"The Strategic Plan" for Decommissioning of Fukushima Daiichi NPS

Overview of Strategic Plan for Fuel Debris Retrieval

Jun 30, 2015

Nuclear Damage Compensation & Decommissioning Facilitation Corporation (NDF)

1st Version of the Strategic Plan Released!

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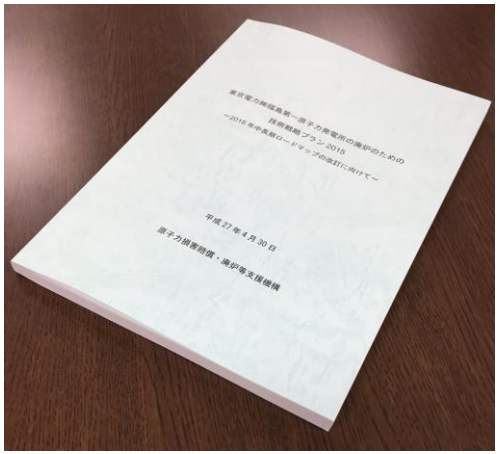


~ 200 Pages

You can get pdf version of the Strategic Plan at NDF web site below!

http://www.dd.ndf.go.jp/ddwp/wp-content/themes/theme1501/pdf/SP2015_20150623.pdf

http://www.dd.ndf.go.jp/ddwp/wp-content/themes/theme1501/pdf/SP2015_20150624_en.pdf

Establishment of Nuclear Damage Compensation & Decommissioning Facilitation Corporation (NDF)

After December 2011, the Government of Japan developed a structure to ensure the TEPCO's decommissioning process based on the master plan described in the Mid-and-Long-Term Roadmap ("Roadmap") determined by the Government.

Government

Determine Roadmap
(Developed in December 2011, revised in June 2013)

Dec 2011 [Roadmap development]	Dec 2013 [2 years later]	Dec 2021 [10 years later]	[30 to 40 years later]
Stabilization activities	Phase 1	Phase 2	Phase 3
	A period until the start of fuel removal from the spent fuel pool	A period until the start of fuel debris retrieval	A period until the end of the decommissioning of all of Units 1 to 4

TEPCO

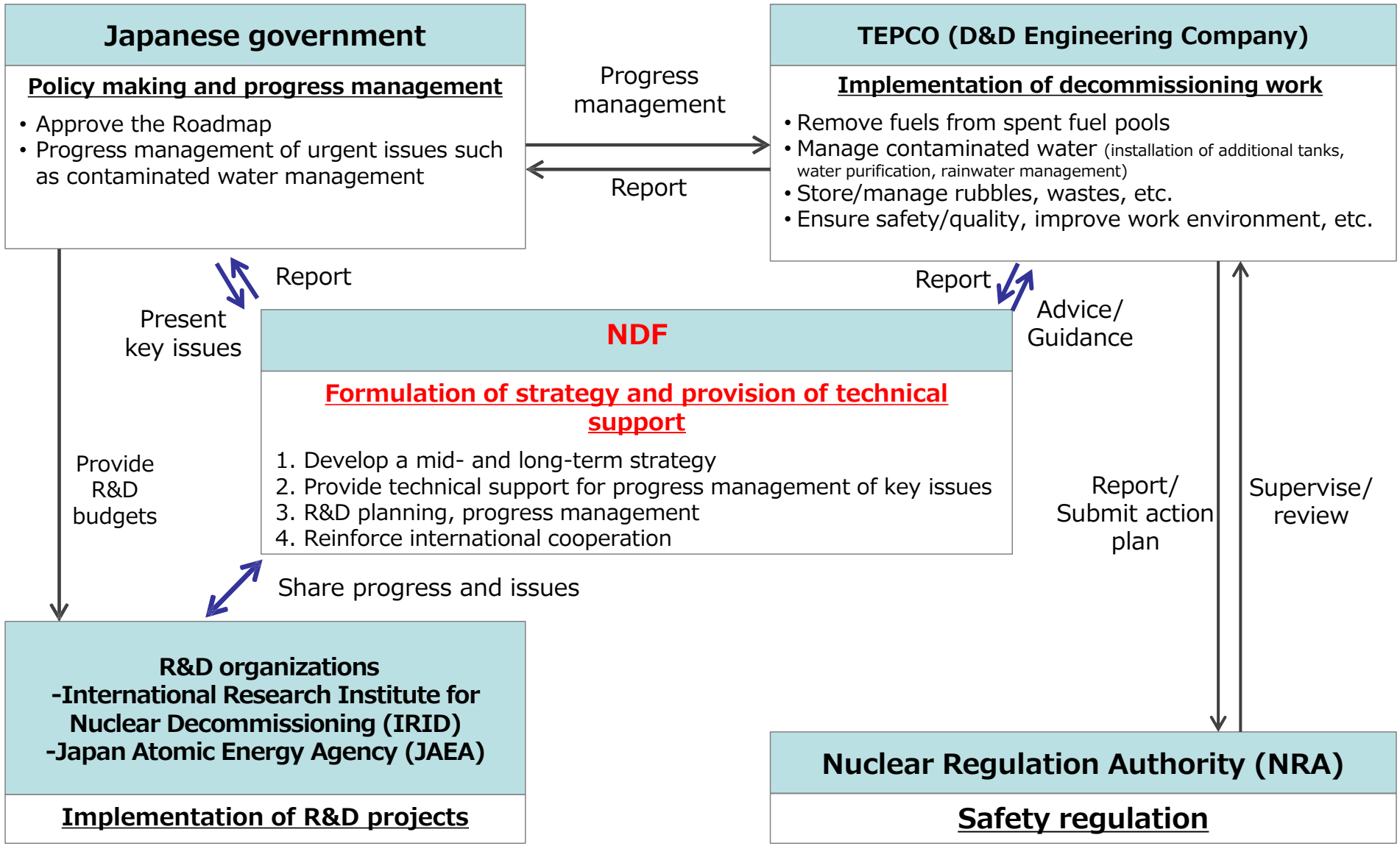
Ensure the decommissioning process.

Source: TEPCO's website

Enhance the support structure so that TEPCO ensures the decommissioning process under the leadership of the Government.

Nuclear Damage Compensation & Decommissioning Facilitation Corporation was established on August 18, 2014. (Nuclear Damage Compensation Facilitation Corporation was reorganized.)

Relevant Organizations involved in Fukushima Daiichi Plant Decommissioning & Contaminated Water Management



Development of “The Strategic Plan”

As an organization of experts in a variety of technological fields, NDF develops a mid-and-long term technical strategy called “The Strategic Plan” through advices with external experts.

