in an environment to allow decision making in a safe and/or digitally guided environment
- **Inspection and Quality Assurance:** Enable faster, thorough monitoring and inspection through visualization and information
- **Repair and Maintenance:** Use real-time visualizations and information to assist in completing a maintenance or repair task

Early adopters are already implementing immersive technology across several parts of the value chain, but they are more advanced in some areas than in others. Figure 5, which shows the most commonly implemented use cases among our survey respondents, illustrates the focus on repair and maintenance and design and assembly.

Figure 5. **A focus on repair and maintenance and design and assembly**



Source: Capgemini Research Institute, Augmented and Virtual Reality Survey; May-June 2018, N=231 organizations that are implementing Augmented Reality; N=175 organizations that are implementing Virtual Reality (some overlap occurs as companies implement both AR and VR). Percentages indicate frequency of use case implementation among all companies implementing AR/VR.



AR yields more benefit and is perceived as more complex than VR

For each sector – automotive, manufacturing, and utilities – we segmented AR/VR use cases according to their relative complexity for implementation and the delivered benefits (see Figure 6). This allows us to identify whether use cases fall into four possible categories:

- Must do – offer the dual advantage of high benefit and low complexity of implementation
- Need to do – offer high benefit although with high complexity of implementation
- Can do – offer low complexity and low benefit
- Do case-by-case – offer high complexity and low benefit

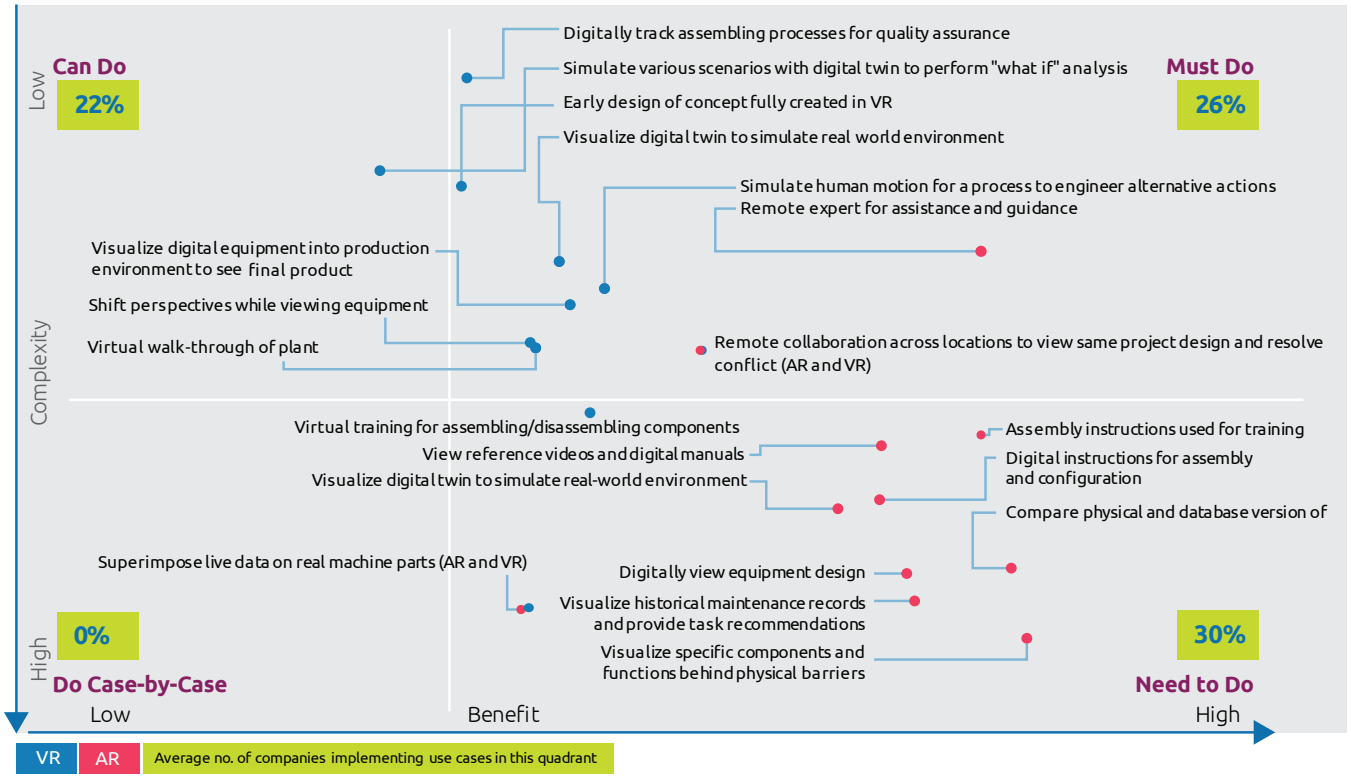
AR is perceived as generally more beneficial, if more complex to implement, than VR use cases. On average, only 23% of the organizations are implementing high-benefit and low-complexity ("must do") use cases.

In the automotive sector, a large share of companies are implementing "need-to-do" cases that yield high benefit, even if they come with higher complexity. One example from industry we heard about was the "digital prototype" or "early design of concept fully created in VR." Frantisek Zapletal, with Volkswagen IT, spoke with us about the financial benefit yielded from one of the Volkswagen AR/VR digital prototype proofs of concept. He says that "one example is a project in which the company used VR to build a prototype that would have otherwise cost €4 million (approximately US$4.7 million)."

This use case can be considered an entry-level use case, great for early design phases when the process is not based on precise CAD (computer-aided design) drawings, hence is of lower complexity. See Figure 6 for other use cases in the automotive sector.

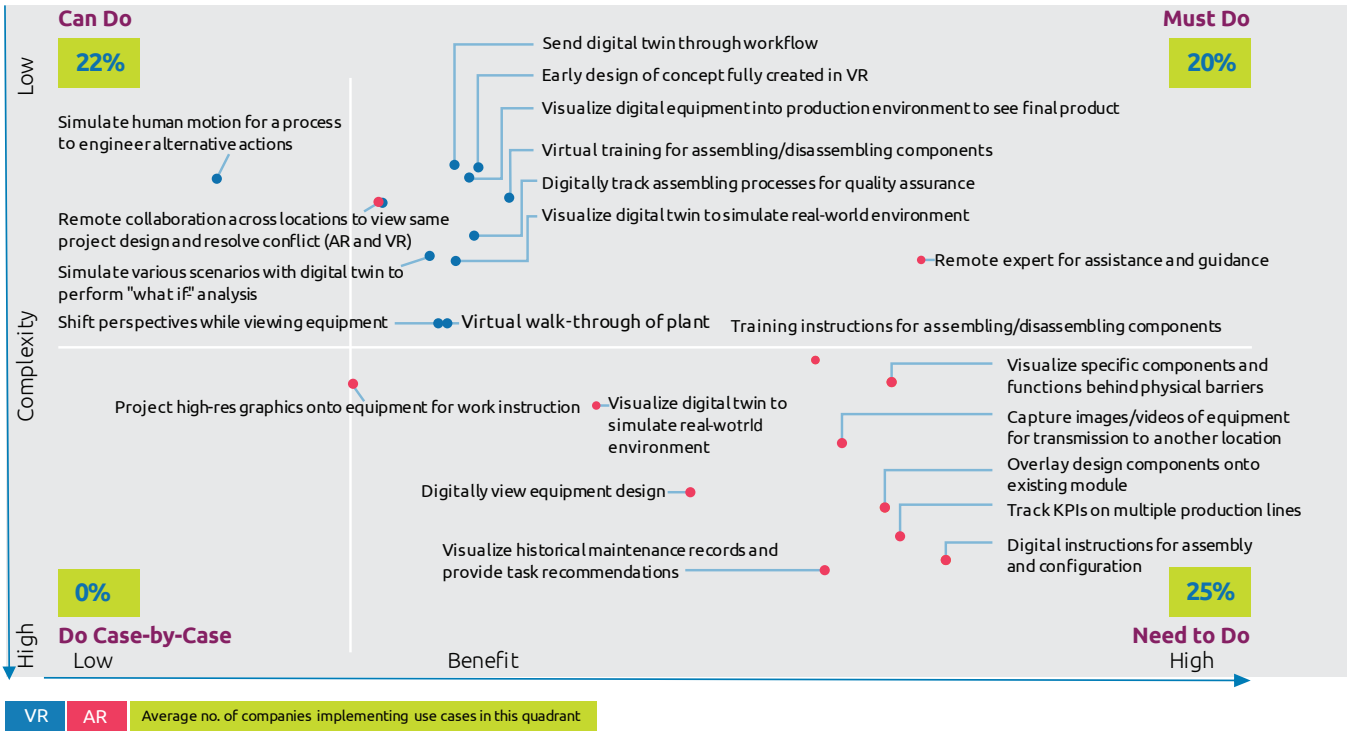
20% Average share of manufacturers implementing "must do" use cases - the lowest across industries

Figure 6. Distribution of Use cases, Benefit vs Complexity, Automotive



Source: Capgemini Research Institute, Augmented and Virtual Reality Survey; May–June 2018, N=212 organizations in the Automotive sector that are exploring and implementing augmented and/or virtual reality.

