

The State of Industrial Augmented Reality 2017



Authors

Mike Campbell, Executive Vice President, ThingWorx Platform, PTC

Shawn Kelly, Vice President, Corporate Strategy, PTC

Rocky Jung, Senior Business Analyst, PTC

Jon Lang, Lead Principle Business Analyst, PTC

The State of Industrial Augmented Reality is part of a series of market research and analysis reports published by PTC. This report examines the what, where, why, how, and when of the rapidly evolving opportunities in the augmented reality (AR) market.

The data insights in the State of Industrial Augmented Reality report are derived from an analysis of survey data from the largest single source (by market share) of industrial enterprises developing AR experiences – ThingWorx Studio customers. PTC surveyed these customers in May and July of 2017 to understand how they are using AR to create business value today.

The respondents were from around the world, with 42% from the Americas; 37% from Europe, the Middle East, and Africa; and 21% from Asia-Pacific. The sample represents a mix of large, medium, and small firms. Forty-four percent of the firms have an annual revenue of more than \$1 billion while 17% have revenues between \$100 million and \$1 billion, and 39% have revenues of less than \$100 million. The respondents were from various types of industries, ranging from industrial equipment, aerospace, government and defense, automotive, and electronics, to software and professional services.

To supplement our proprietary information, PTC incorporated market data from leading research firms and examples from publicly available case studies to provide a full picture of the industrial AR market.

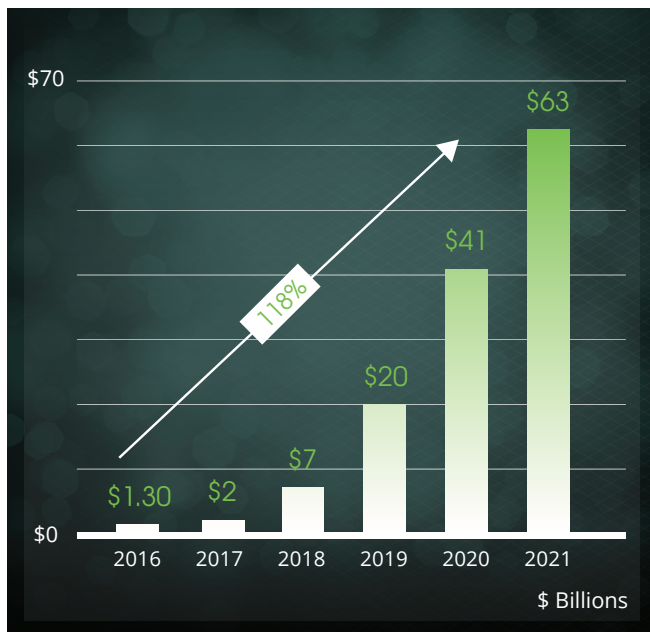
The objective of this report is to provide data-driven visibility into a rapidly evolving technology. Our research highlights which industries are leading AR deployments, the functions within a company using this technology, and the types of business value generated. This report also explores the degrees of success companies are experiencing in implementation, and where they are in transitioning pilots to production deployments.

The Potential Value of the AR Market

The potential value of AR is no longer a secret. Numerous reports from industry analysts have forecasted enormous growth for this market, primarily because of the increasing ability of AR to fundamentally transform the way humans interact with the physical and digital worlds. The growth in connected things and digital content, along with maturing AR hardware, is fueling the emergence of more and more powerful AR experiences.

The analysts' projections for the growth of the AR market vary, however. For instance, reports from Digi-Capital¹, ABI Research², and Markets and Markets³ have estimated the market will reach anywhere from \$24 to \$83 billion by 2021.

Figure 1: Projected AR Market Growth



PTC has taken these numbers into consideration, along with our own research, an analysis of available market reports, and insights garnered from our conversations with thousands of companies piloting and deploying AR. Based on this vast amount of data, we estimate the total AR spend, inclusive of hardware, software, eCommerce, games, and advertising, will grow at a 118% CAGR from 2016, reaching \$63 billion by 2021 (Figure 1).