- Technology experts in NDF’s decommissioning office (about 30 experts)
  - Plant engineering
  - Robotics
  - Civil engineering and architecture
  - Materials, analysis, monitoring
  - Fuel and nuclear reactor engineering
- Experts from external organizations (universities, JAEA and other research institutions)

<Decommissioning Strategy Board>

1st Aug. 21, Thu	6th Jan. 28, Wed
2nd Sep. 30, Tue	7th Feb. 23, Mon*
3rd Oct. 28, Tue*	8th Mar. 26, Thu
4th Dec. 4, Thu	9th Apr. 16, Thu
5th Jan. 6, Tue	

* With the participation of four international special advisors.

<Expert Committee>

・ Fuel Debris Retrieval Expert Committee

1st Oct. 20, Mon	4th Jan. 19, Mon
2nd Nov. 26, Wed	5th Feb. 13, Fri
3rd Dec. 22, Mon	6th Mar. 18, Wed

・ Waste Management Expert Committee

1st Nov. 26, Wed	4th Feb. 25, Wed
2nd Dec. 25, Thu	5th Mar. 30, Mon
3rd Jan. 26, Mon	

Expert-level intensive discussions held repeatedly among ANRE, TEPCO and IRID under the lead of NDF on specific Issues

Purpose of the Strategic Plan and Relationship with the Mid-and-Long-Term Roadmap (Roadmap)

Goals and policies presented by the Government
Key elements of strategies, policies and plans determined by the Government

Roadmap
revised and updated by the Government

1) Strategy
– Provides an approach to conducting activities and making decisions and sets priority in achieving the goals

2) Strategic specification for the implementation of the strategy
– Specific policies and requirements for conducting activities and making decisions

3) An integrated plan to implement the strategy
– An integrated plan for conducting field work and research and development

Strategic Plan
developed by NDF

(2015 Technical Strategic Plan for Decommissioning of Nuclear Power Plants of the Fukushima Daiichi NPP, Tokyo Electric Power Co., Inc.)

Delivery of Decommissioning
by TEPCO and research institutions
(field work, engineering, R&D)

Implementation plans by TEPCO and research institutions

Background of Development of Strategic Plan

Reason why NDF developed Strategic Plan now!

- **Changes of Situation**
- **Response to Uncertainty**
- **Response to Severe Site Situation**
- **Awareness of Time Axis**
- **Sharing the Strategy**

Guiding Principles for the Strategic Plan

- **Principle**
  - The decommissioning of the Fukushima Daiichi Nuclear Power Plant is a continuous risk reduction activity to protect people and the environment from the risk of radioactive materials, resulting from severe accident.
  - A risk reduction strategy along a mid- to-long-term timeline will be designed in the Strategic Plan.

- **5 Guiding Principles** for Risk Reduction

✓ Principle 1: **Safe**	Reduction of risks caused by radioactive materials* and work safety (*Environment impact and exposure to workers)
✓ Principle 2: **Proven**	Reliable and flexible technology
✓ Principle 3: **Efficient**	Effective utilization of resource (human, capital, money, and space etc.)
✓ Principle 4: **Timely**	Awareness of time axis
✓ Principle 5: **Field Oriented**	Emphasize actual place, actual parts and actual situation

Risk Reduction in Strategic Plan

(i) Risk of radioactive materials

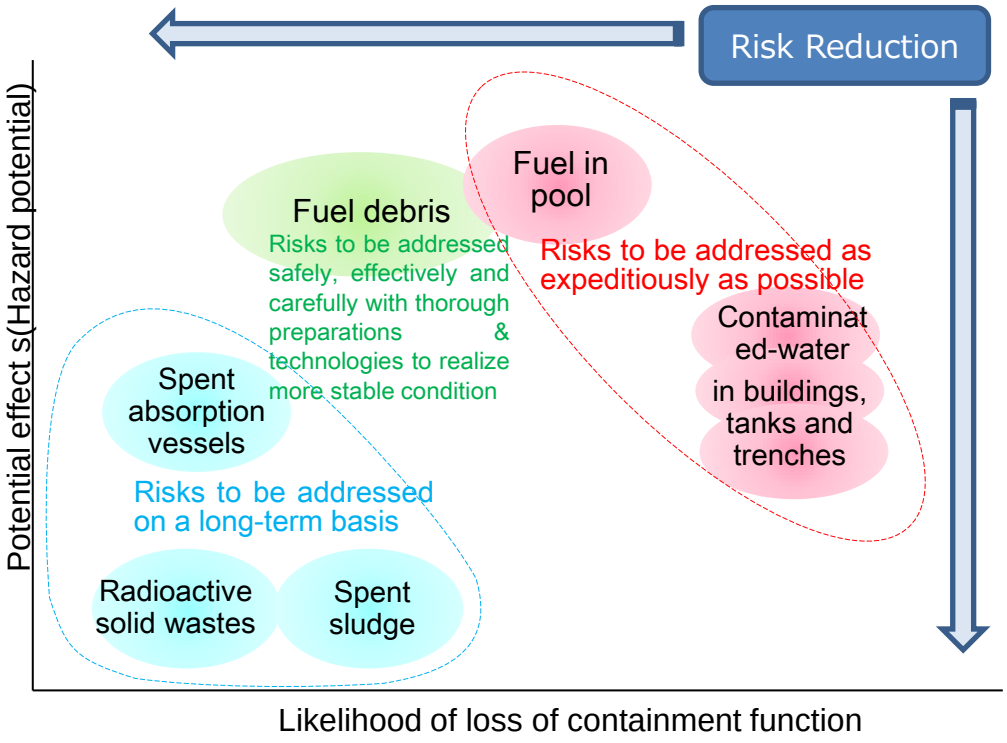
- Risk = Potential effects x likelihood of loss of containment function

(ii) Potential effects

- Potential effects = level of activity x physical state (solid, liquid or gas)

