IRID

Overview and Activities of International Research Institute for Nuclear Decommissioning (IRID)

May 14, 2014

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無断複製·転載禁止　技術研究組合　国際廃炉研究開発機構
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Revision of Mid-and-Long-Term Roadmap and Background of Establishment of IRID

Overview of revised Mid-and-Long Term Roadmap
(Council for the Decommissioning on June 27, 2013)

1. Acceleration of the schedule for each unit corresponding to the respective condition.
   - ✓ Multiple plans were developed aiming at the fuel debris retrieval for initial unit to be conducted ten years later to be flexible with each unit.
2. Enhance communication with local community
   - ✓ Establish “Fukushima Advisory Board (tentative name)”
   - ✓ Provide opportunity to find the corporation in Fukushima in order to collaborate for decommissioning work, and revitalize regional economy by encouraging local corporations supplying equipment/tools.
3. Full scale maintenance of structure to gather knowledge and ideas from around the world.
   - ✓ Establish R&D organization and arrange system to receive advice from overseas experts.
   - ✓ Enhance collaboration with IAEA review mission, and proactive promotion of international joint research.

In addition to the above, following items will be stipulated and addressed in the Mid-and-Long Term Roadmap.

- ✓ Reports the countermeasures on control of groundwater inflow by “Contaminated Water Treatment Committee.”
- ✓ Secure safety of ”Specified Reactor Facility” and measures on regulations, such as of arrangement of new standards. (improve reliability of equipment and facilities, and operation safety for operator and radiation safety etc.)

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Process of Establishment and Role

Establishment

- August 1, 2013: Approved by Mr. Motegi, the Minister of Economy, Trade and Industry, according to the Research & Development Consortium Act of Japan.
- August 8, 2013: General Meeting and the Board of Directors were held to start the consortium. Launched as the International Research Institute for Nuclear Decommissioning.

Basic Role

- Fully committing to technology R&D that helps the decommissioning project of Fukushima Daiichi NPS as an urgent subject, based on which enhancing the technological basis for nuclear decommissioning for the future.

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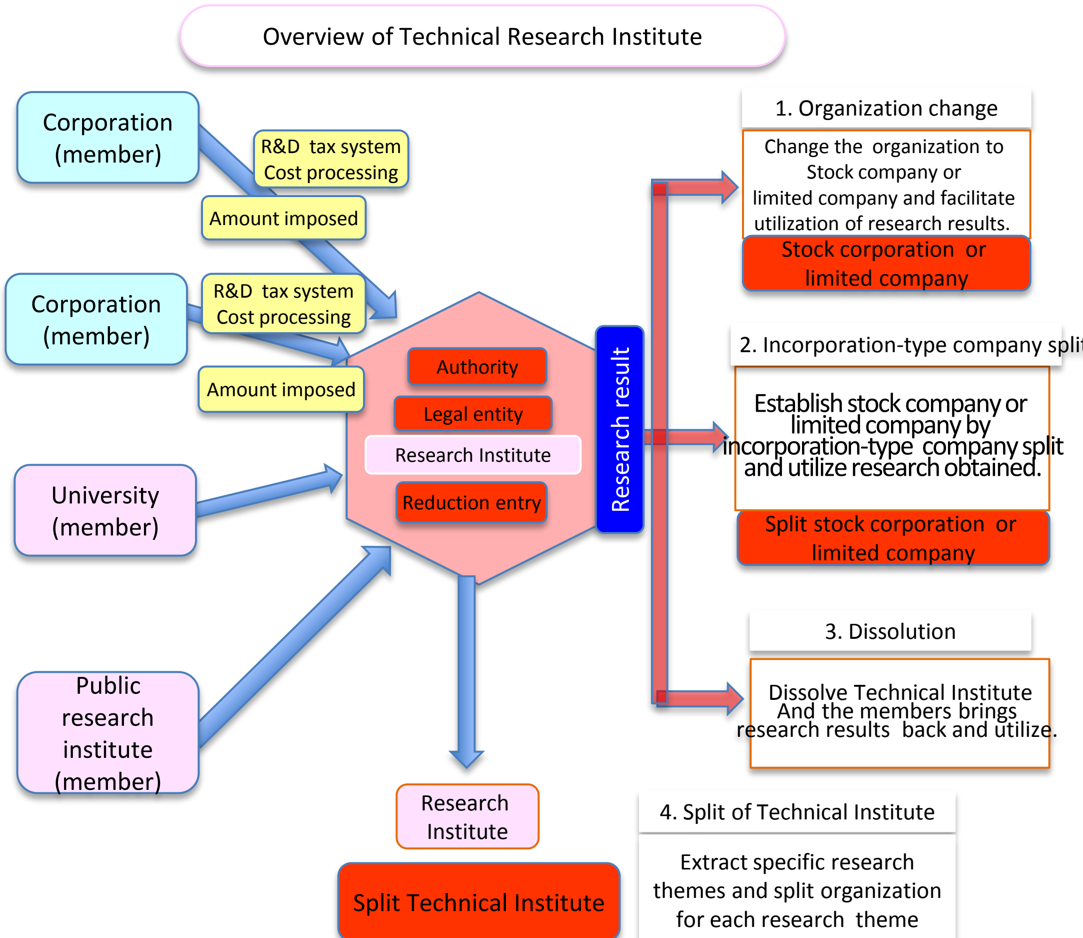
Technical Research Institute

Technical research association is an organization for mutual support where the members conduct joint research on the technologies used for the industrial activities for themselves（non-profitable mutual benefit corporation established in accordance with the Research & Development Consortium Act of Japan).



<Features of Technical Research Association>

- Each member provides researchers, research fund, facilities etc., and manage and utilize those result together.
- Joint research organization with legal personality, independent from the members.
- Improve transparence and reliability of organizational operation through the registration and application for authorization for establishment for the competent minister, and members' general conference and the board of directors.
- Person or party（including domestic corporation, individuals, foreign corporation and foreigner）that utilizes the results of joint research directly or indirectly can be a member of this organization.
- This organization can be utilized as a place of cooperation among government, industry and academia since the universities and independent administrative corporation of test research, technical college, local public body, foundation mainly aiming at the test research etc. members can take part in.

(Excerpts from METI)

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Outline of IRID

1. Name

Research & Development Consortium,
"International Research Institute for Nuclear Decommissioning" ("IRID " in brief)

2. Location of Main Office

6F, Parkplace, 5-27-1, Shimbashi, Minato-Ku, Tokyo, 105-0004, Japan
(http://www.IRID.or.jp)

3. Founding members (18)

- Incorporated administrative agencies:
  Japan Atomic Energy Agency, National Institute of Advanced Industrial Science and Technology.
- Manufacturers:
  Toshiba Corporation, Hitachi-GE Nuclear Energy, Ltd., Mitsubishi Heavy Industries, Ltd., ATOX (since May 29, 2014)
- Electric utilities etc :
  Hokkaido Electric Power Company (hereinafter called as EPC), Tohoku EPC, Tokyo EPC, Chubu EPC, Hokuriku EPC, Kansai EPC, Chugoku EPC, Shikoku EPC, Kyushu EPC, The Japan Atomic Power Company, J-POWER, Japan Nuclear Fuel Limited.

4. Board of directors

President: Dr. Yamana, Vice President: Dr. Arai, and Mr. Kenda, Executive Director: Mr. Suzuki
Director: Mr. Oikawa, Mr. Moriyama, Mr. Uozumi , Mr. Hatazawa, Mr. Seto
Mr. Fukuda and Mr. Kadokami
Auditor : Mr. Konashi

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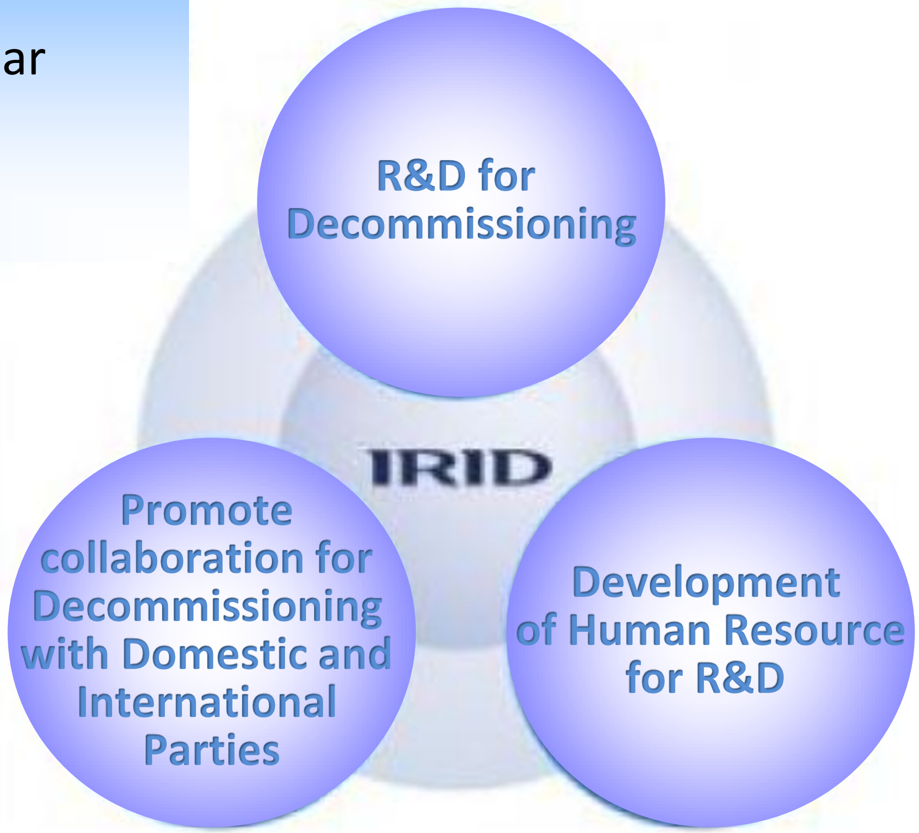
Projects of IRID

IRID gathers knowledge and ideas from around the world for the purpose of R&D in the area of nuclear decommissioning under the integrated management system.

R&D projects:

・Fuel assemblies removed from spent fuel pool
・Preparation for fuel debris retrieval
・Treatment and disposal of radioactive waste



