Reconstruction of JAEA robots for the Fukushima NPP accidents emergency response

- Unitizing for conveyance and reassembly at the confused area by accidents -

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JAEA reconstructed robots for the Fukushima diichi Nuclear Power Plants' accidents, in order to meet the confused situation by accidents. Many rubble were scattered and temporary cables and hoses were constructed in the reactor buildings, so that small robots like as reconnaissance robots should be conveyed by operators. JAEA unitized their small robot systems, in order that operators could convey and reassemble easily to reduce exposure dose.

Key Words: IBARAKI Robot Technology, Emergency response robot system, Mobility, Unitizing,

1. Background

1.1 Importance of mobility of emergency response robots

It has been recognized that mobility of the emergency response robots is important and that the robots have to be transported to accident site and to be deployed immediately. Therefore several efforts had been done for the robots.

1.2 Mobility of RESQ series robots

Japan Atomic Energy Research Institute, presently Japan Atomic Energy Agency (JAEA) had developed remote surveillance squad (RESQ) series robots, two RESQ-A, one RESQ-B and a RESQ-C, in order for initial information acquisition after JCO criticality accidents on September 30th 1999. [1]

All components of RESQ series robots, robots, controllers and accessory equipment, had been installed or stored in two containers so that transportation could be done easily if trailers and drivers could be arranged after accident occurred.

However, addition to two containers mentioned above, two diesel drive electric generators are prepared and are needed to convey by other tracks because large-scale output were demanded.

Fig.1 RESQ robots container

Fig. 2 RESQ-A robots

1.3 JAEA response of robots to Fukushima daiichi accident

JAEA recognized the necessity of gamma ray imaging and measurement in the reactor building after Fukushima daiichi Nuclear Power Plants accidents on March 11th, 2011.

Therefore, JAEA decided and modified one RESQ-A robot to JAEA-3 robot equipped with "gamma eye" which was designed and developed to image and measure gamma ray and to be smaller and lighter for being mounted in small reconnaissance robot. [2]

1.4 Anticipated condition

Beside information were limited, it was anticipated that rubles were scattered in the reactor buildings, that dose rate was tens to hundreds milli Sievert, that it was highly contaminated, and that robot operation time might be longer because of obstacles like as scattered rubles.

Also, road to Fukushima daiichi was damaged too heavily for transporting shipping containers, and it was hard to find drivers to go to Fukushima daiichi.

1.5 Feature of original JAEA-3 robot

JAEA-3 robot had been planned to have high radiation resistance, to be water proof for water spray decontamination and to be transported by smaller tracks with shielded operation BOX, in order to meet with the anticipated condition.

As for radiation resistance of the robot, electronics were excluded as far as possible by moving servo drivers from robot itself to controller and cabling between robot and controller.

As for reducing of radiation exposure to operators during maintenance, cable and tires could be replaced during maintenance and robot including "gamma eye" could be decontaminated 6MPa water spray.

As for transportation, Robot control vehicle was prepared based on 5 tons track.

Additionally gasoline drive electric generator with 100volts output was prepared

2. Actual situation and request from Fukushima daiichi

It was cleared during hearing from Tokyo Electric Power Corporation (TEPCO) operators that the actual situation was beyond the anticipated condition.

In actual situation, operators had to carry the small reconnaissance robots by themselves to inside the reactor building, because the temporary cable, water horses and equipment had already been constructed on the floor and/or corridor, so hand-pushed cart could not be used. [3][4]

Also it became cleared that electric generator was hesitated to use in the building in which hydrogen might be remained.

TEPCO required not only "gamma eye" on tele-operated robot, but also operator portability too.

Fig.3 on site

Fig.4 in reactor building

3. Reconstruction and Unitizing

3.1 Policy for Reconstruction of JAEA-3 robot system

JAEA-3 robot system was reconstructed again according to the policy as below.

1) To divide accessary equipment of the systems to units and to mount each unit on three wheel career and to keep each less than 20kg, except JAEA-3 robot which is platform and “gamma eye” connecting precisely.
2) To reduce connectors and tool free reassembling.
3) To prepare heavy use battery module.
4) To add surveillance camera for full remote operation.

3.2 Outline of Reconstruction of JAEA-3

Original JAEA-3 consists of a vehicle platform equipped with “gamma eye”, controlling equipment like as joystick box, servo drivers and an electric generator.

