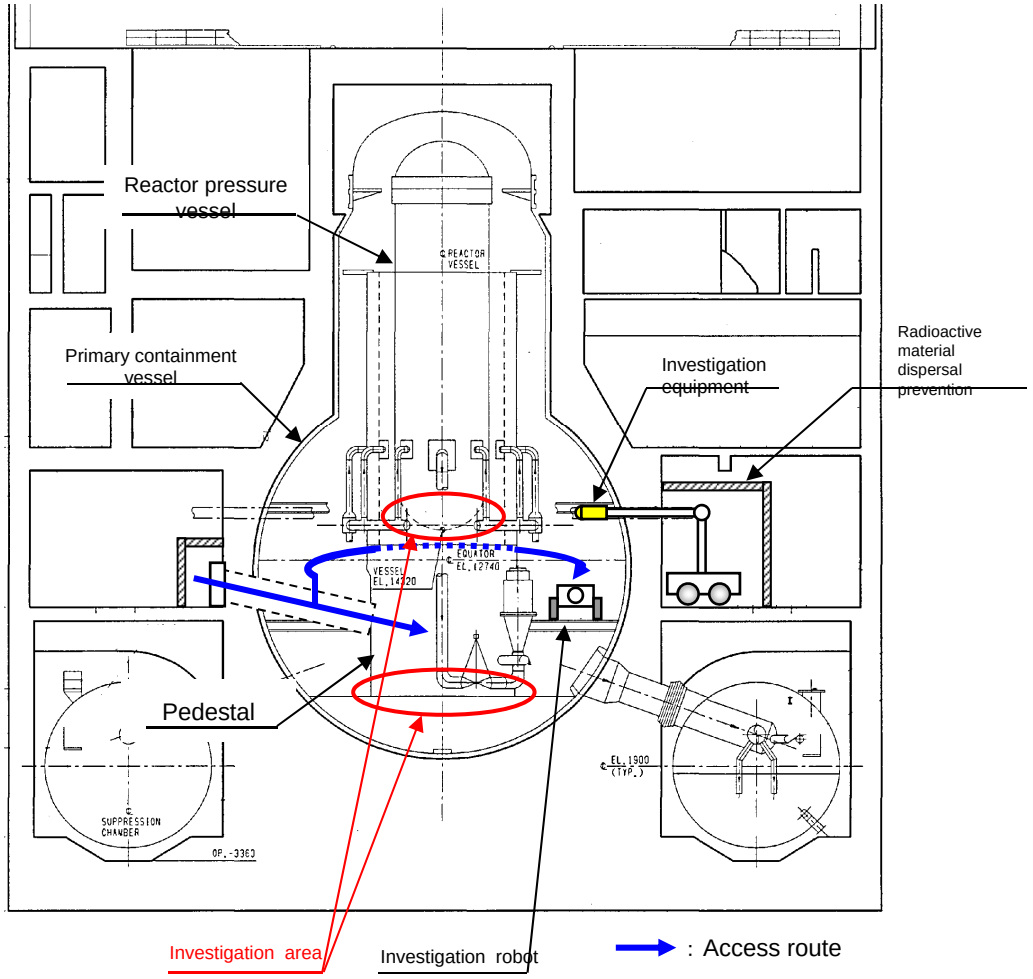
"Development of Investigative Technology for Inside Containment Vessels"

Hitachi GE-Nuclear Energy Co., Ltd.
TOSHIBA CORPORATION
Mitsubishi Heavy Industries, Ltd.

1. Purpose of Research & Development

1. For the technology development of taking out fuel debris, we will research and develop equipment to check the position and state of the debris, along with the condition of the pedestal that supports the reactor pressure vessel.

2. As the inside of the primary containment vessel consists of a severe environments, such as elevated temperature, high humidity, and high radiation dose, we will also research and develop various element technologies corresponding to such a severe environment, along with remote handling equipment, radioactive material dispersal prevention countermeasures upon the opening of a through-hole.