While AR will enjoy steady revenue growth throughout 2017, we believe 2018 will serve as a tipping point for an even greater surge of growth. Driving this will be a significant increase in hardware shipments, initially driven by AR-enabled smartphones, with smart glasses driving an ever-increasing portion.

We believe the hardware market alone will continue to mature and grow at a 227% CAGR over the same period. In addition, our research shows that a large number of small pilot implementations will transition to production environments as they continue to provide positive performance indicators, further fueling market growth.

To enable these market expectations, PTC sees both venture capital (VC) investors and enterprises prioritizing the advances of relevant underlying technologies. The maturation of technologies such as depth-sensing cameras, physical environment mapping, and battery systems are key as the race continues to heat up for the first mass-production ready piece of AR eyewear.

Ultimately, the power of AR is just emerging. Popular consumer applications such as Pokémon Go and Snapchat, with its Geofilter feature, have moved AR front and center in public consciousness and are leading to future growth. In fact, industry reports estimate that by 2021 over 100 million consumers will shop in AR.⁴

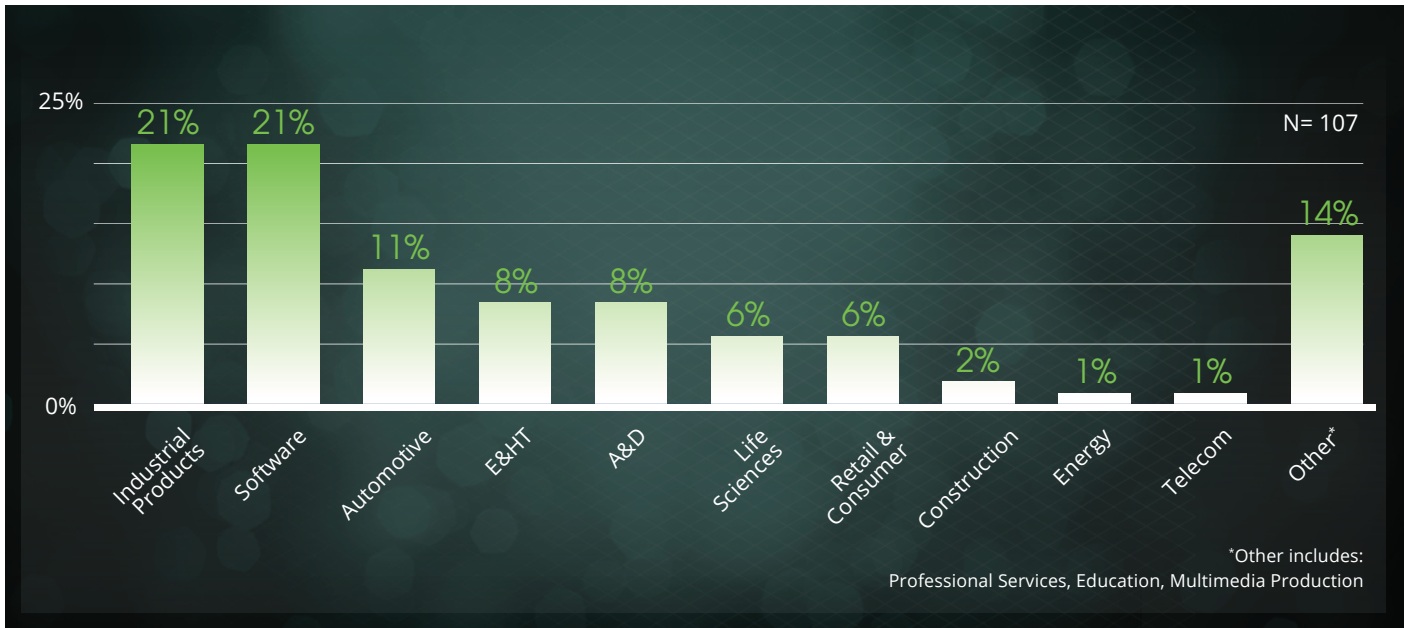
As AR software and hardware continue to mature, we will see more examples of this technology's remarkable potential to transform how digital information can be delivered to humans in a more natural, powerful, and efficient way.

