Development of Disaster Prevention Technologies DMP, kAmI, *Xercyber*®, Simulator for Multi Movement Means Evacuation, CAS

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Since the Fukushima Daiichi Accident, construction for the implementation of safety measures is being carried out at nuclear power plants. On the other hand, attention is also being focused on support system technologies related to disaster prevention for decision making and the evacuation of residents in the event of a nuclear disaster, as well as for precautionary measures against possible future cyberterrorism.

This report presents the following: (1) the DMP support system coupled with kAmI for decision making in times of emergency, (2) ***Xer****cyber*® *cyberattack defense exercise service, (3) evacuation simulation in the event of a nuclear disaster and (4) Clean Air Shelter*® *(CAS) to reduce the internal radiation exposure of evacuees.*

1. Decision-Make supporting Panel (DMP)

When it comes to emergency response in the event of a disaster or other accident, it is not realistic to prepare a manual covering all possible courses of all possible events. Human beings decide how to react. However, information gathering, thinking logic and judgement at the time of making a decision are highly dependent on individual capabilities. Disaster response entails the engagement of a great number of people. The key therefore lies in the quick gathering and the sharing of accurate information.

Under such circumstances, DMP uses digital technologies to help emergency responders to quickly gather accurate information, enabling the director to strategically decide what to do while predicting what course the event will take. **Figure 1** is a diagram to show how DMP can help with decision making and futures of DMP are described in the following (1) to (4).

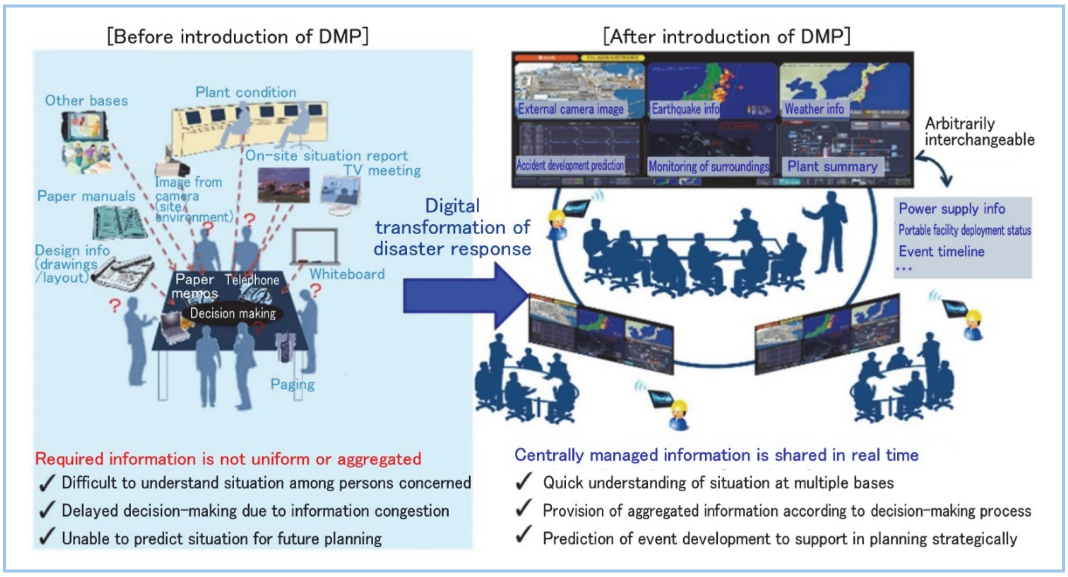

Figure 1 Use of digital technologies to support in making quick and accurate decisions

(1) Provision of contents that enhance responsiveness in the event of an emergency

Necessary functions are programmed as applications in DMP because we have ergonomically analyzed the tasks in response to emergency situations (e.g., behavior observation and task analysis). These applications have a user-friendly interface allowing intuitive understanding and manipulation, owing to our human-system interface design technology, which has been accumulated through our work experience with the main control room of nuclear power plants. As a combination of multiple applications are running in DMP, it is possible to first introduce the most effective one initially (small start), and later the others can be added while DMP is in operation.

