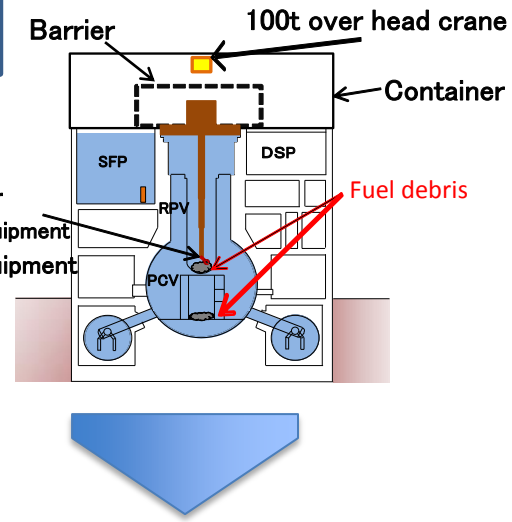
Request for Proposal (RFP) for Conceptual Study of Innovative Approach for Fuel Debris Retrieval and Feasibility Study of Essential Technology

International Research Institute for Nuclear Decommissioning

Purpose of this Project

Submersion Method

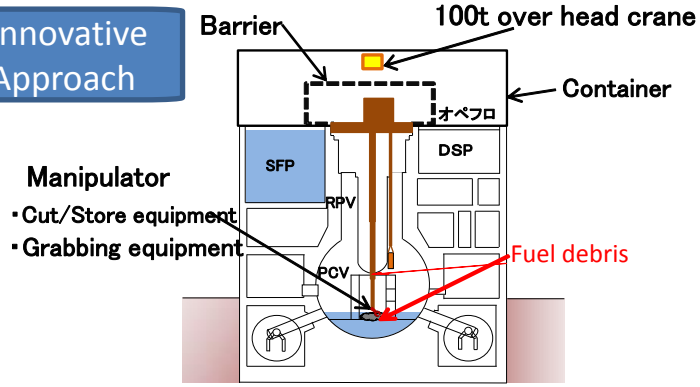


Method to exploit radiation shielding effect by water

→ Submersion up to the top of the PCV or to the level required to cover accumulated fuel debris could be difficult given that the PCV was heavily damaged by the accident.

Alternative retrieval method (Innovative Approach) without submerging PCV with water is deemed necessary and so stipulated in the Mid-to-Long-Term Roadmap stipulated by Japanese Government.

Innovative Approach



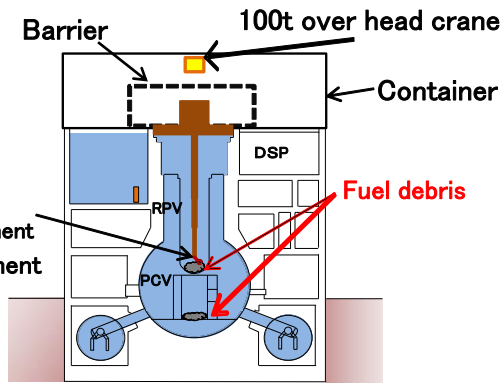
Method without submersion

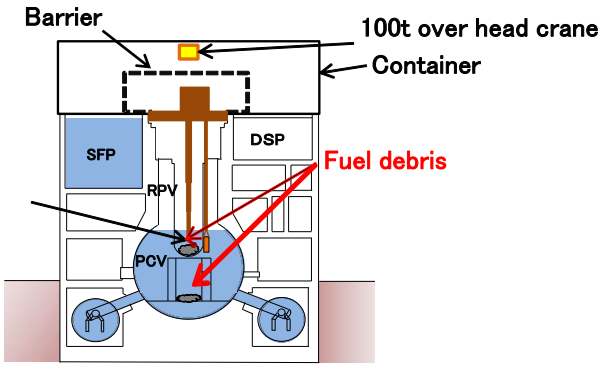
→ Request for Information (RFI) on the Innovative Approach of Fuel Debris Retrieval and relevant technology that supports the Innovative Approach was performed by METI through the IRID. In reference to the results of the RFI, about 200 pieces of information were received from the proposers.

This project is aimed at the conceptual study of Innovative Approach to retrieve the fuel debris without submerging PCV with water and feasibility of essential technologies to support the Innovative Approach.

The concept of Innovative Approach vs submersion method

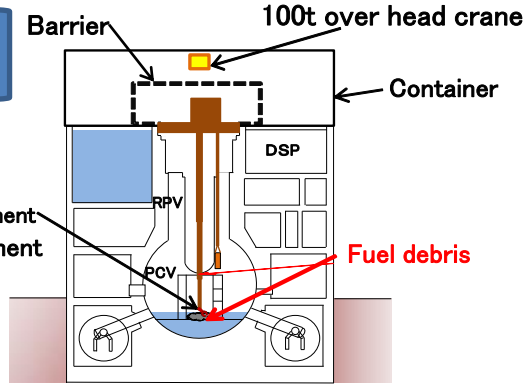
Submersion Method

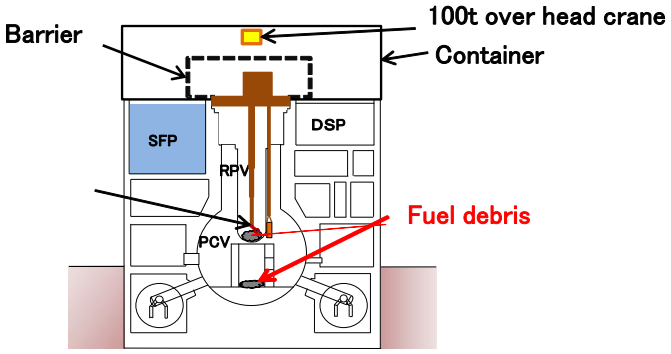




Fuel debris is cut and stored under water.

