Utilizing the Metaverse in the Industrial Sector

— *The "Worksite-Augmenting Metaverse"*—

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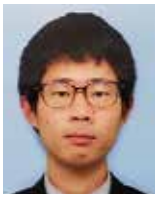

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1. Introduction

Advances in virtual reality (VR) technology, high-performance devices becoming prevalent, and the COVID-19 pandemic encouraging remote work and expanding stay-at-home demands have all contributed to the increasing use of the metaverse in various scenes over the past few years. However, when people hear the word "metaverse," they often think of its entertainment usages, such as VR games or virtually hosted events like music festivals. It may come as a surprise that behind the glamorous metaverse usages in the entertainment industry, the industrial applications of metaverse technology, referred to as the "industrial metaverse," are quietly gaining momentum. In this article, we introduce one of Hitachi's initiatives regarding the industrial metaverse—namely, the "Worksite-Augmenting Metaverse."

2. Difficulties with DX in the industrial sector

Japan's social infrastructure (including electricity, communications, and transportation) was developed between the 1960s and 1980s. In recent years, however, that infrastructure—across numerous industry sectors—has started to deteriorate, so its maintenance and repair is crucial. In the meantime, Japan has also been suffering a decline in the working-age population, which has led to a serious shortage of personnel to carry out the repairs and maintenance. Maintaining social infrastructure with a limited number of personnel requires efficiency, and it is hoped that digital technology will be the key to unlocking that efficiency. Transforming workplaces using digital technology—called "digital transformation" (DX for short)—is ongoing in many industry sectors. However, unlike the IT industry, in which digital technology is relatively easy to apply, the social-infrastructure sector often lacks mechanisms to digitize data from the field and systems to utilize the digitized data. As a result, worksite data are often locked inside the workfloor in a manner that makes it difficult for remote parties to comprehend the situation on the workfloor. This situation negatively affects efficiency, in forms such as miscommunication and unnecessary rework, and hinders DX.

3. Worksite-Augmenting Metaverse

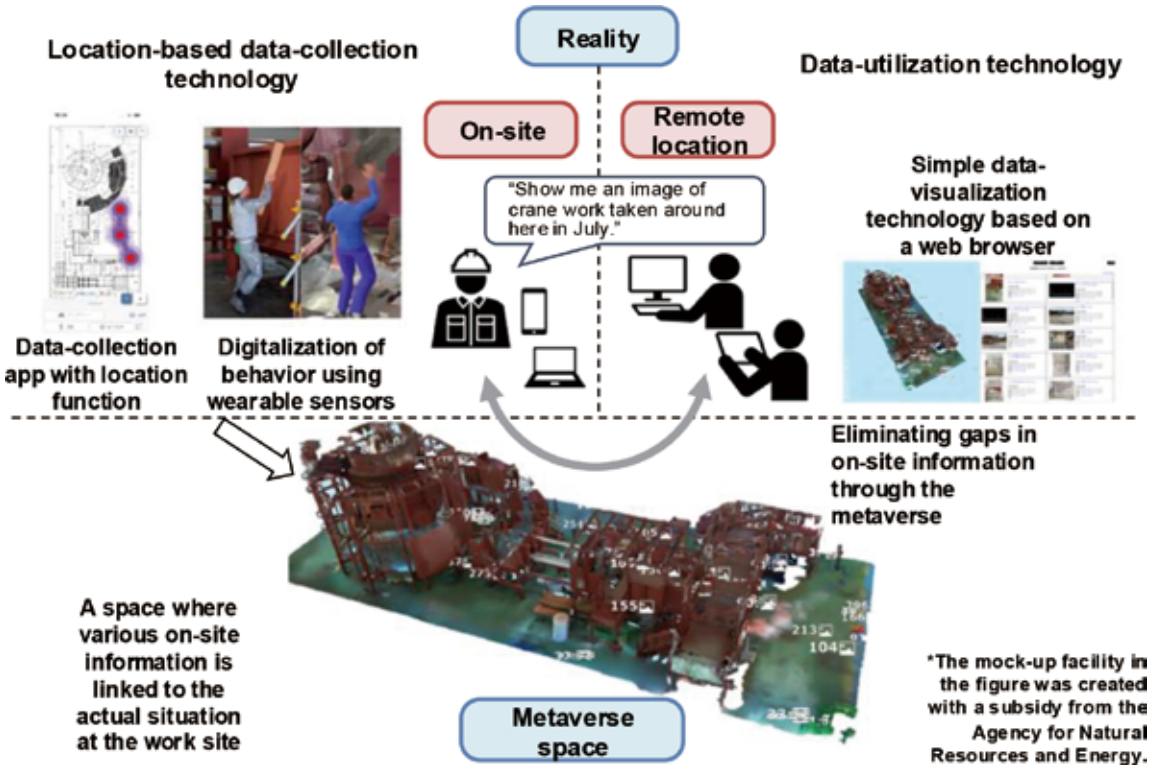
To solve the above-mentioned problems, since 2022, Hitachi has been researching and developing the "Worksite-Augmenting Metaverse" as a platform for efficiently collecting and utilizing data such as on-site work conditions and environmental information.*1 As shown in Figure 1, the Worksite-Augmenting Metaverse is composed of three elements: (i) the metaverse space (which is the core of the platform), (ii) data-collection technology, and (iii) data-utilization technology. It is composed of 3D scan data and/or computer-aided-design data (CAD, i.e., 3D models created for design, etc.) about the site, and it faithfully reproduces the appearance of the site. By virtually reproducing the site, the metaverse space enables people—even people who have never visited the site—to understand the current appearance of the site. This capability is especially beneficial for sites whose appearance changes frequently (such as construction sites).

