DigiDecom 2021

JAEA decommissioning status and its approach for the digitalization

23.3.2021

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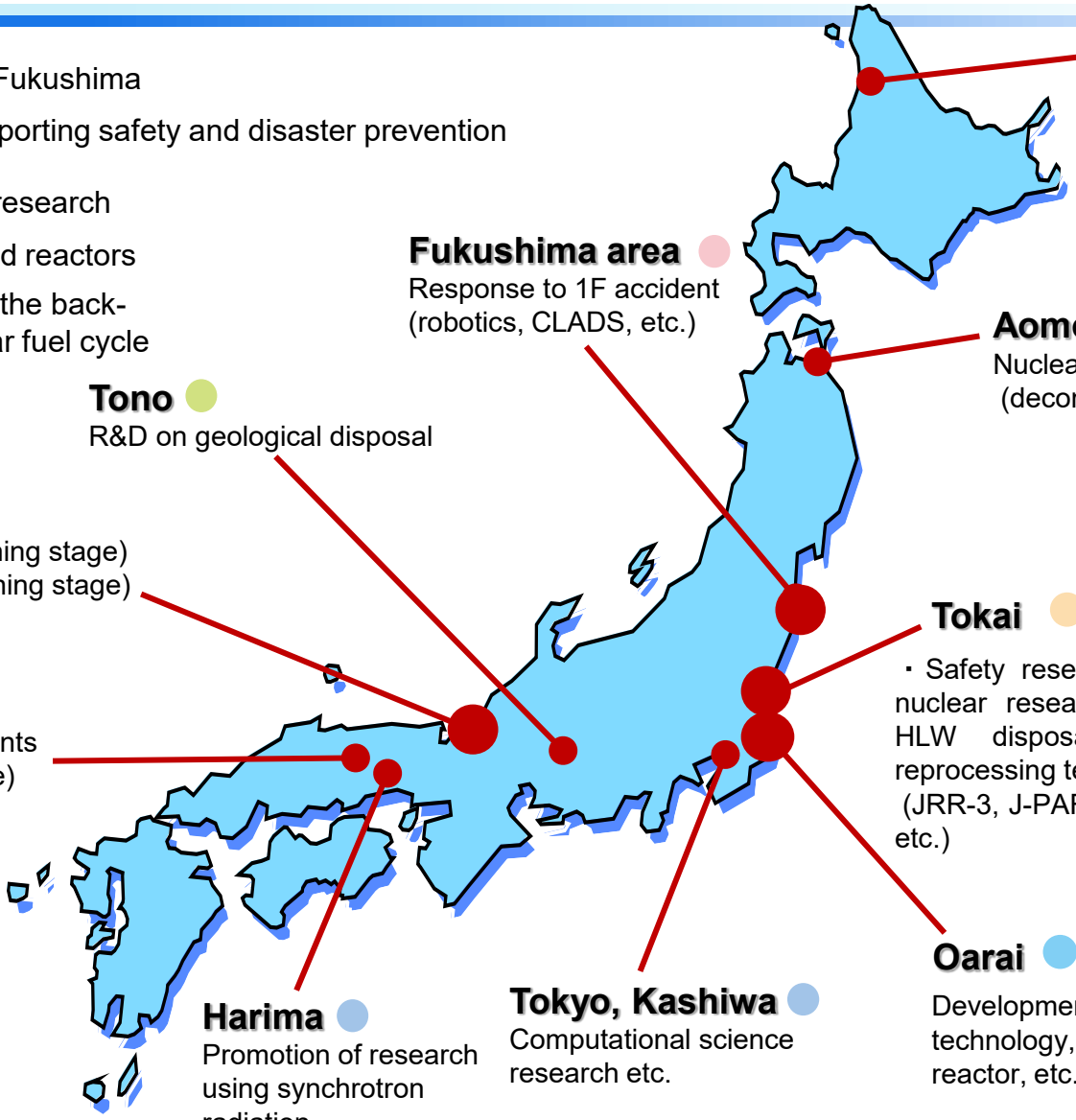
Current status and Backgrounds

