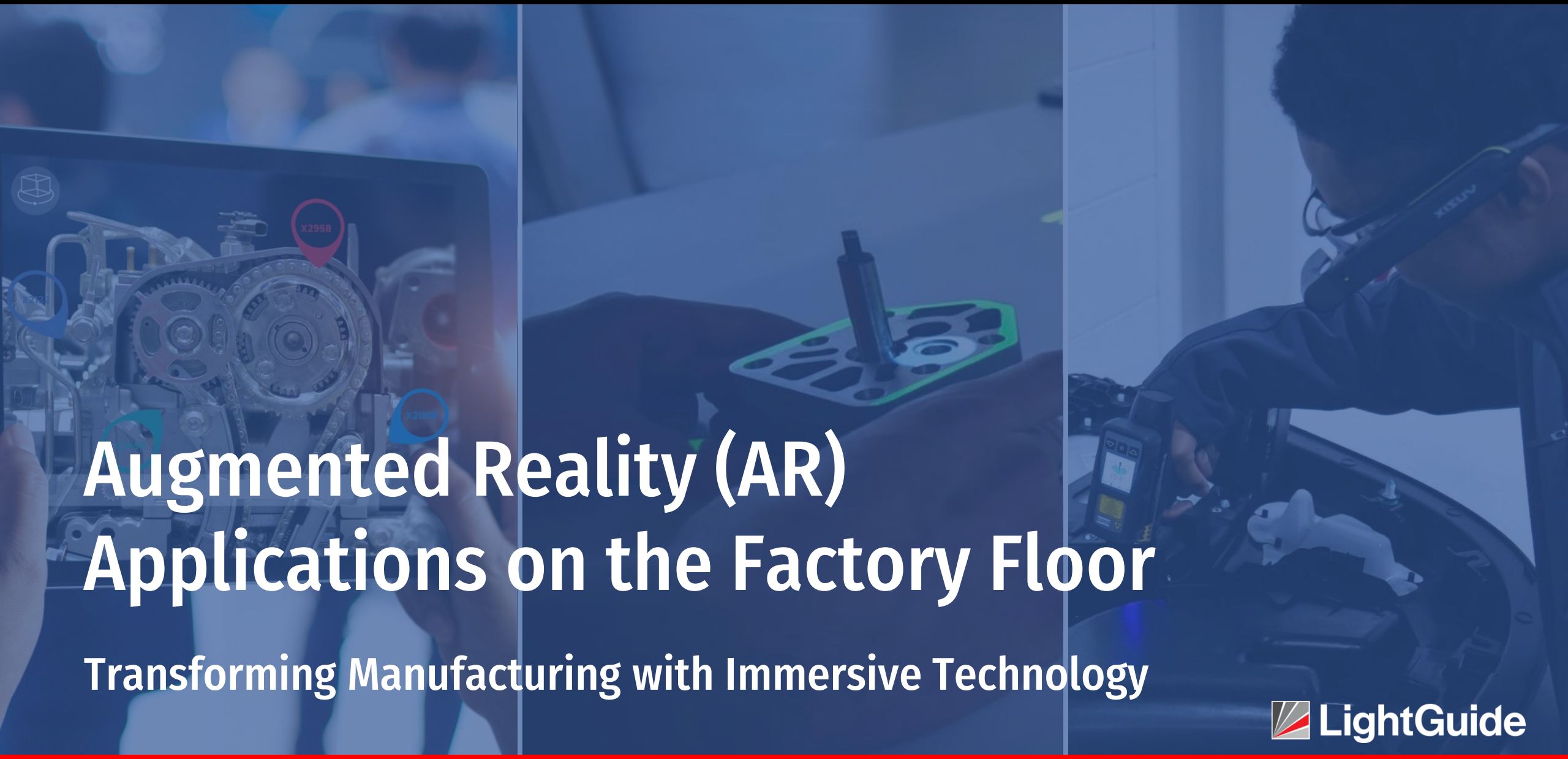


# Augmented Reality (AR) Applications on the Factory Floor

## Transforming Manufacturing with Immersive Technology

LightGuide

# Factory of the Future

The past year advanced Industry 4.0 in ways that no one could have imagined. Businesses are fast-tracking their digital transformation, bringing in innovative new technologies to enhance their factories and catch up with the changing times. These new technologies are profoundly changing industrial production, as business brings the factory of the future into the present.