What Industries Are Adopting AR?

According to PTC data, manufacturers of industrial products, automotive, aerospace, and high-tech are leading the adoption of AR, and a large number of software service providers have emerged to support this demand (Figure 2). There are already examples emerging across a dozen different types of industries, demonstrating the horizontal applicability of this technology. Interestingly, industries heavily impacted by digital transformation initiatives and the Internet of Things (IoT) are leading the adoption of AR.

Why? One of the key reasons is AR's ability to serve as an advanced instruction and guidance tool. In industries that include very complex processes with potentially hundreds or thousands of parts, configurations, and procedures – where minor errors or deviations can incur substantial cost or cause serious harm – this capability could make a significant difference.

Figure 2: Industries Most Rapidly Adopting AR



By combining the advanced instructional capabilities of AR with the ability to visualize real-time data from connected machines and other systems, technicians and operators can repair and maintain machines with greater safety, efficiency, and cost-effectiveness.

Many early adopters in industries that involve complex and numerous processes and high-capital intensity, such as industrial products, automotive, electronics, high tech, and aerospace, and defense, are betting on AR to help them achieve benefits like this.

By implementing AR to provide advanced instruction to their workforce, these manufacturers are hoping to increase their manufacturing consistency and productivity, and ultimately, their competitive advantage in their marketplaces.

As other successful key uses of AR emerge, more and more industries will realize the full potential of this technology.

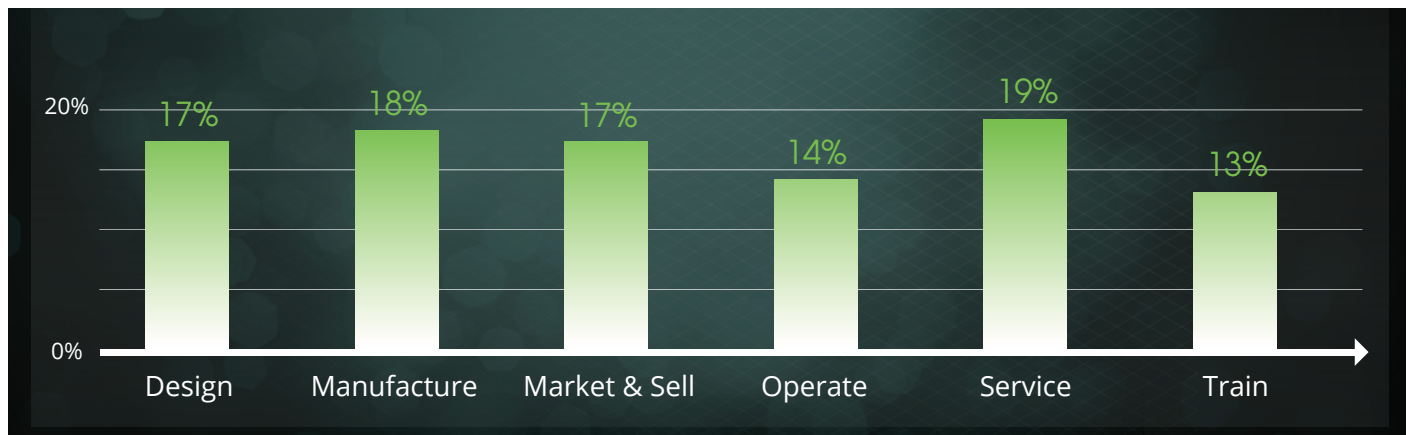
Where in the Enterprise Is AR Used?

The power of AR technology to visualize, instruct, guide, and improve interactions with physical things through digital information is helping to restructure traditional business activities from product design and manufacturing through after-sales service.

PTC data shows there are a number of functions in the enterprise that are already exploring the broad applicability of AR to drive value. Of the survey respondents, they were from the following functions: 19% service, 18% manufacturing, 17% design, and 17% sales and marketing. Additionally, 14% were operators, followed by 13% that were in a training Capacity (Figure 3).