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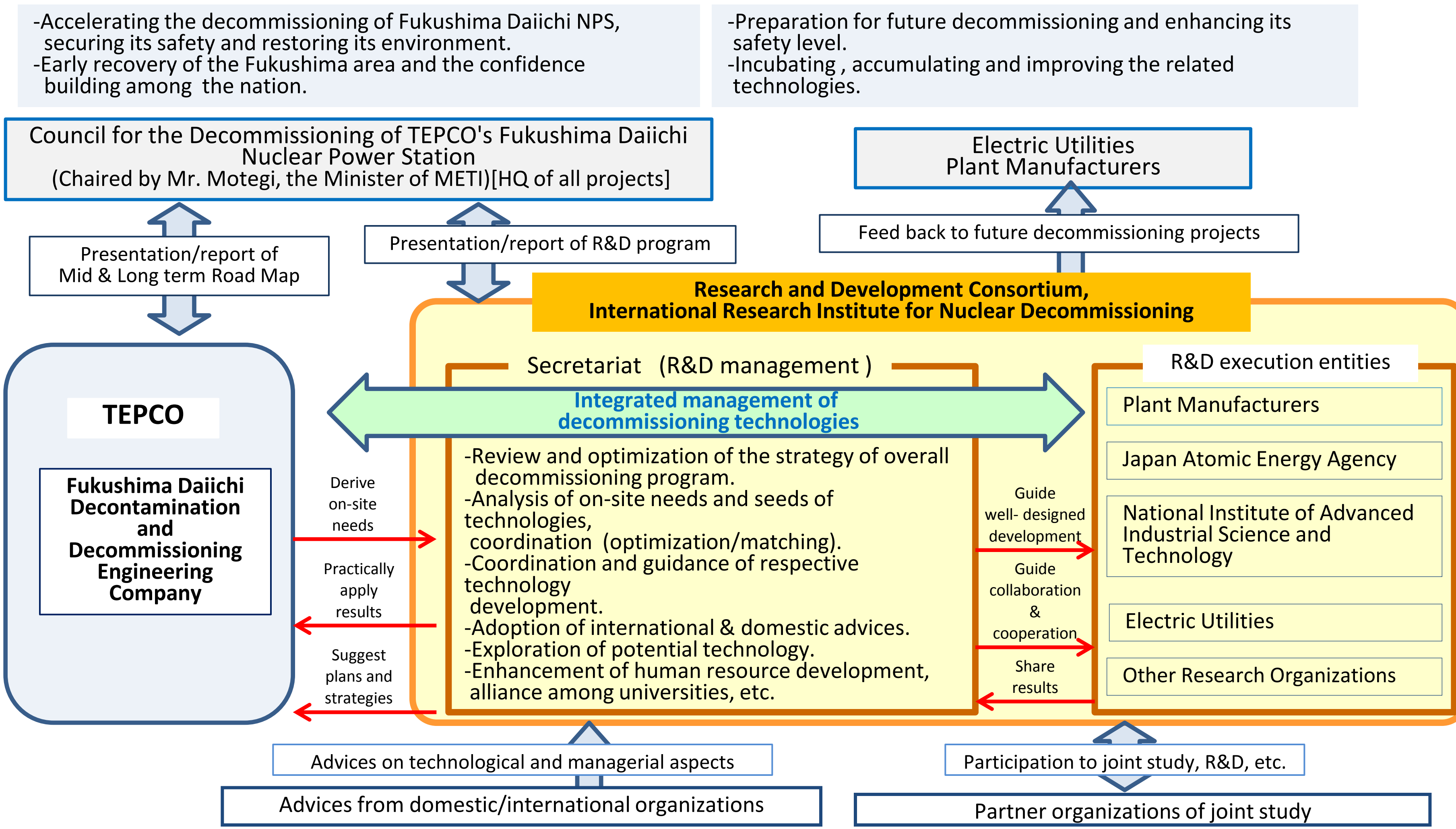
Schematic image of IRID ’s function

<With perspective of enhancing technological basis for reactor decommissioning, focusing on clear and present challenges of Fukushima Daiichi NPS decommissioning.>



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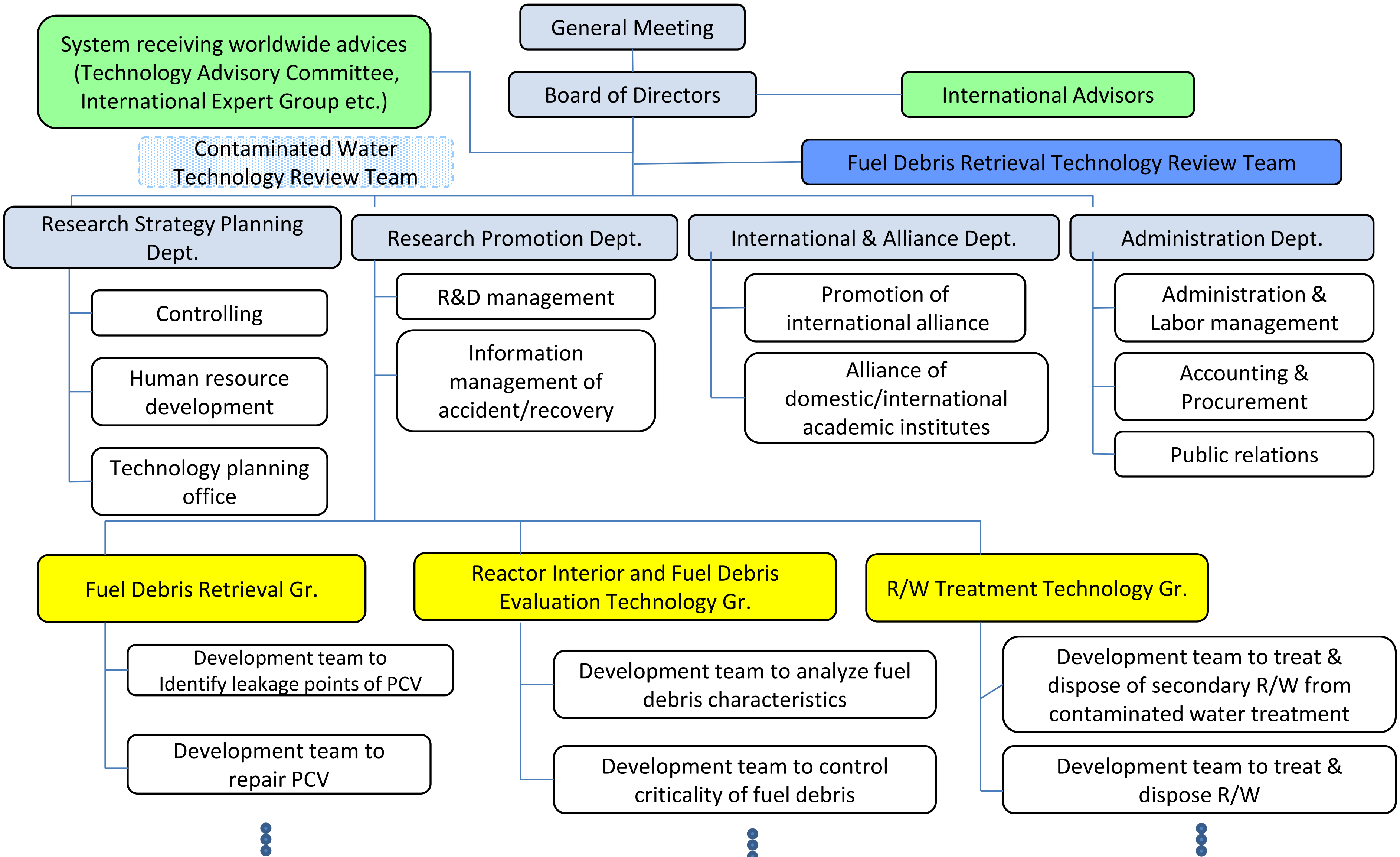
Organizational chart



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Present operation plan (R&D projects)

R&D to set up fuel debris retrieval

- R&D for remote decontamination in reactor building
- Development of technology for investigation of inside of PCV
- Development of repair and stopping water leakage technology for leakage location of PCV
- Development of technology for retrieval of fuel debris and in-core structures
- Development of technology for investigation of inside of RPV
- Development of technology for evaluation of soundness of RPV/PCV
- Estimation of inside of reactor using severe accident analysis code
- Development of technology for grasping of characteristics and treatment of fuel debris
- Development of technology for detection of fuel debris in reactor
- Development of technology for packing, transfer and storage of fuel debris
- Development of repair and stopping water leakage technology for leakage location of PCV
- Full-scale test for repair and stopping water leakage technology for leakage location of PCV

R&D for treatment & disposal of R/W

- Development of technology for disposal of accident waste

R&D to retrieve SFs from SF pools

- Evaluation of long-term soundness of fuel assembly, etc. retrieved from spent fuel pool
- Consideration of treatment method of damaged fuel, etc. retrieved from spent fuel pool

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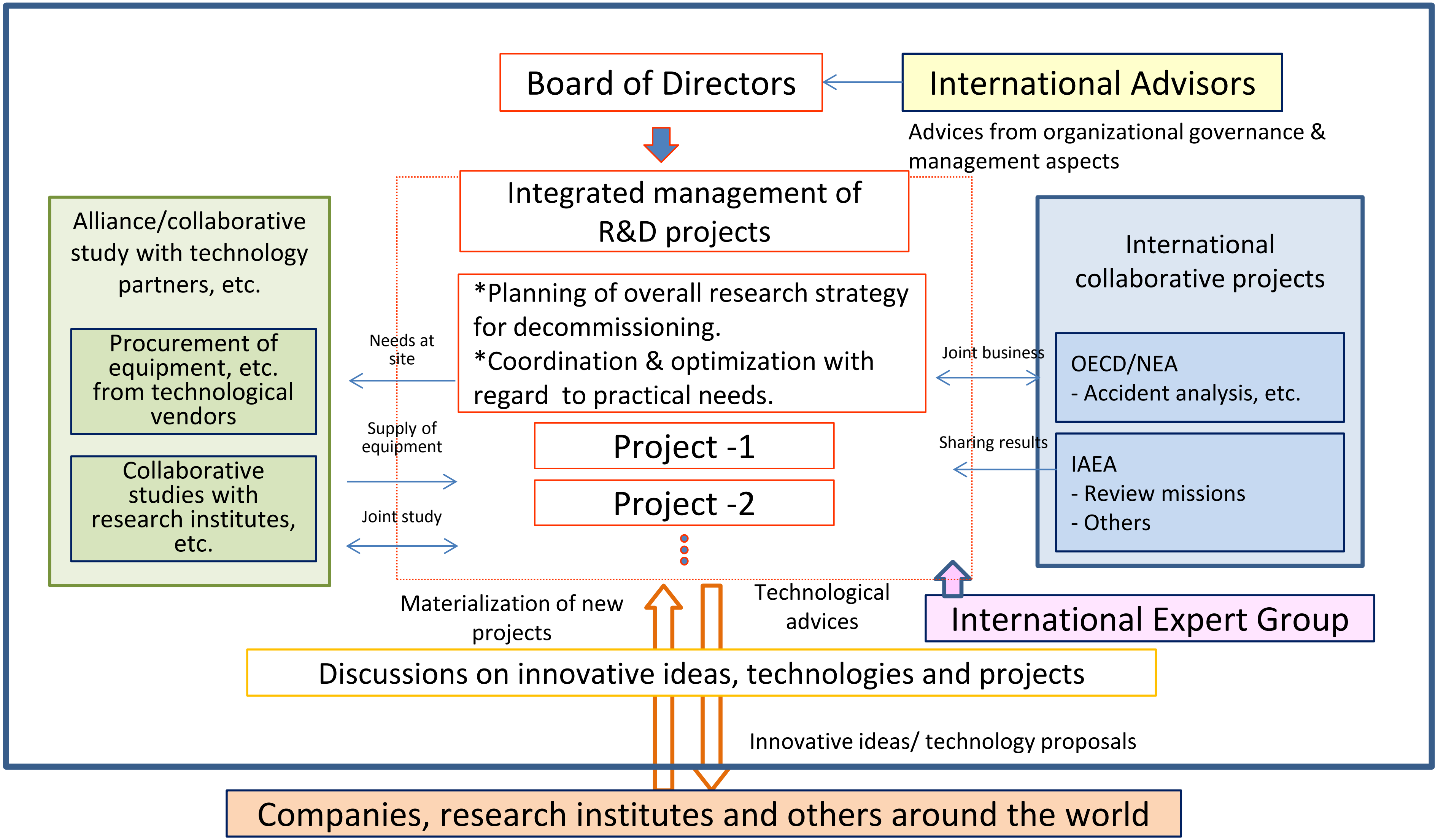
“Open Platform” to integrate knowledge from all around the world



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International Adviser and International Expert Group

Soliciting advices based upon findings & experiences of other countries

- **Advices from the International Advisors on overall management at IRID .**
  - **Mr. Lake Barrett (US):** Former NRC, Individual consultant. (Director of measures to contain the TMI accident.)
  - **Dr. Adrian Simper (UK)**: Director of NDA
  - **Mr. Luis E. Echavarri (Spain)**: Former OECD/NEA Director-General
  - The 1st Meeting held on Jan. 9-10, 2014
- **Technological advices from the International Expert Group**
  - **Douglas Chapin (USA)**: President of MPR (experienced in restoration from TMI accident and clean-up of the facilities.)
  - **Dr. Rosa Yang (US)**: Electric Power Research Institute(EPRI) Senior Technical Executive
  - **Dr. Adrian Simper (UK): Director of NDA**
  - **Dr. Joel Pijselman (France)**: Current Chairman of ETC (former Vice president of AREVA)
  - **Mr. Nikolai Steinberg (Ukraine)**: individual consultant (involved in Decommissioning strategy of Chernobyl Nuclear Power Plant.)
  - **Mr. Anton Leshchenko (Russia)**: Deputy Head of Research Department, Research and Development Company. “Sosny” (engaged in the retrieval work of damaged fuel at Paks Nuclear Power Plant)
  - The 1st Meeting held on Sep. 23-27 (Tokyo/Fukushima)
  - The 2nd Meeting held on Feb. 17-21, 2014 (Tokyo)
  - The 3rd Meeting held on Jun. 24-27, 2014 (Tokyo)

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IAEA Review Mission

- **IAEA International Peer Review on “TEPCO Mid-and-Long Term Roadmap for Decommissioning of Fukushima Daiichi Nuclear Power Station Unit 1-4” (Nov. 25 -Dec. 4, 2013)**

IRID , along with METI and TEPCO, discussed with IAEA inspection team consists of 19 members and obtained following evaluation results.