(2) Real-time information sharing by following changes in the situation

The centralized management of information, coupled with network connection, enables multiple bases to share the same information in real time. As data linkage with the various already-introduced disaster prevention systems is possible, the effect of these systems can be enhanced.

(3) Support in making strategic decisions based on future prediction

Digital twin and AI technologies are used to detect incipient signs before human beings notice. For each proposed measure, simulation is performed to see the future outcome as an indicator and determine which one should be selected, thereby helping the director to make strategic decisions.

(4) Improvement of handwritten information (analog information) sharing

The user's burden of inputting data into the system has been reduced by employing the latest digital technologies such as input by recording a video of the scene, automatic acquisition of location information through systems such as GPS and speech-to-text reporting. However, rapid digitalization causes the operation at the site to change substantially, which may lead to some confusion. Therefore, DMP is equipped with a digital input system that requires no change in the on-site operation, called "kAmI" (named after the word "paper" or kami in Japanese, which contains the letters AI). At headquarters for disaster control, an outline map or whiteboard is used, and the information is manually written on it. While this makes it easy for those present at the site to share information, it is difficult for those away from the headquarters. By using kAmI, the outline map or whiteboard is photographed on a regular basis and AI technology is used to extract updated information based on the deltas. The sharing of handwritten (analog) information has thus been made possible. **Figure 2** shows the flow of data when using kAmI.

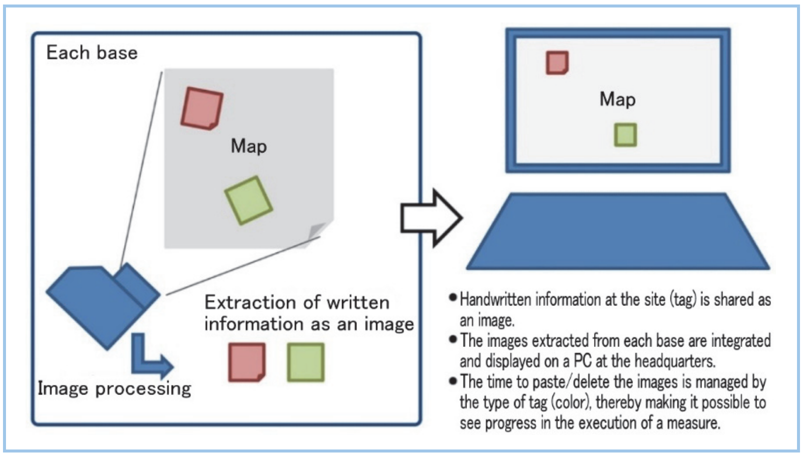

Figure 2 Data flow using kAmI

2. Cyberattack defense exercise service: *Xercyber*®

The increasing number of cyberattacks on not only information systems, but also industrial systems, raises particular concern about the wide-reaching impact on critical infrastructure, for which cybersecurity (CS) measures are urgently required. Continuous efforts are also needed. As CS measures, it is necessary to not only use various types of security assessment/tool applications already in wide use, but also work together on an organization-wide basis, and it is important to improve the literacy of people and organizations and to foster a culture that contributes to it.

In addition to various security assessment/tool applications for nuclear power plants, we have developed a cyberattack defense exercise called *Xercyber*® (so named by combining the words "exercise" and "cyber") in order to improve, as a measure against unexpected events, individual and organizational literacy and creation of culture. It was released early in 2019 as a defense exercise service for customers.

Xercyber® provides a participatory group work exercise. Familiarity (ease of use), reality (realistic scenarios) and portability (usable anywhere) are the three conceptual pillars of the course contents for enhanced effect. There are two courses available depending on the level of the participants. The beginner course, which was already been taken by many participants, has been well received, and many requests have also been made for the advanced course. The characteristics of each course are described below. **Figures 3** and **4** explain what these courses are like.