Innovative Approach

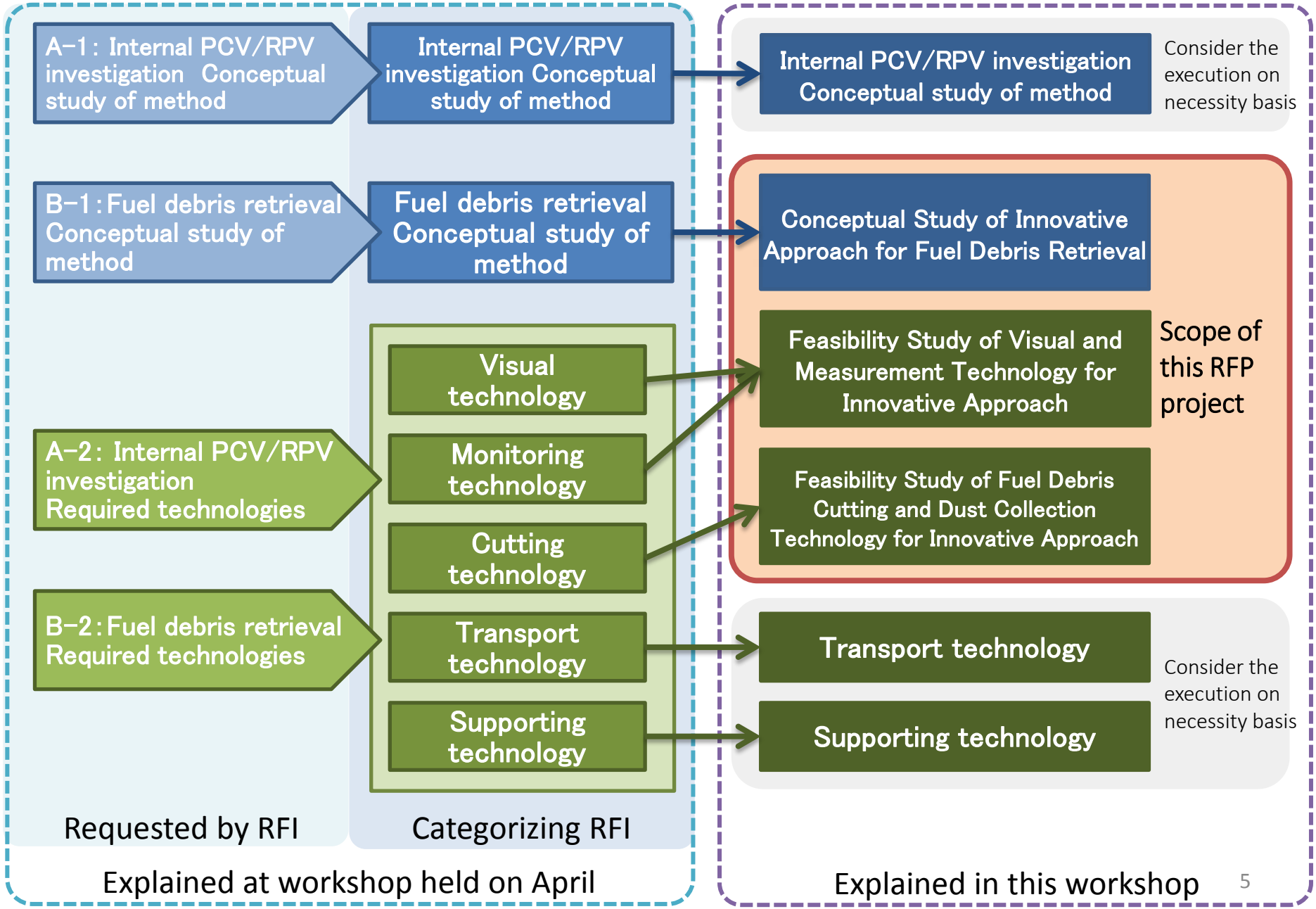




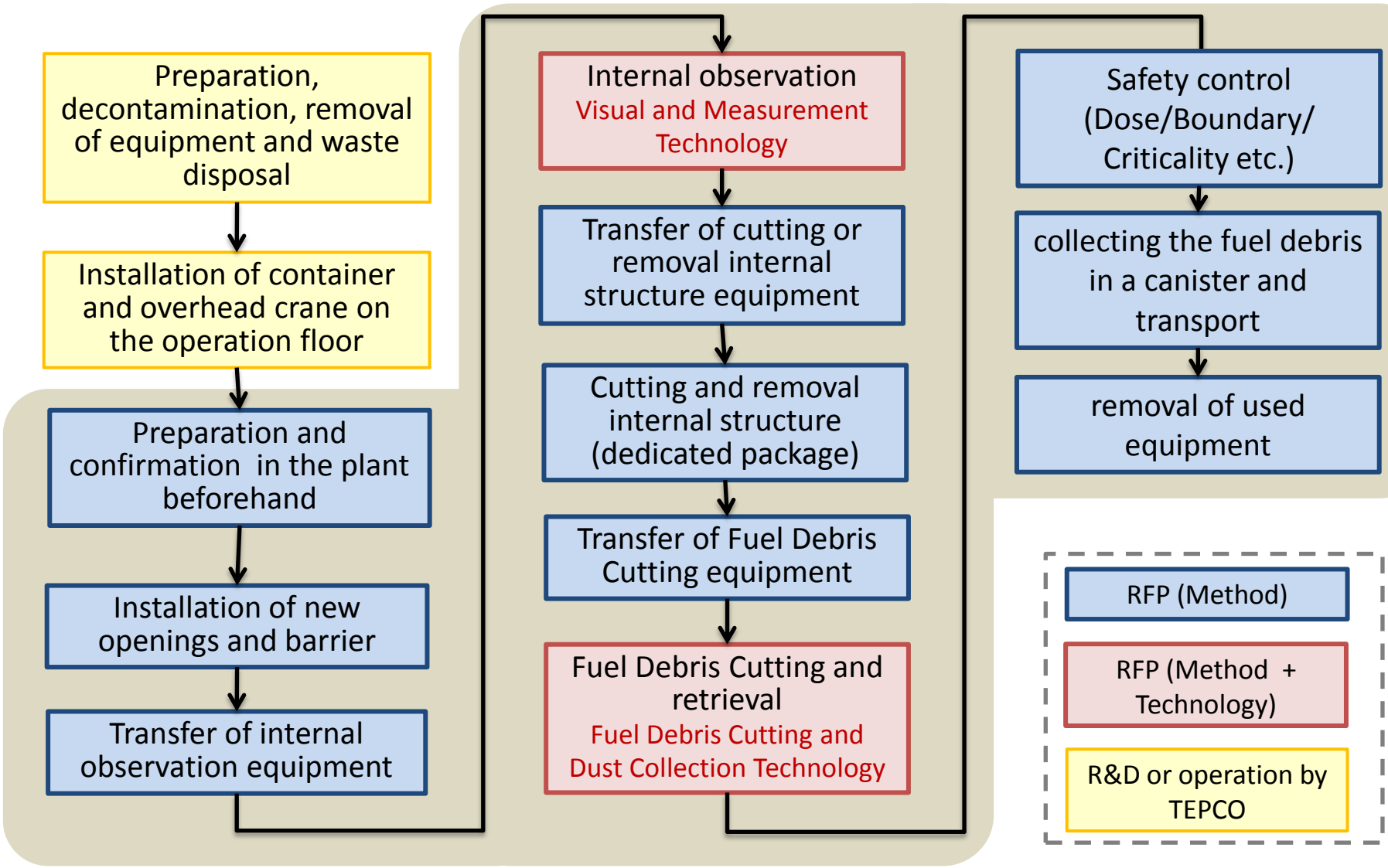
Fuel debris is cut under water but stored in the air, or cut and stored both in the air.

Description of the projects	
Project 1: Conceptual Study of Innovative Approach of Fuel Debris Retrieval	To conduct conceptual study for the method to retrieve the fuel debris in the air in a safe and stable condition
Project 2: Feasibility Study of Visual and Measurement Technology for Innovative Approach	To conduct feasibility study of technology to realize practical application of compact and light-weighted visual equipment with lighting function, and measurement equipment to characterize the properties of the objects both of which can be used under the very high radiation environment
Project 3: Feasibility Study of Fuel Debris Cutting and Dust Collection Technology for Innovative Approach	To conduct feasibility study of technology to realize practical application of the equipment capable of cutting the fuel debris (with dust collection function)

Structure of this RFP project



Relationship between overall step and RFP



Assumptions and Prerequisites(Unit to study, Scope of study, Time schedule)

C/S and F/S shall be conducted in consideration with following conditions.

Unit to study	・ Select the unit to study in proposal. It could be all three units (unit 1 through unit 3) of Fukushima Daiichi NPS, or a specific unit
Scope of study	・ In principle, entire interior of PCV including RPV where fuel debris seems to exist. If the scope of the study is aimed at fuel debris retrieval of a specific part of the unit, please write clearly. ・ Scope of the study covers from the start of the initial operation at the unit for fuel debris retrieval (e.g. removal of shield plug) to storing fuel debris in storage canisters and transferring them to the temporary storage.
Time schedule (*)	• Assume that the status check of fuel debris inside the PCV in 2016 to ensure the feasibility in the fuel debris retrieval. • Assume that the status check of fuel debris inside the RPV investigation in 2018 to ensure the feasibility in the fuel debris retrieval. • Assume that the start of the fuel debris retrieval in 2020.

