Augmented Reality (AR) Applications on the Factory Floor

Transforming Manufacturing with Augmented Intelligence

Third Edition

LightGuide

Contents

Factory of the Future

The past decade advanced Industry 4.0 at an unprecedented pace. Businesses are fast-tracking their digital transformation by incorporating technologies such as augmented reality (AR), artificial intelligence (AI), and robotics. **Rather than replacing human workers, these innovations are driving a broader shift toward augmented intelligence, technologies that enhance human capabilities and empower the workforce.** This evolution is having a disruptive impact on industrial production, bringing factories of the future into the present.

AR stands out as a leading transformative technology for manufacturers, creating a more skilled, efficient, productive, and connected workforce. Industries including automotive, aerospace, heavy equipment, electronics, and medical device manufacturing leverage AR to improve training, productivity, quality control, ergonomics, and safety. Augmented reality supports these goals by overlaying digital information onto the real world, providing workers with real-time AR work instructions and visual guidance.

Benefits of AR for Manufacturing

Training

Worker Productivity

Quality Control

Workplace Ergonomics

Worker Safety

Collaboration

Four in 10 manufacturers have already begun leveraging augmented or virtual reality devices, and that will only increase.

- Manufacturing Leadership Council

AR Empowers the Workforce of the Future

Augmented reality (AR) is transforming how we work, enhancing training, boosting productivity, and improving accuracy across the factory floor.

## Empowering Workers with Real-Time Visual Guidance

AR empowers workers by overlaying digital work instructions, diagrams, and real-time feedback directly onto their fields of view, guiding them step-by-step through complex tasks with adaptive instructions.

By eliminating the need for physical documentation, AR can replace paper manuals and instructions, streamlining workflows and saving time.

Improving Quality, Efficiency, and Productivity

AR guidance reduces the time it takes for workers to complete complex assembly, inspection, maintenance, and material handling tasks. Advanced AR systems that integrate with AI-powered machine vision systems can also verify each task is correctly completed before advancing to the next step.

Additionally, AR can collect data on worker performance and process efficiency, providing valuable insights for data-driven decision-making and process optimization.
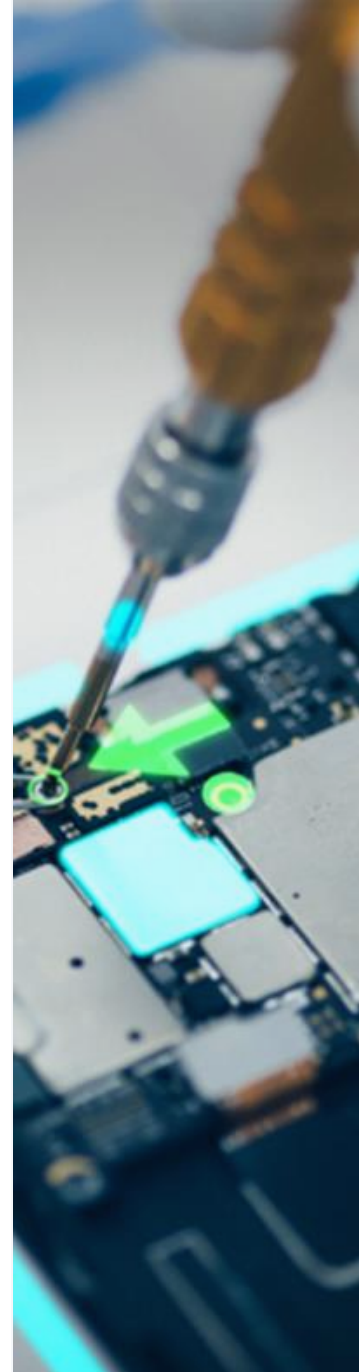
AR Empowers the Workforce of the Future

Enhancing Training and Development

AR can create immersive and interactive training experiences that help workers learn new skills more quickly and effectively. For example, AR can simulate real-world scenarios and provide workers with feedback on their performance.

Enabling Remote Collaboration and Support

AR fosters remote collaboration and support by enabling real-time communication and interaction between workers and remote experts. By bridging the gap between physical workspaces, guidance and troubleshooting is facilitated across distances.

Improving Safety and Compliance

AR enhances workplace safety and compliance by providing workers with real-time information and guidance. AR can alert workers to potential hazards, provide them with information on how to safely operate equipment, and track their compliance with safety procedures.