As mentioned earlier, AR can serve as an advanced tool for providing real-time instruction and guidance to those performing complex service.

Figure 3: Widespread AR Adoption Across the Value Chain



Similar AR capabilities can be applied to manufacturing assembly tasks, where minor errors can lead to costly downtime. Here the ability of AR to provide real-time monitoring and increasing overall equipment effectiveness (OEE) is vital. AR increases the effectiveness of IoT technologies that can spot and diagnose problems before they occur by providing visibility into these problems, thus adding increased value through actionable tasks. By equipping technicians and operators with AR, companies can ensure any identified problems are correctly addressed the first time efficiently and cost-effectively.

The next area in the enterprise that is benefiting from AR is design. This technology can alter the very definition of products, amplifying their capabilities, and transforming the way humans interact with the world around them. For example, research indicates Lego has added a completely new digital field of play to its Nexo Knights fantasy medieval virtual game, which allows customers to augment content directly onto their figurines.

In the automotive industry, car manufactures have enhanced their customers' experience by adding dedicated head-up displays to vehicles, which enable drivers to more intuitively interact with their car's digital information systems.

Companies that are exploring the potential in AR are doing it in multiple function areas, and in multiple disciplines. Our data shows that organizations are testing out AR in an average of two separate functions, with an average of 4.7 applications company-wide.

The execution of this level of AR experiences across the enterprise requires a scalable content strategy. While the level of investment in content required is dependent on the type of application and use cases being targeted, developing purpose-built content for each AR experience will require massive investments in time and resources, and ultimately prove to be unsustainable for widespread adoption.

To resolve these scalability issues, organizations will need to repurpose their existing digital content – including computer-aided design (CAD) models, technical service information, and real-time IoT data – to serve as the basis of the AR experiences. Many existing digital transformation initiatives, such as model-based enterprise, product lifecycle management, and IoT, can serve as a source to provide the critical foundation of content needed for AR experiences.

Our research also indicates that leveraging an AR authoring platform enables companies to rapidly develop and deploy multiple AR experiences and use cases throughout their organization.

How Is AR Used?

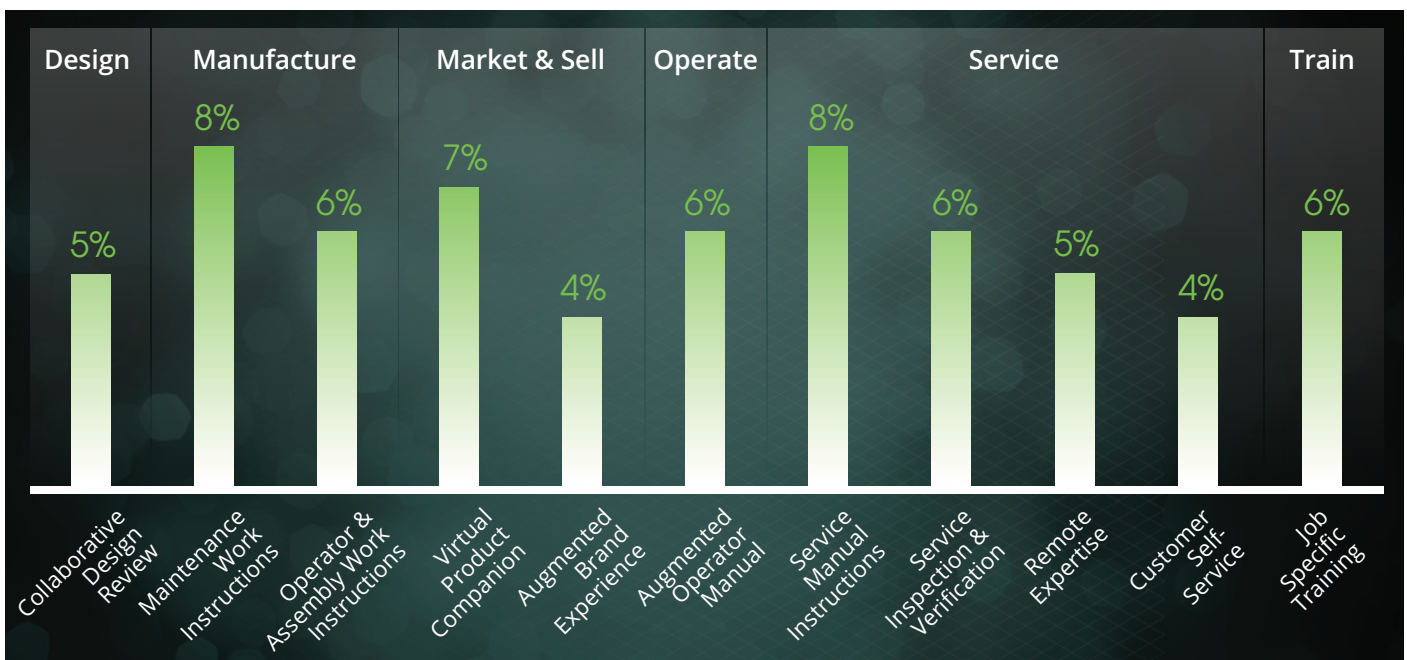
While there are opportunities to apply AR across the value chain, organizations must understand the requirements of each experience for a successful implementation. As with other emerging technologies, the use cases that create the most value may not always be achievable today due to technical limitations. It is important that an organization evaluate the technical and organizational requirements associated with a given use case while establishing its AR roadmap.