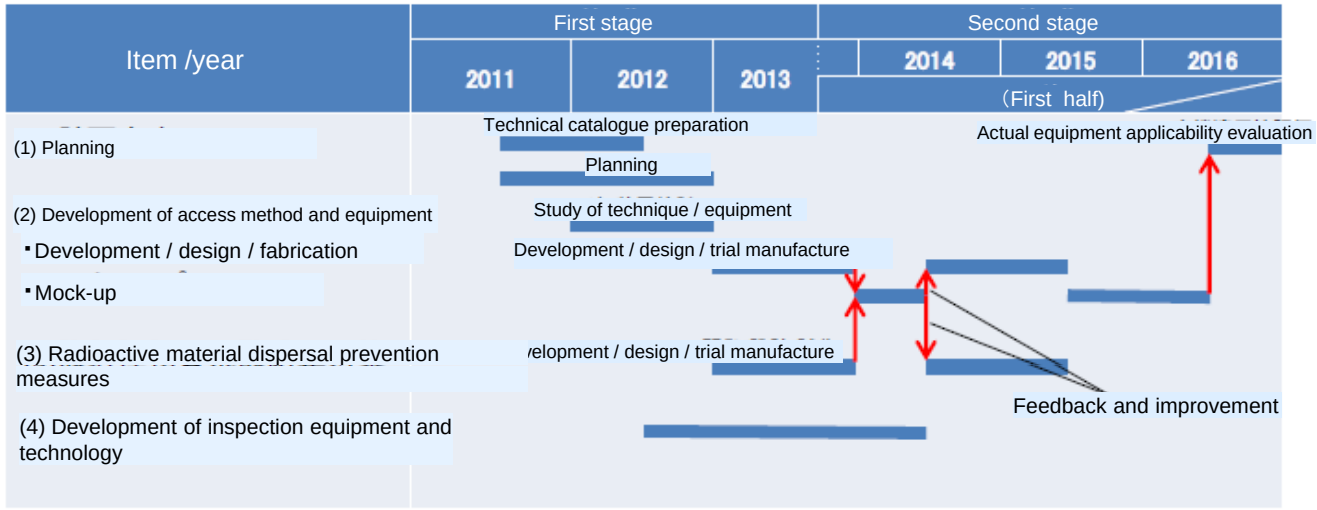
Investigation for inside of PCV : Overview

2. Details of Research & Development

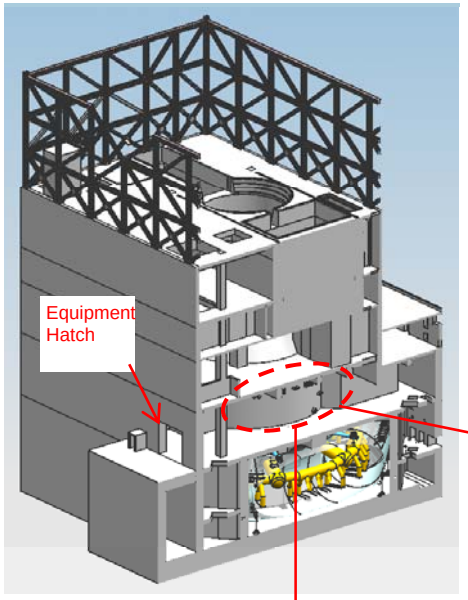
The basic policy of the methods used to investigate the inside of a primary containment vessel is that operators or equipment must gain access to the outside into the PCV and insert remote inspection equipment from a PCV through-hole, etc. We will perform the following research and development according to this policy.

1. Arrangement of existing technology based on the inference results of conditions in a reactor (including this workshop)
2. Development of access methods and equipment (tool)
3. Countermeasures against radioactive material in the primary containment vessel
4. Development of inspection equipment and technology

