The Proof of Concept (PoC) for Shimane unit 2 Digital walkdown system

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Abstract: In the Probabilistic Risk Assessment (PRA), the plant walkdown is conducted to collect actual plant information that cannot be sufficiently obtained from design information document and to identify the differences between the actual plant and the PRA model. Especially, in the Fire PRA, the following kinds of plant information should be collected.

1. Fire partitioning
2. Cable routing
3. Fixed Combustible material information (size, layout, etc.)
4. Distance of equipment, cable tray or electrical cabinet

Since these are widely installed in the plant, it takes a long time to conduct the on-site plant walkdown in the fire PRA. Therefore, by constructing the structure inside the plant using 360-degree images, much of the above plant information can be collected in advance, which will reduce the time of on-site plant walkdown.
This paper reports about the use of 360-degree camera for PRA plant walkdown. In this paper, four kinds of plant area are shot with a 360-degree camera and confirmed the applicability to fire PRA or other PRA. In addition, this paper suggests the utilize of 360-degree plant image other than the PRA.
Keywords: PRA, Plant walkdown, 360-degree camera

1. INTRODUCTION

A plant-specific PRA should reflect the as-built and as-operated plant. A comprehensive plant walkdown is one of the methods to ensure that the PRA is based on the plant-specific information. The plant walkdown for the PRA is usually conducted to gather actual plant information that cannot be sufficiently obtained from design information document, and to identify the differences between the actual plant and the PRA model.

A comprehensive plant walkdown require considerable manpower to prepare the walkdown plan, to proceed the entrance procedures for the nuclear power plant, to confirm numerous components with specialists regarding PRA, plant system, etc. for several days, and to document the results. To use digital technologies can reduce the burden of the plant walkdown (called digital walkdown). The Proof of Concept (PoC) for digital walkdown was conducted for the fire PRA for Shimane unit 2 [1] to confirm the applicability.

Generally, the following kinds of plant information should be collected for the fire PRA.

1. Fire partitioning
2. Cable routing
3. Fixed Combustible material information (size, layout, etc.)
4. Distance of equipment, cable tray or electrical cabinet

Since these are widely installed in the plant, it takes a long time to conduct the on-site plant walkdown in the fire PRA. Therefore, by constructing the structure inside the plant using 360-degree images, much of the above plant information can be collected in advance, which will reduce the time of on-site plant walkdown.
This paper reports the PoC for digital walkdown using 360-degree camera to confirm the applicability to the fire PRA or other PRAs. In addition, this paper suggests the applicability of the 360-degree plant image to technical area other than the PRA.

2. OVERVIEW OF DIGITAL WALKDOWN SYSTEM

2.1. Overview of Digital walkdown system

Figure 1 shows the overview of digital walkdown system. User takes 360-degree image on site by using the 360-degree camera. This system can be linked to the plant layout diagram, and the Structure System and Component (SSC) can be viewed at any position and viewpoint and moved in any direction in the 360-degree image like Google Street view®. The function will be added to increase convenience for plant walkdown (see chapter 4).

2.2. Methodology

Taking of room image can be performed only by walking the whole room while recording video with the 360-degree camera shown in Figure.1, and it can take whole room image in short time (within 30 minutes). After taking 360-degree image, its image and plant layout diagram are inputted in this digital walkdown system. The self location and viewpoint information is estimated from the 360-degree image.