Augmented reality (AR) stands out as a leading transformative technology among the manufacturers' innovations. From automotive to aerospace, heavy equipment to electronics, and even medical device manufacturing, AR has broad applications across a wide variety of industries. Every manufacturer looks to enhance their quality, throughput, and training effectiveness, which is exactly what AR does without the need for paper or monitor-based work instructions.

*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)*

# Factory of the Future

## Types of AR

Manufacturing leaders in every industry are investing in AR-based digital transformations and creating more agile operations.

Currently, there are three main types of AR being used to support manufacturing and assembly operations.

Each of these delivers an immersive experience that enhances operations. But based on a factory's environment and needs, knowing which type of AR best matches an application will lead to the most operational success.

01

### Tablet-Based

Augmented Reality

02

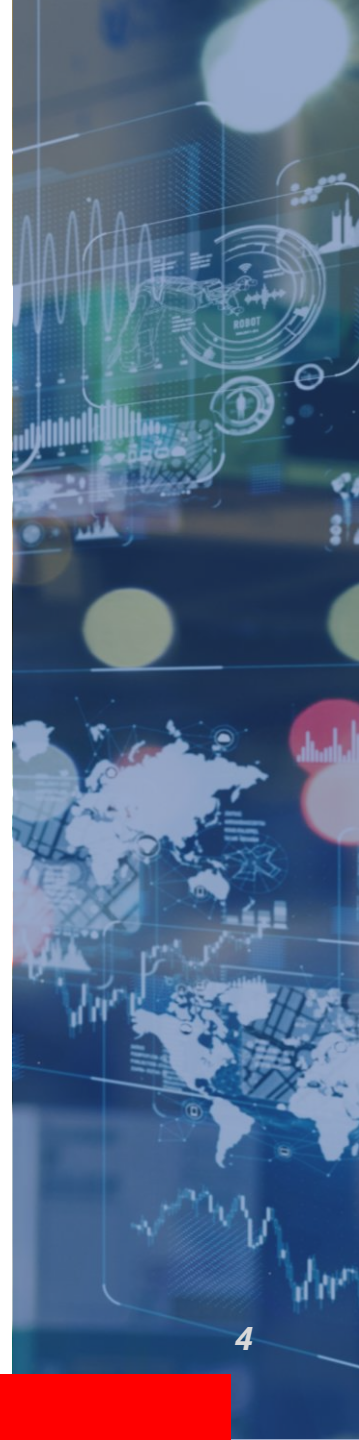
### Wearable

Augmented Reality

03

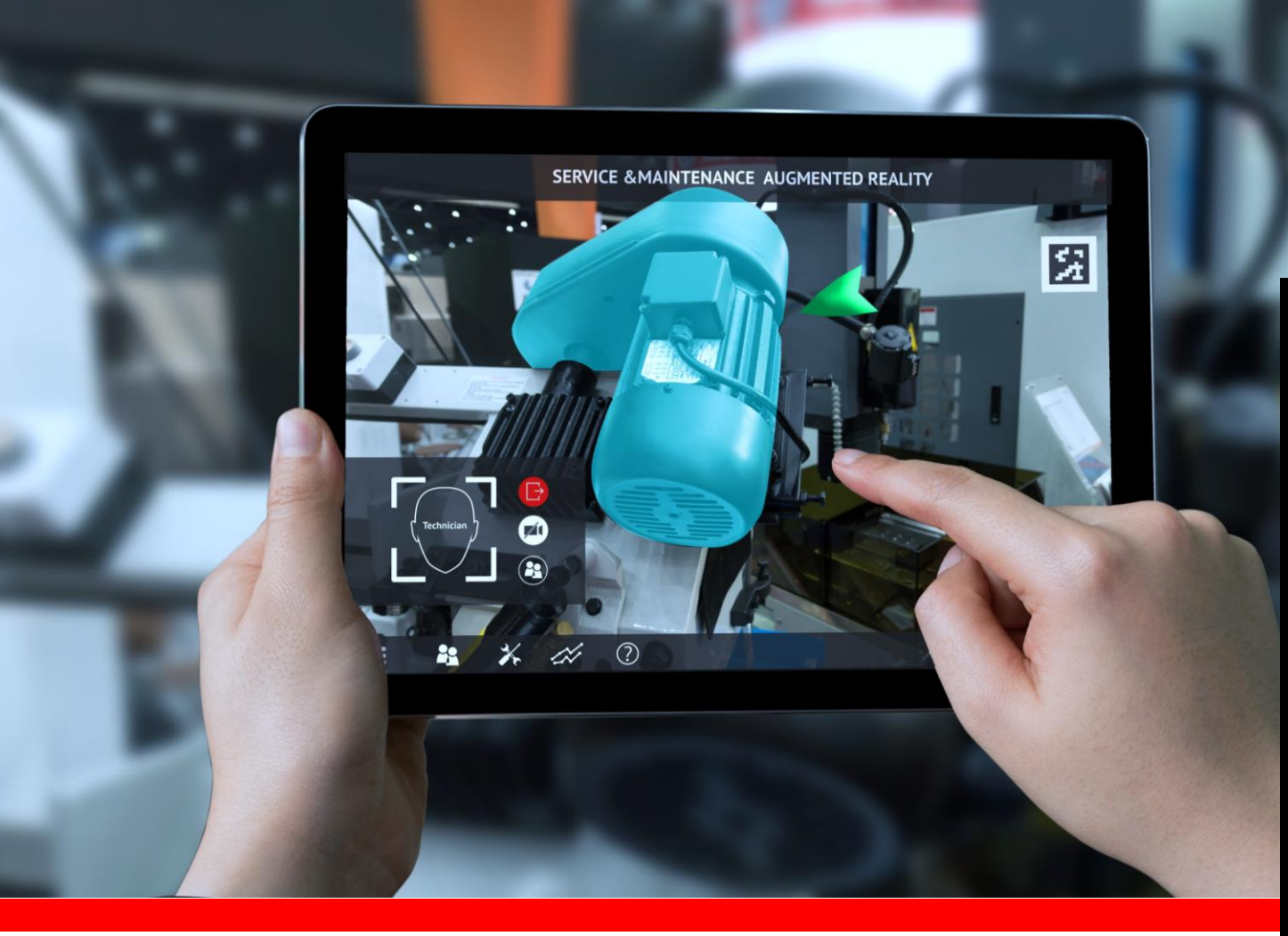