- Japan Atomic Energy Agency (JAEA) is **Comprehensive nuclear R&D institution** in Japan, that based on the Atomic Energy Basic Act
  - Established through the consolidation of the two institutes in 2005
    - Japan Atomic Energy Research Institute (JAERI)
    - Japan Nuclear Cycle Development Institute (JNC)
  - Number of employees: **about 3,100 over**（March 2020）
- JAEA as a national R&D institute in the nuclear field, has operated a large number of research facilities, some of **which dates back to 1960's.**
- As these facilities are **becoming older** and taking into consideration the post-Fukushima circumstances surrounding nuclear energy use in Japan, it has become **difficult to maintain all the facilities** as before.
- We have decided to enter approximately half of the facilities into the decommissioning phase.
  - Facilities which will be decommissioned include **Fast Reactor Monju** and **Tokai Reprocessing Plant (TRP).**
- The implementation of the decommissioning in a safe and stable manner will be the challenges for the decades to come.
- In the presentation, JAEA's recent initiative on the decommissioning and the current status will be briefly explained.

JAEA's R&D Centers

- R&D concerning Fukushima
- Research for supporting safety and disaster prevention
- Nuclear science research
- R&D on advanced reactors
- R&D concerning the back-end of the nuclear fuel cycle



Horonobe
R&D on geological disposal

Fukushima area
Response to 1F accident (robotics, CLADS, etc.)

Aomori
Nuclear ship "Mutsu" (decommissioning stage)

Tono
R&D on geological disposal

Tsuruga
Monju (decommissioning stage)
Fugen (decommissioning stage)

Ningyo-toge
Uranium enrichment plants (decommissioning stage)

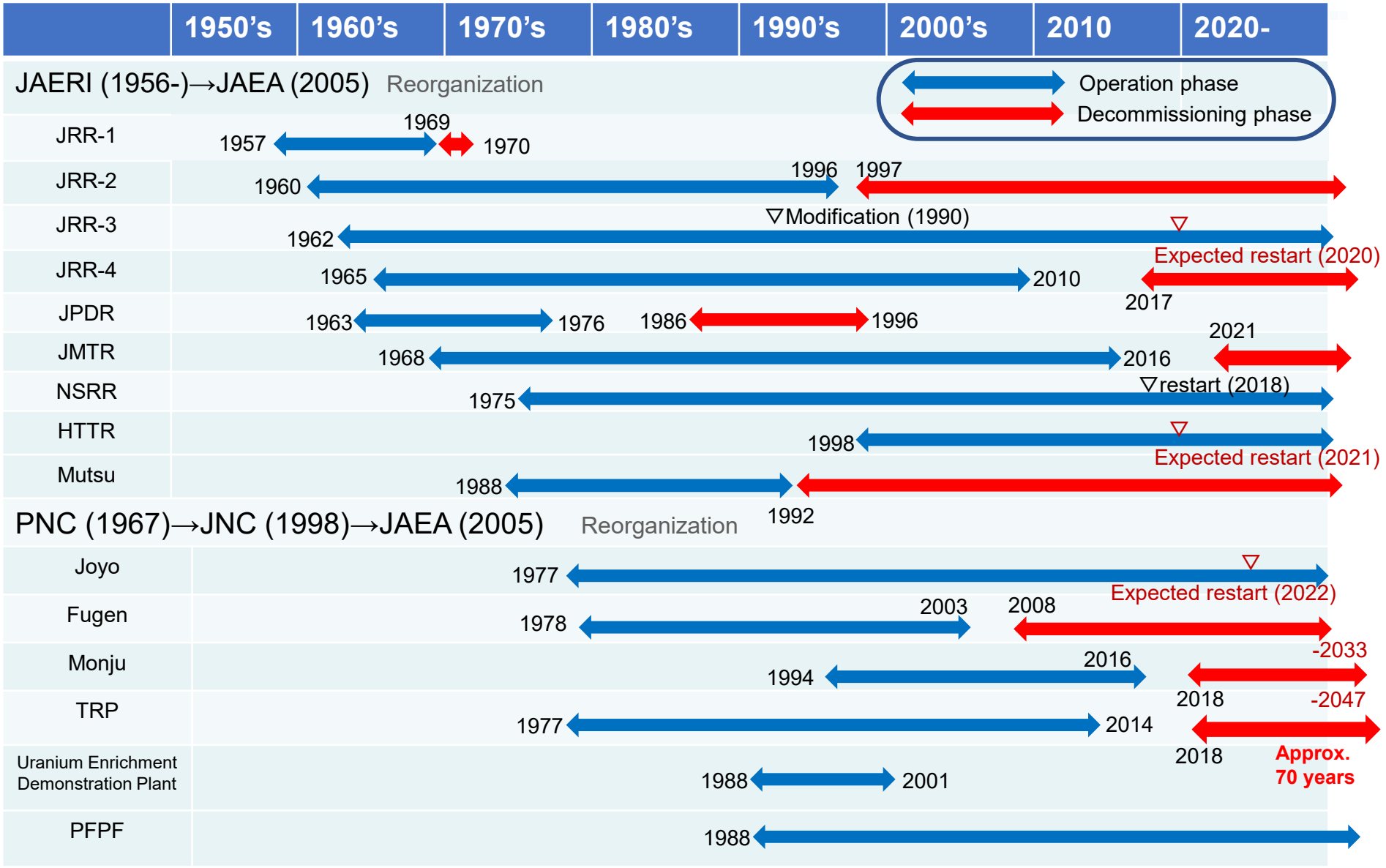
Tokai
・Safety research, Basic and fundamental nuclear research, R&D on technology for HLW disposal, Development of LWR reprocessing technology
(JRR-3, J-PARC, Tokai Reprocessing Plant, etc.)