Figure 7. Distribution of Use cases, Benefit vs Complexity, Manufacturing



Source: Capgemini Research Institute, Augmented and Virtual Reality Survey; May–June 2018, N=208 organizations in the Manufacturing sector that are exploring and implementing augmented and/or virtual reality.

Few manufacturers (20%) are implementing the "must-do" use cases, which are the low-hanging fruits; whereas the largest share of implementations is in the "need-to to-do" category. Gordon Schembri, principal at Baker Hughes, a GE company, shared information about GE's version of a commonly implemented use case. "In our industry, you can extract data from sensors of live turbines, to construct a digital replica, or digital twin. Our customers can then run tests on the digital twin to find the most efficient and effective way to operate their production. Instead of testing on real equipment, which cost millions of dollars to build and operate, you can run the same scenario on the digital twin which then informs how to optimize the workflow," he says.

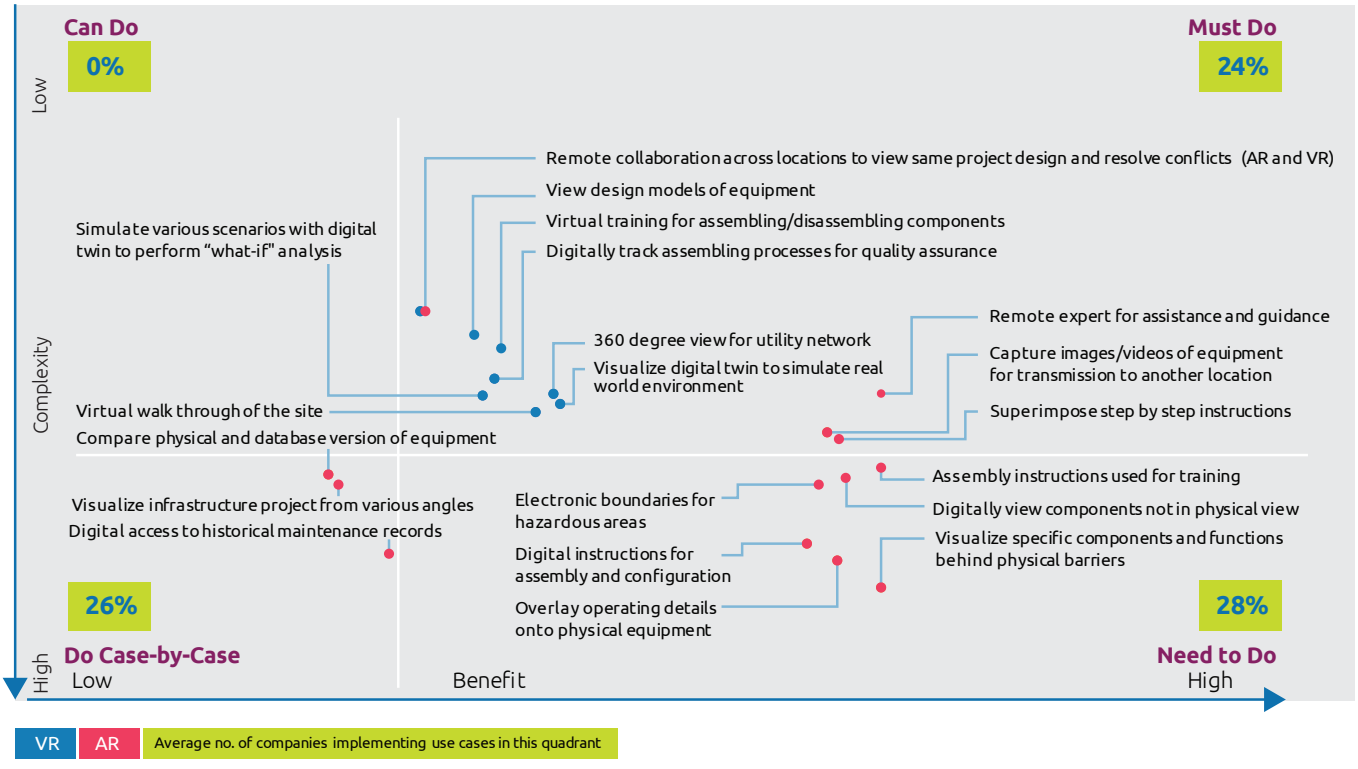
When data is presented in 3D, rather than abstract form such as charts and graphs, it is easier to create actionable insight and make decisions. This is why using AR or VR to view the digital twin in the Baker Hughes example above, is highly impactful.

This specific use case in the chart above, listed as '"visualize digital twin to simulate real-world environment," can be AR or VR, although complexity increases in the case of AR.

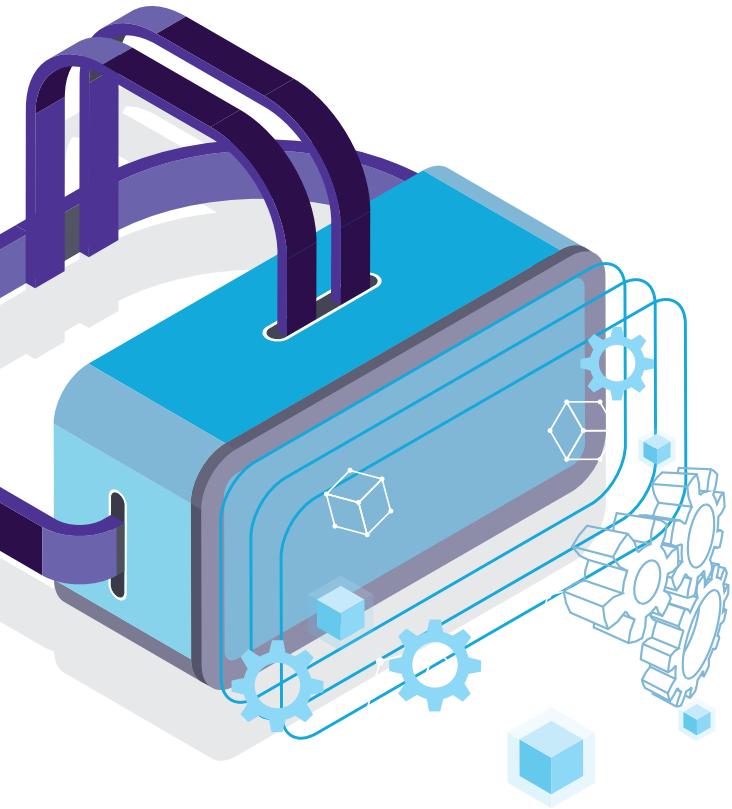
Enhancing reality with digital content rather than visualizing in a completely digital environment (VR) is generally more complex. See Figure 7 above for other use cases in the manufacturing sector.

For the utilities sector, the average implementation level for "must-do" use cases is 24% (see Figure 8). Panu Arvila, who works in digital transformation under the Chief Digitization Officer at Fortum, a leading clean-energy company operating in the Nordic countries, Russia, Poland, and the Baltics, shared one such "must-do" use case. "One instance where we use VR is for training. We have simulations in which we conduct radiation protection training for employees participating in Fortum's scheduled annual outage," he comments. This use case, specifically listed in the chart below as '"virtual training for assembling/disassembling components," is considered minimally complex for implementation since training in VR is typically a "beginner" use case where often, accuracy is less critical.

Figure 8. Distribution of Use cases, Benefit vs Complexity, Utility



Source: Capgemini Research Institute, Augmented and Virtual Reality Survey; May–June 2018, N=208 organizations in the Manufacturing sector that are exploring and implementing augmented and/or virtual reality.



"Must-do" and "Need-to-do" use case examples

Below are some examples of "must-do" and "need-to-do" use cases. The "must-do" cases are the low-hanging fruit that deliver high benefits with low complexity. The "need-to-do," are use cases that, while complex, can deliver significant benefits.