Moreover, when multiple users log in to the metaverse space simultaneously, an avatar of each user is displayed, so it becomes possible to communicate through demonstratives words (e.g., "this," "that," "here") and body language such as finger pointing. In the industrial field, many conversations are about specific locations or equipment, so it is advantageous to be able to clearly indicate the subject of a conversation using non-verbal signs.

However, the metaverse space can only provide external information, so it is difficult to fully understand the situation on the workfloor from the metaverse space alone. To overcome that difficulty, in the Worksite-Augmenting Metaverse, information is

*1 Hitachi Review, "Hitachi Group's Progress on Worksite Augmenting Metaverse for Industry "

Figure 1: Conceptual diagram of the Worksite-Augmenting Metaverse. The mock-up facility in the figure was built with a subsidy from the Agency for Natural Resources and Energy



supplemented by storing data collected from the field and linking it to the corresponding coordinates in the metaverse space. For many industrial worksites, the data collected from the workfloor carries an important "spatial" meaning, so it is important to store the data in a form that can retain such spatial information. For example, by linking the sound of a pump recorded during maintenance work to the physical coordinates of the pump, it becomes possible to link the pump's 3D information to its operating status as inferred from the sound data.

As for the data-collection technology, we developed a smartphone app that enables field workers and others to collect data. The app incorporates indoor-positioning technology that allows location information to be tracked within the site. By using this app, a worker who wants to record a particular matter while working can take a photo or write a note on the spot and save that data linked to the location at which it was collected.

The final element of the Worksite-Augmenting Metaverse is data-utilization technology, including image analysis, voice recognition, text summarization, and other recognition technologies, which are applied to the collected data in a manner that allows the desired data to be accessed quickly.

In conclusion, the Worksite-Augmenting Metaverse represents a significant step forward in industrial DX by redefining the traditional concept of "on-site" presence. It extends physical workspaces into virtual ones and thereby allows stakeholders to access and share on-site data from anywhere in the world. In the following sections, two specific applications of the Worksite-Augmenting Metaverse are described to illustrate its potential in real-world scenarios.

4. Case study: management of plant construction

4.1 Issues at construction sites

During plant construction, information about the progress of construction is shared among many stakeholders, including designers, site supervisors, on-site workers, and executive management, and they discuss how to deal with problems and revise plans as necessary. In such cases, it is essential that the relevant parties have an accurate understanding of the situation; however, due to geographical and time constraints, it is not possible for all involved parties to physically inspect the worksite before every discussion. As such, discussions are often based on photographs and written reports. However, understanding such materials also requires a certain level of on-site knowledge, and often the knowledge gap between the on- and offsite parties is so large that they have difficulty having smooth discussions. Although it is in theory possible to avoid such a situation by sharing very detailed documentations, doing so requires considerable effort. For promoting worksite efficiency, it is therefore necessary to provide a way for the offsite (remote)

parties to grasp the on-site information easily, and satisfying that necessity motivated us to develop the Worksite-Augmenting Metaverse as a platform.

4.2 Worksite-Augmenting Metaverse at construction sites

Hitachi, Ltd., Hitachi-GE Nuclear Energy, Ltd., and Hitachi Plant Construction, Ltd. jointly used—for approximately two months from July 2023—the Worksite-Augmenting Metaverse in a project concerning the relocation of a nuclear-plant mockup. This relocation project required sharing information about the on-site situation and reaching consensus between multiple worksites and head-office departments; it was therefore chosen as a case study to measure the effectiveness of the Worksite-Augmenting Metaverse. The specific operations carried out were (i) daily on-site 3D-point-cloud measurements, (ii) collection of work data via a smartphone app, and (iii) evening meetings in the metaverse. The images shown in Figure 1 represent some of the data collected during this period.