Oarai
Development of fast reactor cycle technology, high-temperature gas-cooled reactor, etc. (Joyo, HTTR)

Tokyo, Kashiwa
Computational science research etc.

Harima
Promotion of research using synchrotron radiation

Status of JAEA's main facilities



Back-End RoadMap

【Facilities considered 】
All existing facilities licensed by "Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors" → **89 facilities** (as of April. 2020)

Promotion of Back-end Measures (Policy for about 70 years)

- Decommissioning
- RW Processing & Disposal
- Management of nuclear fuel material

➢ **The 1st period (- 2028, about 10 years)**
- Period to implement back-end measures while giving priority to ensuring safety of facilities

➢ **The 2nd period (2029 – 2049, for about 20 years)**
- Transitional period toward full-scale decommissioning through the implementation of the disposal of radioactive waste and the establishment of waste processing facilities

➢ **The 3rd period (2050 - , for about 40 years)**
- Period to implement full-scale back-end measures toward completion

Cost for Back-end Measures

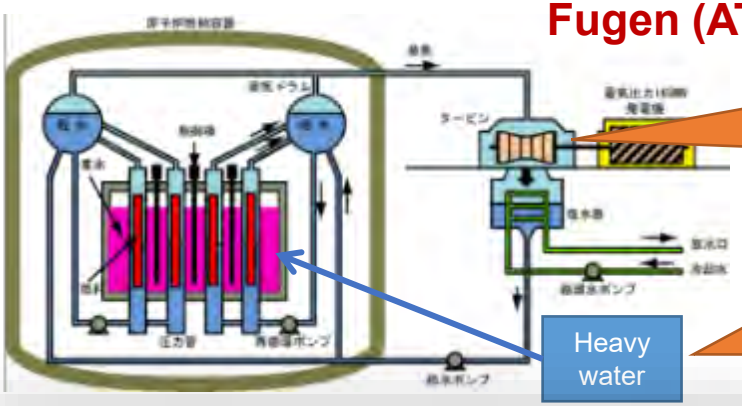
- To estimate cost for decommissioning and RW processing & disposal → **approx. 1.9 trillion yen (=approx. 15 billion EURO)** (for about 70 years)

Effort for Streamlining and Optimization

- To discuss the policy on the development of technology and management system, etc.

