AUGMENTED REALITY FOR MANUFACTURING: BRINGING DIGITAL TRANSFORMATION TO SKILLED WORKERS

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By implementing augmented reality (AR) solutions on the factory floor, manufacturers have established an entirely new avenue for improving the key performance indicators of manual assembly and maintenance operations.

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Executive Overview

The solutions that drive innovation in manufacturing are increasingly data-centric. In this age of digital transformation, value is established by creating and capturing data, deriving insights from data, or executing complex automated tasks based on data.

The engineering and business groups within many manufacturing enterprises are well along in their respective digital transformation journeys. But on the factory floor, manual manufacturing operations still typically rely on legacy tools and methods to capture information and share knowledge. As a result, most workers on the factory floor remain disconnected from the rich information ecosystem on which other functions in the enterprise have come to rely. By properly connecting these workers, organizations reduce manufacturing and maintenance errors while promoting efficiency and democratizing internal expertise. Furthermore, the risk of ignoring this information discontinuity grows as products become more complex and the workforce less experienced.

Companies can no longer rely on traditional hard copy or video work instructions and basic training and expect a highly efficient workforce. Nor can they rely on the memory and skill retention of their operators and technicians to handle the increasing complexity and variation of products and production lines. As the factory floor goes digital, the factory employees must go digital to keep pace.

Augmented reality (AR) has emerged as a powerful new tool to bridge the gap between the digital and real worlds for assemblers, operators, and technicians. By adopting AR solutions for employee training and guidance applications, manufacturing organizations empower their factory workers with information. This helps:

- Optimize asset and personnel performance
- Reduce costs
- Ensure product quality
- Increase on-time delivery

Modern Challenges for Manufacturers

Manufacturers today are encountering increasingly turbulent markets and shifting employee demographics. Companies that can overcome these types of obstacles will find themselves in a better position to succeed in their

industry. The common thread connecting the issues described below is information availability and communication.

Turbulent Markets: Complex Products Lead to Complex Operations

Customers are demanding new, innovative products with increased differentiation, shorter lead times, and better quality. While this is not a new trend, complexity is increasing at an unprecedented rate. Manufacturers can address the growing breadth and complexity of their portfolios by either building additional production lines or improving the availability, productivity, and flexibility of their established lines. The growing use of advanced manufacturing technology has thus far done little to address the burden on assemblers, operators, and technicians who are responsible for executing an increasing variety of tasks. The pace and precision of manual operations often suffer as a result.

In addition to operations becoming more complex, the operation centers themselves are becoming more geographically dispersed to better address unique regional demands. As a result, manufacturing companies must allocate their product and process experts across a global network of facilities and find better ways to share knowledge remotely.

Shifting Employee Demographics: An Eroding Industrial Workforce

As jobs become more complicated, the workforce itself is becoming a barrier to growth. The issue is twofold. First, many technically skilled workers are aging out of the workforce, taking invaluable experience and expertise with them into retirement. Correspondingly, their replacements; the emerging millennial workforce, third-party contractors, and retrained workers from other industries, lack experience and can be difficult to retain. To address this new labor dynamic, manufacturing organizations must implement modern training strategies. A parallel approach aimed at reducing the skill requirements of manufacturing jobs altogether will also be essential.

Empowering the Next-generation Connected Worker with Augmented Reality

Automation and analytics alone are insufficient to address the challenges of modern manufacturing. Operational efficiency has clear limits in the absence of innovations that address the human element of the factory. Companies can no longer expect traditional hard copy or video work instructions and basic, off-line training to be sufficient to develop a high-efficiency workforce. Nor can they rely on the memory and skill retention of their operators and technicians to handle the increasing complexity and variation of products and production lines. The future of factory floor communication will increasingly rely on augmented reality.

What is Augmented Reality?

The term "augmented reality" covers a broad spectrum of software applications and hardware devices that, when combined, provide users with digital information visually overlaid onto their immediate surroundings. This is accomplished with video-see-through technology (like a tablet or smartphone), or with optical-see-through technology (such as smart glasses). Using motion and position sensors, AR devices can determine the user's orientation in space and with that data, anchor the information it provides to a specific point in space, feature, or object. Unlike its sister technology, virtual reality (VR), AR does not occlude the user's view of the real world, making it well suited for applications in the field, plant, or on the factory floor where value is derived through real-world interactions and environmental awareness is essential. AR applications can provide users with information in many different formats, each tailored to the task at hand and the data being communicated.

Remote Assistance
Enables on-the-job training or assistance with on-demand expertise

3D visualization
Provides step-by-step guidance with environment contextualization

Diagnostics and real-time feedback
Enables data driven decision making

Workflows and engineering data
Provides role-based access to drawings, work-instructions, and other PDFs

Many innovative organizations are now well past proof-of-concepts and pilot projects and have moved to full-scale programs. Thanks to these efforts, the industry has come to acknowledge the value of AR to help improve key performance indicators across a wide variety of roles and tasks. Adoption has shifted into the mainstream, especially for applications in guided manual assembly and maintenance.