（＊）Period required for licensing application and permit needs not be considered.

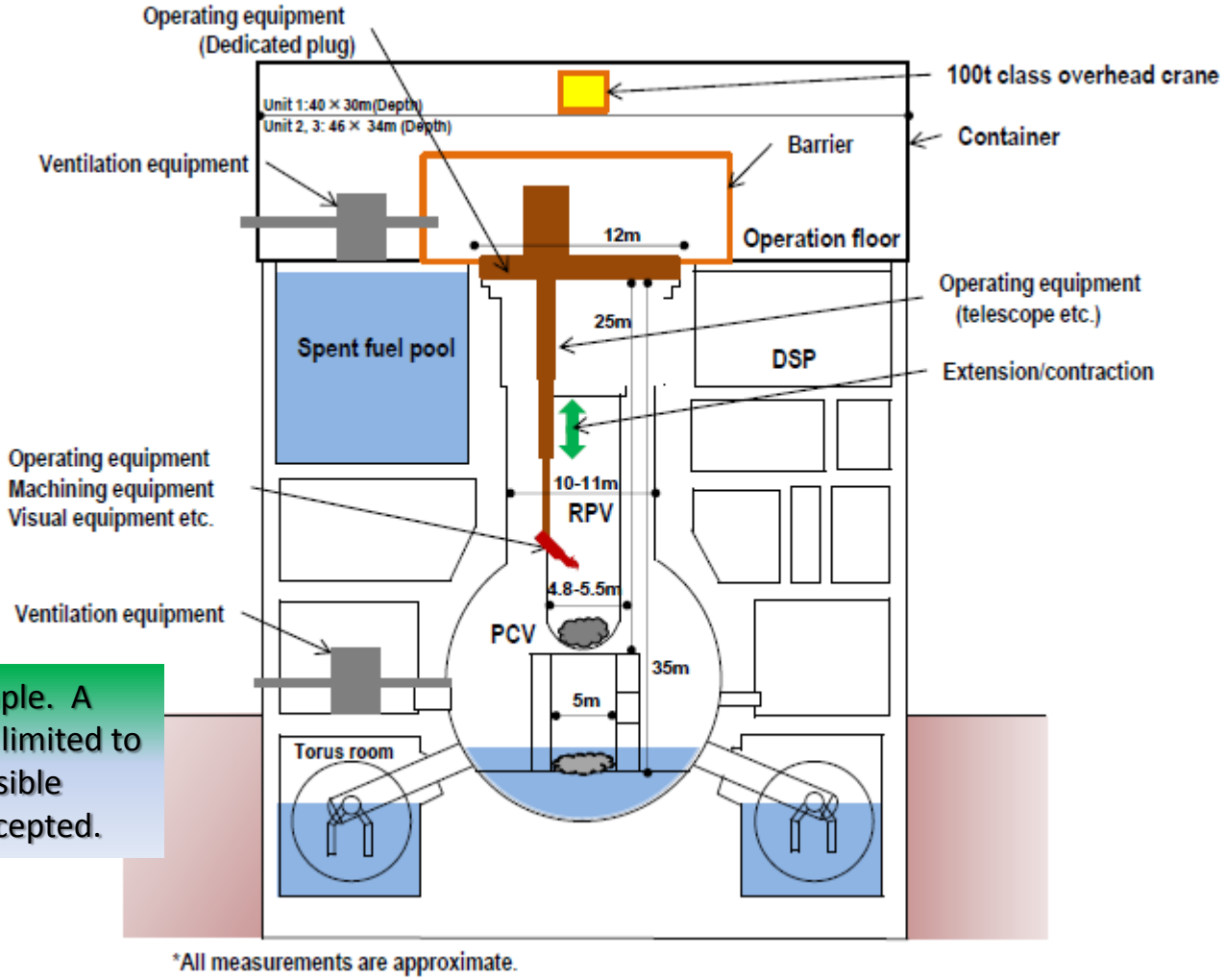
Assumptions and Prerequisites (On-site operation condition)

On-site operation condition

- Assume that the rubbles are removed and decontamination work proceeds in 2020 when fuel debris retrieval starts.
- PCV/RPV is under high radioactivity and high humidity. Water is dripping inside.
- Water level inside PCV is the same as current measured or estimated one as of 2014.
- No radiation shielding effect by water is counted.
- Acceptable maximum load for floor of 1.2t/m2 shall be considered.
- Visibility inside PCV/RPV is very low due to no lighting provided.
- Inside PCV/RPV are densely installed internal structures.
- Assume that air dose rate is 100Gy/h inside PCV, and 1kGy/h inside RPV.
- After the start of the fuel debris retrieval, effective dose rate on the operation floor is 1mSv/h, 3mSv/h in operation area other than operation floor; and 5mSv/h in a passageway inside the building.
- Use existing opening, hatch, and stairs inside the reactor building for accessing to each floor and delivering the equipment to each floor. No new openings, in principle, shall be created on the outer wall of the building. (Seismic resistance and prevention of leakage of radioactive substance should be considered, if new opening is indispensable.)
- Dimension of equipment to be brought in, in principle, shall meet with the passageway width of 1.2m and height of 3m.
- Give consideration to the possibility of the accumulation of hydrogen gas inside PCV/RPV when cutting fuel debris or internal structures.
- By the start of fuel debris retrieval, 100-ton type overhead crane is installed and available, and spent fuels in SFP and the equipment in DSP are all cleared off.
- Total weight of equipment installed on the operation floor shall be minimized in consideration of seismic safety.
- No shielding function or air tight function for boundary is counted to the container covering operation floor.