Improving Operational Scalability

The scalability, flexibility, and integration capabilities of AR systems make them a versatile solution for factories of all types and sizes. Some AR systems can even integrate with existing factory systems and equipment, including MES, PLC, IoT devices, machine vision cameras, 3D sensors, and torque tools.

*Working at its best, AR delivers
the right information (work instructions)
at the right place (in front of the worker)
and at the right time (one step at a time).*

How AR Is Transforming Manufacturing

Manufacturing leaders across industries are investing in intelligent AR solutions to create more agile, efficient, and productive operations. AR technology is empowering workers to achieve unprecedented levels of efficiency and quality.

AR technology manifests in three central forms, each offering unique capabilities and applications in manufacturing environments. Each of these delivers an immersive experience that enhances workforce potential.

Choosing the right type of AR for a particular application will maximize operational success. By carefully considering the specific needs and factory environment, manufacturers can harness the power of AR to transform their manufacturing processes.

Types of AR

01 **Mobile** Augmented Reality

02 **Wearable** Augmented Reality

03 **Projected** Augmented Reality

Mobile AR

Mobile AR technology combines tablets and other hand-held devices (like smartphones) to present augmented visual information through an application running on the device. The device's camera captures images from the real world, which are then enriched with virtual objects that convey enhanced information. AR applications on tablets and phones have been steadily gaining traction in various industries over the years.

Mobile AR Benefits

Accessibility

Tablet and smartphone-based AR systems are typically designed to be intuitive and easy to use, even for workers with limited technical expertise. Most people have experience using these devices in the consumer space, which helps expedite industrial adoption.

Affordability

Mobile AR solutions are relatively affordable and widely available, making them accessible to businesses of all sizes. Compared to more expensive industrial AR systems, tablet and smartphone-based AR offers a cost-effective entry point.

Scalability

Mobile AR solutions are often scalable, allowing manufacturers to expand their AR implementation as their needs evolve. This scalability ensures that businesses can leverage AR technology to support future growth and innovation.

Mobile AR Trade-Offs

Ergonomics and Worker Safety

Phones and tablets are made to fit in the palm of our hands. However, this can hinder productivity when a factory process requires both hands. Imagine trying to assemble a four-foot-long wire harness one-handed.

Prolonged use of tablets or smartphones for AR applications can also lead to ergonomic issues, such as neck strain and eye fatigue. The distraction of looking at a handheld device and away from the work process can become a safety hazard for operators.

Screen Size Limitations

Tablet and smartphone screens are modest compared to the field of view required for some industrial and manufacturing tasks. This limited screen size can make it difficult to view complex AR overlays or visualize large workspaces effectively.

Durability and Ruggedness

Tablets and smartphones are not typically designed to withstand the harsh environments of industrial and manufacturing settings. They may be susceptible to damage from dropping the device or environmental hazards, including dust, moisture, or extreme temperatures.
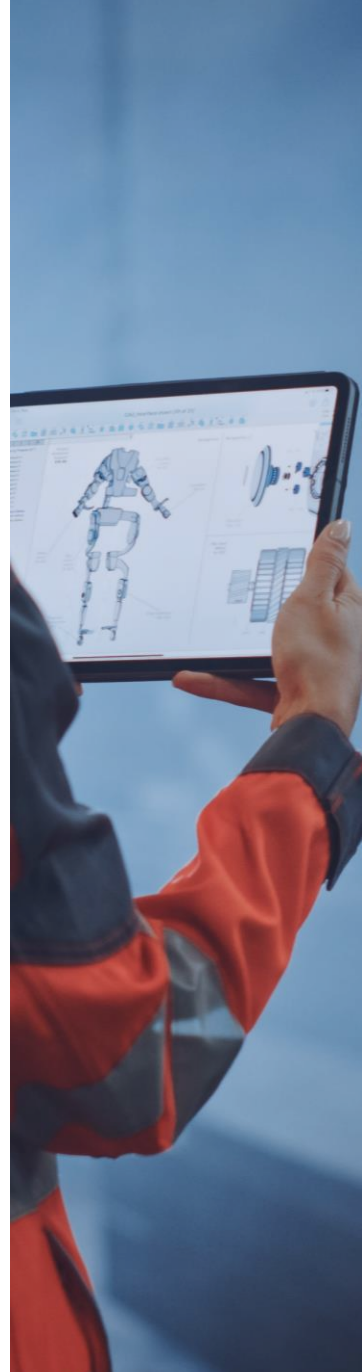
Mobile AR Trade-Offs

Security and Data Privacy

Tablets and smartphones may be more vulnerable to security breaches and data leaks compared to hard-wired AR devices. Implementing robust security measures is crucial to protect sensitive information and ensure compliance with data privacy regulations.

