Message

IRID has been engaged in developing robots for nuclear decommissioning since its establishment. Prof. Hajime Asama, a leader in the robotics field, offers a message.

There are still many areas with high levels of radiation, making it difficult for people to approach such environments. Robots and remote-control technologies are therefore crucial for decommissioning of the TEPCO Fukushima Daiichi Nuclear Power Station.

Various robots and remote-controlled equipment have been deployed to remove rubble, investigate inside buildings (capturing images, measuring levels of radiation, etc.), decontaminate, and take samples (dust, contaminated water, concrete core, etc.). Immediately after the accident, robots for military use and unmanned construction machines were primarily used, but considering the unprecedented requirements for accidents occurring at nuclear power plants, specialized equipment that addresses particular situations must be developed to make progress with specific decommissioning work.

The International Research Institute for Nuclear Decommissioning (IRID) has been in charge of developing many of the more than 40 remote-controlled type of equipment that have been deployed so far. Developing remote-controlled equipment that can operate stably and complete the assigned surveys and tasks in unknown situations and operating environments is extremely challenging. Training is also required for the operators who maneuver the equipment. IRID has developed and implemented various robots and has successfully accomplished many missions. However, there have, of course, been failures. The accumulation of our past experiences and the various types of expertise that have been acquired with the development of remote-controlled equipment will be crucial for further development.

From now on, the primary focus will be on retrieval of fuel debris. However, it is not only the development of remote-control technologies for the retrieval of fuel debris, such as cutting and handling of the fuel debris, that is required, but also new remote-control technologies that assist in the process leading to retrieval, such as technologies for the investigation of fuel debris and sampling, decontamination, and fixing of water leakages. Further development of remote-controlled equipment that can conduct surveys and tasks in more complicated, highly radioactive, and underwater environments will also be necessary. Development of such equipment is not easy. It is therefore of paramount importance that we learn from experiences and gather wisdom from around the world to address this agenda.

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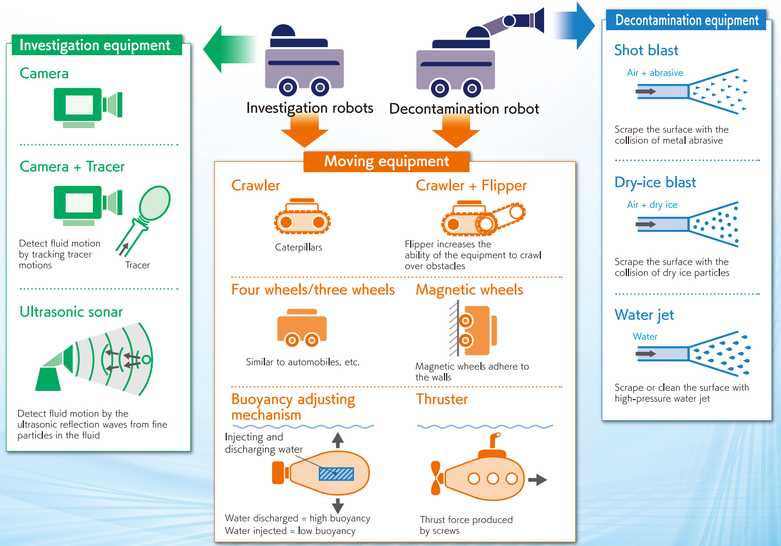
Prof. Hajime Asama

Main functions and names of remote-controlled robots



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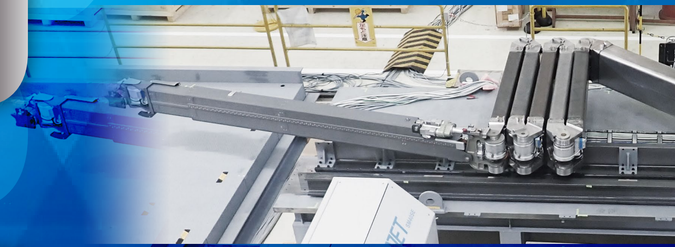
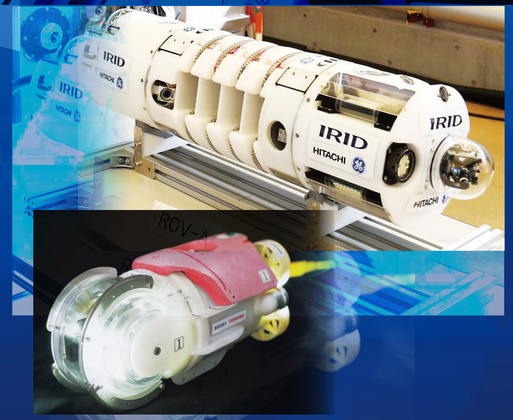
Robots