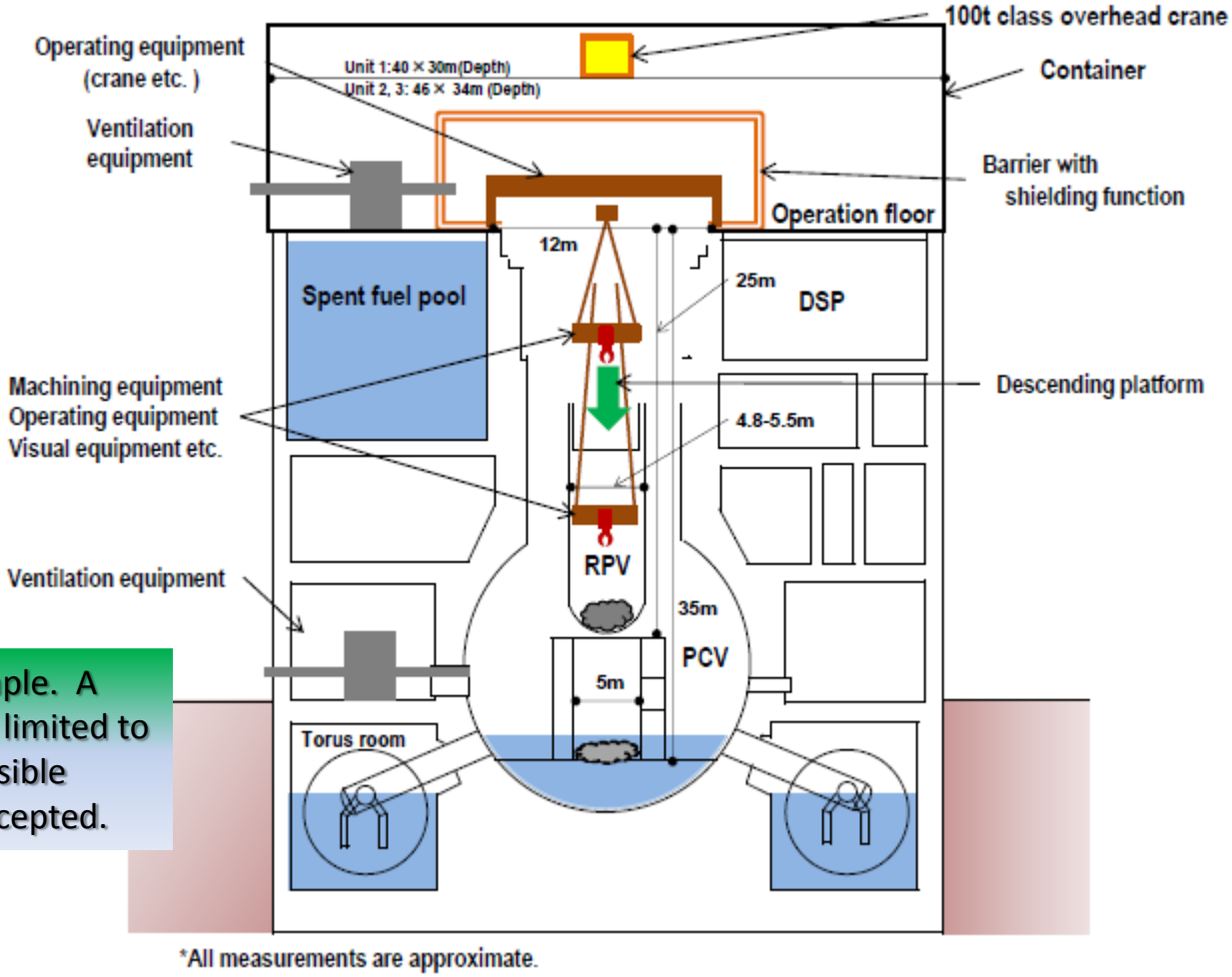
Project 1
Conceptual Study of Innovative Approach for Fuel Debris Retrieval

Consider what we can do to retrieve the fuel debris assuming the water level inside PCV is the same as current measured or estimated one as of 2014.



