Workshop on "Current and Emerging Methods for Optimising Safety and Efficiency in Nuclear Decommissioning"
7–9 February 2017, Sarpsborg, Norway

Experiences of development of IT support systems for decommissioning of Fugen NPS

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PURPORT OF NAMING THE NEW TYPE REACTORS

Having in mind the fact that nuclear power represents a very beneficial discovery of mankind which, depending upon its method of usage, can also be a dangerous discovery, we named the new type power reactors developed in Japan as follows:

Experimental Fast Reactor…… “JOYO” ..(常　陽)

Prototype Fast Breeder Reactor…”MONJU”(もんじゅ) (Manjusri)

Prototype Heavy Water Reactor…”FUGEN” (ふげん) (Samantabhadra)

Explanation

JOYO means Eternal Light in Japanese, and is also the name of the area where this Experimental Fast Reactor is sited and spiritual learning flourished. “Monju” bodhisattva is the left hand attendant of Sakyamuni Buddha symbolizing the attribute of wisdom and is depicted riding upon a lion. Fugen Bodhisattva is the right hand attendant of Buddha symbolizing the attribute of compassion. He rides upon a six tusked elephant. Both the lion and the elephant have great power but still this power remains controlled by the wisdom and the compassion that Monju and Fugen Bodhisattva symbolize. Contemporary man has been overwhelmed by the magnificent achievements of natural science and technology while he has been apt to overlook spiritual learning . With our strong hope and desire to harmonize spirituality and science, we have thus designated the Prototype Fast Breeder Reactor as “MONJU” and the Prototype Heavy Water Reactor as “FUGEN”.

絹本着色普賢菩薩像
12世紀　平安時代
Collection of Freer Gallery of Art
Smithsonian Museum
Washington, D.C.　USA