As mentioned earlier, one of the most popular AR applications is advanced instruction and guidance. Early adopters in service and manufacturing are using AR to enable operators with step-by-step instructions for maintenance and service procedures via service manual instruction and maintenance work instruction applications. In fact, three out the top four use cases focused on improving the dissemination and consumption of instructions.

As an example of what’s possible, GE created an AR experience where service technicians can see maintenance data and alerts from their Predix IoT system that indicate what maintenance procedures are needed and how to perform them.⁵ In this AR experience, machinery data, along with other external information sources from business systems data, such as CAD models and service history, and service instructions, is aggregated and compiled for each specific asset. This solution also incorporates data from asset management systems, service history systems, and supplier databases. The service technician selects the service procedure needed and follows the augmented instructions to drive high-quality service and reduce the costs of poor quality.

Applications like these allow companies to improve vital service metrics such as first-time fix rates and average resolution time.

Figure 4: Top AR Use Cases Across the Value Chain

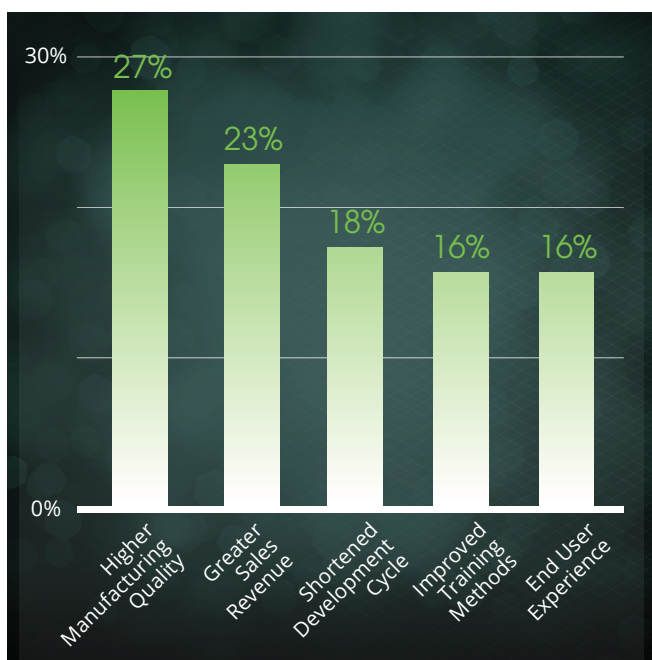


In the design area, product design engineers are using AR to visualize 3D digital designs in the physical environment. For PTC customers, this type of application of AR technology typically enhances design reviews and enables collaborative design review sessions for global design teams spread around the world. In sales and marketing, enterprises are leveraging AR to extend the means by which customers experience products through virtual product companions and interactive product demonstrations.