Robots help with decommissioning work for humans at Fukushima Daiichi Nuclear Power Station.





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Robots help with decommissioning work for humans at Fukushima Daiichi Nuclear Power Station.

★:New robot

Working Robot

Decontamination Equipment for Upper Floors of the Reactor Building

Photograph showing suction/blast type of robot

[Scope of work] Decontamination using four technologies: suction, blast, dry-ice blast, and high-pressure water jet
[Location of work] Floor surfaces and bottom area wall surfaces on the second and third floors of the reactor building in Unit 1–3
[Developed by] Mitsubishi Heavy Industries, Ltd., Hitachi-GE Nuclear Energy, Ltd., and Toshiba Energy Systems & Solutions Corporation
[Demonstration periods] Second half of FY 2015

Notes

Work truck
Mobility: Crawler
Dimensions: W 750 mm × L 1700 mm × H 1700 mm
Weight: Approx. 550 kg

Relay Truck*
Mobility: Crawler
Dimensions: W 1100 mm × L 2000 mm × H 500 mm
Weight: Approx. 680 kg

Carrier/supporting truck*
Mobility: Crawler
Dimensions: W 714 mm × L 2410 mm × H 350 mm
Weight: Approx. 750 kg

* Measurement and weight of the trucks vary depending on the equipment loaded.

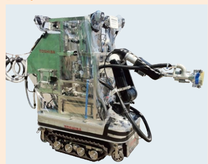
Suction/Blast Decontamination Equipment (MEISTeR)

[Scope of work] Decontamination with shot blast
[Location of work] Floor and lower wall surfaces on the first floor of reactor building in Unit 1–3
[Developed by] Mitsubishi Heavy Industries, Ltd.
[Demonstration periods] Second half of FY 2013

Notes

Mobility: Crawler (variant of MHI-MEISTeR)
Equipment: Arm + shot blast equipment, air transport equipment, and blasting dust collector
Dimensions: W 700 mm × D 1250 mm × H 1300 mm
Weight: Approx. 500 kg

Dry-Ice Blast Decontamination Equipment



[Scope of work] Decontamination with dry-ice blast
[Location of work] Floor surfaces and lower wall surfaces on the first floor of reactor building in Unit 1–3
[Developed by] Toshiba Energy Systems & Solutions Corporation
[Demonstration periods] First half of FY 2014

Notes

Mobility: Crawler
Equipment: Decontamination truck, supporting truck
Dimensions: W 923 mm × D 1460 mm × H 1841 mm
Weight: 730 kg

High-Pressure Water Jet Decontamination Equipment (Arounder)

[Scope of work] Decontamination with water jet
[Location of work] Floor surfaces and lower wall surfaces on the first floor of the reactor building in Unit 1–3
[Developed by] Hitachi-GE Nuclear Energy, Ltd.
[Demonstration periods] First half of FY 2014

Notes

Mobility: Crawler
Equipment: Arm + water jet, water supply/collection equipment
Dimensions: W 600 mm × D 1600 mm × H 1300 mm
Weight: Approx. 850 kg

Dry-Ice Blast Decontamination Equipment for High Places

[Scope of work] Decontamination with dry-ice blast
[Location of work] 5–8 meters high wall surfaces, ceilings, ducts, cable trays on the first floor of reactor building in Unit 1–3
[Developed by] Toshiba Energy Systems & Solutions Corporation
[Demonstration periods] Second half of FY 2015