- A comprehensive structure was developed, such as establishing IRID so as to utilize technical knowledge and technological capability around the world in order to accelerate the decommissioning activities of Fukushima Daiichi Nuclear Power Station more safely.
- The intension to incorporate international experience and to seek international cooperation by having IRID participated was clearly confirmed.
- IAEA confirmed that TEPCO and IRID make contribution toward the development of remote control technologies to identify cooling water leakage in the PCV and repairing the leakage. Application of the equipment to identify the leakage points is a significant step for PCV isolation (leakage points closure)
- Establishing the working group (WG) for the development of remote control equipment will shorten the time between identifying specific needs and the handing over of the facilities assisted by each developed remote technology. For example, after the WG was established, the time it took for the device detecting the leakage inside the dry-well was 7-8 month. Participation of plant representative to the WG will contribute to successful development.

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International Joint Project

IRID contributes to enhance the safety and decommissioning work of nuclear faculties around the world through the international joint work.

- **OECD/NEA BSAF Phase I**
  - **Joint benchmark research on accident status of Fukushima Daiichi and current condition of the core through the analysis codes including improved version for severe accident analysis codes.**
  - **Sharing common data and information database**
- **Project for the next stage (plan)**
  - **BSAF Phase II with expanded scope (Hydrogen, MCCI etc.)**
  - **Sampling, analysis, and property identification of fuel debris**
  - **Issues regarding the management of radioactive waste (methods of identifying and categorizing the properties and disposing the waste material)**

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Evaluation of R&D Project

Technical Advisory Committee (Experts of third parties)

Role : Evaluate and advice on overall R&D strategy and the activities of IRID .
Chairperson: Satoru Tanaka (Professor of School of Engineering, University of Tokyo)
Committee member :
Hajime Asama (Professor of School of Engineering, University of Tokyo)
Yutaka Watanabe (Professor of School of Engineering, Tohoku University)
Shinsuke Yamanaka (Professor of Graduate School of Engineering, Osaka University)
Osamu Tochiyama (Director, Radiation and Waste Safety Research Center, Nuclear Safety Research Association)

Subcommittees
(Evaluation of R&D project)

(1)**Fuel debris retrieval equipment/remote operation technology***
Chairperson:
Hajime Asama

(2) **Spent fuel・PCV/RPV soundness evaluation technology**
Chairperson:
Yutaka Watanabe

(3)**Technology of identifying internal conditions /fuel debris properties**
Chairperson:
Shinsuke Yamanaka

(4)**Treatment/disposal technology of radioactive waste**
Chairperson:
Osamu Tochiyama

*Deliberate and propose solutions through integrating knowledge and experience of remote technology.

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Measurements against the contaminated water issue

In response to the 1st Inter-Ministerial Council for Contaminated Water and Decommissioning Issues on September 10, a review team consisting of the related experts mainly from IRID has been established to implement concrete measures for contaminated water issues.

Solicitation for domestic/foreign technologies, gathering information and classification/sorting of the proposed technologies will be implemented. The results will be then reported to the governmental "Committee on Countermeasures for Contaminated Water Treatment."

<Schedule>

Sep. 20: A website to solicit the technology proposals started. www.IRID.or.jp/cw
Oct. 2: An explanatory meeting on solicitation for the technology proposals (at Iino building, Tokyo).
Early Oct : Information exchange with the foreign organizations, etc.
Oct .23: Deadline for proposals.
Late October to early November: Classification/sorting of the technology proposals.
Nov.15: Report to the Committee on Countermeasures for Contaminated Water Treatment
Dec.10: Summarize Report to the Committee on Countermeasures for Contaminated Water Treatment

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Gathering knowledge on contaminated water issue around the world

■ Call for technical proposal

◇ An expert team established mainly by the International Research Institute of Nuclear Decommissioning(IRID) to gather knowledge from experts around the world collected the technical proposal. (application period: Sep. 25-Oct. 23.)

◇ Ideas submitted were evaluated mainly by "contaminated water treatment committees" to reflect to the preventive and multilayered measurements on contaminated water .

■ Status of submitted idea

◇Total number of proposals submitted was 780. Details are as follows.

Field of proposal	No. of submitted ideas
(1) Contaminated water storage (storage tank, small leak detection technology etc.)	206
(2) Contaminate water treatment (tritium separation technology, method of long-term stable storage of tritium etc.)	182
(3) Purification of seawater inside the bay (Removal technology for radioactive Cs, Sr in seawater etc.)	151
(4)Control of contaminated water inside the building (Indoor water stoppage technology, soil improvement construction technology etc.)	107
(5)Control of drainage flows into the site (water shielding wall construction technology, phasing technology etc.)	174
(6)Identify behavior of groundwater etc. (geological features, groundwater data measurement system, water quality analysis technology etc.)	115
Others (Items not subject to (1)- (6)	34

(Note 1) Field of proposal was selected by applicant.
(Note 2) Some of the proposal submitted for one filed were subject to multiple fields.

(Contaminated water treatment committees meeting)

◇Large picture of countermeasure technology for contaminated water can be overlooked by the technical proposal from around the world, and all the proposals submitted are valuable data.

◇Following technologies are extracted in reference to the level of technological maturity, urgency of measurement, and applicability to the site etc.

(1) Technology which should be utilized as soon as possible after confirming applicability to the actual site

- Large size tank with high credibility , like Double steel shell tank etc.
- Light-weight shielding sheet without lead
- Pollution preventing membrane(silt fence)
- Water stoppage technology (water stoppage inside the building, stoppage of the water around the building)
- Maintain geological condition, ground water investigation, observation network etc.

(2) Technology which should be utilized after selecting execution method in consideration of workability and cost effectiveness etc.

- Countermeasure technology water shielding (phasing , water shielding etc.)

(3)Technology ~~whose~~ that are expected to be effective but need confirmation and verification before utilization.

- Small leak detection technology (including dose rate)
- Tank decontamination technology without using water
- Tritiated water storage ･separation technology
- Purification technology for seawater inside the bay
- Filter in the ground (capturing technology of strontium in soil)
- Unmanned boring technology etc.

(4) Items to be addressed based on the verification results of contaminated water treatment committees.

- General evaluation for tritiated water
- Examination(?) of problems regarding tanker, underground storage etc.

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Promoting fundamental studies and human resource development

- Promote the fundamental studies in alliance with universities, research institutes and so forth to secure human resource and its development from mid-to-long term perspective.
- Through hosting workshops in cooperation with the Ministry of Education, Culture, Sports, Science and Technology (MEXT), disseminate and share the information on R&D programs, as well as considering areas and tasks of any fundamental studies to be focused on that meet practical needs.

(Workshops hosted)

Hosted a series of workshops on R&D programs and fundamental studies.

- 1st (September 25, Kanto-1): R/W, Fuel debris.
- 2nd (October 8, Fukushima): Development of remote controlled equipment and device, Data visualization.
- 3rd (November 1, Kansai/Western Japan-1): R/W, Fuel debris.
- 4th (November 20, Tohoku/Hokkaido): Integrity of PCVs, etc., R/W.
- 5th (November 26, Kanto-2): Development of remote controlled equipment and device.
- 6th (Dec. 20, Kansai/West Japan-2):Development of remote controlled equipment and device.
- 7th (Dec. 25, Hokuriku-2): Integrity of PCVs, etc., Fuel debris.
  Development of remote controlled equipment and device.
- 8th (Jan 18, Chubu): Integrity of PCVs, development of remote controlled equipment and device
  Fuel debris, R/W.
- 9th (Jan. 22, Kanto-3): Fuel debris, material, R/W, and analysis-related issue.

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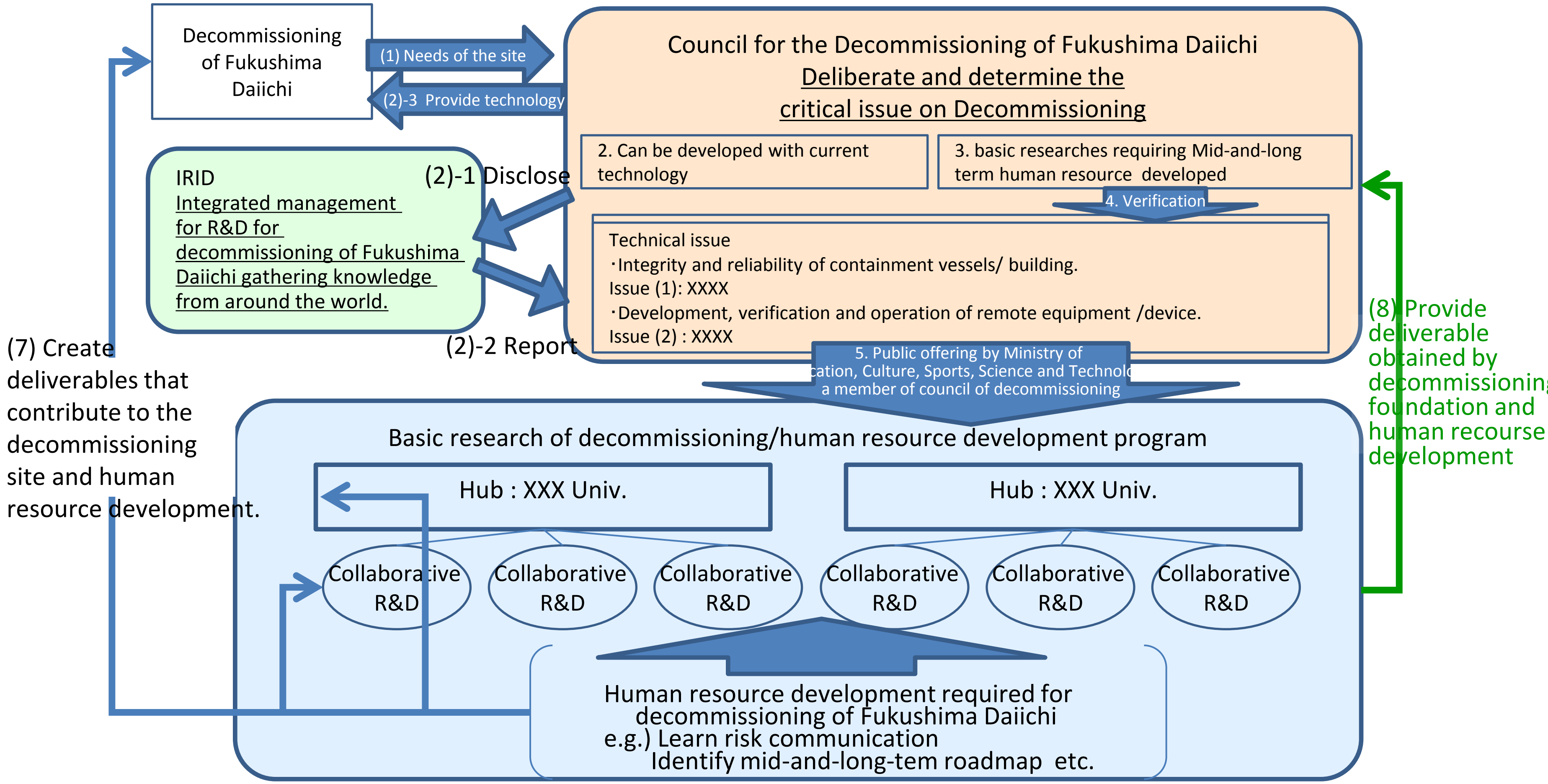
Basic Research for Decommissioning etc. and Human Resource Program

Creation of new knowledge on mid-and-long-term decommissioning etc., and development and securing the human resource development are required through the countermeasures on TEPCO'S Fukushima Daiichi accident.