(iii) Likelihood of loss of containment function

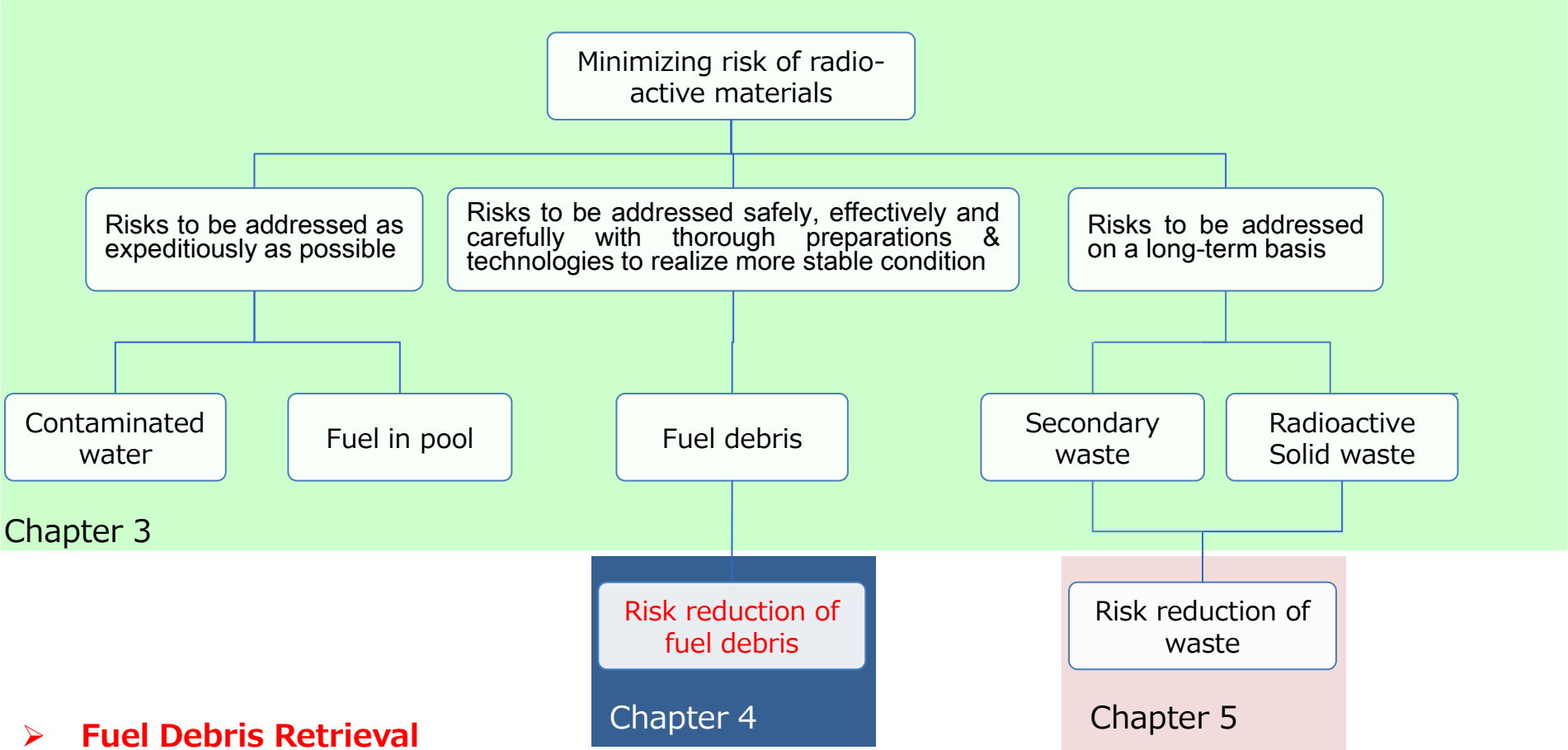
- Likelihood of loss of containment function = possibility of occurrence of the factor x vulnerability of the facility



(iv) How to reduce risk

- Move radioactive materials to a safer and more stable facility.
  → Reduce potential effects
- Decay of radioactivity and change in the physical state
  → Reduce the likelihood of loss of containment function

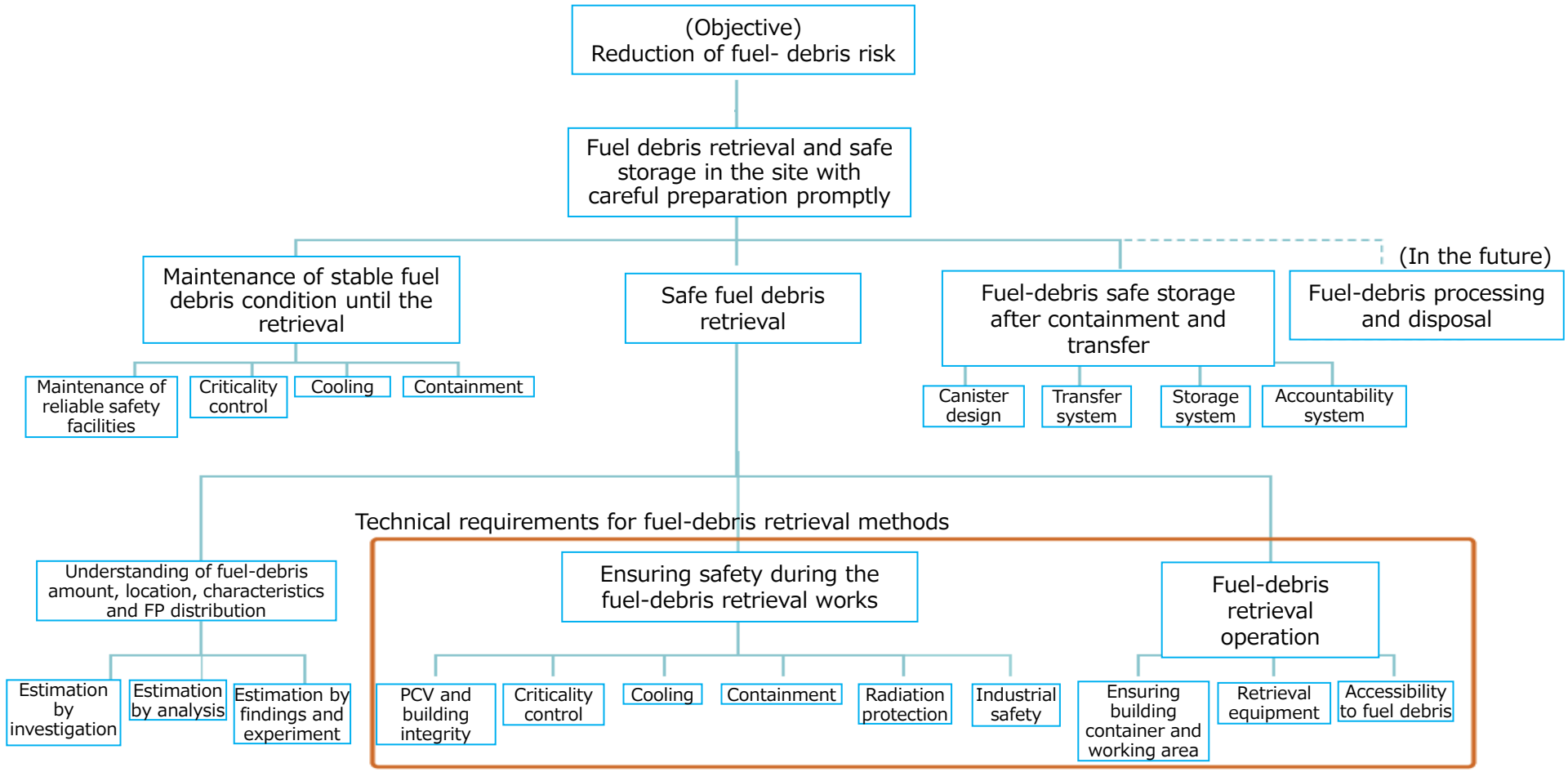
Logic Tree Diagram Regarding Risk Reduction (Summary)