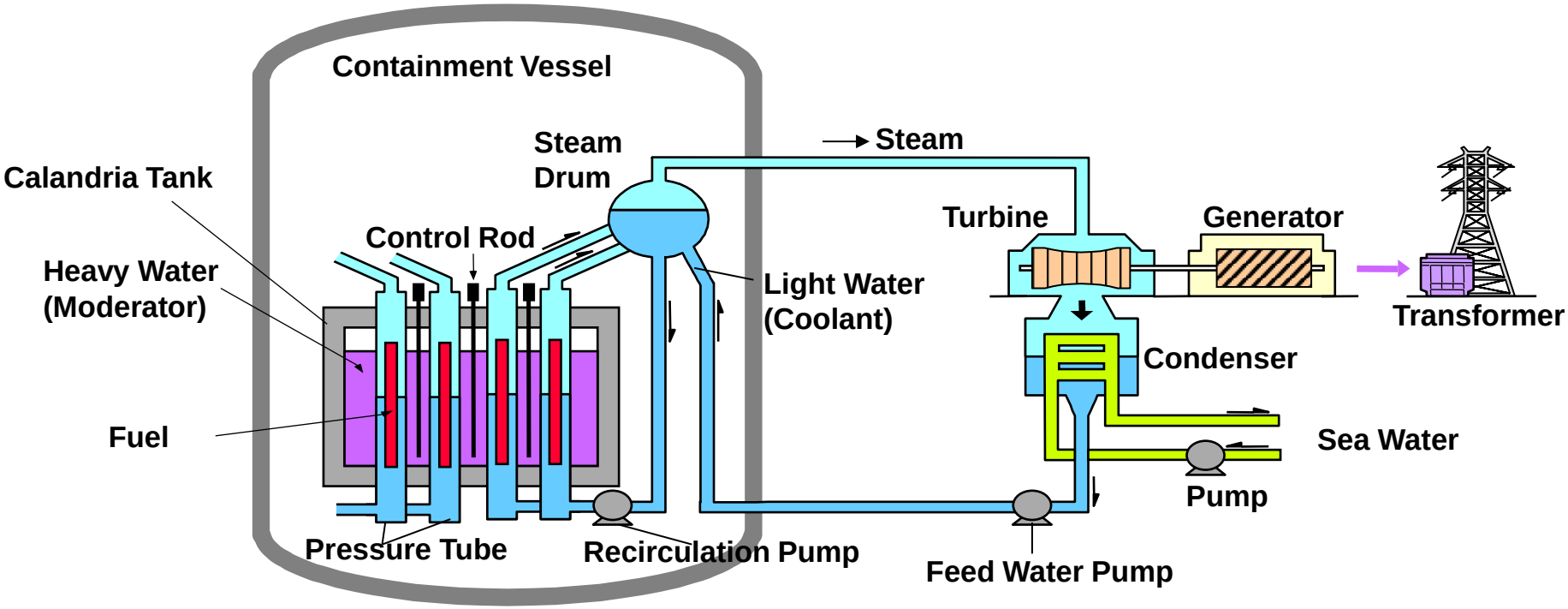
Contents

Schematic Diagram of FUGEN

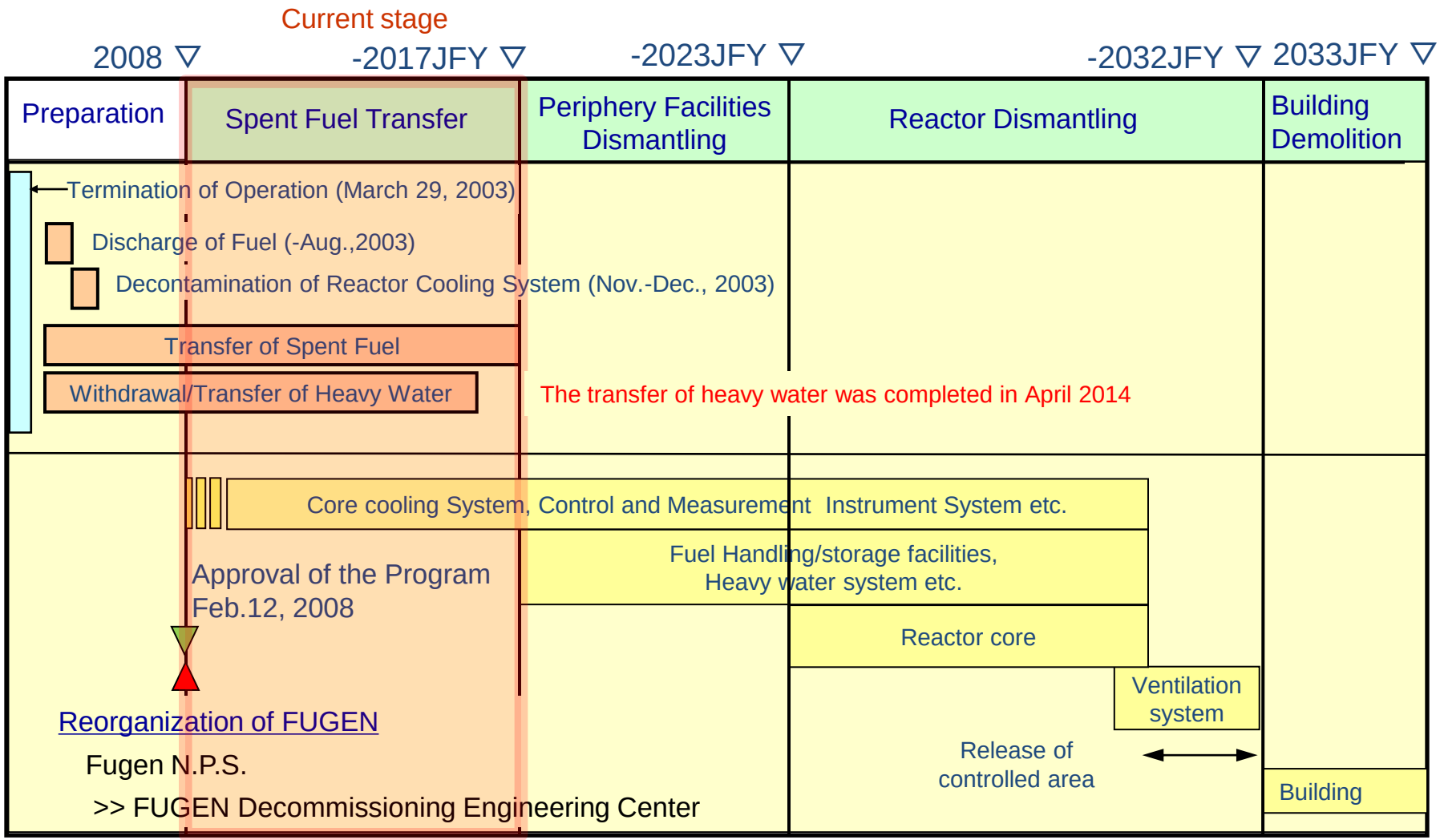
Advanced Thermal Reactor "FUGEN"

Core	: Pressure Tube Type
Moderator	: Heavy Water
Coolant	: Boiling Light Water
Output	: 165 MWe (Proto-type)

- Commercial operation : March, 1979
- Final Shutdown : March, 2003
- Approval of the decommissioning Plan : Feb. 2008



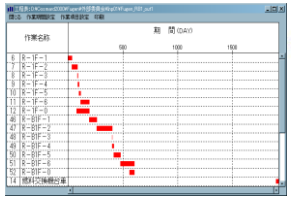
Basic Schedule of Decommissioning

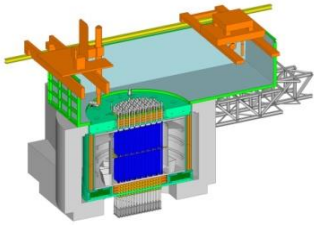


Main technologies for Decommissioning of Fugen

Systems Engineering

•VR Support System





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

Reactor Dismantlement

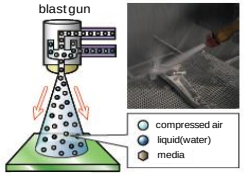
•Dismantlement Machine Study
•Mock-up Facility Planning
•Dismantling Simulation System

Heavy Water or Tritium Related

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

Decontamination

•Development of Optimized Method based on the Decontamination Experience



Reactor Building

Turbine Building.