Examples of these types of use cases, which can be considered industry-agnostic, are outlined in Figure 9. For each use case, we identify the top benefits our survey respondents yield from implementing them

26% Average share of automotive companies implementing "must do" use cases - the highest across industries

Must-do use cases (High benefit and low complexity)
Need-to-do use cases (High benefit and high complexity)

Use Case	Example Application	Top benefits based on our research
Simulate human motion for a process to engineer alternative actions	Ford is using VR technology to identify, and then engineer alternative actions by humans captured by body motion sensors during assembling to decrease risk for injury and re-engineer to increase productivity. This resulted in 70% drop in employee injuries and 90% reduction in ergonomic issues.[11]	- Efficiency Increase - Safety Increase - Productivity Increase
Early design of concept fully created in VR	Engineers and designers at BMW use VR to collaborate effectively by testing how various components of a car look when assembled without physical prototyping. This brings down the cost of the engineering process significantly.[12]	- Efficiency Increase - Safety Increase - Productivity Increase - Cost Saving
Visualize digital equipment piece into production environment to see final product	VR is used at Airbus to integrate digital mock-ups into production environments, giving assembly workers access to complete 3D models of the aircraft under production. This reduces the time required to inspect from three weeks to three days.[13]	- Efficiency Increase - Safety Increase - Productivity Increase - Time Saving

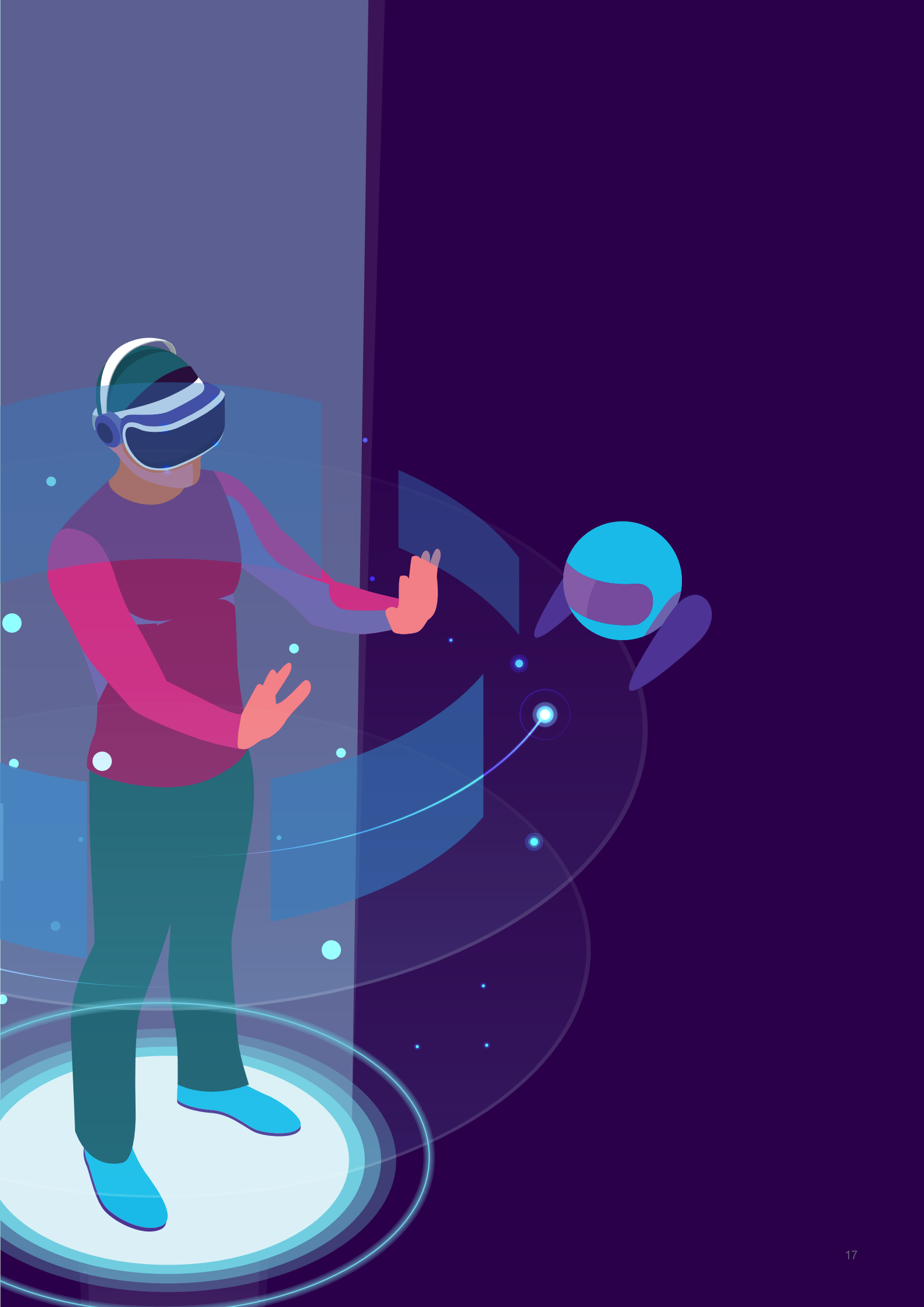
Use Case	Example Application	Top benefits based on our research
Visualize a digital replica or twin" of the equipment to simulate a real-world environment	Researchers at Siemens can use a virtual sensor, based on a digital twin - an exact, functional simulation of what a real sensor would do if it were possible to insert it into a motor. AR allows the user to see an exact simulation of the motor and its interior with a real demonstrator superimposed over it, illustrating how the simulation system works.[14]	- Efficiency Increase - Safety Increase - Productivity Increase - Time Saving
Shift perspectives while viewing equipment	At Ford, VR enables the viewer to experience the car from the perspective of a taller man or a shorter woman; allowing the staff to know what's it like to be in a certain vehicle and from the customer's viewpoint.[15]	- Efficiency Increase - Safety Increase - Productivity Increase
Virtual training for assembling/ disassembling components	At Enel, staff are trained to perform procedures and operations to properly service, repair, and maintain equipment, improving efficiency and increasing the safety by connecting to VR headsets. This assures a higher productivity and fewer risks for all employees.[16]	- Safety Increase - Productivity Increase - Efficiency Increase
Remote collaboration across locations to view same project design and resolve conflict	Designers at Ford collaborate with each other across vast geographic distances to virtually tour a new vehicle with the engineering team. This avoids incurring travel costs and the ability to stay in touch and keep collaborating on vehicle designs is crucial to their success.[17]	- Safety Increase - Efficiency Increase - Productivity Increase
Superimpose step by step instructions	AR provides technicians at Boeing with instructions for airplane wiring schematics in their field of view allowing technician to be hands-free. This cuts wiring production time by 25% and reduced error rates to zero.[18]	- Safety Increase - Efficiency Increase - Productivity Increase - Error Rate Reduction
Capture images/videos of equipment for transmission to another location	Engineers at EDF Energy use Google Glass to capture images and videos of smart meter installations and then transmit these back to a content management system for review. At that point, an office-based quality assurance specialist signs off on the installation.[19]	- Safety Increase - Efficiency Increase - Productivity Increase
Virtual walk through of the site	At Pacific Gas and Electric (PG&E), VR and plant data is used to provide a quicker and safer way for workers to inspect equipment. It lowers the risk of technicians getting hurt and can be used to help pinpoint the area of failure.[20]	- Safety Increase - Efficiency Increase - Productivity Increase - Error Rate Reduction
360-degree view for utility network	At Welsh Water, VR projects virtual images to provide a 360° view allowing designers, engineers, and architects to better design and visualize the space – to design its water and waste water works. The costs for this were recouped on the first project and is now being applied to 50 more projects.[21]	- Safety Increase - Complexity Reduction - Productivity Increase

Use Case	Example Application	Top benefits based on our research
Remote expert for assistance and guidance	Technicians at Porsche use AR glasses that project step-by-step bulletins and schematic drawings across the line of vision while also allowing remote experts the ability to see what the technician sees to provide feedback. This solution can shorten service resolution times by up to 40%.[22]	- Efficiency Increase - Productivity Increase - Safety Increase - Save Time
Digitally view equipment design	Ford successfully concluded a year-long pilot utilizing AR technology by allowing designers and engineers to see and scroll through digital designs and parts as if they were part of a physical vehicle. This makes it easy for teams to analyze designs in a matter of minutes or hours.[23]	- Save Time - Efficiency Increase - Productivity Increase - Complexity Reduction
View reference videos and digital manuals	Workers at a leading auto company use AR to take before-and-after photos of defects, use reference videos to guide their repairs, make notes, and record video instructions.[24]	- Error Rate Reduction - Efficiency Increase - Productivity Increase
Overlay operating details to enhance equipment view	At Welsh Water, an AR layer is used which shows process information and instructions such as directional information for valves and switches, or ideal operating ranges for gauges and dials. This minimizes risk and informs decision-making.[25]	- Error Rate Reduction - Safety Increase - Efficiency Increase - Productivity Increase

Must-do use cases (High benefit and low complexity)
Need-to-do use cases (High benefit and high complexity)

Source: Capgemini Research Institute, Augmented and Virtual Reality Survey; May-June 2018, N=603 organizations that are exploring and implementing Augmented Reality and Virtual Reality. Top benefits derived from survey data where respondents indicated which benefits were observed for each use case.

Overall, as many of these examples show, AR/VR allows users gain a clear understanding of a system, including the analytics and performance with which they can easily make decisions. The technology allows for the collaboration resulting in better communication, understanding, and knowledge transfer for all stakeholders.