- **Fuel Debris Retrieval**
  - Develop a workable scenario for fuel debris retrieval assuming several methods (submersion, dry) and a combination of the methods, taking into account the status of each Unit.
- **Waste Management**
  - Develop a policy for storage management, processing and disposal from a mid-to- long-term perspective, based on the principles for safe waste disposal and appropriate waste processing.

Structure of Strategic Plan for Fuel Debris Retrieval

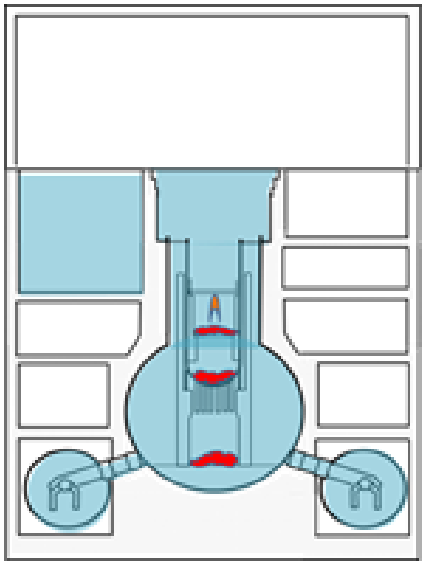
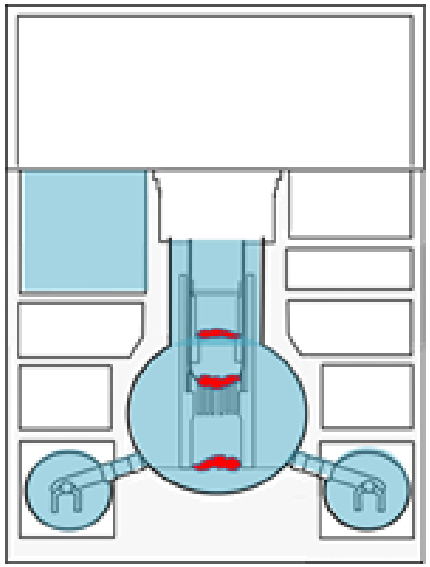
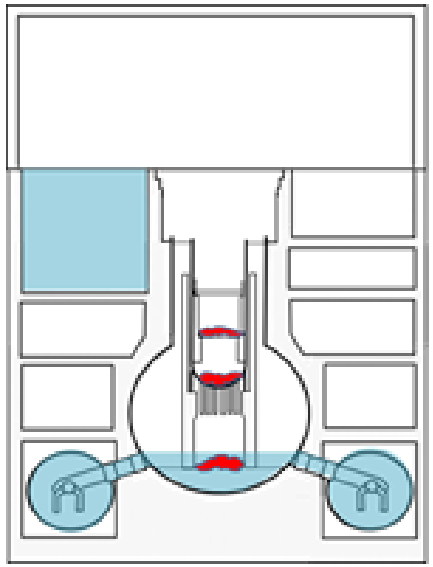
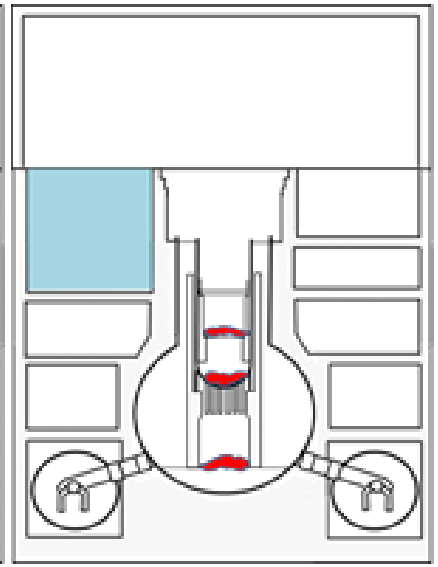
Chapter 4



Status of Plant Investigation and Estimated Fuel Debris Location

Unit	Plant investigation situation	Estimated fuel debris location
Unit 1	• The D/W water level is approx. 3 m from the RPV pedestal floor. • S/C is mostly filled with water. • The leakage from the sand cushion piping was confirmed. • The leakage from the expansion-joint cover of the vacuum break line connected to the W/W venting piping was confirmed. • Hot dose rate (several Sv/h) spot in the southeast area of the reactor building 1st floor.	• Almost all molten fuel dropped down to the RPV lower plenum and no fuel debris remains in the core. • The dropped fuel debris into the lower plenum dropped down to the RPV pedestal bottom. • The dropped fuel debris in the pedestal bottom flew outside of the pedestal (probable attack to the shell).
Unit 2	• The D/W water level is approx. 30 cm from the RPV pedestal floor. • The S/C water level is close to the center, which is almost the same water level to that of the torus. • There is no evidence of leakage in the torus upper section. • The photo of RPV pedestal inside taken from the opening confirms the structure of RPV lower region, which shows that the vessel failure will be not so large.	• Some molten fuel dropped to the RPV lower plenum and on the pedestal floor, and the remaining stays in the core (no fuel debris estimated outside the pedestal).
Unit 3	• The D/W water level is approx. 6.5 m from the RPV-pedestal floor. (estimated from the pressure differential of D/W and S/C) • S/C is mostly filled with water. • The leakage from the expansion-joint of the main steam piping D was confirmed.	• Some molten fuel dropped to the RPV lower plenum and on the pedestal floor, and the remaining stays in the core (no fuel debris estimated outside the pedestal).