Auxiliary Building

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

Concrete Waste

Spent Resin Test Facility

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 for Fugen

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

Legend

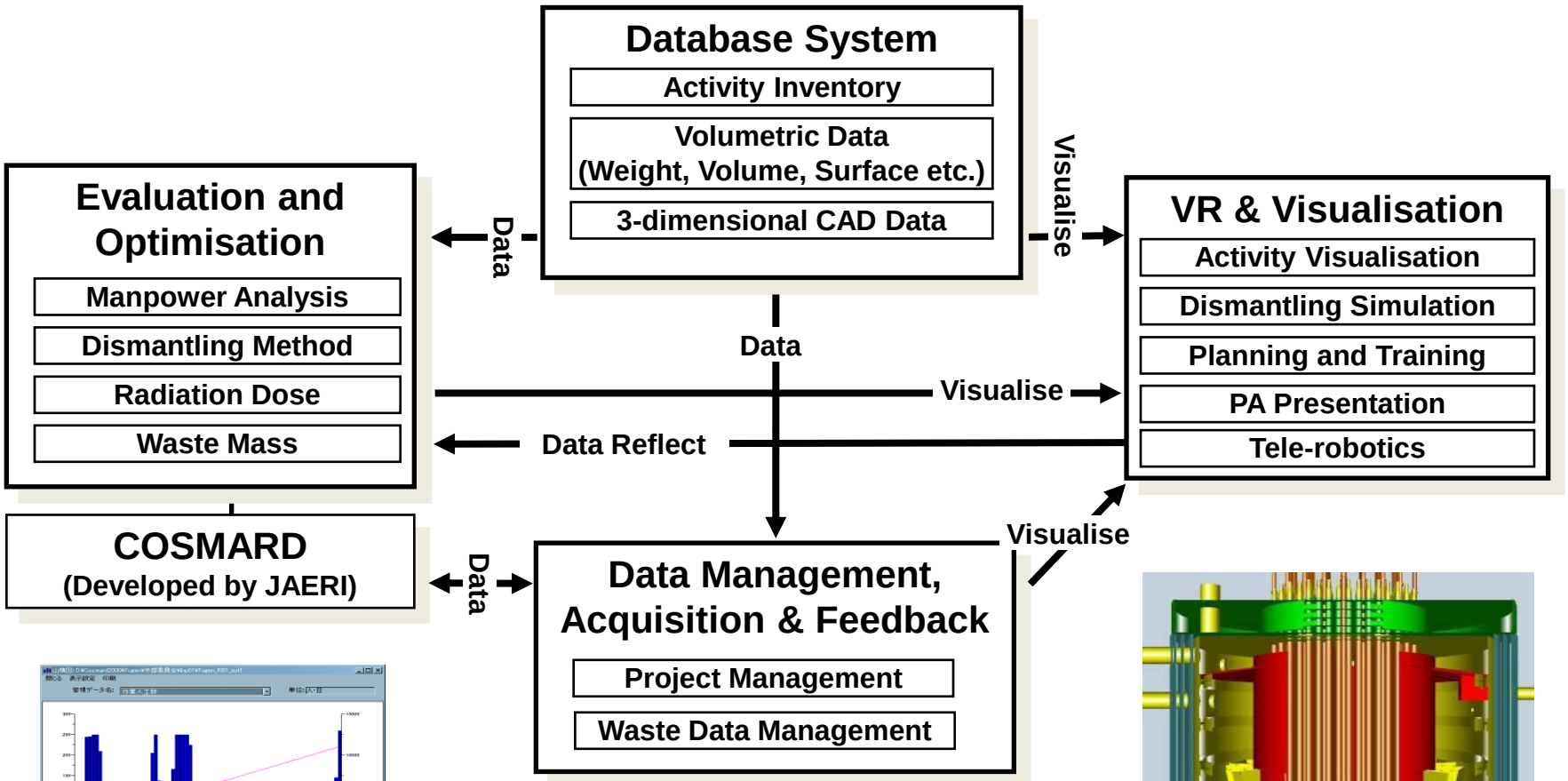
Unique Technology

Common technology

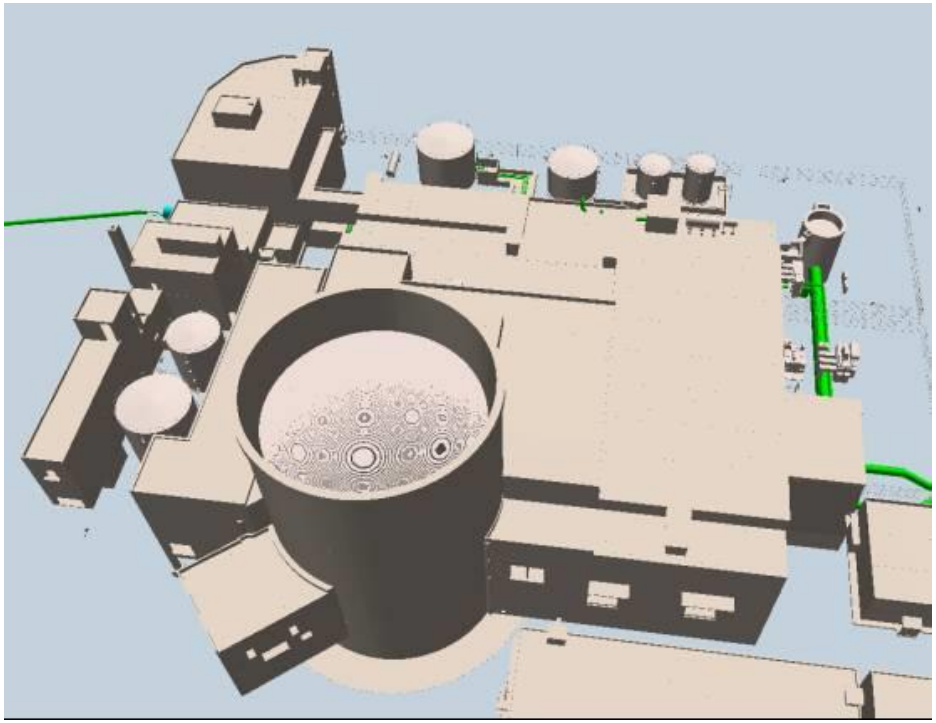
Objectives of IT Systems for Decommissioning

- Optimisation of Decommissioning Project at the Planning Stage
  - Mass Evaluation by 3D CAD
  - Evaluation of Cost, Waste, Dose by Planning Support System
  - More Accurate Evaluation by Virtual Reality (VR) System (VRdose)
  - Public Acceptance
- Effective Project Management at the Dismantling Stage
  - Data Base and Project Management
  - Training and Education
  - Remote Control System

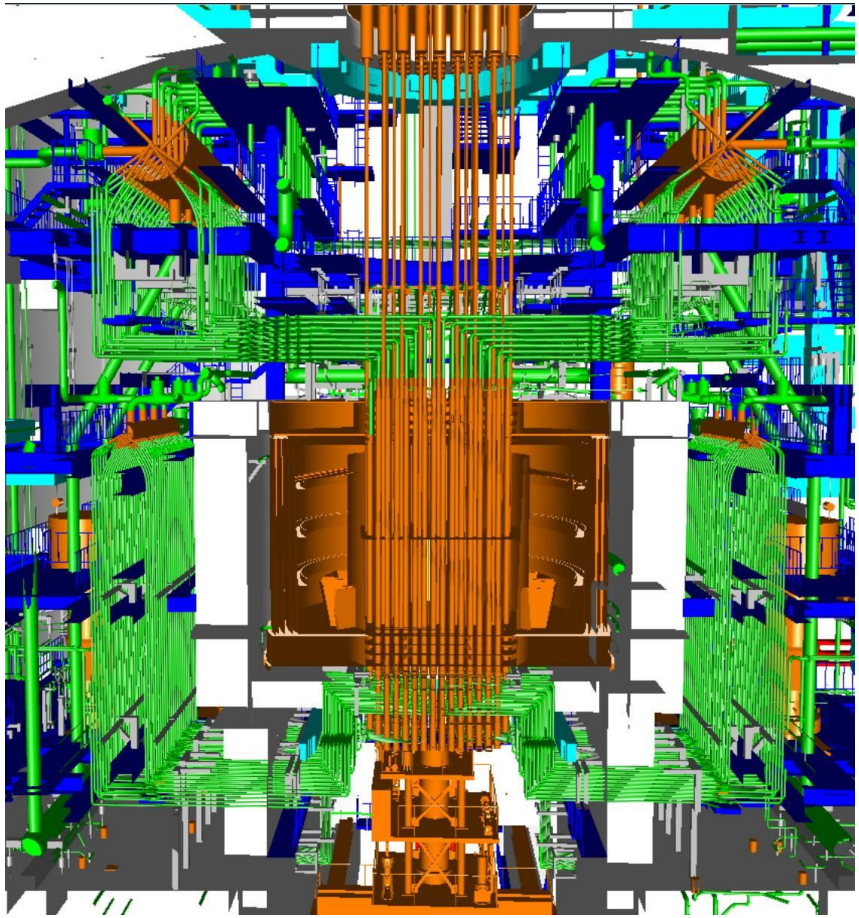
Concept of Decommissioning Engineering Support System (DEXUS)