CASE STUDY ; Digitalization for Decommissioning in case of ATR Fugen

Fugen (ATR: Advanced Thermal Reactor)

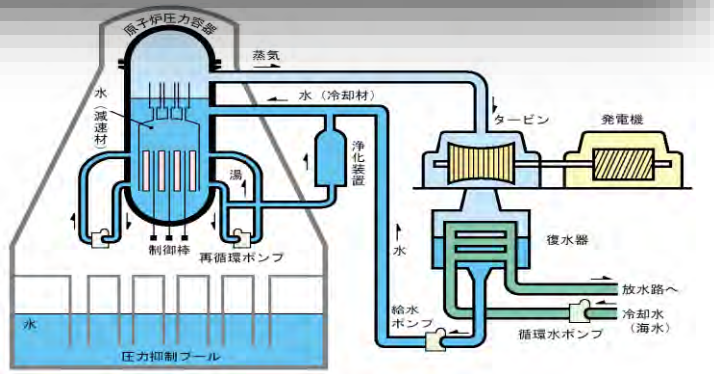


Radioactively contaminated as in the case of BWRs

Including radioactive tritium

	Type of reactor vessel	Moderator	Coolant
Fugen	Pressure tube type	Heavy water	Light water
LWR	Pressure vessel type	Light water	Light water

Power output	Thermal output: 557 MWt Electricity output: 165 MWe
Core	Height: 3,700 mm Diameter: 4,050 mm Number of fuel channels: 224
Fuel	Mixed oxide (MOX) slightly enriched uranium
Heavy water system	Weight with heavy water loaded: 160 t Temperature of heavy water: 70°C
Reactor cooling system	Coolant: light water (H_2O) Pressure: 68 kg/cm^2 Temperature: 284°C (Steam drum) Core flow rate: 7,600 t/h Number of recirculation circuits: 2 loops

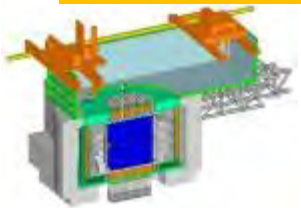


LWR (BWR)

Classification of Decommissioning Technologies in Fugen

Systems Engineering

•VR Support System



•3D-CAD, Evaluation by COSMARD (Planning System), Dismantlement Study, Safety Analysis

Reactor Dismantlement

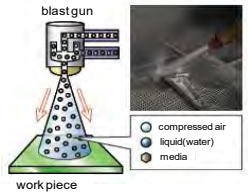
•Study of Dismantlement Machine
•Mock-up Facility Planning
•Dismantling Simulation System

Heavy Water and Tritium Treatment

•Safe and Optimized D2O Removal, Tritium Measurement and Removal, Decontamination

Decontamination

•Development of Optimized Method based on the Decontamination Experience



Dismantling of Common Equip.

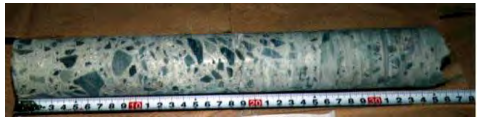
•Study of Automatic and Remote Dismantling System
•Study of Cutting and Secondary Waste Reduction

Material Reuse

•Release Experience
•Study of Metal Reuse
•Study of Concrete Reuse

Processing Work

Spent Resin Test Facility



Concrete Waste

Characterization

•Inventory Assessment by Analysis, Foils, Bonner Ball Measurement and Sampling
•Waste Volume Evaluation by the Inventory, Reflection to Decontamination and Dismantlement

Measurement

•Reflection of Existing Measurement Technique
•Establishment of Optimized Measurement Method

