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Application of Virtual Tour for Online Training Safeguards Exercises

Megumi SEKINE, Hidetoshi SUKEGAWA, Yasuhiro ISHIKURO, Koji OHYAMA, Takashi OBATA, Kazuhiko HAYASHI, Naoko INOUE

Japan Atomic Energy Agency, 765-1 Funaishikawa, Tokai-mura, Ibaraki, 319-1184, Japan

Abstract

The Integrated Support Center for Nuclear Nonproliferation and Nuclear Security (ISCN) of the Japan Atomic Energy Agency (JAEA) developed the virtual tour of a reference nuclear facility. The developed virtual tour was applied to the Design Information Questionnaire (DIQ) workshop exercise for the online regional training course on the State System of Accounting for and Control of Nuclear Material (Online RTC- SSAC) held in November 2020. Also, it was applied to the Complementary Access (CA) exercise for the online workshop of the Nuclear Security and Safeguards Project under the Forum for Nuclear Cooperation in Asia (FNCA), held in February 2021. The workshop exercises have been implemented for in-person format however due to COVID-19 pandemic, a virtual tour was applied.

The virtual tour was found to be a strong tool not only for online training as an alternative for a facility tour but also considered to be more advantageous even for the in-person training. The developed virtual tour of a reference nuclear facility, which is going to shut down, can serve as historical archive. The paper describes how to create a virtual tour of a reference research reactor facility for the DIQ and CA exercises respectively which have different learning objectives. It emphasizes how the features of the reference facility were captured and the challenges encountered to convey to the training participants the importance of providing the required design information while not being physically present at the facility. It also shows the advantage of using the same virtual tour to describe the safeguards-related verification activities of a complementary access. Virtual tours can be applied to a variety of training.

A. Introduction

The Integrated Support Center for Nuclear Nonproliferation and Nuclear Security (ISCN) of the Japan Atomic Energy Agency (JAEA) has been conducting human resource development support programs in the field of nuclear nonproliferation and nuclear security for domestic and international stakeholders since its establishment in 2010. As one of the main areas of its human resource development support program, ISCN has been conducting in-person SSAC training courses and workshops on safeguards. However, due to the impact of the COVID-19 pandemic situation, ISCN started to develop online training in April 2020.

In the development of the online training, the biggest challenge was how to create a credible exercise module that will provide knowledge retention by experience and facilitate relevant discussions, including a visit/tour of an actual research reactor facility. In the case of the in-person SSAC training, the Design Information Questionnaire (DIQ) exercise was structured as follows:

(1) Introduction to the exercise;
(2) Description of the facility design information by the facility operator;
(3) Facility visit to confirm the operator's information provided on the questionnaire while touring the facility;
(4) Group discussions on the facility's relevant information with emphasis on why specific information on the DIQ is important for safeguards implementation;
(5) Representative from each group presents their respective discussion results; and
(6) Further discussions and a wrap-up summary of the exercise by the instructor.

If this exercise is to be delivered online, we found that steps (1), (2), (4), (5), and (6) above could be conducted using the Zoom platform [1]. However, the challenge we encountered was how to conduct step (3) that required a physical visit to the actual facility for an online course to achieve the learning objectives of the exercise.

Since some of the countries, mainly in Asia, targeted for training by ISCN do not have nuclear facilities yet, providing a visit to actual facilities would be very useful for training participants to gain technical knowledge. To address this learning objective, creating a virtual tour of a visit to an actual facility would be useful. We aimed to develop a virtual tour for the world's first online training on safeguards and its implementation in training courses using ISCN's expertise in the production of virtual tours of the ISCN's Physical Protection Exercise Field, which was also developed in 2020 [2].

In this paper, we report the development and application of a virtual tour for the DIQ exercise of the online SSAC course, as well as the Complementary Access (CA) exercise, based on the virtual tour of the same facility.

B. Virtual Tour Development Methodology

B-1. Technical Considerations

A virtual tour as defined in this paper allows the user to move through a virutal space created from 360-degree panoramic photos using a dedicated software package in a cloud server. The virtual tour allows users to view the site and the facility from different locations and perspectives in the online environment. It has the effect of creating a sense of reality as if the users are physically present.

Fig.1 Example of the 360-degree camera with high resolution

In the development of the virtual tour of the research reactor for the DIQ exercise, the following were considered

- To include reactor design features with emphasis on fuel

flow, fuel handling, including storage and equipment, and coolant systems.