Example of 3D-Data

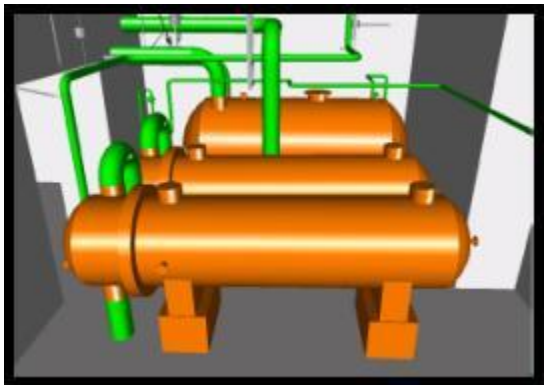


Outlook of Fugen

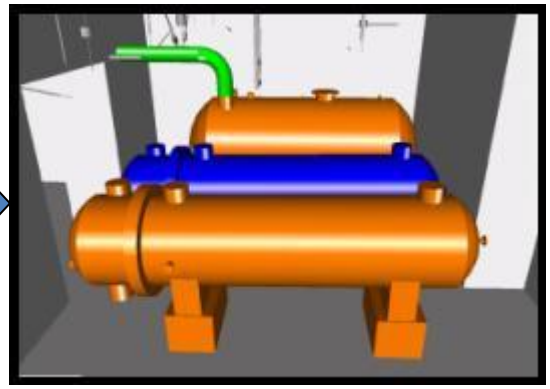


Cut View of Reactor

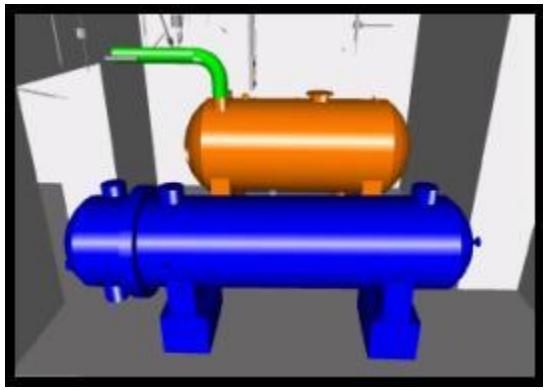
Visualization of Dismantling Schedule



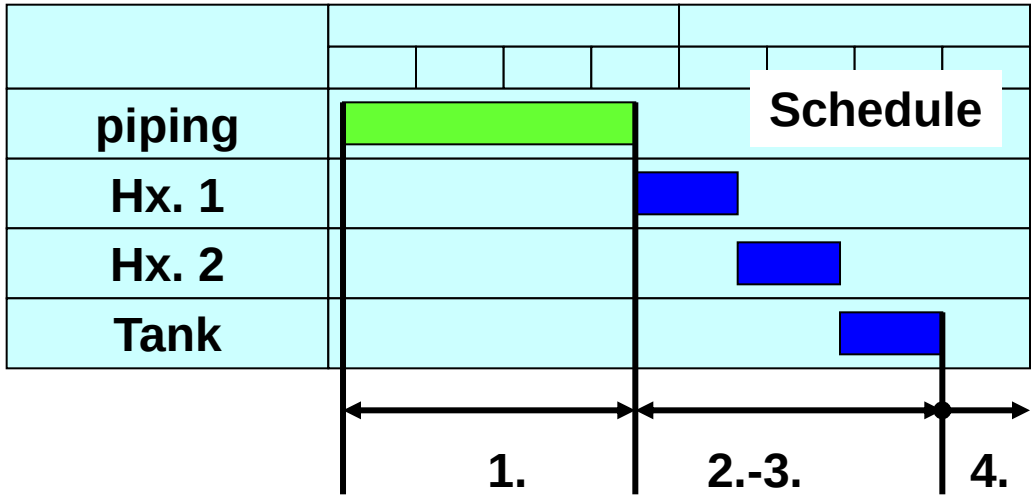
1.Removal of piping

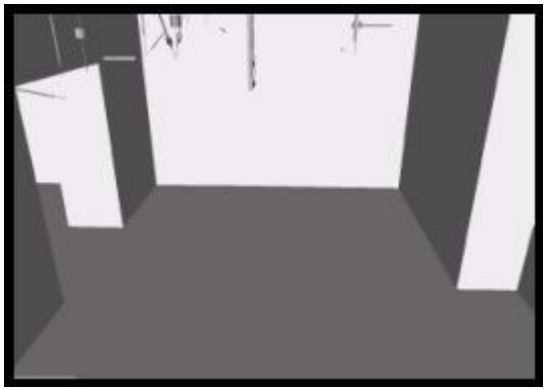


2.Removal of Hx. 1



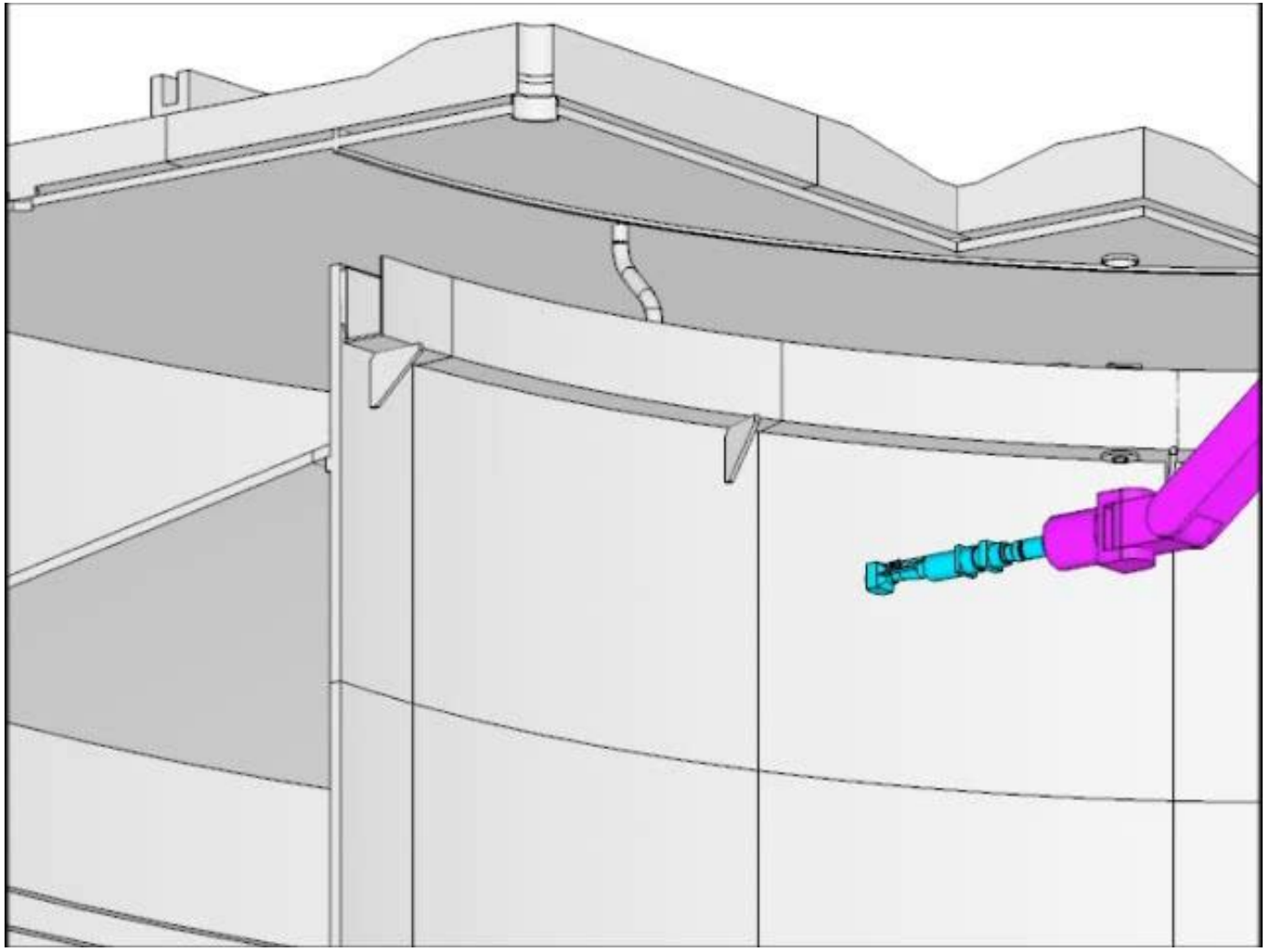
3.Removal of Hx. 2





4.End of Dismantling

Simulation of Cutting of the Reactor



Connection with Database

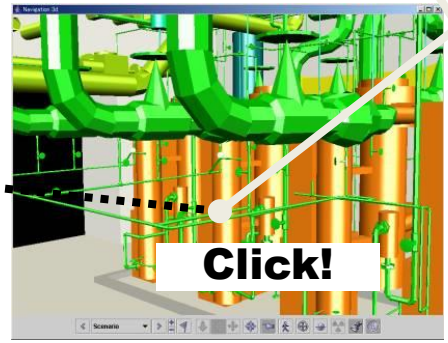