For manufacturers in highly confidential sectors, like aerospace and defense, a wireless Internet connection is often a security risk when transferring proprietary data.

Wireless Connectivity Requirements

Tablet and smartphone-based AR systems require a wireless Internet connection to operate effectively. Within industrial environments, this connection may be difficult to maintain. Furthermore, significant latency exists, slowing work down when these factories require instantaneous digital work instructions to run production.

👓 Wearable AR

Wearable AR technology seamlessly blends computer-generated images and text with your real-world vision through smart glasses or a headset. Popular wearable AR devices include Microsoft HoloLens, Meta Quest, and Apple Vision Pro, all of which serve as lightweight, hands-free computers for displaying and storing information.

Wearable AR Benefits

Hands-Free Operation

The first benefit of wearable AR is that it is hands-free, allowing workers to simultaneously view AR overlays and digital work instructions while having both hands available to perform required tasks.

Improved Accuracy and Precision

Wearable AR superimposes work instructions onto physical objects and workspaces, eliminating the need for workers to shift their gaze away from the work. This integration of instructions into the worker's field of view can result in reduced errors, improved quality, and enhanced precision in assembly and manufacturing tasks.

Remote Collaboration and Expert Assistance

Wearable AR can facilitate remote collaboration by enabling workers to share their field of view with experts or supervisors. This allows for real-time remote guidance, troubleshooting, and problem-solving, reducing downtime and improving overall efficiency.

Wearable AR Trade-Offs

Cost and Investment

Wearable AR devices are typically more expensive than tablet or smartphone-based AR solutions, requiring a higher initial investment. This cost can be a barrier for some businesses, especially smaller manufacturers.

Ergonomics and Operator Safety

Prolonged use of wearable AR devices can be associated with discomfort or ergonomic issues, such as eye strain, dizziness, nausea, or neck fatigue. Wearing an AR headset can obstruct the operator's vision and put them at risk of workplace hazards by distracting them from their immediate surroundings.

Field of View Limitations

The field of view for wearable AR devices is limited compared to the natural field of view, potentially restricting workers' ability to see their surroundings clearly. This can be a restriction in tasks that require a broad view of the workspace.

Wireless Connectivity Requirements

A wireless Internet connection is required to operate wearable AR devices effectively. This can create challenges within industrial environments where Internet latency or wireless connection issues exist.
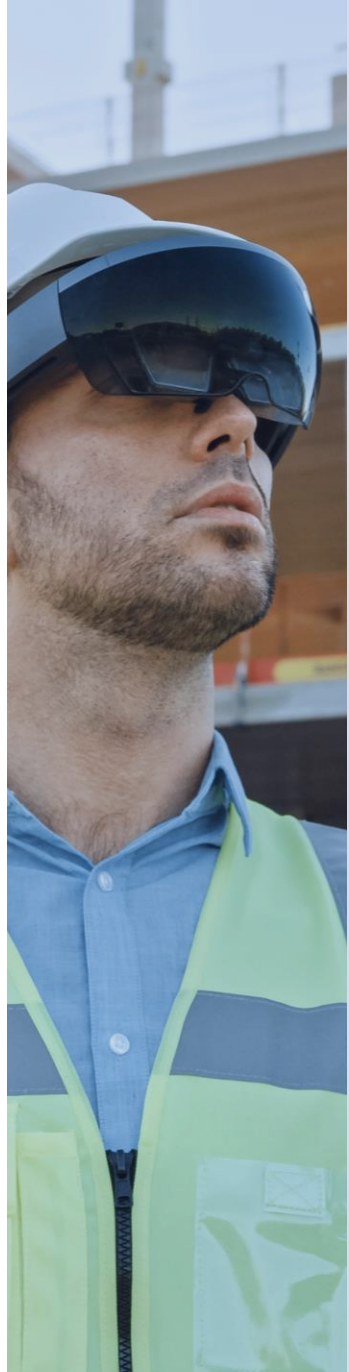
Wearable AR Trade-Offs

Security and Data Privacy

Wearable AR devices collect and transmit data about worker activities and surroundings. This raises concerns about data privacy and security, requiring robust measures to protect sensitive information and comply with data protection regulations. Manufacturers in highly confidential industries, like aerospace and defense, must address the security concerns of wireless data transmission.