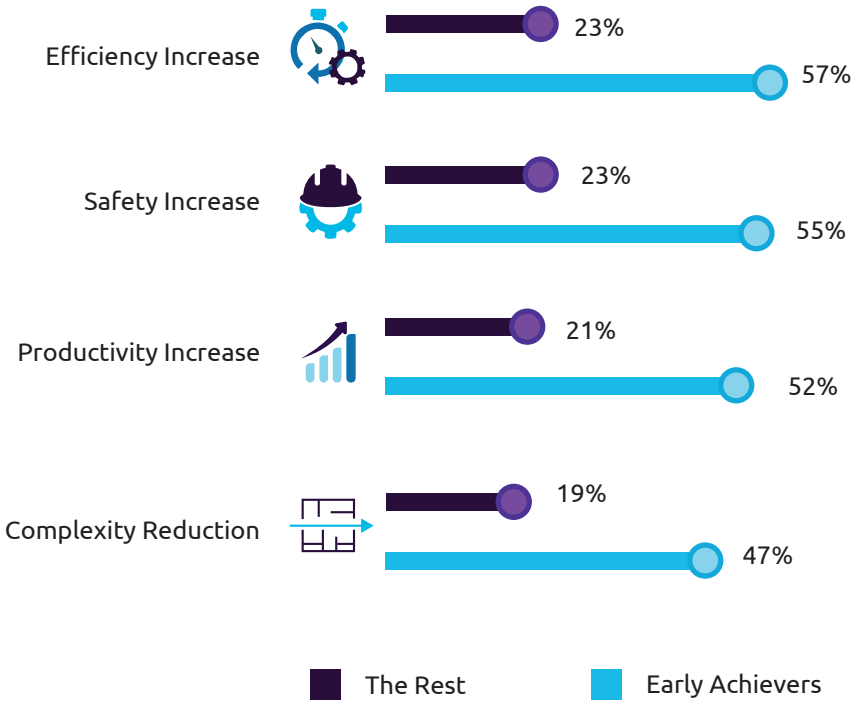


How to extract value from immersive tech?

To understand what we can learn from organizations that are advanced in terms of immersive technology implementation, we identified a group of "early achievers" based on two key factors:

- They characterize their AR and/or VR initiatives as successful
- They implement more than five AR or VR use cases, either small- or large-scale.

Figure 10. **On average, early achievers derive higher benefits as compared to the rest**



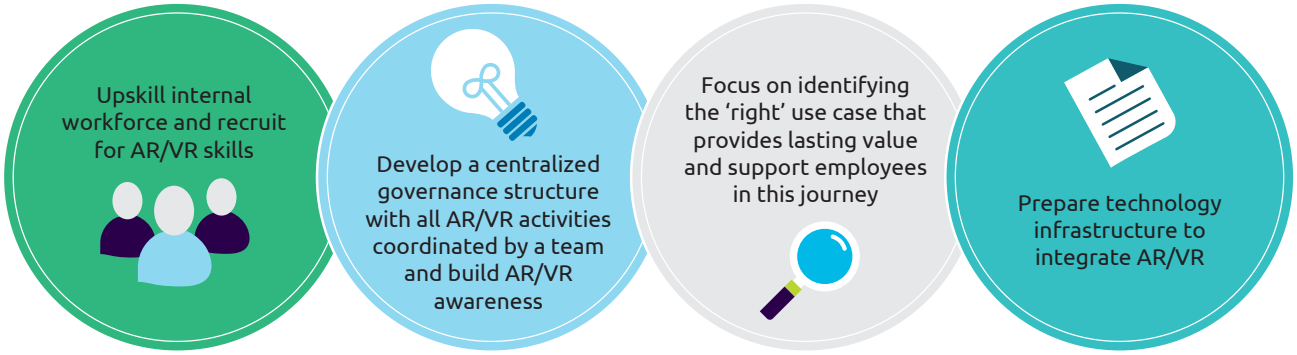
Source: Capgemini Research Institute, Augmented and Virtual Reality Survey; May-June 2018, N=603 organizations that are exploring and implementing Augmented Reality and Virtual Reality; N=134 Early Achievers

Representing merely 16% of all AR and 6% of all VR experimenters and implementers, early achievers may currently be in the minority. However, they derive significantly higher benefits. Figure 10 illustrates that, in contrast to the rest, a higher share of early achievers witness improvements in efficiency, safety, productivity, and complexity in excess of 10%.

71% of early achievers believe that immersive technologies will have a substantial impact on organizations and industry in the near future. Yet, we find that most companies are in the exploratory phase of proofs of concept and pilots.

To close the gap with early achievers, organizations can focus on the steps outlined in Figure 11.

Figure 11. How to begin or enhance your AR/VR journey



Source: Capgemini Research Institute, Augmented and Virtual Reality Survey; May-June 2018

Invest in upgrading talent and focused research initiatives to gear up for future adoption

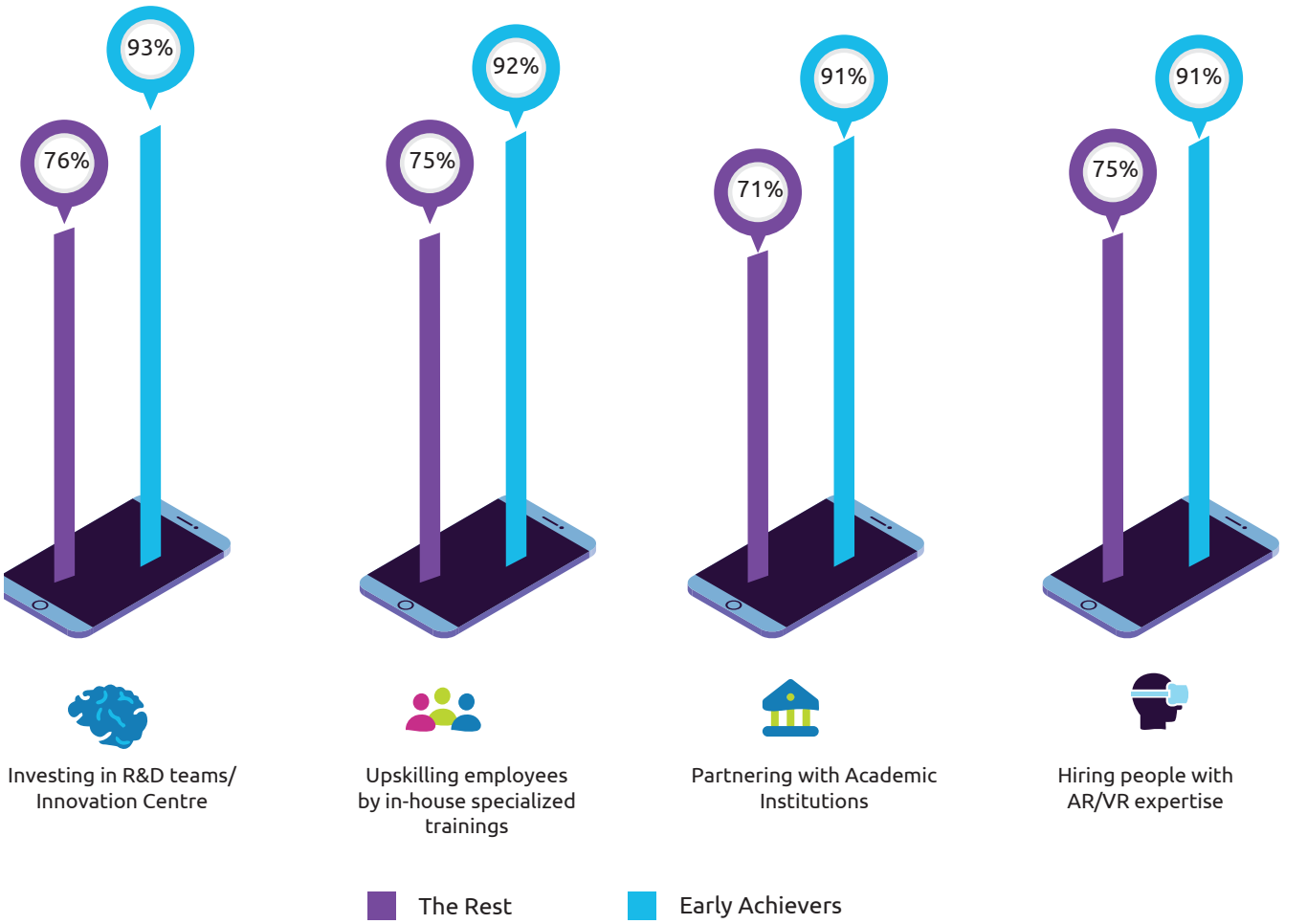
Because the technology is new, it's no surprise that organizations lack in-house AR/VR expertise. In fact, it is one of the top three barriers to growth identified by our respondents.

Bodo Seifert, global design director at Dura Auto, a global automotive supplier, describes the challenge. He states, "in one of my groups I have a design studio with some pretty sharp individuals who use the technology all the time but in another one of my groups, since this technology has not really percolated, only a few people can handle AR/VR." Evidently, upskilling employees is a priority for the company.

Because immersive technologies require new skillsets, early achievers are investing heavily in agile, in-house teams of experts. They avidly conduct specialized in-house training and recruit personnel with AR/VR expertise. Together with building internal capabilities, outsourcing subject matter experts with direct experience in immersive technology is an alternate way forward. For their part, organizations at early stages of adoption can choose to partner with specialized teams and institutions to leverage outside talent and technology (see Figure 12).