(1) Beginner course (gamification exercise): improvement of security awareness/literacy for all staff
- Group-match type game using a nuclear power plant as a model
- Use of game boards/cards/cloud-based software
- Able to take part from an office or meeting room at the site

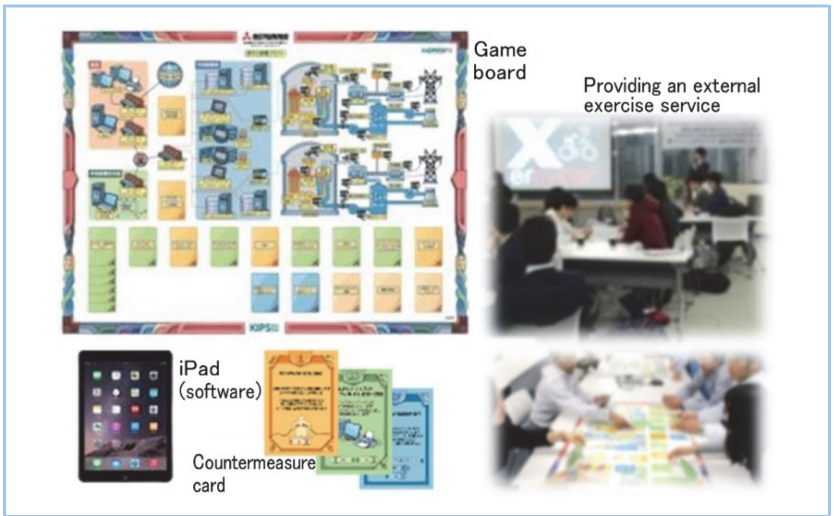

Figure 3 Beginner course image

(2) Advanced course (simulator exercise): improvement of front-line responsiveness for operators, maintenance/repair staff, etc.
- Cooperative exercise using pressurized water reactor (PWR) operation training simulator
- Exercise scenarios according to the actual facilities and safety functions
- Able to take part from a training center or training room

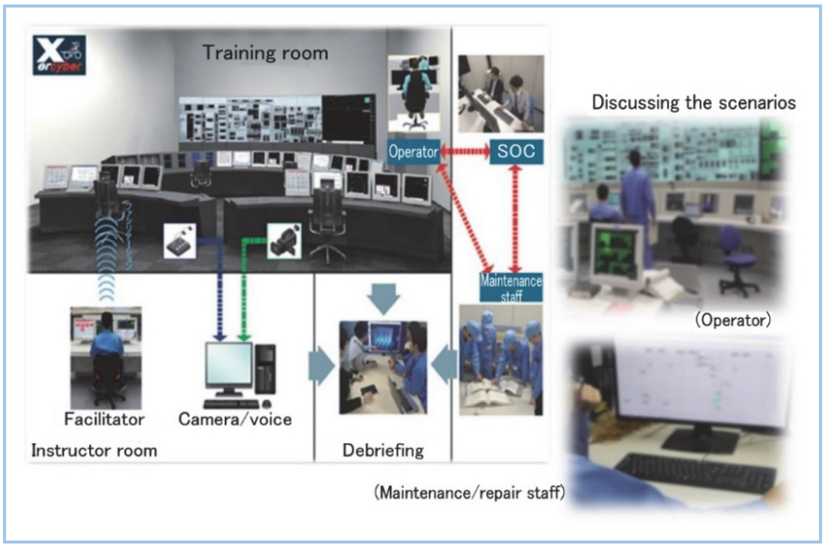

Figure 4 Advanced course image

For critical infrastructure, the risk of cyberattack is increasing and tactics are becoming increasingly sophisticated every day. Under such circumstances, we do hope ***Xercyber***®, which utilizes both our expertise and know-how in the design and maintenance of nuclear power plants will contribute to improve disaster prevention and foster a culture of safety awareness among individuals/organizations so as to be able to appropriately respond even in the event of an unexpected cyber incident.

