

Halve Work Time through Parallelization of Tasks Using AR

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In the outfitting work of space system products, confirming drawings and procedure manuals requires a significant amount of time. To resolve this issue, development aimed at applying AR technology has been underway since fiscal 2022 in collaboration with the Digital Innovation Headquarters, and an approach combining "switching instruction methods utilizing AR glasses" and "constructing a simulated work environment using a pipe mockup" was proposed. As a result, work time was reduced by half, and it was confirmed that work quality equivalent to that of experienced workers could be guaranteed even by novice workers. Furthermore, the use of the pipe mockup allowed improvement and training to be conducted in parallel with the outfitting work, promoting strengthened collaboration among departments and the early detection and resolution of problems. In the future, resolving issues such as 3D data acquisition, human resource development, and the availability of AR glasses will be pursued toward practical application.

1. Introduction

In the outfitting work of space system products, confirming drawings and procedure manuals consumes a significant amount of time. To resolve this issue, development aimed at applying AR (Augmented Reality) technology has been underway since fiscal 2022 in collaboration with the Digital Innovation Headquarters. The aim is to support assembly work by arranging platform tools owned by the Digital Innovation Headquarters to efficiently utilize AR software.

This study aims to reduce worker workload by utilizing AR technology, thereby improving work efficiency and ensuring consistent quality.

2. Background of this initiative

In recent years, as the global space market expands rapidly, Mitsubishi Heavy Industries, Ltd. faces strong demand to increase the production of space systems and equipment, such as the H3 launch vehicle. However, securing the necessary human resources has become extremely challenging due to factors such as the retirement of experienced technicians and Japan's declining birthrate. Against this background, new initiatives are essential to efficiently scale up production with limited resources.

Outfitting work for space system products, particularly wire harness assembly work, is highly difficult due to its characteristics. The factors for this include the following: (1) Many sections of the wire harness are routed through open space, making accurate installation difficult; (2) Due to their flexibility, wire harnesses must be carefully installed while adjusting their routes and shapes during assembly; and (3) Since the wire harnesses are fixed by clamps at several points, identifying the fixing positions and performing the installation work requires high-level skills. Due to these factors, workers need to frequently check drawings and procedure manuals while proceeding with the work, resulting in a substantial amount of time spent on verification. Under

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these circumstances, there is a strong demand to improve the efficiency of wire harness assembly and reduce worker workload.

3. Details of initiatives

To address the challenges in wire harness assembly work, this study investigated the feasibility of AR-based work support, aiming to streamline outfitting work. Specifically, two approaches were proposed: switching from the conventional instruction method using drawings and procedure manuals to an instruction method utilizing AR glasses, and constructing a new simulated work environment combining AR with pipe mockups.

(1) Switching instruction method using AR glasses

A method was introduced to generate AR data from 3D data of the product and displayed it on the structure to be outfitted. **Figure 1** illustrates the outfitting process based on this approach. By using this method, workers could view instructions in real time via AR glasses, which was expected to improve work efficiency.

While this method proved effective to some extent by reducing the man-hours of novice workers. However, it did not achieve a sufficient reduction in man-hours across all workers, including experienced personnel. This is likely because the instructions via AR glasses did not cover details of the work, and the work still depended significantly on the workers' experience.

Specifically, while the instructions displayed on the AR glasses were sufficient for gaining a general overview of the process, detailed guidance such as the installation positions and angles of individual parts were difficult to understand. Consequently, even though workers proceeded with the work while operating the AR glasses, checking drawings and work instructions was still required to understand detailed instructions, causing the flow of work to be interrupted.