Notes

Mobility: Crawlers
Equipment: Work truck for remote-controlled decontamination of high places, supporting truck, etc. (use of equipment for low places)
Dimensions: W 930 mm × L 2069 mm × H 1961 mm
Maximum reachable height of equipment: 8000 mm
Weight: Approx. 1700 kg

Suction/Blast Decontamination Equipment for High Places (Super-Giraffe)

[Scope of work] Decontamination with shot blast
[Location of work] High wall surfaces and structures on the first floor of reactor building in Unit 1–3
[Developed by] Mitsubishi Heavy Industries, Ltd.
[Demonstration periods] Second half of FY 2015

Notes

Mobility: Four-wheel drive, four-wheel steering (variant of NEDO Super-Giraffe)
Equipment: Arm + shot blast, air transport equipment, blasting dust collector
Dimensions: W 1300 mm × D 2350 mm × H 1700 mm
Maximum reachable height of equipment: 8000 mm
Weight: Approx. 4000 kg

High-Pressure Water Jet Decontamination Equipment for High Places

[Scope of work] Decontamination with water jet
[Location of work] High wall surfaces of 2 meters or more and structures on the first floor of reactor building in Unit 1–3
[Developed by] Hitachi-GE Nuclear Energy, Ltd.
[Demonstration periods] Second half of FY 2015

Notes

Mobility: Crawlers
Equipment: Arm + water jet equipment, water supply/collection equipment
Dimensions: W 760 mm × D 2098 mm × H 1555 mm
Maximum reachable height of equipment: 6105 mm (high-pressure water can be ejected up to a height of 8000 mm)
Weight: Approx. 1300 kg

Shielding Block & Iron Plate Detaching Equipment (TEMBO)

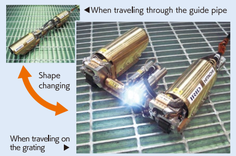
[Scope of work] Removing shielding blocks and iron plates
[Location of work] The first floor of reactor building in Unit 2
[Developed by] Mitsubishi Heavy Industries, Ltd.
[Demonstration periods] First half of FY 2015

Notes

Mobility: 3 wheels
Equipment manipulator, end effecter
Dimensions: W 1100 mm × D 4000 mm × H 2100 mm
Weight: Approx. 3500 kg

Investigation Robots

Unit 1: Investigation Equipment for inside Primary Containment Vessel (PCV) (shape-changing robot, PMORPH-1)

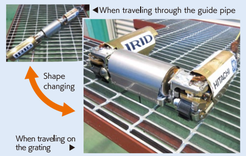


[Scope of investigation] Capturing images, measuring radiation levels and temperature on grating on the first floor outside pedestal in Unit 1 PCV (B1 investigation)
[Location of investigation] Grating on the first floor outside the pedestal in Unit 1 PCV
[Developed by] Hitachi-GE Nuclear Energy, Ltd.
[Demonstration periods] First half of FY 2015

Notes

Mobility: Crawler
Investigation equipment: Camera, dosimeter, thermometer
Dimensions: (when traveling through the guide pipe) approx. L 600 mm × W 70 mm × H 95 mm; (when traveling on the grating) approx. L 220 mm × W 290 mm × H 95 mm
Weight: Approx. 10 kg (excludes weight of cables)
Resistance to radiation: More than 1000 Gy

Unit 1: Investigation Equipment for inside Primary Containment Vessel (PCV) (shape-changing robot, PMORPH-2)



[Scope of investigation] Capturing images and measuring radiation levels on the pedestal basement floor in Unit 1 PCV (B2 investigation)
[Location of investigation] Pedestal basement floor in Unit 1 PCV
[Developed by] Hitachi-GE Nuclear Energy, Ltd.
[Demonstration periods] Second half of FY 2016

Notes

Mobility: Crawler
Investigation equipment: Camera, dosimeter
Dimensions: (when traveling through the guide pipe) approx. L 699 mm × W 72 mm × H 93 mm, (when traveling on the grating) approx. L 316 mm × W 286 mm × H 93 mm
Weight: Approx. 10 kg (excludes weight of cables)
Resistance to radiation: More than 1000 Gy

Unit 2: Investigation Equipment for Primary Containment Vessel (PCV)