Methods of Fuel Debris Retrieval according to the Water Level inside of PCV

Full submersion method	Submersion method	Partial submersion method	Dry method
			
Water level up to the reactor well top	Water level over the fuel-debris location	Water level lower than the upper fuel-debris location	No water and all fuel-debris is open to the air

Options for Fuel Debris Retrieval Method Considered PCV Water Level and Access Direction

		Access direction		
		Top	Side	Bottom
Water level	Full submersion	a.		
	Submersion			
	Partial submersion	b.	c.	
	Dry			

: Possibility of water flowing out from the openings

: Difficulty of constructing new access route

: Difficulty of evaluating cooling performance

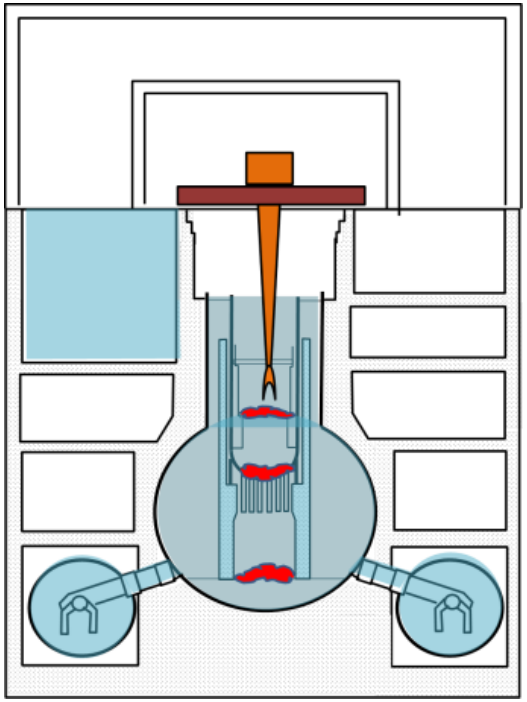
Methods to be focused were selected with due consideration of features of the water level and the access direction

Methods to be focused

a. Submersion method (including full submersion)
b. Partial submersion – top entry method
c. Partial submersion – side entry method

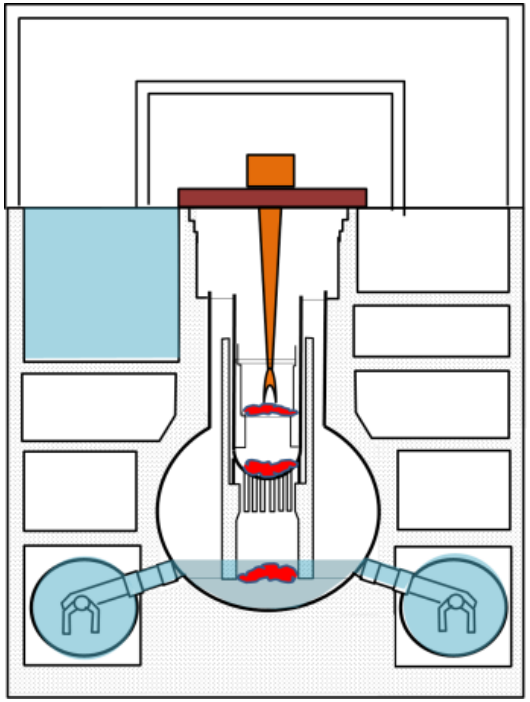
Note: The partial submersion method with side access has a possibility of water flowing out from the access openings.

Three Methods of Fuel Debris Retrieval to be focused



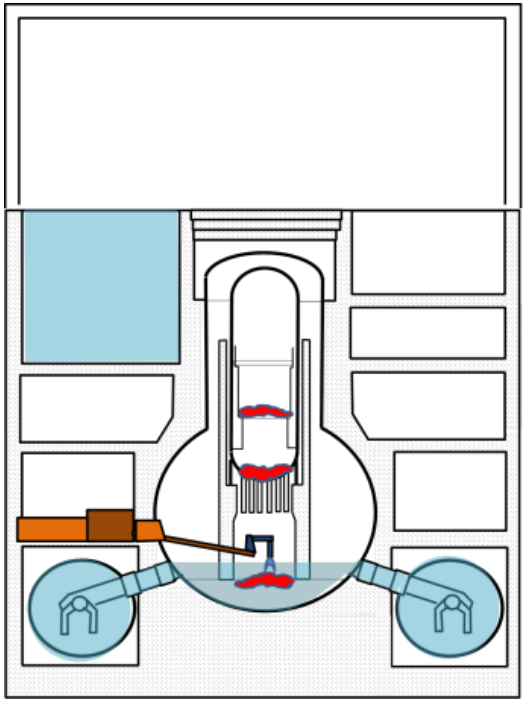
Submersion method

Image on condition that the removal of core internals above fuel debris has finished.



Partial submersion - Top entry method

Image on condition that the removal of core internals above fuel debris has finished.



Partial submersion - Side entry method

Image on condition that RPV pedestal exterior component inside PCV and the interference have been removed.

Fuel debris retrieval method scenarios and retrievable locations of fuel debris

Scenario	Method: Submersion-Top entry	Method: Partial Submersion-Top entry	Method: Partial Submersion-Side entry	Location of debris where The retrieval method is feasible: Inside RPV	Inside RPV pedestal	Outside RPV pedestal
(1)	○	—	—	OK	OK	NG[1]
(2)	—	○	—	OK	OK	NG[1]
(3)	—	—	○	NG[2]	OK	OK
(4)	1)	—	2)	OK	OK	OK
(5)	2)	—	1)	OK	OK	OK
(6)	—	1)	2)	OK	OK	OK
(7)	—	2)	1)	OK	OK	OK

The above numbers 1) and 2) indicate the order of procedure.