Battery Life and Power Consumption

Wearable AR devices require batteries which can restrict their use in continuous operation scenarios. With a typical battery life between three to five hours, operators may need to stop and charge (or change out) batteries multiple times throughout a shift.

Lack of User Acceptance and Adoption

Some workers may be hesitant to adopt wearable AR due to concerns about wearing devices, potential privacy issues, or unfamiliarity with the technology. For sanitary reasons, workers may be reluctant to share wearable devices with other employees. Most manufacturers find the costs prohibitive to purchase individual AR headsets for every worker.
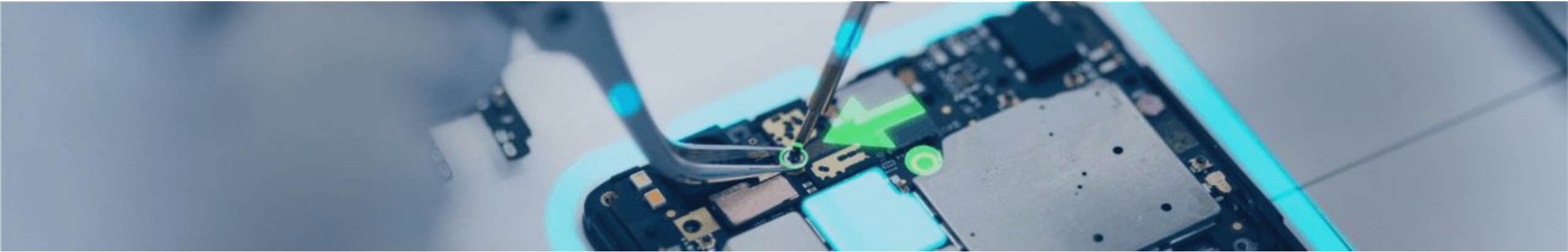
Projected AR

Projected augmented reality has emerged as a powerful tool for industrial applications, overlaying digital information like text, images, and videos onto real-world physical objects or surfaces. This creates a dynamic way of providing digital work instructions, warnings, or other information to workers in real time. Unlike other forms of AR, this technology is truly hands-free and requires no additional devices to be worn or carried by operators.

Projected AR Benefits

Hands-Free Operation

Projected AR does not require workers to hold or wear devices, allowing them to work without restrictions. This hands-free, wearable-device-free operation can enhance productivity and reduce fatigue.

Large Field of View and Enhanced Visualization

Projected AR seamlessly integrates digital information onto large work surfaces or physical objects, offering workers an expansive field of view compared to mobile and wearable AR solutions. This large-scale visualization fosters enhanced situational awareness and promotes collaboration among workers, enabling multiple people to view projected AR content simultaneously.

Projected AR Benefits

Secure Integration with Smart Manufacturing Systems

Projected AR platforms use EtherNet/IP to securely integrate with warehouse management systems, eliminating the need for wireless connectivity. This reliable link enables seamless interaction with existing software, cobots, and AI-driven machine vision, supporting real-time updates and data sharing. By capturing data from IoT and IIoT devices and connecting to AI-powered cloud platforms, projected AR transforms raw data into actionable insights for smarter decisions and continuous optimization.

Precision and Accuracy for Enhanced Quality

Projected AR can provide highly accurate overlays, aligning precisely with physical objects and workspaces. This precision is crucial for tasks requiring high levels of accuracy, such as assembly and inspection. The real-time instructions are concise, keep workers' eyes on their operation, and focus on the quality of each action. Coupled with 3D sensors and vision cameras, projected AR systems detect and prevent errors in real time while capturing data and insights on operators' performance and quality.

Always-On Reliability

Projected AR systems are durable, line-powered, and do not use batteries; they never require charging and support 24/7 factory environments. It is robust enough to operate in the toughest manufacturing environments, making it an industrial-grade solution suitable for dusty, noisy, or hazardous conditions.

