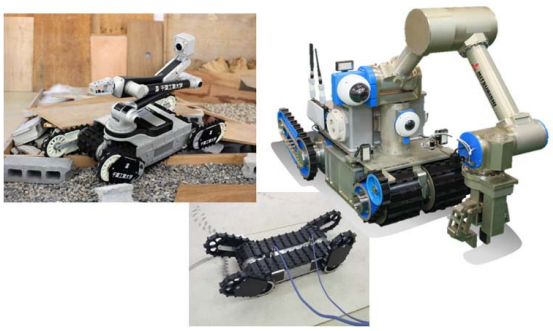
Application of Sakura II and MHI-HERCULeS Develops into Social Infrastructure Maintenance



Nuclear Energy Systems Department,
Business Division,
Energy & Environment

Remote-controlled robots are required for surveillance and work in areas where levels of radioactivity are too high or that have been devastated by disasters. In such locations, robots require high traction performance, even over precarious terrain such as stairs and debris. Mitsubishi Heavy Industries, Ltd. (MHI) and the Chiba Institute of Technology (CIT) signed a technical cooperation agreement, and MHI started the manufacture and sales of the Sakura II robot based on its predecessor Quince[*1] developed by CIT. Quince is a mobile robot that showed high traction performance at the Fukushima Daiichi Nuclear Power Station. Leveraging this robotic technology, MHI developed the MHI-HERCULeS[*2] and delivered it to the Nuclear Emergency Assistance Center of the Japan Atomic Agency (J-NEACE), which manages and operates equipment and materials such as robots necessary to assist power plants in urgent situations due to disasters. MHI is also developing an exploration robot that has the equivalent traction performance and the capability to work under flammable-gas-filled conditions such as in tunnel disasters.

*1 Quince is a trademark of Chiba Institute of Technology
*2 HERCULeS: HEx crawler ResCUe robot with Lighting and Exploring System

1. Outline of MHI robots

Quince, a mobile robot developed by CIT, is the only robot in the world that was able to reach and survey the top floor (fifth floor) of the Fukushima Daiichi Nuclear Power Station. Under a technical cooperation agreement with CIT, MHI will manufacture and sell the Sakura II robot developed based on the knowledge gained through Quince development. Sakura II features wide crawlers, which avoid stranding, showing high traction performance even over punishing terrain such as stairs and debris.

The MHI-HERCULeS robot, which is specialized in removing obstacles in nuclear disasters, inherits the wide crawlers of the Sakura II and has a manipulator with a large portable mass based on knowledge gained from other remote robots for maintenance and inspection at nuclear power plants. The robot can ascend and descend stairs, as well as pivot and climb up narrow spaces such as stair landings with its manipulator folded.

Based on the Sakura II, MHI is also developing a new exploration robot for response and management in infrastructure disasters such as tunnel collapse accidents. The new robot will measure oxygen and flammable-gas concentrations and capture video images to grasp the scale of a collapse. For this purpose, the robot will be highly environmentally-resistant and lightweight – making it easy for someone to carry – with an explosion-protection structure allowing it to work under flammable-gas-filled conditions.

2. Specifications of each robot

(1) Sakura II

Table 1 shows the basic specifications of the Sakura II and **Figure 1** shows its full view and appearance when it is operating. Specifications such as its operational capabilities can be customized to meet customer needs. The robot can ascend and descend stairs with inclinations

up to 45 degrees and pivot at narrow stair landings thanks to its small in-place turning radius of 900 mm. The robot is light at 47.5 kg but moves fast at 1.5 km/h while carrying heavy loads up to 60 kg. The main body features a dust- and water-tight structure to meet radioactive decontamination requirements. The optional manipulator which mounts the wide-angle camera can handle light work such as debris removal and sample collection, and can collect information in overhead locations and narrow spaces.

Table 1 Basic specifications of each robot

Robot	Sakura II	MHI-HERCULeS	Exploration robot for flammable-gas-filled conditions*
Dimension (mm)	Length 720 (when sub-crawlers are folded) to 1,140 (when sub-crawlers are unfolded), width 510, height 450	Length 1,090 (when sub-crawlers are folded) to 1,440 (when sub-crawlers are unfolded), width 770, height 890	Length 700 (when sub-crawlers are folded) to 1,140 (when sub-crawlers are unfolded), width 420, height 600
Weight (kg)	47.5 (without optional manipulator) 69 (including optional manipulator)	250	55
Speed (km/h)	1.5	0.9	1.2
Loading capacity (kg)	60 (without optional manipulator)	-	-
Vision	On-board pan-tilt-zoom camera with lighting Visual observation from up to 2.2 m elevation	48x zoom pan-tilt-zoom camera with lighting, front monitoring camera, rear monitoring camera, gripper monitoring camera	48x zoom pan-tilt-zoom camera, front monitoring camera, rear monitoring camera, gas detector monitoring camera
Sensor			Gas-detection (H_2S, CH_4, H_2), O_2 concentration (0 to 25 vol%)
Manipulator length (mm)	1,900	1,900	-
Portable mass of manipulator (kg)	4.5	30 (when manipulator is extended), 135 (near-field objects)	-
Operating method	Wired and wireless LAN control with laptop PC and joypad	Wired and wireless LAN control with laptop PC and joypad	Wired (1,000 m) and wireless LAN (100 m) control with laptop PC and joypad
Power source	Li-ion battery lasting for about 4 hours	Li-ion battery lasting for about 4 hours	Li-ion battery lasting for about 2 hours
Dust- and water-tight performance	IP67-equivalent	IP56-equivalent	IP47-equivalent
Explosion-protection structure and performance			Pressurized enclosure＋flameproof enclosure (Ex px [d] IIB＋H_2X T4Gb)
Applicable hazardous zone			Zone 1

*Target specifications as it is currently under development.