⇒ In collaboration with International Research Institute for Nuclear Decommissioning, implement basic research by gathering knowledge and ideas from various fields of research institute such as of universities for the priority area regarding human resource development defined by the Council for the Decommissioning from perspective of human resource of Mid-and-long term and create the deliverables which can contribute to the decommissioning site and human resource development.



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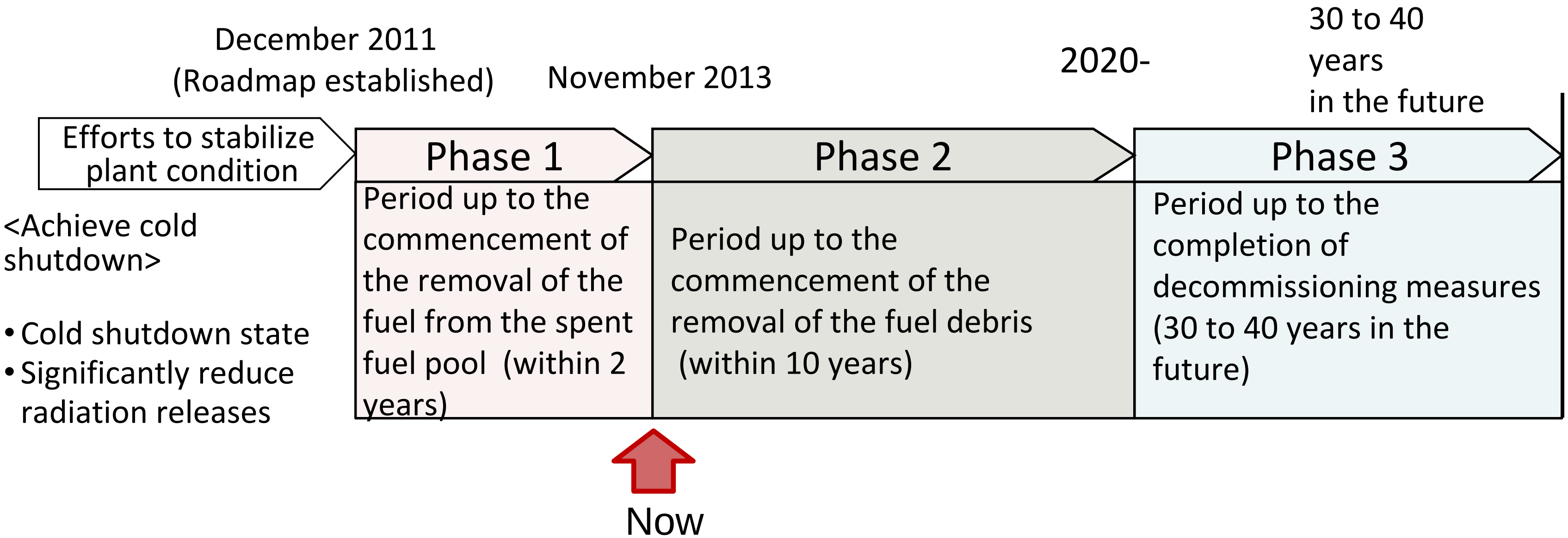
R&D schedule

Having completed Phase 1 of Mid-and-Long-Term Roadmap, R&D will be addressed as follows from the Phase 2.

1. Promotion of long-term R&D in response to the start of fuel removal from spent fuel pool.
2. Development of multilateral･multilayered method and equipment for full scale preparation of fuel debris retrieval(1) - Submersion method-
3. Development of multilateral･multilayered method and equipment for full scale preparation of . fuel debris retrieval(2) - Alternative method-
4. Stable promotion of R&D inconsideration of treatment and disposal of radioactive waste, and decommissioning.



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R&D Activities of IRID

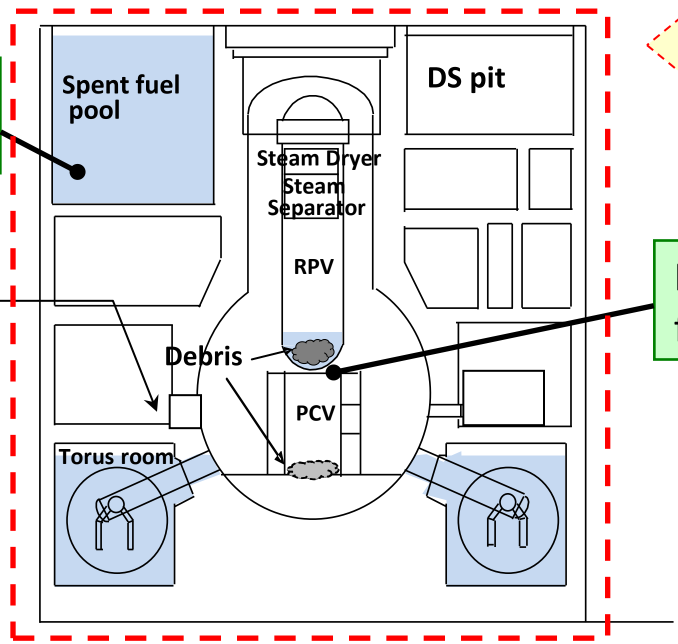
■ R&D activities to be carried out in order to meet <u>severe conditions</u> of reactor buildings at Fukushima Daiichi.

High dose rate	High temp.	High humidity	Rubble
Elevated places	Underwater	Narrow places	Injection of sea water

R&D for fuel removed from spent fuel pools

R&D for treatment and disposal of R/W

R&D for preparation for fuel debris removal



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1. Promotion of study from long-term perspective in response to the start of fuel removal from SFP

・Fuel removal from spent fuel pool at Unit 4 was started on Nov. 18, 2013.

・Soundness of transferring these fuels and storage was approved by TEPCO.

・IRID established evaluation method for soundness of long-term storage at the common pool (corrosion resistance etc.), regarding this as one of IRID's research targets, by obtaining verified data from the fuel at the actual unit. The results obtained from the research will be reflected to the actual evaluation.

< Major activities >

- Establish test conditions for the long-term soundness evaluation based on the result of trial examination within 2013
- Also, conduct corrosion test for fuel material, strength test, technology of water quality effect evaluation.

・ In addition, a research on the index for judging the possibility of reprocessing the retrieved damaged fuel, while taking the adhesion of salt contained in the seawater and physical damage by the rubbles into consideration, is ongoing.

< Major activities >

- Aiming to obtain the research results in 2017, in order to determine the methods of the spent fuel management and storage based on the case study conducted overseas in 2013.

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R&D and tasks for fuel removal from spent fuel pool – (1)

■Evaluation of long-term integrity of the fuel assembly removed from the Spent fuel pool

･development of the methods to evaluate long-term integrity of fuel assembly considering the specificity of sea water inflow and debris mixing and study of long-term storage methods.

■ Tasks

･Corrosion evaluation considering influences such as sea water inflow at SFP and debris falling etc. in a common pool fuel

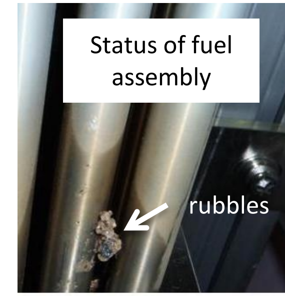
･development of fuel assembly strength evaluation method considering corrosion

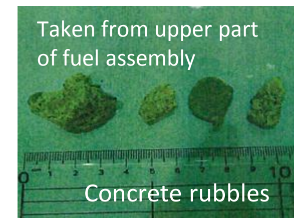
･dry storage evaluation points study considering environmental history, technical evaluation

<u>Common Pool (wet type) concerns at storage</u>

corrosion in the common pool

- material factors
  - Influence to the material character by an irradiation history using in the reactor
  - New aspect exposure by rubbles falling
- environmental factors
  - Elusion from debris with fuel taken from SFP
    - component of sea water
    - concrete component
  - FP elusion from damaged part of fuel assembly

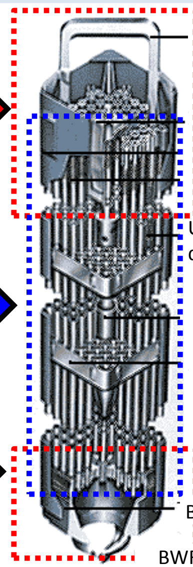




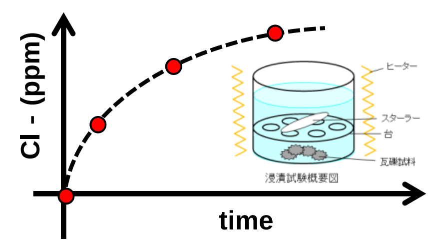
<u>Structural integrity</u>
- Handle
- Top tie plate
- Tie rod bolt joint

<u>Sealability of cladding</u>
- Fuel cladding

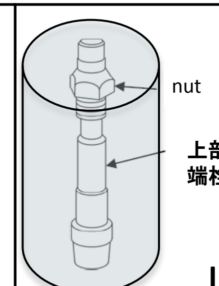
<u>Structural integrity</u>
- Bottom tie plate



【structural integrity and sealability of cladding】

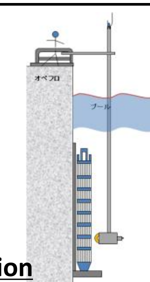


<u>Dissolution test by debris</u>



(1)Influential factor validation test by unirradiated material (2013-2014)
(2) accelerating test using spent fuel from SFP (2014-)

<u>Immersion test</u>



<u>Common pool storage status of fuel examination</u>

<u>Planning of investigation and examination</u>

･regulation
･examples
･existing test data

Dry storage technical evaluation
･Unirradiated material
･storage spent fuel
･1F transferred spent fuel

<u>Feasibility validation of dry storage</u>

<u>Technical evaluation for dry storage</u>

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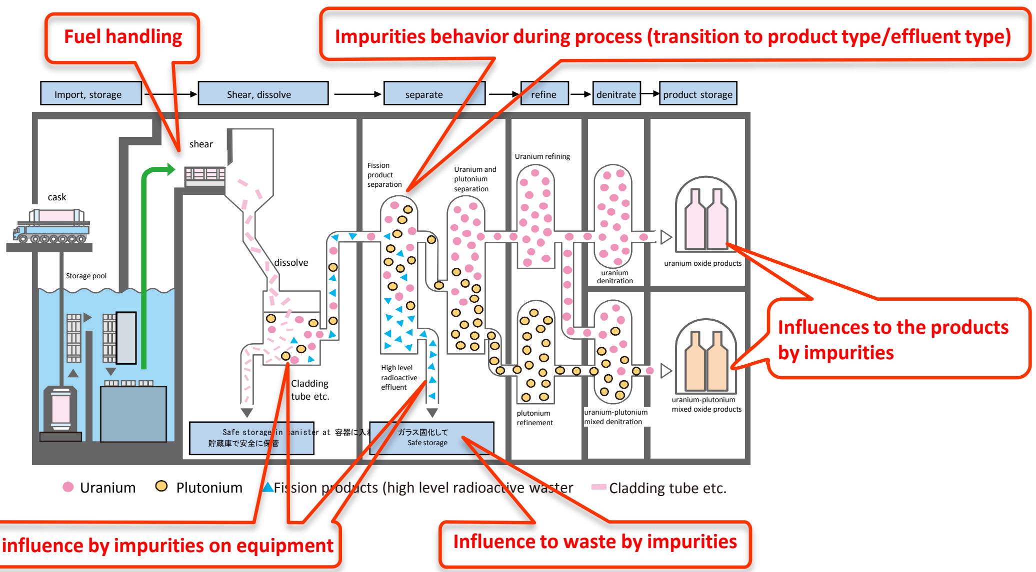
R&D and tasks for fuel removal from spent fuel pool – (2)

■Study for the treatment method of damaged fuels removed from the spent fuel pool

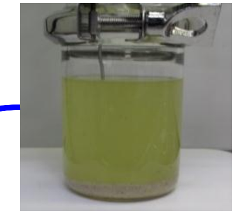
・impurities attached and research/study of tasks in the assumption of fuel reprocessing in the possibly damaged spent fuel pool, examination and indexes examination related to reprocessing propriety decision.