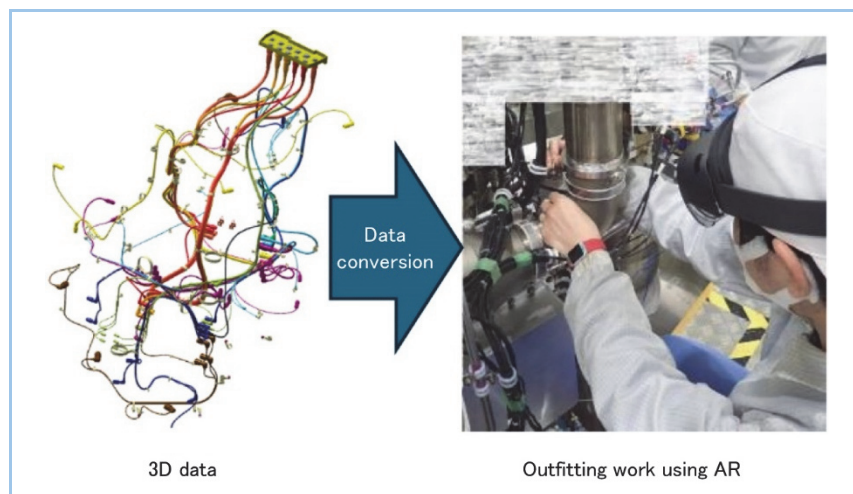


Figure 1 Outfitting work using 3D data (1)

(2) Construction of simulated work environment using pipe mockup

As a second approach, the construction of a new simulated work environment using a pipe mockup in addition to the instructions via AR glasses was examined. Specifically, the outfitting route of the wire harness is superimposed via AR glasses onto the pipe mockup of the structure to be outfitted, and workers install the wire harness along the displayed route. By combining the pipe mockup with AR glasses, features are incorporated to help workers to understand the installation positions and angles of individual parts, enabling them to proceed with work without checking drawings or procedure manuals. The wire harnesses outfitted on the pipe mockup are bundled by outfitting route and installed according to instructions from the same AR glass guidance. Since this installation work has already been experienced once through the work on the pipe mockup, workers can execute the actual operation without re-checking drawings or procedure manuals again. **Figure 2** shows a superimposed display of the outfitting route on the pipe mockup.

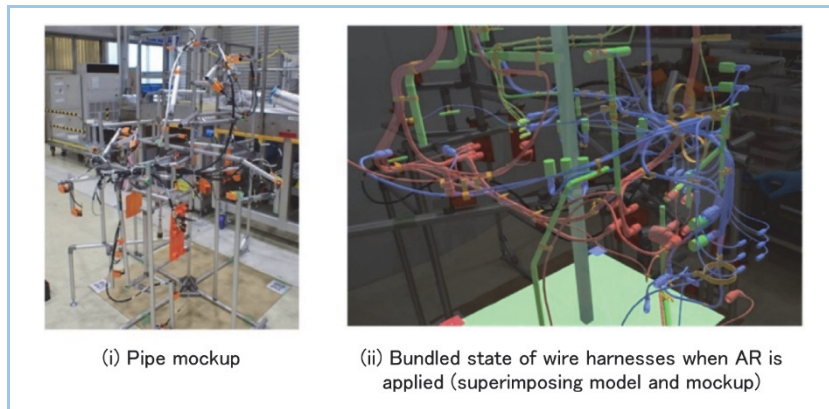


Figure 2 Superimposed display of outfitting route on pipe mockup

These improvements resolved the problem of understanding detailed instructions experienced when relying solely on AR glasses, resulting in a smooth and uninterrupted workflow.

The proposed method using the pipe mockup reduces work time in three areas, in addition to the aforementioned benefits.

First, multiple cabtire cables are converted into 3D harnesses on the pipe mockup. Specifically, by bundling 23 cables into two groups, a substantial reduction in the outfitting work on the product is expected.

Second, the method reduces adjustment work during installation onto the product. When installation was performed on the pipe mockup, slight deviations were observed due to factors including 3D routing through open space, the keying angles of the connectors, and cable tension. These deviations pose a problem during product outfitting. If a deviation occurs, it becomes necessary to disassemble and adjust the harness again on the product, which may reduce work efficiency. Therefore, as a countermeasure, the harness was secured on the pipe mockup by using hook-and-loop fasteners. This method could absorb deviation during installation onto the product, and it was confirmed that outfitting could be performed without unbundling or applying excessive tension. This countermeasure eliminates the need for adjustment work on the product and is expected to reduce work time and enhance quality. Furthermore, reducing the stress caused by cable tension may improve the durability of the harness. **Figure 3** shows a conceptual diagram of the outfitting process utilizing the pipe mockup.

Third, this approach enables parallel execution of multiple tasks. Performing task preparation on the pipe mockup beforehand (off-line setup) made it possible to proceed with outfitting work on the product in parallel, thereby reducing the overall work time in half.