- To include detailed descriptions of the relevant equipment, as well as relevant locations, and systems that are not visible in the virtual tour. (e.g., inside the reactor core, how the neutron beam can be used for cancer treatment, etc.)
- How to conduct smoothly the online virtual tour while maintaining consistency and the participants' sense of direction on viewing the presented information.
- How to protect sensitive and proprietary facility information.

Based on these considerations, the appropriate software package for the virtual tour that is user-friendly was chosen. It allowed us to learn and implement the virtual tour in a short period meeting the targeted deadline, Also, a compatible camera with a high resolution and a 360-degree view was used. The features are shown in Table 1.

Table 1 Specifications of the equipment used [3], [4]

Camera	Software
・ GoPro Inc. GoPro Max, made in the US (Fig.1) ・ 360-degree capture ・ Image : 360-degree mode 5.6k, 30 frames per second ・ Weight : 154 g	・ Panorama-Kobo Inc., Pano Creator, made in Japan ・ Dedicated content and editing functions for virtual tours ・ The web application that runs on a browser ・ Available for use in a dedicated cloud server ・ Function to convert 360-degree JPEG images into panoramic images for virtual tours

B-2 Development Process

The following steps were undertaken to develop the virtual tour of a hypothetical facility:

(1) Preliminary visits to the site/facility and scenario development.

Based on the facility design and system description, the floor plans of the facility were used to strategically organize what, where, and how the subjects would be photographed. The scenario for the tour was also developed in collaboration with the facility operator.

(2) Photographing the site/facility (see Fig.2)

The photographer used a GoPro Max (360-degree camera) to film the identified routes. This simulates the possibility to provide an actual walk-through experience of the facility..

Fig.2 How to take 360-degree pictures

(3) Physical Protection (PP) check

Since existing research reactor facility was used, all the photos have to go through security-related screening by the security division. Sensitive PP-related images were either removed or masked by image processing.

(4) Construction of the virtual tour

(a) The 360-degree panoramic images taken were imported into the software as JPEG files and converted into panoramic virtual reality (VR) images.

Fig.3 Example of the 360-degree panoramic photo

(b) The pictures taken were assembled into a tour that connects several points, and further pop-up points were added. It was created in such a way that when you click on a pop-up point, a specific image or picture with the text on the subject which was set as the link for that point will be displayed.

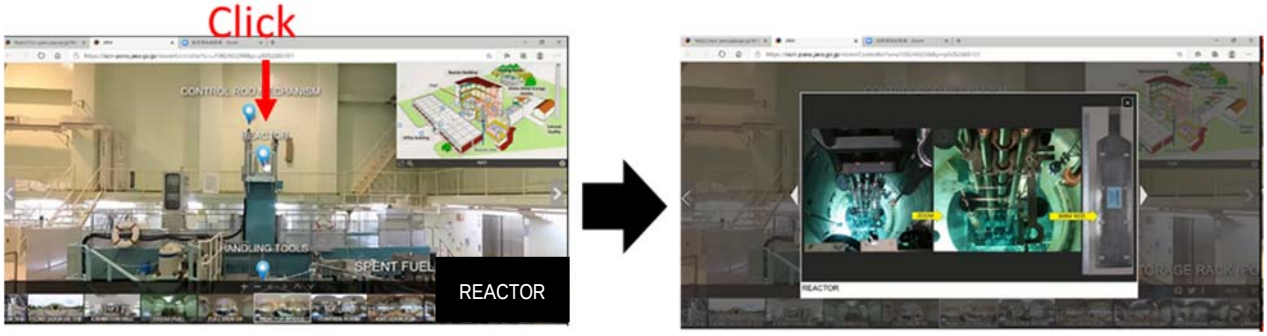

Fig.4 An example of what is shown and the relevant pop-up explanation of the reactor core

(c) To make the tour route easy to follow and understand, a map of the facility is referred to and displayed so that the current location can be shown (see Fig.5). Also, a jump function is added to each area so that clicking on a point on the map will take you directly to a specific location on the screen.

Fig.5 Facility map and location check

The advantage of the software that was used is that it not only shows the image in a 360-degree panoramic picture view, but also allows the user to add any pop-up point to the image. Clicking on that point will display further information (e.g., description, 2D photo, video, etc.) that is useful to provide a better understanding of system functions and operational relationships.

Fig.6 Images of the production steps from (a) to (c)

C. Results

Application of the virtual tour on safeguards-related training

Table 2 is an overview of the use of virtual tours on safeguards-related training. Two exercise modules are reported.