■ Tasks

・Considering the influence by engineering damage etc. by falling debris. etc.
・Considering material corrosion by salt and rubbles inside spent fuel cracks, chemical process, and the influence to the property of the waste

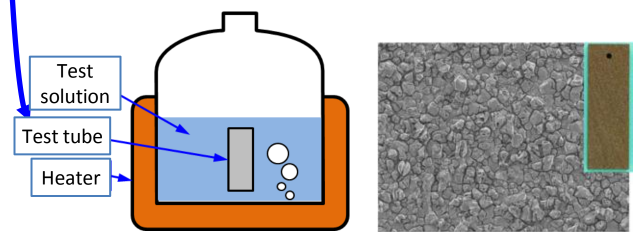


【possible influences on reprocessing steps by impurities attached or damaged spent fuel】

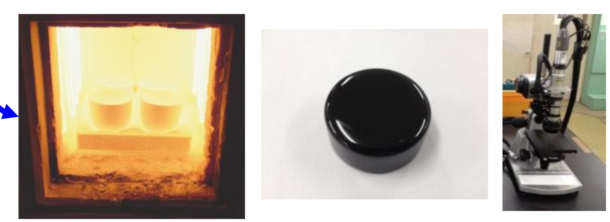


【Nitric acid solution of seawater and concrete】

【behavior check for impurities at the reprocessing (image)】



【solution including impurities corrosion test (image)】



【trial material of glass solidification with impurities (image)】

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2. Method and equipment in preparation of implementation of fuel debris retrieval (1) -Submersion method-

<u>(1) Acceleration of investigation and repair (water stoppage) technology development in repose to the case of water flowing around the lower part of containment vessel</u>

・ Water flow around the containment vessel at Unit 1 was confirmed from the research result obtained by the remotely operated boat developed through the task force of remote operation technology (Nov. 13-14, 2013) .

・Based on this result, aiming at accelerating the process including the investigation for other units in preparation of development of remote equipment for Investigation and repair of lower part of containment vessel (water stoppage) that IRID promote .

＜Major activities＞

－ In FY 2013, continued development of investigation and repair (water stoppage)equipment, and aiming at conducting demonstrations this year while reviewing the development plan (target and process) based on the actual conditions.

－ In FY 2015, aiming at conducting demonstrations at mock-up facilities and on site.

－ Also, establishing remote operation subcommittees (tentative name) in IRID technical committees and build ~~the~~ structures to receive advice for the development and site operation as well as evaluating the research projects.

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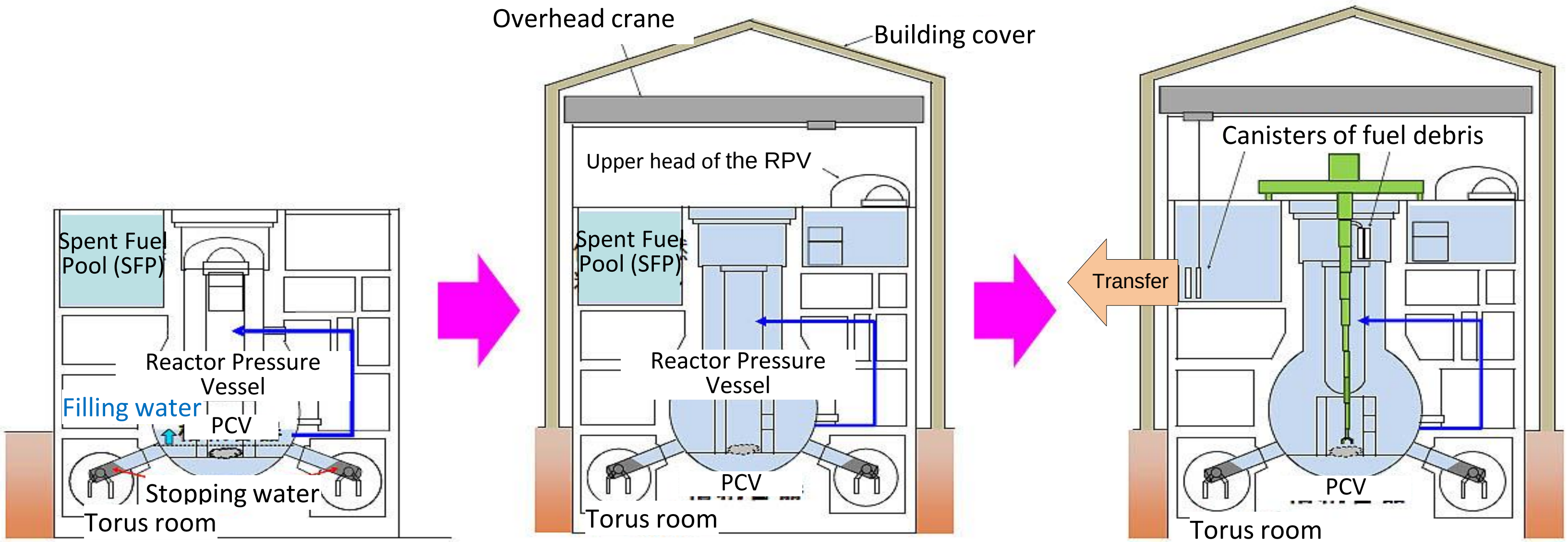
Operation image of the fuel debris removal

- The approach of removing the fuel debris submerged in water is the safest approach from the standpoint of minimizing exposure of workers.
- The primary containment vessel (PCV) will be examined and repaired for filling the PCV with water. Furthermore, R&D for the fuel debris removal and storage will be implemented.



Repairing lower section of the PCV (water stoppage)
- Filling lower section with water

(Reference) This figure is based on the documents of the Council for the Decommissioning of TEPCO's Fukushima Daiichi NPS on June 27, 2013.

retrieving the fuel debris

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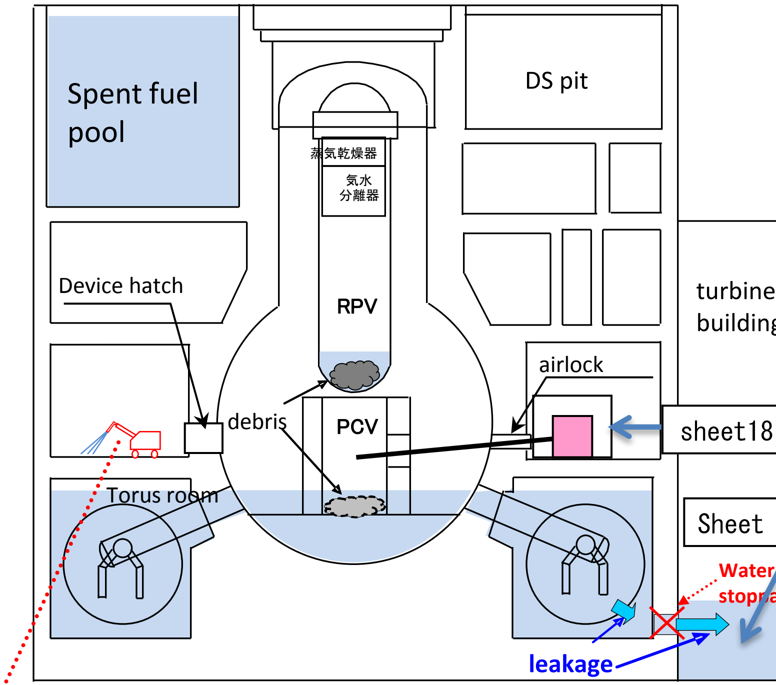
R&D and tasks in preparation for fuel debris retrieval (1)

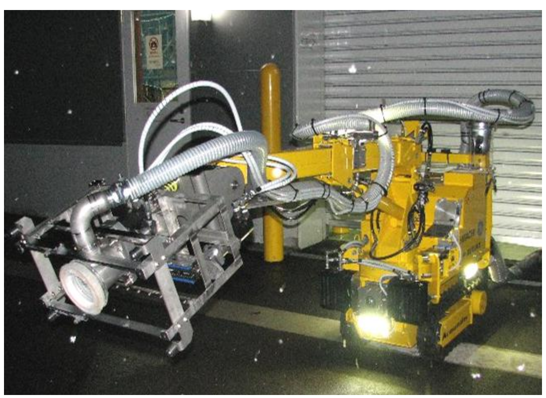
■ development of technology for remotely operated decontamination in the reactor buildings

- Developing the remote operated decontamination equipment corresponding to the contamination condition at the site to improve the environment of investigating leakage of the PCV and repair works for fuel debris retrieval.

■ Tasks

- Performance verification of developed device by field test
- Development of decontamination devices for high place and upper floors
- Study of environment improving method after retention water dried up
- Operation planning to reduce the exposure of workers to radiation comprehensively such as combination of decontamination and shielding




High pressure water decontamination device


Dry ice blast decontamination robot


Blast & suction recovery decontamination device

R&D and tasks in preparation for fuel debris retrieval (2)

■ **development of technology investigating inside the PCV**

- developing the devices, research method for understanding the condition inside PCV and fuel debris by remote operation

(developing the device to access from X-6 (CRD hatch) to check the condition under PCV (pedestal))

■ **Tasks**

- Achieving both performance maintenance of investigating devices and accessing device in the high radiation dose environment and downsizing.
- sorting of research areas and items for other projects (fuel debris retrieval etc.)
- performance verification of developed devices by demonstration test

Replacing or replacement

＜access route example to the researching part＞

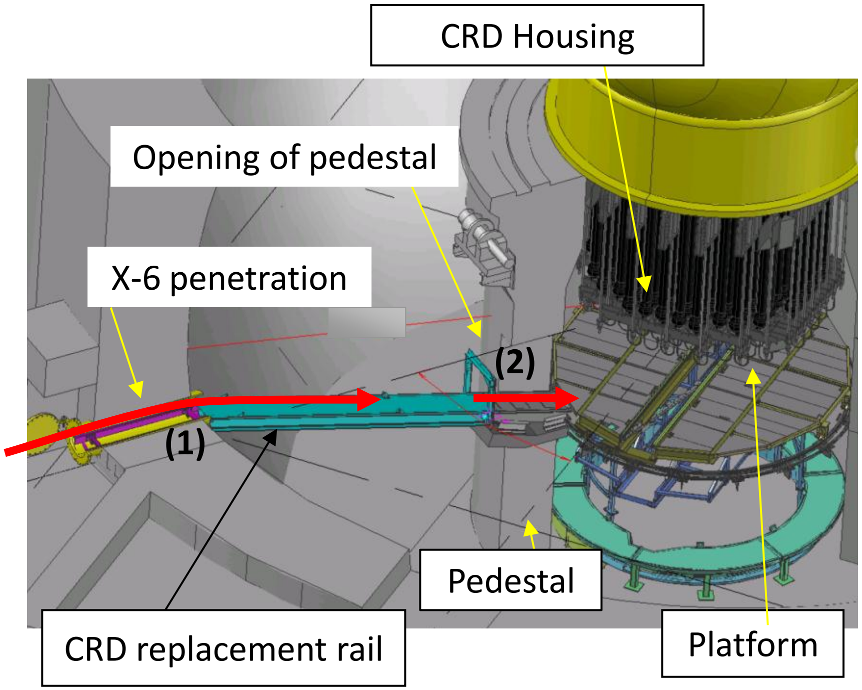


Image of accessing inside the PCV

<Access route>
(1) Entering from X-6 penetration
/ transferring on the CRD replacement rail
(2) Entering the inside of the pedestal through the opening on the pedestal

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R&D and tasks in preparation for fuel debris retrieval (3)

■Development of technology to identify and repair the leakage points in the PCV

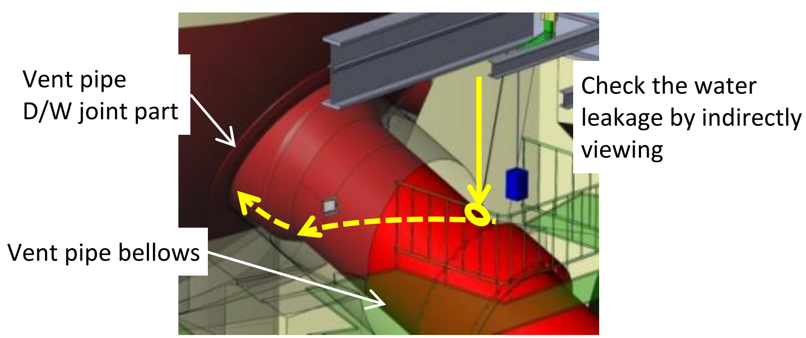
- Development of the methods and equipment to investigate and repair for the leakage from the PCV, etc. (water stoppage) considering the environment, such as high places, high radiation dose, narrow spaces, and under water.