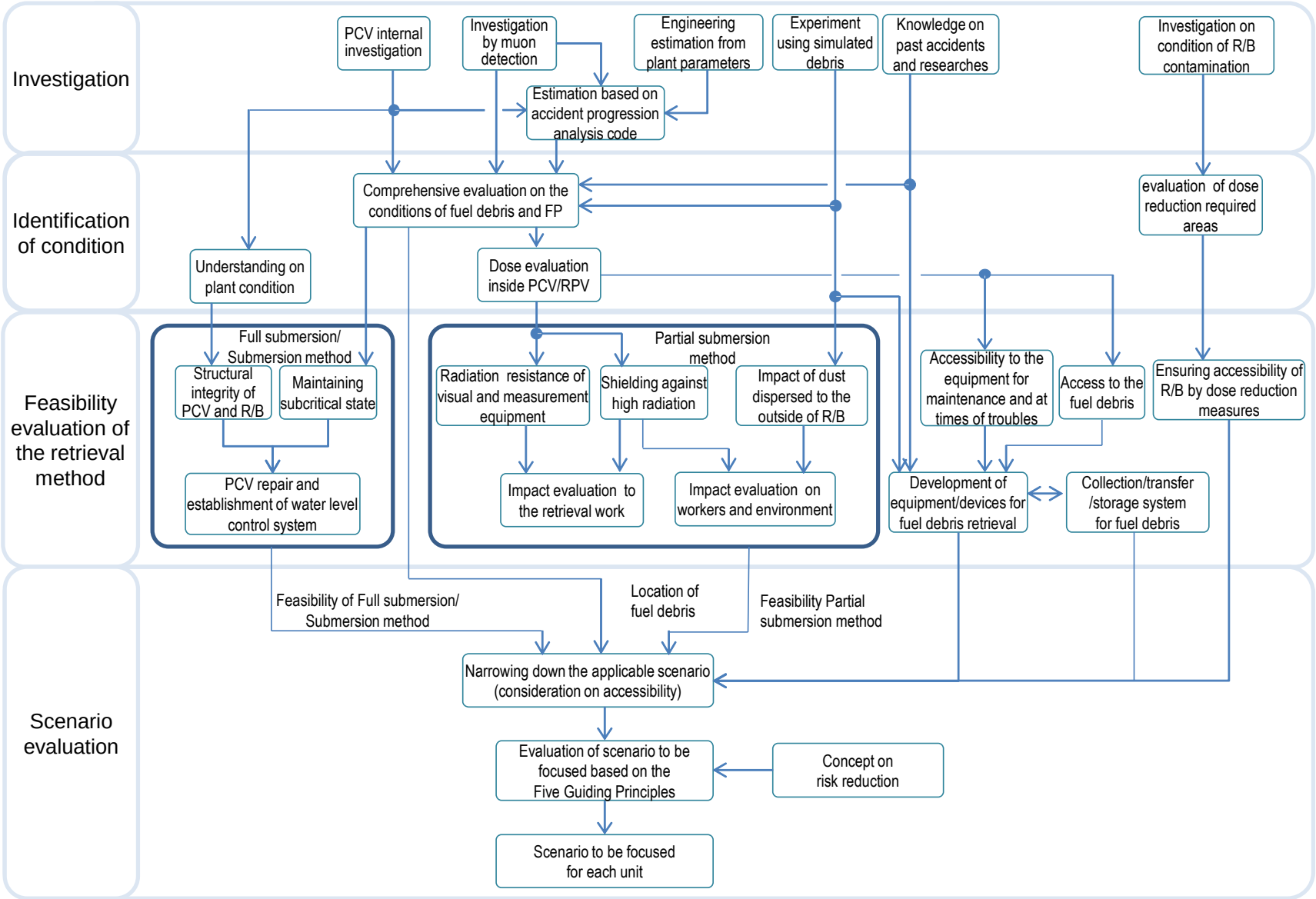
1: Retrieval of fuel debris outside the RPV pedestal will be difficult if only the Top entry method is used.
2: Retrieval of fuel debris inside the RPV pedestal will be difficult if only the Side entry method is used.

Technical Challenges of Fuel Debris Retrieval Methods

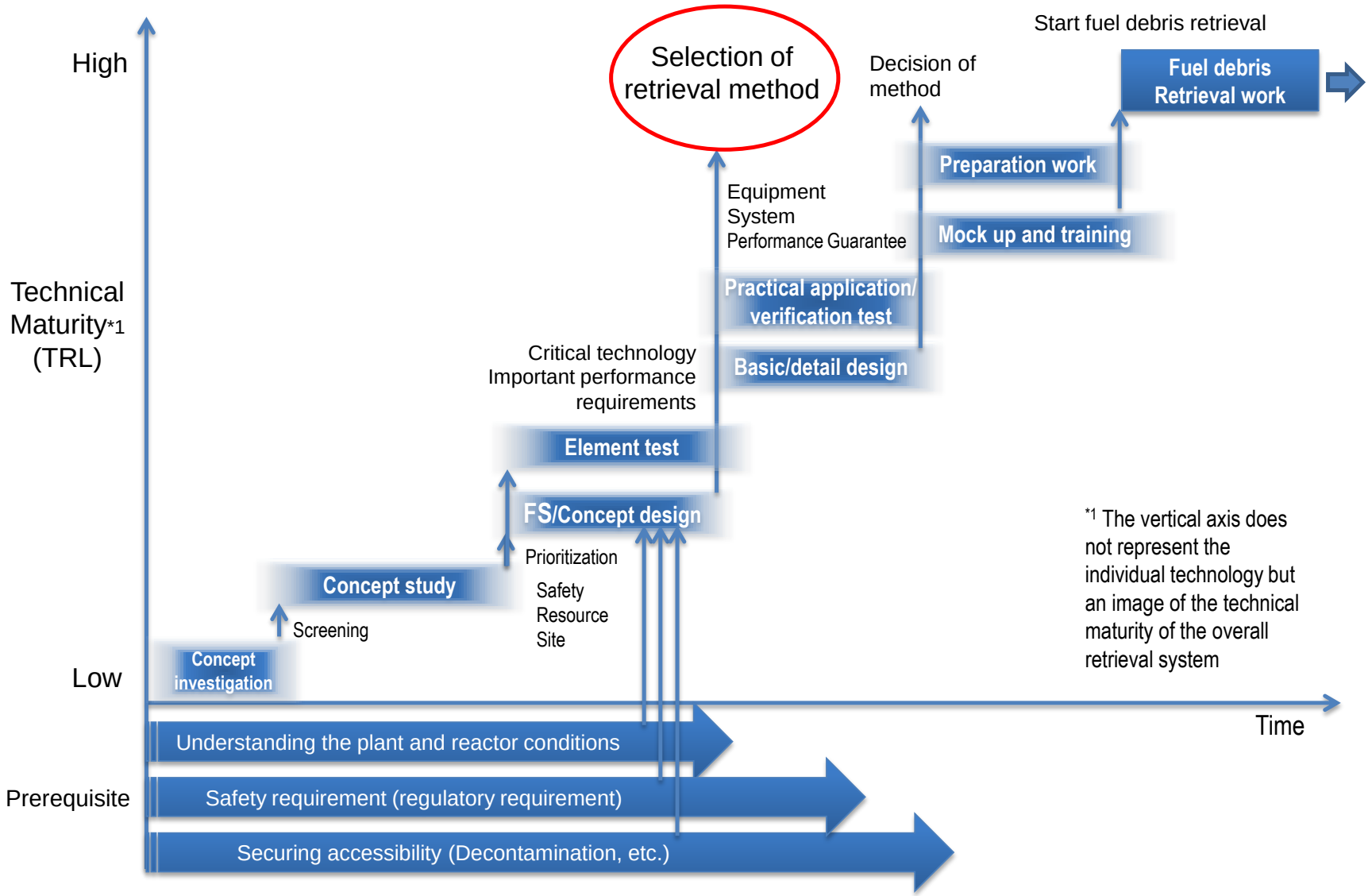
Technical Requirements	Submersion Method	Partial Submersion Method
1. Structural Integrity	☆ Load by flooding and Aging	○
2. Criticality	☆ Sub-criticality at Water Level Increase	○
3. Cooling	○	☆ Debris Coolability by Air
4. Containment	☆ PCV Repair & Water Level Control	☆ Dispersion of Radioactive Dust
5. Radiation Protection	◎ Dose Reduction in R/B	☆ Shielding of Fuel Debris ◎ Dose Reduction in R/B
6. Industrial Safety	○	○
7. Retrieval Equipment	◎ Repair & Maintenance	☆ Radiation Resistance ◎ Repair & Maintenance
8. Accessibility to Debris	◎	◎
9. System & Work Area	○	○
10. Canister, Transfer, Storage	◎	◎