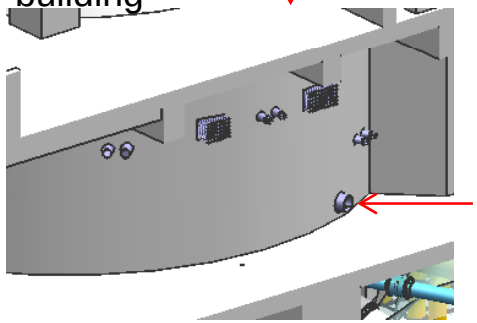
Operating schedule



3. Place of Use (Example)

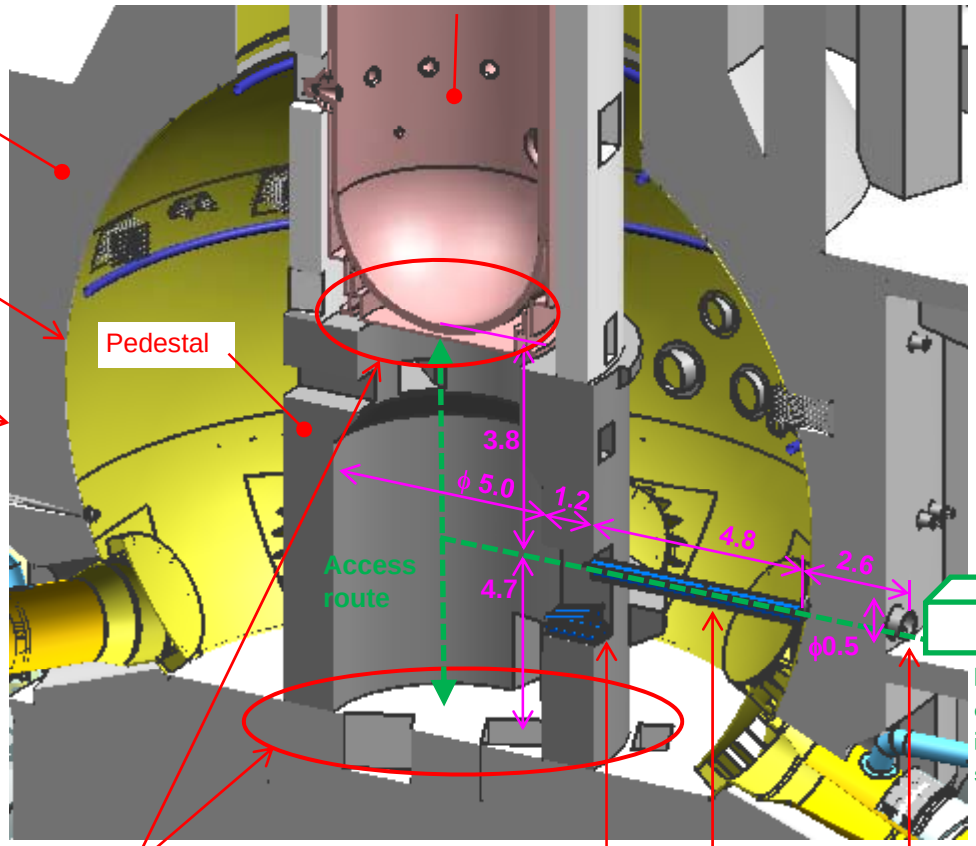


Reactor building



Existing through-hole (X-6 penetration)

Reactor building, first floor



Sectional drawing, investigation area, and outline dimensions (m)

Specially required technology

1. Technologies that enable equipment to access the inside of the primary containment vessel from a through-hole and to investigate the conditions of inside and outside the pedestal
2. Technologies that can visualize conditions in the primary containment vessel and to investigate the position and the state of molten fuel

4. Required Specifications for the Equipment

<table>
<tr><th>Operating environment</th><th>Operating temperature</th><th>Radiation resistance</th><th>Access conditions</th></tr>
<tr><td rowspan="2">Containment vessel inside:
In air/under water

Containment vessel outside:
In air</td><td rowspan="2">Containment vessel inside:
80ºC or less

Containment vessel outside:
Normal temperature</td><td rowspan="2">Atmosphere: 3 Sv/h or more
Accumulation: 100 Gy or more

Consider the possibility of component replacement.</td><td>1. Carry the equipment into the reactor building from an entrance such as the equipment hatch of the reactor building, and move to the first floor to access the vicinity of the existing through-hole (X-6 penetration).</td></tr>
<tr><td>2. Take the radioactive material dispersal prevention measures around the through-hole (X-6 penetration), and allow the equipment to enter the inside of the containment vessel from the through-hole.</td></tr>
</table>