In addition, the use of the pipe mockup enabled improvement discussions with related departments, such as design, manufacturing, production engineering, and quality assurance, without using the product. As a result, as shown in **Figure 4**, outfitting work, improvement activities, and training could be conducted in parallel, promoting strengthened collaboration among departments and the early detection and resolution of problems. Furthermore, skill training without using the product became possible, contributing to the skill improvement of on-site workers and the reduction of training costs. In particular, since the pipe mockup has almost the same shape and size as the product, workers could practice in an environment close to the actual equipment, contributing significantly to the improvement of skills.

It was confirmed that the integration of AR-glass instructions and a pipe mockup, as explained above, allowed workers to proceed with the work more intuitively, thereby reducing errors and ensuring consistent quality. This confirmed that even novice workers can maintain the same work quality as experienced workers. In addition, parallel processing of tasks reduced the work period in half.

Moving forward, based on these mockup results, it is important to consider application to actual design and manufacturing processes for further efficiency and quality improvement. Specifically, this countermeasure will be deployed on actual products and its long-term effects will be evaluated. Its expansion to other cable harnesses will also be explored.

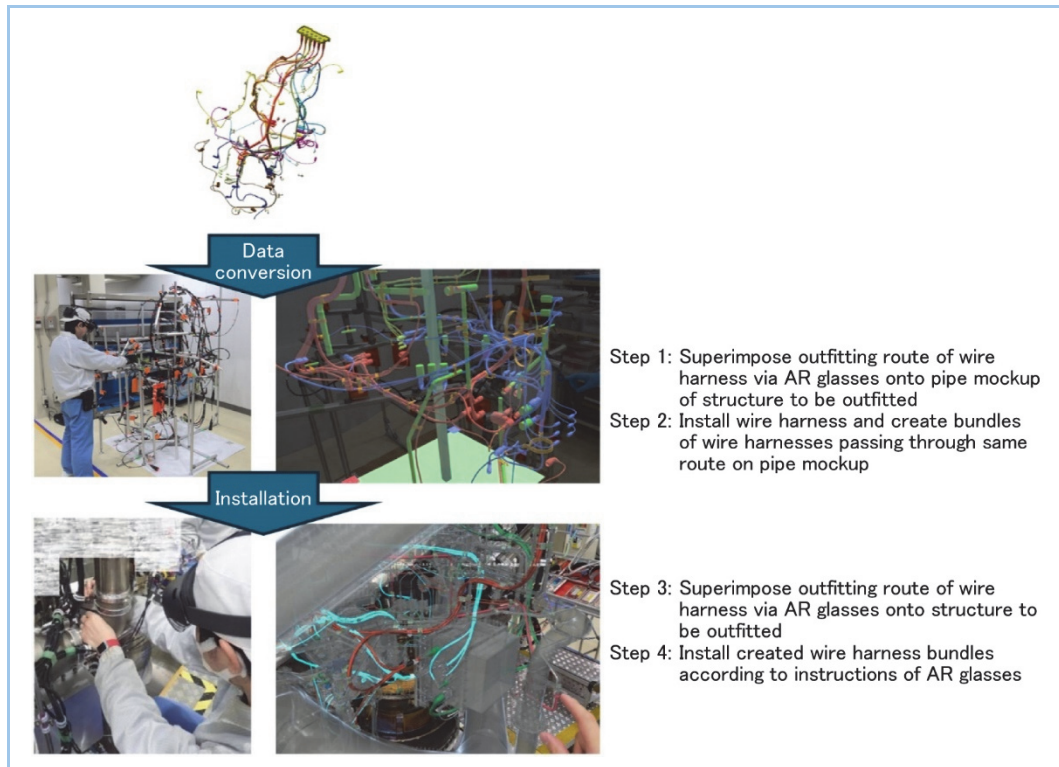


Figure 3 Outfitting work using 3D data (2)