Projected AR Trade-Offs

Fixed Placement Limits Mobility

Projected AR systems are typically installed in fixed locations and require a direct line of sight between the projector and the work surface. This can be a limitation if the work surface is obstructed, or the worker needs to move around frequently. Because the system is fixed and secured onto the workstation, it takes more time to redeploy in other areas of a factory. Unlike other portable forms of AR, projected AR is less suitable for use cases like field servicing that require workers to move freely around a factory.

Limited Familiarity

While projected AR's potential is undeniable, its widespread adoption in manufacturing settings has been hindered by a lack of awareness surrounding its numerous success stories. As a result, some manufacturers may have limited exposure to its implementation within their manufacturing settings.

Environmental Sensitivity and Ambient Light Interference

Ambient light must be considered when using projected AR and the 3D sensors and vision cameras often integrated into these platforms. Typically, specifying the right hardware to suit the ambient light conditions results in successful deployments. However, in some factory environments, additional steps may be required to optimize the light levels for this technology to work most effectively.

Summary of AR Technologies

Different applications of augmented reality on the factory floor deliver distinct operational outcomes.

Therefore, manufacturing leaders must carefully assess their unique needs, evaluate the potential benefits of each AR solution, and strategically invest in the AR technology that best aligns with their specific requirements.

Mobile AR

For general, short-term guidance needs, mobile AR is a strong option to integrate into operations for business of all sizes. It is an affordable and accessible AR system that is designed to be intuitive, easy to use, and mobile. However, mobile AR trade-offs include small screen size, limited battery life, and the operational risks due to the handheld nature of the devices. Another drawback is the requirement of a stable wireless Internet connection.

Wearable AR

Enhanced mobility coupled with hands-free access to work information displayed in a worker's field of view are two strengths of wearable AR. Mobile operations, like warehousing, maintenance, and field servicing, are well suited to wearable AR. The trade-offs of wearable AR include the need for a reliable wireless Internet connection and limited battery life. Other drawbacks include safety concerns with a device that may impede the operator's vision and ergonomic issues that reduce user acceptance and adoption.

Projected AR

Projected AR is well-suited for a wide-range of industrial applications where precise hands-free digital work instructions are needed, such as assembly, part picking and kitting, testing and inspection, and training. It can project accurate AR guidance onto large work surfaces or physical objects, while detecting and preventing errors with 3D sensors and AI-powered vision cameras. Projected AR integrates seamlessly into demanding 24/7 manufacturing environments without the need for batteries or wireless connectivity. One drawback of this technology is limited mobility due to the fixed placement of the system.

[*AR is not only part of the next generation of Industry 4.0, but it is changing manufacturing entirely.*]

- Forbes

AR Technologies Comparison

Poor ○ ◐ ● Strong

| Requirement	Mobile AR	Wearable AR	Projected AR
Awareness of Technology	●	●	◐
Augments Real-World with Visual Information	●	●	●
Hands-Free Operation	○	●	●
Ergonomic	○	○	●
Always-On Capability (Battery-Free)	○	○	●
Remote Collaboration	●	●	◐
Enhanced Cybersecurity	○	○	●
Industry 4.0 Factory Integration	◐	◐	●
Worker Safety	◐	◐	●
Unrestricted Field of View	◐	◐	●
Durability and Ruggedness	○	◐	●
ROI	○	◐	●

Projected Augmented Reality: Shaping the Future of Manufacturing

Imagine step-by-step manufacturing instructions seamlessly projected onto the work surface, guiding operators with precision and clarity. Envision these digital work instructions adapting in real time, synchronized with the operator's every move.

Advanced 3D sensors and AI-powered vision cameras detect errors as they occur, preventing defects and ensuring unwavering quality control. Simultaneously, operational metrics are captured throughout the manufacturing process, enabling comprehensive digital traceability.

This is not a distant vision of the future; it is a reality made possible by LightGuide's projected AR work instruction platform.