Fugen Database (Oracle)

TAG Data

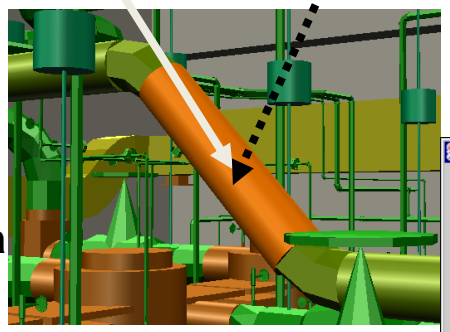
VRdose

Detailed specification is displayed on the screen

Browser (IE)

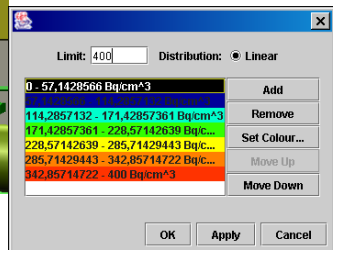


Data

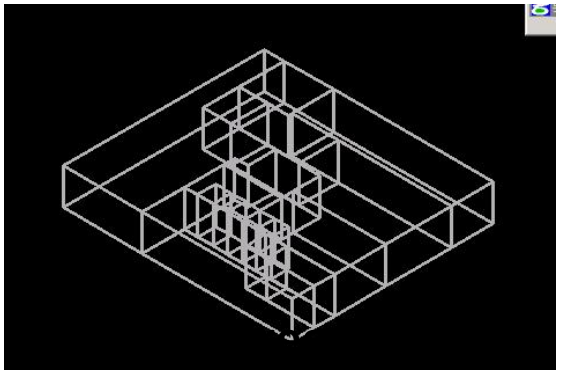


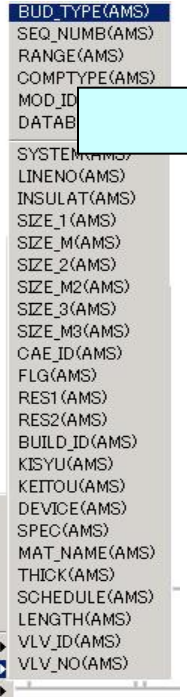
VRdose inside

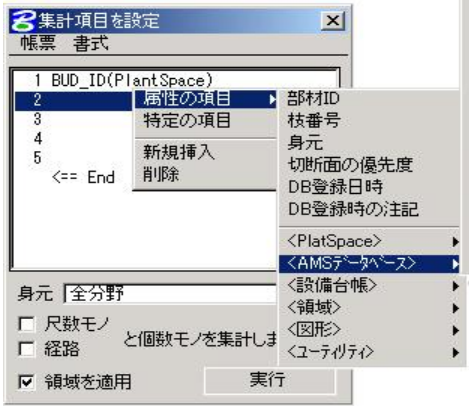
Contamination data is transferred and coloured according to the concentration



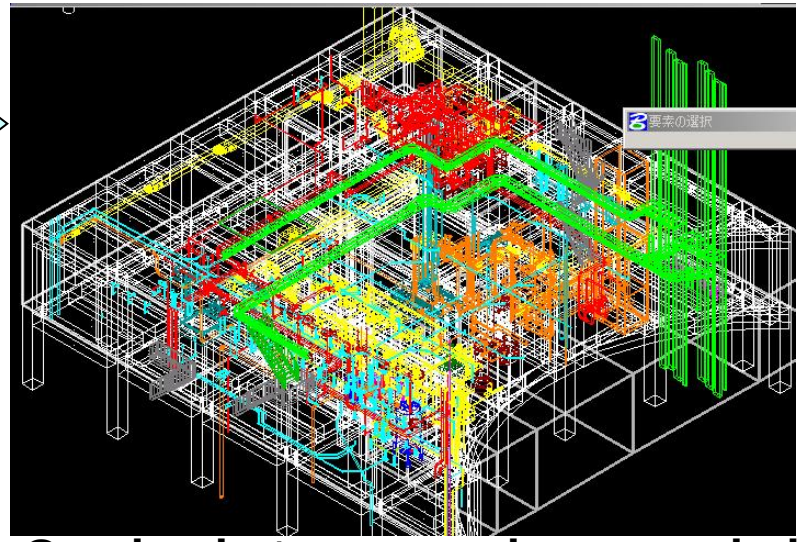
Mass Evaluation Function in the Work Area (Arbitrary space)