☆ : Critical Challenges for the Method, ◎ : Common Important Challenges for both Methods
○ : To be confirmed

Decision Flow for Selection of Fuel-debris Retrieval Method Scenario

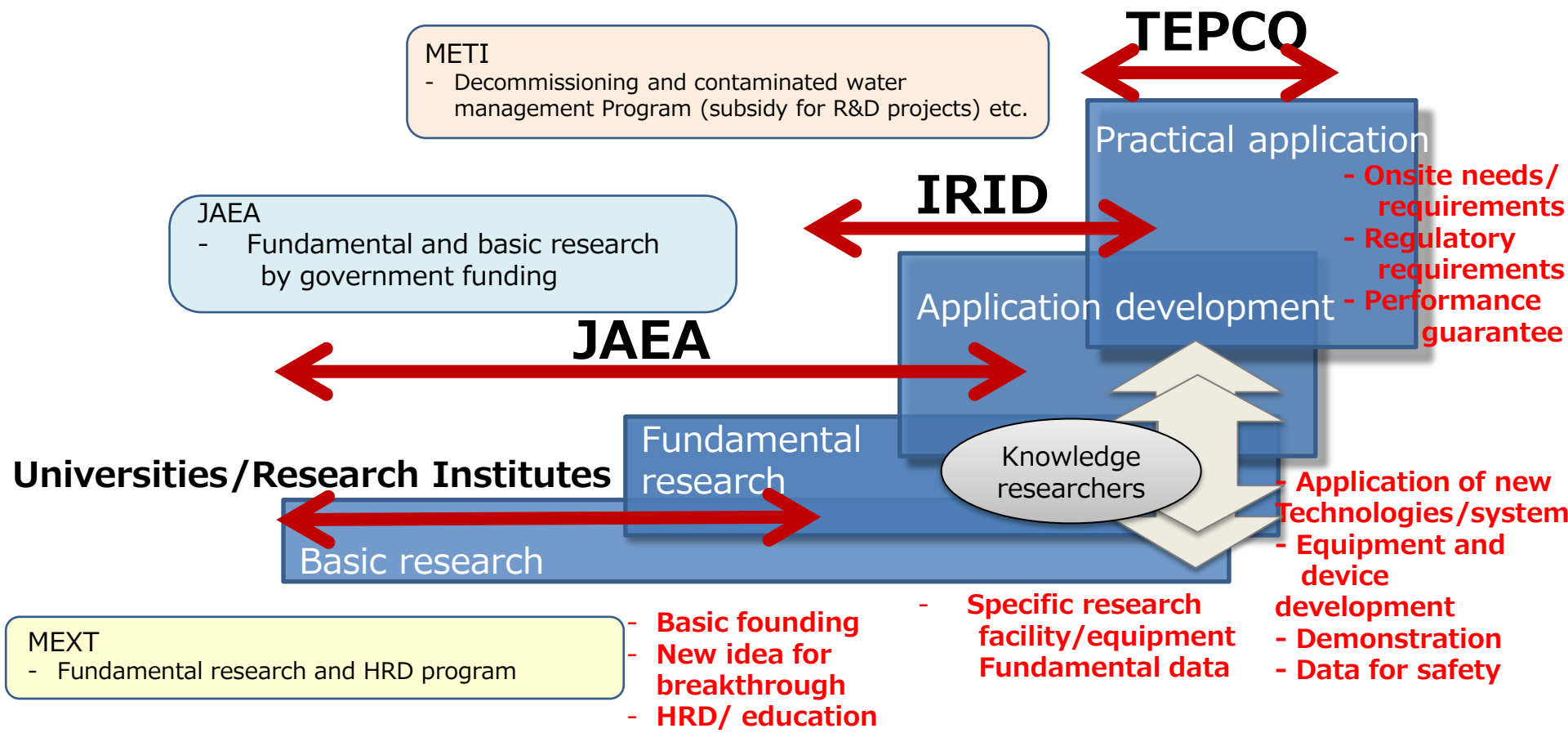


Road towards Fuel Debris Retrieval



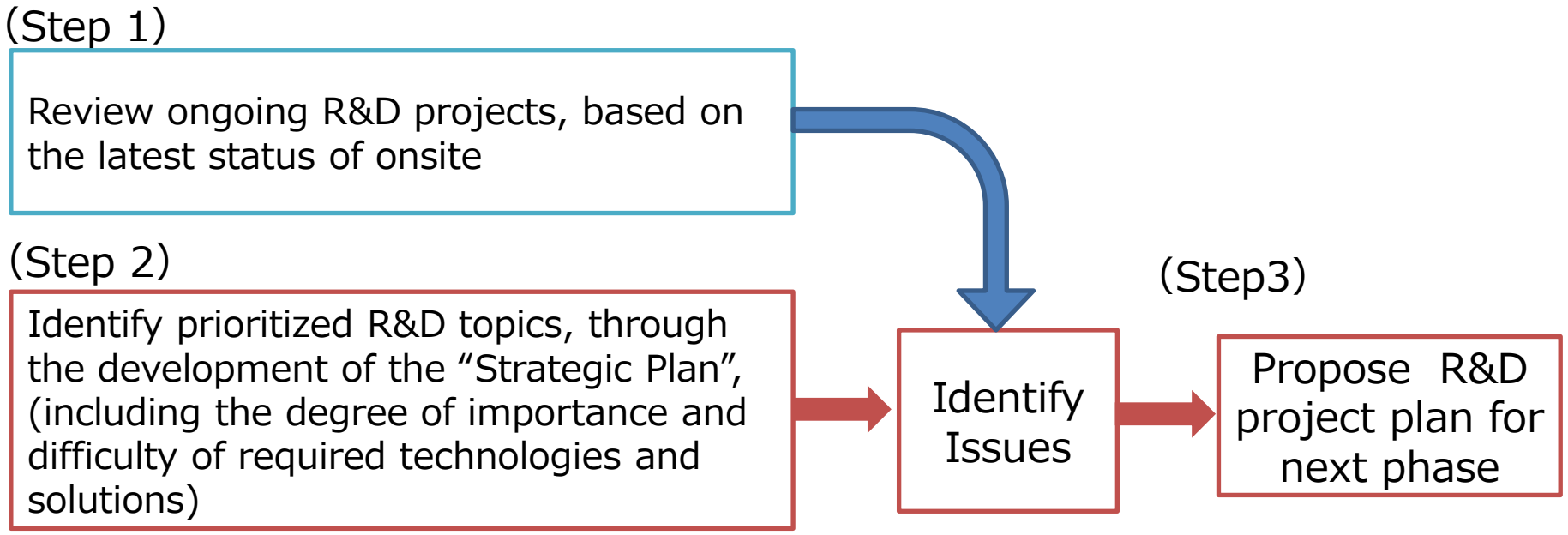
Overview of R&D activities related to Decommissioning of Fukushima Daiichi NPPs

