

Revolutionizing On-site Operations by Overlaying Actual Objects with AR/MR Technology to Dramatically Improve Efficiency and Quality



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In recent years, head-mounted display devices utilizing augmented reality (AR) and mixed reality (MR), technologies that can superimpose virtual information over real space, have made rapid progress toward practical use in various industrial fields. Mitsubishi Heavy Industries, Ltd. has been promoting the development of technologies that can superimpose 3D models over actual large products or complex structures, such as aircraft, ships, and plants, with high accuracy, as well as user interface technologies suitable for on-site operations. In addition, MHI is working on standardizing and platformizing AR/MR environments, aiming to apply and expand these technologies to various products. This report presents two application examples utilizing these technologies: marking work for chill placement on mold patterns, and operations to determine the weight and center of gravity of ships. It also describes how these contribute to improved efficiency and quality of on-site operations.

1. Introduction

In recent years, the practical application of head-mounted display devices utilizing augmented reality (hereinafter referred to as AR) and mixed reality (hereinafter referred to as MR), technologies that can superimpose virtual information over real space, has made rapid progress toward practical use. Application of these technologies has been rapidly expanding into various industrial fields including manufacturing, construction, and inspection. Mitsubishi Heavy Industries, Ltd. (hereinafter referred to as MHI) has adopted the AR/MR device Magic Leap 2, manufactured by Magic Leap, Inc., as a primary device, and has continued to work on the development of technologies that can superimpose 3D models over actual large products or complex structures, such as aircraft, ships, and plants, with high accuracy, as well as user interface technologies that support on-site assembly and inspection operations.

Instructions regarding operations and inspections for large products and structures, including marking positions, wiring routes, and part installation positions, have conventionally been provided mainly using two-dimensional (2D) drawings. However, to understand complex three-dimensional structures, the experience and proficiency of skilled workers was indispensable, and issues such as prolonged working hours and operational mistakes arose. In response, virtual 3D models, along with operation/inspection points and processing information, are superimposed onto actual products through the optical see-through lenses of an AR/MR device, in order to realize an environment where operators can visually and intuitively obtain the required information, dramatically increasing operation efficiency and quality.

Furthermore, MHI has promoted the standardization and platformization of procedures for constructing and operating AR/MR environments, establishing a system where even operators without specialized knowledge can easily construct and operate these environments. Consequently,

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as of the end of June 2026, application and trials have proceeded across 12 internal departments, primarily in the defense and space sectors, significantly contributing to the promotion of digitalization in on-site operations.

This report introduces two specific application examples utilizing the aforementioned technological foundation: marking work for chill placement on mold patterns, and operations to identify the weight and center of gravity of ships. It also describes the effects observed in each example.

2. Standardization and platformization of AR/MR environment construction and operational procedures

2.1 Operational issues

When applying AR/MR technology to on-site operations, construction of the AR/MR environment and content creation are independently carried out by each department, leading to the personalization of technical know-how, an increased workload, and variation in the quality of deliverables, which is a factor that impedes the acceleration of internal development. Therefore, standardization and platformization of procedures in the construction and operation of AR/MR environments are indispensable.

On the other hand, MHI handles a wide variety of products, with various 3D CAD data formats depending on the business department and product. In addition, the scope of applicable operations varies widely. Handling these under a unified framework to achieve standardization was a primary challenge.

2.2 Efforts in standardization and platformization

To solve these issues, an AR/MR platform equipped with the following functions was constructed. First, a function to reduce the weight of data and convert various 3D CAD data formats while preserving shape, color information, and part hierarchies, was integrated into the platform establishing an environment where CAD data, which differs by department and product, could be unified and converted into AR/MR content. Next, a function was realized to link compatible objects to a 3D model by describing and loading operations/inspection points and processing information in the specified CSV format. By providing these as applications compatible with multiple AR/MR devices and tablet devices, a foundation was established that enables the generation and operation of AR/MR content on a single platform, even for different target products and tasks. The configuration diagram of this standardization and platformization of the AR/MR environment is shown in **Figure 1**.

Furthermore, a function to record the results of marking and work instructions carried out by operators on AR/MR devices within the application in real time, and export the work records from the device in CSV format, was implemented. As a result, work history and link information to subsequent processes could be efficiently managed.