5. Required Technology Elements

For this "Development of Investigative Technology for Inside Containment Vessels," the specially required technologies are as follows:

(1) To enable equipment to access the inside of the primary containment vessel from the through-hole and to investigate the conditions of inside and outside the pedestal. (Through-hole [X-6 penetration]; inside diameter: About 500 mm)

(2) To be able to visualize conditions in the primary containment vessel and to investigate the position and the state of fuel debris

Technical Catalogue/Vendor List (PCV Internal Investigation)

Classification	Required technology (elements)	Technical description (needs)	Vendor holding the technology	Remarks
PCV internal investigative equipment Radioactive material dispersal prevention cover Inspection equipment To be continued on the following page **Specially required technology:** 1. Technology that enables equipment to access the inside of a PCV from the through-hole and to investigate the conditions of the inside and outside of the pedestal 2. Technology that can visualize conditions in the primary containment vessel and to investigate the position and conditions of molten debris	Traveling mechanism	· Mechanism to equipped with the below-mentioned working mechanism and measuring device to access an investigation area · Mechanism to install or throw equipment into the through-hole of the outside of the PCV and advance such into the PCV · Mechanism to investigate the conditions of the inside and outside of the pedestal * These mechanisms include control devices and communication devices for remote control.	Q.I Inc.	
			Inuktun Services Ltd.	
			HIBOT CORP.	
			iRobot Corporation	
			Ishikawa Iron Works Co.,	
			NEOVISION	
			SHIN-NIPPON NONDESTRUCTIVE INSPECTION CO.,LTD.	
			Mitsui Engineering & Shipbuilding Co., Ltd.	
			TODEN KOGYO CO.,LTD.	
			KUBOTA Corporation	
			QinetiQ	
			Adept MobileRobots (Adept Technology, Inc)	
			Topy Industries Ltd.	
			Mitsubishi Electric TOKKI Systems Corporation	
			Raytheon Company	
			Mitsubishi Electric Corporation	
			iXs Research Corporation	
			CONTEC CO., LTD.	Wireless unit
			Advantech Co., Ltd.	Wireless unit
			maxon motor	Control device
			Toshiba Corporation	
			Mitsubishi Heavy Industries, Ltd.	Catalogue sample: Attachment 1
			Hitachi, Ltd.	Catalogue sample: Attachment 2
	Communication equipment	Included in the traveling mechanism	-	
	Control device	Included in the traveling mechanism	-	
	Working mechanism To be continued on the following page	· Equipment that is equipped with the traveling mechanism and that supports the measurement work of the below-mentioned measuring device (adjustment of the measurement direction, etc.). To be continued on the following page	YASKAWA Electric Corporation	
			FUJITSU FRONTECH LIMITED	
			Honda Motor Co., Ltd.	
			DENSO WAVE INCORPORATED	
			FANUC CORPORATION	
			MEIDENSHA CORPORATION	
			Ube Central Consultant	
			Nittoku Machine Co., Ltd.	
			Nikkaki Bios	
			Yanaco Analytical Systems, Inc.	
			Hirado Kinzoku Kogyo Co.,Ltd.	
			KONDOH SEISAKUSHO Co., Ltd.	
			SCHUNK Intec K.K.	
			SQUSE	
			SCHUNK GmbH & Co. KG	