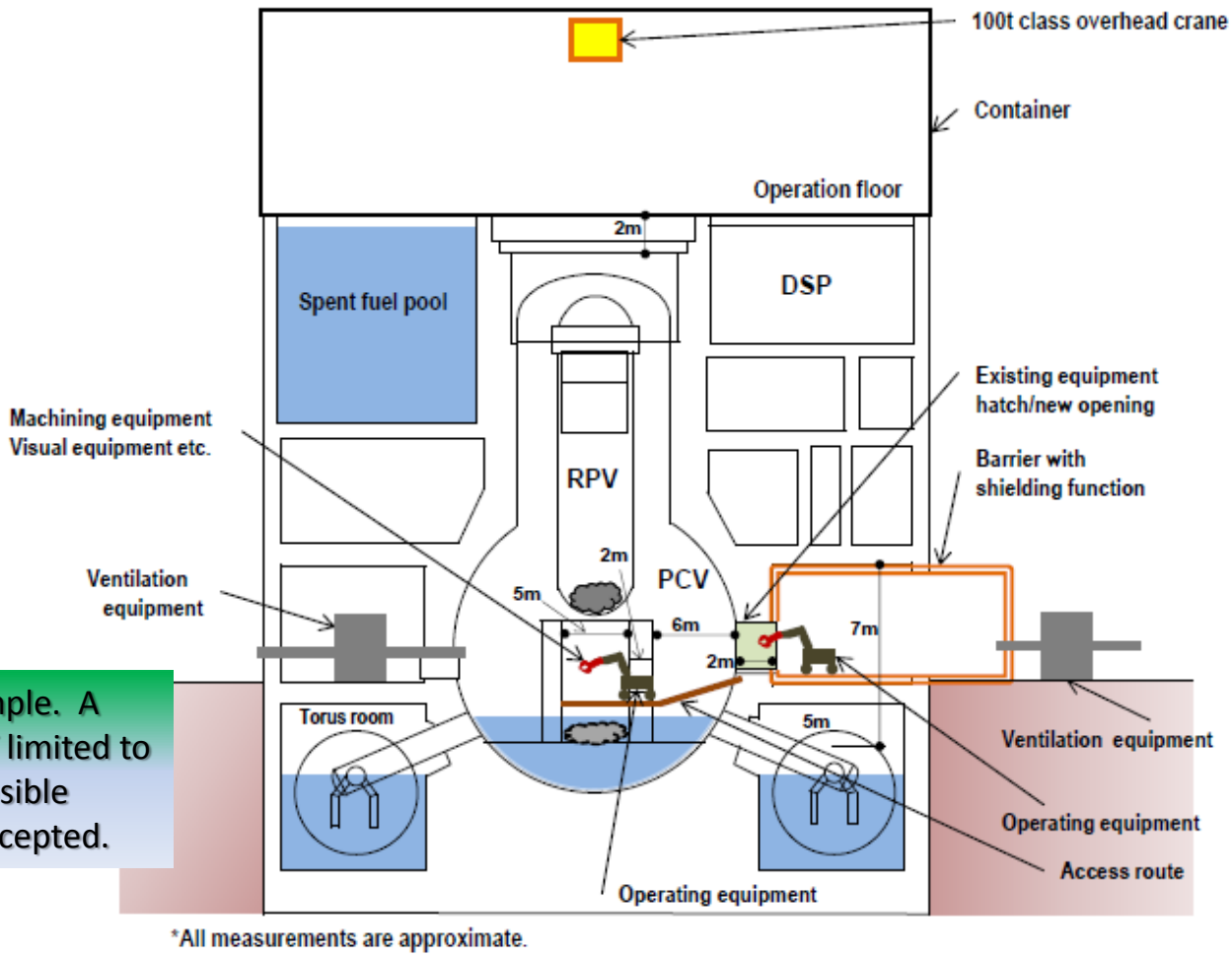
NB: This is an example. A proposal is NOT limited to this, and any feasible proposals are accepted.

Fig.1-1 Method of retrieving the fuel debris in the air from the top (fixed transport equipment)



NB: This is an example. A proposal is NOT limited to this, and any feasible proposals are accepted.

Fig.1-2 Method of retrieving the fuel debris in the air from the top (mobile platform)



NB: This is an example. A proposal is NOT limited to this, and any feasible proposals are accepted.