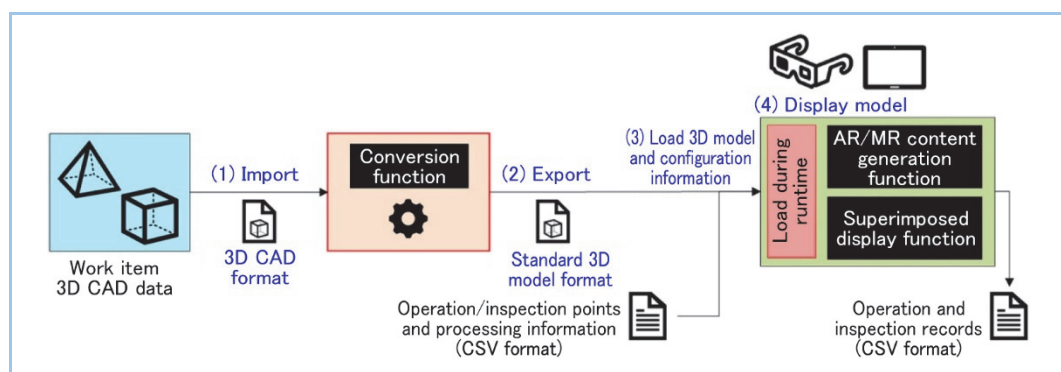


Figure 1 Standardization and platformization of AR/MR environments

2.3 Results

Through these efforts in standardization and platformization the time to construct an AR/MR environment was shortened, and rapid deployment to new application areas was realized. In addition, by utilizing a common operational foundation across multiple business departments, knowledge sharing between departments was promoted, contributing to the standardization of the

quality of operations and the acceleration of a continuous improvement cycle.

3. Marking work for chill placement on mold patterns

3.1 Operational issues

In order to ensure uniform cooling of thick sections of castings and prevent cavities from forming, marking work is required to indicate the positions where metal blocks called chills should be placed on mold patterns.

Since mold patterns often have irregularities and curved surfaces, inexperienced workers have difficulty understanding the marking positions when reading 2D drawings. In addition, the number of installed chills exceeds 100 in some cases, which poses problems such as prolonged working hours and variations in quality. The status of marking work on a mold pattern is shown in **Figure 2**.



Figure 2 Marking work on a mold pattern

3.2 Marking work utilizing AR/MR devices

By applying a method that can load a 3D model of the mold pattern, including the installation positions of chills, into an AR/MR device and superimpose it over the actual mold pattern in a real space, operators can intuitively identify the exact installation positions without referring to 2D drawings or performing a separate measurement.

Furthermore, workability and visibility were significantly improved by implementing a function to prevent missing markings, which places balloon objects to visually indicate marking points and records the completion status via touch operations to instantly identify unmarked points, along with a layer display function for the model. **Figure 3** shows an example of superimposing the 3D model of a mold pattern and displaying balloon objects.

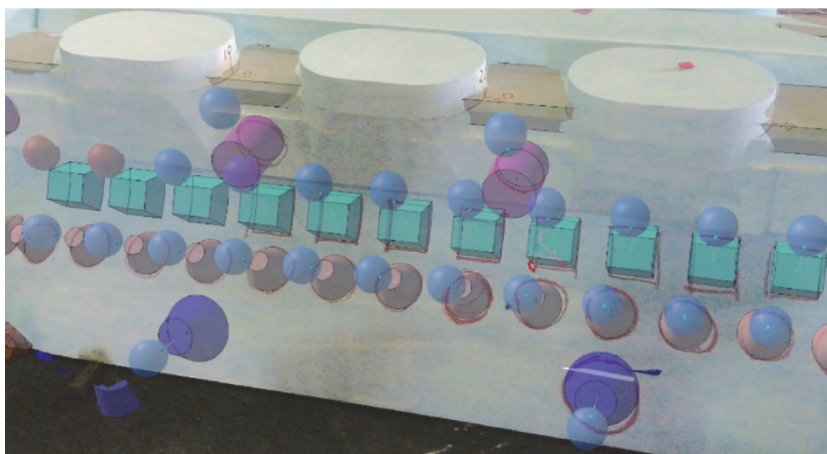


Figure 3 Superimposed display of a 3D model and balloon objects

3.3 Results

Through the application of this method, even inexperienced workers can carry out marking work accurately. In addition, a reduction in working hours up to 75% compared to conventional working hours was confirmed, achieving significant improvements in both operation efficiency and quality.