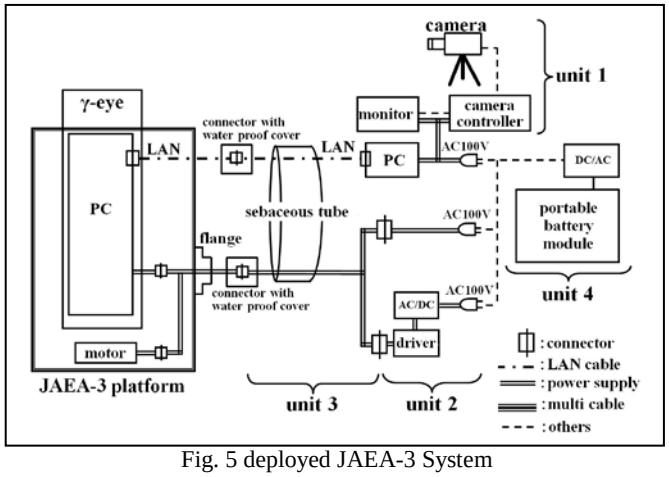

Fig. 5 deployed JAEA-3 System

According to the policy above mentioned, the system was divided to vehicle platform and four units. See Fig 5 and Table 1.

The vehicle platform with “gamma eye” was newly equipped with shoulder belts addition to existing holding handles for two operators to convey safely.

Unit 1 consisted of newly prepared surveillance camera, tripod, cable from the camera to controller.

Unit 2 consisted of gamma eye operation PC, monitor for surveillance camera, joystick box, motor drivers

Unit 3 was box for 50m cabled between robot and controller

Unit 4 was battery module.

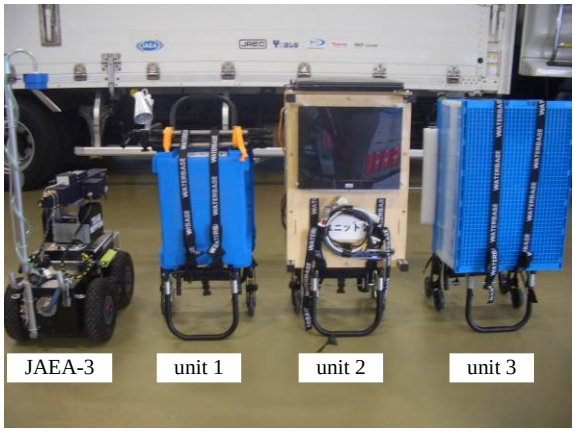

Fig.11 : JAEA-3 robot and unitized equipment

Table 1 Contents of each unit

Unit No.	Contents	remarks
	JAEA-3 robot	Equipped with “gamma eye”
1	Surveillance Camera	Picture was showed in monitor on unit 2
2	Controller	Include two 12 volts lead batteries and a DC/AC inverter.
3	Cable	Consists of multi-line cable, a twist pair cable and a stainless steel wire.
4	Battery module	Consist of two 12volts lead batteries and DC/AC inverter.

3.3 Device and design

The vehicle platform was equipped with cable flange for water proof, the normal removal bolts was replaced with butterfly screw for operator handling with rubber gloves and not for missing bolts.

All connectors, which were handled for reassembly, were tool free. Therefor no hand tools were needed.

A battery module was also elaborated because gas drive generator was hesitated. The battery module should bear motors’ surge current, should be able to recharge easily and to have, in order to meet gamma eye, surveillance camera input.

Above mentioned parts were adopted from the view point of robustness, reliability conformity of 100 volts AC output and short time procurement, besides solid state batteries like as Ni-MH, DC/DC converters were desirable from the viewpoint of miniaturization and weight saving,

4. Conclusion

JAEA could reconstruct one RESQ-A robot to JAEA-3 robot equipped with gamma ray imager based on anticipated condition, but actual situation was beyond the anticipation.

Unitizing policy was developed based on the actual situation recognized and requests from operators of Fukushima daiichi.

Unitizing increases mobility of small robot by enabling operators to convey. Mobility is very important for emergency response robot and operators’ conveyance should be considered in worst case.

5. Perspectives

Policy for unitizing became the key policy for JAEA’s remote operational equipment for nuclear emergency, which has been being prepared.

Battery unit should be studied for weight saving, robust power supply and safety, and also cabling should be studied easier handling and radiation exposure reduction.

References

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