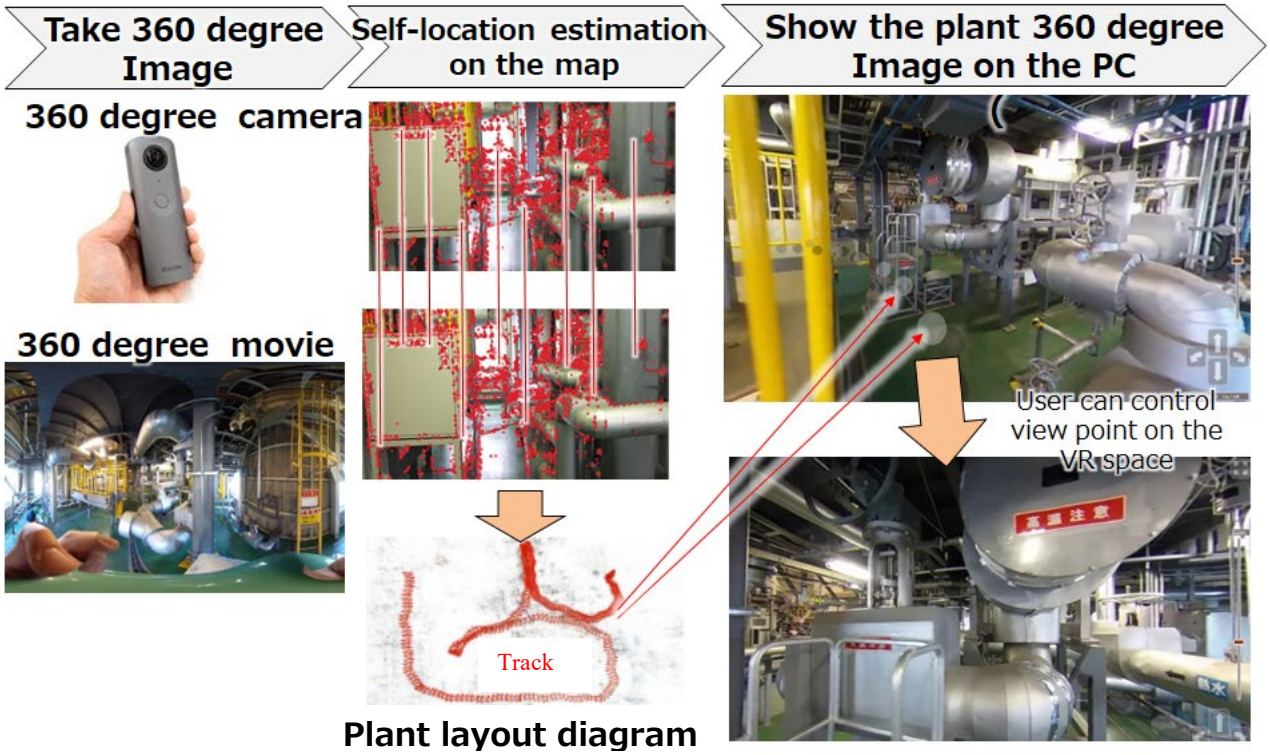

Figure 1. Overview of digital walkdown system

2.3. Application to PRA

There are some kinds of PRAs such as the internal events, the internal hazards (flood, fire, etc.) and the external events (seismic event, tsunami, high wind, etc.). The viewpoints during a plant walkdown should depend on the type of PRAs. The viewpoints during a plant walkdown are summarized from the requirements in the ASME/ANS PRA standard [2] in Table 1.

The digital walkdown for the PRA can help the plant walkdown for some viewpoints described in Table 1, especially for the identification of SSCs, observation of the exterior of SSCs and scaling the distance.

For example,

- Preparatory plant walkdown to confirm the location of SSCs, scale the size, etc. is conducted by the digital walkdown.
- SSCs are not risk-significant are intensively confirmed by the digital walkdown and the actual plant walkdown focuses on the risk-significant SSCs with the graded approach.

Table 1. Examples of Viewpoints during Plant Walkdown

Type of PRA	Viewpoint	ID for SR
Common	- Structures, Systems and Components (SSCs) modeled by the system fault trees. - SSC location, SSC type, SSC function, operating status.	SY-A4
	- Spatial impacts such as potential accessibility concerns for local operator actions, potential interaction concerns between SSCs - Environmental impacts such as high / low ambient temperatures, humidity impacting SSCs or accessibility for local operator actions and HVAC systems that support multiple systems.	SY-B8
Internal Flood	- Spatial information needed for the development of flood areas. - Plant design features credited in flood areas.	IFPP-A5
	- Location of flood sources and in-leakage pathways	IFSO-A6
	- SSCs located within each flood area. - Flood / Spray / Mitigative features (drains, shields, etc.) - Flood propagation paths.	IFSN-A17
	- Engineering analyses such as the calculations of flood depths. - Human reliability analyses such as accessibility of flooding isolation valves. - Spray / Spray shields / pipe whip restraints. Screening bases	IFQU-A11
Internal Fire	- Plant partitioning such as fire barriers.	PP-B5
	- Cable routing. - Fixed combustible material information (size, layout, etc.). - Distance of equipment, cable tray or electrical cabinet. - Fire detection and suppression equipment, etc.	FSS-D10 and FSS-D11
Seismic event	- Failure mode of structures such as sliding, overturning, yielding and excessive drifts. - Failure mode of equipment such as anchorage failure, impact with adjacent equipment and structures, bracing failure and functional failure. - Failure mode of soil such as liquefaction, slope instability and excessive differential settlement. - Seismically induced fire and flooding	SFR-D1 and SFR-E1 to SFR-E5
	- Earthquake-caused “very small loss-of-coolant accident”	SFR-B8

SR: Supporting Requirement in the ASME/ANS PRA standard [2]

3. POC IN SHIMANE UNIT 2

3.1. Purpose of PoC

To confirm the applicability to Fire PRA and other PRA, the PoC test was conducted.
This PoC test was conducted for four rooms in the Shimane nuclear power plant unit 2 as shown in Table 2 so as to confirm the visibility of SSCs and accessibility of narrow space or high place.