Selection of evaluation item



Overlap between work area and plant

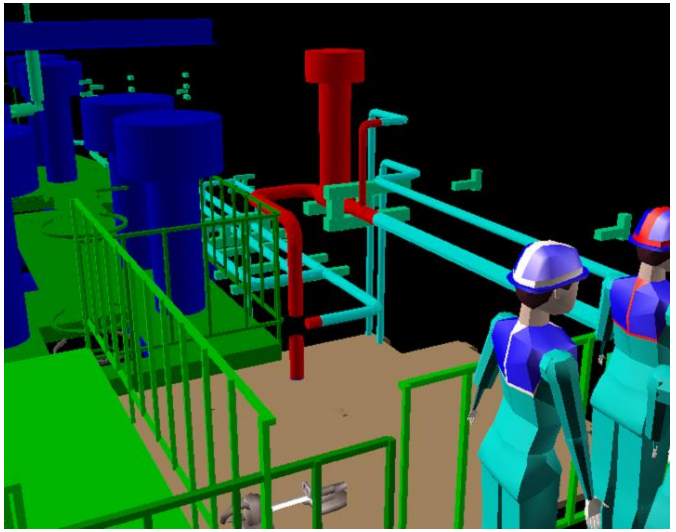
Evaluation Results (CSV format)

Room ID	BUD_ID (PlantSpace)	Compornect Type1 (PlantSpace)	部材ID		Area (m2)	Vol.(m3)
1106	24	CONC	24	–	25.92	5.76
1105	25	CONC	25	–	25.92	5.76
1102B	26	CONC	26	–	28.8	7.2
1104	29	CONC	29	–	25.92	5.76
1105	30	CONC	30	–	25.92	5.76
1102B	31	CONC	31	–	25.92	5.76
1106	34	CONC	34	–	29.92	6.72
1105	35	CONC	35	–	29.92	6.72
1102B	36	CONC	36	–	29.92	6.72
1101A	37	CONC	37	–	29.92	6.72
1104	40	CONC	40	–	24.752	5.47968
1104	41	CONC	41	–	18.696	4.02624

1. Piping, ducts and trays are automatically evaluated

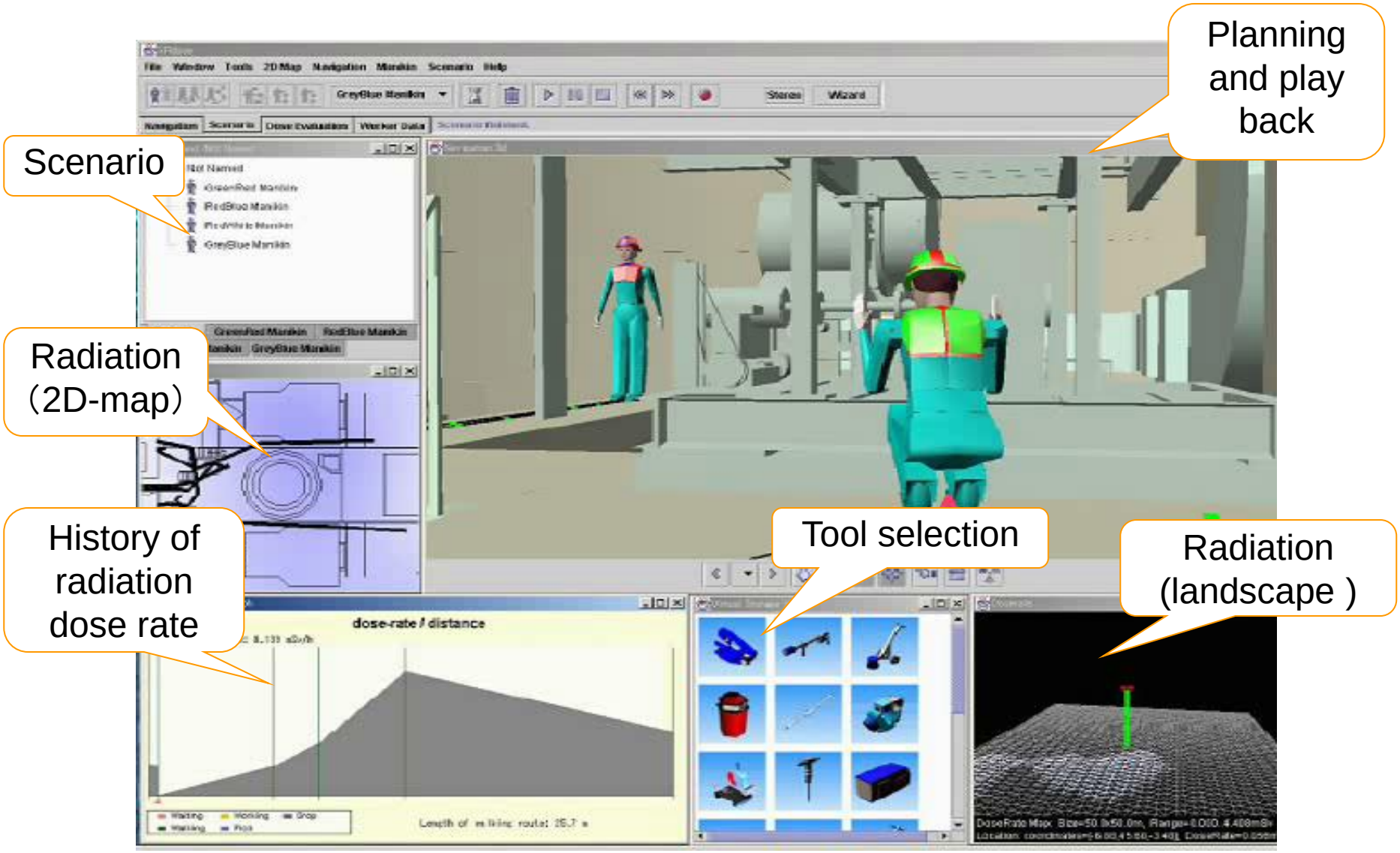
Exposure Dose Evaluation System (VRdose)