Clearance Measurement Device and Metal Waste

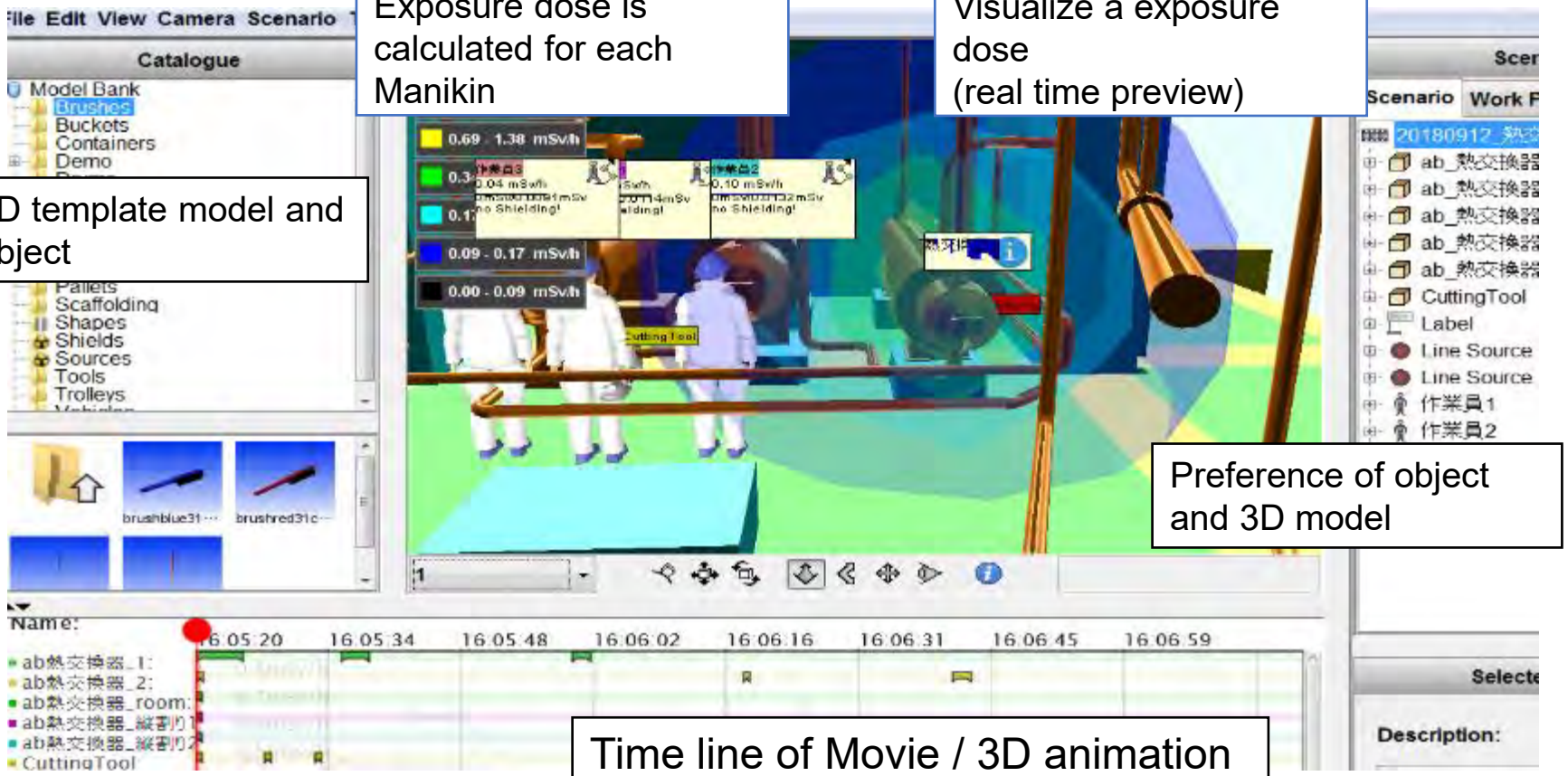
Waste Treatment

•Study of Tritium Waste Treatment
•Study of Large Waste Container
•Development of Spent Resin Reduction and Stabilization
•Design of Waste Treatment Facility

Unique Technology Common technology

Decommissioning simulation software "VRdose"