One event that we put particular effort into on-site was the metaverse evening meeting [operation (iii) above]. Daily evening meetings, which were previously held on-site, were instead held in the metaverse, where stakeholders in remote locations reported and discussed the latest situation by utilizing the measured on-site 3D-point-cloud data and work data acquired on the day. It thus became possible for different, remote departments to reach agreement on, for example, drawing up logistics plans for the next day based on the dismantling status or revising drawings and arranging parts in a timely manner according to the on-site status. We also found that this type of smooth consensus building prevents inefficiencies, such as unnecessary rework due to misunderstandings or waiting for the completion of other tasks, and has a positive effect on carrying out work as planned. Over the course of two months, we confirmed the effectiveness of the Worksite-Augmenting Metaverse in promoting consensus building and improving work efficiency.

5. Case study: maintenance of rolling stock

5.1 Issues at railway sites

Responding to emergencies such as accidents and breakdowns concerning railway rolling stock requires rapid information sharing among different organizations, such as the railway company performing maintenance and the manufacturer responsible for vehicle design and manufacturing. However, in the case of traditional information-management methods, technical and know-how information tend to get disorganized in a manner that makes it difficult to retrieve the information and understand the worksite situation.

5.2 Worksite-Augmenting Metaverse at railway sites

In cooperation of Tobu Railway Co., Ltd., we developed a prototype of the Worksite-Augmenting Metaverse (called the "rolling-stock metaverse") for the company's Spacia X*2 train and examined its use in maintenance scenarios. In contrast to the construction site example presented in the previous section, where the site appearance changes significantly as work progresses, in this rolling-stock-maintenance scenario, it is necessary to manage each individual part. To meet that need, we utilized the CAD information synthesized during the vehicle design as the basis of the metaverse space, instead of the 3D scan data. Information such as design changes and operation incidents were then registered alongside the 3D information. By centrally managing various types of information that may be required during maintenance, the rolling stock metaverse aims to promote intuitive communication and acquisition of information across organizations in a manner that supports the safe operation of rolling stock.

An example of how the rolling-stock metaverse can be used is shown in Figure 2. The image to the right shows a sample scene from the rolling-stock metaverse, where precautionary information about automatic-door inspection is presented in the metaverse space. This intuitive visualization allows design drawings to

Figure 2: Using the rolling-stock metaverse for maintenance. Stakeholders from various departments can participate in the metaverse space and check information linked to work content and location

*2 Spacia X is a registered trademark of Tobu Railway Co., Ltd.

be understood in three dimensions in a way that promotes the sharing of on-site know-how and other technical information. Furthermore, by centrally managing a wide variety of data in the metaverse, it becomes easier to search and utilize data by using generative AI. As a result, the users can interact with the accumulated information more intuitively, in a dialogue format using natural language.

6. Future developments

Nearly two years have passed since Hitachi began researching and developing the industrial metaverse, and we have made significant progress through actual testing of the metaverse as a digital copy of the industrial worksite and as a forum for fostering discussion between various stakeholders. The introduction of the Worksite-Augmenting Metaverse has been a major success since it has made it possible to understand—remotely—**what** is happening at work sites, **where** it is happening, and **when** it is happening—which were previously obscure remotely. However, visualization of the worksite is just one milestone, as our ultimate goal is to provide feedback based on the collected data, and thereby improve worksite operations, as summarized in the roadmap shown in Figure 3. We are currently on the far left in the roadmap, in which the Worksite-Augmenting Metaverse is mainly used for collecting and visualizing on-site data. Feedback to workers is limited to visualizing and organizing data and training in the metaverse space.

The next step on the roadmap is developing an AI agent that can give advice to workers. Unlike ordinary AI agents that only have general common knowledge, our AI agent will be able to provide more detailed support by utilizing the data accumulated in the Worksite-Augmenting Metaverse, which is rich with "what," "when," and "where" information about the worksite. Using the data accumulated in the metaverse, the AI agent will be able to answer questions that previously could only be answered by experts.

We believe that one of the goals of the Worksite-Augmenting Metaverse is to become a collaboration platform between human workers and robot agents. For example, the use of robots on construction sites is currently dominated by simple tasks such as assembly work; therefore, considering the evolution of AI and robotics research, as well as the needs of a declining productive population, it is highly likely that in the near future humanoid robots will take on the same jobs as construction-site workers. In this regard, we envision that the Worksite-Augmenting Metaverse, which is a virtual copy of the worksite, will serve as (i) a simulator for virtual trial and error when customizing robots for each site and (ii) a knowledge base that is updated sequentially after the robots are deployed in the field.

As mentioned at the beginning of this article, the word "metaverse" is typically associated with the entertainment industry. However, anticipating that the metaverse will drive the much-needed DX, we firmly believe in potential applications of the metaverse within the industrial sector. Though hardships such as differing statuses and laws regarding various worksites will make it difficult for us to make huge leaps at once, we remain committed to advancing the technologies of the Worksite-Augmenting Metaverse and its commercialization one step at a time. Guided by our vision, we aim to enhance labor productivity, foster human growth, and promote happiness for all workers.

Acknowledgements

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Figure 3: Roadmap for using the metaverse to support field workers