LightGuide is revolutionizing the manufacturing landscape, empowering workforces, and helping companies across industries gain a competitive edge and measurable results.
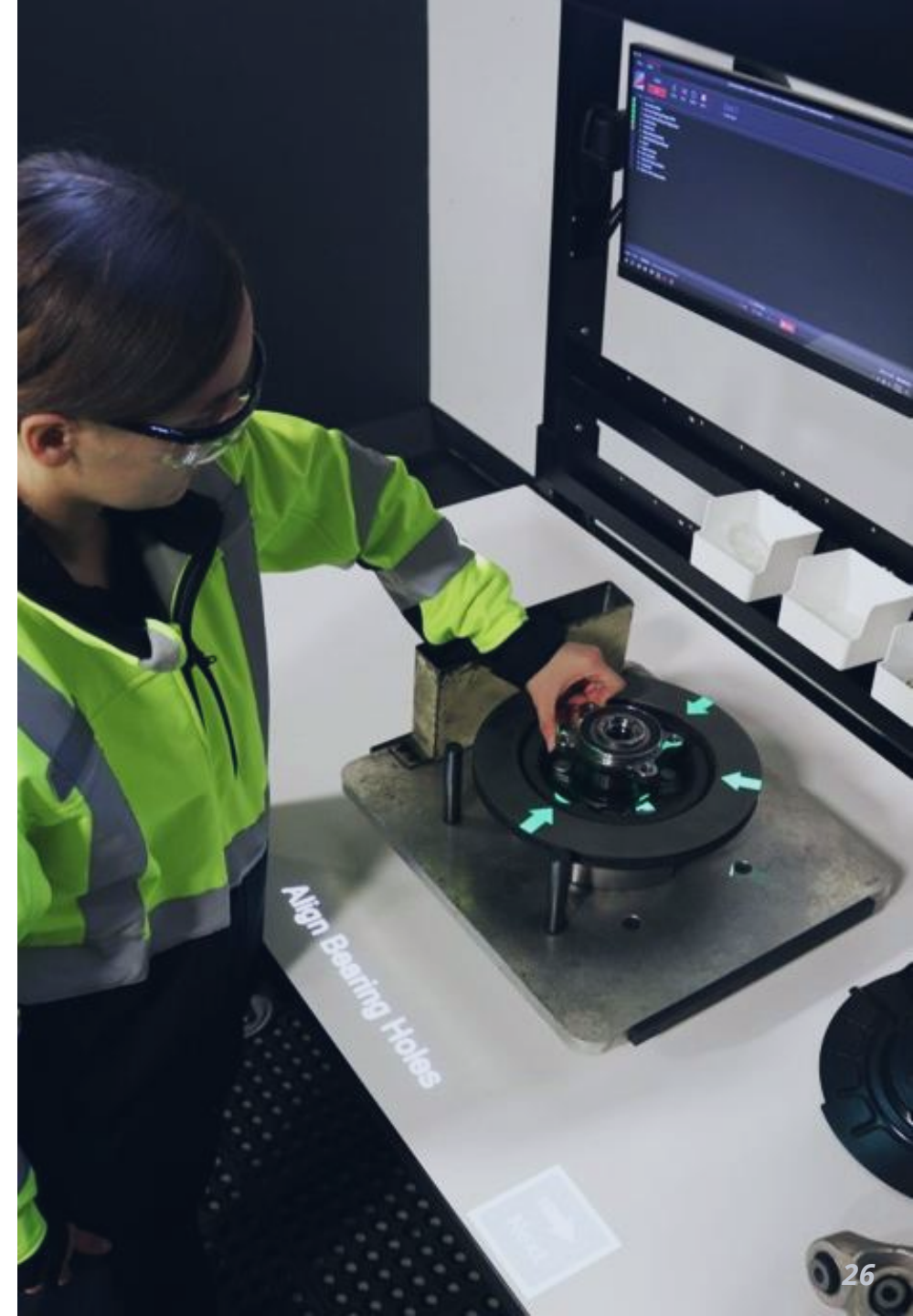
Projected Augmented Reality Enhanced by AI

LightGuide is leading the way in augmented intelligence, seamlessly combining AR-powered visualization and AI-enabled insights to enhance workforce productivity. Our AI tools adapt workflows in real time, while projected AR guidance ensures precision at every step.

AI Vision Systems: LightGuide integrates with industry-leading AI-powered vision solutions from Cognex, Keyence and many others, ensuring real-time quality control and automated error detection.

AI-Powered Analytics: LightGuide seamlessly collects data from IoT and IIoT-connected devices, integrating it with AI-enabled cloud platforms like Siemens, AWS, Microsoft Azure and Google Cloud.

Data Hygiene Tools for AI Model Creation: LightGuide's built-in data record manager ensures clean, structured datasets, helping you build better AI models to drive continuous improvement.