3. Simulator for multi movement means evacuation

Nuclear disasters are characteristically differentiated from other disasters, for example, because of the identifiable location of the disaster before an incident actually occurs, and the extensive area to be included for the implementation of precautionary measures (according to the national government, the area requiring an enhanced system for nuclear disaster prevention is designated as an area within a radius of about 30 km around a nuclear power plant). Because of this, for nuclear disaster prevention, it is important to perform evacuation simulation beforehand so that possible problems can be extracted. This enables appropriate measures to be implemented. The resulting effect should be confirmed by disaster drills. However, urban areas are often included within an area of a radius of 30 km around a nuclear power plant. In such urban areas, the number of people subject to evacuation may amount to nearly a million. Furthermore, since it is difficult to predict in advance the exact situation of the disaster that has occurred at a pinpoint, simulation needs to be performed based on multiple disaster scenarios.

Therefore, large-scale computation needs to be rapidly performed by simulation programs (to simulate the behavior of a million evacuees who are moving within an area of a radius of several dozen km). For this, MHI has developed an original program based on the simulation technology accumulated through our expertise in nuclear fusion.

In the particle-in-cell (PIC) method used for nuclear fusion plasma simulation, plasma fluid is represented by several tens of thousands to several million particles and their behavior is simulated. As the interaction between particles is also considered, high-speed processing is employed to perform such large-scale computation. In the development of an evacuation simulation, the behavior of charged particles is replaced by that of evacuating vehicles. Thus, by applying many components of the plasma analysis program to evacuation simulation, we succeeded in developing a network potential method in a short period of time. With this method, it has become possible to perform simulation with a population of 970,000 individuals within an area of a radius of 31 km to evacuate (the time allowed for evacuation is 48 hours) in about 10 minutes. **Figure 5** illustrates the concept of the network potential method. The areas in proximity to hazards are regarded as high potential, while shelters, etc., are considered low potential. Supposing that the potential is propagated through the network, Poisson's equation is solved to calculate the potential in the evacuation route. The behavior of evacuees is simulated by supposing that they move from high potential to low potential areas.

So far, we received simulation requests for five nuclear power plants, thereby helping to improve evacuation plans in these areas by using this technology.

As related technologies, we have recently developed a simulation program for the estimation of the number of responders necessary to build an evacuation system or the creation of an action time schedule for relevant organizations, thereby also enhancing the viability of evacuation plans.