Table 2 Safeguards training with virtual tours

	Course Title	Exercise	Schedule	Participants	The facility type used for a virtual tour
1	Online Regional Training Course on State Systems of Accounting for and Control of Nuclear Material (Online RTC-SSAC)	DIQ	November 2020	Parties involved in safeguards and safeguards-related activities, especially in Asia (regulations and facilities), 16 members	A nuclear research reactor
2	10th Workshop on Nuclear Security and Safeguards Project of Forum for Nuclear Cooperation in Asia (Online FNCA)	CA	February 2021	Point of contacts from FNCA member countries , especially in Asia, 21 members	

C-1. DIQ Exercise

The learning objective of this exercise is to enable the participants to describe the required design information and explain the safeguards-relevance of the design information following the DIQ lecture. More important to note is that the exercise should be designed to allow participants to discuss the information to

Fig.7 Break-out Room layout for the DIQ exercise

be provided in the DIQ and the relevance of the DIQ information to safeguards implementation. The structure of the online exercise is as follows:

(1) Introductory presentation on the DIQ exercise

Same as the in-person course, provided the exercise learning objectives, how to proceed with the group exercise, and the workshop tasks were explained.

(2) Introductory presentation of the facility by the facility operator

Same as the in-person course, provided an overview of the research reactor and its use; fuel flow, fuel handling, including storage and equipment, and the cooling system were explained.

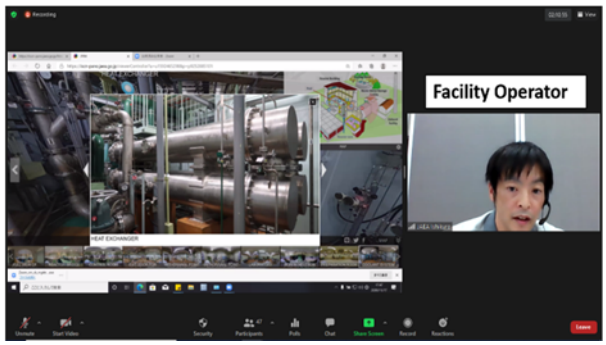

Fig.8 The facility operator guiding the virtual tour

(3) A virtual tour of the facility

A research reactor facility operator guided the virtual tour and described the design and operational information related to the facility. The hypothetical facility used for the virtual tour is a pool-type research reactor. It is simple enough to be easily understood and considered an appropriately relevant training tool. As a result of the feedback from the dry-run, it was decided that the facility operator will act as the virtual tour guide and the operator of the software for smooth operation of the virtual tour. This decision was made to minimize the stress for the training participants in viewing and following the online virtual tour.

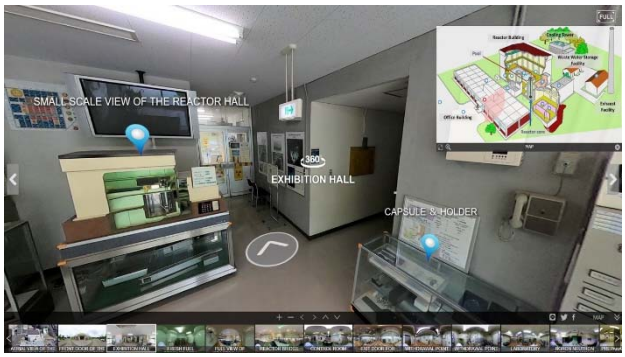

Fig.9 Clicking the Arrow moves the virtual tour to the next room

(4) Group discussion

The discussions were conducted in the designated virtual break-out rooms as shown in Fig. 10 and Fig.11 respectively. The participants were divided into 4 groups with 4-5 members for each group. A facilitator was assigned to each group. A facility operator was also assigned to each group; it allows the participants to ask

Fig.10 Group layout (Each group has Instructor, Facility operator and technical staff. Instructor confirms reaction from participants using a bigger screen.)

questions to the operator during the group discussion. This made the exercise as effective as an actual facility visit. During the first 30 minutes, each group discussed the DIQ as a whole. However, thereafter for the next 20 minutes, each group was assigned a specific topic: nuclear reactor, fuel flow, fuel handling and storage, and coolant system respectively. The participants are requested to review the contents of the questionnaire, and confirm the consistency of the information provided by the facility operator against those presented through the virtual tour; discussed the contents to be provided in the DIQ, and explained why the DIQ is important for safeguards implementation.