Adaptive Workflows: LightGuide's intelligent platform dynamically adapts to each operator's skill level and real-time workflow, delivering step-by-step guidance tailored to their needs.
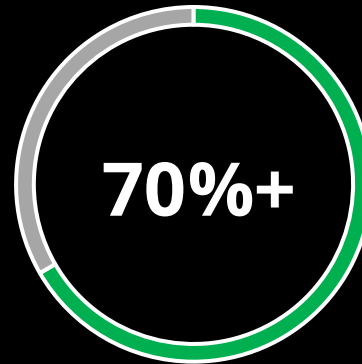
LightGuide AR Delivers Proven Results

Deployed across aerospace and defense, automotive, electronics, and diverse manufacturing customers in 36 countries worldwide, LightGuide is a practical and proven digital work instruction platform delivering value.

90%+
Quality
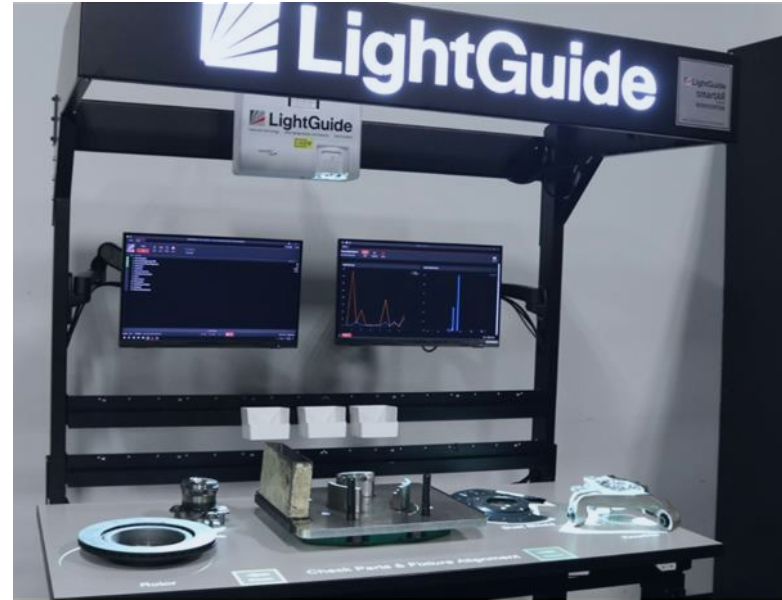Improvement

70%+
Training
Efficiency

50%+
Productivity
Increase

AR Work Instructions for Every Application

LightGuide smartAR™ Desktop

The smartAR Desktop is an all-in-one system for AR work instructions, training, and more.

LightGuide smartAR™ Workstation

The smartAR Workstation is an industrial-grade AR system for error-free assembly, inspection, and training.

LightGuide smartAR™ Workcell

The smartAR Workcell is a scalable platform supporting the largest and most complex manual industrial applications.

Real-World Examples of Augmented Reality in Manufacturing

Numerous case studies demonstrate the transformative impact of LightGuide's AI-optimized augmented reality on manufacturing. To illustrate how AR empowers the connected worker, consider several examples from diverse industries.

Install Rotor

Automotive Manufacturer Adopts AR Work Instructions for Error-Free EV Assembly

Lightning eMotors uses AR to assemble battery-electric vans, trucks, and buses. Using LightGuide's projected AR work instructions to standardize and streamline assembly workflows, the company has improved quality, efficiency, and safety.

AR instructions guide connected workers through complex assembly tasks in real time, ending the need to memorize procedures and reducing errors.
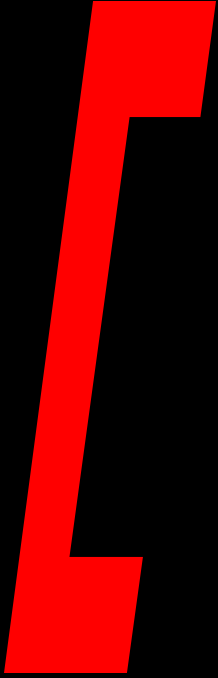
>50%

Decrease in Training Time

>75%

Decrease in Cycle Time

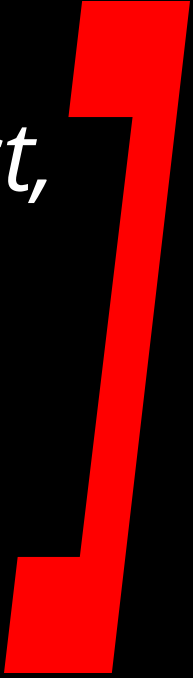**Read Full Case Study ➡**

[LightGuide] puts work instructions exactly where you build your product, so you're reducing time looking at printed instructions by putting the focus exactly where operators' attention should be.