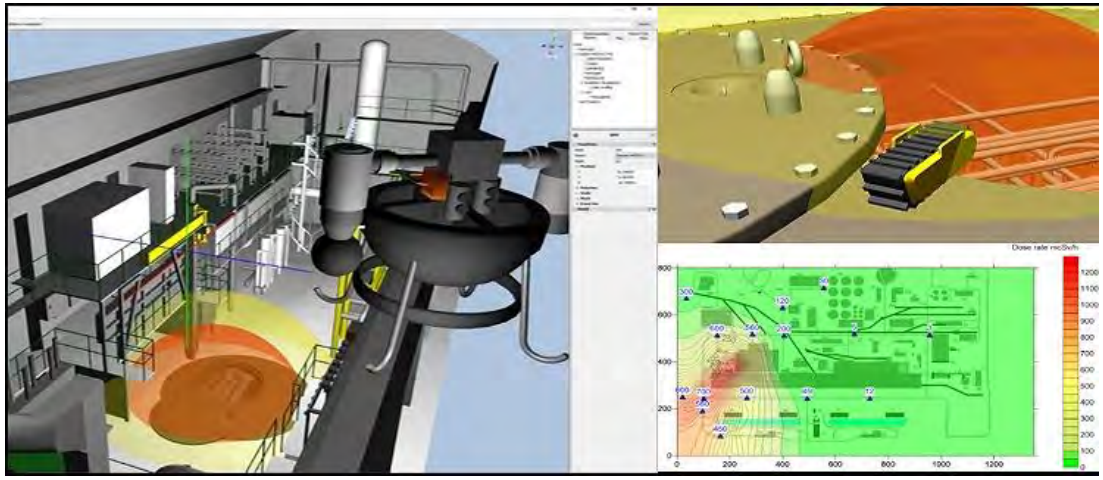
- VRdose is a 3D simulation software that simulates radiation dose risk on real time.
- Fugen and IFE (Institute for Energy Tech. in Norway) have developed VRdose since 1999.
- New functions such as annotation tags for Knowledge Management with expert knowledge or 3D touch function to discuss dismantlement planning, etc.



Advantage and Future possibilities of Virtual Reality

- A VR system called "VRdose" was developed for simulation of work evaluation under radiation environment.
- The system can contribute to the training of decommissioning work and lead to reduction of exposure dose, manpower and cost.
- This concept can be expanded to support additional requirements for use as a training system, coupled with a remote control system, project management and decommissioning knowledge management system, etc.

- The system will be useful for the remediation of the plant after a severe accident such as Fukushima-Daiichi NPP.