- It is important to facilitate interaction and communications among researchers and engineers involved in a series of R&D initiatives.



Viewpoints for R&D Plan Review for Next Phase

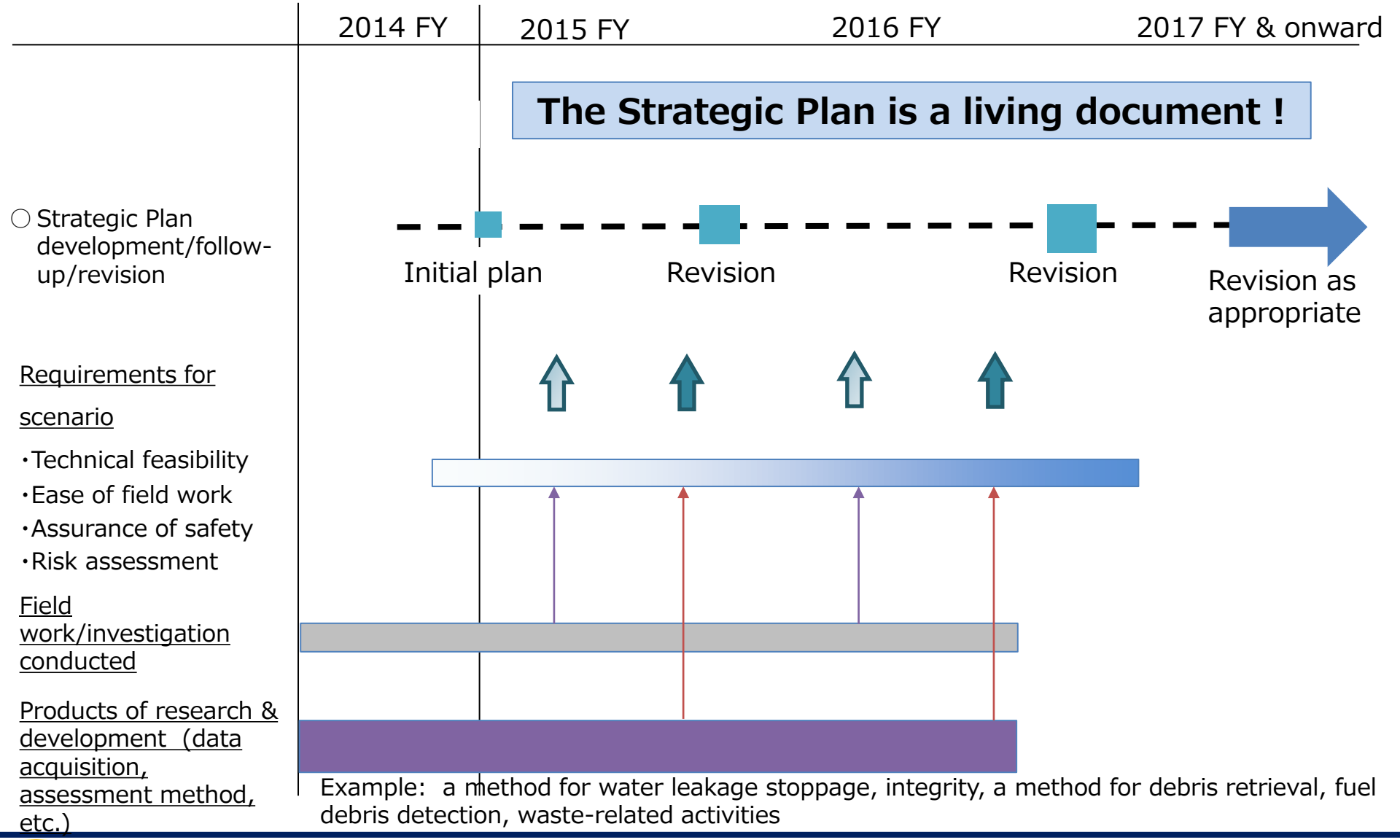
1. Identify issues, through the confirmation and review process of ongoing R&D projects taking into account latest status of Fukushima Daiichi NPP.
2. Identify and prioritize R&D topics to be addressed, through the course of developing the “Strategic Plan.”
3. Propose individual R&D project plan for the forthcoming term, including the efforts for new and additional issues, based upon the above two steps.



Next Phase R&D Plan

- Fuel debris retrieval
  - Decontamination and dose reduction
    - ✓ Development of remote decontamination technologies & comprehensive dose reduction plan
  - Water leakage prevention from PCV
    - ✓ Development of technology to repair leaks and water stoppage of PCV
    - ✓ Full-scale test for repairing leaks from PCV and water stoppage of PCV
  - Internal investigation
    - ✓ Development of technology to investigate the inside of the PCV
    - ✓ Development of technology to investigate the inside of the RPV
    - ✓ Sophistication of internal investigation using accident progression analysis and actual unit data
    - ✓ Development of technology to detect fuel debris in the reactor (Muon)
  - Fuel debris retrieval method
    - ✓ Technological development for fuel debris retrieval and internal structures
    - ✓ Technological development for collecting, transferring and storing the fuel debris
    - ✓ Technological development for integrity assessment of RPV/PCV
    - ✓ Technological development for fuel debris criticality control
  - Fuel debris analysis
    - ✓ Understanding of fuel debris properties, using simulated debris and accrual debris analysis

Future Development of the Strategic Plan



Example: a method for water leakage stoppage, integrity, a method for debris retrieval, fuel debris detection, waste-related activities