### Projection-Based

Augmented Reality



*By 2025, it's estimated that industrial AR will reach a market value of $70 billion.*

***- PR Newswire***




# Tablet-Based AR

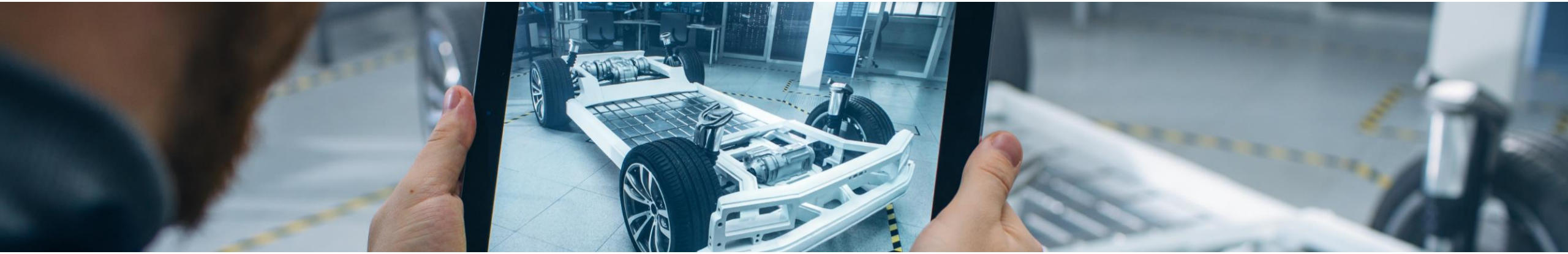
Tablet-based AR technology is a combination of tablets and other hand-held devices (like smartphones) that present work instructions through AR apps.

Most people are aware of the AR applications on social media, like Snapchat filters. However, tablets and phones have made their way into industry more and more over the past few years.

## Benefits

The easiest-to-use form of AR, tablet-based AR reduces start-up time and training through its simplicity and familiarity.

# Tablet-Based AR Benefits



## Setup

Setting up operations with a tablet only requires downloading an AR app. This makes it quick to get up and running within a few hours, if not minutes.

## Accessibility

And as most people know how to use a tablet, this type of AR doesn't have a technological skills gap. People can pick up the device and begin using it automatically—because they already have experience with these devices in the consumer space.