- Planning and administration of the decommissioning work process under radiation environment
- More accurate evaluation of dismantling labor
- Visualization of radiation and dismantling tasks
- Quick evaluation of radiation exposure dose
- Staff training before dismantling
- Public acceptance

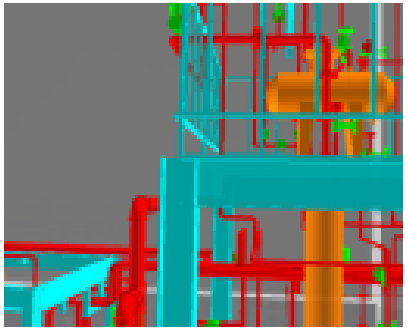


Developed by cooperating with IFE, Norway

User Interface of VRdose



Future Possibility (Development of AR System)

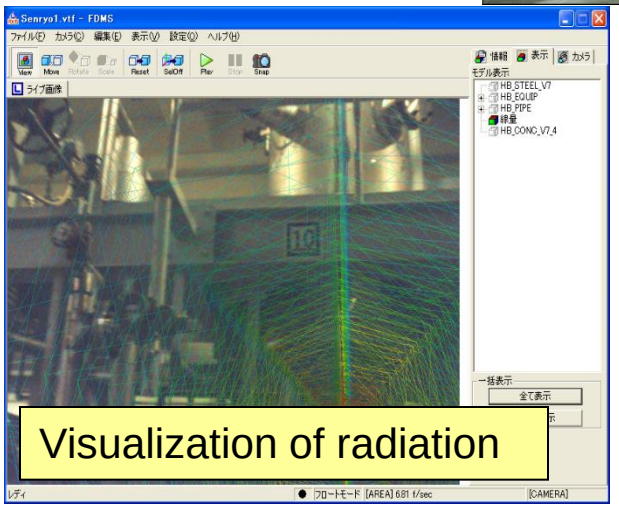


3D-CAD image

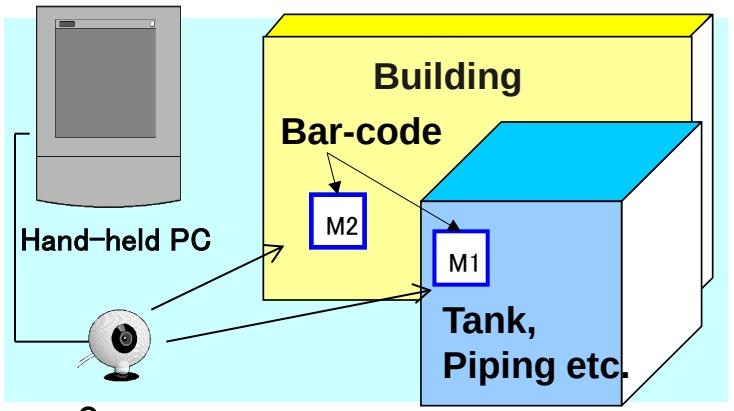
Actual image

Superimpose

Informing on facilities



Visualization of radiation

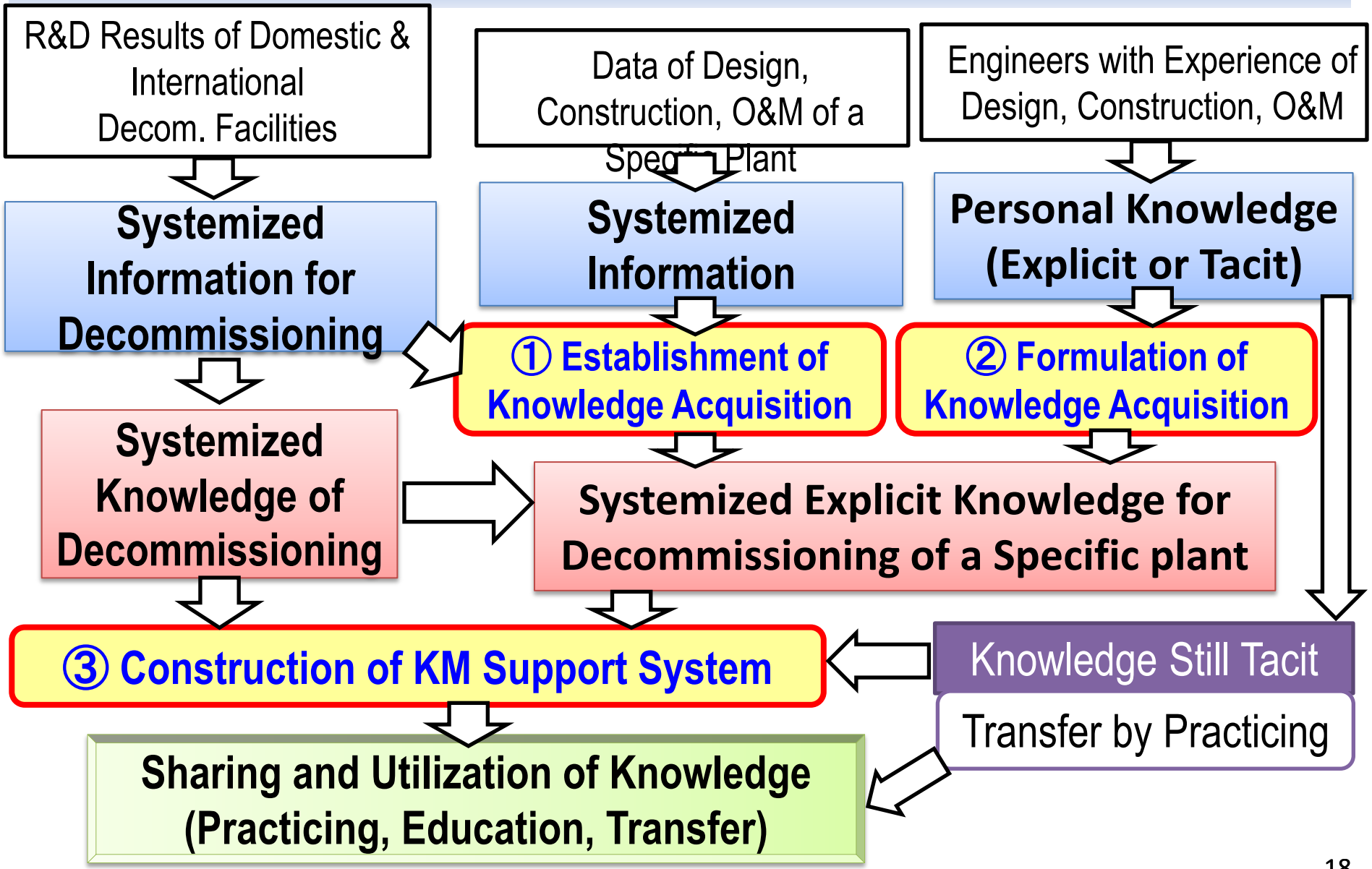


Developed by cooperating research with Kyoto University

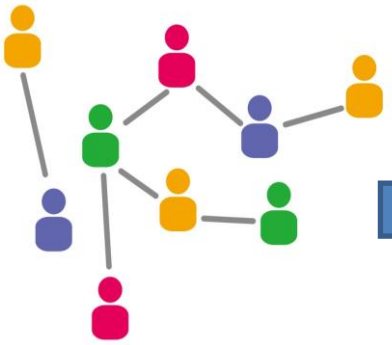
Future Possibility (Knowledge Management - Background)