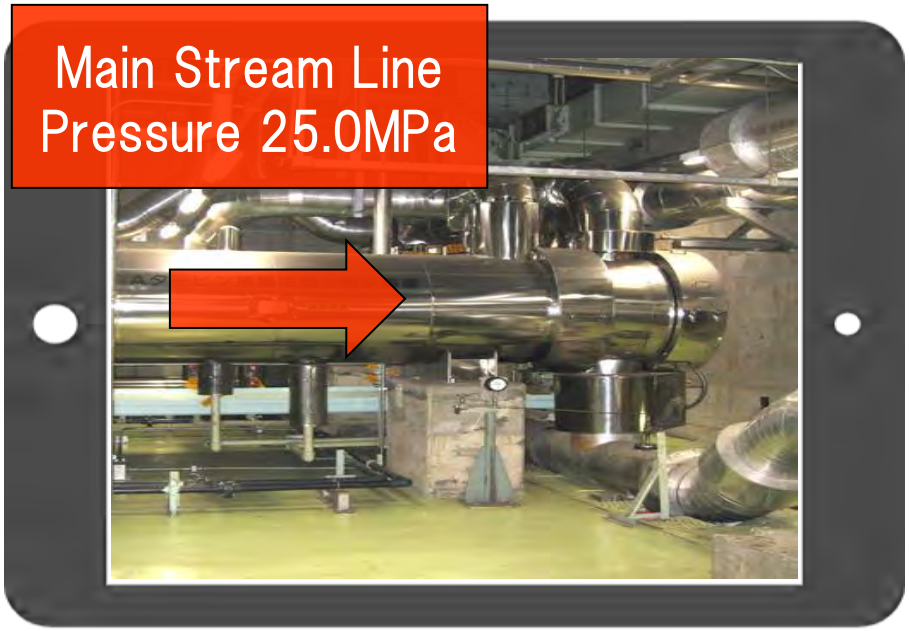


Concept of combination with robotics

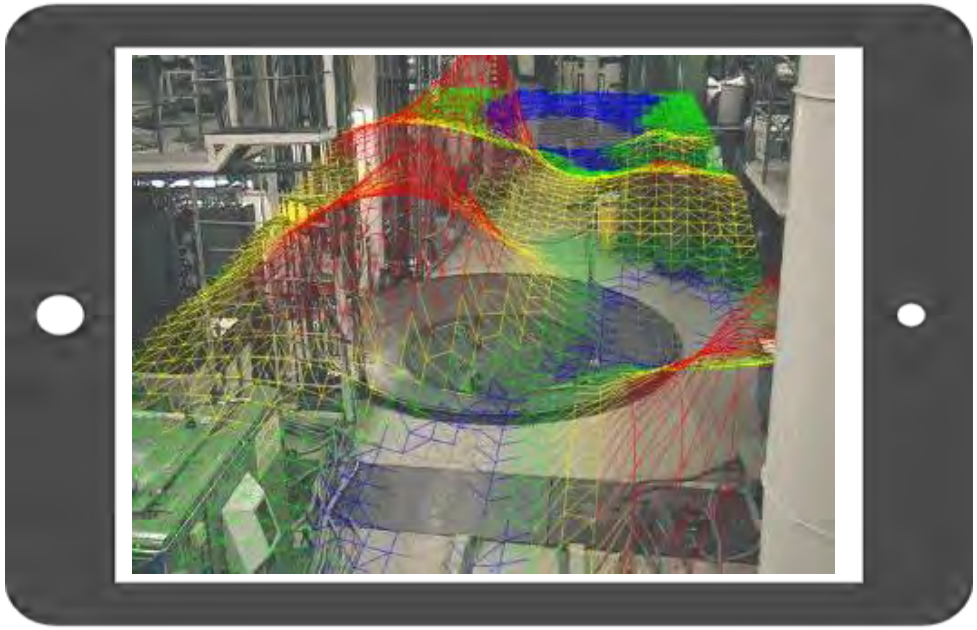
AR system and futures

- AR allows users to see virtual objects generated by computers and real objects in a real environment simultaneously.
- AR can make invisible information visible.
- We are co-operate with other research agency.

JAEA (C) 2015



AR view image ;Visualizing parameters of a pipe's internal flow



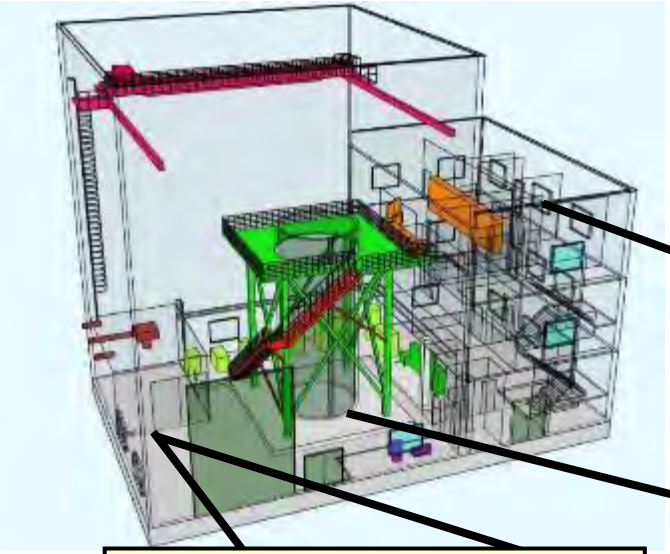
Radiation visualization

FUKUI Smart Decommissioning Technology Demonstration Base

- JAEA opened a central facility of "FUKUI Smart Decommissioning Technology Demonstration Base" (Sumadeco) , as a decommissioning technology demonstration test center on June 16th, 2018.
- This facility is a base to train local companies about technology concerning the decommissioning of nuclear power plants.
- It contributes to the development of the regional economy and the solutions to problems of decommissioning.
- The facility is opened to the utilization by private companies or academia.
- The facility consists of 3 fields:
  1. **Decommissioning Dismantling Technology Demonstration Field**
  2. **Laser Processing Test Field**
  3. **Decommissioning Mock-up Test Field**