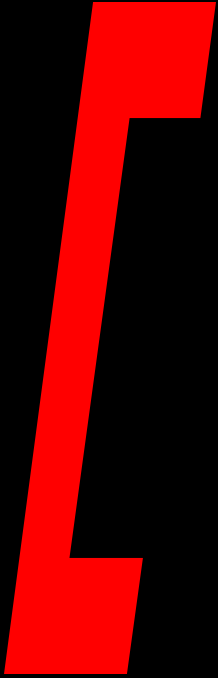**- Senior Process and Manufacturing Engineer, Lightning eMotors**

Leading Aerospace Manufacturer Eliminates Defects with AR Technology

L3Harris Technologies, an aerospace and defense manufacturer, implemented LightGuide's AR software to standardize digital work instructions and reduce the cognitive load on workers. The system also uses 3D and infrared sensors to track the operator's hand position and provide real-time feedback on their progress.
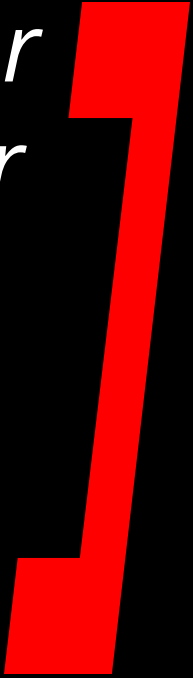
As a result of implementing LightGuide, L3Harris has been able to eliminate assembly-related defects and make better, data-driven decisions. The company has also been able to streamline its processes and reduce the cognitive load on its workers. For example, **on a line with 17 variants of one product, LightGuide helped to consolidate parts and eliminate changeover per variant. This resulted in zero assembly-related defects.**

Read Full Case Study ➡

33

LightGuide has been a great asset for us, they've helped us understand our process better, and even help streamline it by asking the right questions about our order of operations.

- L3Harris Engineering Manager

Tech Insurance Company Transforms Electronics Repair Processes with AR

With an annual repair volume exceeding 4 million devices, this leading tech insurance company was facing significant challenges in repairing and supporting consumer electronics. The company's technicians were struggling to keep up with the latest device models and repair procedures, which was leading to errors and delays.

To address these challenges, **the company implemented LightGuide to overlay virtual repair guides with step-by-step instructions directly onto physical devices**, enabling technicians to complete repairs quickly and accurately regardless of their experience level. Integrations with sensors and vision cameras provided an additional layer of quality control. Real-time analytics enhanced traceability and provided valuable insights into operational performance.

Read Full Case Study ➡

Our Mission:

LightGuide empowers people to build a brighter tomorrow.

We are creating a future in which frontline workers reach their maximum potential, enabled by augmented intelligence.

LightGuide

About LightGuide

LightGuide is the leading AI-optimized projected augmented reality work instruction software platform that transforms manual manufacturing processes for companies worldwide. By directly projecting step-by-step digital work instructions onto the "operating canvas," LightGuide creates an immersive, interactive work experience that optimizes human operator performance and efficiency. Coupled with cutting-edge 3D sensors and AI-powered vision cameras, the system detects and prevents errors in real time, ensuring no-fault forward quality control. LightGuide's ability to capture live operational metrics enables full digital traceability for even the most complex manufacturing processes.

Today, LightGuide partners with numerous industry leaders in automotive, aerospace & defense, electronics, and diverse manufacturing industries. Headquartered in Wixom, MI, LightGuide maintains an EU office in Czechia and a sales office in Suzhou, China. The LightGuide AR software platform has been successfully deployed in 36 countries worldwide.

Connect with Us

lightguidesys.com

LinkedIn

YouTube

Are you ready to see how AI-optimized AR work instructions can help you improve your manufacturing operations?

Schedule a personalized demo to explore how LightGuide can be used in your specific industry and application.

Schedule a Demo ➡