■Tasks

- Performance verification of developed devices by demonstration test
- Establishing measuring technology for determining the necessity of repair and judging points.
- Development of boundary considering things other than PCV main body (system-side)

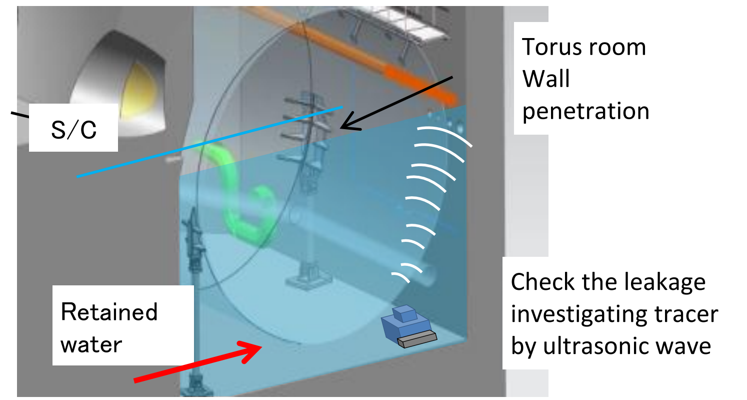
Vent pipe - D/W joint

Adhering and running from the hole on the first floor to Vent pipe and checking the joint part

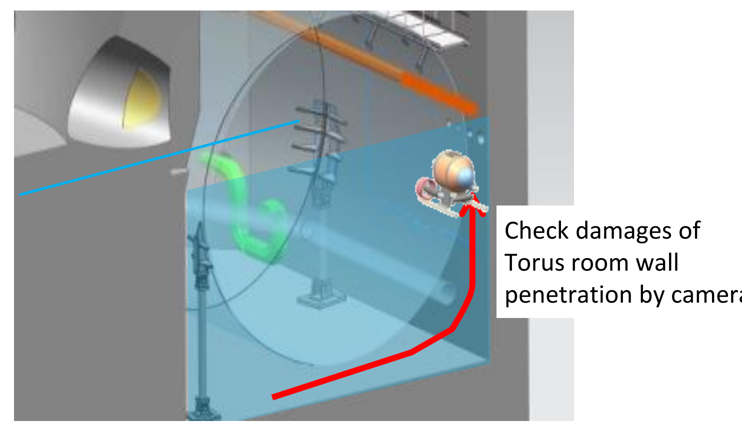


(R&D example)

Torus room wall



Traveling under water and checking Torus room wall penetration



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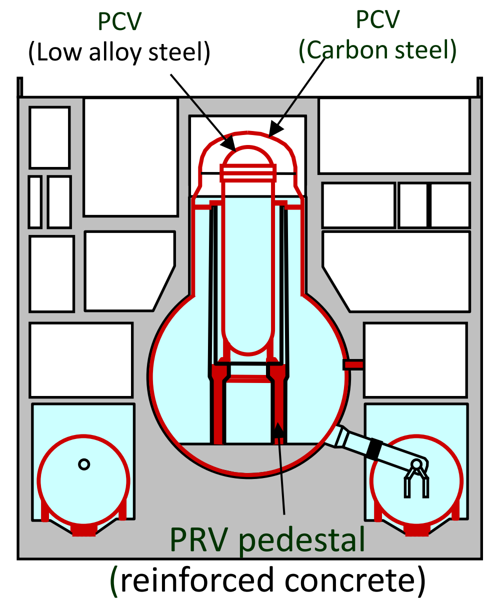
R&D and tasks in preparation for fuel debris retrieval (4)

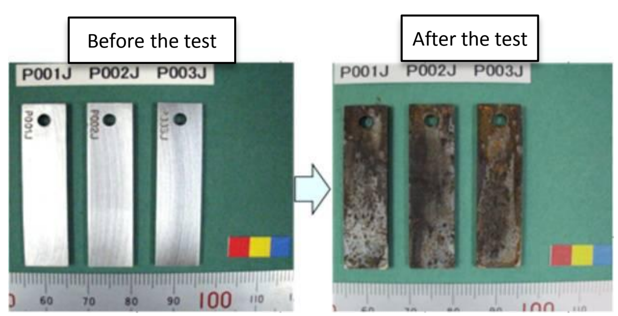
■**Development of integrity verification technology of RPV / PCV**

- Estimation of structural strength decline by sea water inflow
→Evaluating device/structural integrity and remaining life at various possible plant conditions toward fuel debris retrieval
- Establishing the method of prolonging life such as corrosion inhibition etc.
→Applying devices with less tolerance on the above evaluation as necessary

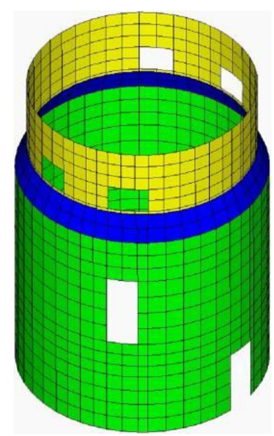
■**Tasks**

- The acquisition of a parameter of key actual unit and establishment of rational evaluation terms under the unclear circumstance of actual unit conditions.
- Estimation of long-term integrity on the material deterioration data in the limited evaluation time





Corrosion testing status and example of the results
(carbon steel / low alloy steel)



PRV pedestal
seismic-assessment model

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R&D and tasks in preparation for fuel debris retrieval (5)

■understanding fuel debris conditions / treatment technology development

- Estimation in advance of various debris characters information for fuel debris retrieval safety guarantee, retrieval equipment, storage container development etc.
- study of each treatment for the discussion of the debris end-state choice after retrieval

■Tasks

- Considering special terms of 1F accident (seawater influence etc.)
- Actual debris sampling at 1F will take time

  ・TMI-2 and previous severe accidents research

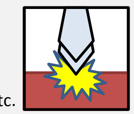
  ⇒ ・combination of accident progress analysis and chemical equilibrium calculation

  ・Simulation debris making and the property determination

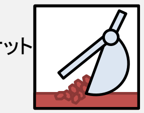
The property estimation of these combinations are needed

【Fuel debris sample taken from TMI-2】

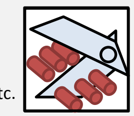
1. Cutting tool A
Example: Air Chisel
Principle: strike / shock
Utility: massive debris crushing etc.



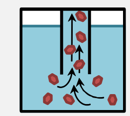
4. Collecting tool
Example: スペードバケット
Principle: Pick & Place
Utility: collecting small piece of debris



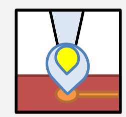
2. Cutting tool B
Example: Heavy duty shears
Principle: shearing
Utility: pipe, thin board cutting etc.



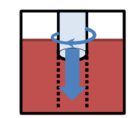
5. Suction system
Example: Air Lift
Principle: suction
Utility: collecting pulverize debris



3. Cutting tool C
Example: plasma arc cutter
Principle: fusing
Utility: complicated structure fractionalization



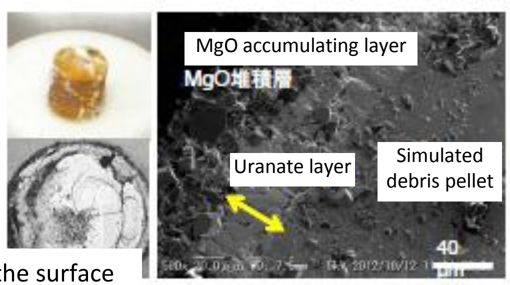
6. Core boring
Example: Boring system
Principle: grinding・compression
Utility: Hard crust drilling etc.



【classification of tools for retrieval】

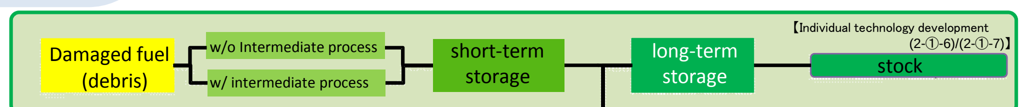
Test result sample

Heating pellet type simulated debris with seawater salt (in the air – 1000c-12h)

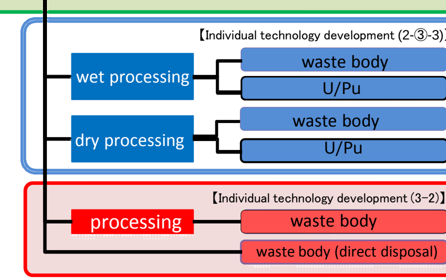


- MgO accumulating on the surface
- Forming the uranate layer

【high-temperature reaction test of simulation debris and seawater salt】



<Treatment scenario study>
Each scenario information are arranged preparing for discussion on comparative evaluation until fuel debris retrieval starting (around 2020)

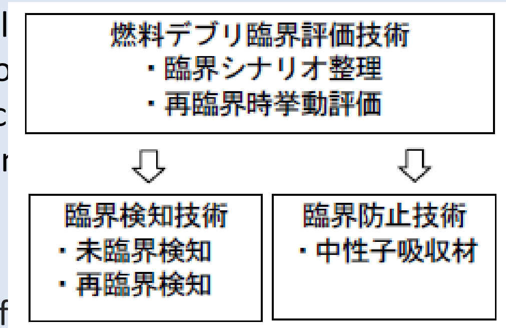


【Choices related to the treatment （processing, disposal) (examples) 】

R&D and tasks in preparation for fuel debris retrieval (6)

■ Development of fuel debris criticality control technology

Developing critical
subcritical evaluatio
etc., monitoring tec
technology (neutror



■ Tasks

▪ data requirement f
elaborating evaluation reflecting latest news
▪ Monitoring method during operation, boric acid amount at the critical point, proposal for the critical point management to the site
▪ Evaluation of the possibility of critical point based on the scenario, formulation of the determination reference for reasonable critical point evaluation
▪ Establishment of critical point management
Depend on construction method / design of fuel debris retrieval, storage etc.