# Tablet-Based AR

## Trade-Offs

However, there are some trade-offs. The simplicity and familiarity of tablets are paired with size and scalability limitations, as well as worker engagement issues.

Phones and tablets were made to fit in the palm of our hands. That's part of the appeal. However, the size and mobility can be a disadvantage when a factory process requires the use of both hands. Imagine trying to assemble a four-foot-long wire harness one-handed.

Tablets also require battery power and a wireless Internet connection to operate. Charging a device holds up operations and decreases production time. If one worker finishes their shift and plugs in the tablet, charging could delay the use of that tablet during the next shift, potentially by hours.

And for manufacturers in highly confidential sectors, like aerospace and defense, a wireless Wi-Fi connection is often a security threat when proprietary data is transferred wirelessly rather than through hard-wired connections. Furthermore, significant latency exists, slowing work down when these factories require instantaneous work instructions to run production.

# Tablet-Based AR

## Trade-Offs

How people interact physically with tablets and phones has a huge impact on their ability to operate them successfully.

Research has shown that staring at a screen for long periods can affect our eyesight. The Eye Center of Texas research confirms this.

*2 out of 3 Americans will experience eye strain caused by excessive phone use.*

*The average person looks at their smartphone 150 times per day*

And that's just the eye strain incurred in our personal lives. When pairing that with a full day of looking at a small tablet screen in the workplace, the problem is amplified.

Along with that, spending time looking at a tablet draws focus away from the actual work surface. Work becomes less efficient, causing bottlenecks in productivity and potentially leading to more quality issues.

All of this sways the decision to use tablets full-time. But that doesn't mean they don't have a place in a factory.

# Tablet-Based AR

## Summary

Overall, tablets are an affordable method of bringing augmented reality into a factory. However, their affordability rarely outweighs their challenges. They require time to charge and have operational risks for safety and productivity. With that, how do you determine the best applications for tablet-based AR?

- In short, tablet-based AR should be used for applications that need **general guidance and short bursts of information** when instantaneous work instructions are not a requirement and delays are acceptable**.**
- **Limited use applications,** such as referencing a service manual during a maintenance event, are optimal because less time is spent looking at a tablet, lowering the risks.
- **A short, simple set of work instructions in a low variation operation** is the best opportunity for operational success with tablet-based AR as they can deliver the right information, but not necessarily at the right place and right time.

## Wearable AR

Wearable AR technology projects an overlay of graphics onto the environment around you through glasses or a headset.

Most people are familiar with wearables like Google Glass and Microsoft HoloLens. These act as lightweight, hands-free computers to display and store information.

## Benefits

Compared to tablet-based AR, wearable technology is a popular choice in factories due to its mobility and dynamic graphics.

# Wearable AR Benefits

## Hands-Free

The first benefit of wearables over tablets is that they are hands-free. Workers increase their productivity by simultaneously viewing work instructions while having both hands available to perform the work required.

## Right Place

This directly affects the second benefit; wearables move work instructions closer to the operation. They put information closer to where you need to see it rather than needing to look back and forth between a tablet or monitor and a workstation. Therefore, a worker does not need to look away from their work and completes it faster and with fewer errors.

# Wearable AR

## Trade-Offs

On the other hand, wearables have many of the same issues as tablets—and they occur more often.

Like tablets, wearables require battery power and Internet connection. The same issues occur, where the time needed to charge the technology takes away from overall efficiency. Typical battery life is three to four hours. In many cases, you need to stop and charge (or change out) batteries multiple times throughout a shift. They also require a connection to a Wi-Fi network and create the same security risks, and latency challenges, as tablets.

Wearables generally have more powerful chipsets than tablets and can process more complex software. However, this creates another potential source of information delays. This is especially challenging in high-volume operations, where processing large amounts of information can be hindered by a slow wireless connection and data bottlenecks.

Between the amount of time needed to charge wearables and delays in information, hours of wearable downtime could be lost in every shift.

From a safety standpoint, wearables can easily obstruct the operator's vision and put them at risk of workplace hazards. They have been known to cause users to feel dizzy or nauseous. Like tablets, the smaller digital screen strains workers' eyes and is not designed for prolonged use.