Why Are Businesses Pursuing an AR Strategy?

From this research, we see that AR has officially moved past the “WOW factor” stage that is often associated with new technologies. As the AR market continues to gain traction, the risk of investment has diminished, making AR a safe bet for VC firms and enterprises alike. As such, investment in underlying technologies such as depth-sensing cameras and computer vision algorithms has continued to grow, helping to accelerate the adoption of AR technologies. Industry giants such as Apple now see AR as a core technology and companies like Microsoft continue to invest billions in their AR hardware to drive future adoption.

Figure 5: Desired AR Benefits



The business outcomes being pursued also highlight a breadth of opportunity such as higher manufacturing quality, greater sales revenue, and shortened development cycles (Figure 5). Manufacturers are leveraging AR assembly work instructions to improve product quality. By providing workers with dynamic, in-context real-time assembly and inspection instructions, they can reduce the time required for workers to perform tasks and lower the number of errors and defects in the production process.

Companies such as IKEA⁶, Lego⁷, and Lowes⁸ are leveraging augmented product solutions to improve customer confidence and positively impact the buying decision, ultimately driving top-line sales revenue growth.

In service functions, enterprises are exploring AR as a means for enabling dynamic telepresence with remote experts, reducing the number of people needed on site to perform service. For instance, Caterpillar⁹ is exploring the use of AR to provide field technicians with remote expertise. They can share a live video feed of their immediate surroundings and communicate in real-time with an expert back in the office that provides step-by-step instruction. Ultimately, by deploying AR, Caterpillar can centralize its expertise while also improving vital service metrics.

In engineering, development teams can now more effectively review design changes in-context and remotely collaborate in ways not previously possible. This is drastically reducing the time needed for development cycles. Volkswagen¹⁰ is using AR for digital design review during the prototype inspection process. By using AR, the company can project design data, like the wiring harnesses, directly onto existing and prototype cars, ensuring the physical prototype matches the digital design. This allows Volkswagen designers to validate changes in less than one minute, a process that previously took 5-10 minutes.

In human resources, the training of employees on complex work procedures can be extremely time-consuming. Boeing is using AR to improve traditional training practices, and has reduced the time required to train an employee in aircraft door assembly by four times.¹¹

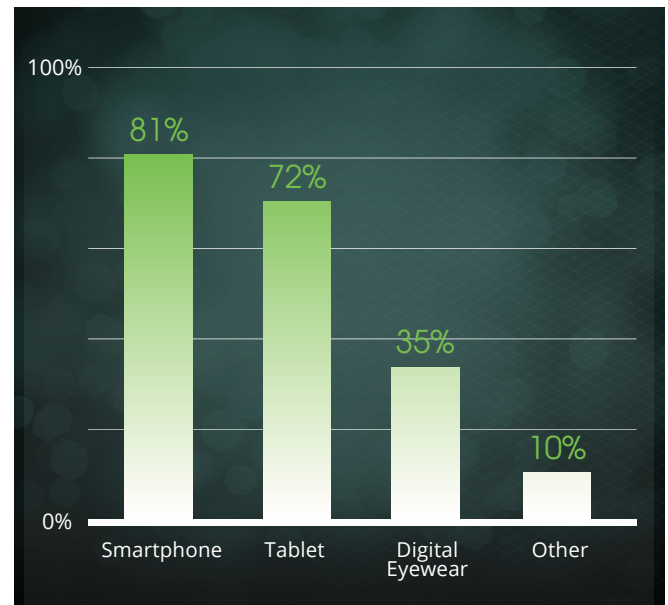
Finally, in today's market, products are increasingly being delivered as services through subscriptions, such as electrical power by the hour. Customer success is paramount, and people are increasingly demanding more dedication to their success with products as the bar continues to be raised on response time and overall customer experience. To address this rising demand for better servicing, Xerox is leveraging AR to offer remote expertise and guidance for both its own field engineers as well as its customers.¹²

What Hardware Is Used with AR experiences?