Guiding Manual Assembly with Augmented Reality Workflows

The capabilities of AR-based work instruction go far beyond those of static, hard-copy instructions. From a functional standpoint, several key elements differentiate AR work instructions:

- AR instructions can be delivered step-by-step in real time and in context.
- AR instructions can be presented as any combination of simple 2D and complex 3D digital assets.
- AR instructions can be viewed without shifting attention away from the workpiece.

Additionally, AR devices can be used to monitor assembly progress, provide real-time feedback and, in more advanced applications, incorporate automated inspection for quality control. Digital work instructions are perfectly preserved; unaffected by harsh factory environments; unaltered by unauthorized personnel; and remotely updated to implement new best practices, accommodate changes in product design, improve consistency across production lines, or address incoming or outgoing quality concerns.

Decrease Cycle Times
- Increase on-time delivery
- Increase capacity utilization

Reduce Rework and Scrap
- Decrease manufacturing cost per unit
- Increase labor utilization

Reduce Quality Spills/Non-Conformance
- Increase customer satisfaction
- Increase yield rates

With AR, work instructions evolve from simple, static reference materials created with little to no consideration for the user experience, to flexible workforce multipliers that can be designed ergonomically to achieve better performance regardless of the user's skill level. By switching to AR from document-based work instructions, manufacturing organizations are achieving faster throughput, reducing rework, and experiencing fewer quality issues.

Digital Transformation of the Maintenance Technician

AR is also proving to be a powerful tool for maintenance and service technicians. In a modern factory, a single asset can require dozens of maintenance procedures that involve hundreds of components and complex steps. For the most common and critical maintenance procedures it makes sense to create digital workflows. However, the growing number and complexity of manufacturing equipment make it impractical if not impossible to capture every procedure. For those cases, companies rely on AR to supply their technicians with work order information, asset diagnostics, video recording capabilities, and remote expert assistance.

With remote expert assistance a remote party can connect to the video feed of an AR device and provide the user with engineering data and digital annotations to guide him or her through a procedure. Manufacturing organizations are also creating libraries of recorded procedures that can be accessed and used on site by AR-wielding technicians. In some cases, companies have created mentor roles for experienced field or factory workers to provide remote expert assistance as an intermediate step between full-employment and retirement. These tools are effective at helping stem the loss of tribal knowledge and augmenting the skills of younger, less experienced employees. This enhances productivity and safety, reduces asset downtime, and increases first-time fix rates.

Democratize Tribal Knowledge
- **Accelerate onboarding**
- **Reduce effects of "brain-drain"**

Increase First Time Fix Rate
- **Increase asset uptime**
- **Reduce roll-outs**

Enhance Productivity and Safety
- **Increase customer satisfaction**
- **Increase yield rates**

Principals for Adopting Augmented Reality

As manufacturing operations become more complex, data connectivity, analytics, and automation will play increasingly important roles. However, to help empower the equally critical human assets, operations and maintenance people must also be digitally connected. It's becoming clear that AR technology will play a critical role in providing this connection for the modern factory worker. As Industrial IoT continues to grow, so too will the value of AR applications that tap into the rich world of connected assets and data.

As companies begin their research into how implementing AR programs could help them meet today's interrelated manufacturing and human challenges, they should keep these points in mind:

- **Pick the low-hanging fruit** – There are already many reproducible examples of successful AR implementations that require little time to develop. Remote expert applications, for example, are easy to set up and provide some of the greatest return on investment. Once a successful AR program is in place, organizations can then begin exploring niche or company-specific applications.

- **Leverage veteran experience** – With the right software, it can be surprisingly easy to create and publish AR content. However, content value is based on the knowledge it conveys, not the speed at which it's produced. It is therefore vital that AR programs recruit veteran experience from their manufacturing and maintenance operations to ensure content translates into effective tools once it reaches the factory floor.

- **Reuse digital assets** – With software development kits (SDKs) like PTC's Vuforia Studio, companies can reuse their digital assets coming from design engineering to quickly create 2D and 3D instructions and visual aids for the manufacturing and maintenance groups. With the proper tools, creating these guides should be simple and straightforward.

- **Focus on addressing complex, repetitive tasks** – AR is not necessary for every manual process in the factory. It is important to address complex tasks, since they require the most experience to execute efficiently and often contribute to quality issues. Generally, it is easier to develop AR applications for repetitive tasks since less variability needs to be accounted for.

- **Start small, but ensure scalability** – When launching a pilot project, companies should consider the resources that would be required to scale the solution to meet future needs regardless of the initial intent of the program. Seek AR authoring and publishing solutions designed with a focus on enterprise applications; it is generally easier to scale these down, than scale other applications up.

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