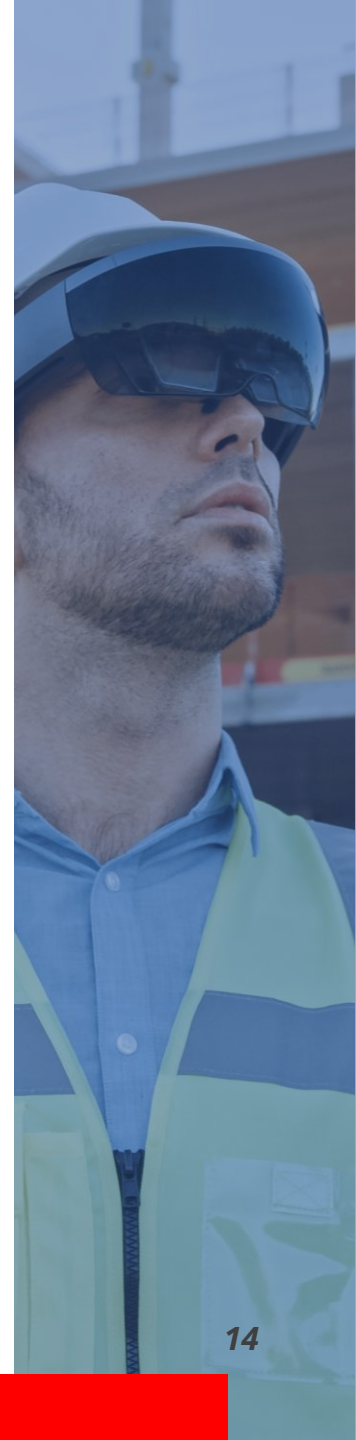
On top of all that, there could be issues with workers using the wearables at all. In the age of COVID-19, health concerns are more prevalent than ever. Many people are cautious of what they touch after someone else uses it. On the factory floor, this could appear as a worker on shift two not wanting to use the same headset as a worker from shift one. And it would be cost prohibitive to purchase individual headsets for every worker.

# Wearable AR

## Summary

With all of this in mind, it is important to understand the industrial applications that are a good fit for wearable AR technology. Enhanced mobility coupled with hands free access to work information that is displayed in a worker's field of view are two strengths of wearable AR. Some forms of wearable AR allow operators to take photos and videos, including a "See What I See" capability that facilitates live remote assistance between employees.

- Overall, wearables are best used in **field servicing, mobile warehousing, and maintenance applications.**
- These applications usually do not communicate a lot of proprietary information and they are one of the most reliable options to **serve the mobility and remote guidance needed** as wearables can deliver the right information at the right place, but not necessarily at the right time.
- **Interactive, immersive, AR-enhanced training** is another use case well-suited to wearable AR.




## Benefits

Projector-based augmented reality uses advanced projection technology and vision sensors to overlay a virtual operating “canvas” onto any work environment, and guides operators through a series of audio and visual prompts.

## Projection-Based AR

Projected AR uses a combination of projectors and vision sensors to display virtual step-by-step interactive graphics onto any work surface. For over 10 years, projected AR has delivered proven results for leading manufacturers around the world in automotive, aerospace, electronics, heavy equipment, diverse manufacturing, food and beverage, and medical vertical markets. It is usable across a wide range of manufacturing solutions, including assembly, part picking and kitting, testing and inspection, training, and maintenance.

# Projection-Based AR Benefits

## Visualization

By projecting graphics, animations, videos, text, and even adding audio prompts (among many other indicators), precise work instructions appear directly onto the fixture or part being assembled, and only one step at a time. Therefore, the instructions are concise, keep workers' eyes on their operation, and focus on the quality of each action. All of these factors increase safety, cognitive capacity, and overall operational performance.

## Error-Prevention

One of the unique features of projected AR software is enhanced "no-faults forward" error prevention. Instead of only detecting errors after they have already occurred, the software prevents errors by guiding workers throughout the process with confirmation for key steps that the work was performed correctly.

## Reliability

Finally, projection-based AR hardware is extremely durable and flexible to run in 24/7 manufacturing operations without the need to charge batteries or rely on wireless connectivity. Projected AR hardware integrates within new or existing production cells and is easily re-deployable around the factory. It is robust enough to operate in the toughest manufacturing environments, making it ideal for even the most challenging applications.

# Projection-Based AR

## Trade-Offs

The main concern with projection-based AR is that it is not yet a well-known technology. Therefore, manufacturers question its reliability and impact. In actuality, projection-based AR is already in use across 1,000s of systems worldwide and is proven to deliver the highest value for manufacturing operations.