4. Operations to identify weight and center of gravity of ships when launching

4.1 Operational issues

During ship launching work, accurately determining the weight and center of gravity of the hull is necessary. Therefore, a full verification is visually conducted against arrangement drawings to confirm that loaded objects other than the ship's built-in equipment are placed in their designated positions. In cases where loaded objects exceed 300 items, or across large ships exceeding 100m in length and multiple decks, performing this full verification required a significant amount of labor hours. In addition, when re-measurements were required due to a positional deviation, the measurement results tended to vary depending on the experience and skill of the operator. Furthermore, an increase in labor-hours for manually organizing records was also a problem. Operations to verify the layout of ship-loaded objects (conceptual image) are shown in **Figure 4**.

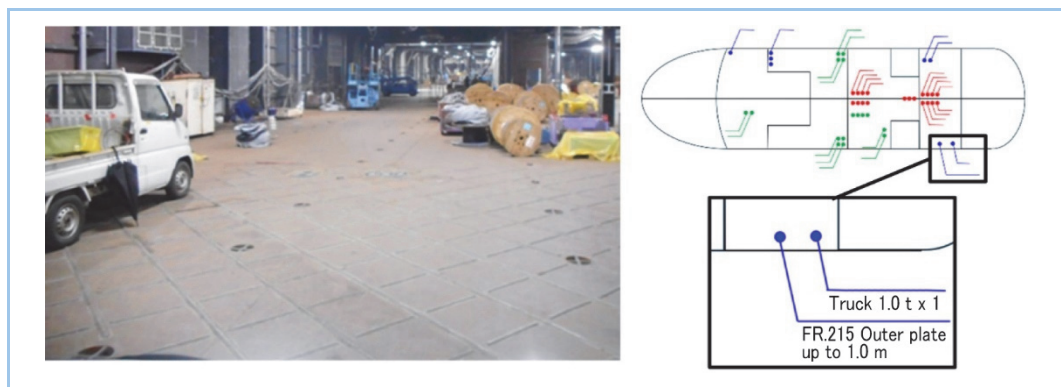


Figure 4 Operations to verify the layout of ship-loaded objects (conceptual image)

4.2 Operations to identify weight and center of gravity utilizing AR/MR devices

In this method, placing just a small number of alignment markers achieves highly accurate superposition, even across large ships exceeding 100 m in length or spanning multiple decks. To ensure visibility and enable verification, 1-meter cubic objects and balloon objects for verification are arranged at the specified coordinates of each loaded item and their images are superimposed over the actual ship. By overlaying these objects onto the loaded items, operators can easily check the placement status against the designated position without referring to arrangement drawings. In addition, when a target item is selected from the loaded item list, a guide beam is displayed, enabling operators to instantly identify the position of the target item even within the vast interior of the ship. The objects are displayed superimposed onto the loaded items, along with the list of loaded objects, as shown in **Figure 5**.

For loaded items with positional deviations, operators can immediately record actual coordinates in real time by moving the item in the AR/MR space to match the item's actual position. This saves the labor required in conventional re-measurement operations while ensuring consistent measurement accuracy. In terms of recording and management, verification results and coordinate information can be exported in CSV format, reducing the workload needed to manually record the information. Additionally, management accuracy is improved through functions to newly add or delete items and check off confirmed objects.



Figure 5 Superimposed display of cube and balloon object over loaded objects

4.3 Results

Through the application of this method, a reduction in work hours by approximately 80% compared to conventional methods could be confirmed. In addition, automated coordinate acquisition by the system ensured consistent measurement accuracy, while CSV export streamlined record-keeping operations. Furthermore, it was confirmed that stable superimposing accuracy can be maintained regardless of the vessel size simply by placing a few alignment markers. This contributes to the consistent operational quality even across large ships and expansive environments spanning multiple decks.

5. Conclusion

This report described efforts in standardization and platformization of AR/MR environments developed by MHI. Furthermore, through two application examples- marking work for chill placement on mold patterns and work to identify the weight and center of gravity of ships during launching- superimposed display technology with high accuracy for 3D models utilizing MR devices and user interface technologies applicable to on-site operations were introduced, demonstrating significant reduction in working hours and improvements in quality.

Moving forward, MHI will select and apply optimal devices, including newly planned AR/MR devices to be released, in response to the diverse applications and requirements of MHI products, and will continue to work to further improve the efficiency and quality of on-site operations.