- The decommissioning of a nuclear facility is a long term project.
- The decommissioning project is likely to be delayed.
- The transfer of knowledge and education to the next generation is a crucial issue.
- In Japan, based on the past experience, the increasing decommissioning projects are going on.
- Organized methods or a system for knowledge management is necessary in order to solve it.
- Knowledge Management (KM) (for decommissioning) should be well planned through all the life stages of nuclear facilities.

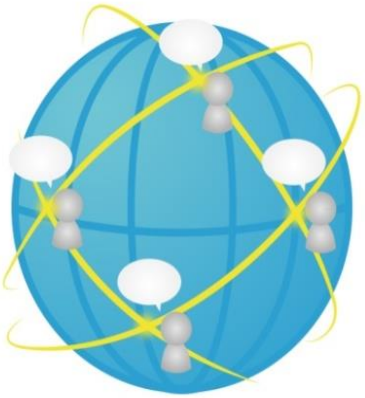
Outline of the Knowledge Management Approaches



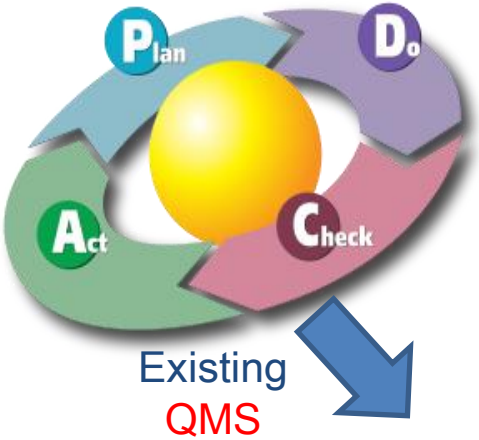
Knowledge Management Support System (Information Exchange and QMS based IT systems)



Information exchange by person to person level

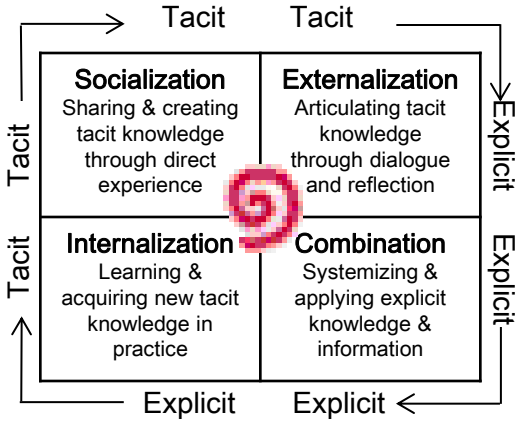


Enhancement of information sharing and knowledge acquisition



Existing QMS

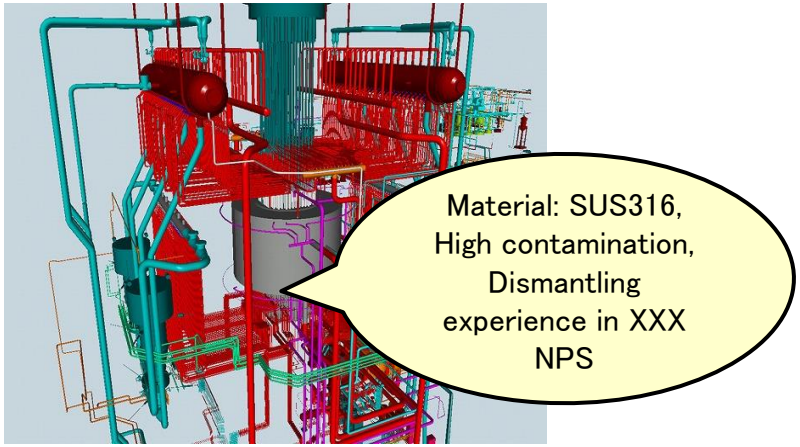
Knowledge acquisition process (SECI Model)



- **Enhancement of communication between employees**
  - Personal profile and expertise data
  - Enhancement of daily communication
  - Knowledge search such as Q&A system
- **Extraction of useful knowledge**
  - Knowledge acquisition during the daily work
  - Knowledge acquisition process based on the Quality Management System

Knowledge Management Support System (Knowledge Transfer and Education etc.)

- **Transfer of knowledge from retirees to existing employees**
  - Questionnaire or interview to elderly employees
  - Education in the office or field
  - Study meeting or face to face education
- **Support system by advanced technology Virtual Reality or Augmented Reality based on 3D-CAD**
  - Embedding of necessary data, information and knowledge in the virtual model
  - Provision of knowledge of decommissioning planning and implementation when necessary



Lessons Learned of IT Systems for Decommissioning

- The financial optimization is necessary because the decommissioning of a plant is non-profit and one-time-only activity
- A graded approach should be introduced
  - 3D-CAD data is very useful for the planning of dismantling of highly radioactive materials.
  - Simulation by VR is useful for the planning and training of workers when it is necessary to consider occupational dose.
  - However, if the radiation level is relatively low, the material is accessible, the detailed data and computer system may be unnecessary.

Conclusions and Future Prospects

- IT system for decommissioning is useful for planning, implementation, data acquisition, evaluation and feedback.
- The system may contribute to the reduction of waste, exposure dose, manpower and cost.
- The systems should be effective for the reduction of the total cost of the decommissioning and the improvement of safety during the dismantlement.
- We have to keep up with the new IT technologies, e.g. Augmented Reality (AR) or Knowledge Management System (KMS) for the optimizing decommissioning and transfer and education of lessons learned to the next generation or sharing knowledge.

Thank you for your attention!