57% of early achievers have experienced over 10% efficiency increase with AR/VR compared to only 23% of the rest of the companies

Figure 12. Strategy for expanding AR/VR initiatives, Early Achievers vs. The Rest



Source: Capgemini Research Institute, Augmented and Virtual Reality Survey; May-June 2018, N=603 organizations that are exploring and implementing Augmented Reality and Virtual Reality of whom, N=134 Early Achievers
*Based on the percentage of organizations agreeing to the question (rating of 5, 6, 7 on a scale of 1 to 7).

Companies face fierce competition for talent. In the US, demand for freelancers with VR expertise has increased more rapidly than that for any other skill in Q2 2017; a thirty-fold, year-on-year increase.[26]

Our earlier study, "The Digital Talent Gap," points to a growing divide in the overall digital skills supply chain and indicates that over half of organizations surveyed have lost competitive advantage because of a shortage of digital talent.[27]

Put a centralized governance model in place and build AR/VR awareness

Early achievers have dedicated, central teams or an innovation center that manage the organization's overall AR/VR activities (see Figure 13).

The governance structure must be established by a committed team to allow the technology to develop and flourish. Immersive technology key stakeholders may be operations managers, for example plant managers or process engineers, who are accountable for delivering on key operational metrics. However, overall planning and execution should be led through a centralized unit, improving governance and making best use of resources. Examples of companies that have a centralized unit working on AR/VR are Airbus, Volkswagen

Group, and Finnish energy firm Fortum, all of whom have contributed to this study.

A common observation we've seen with clients is their general lack of awareness of what AR or VR is, how it can be applied, and what benefits it can yield. Hopefully this report helps fill that gap but organizations shouldn't underestimate the power of influencers proactively building that awareness throughout the organization, a role that can also be carried out by a centralized unit.

Focus on identifying the right use case that provides lasting value and supports employees in this journey

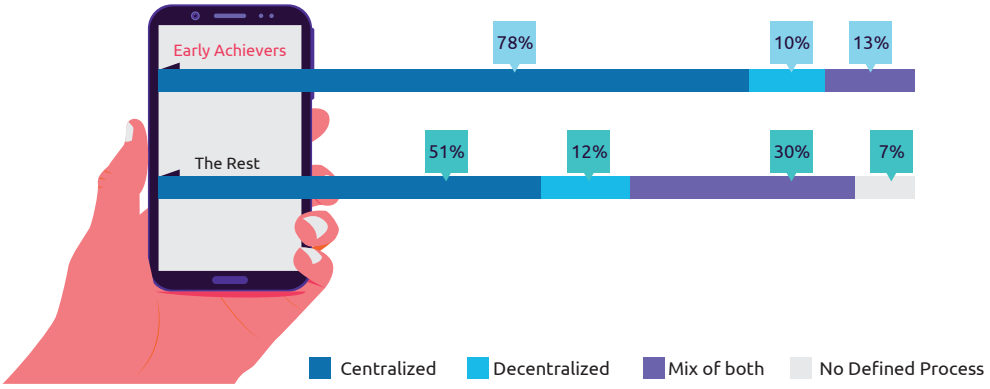
AR/VR providers state that organizations are eager to try the technology before really knowing how to apply it. Our research shows that the inability to identify a use case is a challenge for more than 50% of organizations.

A simple way to identify a potential use case, says Peter Kjeldgaard, global alliance manager at Upskill, the GE- and Boeing-backed AR start-up, is by "focusing on operational impact." He adds: "think about the job your employees do and how small amount of digitization can help them do it better."

Our research reveals that finding the right use case and testing its applicability is a part of the top three priorities for early achievers. "First, focus on your use case and not on the technology itself," says Jan Pflueger from Audi's Center of Competence for AR/VR. "After you identify your use case, focus on your information handling and data so you can deliver the right information to the technology."

When focusing on a particular use case, organizations should encourage employees to apply it and embrace augmentation. AR/VR tools pose a significant change to traditional ways of working and should be managed like any other technological change in order to overcome employee resistance. Similar to other technology changes, AR especially augments operational processes, making change management vital to overall acceptance. Organizations can gamify the AR/VR experience to engage their workforce and reward them for making use of immersive tools. For instance, Light Guide Systems, an enterprise AR technology provider, turns a set of manufacturing tasks into a sequence of challenges where employees can score points and effectively track key metrics.[28] This provides positive motivation and a competitive environment for completing those tasks. Digital Transformation Manager at Fortum, Panu Arvila, agrees that employees need to be part of the development and their feedback and development ideas should be heard. "You need to be able to demonstrate how the new technology can support the daily work and encourage them to adopt this new way of doing things," he comments. Organizations must also make on-request training and support staff available to help employees clarify their doubts and concerns regarding the technology.

Figure 13. **Governance structure, AR/VR, Early Achievers vs. The Rest**



Source: Capgemini Research Institute, Augmented and Virtual Reality Survey; May-June 2018, N=603 organizations that are exploring and implementing Augmented Reality and Virtual Reality of whom, N=134 Early Achievers

The first step for Thomas Perpère at Diota, a France-based, augmented reality software company, begins with employee acceptance. "It can be a tricky situation because under certain conditions, employees might feel that wearing AR/VR headgear makes their task cumbersome." In such conditions, employees must be convinced that immersive technology can make their overall workplace experience safer and more productive.

Companies should consider a reasonable investment for a predetermined use case(s) to understand where the business potential lies while taking into account the user experience (usability and ergonomics).

Prepare technology infrastructure to integrate AR/VR

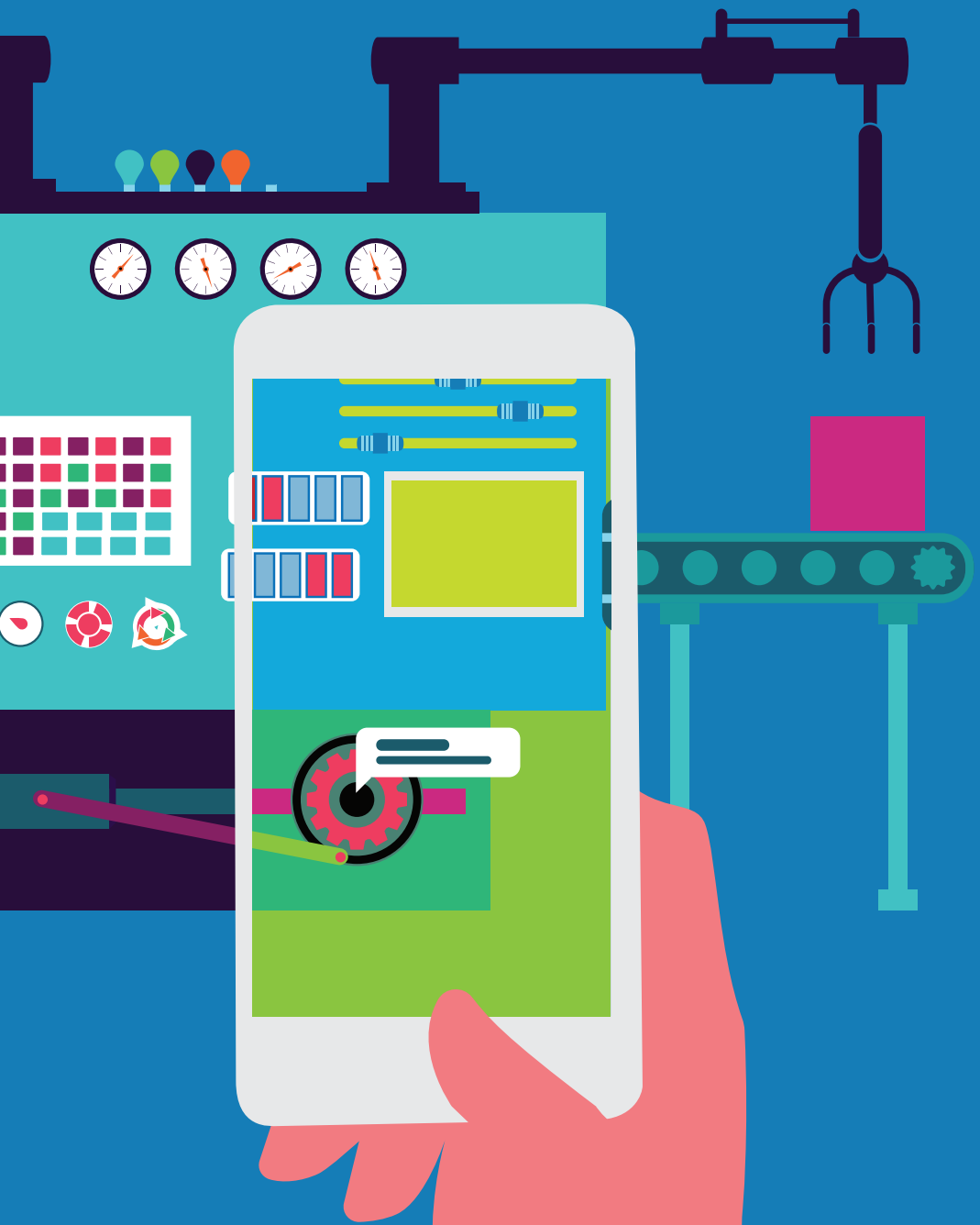
Sixty-one percent of organizations exploring and implementing AR/VR believe that complexity in execution is a major barrier for adoption, while 54% blame lack of data and technology readiness.