The concept of AR has been around for decades, but the hardware technology required to deploy AR at scale across the enterprise is just now emerging. The preferred hardware required to deploy an AR experience is largely dependent on the use case. For example, digital eyewear is ideal for manufacturing and service use cases that require hands-free operation. Conversely, sales and marketing use cases are dependent on the ubiquity of smartphones and tablets.

Currently, our data shows a majority of enterprises are exploring the use of smartphones and tablets to deploy AR experiences, most likely because these are tools people already have. There is, however, a growing interest in head-mounted displays, as over 30% of those surveyed in our research are experimenting with digital eyewear (Figure 6).

Figure 6: AR Hardware Usage

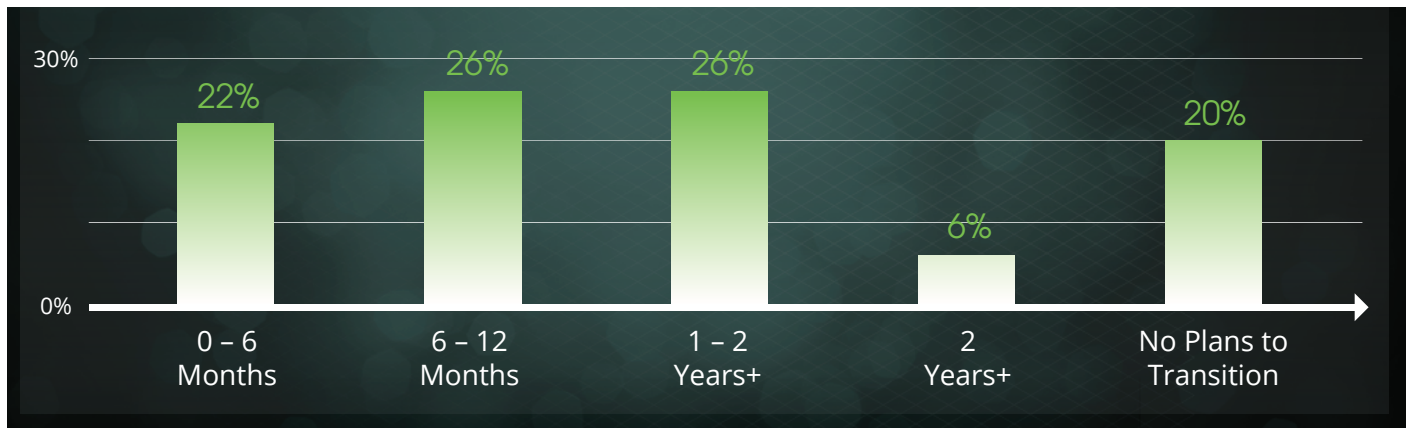


We believe constraints such as technology maturity and prohibitive costs are the main obstacles to widespread adoption. While use cases in service and manufacturing functions have been shown to provide the greatest potential for ROI, they are also dependent on the technician's hands being free to deliver value. Because of this, companies such as Microsoft, RealWear, Vuzix and Osterhout Design Group are investing significant resources into advancing digital glasses, focused on improving critical requirements such as battery life, connectivity, field of view, and interaction methods. Advances in these key technologies will drastically impact the current cost and usability issues associated with smart glasses.

When Are Companies Transitioning to Production?

As is often the case with emerging technologies, many AR projects are still in the proof-of-concept (POC) stage for most companies. However, 85% of those we surveyed had already completed or were on track to successfully complete their POCs and transition to a production environment. Forty-eight percent of these companies have plans to transition their pilots within the next 12 months, while an additional 26% will achieve this within two years (Figure 7).