Classification	Required technology (elements)	Technical description (needs)	Vendor holding the technology	Remarks
			KUKA Roboter GmbH	
PCV internal investigative equipment Radioactive material dispersal prevention cover Inspection equipment Continued from the preceding page	Working mechanism Continued from the preceding page	· Equipment that is equipped with the traveling mechanism and that supports the measurement work of the below-mentioned measuring device (adjustment of the measurement direction, etc.). Continued from the preceding page	Neuronics/ AAI Japan, Co. Ltd.	
			OC Robotics	
			Barrett Technology	
			Insutitute of Robotics and Machatronics	
			HWM	
			PaR	
			Argonne National	
			Carnegie Mellon University	
			Oak Ridge National Laboratory	
			TOSHIBA MACHINE	
			Toshiba Corporation	
			Mitsubishi Heavy Industries, Ltd.	
	Measuring device	· Equipment that can visualize the conditions (pedestals and debris fuel) in the PCV and that can operate from outside the PCV · Equipment that can measure the aerial dose in the PCV and its surrounding areas · Equipment that can check the damage and loss of the PCV and the pedestal	Japan Atomic Energy	
			Olympus Corporation	
			DIAKONT/ MILS SYSTEMS CO., LTD.	
			Nisco co., ltd.	
			Mirion Technologies, Inc.	
			Hitachi Aloka Medical, Ltd.	
			MITSUBISHI CABLE INDUSTRIES, LTD	
			MHI Solution Technologies Co.,LTD.	
			Q.I Inc.	
			Karl Storz GmbH & Co.	
			NUCRON Co., LTD	
			Centronic Raditec	
			Thermo Fisher Scientific K.K.	
			Ahlberg Electronics	
			Cypress Semiconductor Corporation	
			Point Grey Research, Inc.	
			TOSHIBA TELI CORPORATION	
			Toshiba Corporation	
			Mitsubishi Heavy Industries, Ltd.	
	Working device	Included in the working mechanism	-	
	Support equipment	· Equipment that is independent of the abovementioned equipment and that assists the work	Yoshizawa-la Co.	Dispersal prevention equipment
			MIWA MFG CO.,LTD.	Glove box
			KITO CORPORATION	Lifting device
			Kyomachi Co., Ltd.	Heavy load traction
			Shiro industry Co.	High work location carriage
	Radiation-resistant parts	· Parts available to be used in a radioactive environment	Fujikura Ltd.	Wire
			Mutsubishi Rubber Co., Ltd.	Seal material
			HAYAKAWA RUBBER CO., LT	Seal material
			Bitrex Japan	Seal material

Specially required technology:

1. Technology that enables equipment to access the inside of a PCV from the through-hole and to investigate the conditions of the inside and outside of the pedestal

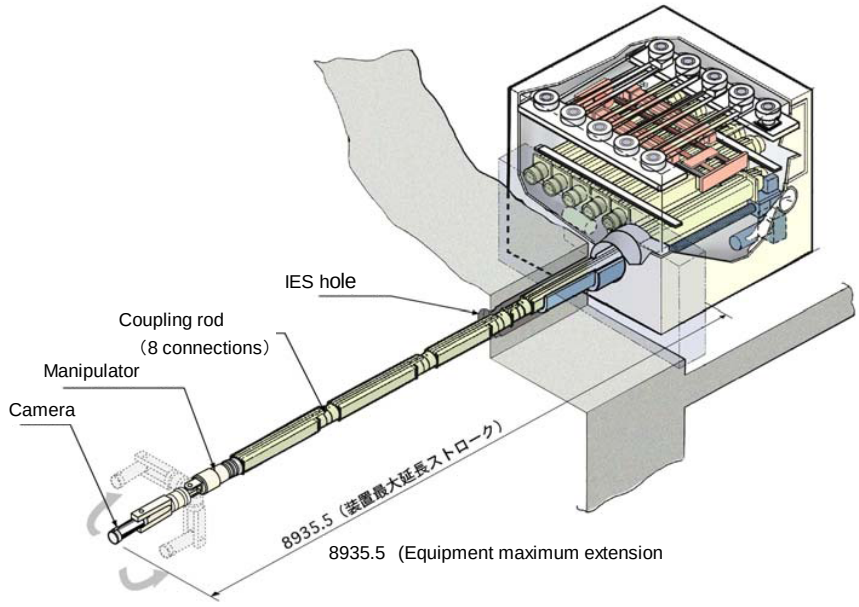
2. Technology that can visualize conditions in the primary containment vessel and to investigate the position and conditions of molten debris

Technical Catalogue

Classification	Traveling mechanism
Title	Rod automatic coupling-type robot
Proponent	Mitsubishi Heavy Industries, Ltd.

1. Technical details (features, specifications, and performance)

This robot can automatically connect rods and insert a camera into a closure space.
The camera can be inserted approx. 9-m back from a hole with a 200-mm diameter.