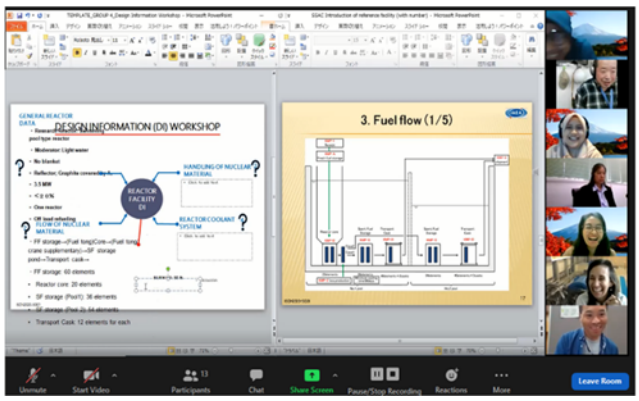

Fig.11 An example of a group discussion using Zoom

The participants were given the time to work on the summary of their discussions before the presentation.

(5) Presentation by the participants

Same as in-person course the representative from each group presented the results and assigned points for the discussion in the main room. This was done on the next day.

(6) Wrap-up summary of the exercise

Same as in-person course following the group presentations and Q/A, the lead instructor provided feedback and a wrap-up summary of the exercise.

Based on the training course survey results the participants have commented that the DIQ exercise was well received and that the virtual tour was effective and excellent.

C-2. Complementary Access (CA) Exercise

CA exercise was conducted as part of the FNCA Workshop in February 2021 with the aim at providing an overview of CA with emphasis on what the participants (e.g., safeguards-related personnel from national authorities and stakeholders/operators) need to know to prepare in advance of CA. This exercise used the same virtual tour contents as the research reactor used for the DIQ exercise. However, some of the route order was modified and utilized for the CA exercise. The structure of the CA exercise is as follows:

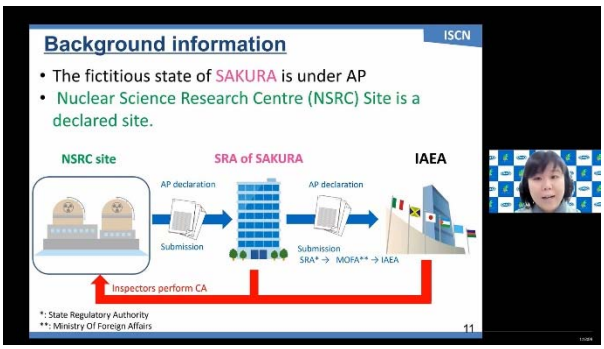

Fig.12 A scenario presentation on Zoom

(1) A scenario presentation and flow of the CA of a hypothetical country

Firstly, an overview of the CA was explained,

followed by a scenario-based exercise as shown in Fig.12. The demonstration consisted of a provision of an advanced notice of the CA, exchange of notices/information between the State Regulatory Authority (SRA) and the facility operator, an opening meeting on the day of the scheduled CA, a closing meeting, and an open discussion with participants. The demonstration with the virtual tour was conducted between the opening meeting and closing meeting of the CA scenario-based exercise.

(2) Demonstration of in-field verification with the virtual tour

The IAEA inspector's activities (environmental sampling, taking pictures, interviews, etc.) were shown as pop-ups and a demonstration of taking environmental samples from the newly created air duct flow was conducted using a virtual tour as shown in Fig.13. This was a modification made by using the previous virtual tour from the DIQ exercise to demonstrate the CA exercise.

Fig. 13 Images of the virtual tour for CA exercise
(left: Exhaust facility, right: Pop-up and explanation of the IAEA activities conducted)

(3) Open discussion

The facilitator initiated the discussion by asking a question. For example: “What can the SRA/operator prepare in advance for the CA?”. Answers from the participants are actively received and discussed. Since some of the FNCA participants are not familiar with CA activities the virtual tour gave them a better description of what is needed and how to strengthen SSAC in their respective countries.

D. Experience - Effectiveness of Virtual Tours

When physically touring a facility during an in-person training course, with the narrow hallway in the facility, the amount of information needed to confirm the equipment being explained by the facility operator may differ from theparticipant.. It may also require the need for more staff from the facility as escorts to satisfy nuclear security regulatory requirements. However with the virtual tour, the equipment or location that needs to be emphasized can be explained on the screen in a static or enlarged format. Thus, everyone can confirm the object is explained in the same way. It also eliminates the need for security escorts and administrative procedures for radiation protection

requirements for training participants.

This virtual tour runs in the cloud server. It is also possible to record a video of the tour in mp4 format . So it can be provided as a video in environments where the cloud server is not accessible.

The virtual tour can be considered an effective tool for in-person courses as well. In the case of in-person courses, after visiting the actual facilities, the only way to discuss the contents of the tour was recalling one's memory. However by creating the virtual tour, it became possible to review and discuss by using the videos of the virtual tour during the group exercises.