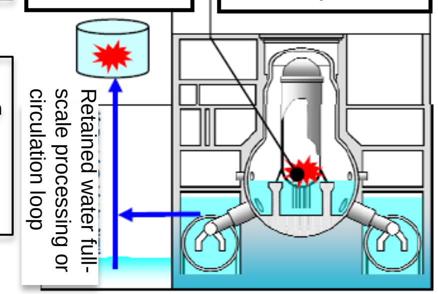
Fuel debris critical estimation technology
- Critical scenario sorting
- Re-criticality behavior evaluation

⇩ ⇩

Critical point detection technology
- non-criticality detection
- re-criticality detection

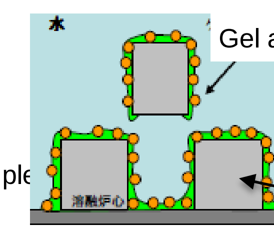
criticality prevention technology
- neutron absorbent

Fuel debris critical point management technology development



Object of critical point detection technology

Neutron absorber examination case	
Solubility	Pentaboric acid sodium etc.
Insolubility	Absorber : borosilicate glass, B4C/SUS sintered body, gadolinia etc. binder : Slurry, gel, cement, water glass etc. Right : binder example



Binder: Medium absorbing absorber for fuel debris

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R&D and tasks in preparation for fuel debris retrieval (7)

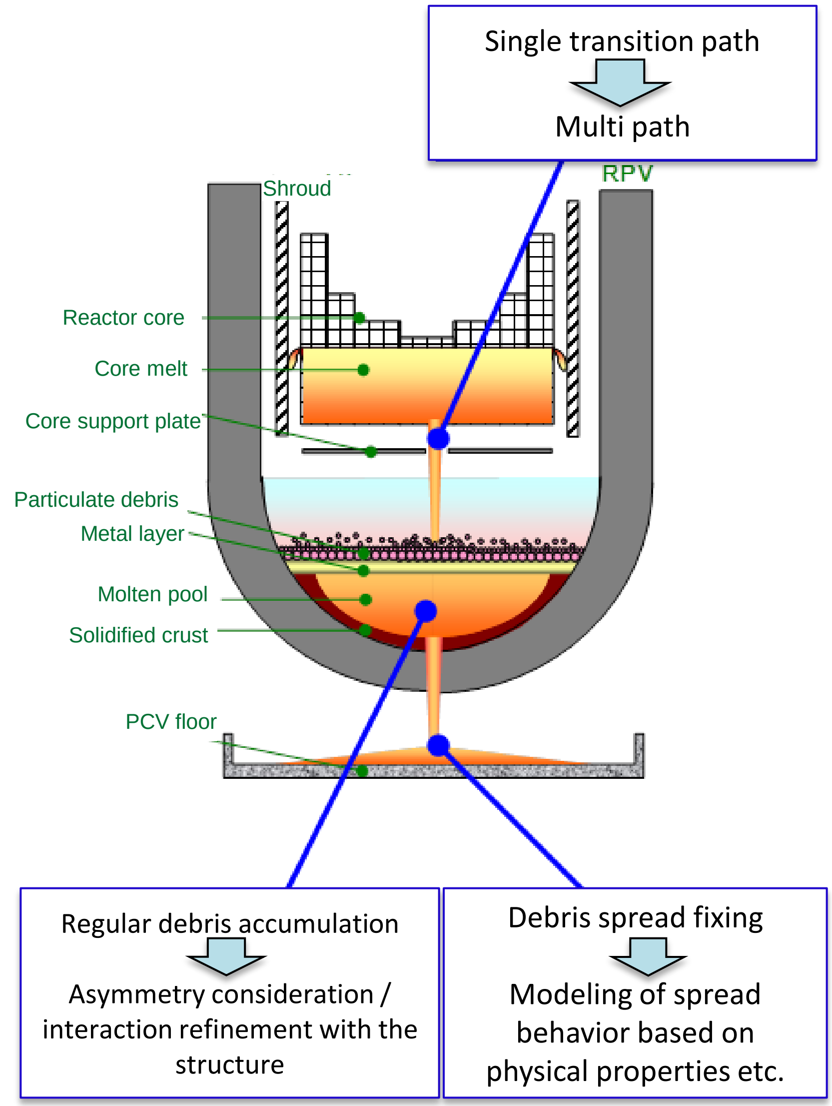
■Understanding of the Reactor core condition utilizing severe accident analysis code

To carry out the accident progress analysis by the latest severe accident analysis code, compared with actual unit parameter and extracted improved code items based on PIRT, upgrading improved items of accident progress analysis code, estimate and understand the condition inside the reactor utilizing upgraded analysis code.

■Tasks

・Improving a model accuracy

・ In the process of creating PIRT, younger generation participate discussion with national and international experts to cooperate with Atomic Energy Society of Japan during creating process and workshops etc. at OECD / NEA. Arranging these opportunities continuously is needed for future human resource development.



Note: PIRT(Phenomena Identification and Ranking Table)

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R&D and tasks in preparation for fuel debris retrieval (8)

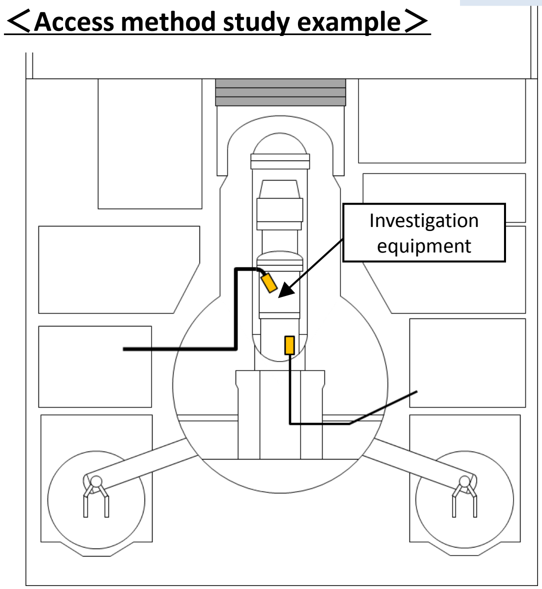
■the inside of RPV investigation technology Development

・Retrieval from the inside of Reactor Pressure vessel (RPV) For retrieval from the inside of Reactor pressure vessel (RPV), to develop the technology to understand the situation inside the RPV (pressure, temperature, dose, equipment damages inside the reactor, fuel debris position etc.) and to enable fuel debris sampling

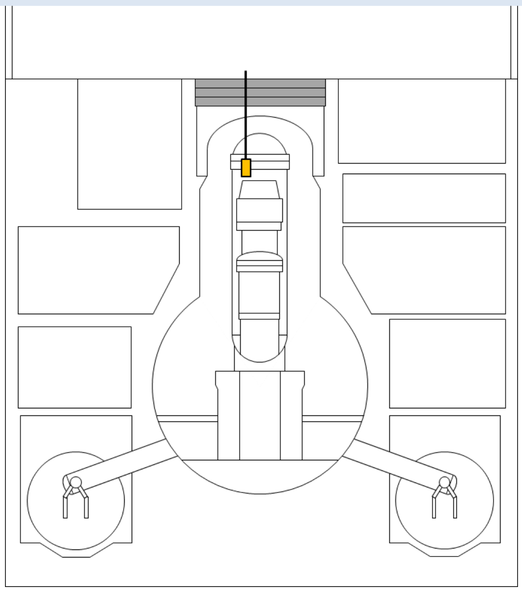
■Tasks

・access to the inside of RPV technology development considering the investigation purpose, site environment (dose, equipment damage etc.)
・Investigation technology development to enable to use at the possible severe condition (high dose, high humidity etc.) inside the RPV.

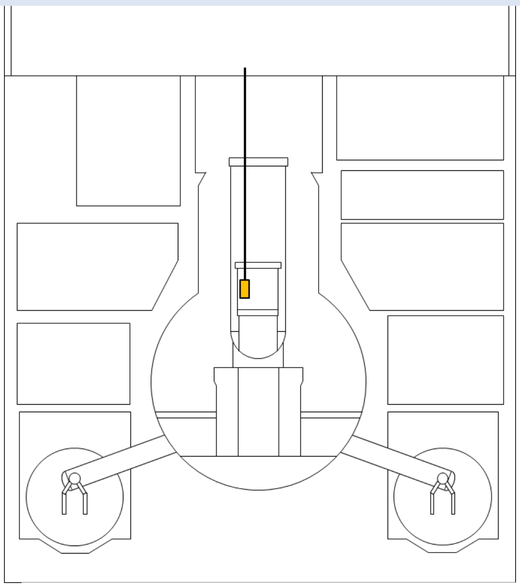
<Access method study example>



Example to access through pipes



Example to access opening the hole



Example of accessing method after opening the reactor

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R&D and tasks in preparation for fuel debris retrieval (9)

■Fuel debris collecting, transferring, storage technology development

Examination related to damaged fuel transfer and storage result examination

Damaged fuel (including leaked fuel) transfer, storage result examination (N. America (TMI-2), Europe (Paks))

Examination of Fuel debris storage system

Storage actual result of Spent fuel debris (concrete cask system (including horizontal silo) Vault method)

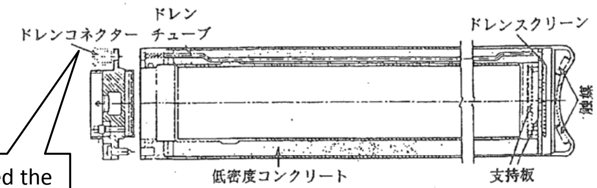
Task extraction and master plan creating

■Tasks

To extract technical tasks for the container management technology development and the container specifications for transfer and storage, considering 1F fuel debris distinctive condition (high radiation work environment, introduce seawater into the inside of the reactor).

To sort the interface information (Debris property understanding PJ, retrieval method PJ etc.) for developing and necessary timing.

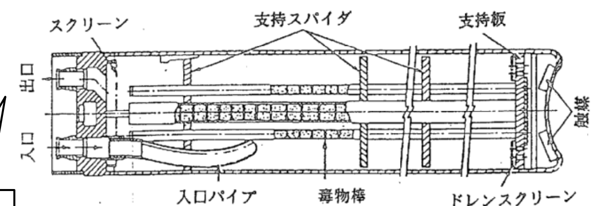
•To reflect onto the storage can development project.



Opened the lid and Fuel loading

＜Fuel canister*＞

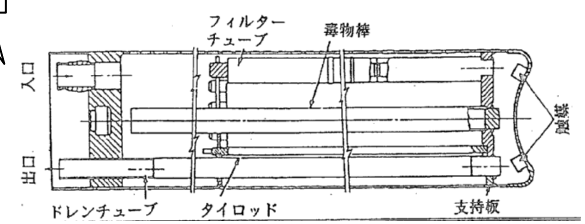
・Filling piece of fuel assembly or fuel debris capable of handling jig by remote control handling jig



Debris inflow from the through-hole

＜Knockout canister* ＞

・collecting particles over 140µm by vacuum suction system



＜Filtering canister※ ＞

・collecting particles under 800µm by vacuum system

※：Storage can is called Canister at TMI

Several canisters are used based on the form of fuel or fuel debris but those external dimensions are all same and the transfer container is used in common

Fig. Canister for debris inside the reactor (TMI case)

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３. Development of multilateral and multilayered method and equipment in preparation of implementation of fuel debris retrieval (2)　-Innovative approach-

(２) Innovative approach and Request for Information of technology for the identification of fuel debris condition and acceleration of retrieval

・ Mid-and-long-Term Roadmap states that the innovative approach other than Submersion method shall be considered. Therefore started Request for Information (RFI) to seek information from overseas research institutes and corporations, aiming to conduct feasibility study (Ｆ/Ｓ, after 2015) of the technologies to identify the location and the condition of the fuel debris required for the methods of investigation and retrieval work.

・ Information submitted will be utilized for Conceptual Study and Technical feasibility study (Ｆ/Ｓ).

・ IRID expect this RFI to be an opportunity for collaboration with related parties around the world.

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Announcement on RFI procedures and promotion for invitation

IRID has been promoting publication and application for RFI, and announcement of RFI procedures since fall of 2013 as well as providing reference information necessary for the study.

Announcement of RFI procedures and Promotion activity of RFI invitation

•Nov.
- Opened website for invitation.
- **Held overseas workshop.**
- Sent reminder mail.

•Dec.
- Announced RFI procedures .
- **Held domestic workshop.**
- Set up web forms for application.

•Jan
- Uploaded basic data of Fukushima Daiichi NPS on the web.
- Uploaded technical issues・related R&D status.
- Sent reminder mail.

Outline of activities

•Establishment/ announcement on RFI procedures

・Established **Entry form** as well as opened **website for application** and announced procedures for RFI for applicant's convenience.

•Holding of workshop

・**Held workshop in Japan and overseas for the publication of background and purpose of RFI and promoted invitation.**

Venue : UK, France, US, Canada, Germany and Japan.

- Tens of people attended from related company, R&D agency for each workshop. About 130 participants from Japan.

• Provision of reference info for related technology.

・**Disclosed reference technology data on the website for information collection for RFI**

- Basic data of Fukushima Daiichi NPS (Structure /external dimension etc.)
- Technical issues and status of R&D in Japan/overseas.

•Delivery of RFI notice

・Made announcements regarding implementation of RFI and uploading of reference information for followings.

- Overseas and domestic related academic meeting , and industry organization.
- Companies participated in previous workshop .