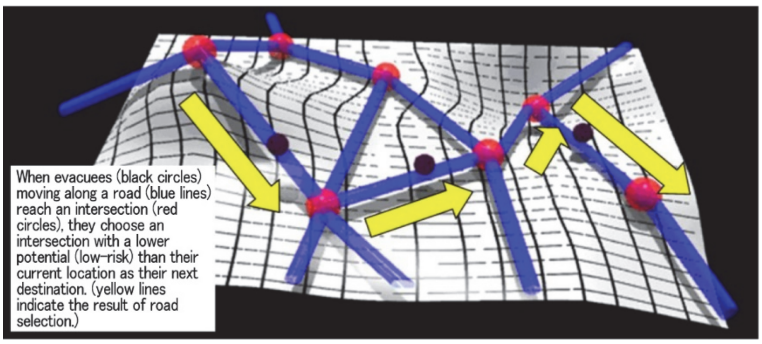

Figure 5 Concept of network potential method

4. Clean Air Shelter®: CAS series

Facilities such as gymnasiums and community centers, which are designated as shelters in the event of a nuclear disaster when shelter in place is activated, may be equipped beforehand with air shelters, as a measure for airtightness. These air shelters can be quickly set up to reduce the internal radiation exposure of evacuees. The Clean Air Shelter® (CAS) consists of the air cleaning unit (constituted by an air blower, HEPA (High Efficiency Particulate Air Filter) filters and a radioactive iodine removal filter) and a tent. In addition to the capture efficiency of the high-performance filter, CAS can prevent the entry of radioactive substances into the air shelter by maintaining positive pressure inside using the air cleaned by the air cleaning unit. A total of 61 CAS units have already been distributed to 22 facilities in Japan (as of April 1, 2020). The HEPA filter boasts an air cleaning performance with a capture efficiency of ≥99.97% for radioactive particles such as cesium (particle: 0.15 μm). The radioactive iodine capture efficiency of the radioactive iodine removal filter (activated carbon fiber filter) is ≥99.99%, and with these levels of performance, evacuees can be protected from radiation exposure. **Figure 6** gives the major characteristics of CAS.

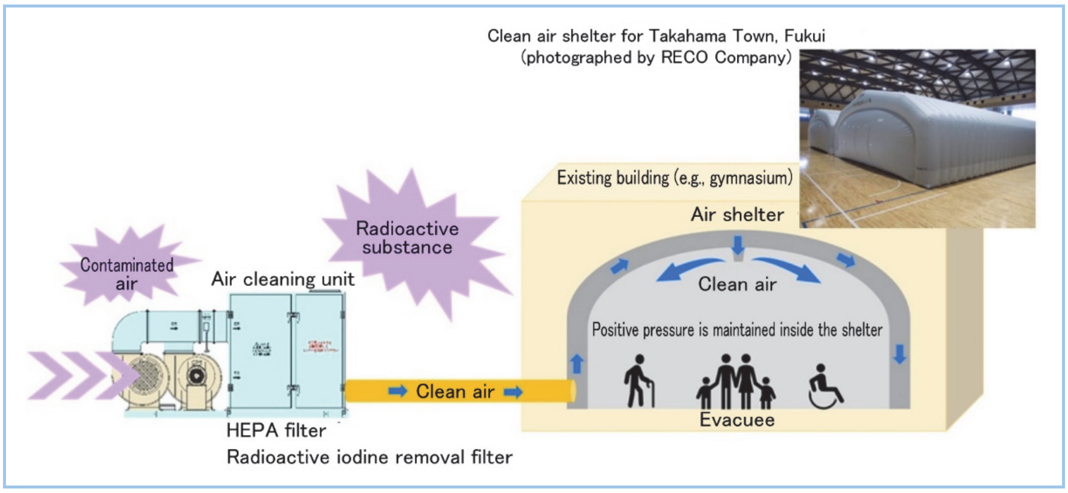

Figure 6 Characteristics of CAS

Having a predetermined sheltering facility in which necessary equipment is installed is a prerequisite for CAS use. In the event of a natural disaster such as an earthquake, shelter-equipped facilities such as gymnasiums may not be available because of building damage or landslides on roads. On the other hand, it is difficult to provide CAS to all facilities serviceable as a shelter. Therefore, based on CAS, MHI has developed the Movable Clean Air Shelter (M- CAS) that does not require a predetermined place for installation. The components of M-CAS such as the air cleaning unit and an air shelter made of lightweight and high-strength polyester suitable for compact storage can be stored at bases for stock in ordinary times, and in the event of an emergency, these modular components can be promptly transported by 4-ton truck to a designated facility for installation. **Figure 7** shows how this is done.

Moreover, using CAS technology, MHI has also developed a clean air shelter for medical purposes that can be used as a measure against Covid-19 infection (Medical CAS or Me-CAS). With the negative pressure inside Me-CAS, an exhaust system with medical filters is operated to prevent the spread of viruses, etc., from the inside of the shelter (meeting the standards for medical isolation facilities by the U.S. Centers for Disease Control and Prevention or CDC). **Figure 8** depicts an exterior and a plan view of Me-CAS, while **Table 1** lists the specifications.