Experience from the DIQ and CA exercises has demonstrated that the same virtual tour of a research reactor could be used for various exercises. When a virtual tour for a facility is developed, it can be used asa training tool for multiple topics by changing the pop-up screen and tour route as shown in Fig.14.

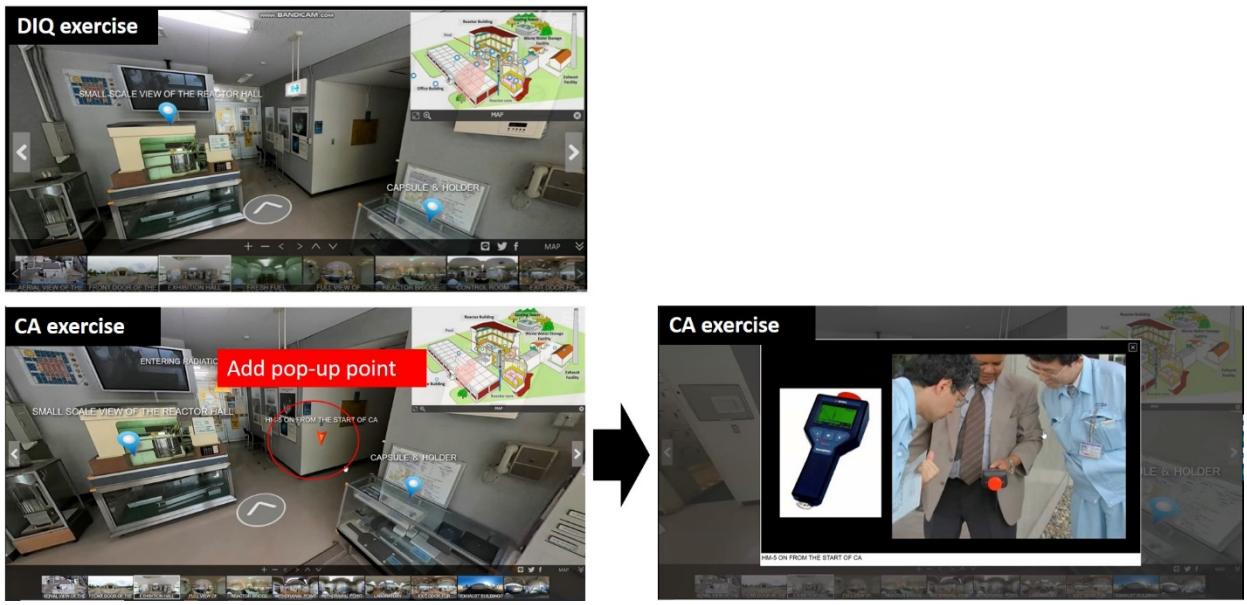

Fig. 14 Example: add a pop-up for CA exercise to a scene for DIQ exercise.

Although this facility is scheduled to be shut down in a few years, the structure of the research reactor facility is very simple and easy to understand for educational purposes, so by creating a virtual tour of the facility, the assets of JAEA can continue to be used for educational purposes in the future. It will also serve as a historical record of the facility.

Furthermore, this developed virtual tour has the potential to be used in the field of physical protection of nuclear materials. For example, to introduce the equipment used for physical protection systems such as cameras, sensors, and so on.

E. Conclusion

ISCN has successfully developed the world's first online virtual tour of a safeguards-related verification activity, for a DIQ exercise in the Online RTC-SSAC held in November 2020. The development of the virtual tour proved to be a very effective tool in the online course. It has

succeeded in stimulating the intended discussion during the group exercise. The virtual tour can be an effective tool for in-person courses as well because of its video capability. Both instructors and participants can easily go back to the facility images that may need further explanation.
Based on the virtual tour created for the DIQ exercise, a modified version was also created for a CA exercise in the online workshop of the Nuclear Security and Safeguards Project under the FNCA held in February 2021. Following the successful results from these exercises, it was found that if a virtual tour is created even for one facility, the developed virtual tour can be used as a great training tool for numeroustopics by changing the pop-up screen and tour route. Modifications can easily be made to tailor the virtual tour for an intended exercise.
It is also worth mentioning that the use of virtual tours has eliminated the need for security escorts and administrative radiological requirements for training participants.
This time, ISCN created a virtual tour of a hypothetical facility using a research reactor that is scheduled to be shut down. It was shown that the virtual tour would allow ISCN to continue to use JAEA's property for educational purposes in the future, and would also serve to be useful as a historical record of the facility. Furthermore, the developed virtual tour has the potential to be used in the field of physical protection of nuclear materials, for example, to introduce equipment used for physical protection systems.

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