Whereas commercials for tablets and wearables show off apps and graphics that are edited to simulate what is seen by the end-user, projection-based AR shows the exact user experience. The projector functions in any environment to display visuals. Demonstrations of this technology mimic exact manufacturing scenarios.

Another perceived drawback of projection-based AR is limited mobility. Because the system is fixed and secured onto the workstation, it takes more time to redeploy in other areas of a factory. This can also be used as an advantage, as there is no risk of a worker moving around or being distracted and placing themselves into unsafe situations.

# Projection-Based AR

## Summary

Projection-based augmented reality is the one type of AR that provides instantaneous, full-time operational guidance. Among its software and hardware benefits: intuitive, interactive instructions, placing the right information in the right place and at the right time, durability, scalability, and security.

Implementing systems that create more worker engagement and empowerment can reinforce and even enhance a positive company culture. More accommodating work creates more worker satisfaction. And, as projected work instruction guidance alleviates stress, more time is spent thinking about the process and engaging with the work.

This new mindfulness can cause workers to think of new solutions and enhancements to operations.

- When combined with the ability to capture and communicate real-time data and analytics, these new capabilities delivered by projection-based AR **increase the agility of the business**, propelling it into the future.
- Even the toughest manufacturing environments use projection-based AR, **running operations 24/7 with no latency**.
- Projection-based AR **prevents errors before they occur** with “no fault-forward” guidance that confirms work instruction steps were completed correctly.

# Summary of AR Technologies

Altogether, it is simply stated that different applications of AR on the factory floor enable different results in operations. That is why it is extremely important that manufacturing leaders consider their needs before investing in a given form factor of AR.

## Tablet

For general, short-term guidance needs, tablet-based AR is the best option to integrate into operations. It is an affordable option that is easy to use because of its applications in the consumer world as well as the industrial world. However, it is important to consider the scale of an operation and if use time or the need to be hand-held will hinder production.

## Wearable

Mobile operations, like warehousing and field servicing, are best suited to wearable AR. The necessity to move work instructions quickly to different areas increases efficiency, putting the instructions closer to the operation and making the instructions hands-free. But, like tablet-based AR, manufacturers' knowledge of their application will determine if a disruptive Internet connection, lengthy charging times, or safety concerns will adversely affect their operations.

## Projection

Projection-based AR is ideal for nearly every combination of high mix/low mix and high volume/low volume operations across most industries and applications. Because projection-based AR keeps the work instructions directly on the work surface and delivers them at precisely the right time, previously complex operations become simple and intuitive even at high levels of variation. While projection-based AR is not yet a well-known technology, its versatility provides a practical advantage for manufacturing applications.

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

***- Forbes***

# AR Technologies Comparison

| Requirement | Tablet-based AR | Wearable AR | Projection-based AR |
|---|---|---|---|
| Awareness of this Technology | ● | ◑ | ○ |
| Hands Free | ○ | ● | ● |
| Right Information, Right Place, Right Time | ○ | ◑ | ● |
| Visual Layered Audit Capability for Manufacturing | ○ | ○ | ● |
| Proven Technology Delivering 24/7 Manufacturing Results | ○ | ○ | ● |
| Always On/No Battery/No Wireless Internet Required | ○ | ○ | ● |
| Enhanced Cyber Security | ○ | ○ | ● |
| Industry 4.0 Factory Capable without Latency | ○ | ○ | ● |
| Maximized Safety on Factory Floor | ○ | ○ | ● |

**Poor** ○ ◑ ● **Strong**

# The Future of AR

As manufacturers invest in Industry 4.0 technology, it is important to keep in mind their current and future operational needs. Again, PR Newswire estimates that industrial augmented reality will reach a market value of $70 billion by 2025. Forbes states that AR is not only part of the next generation of Industry 4.0, but that it is changing manufacturing entirely. With this in mind, it's clear that strategic implementation of AR technology is absolutely necessary to the future of industry.

## About LightGuide

LightGuide is the leading projected augmented reality (AR) software platform that transforms manual assembly and manufacturing processes for companies worldwide.

Today, LightGuide works with a variety of leading automotive, aerospace & defense, electronics, food and beverage, diverse manufacturing, and healthcare companies to solve a growing variety of challenges.

LightGuide is headquartered in Wixom, Michigan,  with an EU office in the Czech Republic and an AP office in Suzhou, China. LightGuide systems are currently running in 34 countries worldwide.

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