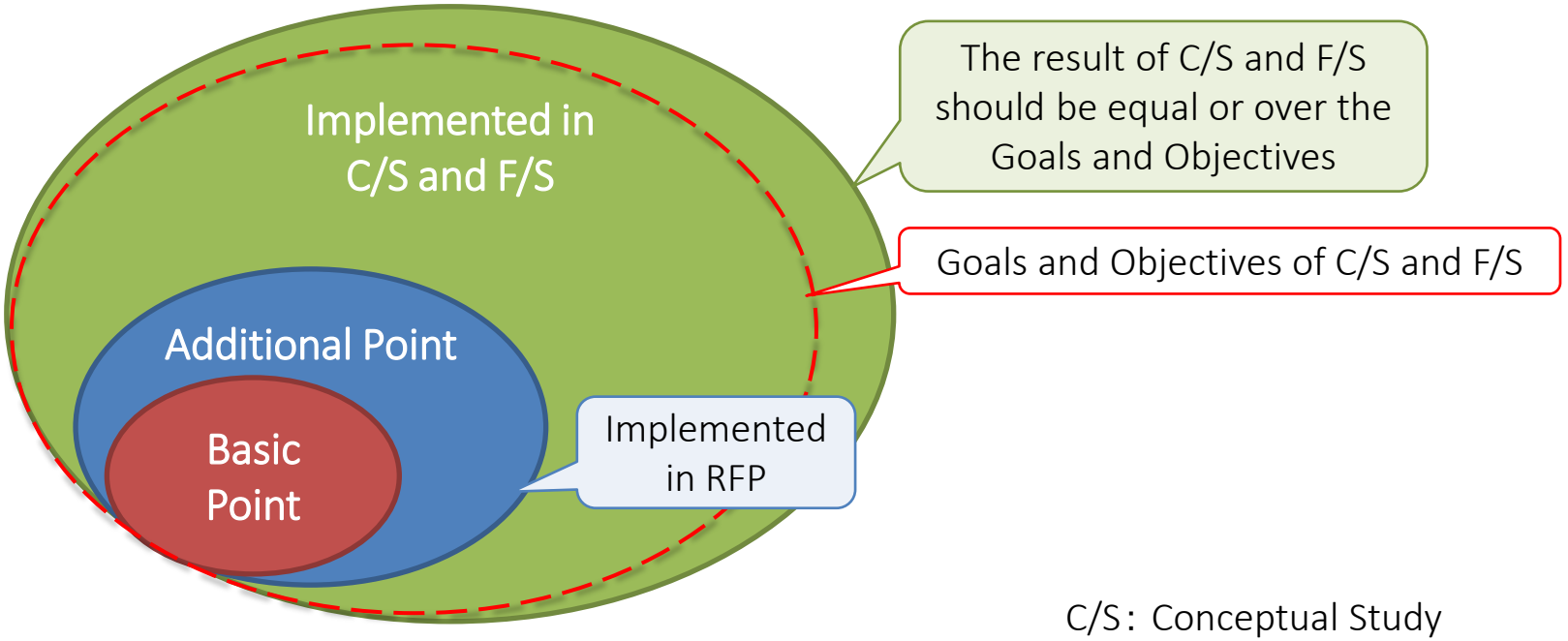
Fig.1-3 Method of retrieving the fuel debris in the air from the side

Goals and objectives of C/S

A scope of this C/S is a series of operations from delivery and installation of the equipment, fuel debris retrieval, and removal of used equipment.

Method of fuel debris retrieval	Steps
	Layout
	Access
	Internal observation
	Debris cooling
	Collecting debris
	Retrieval technology
	Equipment
	Waste
Items to be considered on safety operation	Dose reduction
	Retention of boundaries
	Seismic safety
	Maintenance
	Hydrogen
Development plan	
Others	

Scope of C/S and F/S, and Requirements in RFP



C/S : Conceptual Study
F/S : Feasibility Study

Basic Point	• All items should be filled out (No missing allowed to proceed to the step of proposal evaluation)
Additional Point	• Optional • Points are added according to the contents

Project 2
Feasibility Study of Visual and Measurement Technology for Innovative Approach

Visual and measurement technologies are requested to aim the challenging target specifications.

Project Implementation

- Scope of visual and measurement technologies -

Common for visual and measurement technology

- Usable under **high radiation environment**
- **Compact and light-weighted**

Visual technology

- The equipment (with lighting function) shall be developed to detect conditions and locations of internal structures and the fuel debris in the PCV and the RPV.

Measurement technology

- The equipment is required to be developed to **distinguish fuel debris** by its internal condition, external shape and properties.
- The equipment to measure the radiation field around the objects to be cut, and to detect the Hydrogen concentration.

Example of visual and measurement technology

Visual technology	camera, endoscope, and fiber scope
Measurement technology	radiation monitor, ultrasonic detector, laser scanner, radionuclide analyzer, thermography, and hydrogen concentration detector.

Target Specifications for Visual and Measurement Technologies

Severe conditions necessitate challenging specifications.

Application process	Application area	Target specification		
		Radiation resistance	Basic shape	Target object
Status check of fuel debris	PCV	1kGy/h or more 30kGy or more	Dimension of X-6 opening (W550mm× H330mm) or less	Internal structures and fuel debris
	RPV	10kGy/h or more 300kGy or more	ϕ100mm or less	Internal structures and fuel debris
Fuel debris retrieval	PCV,RPV	10kGy/h or more 2MGy or more	ϕ100mm or less	Internal structures and fuel debris

Radiation resistance (dose rate)

Status check of the fuel debris in PCV:

About 10 times the air dose currently measured inside the PCV

Fuel debris retrieval work and status check of the fuel debris in RPV:

About 10 times the air dose currently measured inside the PCV

Radiation resistance (Cumulative dose rate)

Operation hours to calculate cumulative dose rate are set as follows:

Status check of the fuel debris:
1 day (24 hours)

Fuel debris retrieval:
7 days (168 hour)

Basic shape

A basic shape of the equipment was determined envisaging the insertion of equipment from the existing opening.