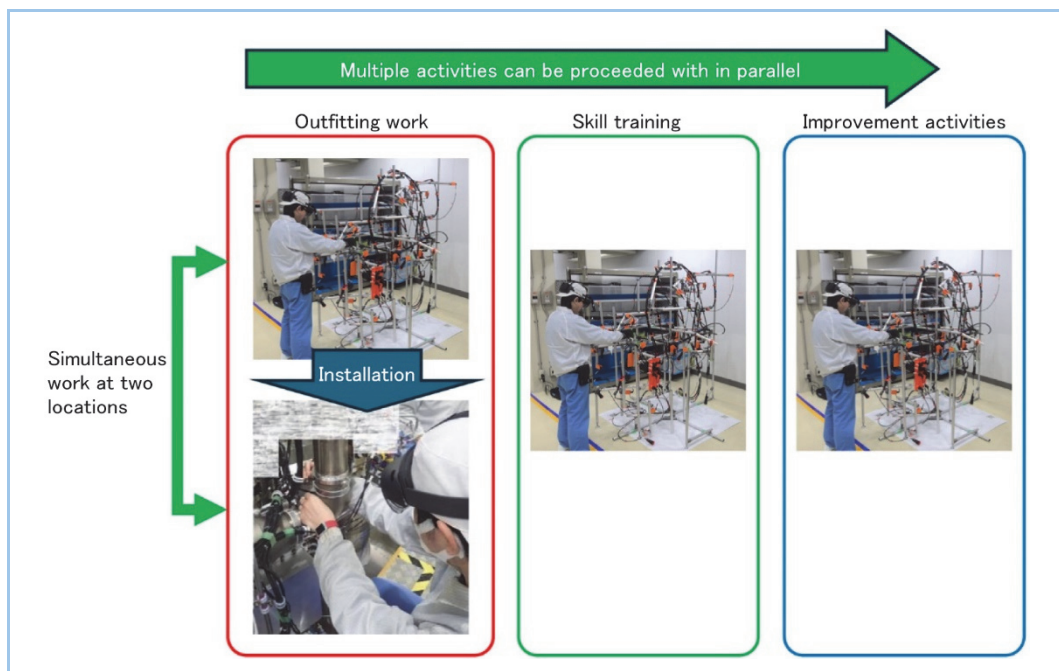


Figure 4 Parallel work after introduction of pipe mockup

4. Results

By conducting the outfitting operations according to the procedure shown in Figure 3, work time was reduced by 50% (from 3 days to 1 day) for certain tasks, and it was confirmed that even novice workers could guarantee work quality equivalent to that of experienced workers. This achievement indicates that the combination of AR technology and the pipe mockup brings significant benefits both in work efficiency and quality. Below is the summary of issues identified through this proposal and their countermeasures.

(1) 3D data acquisition

In the current system, generating 3D data from drawings is a manual process that consumes a significant amount of time. To address this issue, automation of the drawing management system and other measures will be pursued in future developments.

(2) Human resources for AR data creation

Creating AR data requires specialized knowledge and skills. However, there is currently a shortage of qualified personnel. To address this, the number of qualified personnel will be increased by adopting to the internal XR standard platform being promoted across the company.

(3) AR glasses availability

Supply of AR glasses in the market is currently unstable, making it particularly difficult to procure models suitable for this operation. To address this, alternative AR glasses that are stably supplied will be examined and evaluated for potential for adoption.

5. Conclusion

In this report, a method was proposed to switch from conventional instructions based on drawings to instructions using AR glasses, aiming to reduce work duration and improve quality. This method aims to improve work efficiency by eliminating frequent drawing checks and enabling workers to view instructions in real time via AR glasses. Specifically, by generating AR data from 3D data of the product and projecting it onto the structure to be outfitted, workers can proceed with work intuitively. Although this was expected to significantly reduce confirmation time, decrease errors, and ensure consistent quality, the expected effects could not be fully realized.

It was confirmed that, in addition to the instructions using AR glasses, overlaying the outfitting route of the wire harness via AR on the pipe mockup achieved efficient and accurate work, while contributing to the reduction of instruction confirmation time and the improvement of work quality. Since the pipe mockup closely matches the actual product in shape and size, workers could practice in an environment close to the actual equipment, contributing significantly to the improvement of skills. Furthermore, the use of the pipe mockup enabled improvement discussions with related departments, such as design, manufacturing, production engineering, and quality assurance, without using the actual product, promoting strengthened collaboration among departments and the early detection and resolution of problems. In addition, skill training without requiring actual products became possible, contributing to the skill improvement of on-site workers and the reduction of training costs.

Moving forward, expanding the scope of the pipe mockup to other tasks will enhance organizational productivity and technical capabilities. Through these efforts, the method proposed in this study is expected to be applied to a broader spectrum of operations, serving as a foundation for achieving sustainable growth.

References

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