(1) Visibility of SSC
During the plant walkdown, the location and the operating status of SSCs are confirmed; e.g., the location of combustible material information (size, layout, etc.) for Fire PRA. It is confirmed in the PoC test whether the 360-degree image shows the SSC overview and the identifier (ID) on the SSC.

(2) Accessibility of narrow space or high place
It is sometimes difficult to get close to SSCs in the narrow space or the high place during the on-site plant walkdown. For example, a cable tray is installed nearby the ceiling of the room. The 360-degree camera has a potential to take a images of SSCs where it is difficult for a man to get close.

3.2. Result

Figure 2 shows the image of electric cabinet and its ID, and Figure 3 shows the image in the high space. In this PoC test, one person took a 360-degree image, and two persons handled the lighting for taking 360-degree image and the checking of image on the PC after taking. The time of Taking 360-degree image per room took about 30 minutes in the largest room.

The detail confirmation results of the visibility of SSCs and accessibility of narrow space or high place are described below.

(1) Visibility of SSC
As shown in the Figure 1, the 360-degree images taken during the PoC made it possible to confirm the SSC overview, and its main ID.
However, the SSC where is installed in dark area (e.g., the ceiling above the room light) was difficult to read ID. And the small ID plate was also difficult to read. These problems can be solved by improving the resolution of the camera and preparing enough light sources.

(2) Accessibility of narrow space and high place
Figure 2 shows the image in the narrow space and high place taken in this PoC test. This image was taken by using of selfie stick. It could be confirmed that the 360-degree camera has a potential to take a images of SSCs where it is difficult for a man to get close.

From the above results, the applicability to PRA that could be confirmed through the PoC test are shown in Table 3.It was confirmed that the digital walk down system can basically find the SSCs on the rooms in the nuclear power plant. If the pre-confirmation of SSCs is performed before an on-site plant walkdown, walkdown members focuses on the other aspects during the actual walkdown.

Table 2. Features of Rooms for PoC of Digital Walkdown in Shimane Unit 2

Room	Feature of room
Electric cabinet room	- Large number of cable tray in high place (ceiling) - Large number of electric cabinets
Component room A	- Large number of valves - The components are installed in the narrow space
Component room B	This room installed the rack for access to the SSCs and there are many narrow spaces. Thus, the visibility in the narrow space is confirmed in this room.
Component room C	Large number of components are installed in large room (1,300 m^2)

Table 3. Example of Applicability to Fire PRA, Internal Flood PRA and Seismic PRA

Type of PRA	Applicability
Fire	- The actual features (overview or difference with the design information) of Plant partitioning such as fire barriers - Cable routing - Fixed combustible material layout and overview
Internal Flood	- Flood / Spray / Mitigative features (drains, shields, etc.) - Location of flood sources
Seismic event	- The actual features (overview or difference with the design information) of seismic countermeasures. - Impact with adjacent equipment and structures

Figure 2. The image of electric cabinet (Load center)

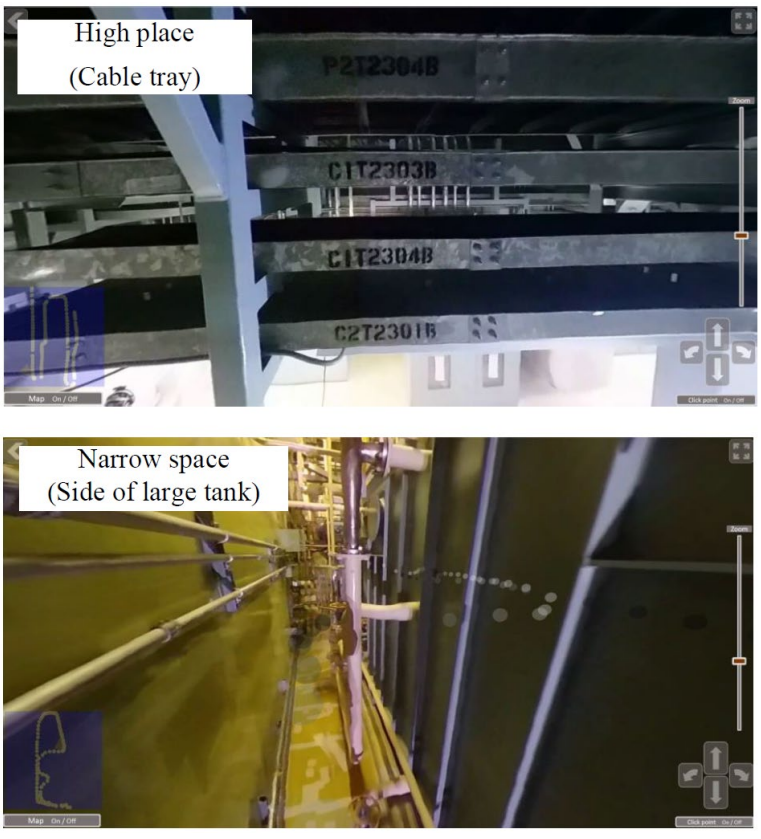

Figure 3. The image of high place and narrow space

4. FUTURE WORK

4.1 Additional function for digital walkdown

As mentioned in Section 3, the current digital walkdown system can basically find the SSCs in a nuclear power plant. If the following functions are added to the digital walkdown system, the system would be more useful for PRA walkdowns,