Companies should ensure that the key technology building blocks are in place and well-integrated:

- **Ensure content availability.** Organizations should have a repository of content and data available in the proper format for a well-functioning AR/VR system. It is not easy to aggregate and collate data from operating and repair manuals that need to be coded in order to create work instructions for a procedure. Replicating workers' tribal knowledge into a database is an additional challenge. Various types of data such as system specifications, performance metrics, and vital statistics of machines that operators work on, when combined with AR/VR systems can be a powerful enabler. However, making this data available for AR/VR systems is a daunting task. An IT Innovation Manager at a multinational automotive manufacturing company says, "data preparation is the biggest challenge we face with immersive technology. Much time is required to prepare the data, there is a need for automated processes, and general data standardization." Professor John Erkoyunco at Cranfield University agrees that data is the foremost challenge to AR or VR adoption. "Data architecture, how data is being collected and structured internally, and how it's shared across departments is a big struggle," he attests. Consider shifting the mentality from the traditional way engineers develop and design products. To be successful, organizations need to think in terms of information rather than hardware.
- **Evaluate partnering with experienced vendors to minimize complexity.** To minimize AR/VR complexity in execution, organizations can collaborate with software providers, often times found in a start-up company ecosystem. Many of these solutions originated as custom solutions created on a case-by-case basis, but have since evolved to include a variety of turnkey AR/VR solutions. Diota is a prime example of this evolution. "After building custom solutions for customers, we found that we could address 80% of the use cases with one application so we said, 'let's develop this application,'" says Thomas Perpère, of Diota. For David Nedohin, president and founder of ScopeAR, an augmented-reality software company, these solutions are just part of his company's offering. "Some customers know they want to use AR and build content but they aren't ready to do it themselves, yet which is why we offer both a custom and turnkey solution," he says.
- **Carefully consider connectivity requirements for your AR/VR use cases.** Not all use cases need a high availability of network and bandwidth. However, for those use cases that do, the absence of remote collaboration, or a lack of proper connectivity and bandwidth can be a deal breaker. For use cases that can work without network connectivity, computing power proves to be more crucial as most AR/VR systems involve heavy use of graphics and real-time rendering.
- **Integrate AR/VR solutions with existing technologies to reap full benefits.** To yield higher benefits, consider AR/VR as an important part of a larger digital journey. Part of this journey is the integration with the company's various enterprise systems such as enterprise resource planning (ERP), product lifecycle management (PLM), etc. Organizations should also keep in mind the process changes and associated investment necessary for such integration. Moreover, because AR/VR is a fairly new technology that is advancing and being integrated with legacy systems, security and privacy is key. Surveyed organizations reveal cybersecurity and data-privacy concerns to be one of the top three challenges that hinder adoption. This challenge should be addressed with a proper security and privacy framework built-in, to avoid exposing sensitive and proprietary information.

Conclusion

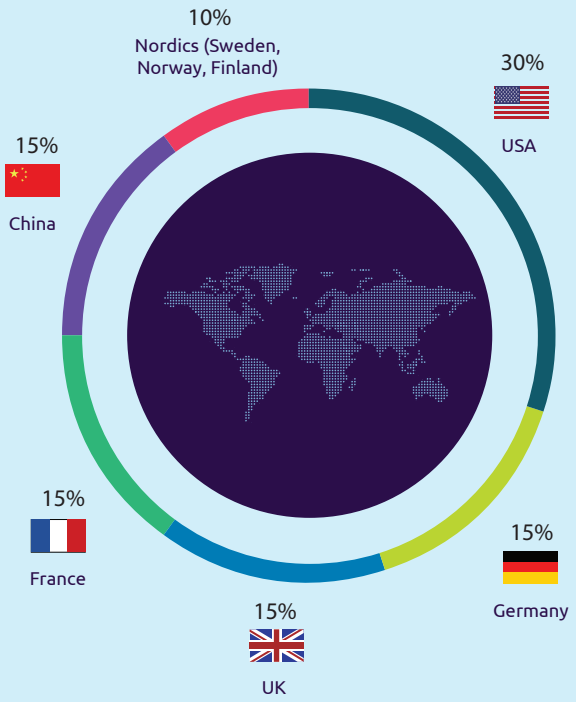
Immersive technology has come a long way in a short time and will continue to evolve. For organizations, the major brakes on progress will be technological integration, data readiness, the inability to identify use cases, talent, and general awareness. However, we do not believe that these challenges outweigh the long-term growth potential this technology offers. Even among the organizations in our study that are not exploring AR/VR, 50% plan to do so within the next three years. For those looking to begin or advance their journey, having a centralized governance structure and focusing on the most valuable use cases will be key. Additionally, until broader adoption happens, companies shouldn't overlook the importance of having internal key influencers champion AR/VR technology to bring awareness of its potential benefits.



Research Methodology

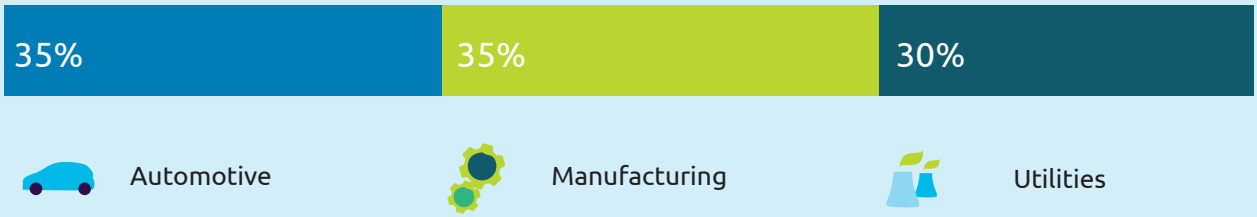
We surveyed 709 individuals with considerable knowledge of their organization's AR/VR initiatives at 709 companies. Seventy-three percent of organizations reported revenue of more than US$1 billion in FY 2017. The research focused mostly on companies that are active in AR/VR with 603 of these organizations currently experimenting or implementing AR/VR. This survey was conducted from May to June 2018.

Organizations by location



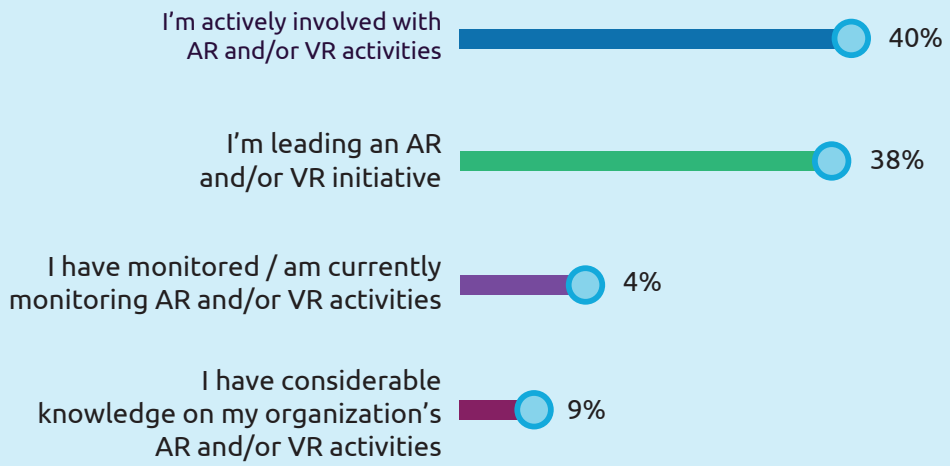
Source: Capgemini Research Institute, AR/VR Survey; May–June 2018, N=709 organizations.

Organizations by industry



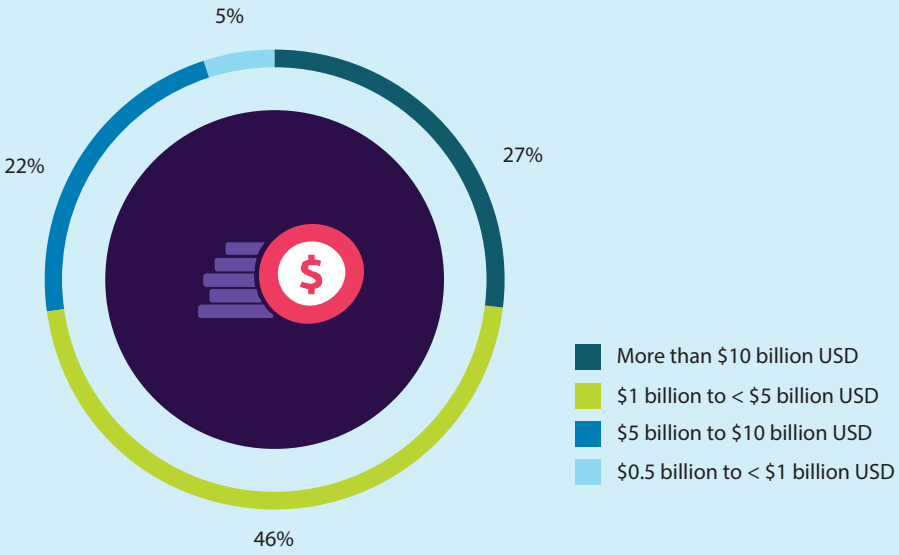
Source: Capgemini Research Institute, AR/VR Survey; May–June 2018, N=709 organizations.