Please see
https://fsd.jaea.go.jp/contact/pamphlet_eng.pdf

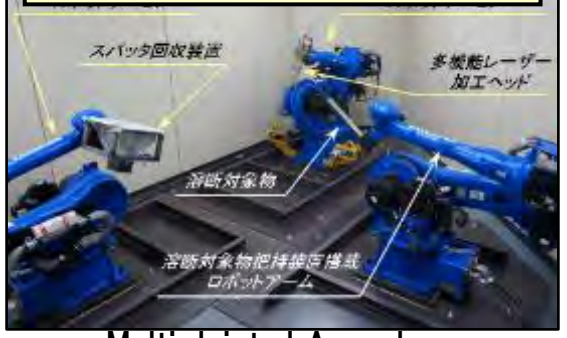
Facilities of Decommissioning Technology Base



Decommissioning Dismantling Technology Demonstration Field

Mixed Reality (MR) System

Laser Processing Test Field



Multi-Jointed Arms Laser Processing System

Mock-up Test Field

Aerial Demonstration Area

Demonstration of Heat Cutting

Demonstration of Mechanical Cutting

【Image of demonstration of cutting of actual materials】

Underwater Demonstration Area

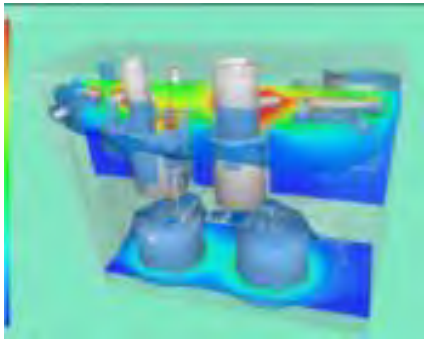
Cylindrical Water Tank
(Height: ca.10.5m, Diameter: ca.4.5m)

Ability of Mixed Reality System

- The MR system is applied to decommissioning work to be used for observing the inside of the plant from the worker's point of view with the actual scale, and also for education and training of optimum working procedures in each phase of the progress of the decommissioning work such as carrying in/out, installation and dismantling etc. of equipment.

Training with MR

Confirmation of work site (The data is from Fugen)
(Realistic sense of presence, checked with worker's eyes)



Consideration of interfering objects

Visualization of the dose equivalent rate (mSv/h)

Confirmation of workability

Confirmation of working space

Confirmation of tool Interference

Confirmation of working posture

<Major features>
1.Examination of optimum work procedure
2.Examination of exposure dose of workers
3.Confirmation of workability (Tool interference, working posture, etc.)

Our Impressions and Comments to VR, AR

- These system can contribute to the planning of the decommissioning and useful for the real situation of dismantling work.
- The system is useful for the training of the workers for dismantlement of the plant in more realistic environment.
- The system enables visualization of the radiation level at the site, examination of the dismantling procedure of the facilities realistically.
- Challenges & Solutions:
  - Making full 3D-CAD data from scratch is very expensive
  - Introduction cost of the system should be reasonable considering the decommissioning cost
    - Cost reduction by laser scanning system
    - System application to the limited places such as high radiation area
  - Workers are typically conservative to new technologies
    - The system should be user-friendly and attractive
    - The system can be used for presentations for citizens or regulators.
- To proceed efficiently, it is necessary to integrate “Digital Decom” and “KM”.

Summary

- Since the early 2000s, ATR FUGEN has been promoting 3D simulation and CAD data preparation as digitization for safety and efficient decommissioning.
  - Currently, tsuruga area is migrating the CAD version to a new one and promoting the use of point cloud data.
  - In addition, spherical images are taken and maintained so that general visitors can tour the inside of the reactor building with VR. It is expected to be available to visitors after this April.
  - FBR Monju is currently acquiring point cloud data and plans to use it for decommissioning.
- In the Tsuruga area, we are currently discussing the promotion of decommissioning measures that utilize digital technology, such as IT and DX, with a broad view of digital technology.
- The aspect of Knowledge Management, We have begun efforts to archive data during the driving era, aggregate databases, search, convert paper data to PDF, and formalize the knowledge of the veteran staff.
- In connection with these, we are developing an engineering system for decommissioning that is integrated with the purpose of more efficiency in decommissioning work, not for IT technology alone.

- Thank you for your attentions.