Decommissioning Process **"Common Issues"**
Investigation Subject **"Visualization technology (including 3D)"**

Needs

1. Developing a technology for three-dimensional visualization under high radiation

Fuel Debris Retrieval：【Short】【Long 2】

Desired state and reasons for it

- In order to understand the dose field and contamination status based on the information of source strength, source direction, distribution, etc., by using the radiation measurement results, it is desirable to develop a visualization technology using virtual reality, etc. The visualization technology is expected to lead to effective decontamination and worker exposure reduction by identifying contamination locations.
- It is desirable to be able to measure the nuclides and properties of nuclear fuel and radioactive material remotely or on-site..
- It is also desirable to have a technology to visualize not only the results of radiation measurements but also the huge amount of data obtained..
- Video is taken when surveying inside the primary containment vessel (PCV)／reactor building. It is desirable to be able to quickly and automatically digitize the video data in three dimensions so that the surrounding situation can be recognized in three dimensions and from a bird's eye view.
- In the future, an internal investigation of the RPV will be conducted, where higher radiation dose is expected. Since the RPV is expected to have a distribution of radiation dose even inside, it is needed to understand the distribution of FP and fuel debris by visualization of radiation／neutrons.
- Radiation resistant technology is required to visualize the internal environment even under high radiation dose (in PCV／RPV) and poor visibility environment during fuel debris removal.

Current state against ideal

- Since FY2021, as part of the research and development for the project for decommissioning of nuclear power plants and treatment of contaminated and treated water, a digital technology to identify radiation sources using environmental survey data and to visualize the environment and source distribution using digital technology have been developed in order to establish a safe and efficient work plan. In FY2022, a prototype was built, and since FY2023, development has been underway to improve the functionality of the technology for field application.
- For further expansion of the scale of retrieval of fuel debris and in-core structures, visually understanding of contamination sources, grasping air dose rates, etc., and estimation of source distribution on the surface of structures are important processes. Then, there are two technology direction: one is a visualization technology using on-site measurement equipment, and the other is a 3D visualization technology using secondary processing of the measurement data by separate software processing.
- As for visualization technology using on-site measurement equipment, the development of a compact and lightweight gamma camera (compact Compton camera) that can measure even in high-dose environments has enabled rapid visualization of localized contamination (hot spots)

with surface dose rates of a few mSv／h, as well as 3D display and confirmation of such contamination. Gamma-ray imagers equipped with a fisheye camera enable 360° scanning of spherical objects.

- As a technology for 3D visualization with secondary processing by software, research and development is underway for a source inversion estimation system that estimates the source distribution on the surface of a structure based on information on the structure's condition (location, shape, physical properties, etc.) and spatial dose rate, and for visualization in cyberspace using digital technology such as VR, etc. A system that generates pseudo-overhead images using images taken by cameras mounted on a robot from the front, back, left, and right has also been reported. In the future, it is expected that drones and robots will be mounted to remotely grasp detailed contamination distribution in the buildings, and that development of measuring and visualization equipment that integrates the above two types of technology directions will also progressed.
- The conditions inside the primary containment vessel (PCV)／reactor building (location of equipment and facilities, condition of floors, walls, and ceilings) have changed drastically after the accident, though currently it is not completely grasped the situation in each area. In addition, camera images are not available for 360 degrees, and since they are obtained with limited lighting, in a high-dose environment by remote operation, it is not possible to spend a lot of time to understand the current situation and obtain data.

Issues to be resolved

- As a prerequisite for visualization technology, it is necessary to have a processing device that can even transmit image data under high radiation.
- It is necessary to improve radiation resistance of electronic integrated circuits such as CMOS.
- In particular technologies that can automatically measure and automatically visualize data are required for radiation measurement, etc.
- It is necessary to proceed with the development of visualization technology keeping in mind whether the main radiation is gamma rays or beta rays, etc.
- It is necessary to develop position detectors for alpha and beta nuclides, which are difficult to detect.
- It is necessary to develop a technology for 3D imaging of radiation distribution in high-dose rate areas in buildings by integrating 3D optical images with radiation images measured with a measuring device mounted on a robot. In particular it is important to understand where the sources are located in high-dose areas. The ability to create 3D maps will enable the formulation of decontamination and other countermeasures.
- Currently, 2D imaging is used, which has the issue that it is difficult to get a sense of perspective. It would be good if it can be visualized in 3D on the working screen.
- It is desirable to construct an advanced 3D visualization system integrated with VR.
- In the future, as work in the reactor building (by humans and remote equipment) will increase for the retrieval of fuel debris, etc., it will become increasingly important to understand the situation inside the building from the perspective of improving safety and work efficiency. To understand such situation, it is desirable to be able to quickly obtain detailed on-site 3D data and use it for the next work plan. Therefore, it is necessary to have a technology that can quickly and automatically digitize 3D data from moving images (e.g., an optical camera attached to workers entering the on-site or a remote device).
- It is difficult to discriminate neutrons in the RPV due to the high radiation environment. In such a situation, if the location of fuel debris can be easily identified by a radiation imager and a neutron imager, it is expected that conservative measures can be relieved in terms of criticality control during the internal investigation and fuel debris removal, thus leading to efficient fuel

debris removal. Radiation and neutron imagers are required to have high radiation resistance and a certain level of accuracy (especially neutron discrimination).

- In fuel debris retrieval, dust is generated while fuel debris and in-core structures are processed, and the environment will be dusty in the air and turbid in the water. In such an environment, it should be possible to accurately grasp the fuel debris fabrication site and surrounding conditions. In a dusty environment in air and a turbid water environment in water, there are limitations in knowing the situation using an optical camera. Therefore, a radiation-resistant ultrasonic measuring instrument should be considered for use. The technology that can be applied especially in turbid water environment can be used in investigation of the interior of the suppression chamber.

Relevant Issues

- FDR-106 “Understanding contamination status inside buildings”
- FDR-202 “Shielding and decontamination measures”
- FDR-203 “Exposure control of workers inside buildings”
- FDR-204 “Site boundary dose assessment”
- DRB-101 “Assessing conditions inside reactor and buildings (for dismantling)”
- DRB-202 “Establishing sorting criteria by alpha, beta and gamma contamination”
- DRB-205 “Decontamination and dose rate reduction”