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Contents of RFI

Topic A: Internal PCV/RPV investigation

A-1:Conceptual study of method (following are samples)

1. Method of inserting investigation device e.g. cameras inside.
   a. Utilize current throughbore such as piping/penetration.
   b. Create new throughbore .
   c. Methods of shielding penetrations and of equipment operation in terms of reduction of radiation exposure.
2. Method of detecting fuel debris location by measuring from outside, etc.

A-2:Required technologies (following are samples)

1. Advanced measurement technology (e.g. camera, dosimeter, thermometer)
   a. High performance optical equipment(e.g. camera), other measurement technology (e.g. ultrasonic, laser)
   b. Control technology of measuring instrument, and information transmission technology .
2. Technology to detect whether the substance in the reactor is fuel debris or not.

Topic B: Fuel debris retrieval

B-1:Conceptual study of method (following are samples)

1. Access to fuel debris from the top of PCV underwater
2. Access to fuel debris from the top of PCV in the air*1
3. Access to fuel debris from the side of PCV in the air*1
4. Access to fuel debris from the bottom of PCV in the air*1

*1 including partial submergence

B-2:Required technologies (following are samples)

1. Technology regarding fuel debris retrieval (cutting, suction).
2. Equipment/device such as remote control manipulator, with superior control capability from long distance.
3. Technology of shielding against fuel debris with high radiation.
4. Device and equipment capable of working under the high radiation environment.
5. Equipment/device to create a borehole on the building concrete and PCV to enable access from the side or bottom of the PCV.
6. Technology to store fuel debris safely in PCV/RPV before retrieving.

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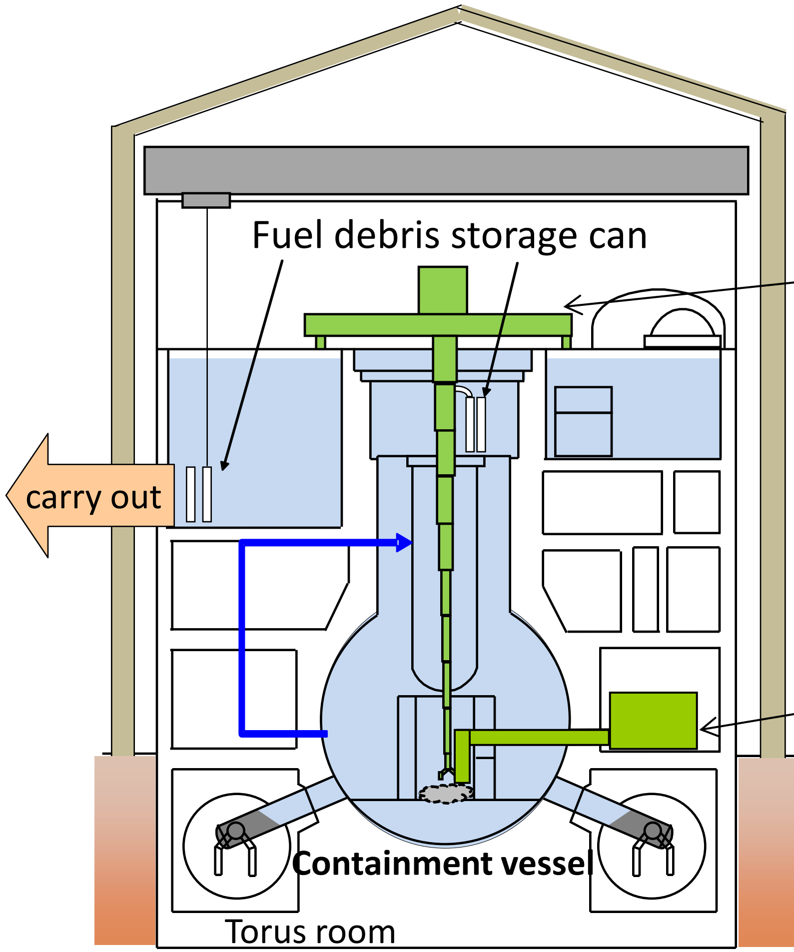
e.g. Fuel debris retrieval work (from top and side)



Fuel debris retrieval

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Results of RFI

About 60% and 40% of the proposal were submitted from Japan and overseas countries respectively

	•Field of proposal for RFI	Total	Breakdown by country							
			JPN	US	UK	GER	FRA	BEL	CAN	RUS
Topic A Internal PCV/RPV investigation	A-1:Conceptual study for the method	33	20	7	3	-	2	-	1	-
	A-2:Required technology	58	32	6	10	6	2	2	-	-
Topic B Fuel debris retrieval	B-1:Conceptual study for the method	43	23	8	3	2	5	-	1	1
	B-2:Required technology	60	41	7	3	4	2	2	-	1
Total (No. of items of information)		**194**	116	28	19	12	11	4	2	2

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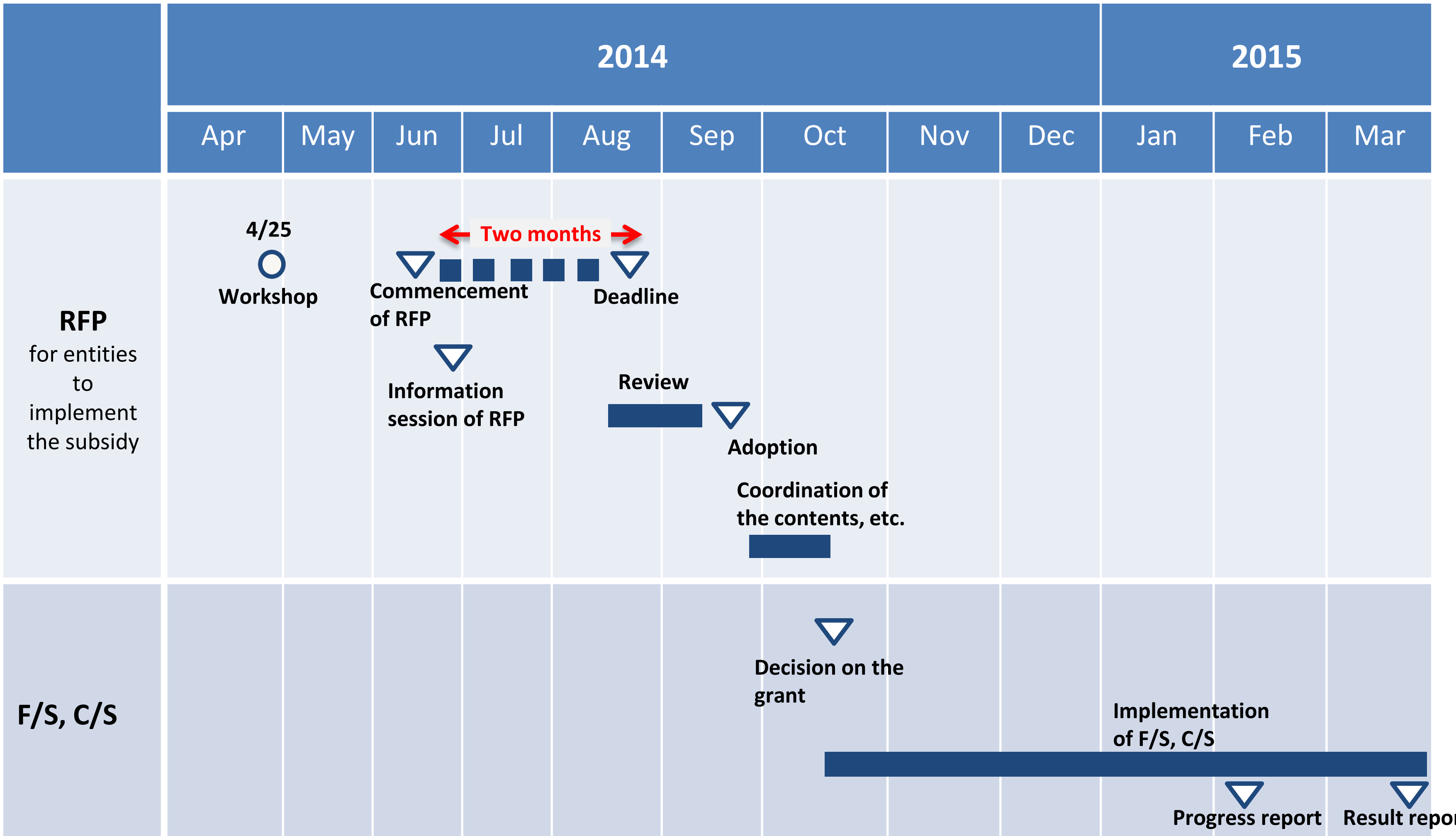
Reference: Upcoming schedule



”Project scheme of Decommissioning and Contaminated Water Management and RFP schedule” (Taken from a document by MRI’s Management Office for the Project of Decommissioning and Contaminated Water Management)

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4. Stable promotion of R&D from the perspective of radioactive material treatment and disposal

- Conducted radionuclide analysis of sampled rubbles, felled tree and contaminated water among other specimens from the site. Currently working on inventory evaluation of waste material based on the results of these nuclide analysis.
- Further accumulation and evaluation of analysis data are planned. In addition, a prospect of the adsorption vessel of waste zeolite generated by contaminated water treatment maintaining its soundness at the salt concentration level in the storage condition has been already confirmed.

< Major activities >

― Continue studies on the technologies for storage, identifying the properties, waste forming and disposal to secure a prospect of maintaining the safety of the treatment and disposal of solid waste

― Examine and establish the decommissioning scenario by collecting and organizing the concepts of security control for the decommissioning from 2014.

― For the issues with relatively high risks which are required to be addressed promptly, according to the progress of decommissioning, promote studies flexibly while taking account of relations with R&D plans defined in the Mid-and-Long-Term Roadmap and the priorities

For example, stabilization of the watery waste material such as slurry coprecipitation with iron and slurry of settled carbonate, which are expected to be generated by ALPS as countermeasures for the contaminate water, shall be promoted forthwith.

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R&D and tasks of radioactive waste processing and disposal

■ Development of radioactive waste treatment and disposal technology

Having the prospect of the safety for processing, disposal, with studying of property understanding and disposal, study of radioactive waste disposal (including long-term storage).

■ Tasks

- adhesion of radioactive nuclide caused by damaged fuel, seawater component-containing etc. It has different character from radioactive waste produced by current Nuclear power station, radioactive waste produced by the accident is including the one which rarely process and dispose in Japan.

Study of method waste

- the property understanding (Inventory, chemical composition etc.)
- Secondary waste reflex/Review of waste sorting
- Study for radioactive waste processing (inc. storage, preprocessing, being waste disposed

Study for waste disposal

- Disposal concept study
- Safety evaluation

Analysis subject samples, the priority-based rating nuclide etc.

setting of targets to improve efficiency of waste body, etc.

<sampling at the site>

Rubble

Cutting trees

<Development of waste solidified technology>

Geopolymer
amorphous state inorganic material mainly consisted by Al and Si

Character ・**high Metal ion** CONTAINMENT
・**fire-resistant**

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Summary

1. **IRID** was established in Aug. 2013 as an integrated organization to conduct researches by gathering knowledge around the world according to the Mid-and-Long-Term Roadmap.

2. As for **R&D,** IRID conducts an integrated management to promote multiple R&D projects effectively. Fields of the R&D consist~~s~~ of following three. IRID also plans a total strategy of the technologies required for the decommissioning by optimizing the on-site needs and technological seeds.

   1. Removal of fuel from spent fuel pool
   2. Preparation of fuel debris removal
   3. Treatment and disposal of radioactive materials

3. **For the purpose of gathering knowledge around the world ,** IRID advances the establishment of a structure to receive advise from the experienced experts around the world through **"**International Advisors", "Technology Advisory Committee" and "International Expert Group", as well as considering the involvement in the joint research project through OECD/NEA and responding to the IAEA review. Also, conduct Request for Information (RFI) internationally for the countermeasures on contaminated water and fuel debris retrieval.

4. Hold workshops to build a structure to promote basic researches in collaboration with research institutes and universities with **Mid-and-Long-Term human resource development** in consideration**.**