Respondents by involvement in company AR/VR Initiatives



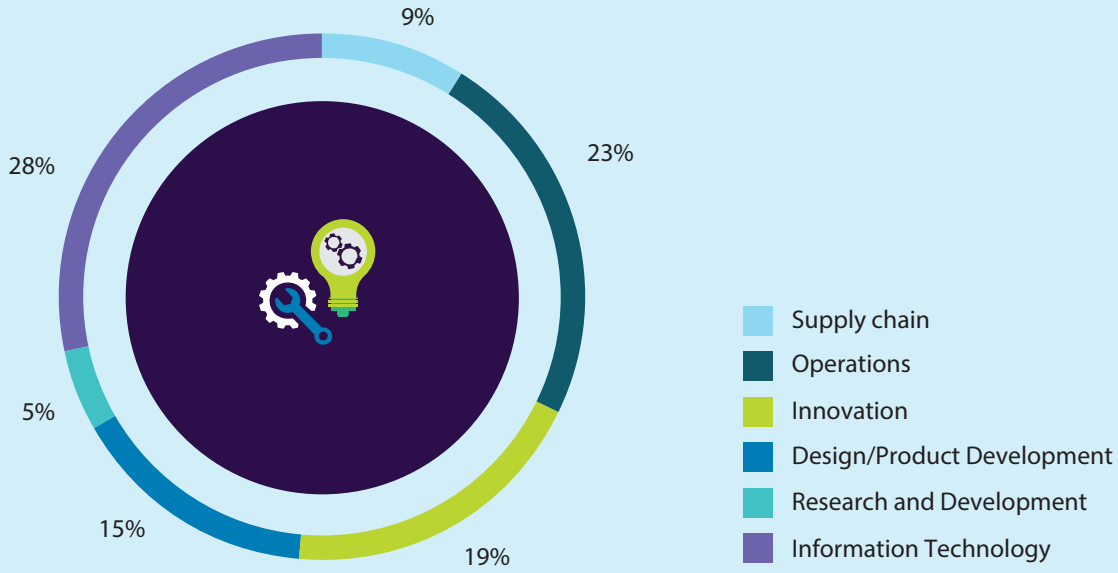
Source: Capgemini Research Institute, AR/VR Survey; May–June 2018, N=709 organizations.

Organizations by revenue



Source: Capgemini Research Institute, AR/VR Survey; May–June 2018, N=709 organizations.

Distribution of survey respondents across functions



Source: Capgemini Research Institute, AR/VR Survey; May–June 2018, N=709 organizations.

A note about the analysis:

The total number of survey respondents is 709, however the target audience for this survey represents companies exploring and implementing AR and/or VR. The objective of the survey was to understand how AR/VR is currently being implemented, and is not meant to represent overall AR/VR penetration.

Appendix

Appendix. Benefit per sector - AR and VR

Benefits of AR

	Saves Time	Error-rate Reduction	Complexity Reduction	Efficiency Increase	Safety Increase	Productivity Increase
Automotive						
Manufacturing						
Utility						

Benefits of VR

	Saves Time	Cost Savings	Complexity Reduction	Efficiency Increase	Safety Increase	Productivity Increase
Automotive						
Manufacturing						
Utility						

1	Highest benefit
2	
3	
4	
5	
6	Lowest benefit

Source: Capgemini Research Institute, AR/VR Survey; May–June 2018, N=709 organizations

Appendix. Heat map for each industry indicating the highest benefit

Automotive

Use Cases		Benefits						
		Save Time	Error Rate Reduction	Complexity Reduction	Efficiency Increase	Safety Increase	Productivity Increase	Cost Savings
Assembly instructions used for training	AR							
Visualize historical maintenance records and provide task recommendations	AR							
View reference videos and digital manuals	AR							
Compare physical and database version of equipment	AR							
Remote expert for assistance and guidance	AR							
Digitally view equipment design	AR							
Visualize digital twin to simulate real-world environment	AR							
Digital instructions for assembly and configuration	AR							
Visualize specific components and functions behind physical barriers	AR							
Virtual training for assembling/disassembling components	VR							
Early concept design fully created in VR	VR							
Superimpose live data on real machine parts	VR							
Digitally track assembling processes for quality assurance	VR							
Visualize a digital version of a piece of equipment into a production environment to see final product	VR							
Shift perspectives while viewing equipment	VR							
Simulate human motion for a process to engineer alternative actions	VR							
Visualize a digital replica or twin" of the equipment to simulate a real-world environment	VR							
Virtual walk-through of plant	VR							
Remote collaboration across locations to view same project data	VR							
Simulate various scenarios with digital twin to perform "what-if" analysis	VR							

Less than 5.00%	
5.01%-10.00%	
10.01%-15.00%	
15.01%-20.00%	
More than 20%	

Appendix. Heat map for each industry indicating the highest benefit

Manufacturing

Use Cases		Benefits						
		Save Time	Error Rate Reduction	Complexity Reduction	Efficiency Increase	Safety Increase	Productivity Increase	Cost Savings
Digital instructions for assembly and configuration	AR							
Remote expert for assisstance and guidance	AR							
Training instructions for assembling/disassembling components	AR							
Track KPIs on multiple production lines	AR							
Overlay design components onto existing module	AR							
Digitally view equipment design	AR							
Visualize historical maintenance records and provide task recommendations	AR							
Visualize specific components and functions behind physical barriers	AR							
Project high-res graphics onto equipment for work instruction	AR							
Visualize digital twin to simulate real-world environment	VR							
Capture images/videos of equipment for transmission to another location	VR							
Simulate human motion for a process to engineer alternative actions	VR							
Remote collaboration across locations to view same project data	VR							
Virtual training for assembling/disassembling components	VR							
Early concept design fully created in VR	VR							
Visualize a digital replica or twin" of the equipment to simulate a real-world environment	VR							
Simulate various scenarios with digital twin to perform "what-if" analysis	VR							
Digitally track assembling processes for quality assurance	VR							
Send digital twin through virtual workflow	VR							
Virtual walk-through of plant	VR							
Visualize a digital version of a piece of equipment into a production environment to see final product	VR							
Shift perspectives while viewing equipment	VR							

Less than 5.00%	
5.01%-10.00%	
10.01%-15.00%	
15.01%-20.00%	
More than 20%	

Appendix. Heat map for each industry indicating the highest benefit

Utility

Use Cases		Benefits						
		Save Time	Error Rate Reduction	Complexity Reduction	Efficiency Increase	Safety Increase	Productivity Increase	Cost Savings
Electronic boundaries for hazardous areas	AR							
Superimpose step by step instructions	AR							
Remote expert for assisstance and guidance	AR							
Visualize specific components and functions behind physical barriers	AR							
Assembly instructions used for training	AR							
Digital instructions for assembly and configuration	AR							
Overlay operating details to enhance equipment view	AR							
Capture images/videos of equipment for transmission to another location	AR							
Visualize infrastructure project from various angles	AR							
Visualize historical maintenance records and provide task recommendations	VR							
Compare physical and database version of equipment	VR							
Virtual walk through of the site	VR							
Simulate various scenarios with digital twin to perform "what-if" analysis	VR							
360 degree view for utility network	VR							
Visualize a digital replica or twin" of the equipment to simulate a real-world environment	VR							
Virtual training for assembling/disassembling components	VR							
Digitally track assembling processes for quality assurance	VR							
Remote collaboration across locations to view same project data	VR							
View design models of equipment	VR							

Less than 5.00%	
5.01%-10.00%	
10.01%-15.00%	
15.01%-20.00%	
More than 20%	

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About the Authors

Lanny Cohen
Chief Innovation Officer, Capgemini
lanny.cohen@capgemini.com

Lanny Cohen is Capgemini's Chief Innovation Officer. Lanny is responsible for Capgemini's global applied innovation strategy, as well as its worldwide network of 16 applied innovation centers. During his 35 year plus career at Capgemini and Ernst & Young combined, Lanny has held positions along the entire spectrum of business management, account management, business development, and delivery management from consultant to partner/vice president.

Patrice Duboé
Innovation Executive Vice President
patrice.duboe@capgemini.com

Patrice Duboé has been working in Innovation & Technology for more than 20 years in multicultural environments. He is now Innovation Executive Vice President within the CTIO Office of Capgemini and CTO of Capgemini Engineering Services. He is leading the Global Architects community gathering more than 6000 Business & Technology experts in over 40 countries. He has been training & coaching enterprise architects & technology experts for Capgemini & global clients over the last 20 years.

Jerome Buvat
Global Head of Research and Head,
Capgemini Research Institute
jerome.buvat@capgemini.com

Jerome is head of Capgemini's Research Institute. He works closely with industry leaders and academics to help organizations understand the nature and impact of digital disruptions.