(1) Link to design information
This function is possible to confirm the design information (drawings, specifications, etc.) on the 360-degree image. Since this function makes it possible to check the difference between the on-site and the design information on the digital walkdown system, the overall time of the PRA plant walkdown can be reduced. In addition, by comparing design information with on-site conditions, or capturing changes in on-site conditions over time, it may also be useful in detecting temporarily stored combustible materials.
(2) Dimensional measurement function
In the fire PRA, the size of SSCs and distance with the adjacent SSC is one of important inputs to model the plant specific PRA. This measurement takes much time on-site plant walkdown. Thus, this function contribute to reduce the time of on-site plant walkdown.
(3) Data sharing between the utility and the supplier
A plant-specific PRA should reflect the as-built and as-operated plant. Thus, this plant walkdown system should be updated continuously.
Figure 4 shows an image of data sharing. the 360-degree image is taken by the utility and supplier to update continuously. The taken 360-degree image is linked to plant equipment layout and other design information, and then input to the shared server for digital plant walkdown system. The shared server will be accessible to both utility and suppliers. This shared server makes possible to continuous update of 360-degree image.

4.2 Suggestion of the application to other technical area

This system has a potential to apply to other technical areas as follows.

(1) Use in training
Since the on-site plant image can be viewed remotely using this digital walkdown system, it can be used for training on desk. It is possible to check areas at the training that are difficult to access such as high place, narrow space and high radiation dose area.
(2) Communication tool between utility and supplier
By sharing the 360-degree image of on-site plant with digital walkdown system, it is possible to share the plan of field engineering visually and conduct the risk prediction with the 360-degre image.

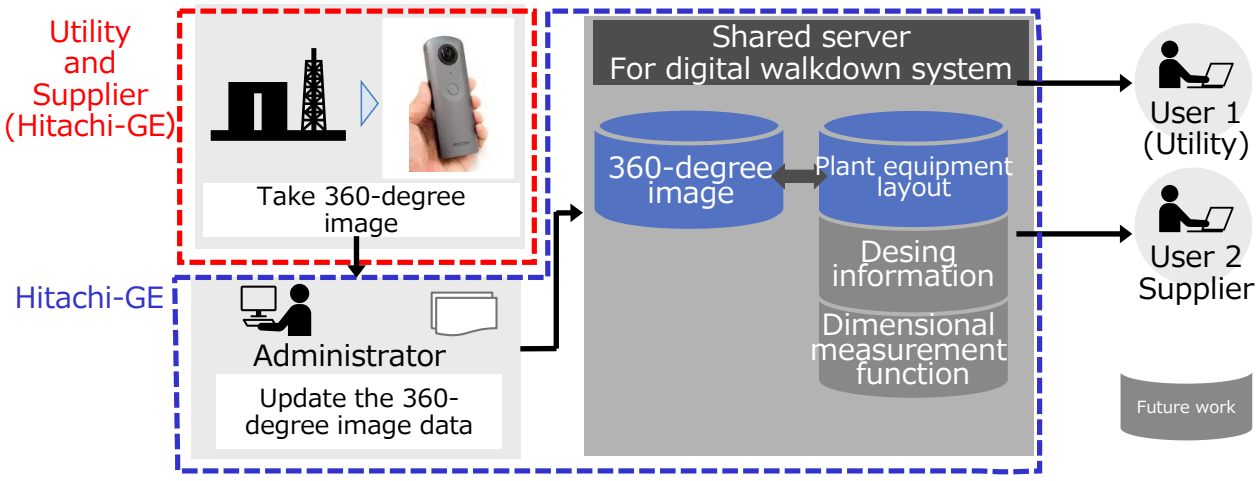

Figure 4. Image of Data Sharing between Utility and Supplier

5. CONCLUSION

This paper reports the PoC for Shimane unit 2 digital walkdown system. The 360-degree images were taken in the four kinds of room in Shimane unit 2 plant to confirm the visibility of SSCs and to improve the accessibility of narrow space or high place.

This PoC test proofed that the 360-degree image was possible to collect plant information for the fire PRA and other PRA plant walkdowns. That is possible to reduce the time of on-site plant walkdowns.

As a future work, this report suggests the functions should be developed for the digital walkdown system to enhance the applicability. The next step is to take 360-degree images for the whole rooms in the nuclear power plant. The digital system will make it more useful to not only PRAs but also plant operation.

References

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