[Scope of investigation] Confirming the conditions of platform on the inside of pedestal in the Unit 2 PCV (existence of obstacles and damaged conditions, etc.)
[Location of investigation] Platform on the inside of the pedestal in the Unit 2 PCV
[Developed by] Toshiba Energy Systems & Solutions Corporation
[Demonstration periods] Second half of FY 2016

◀When travelling in narrow spaces

A2 investigation robot (Scorpion robot)

Notes

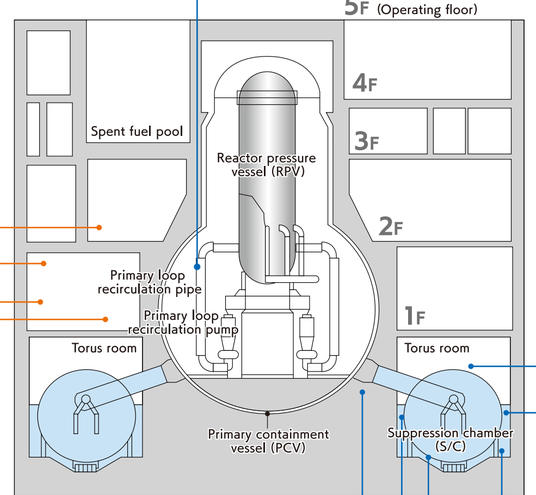
Mobility: Crawlers
Investigation equipment: Camera, dosimeter, thermometer
Dimensions: (when traveling through the guide pipe) approx. L 590 mm × W 90 mm × H 90 mm; (when traveling on the grating/CRD rail) approx. L 260 mm × W 90 mm × H 220 mm
Weight: Approx. 5 kg
Resistance to radiation: More than approx. 1000Gy

◀When travelling on the CRD rail

Deposit removal equipment

Notes

Mobility: Crawler
Purpose: Ensuring of investigation route for the robot, while removing deposits on the rail by water pressure.
Dimensions: Approx. L300mm × W 90mm×H90 mm
Weight: Approx. 3kg
Resistance to radiation: More than approx. 1000Gy



Unit 1: Boat-Type Access Equipment with Submersible Functions for Investigation inside PCV (IRIDOLPHIN)

[Scope of investigation] Investigation to understand the structural conditions of a wide range of pedestal periphery, distribution of deposits, and pedestal opening
[Location of investigation] Basement floor of outside the pedestal in Unit 1 PCV
[Developed by] Hitachi-GE Nuclear Energy, Ltd.
[Demonstration periods] Second half of FY 2021

Notes

Boat-type with submersible functions
Purpose: Cable guide (guide ring) installation for wide-range movement of the pedestal periphery
Dimensions: φ 250 mm diameter, approx. 1100 mm in length
Weight: Approx. 40 kg

★Unit 2: Access and Investigation Equipment for Fuel Debris Trial Retrieval of Primary Containment Vessel (PCV) (Robot Arm)

[Scope of investigation] Investigation to understand the conditions of the structures and distribution of sediments inside the pedestal of Unit 2 PCV
[Location of investigation] Inside the pedestal of Unit 2 PCV
[Developed by] Mitsubishi Heavy Industries, Ltd.
[Demonstration periods] Second half of FY 2022 (planned)

Notes

Mobility: Long and multi-joint arm
Purpose: Investigation inside the pedestal and fuel debris trial retrieval
Dimensions: Approx. 22 m in length
Weight: Approx. 4.6 ton

Unit 3: Investigation equipment for inside the primary containment vessel (PCV)

[Scope of investigation] Investigation of the conditions inside the pedestal of Unit 3 PCV
[Developed by] Toshiba Energy Systems & Solutions Corporation
[Demonstration periods] First half of FY2017

Notes

Mobility: Submersible type
Investigation equipment: Camera
Dimensions: Approx. 130mm outside diameter, approx. 300mm in length
Weight: Approx. 2kg (in the air), neutral buoyancy (in water)
Cable length: Approx. 60m
Resistance to radiation: More than approx.200Gy