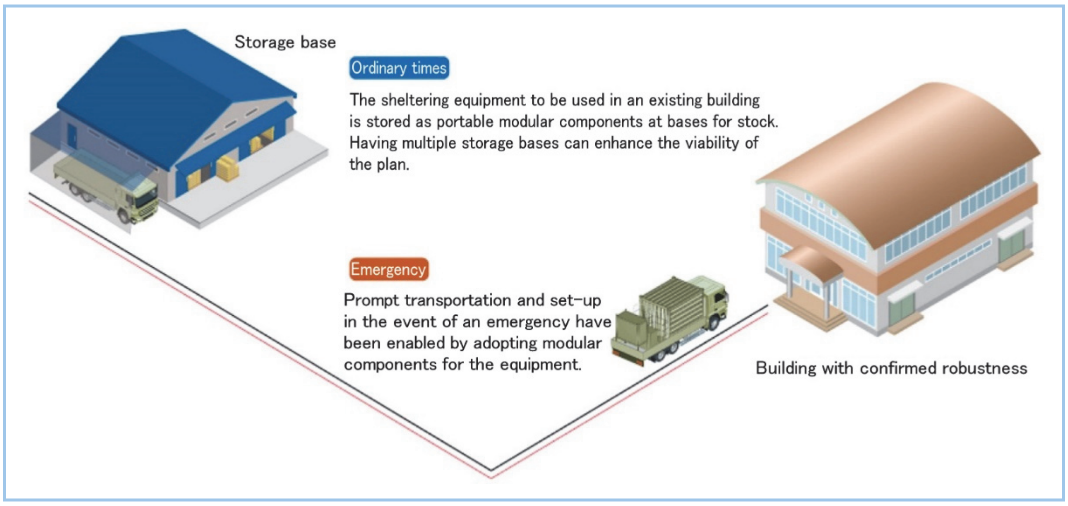

Figure 7 Illustration of M-CAS use

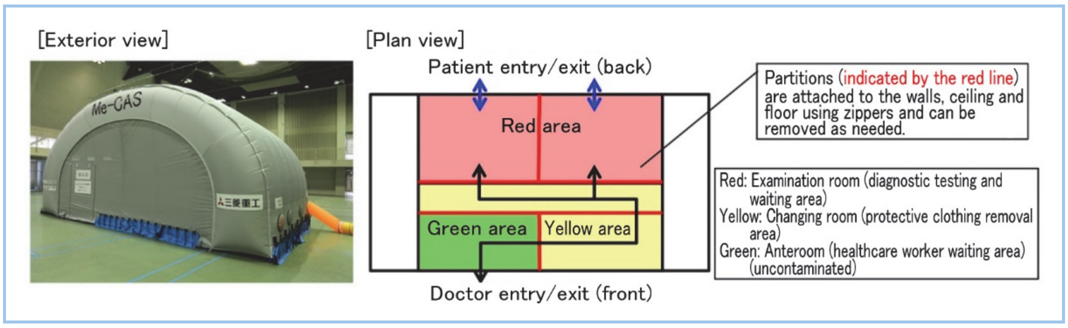

Figure 8 Me-CAS exterior and plan view

Table 1 Me-CAS specifications

Item	Specifications
Tent	External dimensions: 8400 mm (W) × 4380 mm (D) × 3900 mm (H) Internal dimensions: 6000 mm (W) × 4380 mm (D) × 3000 mm (H) Place to install: Outdoor Separated lines of flow: Entry and exit areas for healthcare workers are separated from those for patients.
Exhaust fan with HEPA	Air flow: ≥8.5 m^3/min Filter: Infection prevention HEPA filter Power supply: AC 100 V, 50/60 Hz
Frequency of air change	All rooms: ≥6 times per hour (≥12 times in the case of examination room)
Operating pressure	-3 Pa

5. Future prospects

As a plant manufacturer, MHI will continue to strengthen hardware/software support systems for disasters related to not only nuclear power plants, but also various types of natural disasters and accidents.

Xercyber® is a registered trademark of Mitsubishi Heavy Industries, Ltd. (MHI) in Japan, while Clean Air Shelter® is a registered trademark of RECO Company, Ltd. (an MHI group company) and Teijin Frontier Co., Ltd.