Project 3
Feasibility Study of Fuel Debris Cutting and Dust Collection Technology for Innovative Approach

Technology to be applied to cutting of various types of fuel debris is desired, as well as collecting and capturing resulted chips, crumbs, fumes, and dust.

Project Implementation

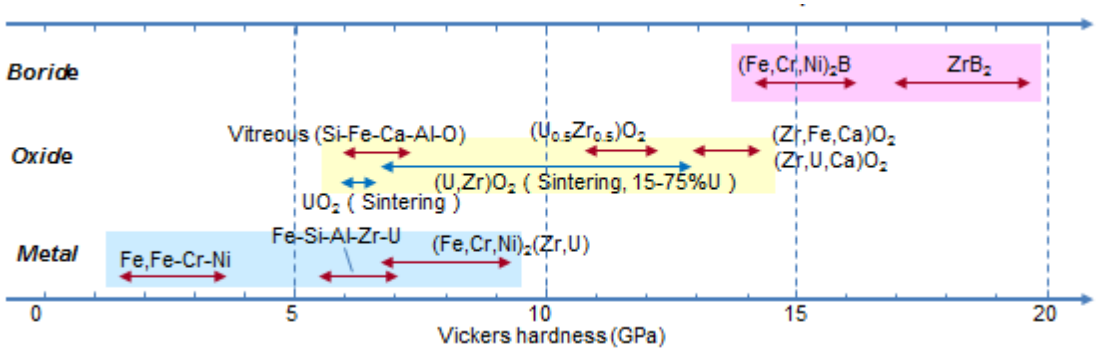
Uncertainties of fuel debris characteristics could be a key challenge for technology development.

Cutting and Dust Collection Technology

- Usable under **high radiation environment**
- Capable of cutting fuel debris with **different levels of hardness**
- The function of **collecting and capturing** the resulted chips and crumbs, fume and dust need to be considered.

Example of Cutting and Dust Collection Technology

laser, plasma, core boring, and rock drill etc.



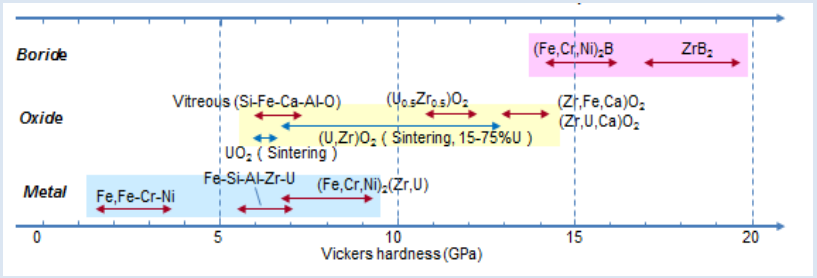
Vickers Hardness in each Phase of Simulated Debris

Target Specifications for Fuel Debris Cutting and Dust Collection Technology for Innovative Approach

Application process	Application area	Target specification			
		Radiation resistance	Target object	Target object of Material	Cutting size
Fuel debris retrieval	PCV RPV	10kGy/h or more 2MGy or more	Fuel debris	Compound with different levels of hardness in which boride, oxidized material, metal etc. are distributed heterogeneously	100x100x100 mm or less

Target object of Material

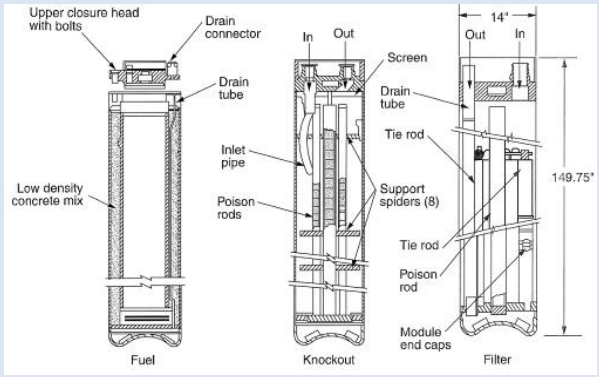
The material properties of fuel debris are based on the results of R&D for simulated debris addressed by National Project.



Vickers Hardness in each Phase of Simulated Debris

Cutting size

The cutting size is determined based on the capacity of fuel storage container used for TMI-2



(『TMI Fuel Characteristics for Disposal Criticality Analysis (DOE/SNF/REP-084)』参照)

Goals and objectives of F/S

Items to be studied in F/S of Project 2 and Project 3 are summarized as below.

Basic concept and feasibility of the proposed technology
Study of applicability of the technology to the site
Study of schedule, project organization, and cost to realize the proposed technology

Summary

- RFP was launched on June 27, 2014 and will be closed on August 27, 2014.
- Considering the schedule to start the fuel debris retrieval expected in 2020, we're awaiting many excellent proposals to arrive from Japan and from all over the world.

Project 1: Conceptual Study of Innovative Approach for Fuel Debris Retrieval
Project 2: Feasibility Study of Visual and Measurement Technology for Innovative Approach
Project 3: Feasibility Study of Fuel Debris Cutting and Dust Collection Technology for Innovative Approach