Dorine Melton
Senior Consultant, Capgemini Consulting
dorine.melton@capgemini.com

Dorine is a Senior Consultant at Capgemini Consulting North America. She works with business leaders to solve challenges relating to organizational change management and employee engagement.

Amol Khadikar
Manager, Capgemini Research Institute
amol.khadikar@capgemini.com

Amol is a manager at Capgemini Research Institute. He leads research projects on key digital frontiers to help clients design and implement digital transformation strategies.

Hiral Shah
Senior Consultant, Capgemini Research Institute
hiral.b.shah@capgemini.com

Hiral is a Senior Consultant at Capgemini Research Institute. She works closely with industry/business leaders to help them leverage digital technologies to transform their organization and business operations.

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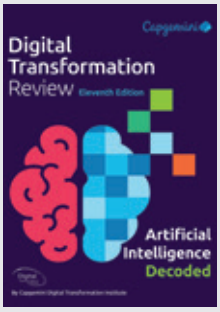

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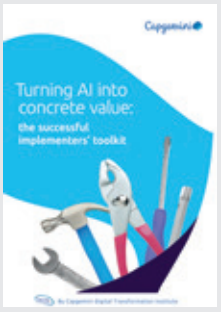

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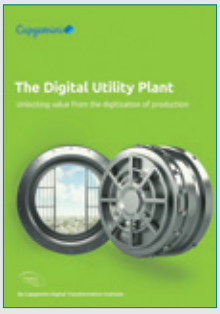

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Digital Engineering: The new growth engine for discrete manufacturers

The Secret to Winning Customers' Hearts With Artificial Intelligence: Add Human Intelligence

For more information, please contact:

Global

Lanny Cohen (US)
lanny.cohen@capgemini.com

Patrice Duboe (France)
patrice.duboe@capgemini.com

Germany

Udo Lange
udo.lange@capgemini.com

India

Aashish Chandorkar
aashish.chandorkar@capgemini.com

Satishchandra Nayak
satishchandra.nayak@capgemini.com

Sanjeev Gupta
sanjeev.a.gupta@capgemini.com

Italy

Michela Cotich
michela.cotich@capgemini.com

Netherlands

Henk Vermeulen
henk.vermeulen@capgemini.com

Nordics

Ken Olling (Norway)
ken.olling@capgemini.com

United Kingdom

Priscilla Li
priscilla.li@capgemini.com

Alex Smith-Bingham
alex.smith-bingham@capgemini.com

Spain

Eugenio Montoro
eugenio.montoro-mateos@capgemini.com

César Tauste
cesar.tauste-martinez@capgemini.com

Bridge the gap between digital and physical worlds for workers in mobility

At a time when competitiveness's challenge is based on engineering, manufacturing, operations and maintenance cycles, Andy3D has been specifically designed to accelerate data and asset visualization, reduce mistakes and improve comfort and safety of the operators in the field. Capgemini' Andy3D is a suite of mobile apps, fully customizable to customers' context for business challenges and information system integration. It can be tailored to clients' needs and is available thanks to a plug and play deployment, with no third party software licensing, with high performance capabilities and state of the art ergonomics.

- **Andy3D – Remote** bridges the gap between physical and digital worlds for workers in mobility. By using multi-media channels, live streaming and exchanging digital data, in real time between the field and remote expertise centers, our Immersive Remote Assistance Platform reduces expert's mobilization and unexpected issues fixing time. Andy3D - Remote is the only remote assistance platform providing digital continuity of 3D models, including enhanced AR/VR features.

It provides:

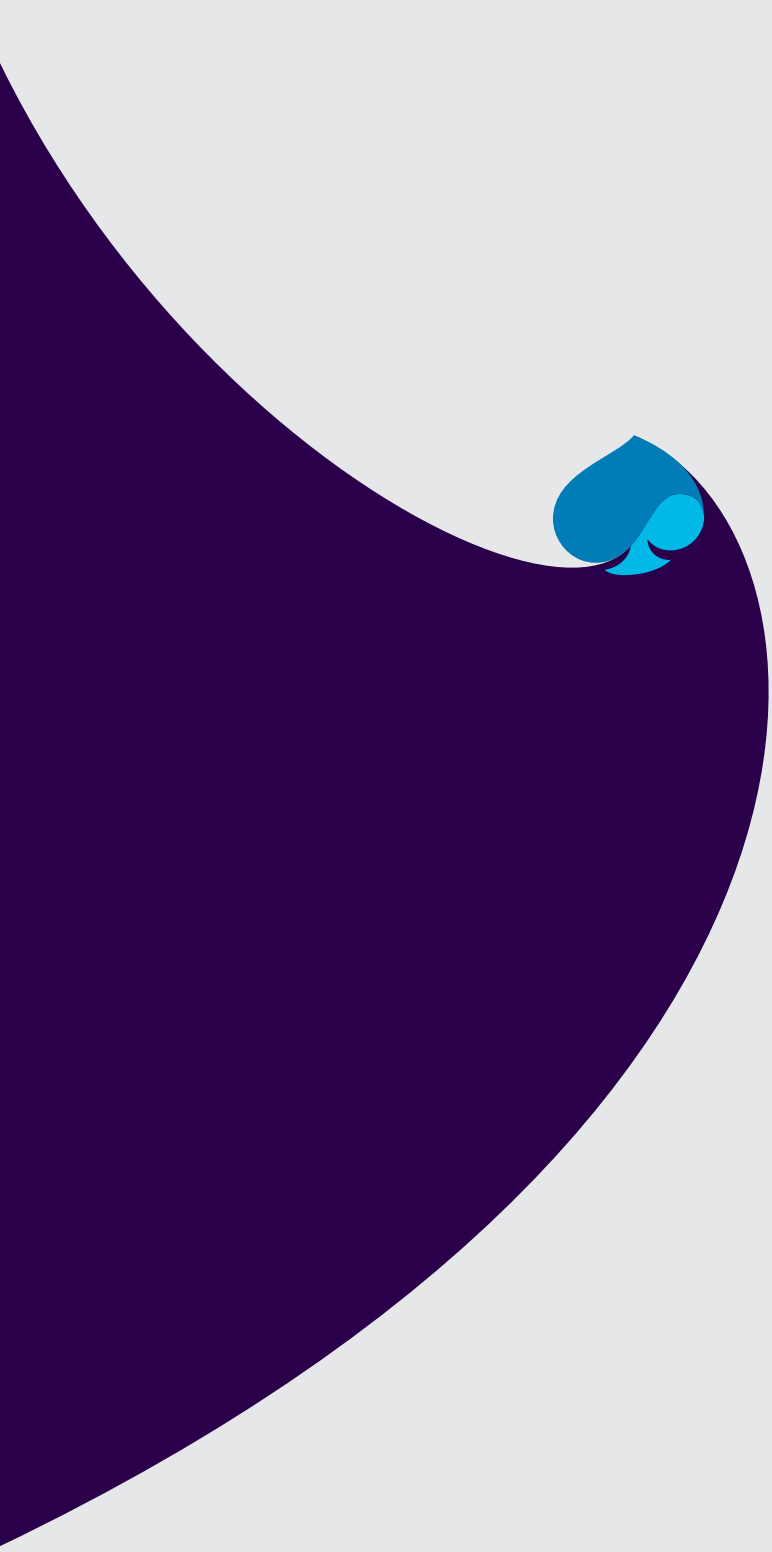
- Collaboration and knowledge sharing, between workers in mobility – in-situ or on customers' sites – and remote center of excellence, such as Engineering, Maintenance and Customer services.
- 3D Digital-physical convergence throughout all development phases: Prototyping, Industrialization, Validation, Launching, Inspection and Maintenance.
- Full handling of operations both in products and infrastructures worlds.

- **Andy3D – Revamping** focuses on vertical and linear revamping by hybridizing laserscan and 3D models in the field. Our Asset Revamping Platform leverages Capgemini's cutting edge Open Cascade 3D technology and web browser capabilities, to enable easy life-size simulation. Andy3D – Revamping is the only platform providing real interactive and easy-to-use 3D hybrid digital mockup in a web browser from any device. With VR features, Andy3D – Revamping allows a deeper and more precise navigation into the asset to better interact with and benefit from 3D data.

This solution can be experienced for:

- Integrating a new industrial equipment in an existing factory
- Increasing manufacturing output and capabilities without any building extension
- Renovating a rundown plant or building with very limited technical documentation

To find out more: https://www.capgemini.com/resources/andy3d-remote-and-web-platform/



About Capgemini

A global leader in consulting, technology services and digital transformation, Capgemini is at the forefront of innovation to address the entire breadth of clients' opportunities in the evolving world of cloud, digital and platforms. Building on its strong 50-year heritage and deep industry-specific expertise, Capgemini enables organizations to realize their business ambitions through an array of services from strategy to operations. Capgemini is driven by the conviction that the business value of technology comes from and through people. It is a multicultural company of 200,000 team members in over 40 countries. The Group reported 2017 global revenues of EUR 12.8 billion.

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