Unit 1: Investigation Equipment for Upper Part of Suppression Chamber (S/C) (Tele-runner: Investigation of Upper Part of S/C)

[Scope of investigation] Investigation of leaks from the upper structure of the S/C from C/W
[Location of investigation] Upper part of S/C in Torus Room of Unit 1
[Developed by] Hitachi-GE Nuclear Energy, Ltd.
[Demonstration periods] First half of FY 2014

Notes

Mobility: Crawler, flipper
Investigation equipment: Camera, dosimeter, thermometer/hygrometer, and microphone
Dimensions: L 600 mm × W 500 mm × H 800 mm
Weight: Approx. 70 kg

Investigation Equipment for Torus Room Wall Surface (Tri-Diver: Crawling Robot)

[Scope of investigation] Investigation of water flow at penetration parts in wall surface under muddy water
[Location of investigation] Penetration points in torus room and turbine building (underwater)
[Developed by] Hitachi-GE Nuclear Energy, Ltd.
[Demonstration periods] First half of FY 2014

Notes

Mobility: Crawler, thruster
Investigation equipment: Camera, ultrasonic sonar, water temperature gauge
Dimensions: L 600 mm × W 500 mm × H 400 mm
Weight: Approx. 40 kg (in air), approx. 1.5 kg (in water)
Water pressure resistance: 10 m

Investigation Equipment for Torus Room Wall Surface (Gengo ROV: Underwater Floating Robot)

[Scope of investigation] Investigation of penetration parts in the wall surface underwater
[Location of investigation] Penetration parts in the torus room and turbine building (underwater)
[Developed by] Hitachi-GE Nuclear Energy, Ltd.
[Demonstration periods] First half of FY 2014

Notes

Mobility: Thruster, buoyancy adjusting mechanism
Investigation equipment: Camera, water temperature gauge
Dimensions: L 500 mm × W 400 mm × H 400 mm
Weight: Approx. 22 kg (in air), neutral buoyancy (in water)
Water pressure resistance: 10 m

Investigation Equipment for Joint Section between Vent Pipe and Dry Well (D/W) (VT-ROV)

[Scope of investigation] Autonomous driving equipment adheres to outer surface of vent pipe and moves to joint section inspection point of the vent pipe and D/W shell to detect leaks from vent pipe and D/W joint section as well as water flow inside lower area of the concrete wall outlet using light and camera.
[Location of investigation] Joint section of vent pipe in the torus room and PCV shell (in the air)
[Developed by] Toshiba Energy Systems & Solutions Corporation
[Demonstration periods] First half of FY 2014

Notes

Mobility: Magnetic attraction wheels
Investigation equipment: Camera
Dimensions: L 280 mm × W 280 mm × H 90 mm Weight: 10 kg

Investigation Equipment for Sand Cushion Drain Pipe (DL-ROV)

[Scope of investigation] Equipment drifts through the water in the torus room up to the submerged sand cushion drain pipe outlet to detect leaks of 1 L/min or more from the submerged sand cushion drain pipe outlet using lights, camera, and a tracer release mechanism.
[Location of investigation] Exit of sand cushion drain pipe in the torus room (underwater)
[Developed by] Toshiba Energy Systems & Solutions Corporation
[Demonstration periods] First half of FY 2014

Notes

Mobility: Thruster (two thrusters: one on top, one on bottom)
Investigation equipment: Camera
Dimensions: L 530 mm × W 290 mm × H 300 mm Weight: 14 kg

Investigation Equipment for Lower Outer Surface of Suppression Chamber (S/C) (SC-ROV)

[Scope of investigation] Autonomous driving equipment adheres to outer surface of SC and moves to inspection point of the lower outer S/C to detect holes with a diameter larger than 30 mm on the lower outer surface of the S/C by using lights and cameras (four cameras mounted front and rear, right and left).
[Location of investigation] Outer surface of the S/C in the torus room of Unit 2
[Developed by] Toshiba Energy Systems & Solutions Corporation
[Demonstration periods] First half of FY 2014

Notes

Mobility: Magnetic attraction wheels
Investigation equipment: Camera
Dimensions: L 280 mm × W 280 mm × H 140 mm Weight: 10 kg