Figure 1 Sakura II in operation

(2) MHI-HERCULeS

Table 1 shows the specifications of the MHI-HERCULeS and **Figure 2** shows its appearance. The robot weights 250 kg, and the portable mass of the manipulator is 30 kg when extended and 135 kg for near-field objects. The robot also can ascend and descend stairs with inclinations up to 45 degrees like the Sakura II robot, and is outfitted with 4 cameras and 6 lighting, allowing operation in dark places.

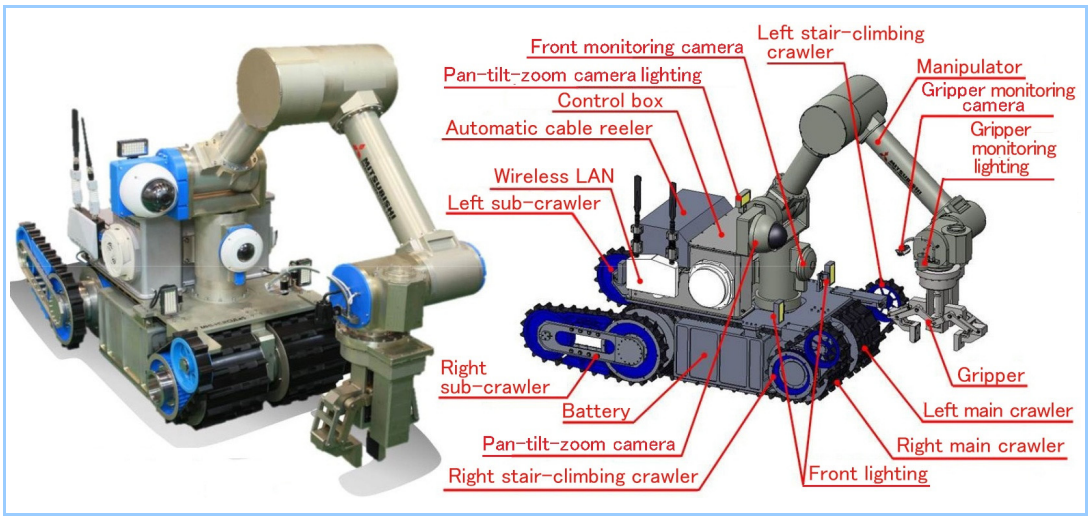


Figure 2 Appearance and part names of MHI-HERCULeS

(3) Exploration robot for flammable-gas-filled conditions (target specifications)

Table 1 shows the target specifications of the exploration robot for flammable-gas-filled conditions, which is under development under the "System development project to manage social problems of infrastructure maintenance and renovation" by the New Energy and Industrial Technology Development Organization (NEDO) of the National Research and Development Agency, and **Figure 3** shows its appearance. This robot will have an explosion-protection structure and the mass is targeted to fall under the weight portable by two people. It features a long wired communication performance of 1,000 m, which is the necessary length for remote control in tunnels where the transmission of electromagnetic waves can be interrupted.

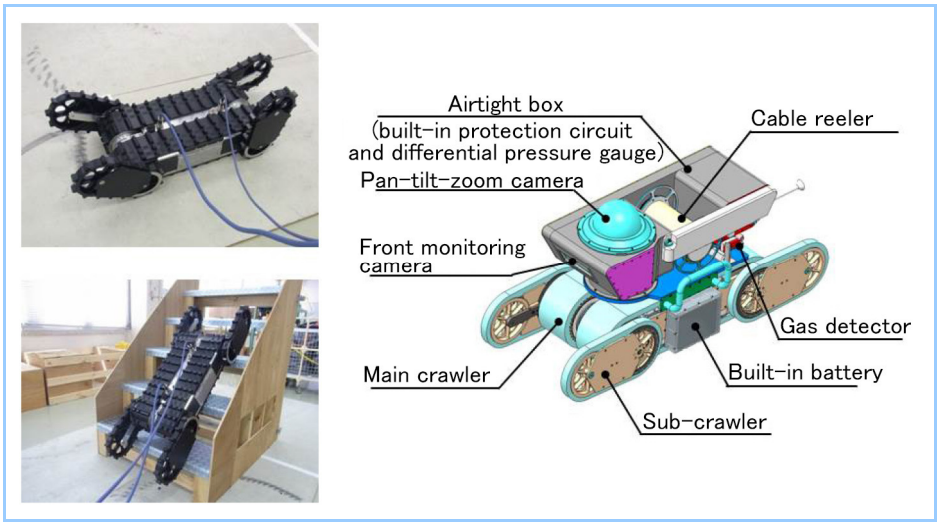


Figure 3 Appearance and part names of exploration robot for flammable-gas-filled conditions