2. Past application (including past applications at domestic plants, foreign plants, and in other industries)

Applied to nuclear power plants

3. Reasons to be considered as applicable to Fukushima Daiichi Nuclear Power Station, along with technical issues

Applicable issue	Applicability	Remarks and reasons (quantitatively)
Usability in a radioactive environment	YES	Radiation-resistant specifications
Usability in a high-temperature environment (60°	YES	Design condition: 10–60°C
Access to the inside of the ped	YES	Accessible from outside the PCV by using rod automatic couplings
Investigation of the position/conditions of fuel	YES	Possible to use a camera at the rod end
Correspondence to the disclosure of technical information and remodeling	YES	Customization according to the intended purpose is possible.
Dispatch of operation engineer	YES	Dispatch to Fukushima Daiichi Nuclear Power Station is possible.

4. Technologies to be developed (example)

5. Remarks

Technical Catalogue

Classification	Traveling mechanism (including the handling device and working device)
Title	Magnetic crawler-mounted adsorption mobile robot
Proponent	Hitachi, Ltd.

1. Technical details (features, specifications and performance)

This adsorption mobile robot distributes its own weight to all the magnets that are attached to the wall surface by using load distribution-type magnetic crawlers to prevent detachment and to thereby increase adsorption capability. The shape of the crawler can passively follow the shape of a wall surface, and it is possible to travel on curved surfaces, projections, and steps. An ultrasonic scanning

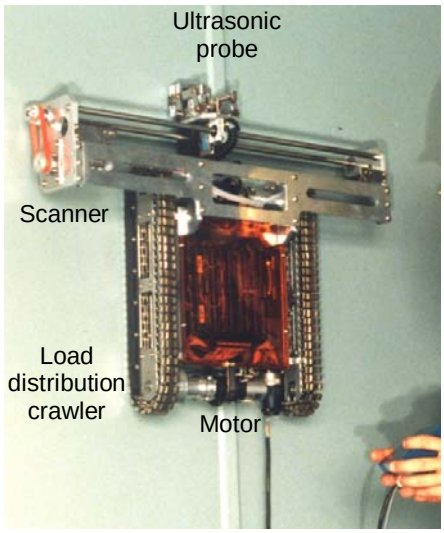


Fig.1: Overview of magnetic crawler-mounted adsorption mobile robot

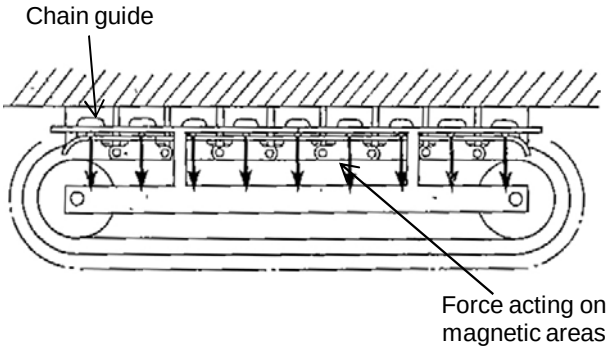


Fig. 2: Principle of the load distribution crawler

2. Past application (including past applications at domestic plants, foreign plants, and in other industries)

Applied to nuclear power plants

3. Reasons to be considered as applicable to Fukushima Daiichi Nuclear Power Station, along with technical issues

Applicable issue	Applicability	Remarks and reasons (quantitatively)
Usability in a radioactive environment	YES	Actually applied; no use of electronic components; highly radiation resistant
Usability in a high-temperature environment (60°C)	NO	Has not been applied
Access to the inside of pedestal	YES	It is possible for it to self-travel on a metal surface, in addition to a floor face, through
Investigation of position/status of fuel debris	NO	Combination with measuring devices is required
Correspondence to the disclosure of technical information and remodeling	YES	Customization according to the intended purpose is possible.
Dispatch of operation engineers	YES	Dispatch to Fukushima Daiichi Nuclear Power Station is possible.

4. Technologies to be developed (example)

It is necessary to combine this robot with measuring devices to visualize fuel debris.

5. Remarks