Figure 7: Transition to Production



These transition plans signal a significant increase in the acceleration of AR adoption in the near future. There are two key factors driving this acceleration: The ability of POCs to demonstrate ROI, and the continued improvement of AR hardware. As AR pilots move towards production and early adopters begin to reap substantial efficiency and competitive advantages from their AR initiatives, companies will have no choice but to adopt the new technology. Simultaneously, the maturity of underlying hardware will increase the viability of AR use cases in industrial environments and lead to stronger, more valuable AR experiences. Combined, these two factors will help AR to reach its incredible potential.

Conclusion

For many of the companies surveyed for this analysis, AR is already becoming a critical component of their overall digital transformation. In fact, one respondent called AR a “survival strategy,” noting that adopting AR is not an option for his or her company. Another noted that current use cases are addressing how the respondent’s organization can increase sales revenue and accelerate the buying habits of its potential customers.

By incorporating AR into their strategy, companies are already profiting from improved service, better customer experiences and operations, and increased engineering and manufacturing quality.

As the technologies, business models, and appetite for AR technologies continue to mature, there are sure to be additional successes in the adoption of AR use case. Current trends indicate the following:

- ▶ Industries such as industrial products, automotive, and aerospace and defense are leading the way in early AR adoption.
- ▶ AR has broad applicability to all functions of the value chain, and especially service and manufacturing.
- ▶ The application of AR to serve as a powerful instruction and guidance tool is providing an entry point for many organizations, particularly those industries that are defined by hundreds of vital processes.
- ▶ AR adoption is reaching a critical tipping point, spurred on by massive investments into the underlying hardware and software technologies that are enabling a rapid transition of pilot projects into full production environments.

About PTC

PTC recognizes the transformative potential of AR and its potential to transform the way humans interact with their surroundings. For more information on how we help customers achieve the most out of their AR and IoT strategies, you can explore the following:

Learn how PTC is uniquely positioned, with our extensive investment in AR and IoT, to help customers truly unlock the value of the [Physical and Digital Convergence](#).

As part of the industry-leading ThingWorx IoT Platform, [ThingWorx Studio](#) is a powerful solution for building and publishing AR experiences for connected products. Explore how content creators can build experiences in just minutes, and take advantage of existing 3D assets created with leading CAD tools.

For more information about this research report, [contact PTC](#) to today.

© 2017, PTC Inc. (PTC). All rights reserved. Information described herein is furnished for informational use only, is subject to change without notice, and should not be taken as a guarantee, commitment, or offer by PTC. PTC, the PTC logo, and all PTC product names and logos are trademarks or registered trademarks of PTC and/or its subsidiaries in the United States and other countries. All other product or company names are property of their respective owners. The timing of any product release, including any features or functionality, is subject to change at PTC's discretion.

J10018-State-of-AR-WP-EN-1017

External Sources:

¹ <https://www.digi-capital.com/reports#augmented-virtual-reality>

² <https://www.abiresearch.com/market-research/product/1027207-augmented-and-mixed-reality-devices-and-en/>

³ <http://www.reportsnreports.com/reports/434857-augmented-reality-market-by-component-sensor-display-software-display-type-head-mounted-head-up-handheld-spatial-application-aerospace-defense-consumer-commercial-and-geography-global-forecast-to-2020.html>

⁴ [Gartner Top 10 Strategic Predictions](#)

⁵ <https://www.youtube.com/watch?v=UEyv5CVF0g0>

⁶ <http://newatlas.com/ikea-augmented-reality-catalog-app/28703/>

⁷ <https://techcrunch.com/2016/12/31/toymakers-are-the-early-adopters-pushing-ar-into-the-mainstream/>

⁸ <http://www.lowesinnovationlabs.com/tango/>

⁹ <https://www.automationworld.com/article/industry-type/all/caterpillars-augmented-reality>

¹⁰ <https://www.volkswagenag.com/en/news/stories/2017/03/how-volkswagen-is-developing-the-car-of-the-future-virtually.html>

¹¹ <https://www.recode.net/2015/6/8/11563374/boeing-says-augmented-reality-can-make-workers-better-faster>

¹² <https://www.fieldbit.net/resources/empowering-xeroxs-field-service-force-with-augmented-reality/>