Utilization of Robots (Remote Control Machines) In the Accident of Fukushima Daiichi Nuclear Power Station

April 28, 2011

Tokyo Electric Power Company

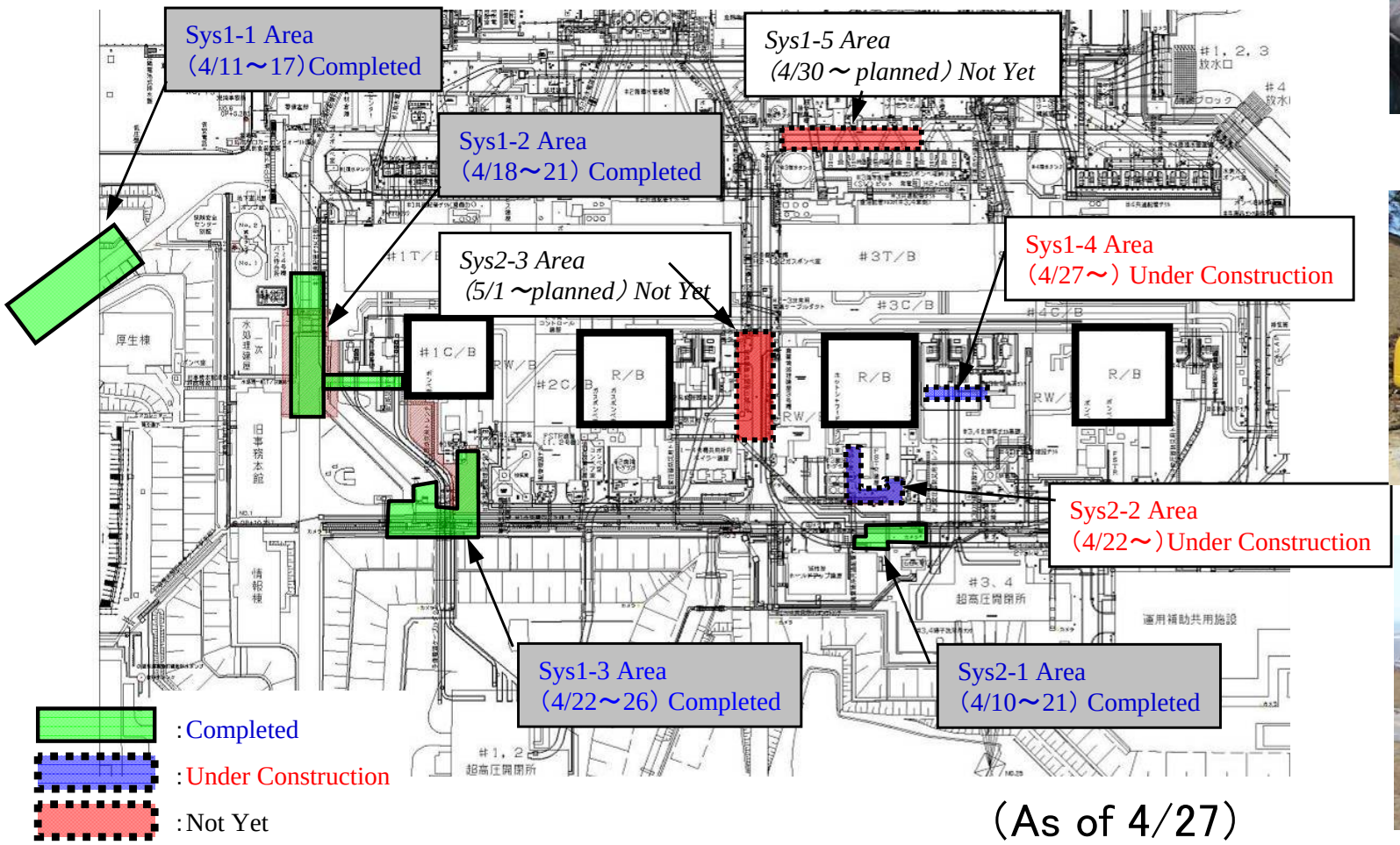
Purpose：Support for various works using remote control heavy machines and small robots

- In order to reduce exposure of radioactive ray to the workers and improvement of work efficiency, remote control machines have been introduced and considered for project teams such as a team for building permanent cooling system

  - Remote Control Heavy Machine for Treatment of Rubble (Using Robot Technology)
  - Monitoring Small Robots (Domestic and Foreign Products)
  - Revising Concrete Pump Vehicle to Remote Control

Removal of Outside Rubble by Remote Control Heavy Machines

- **Contractor: JV (Taisei, Kajima, Shimizu)**
- **Heavy Machines**
  - **Komatsu･･･Oil Pressure Shovel 3 cars, Crawler Dump 2 cars**
  - **Hitachi-Kenki･･･Crawler Dump 1 car**
  - **Caterpiller Japan･･･ Oil Pressure Shovel 1 cars，Bulldozer 1 car**



（As of 4/27）

Inside of Operation Car

Loading

Operation Car and Machines

Results of Removal of Rubble

◆Sys1-2 ：1R/B North Side (4/18～21)

Before

After

◆Sys1-3 ：1R/B West Side (4/22～26)

Before

After

Site	Status	No. of Container
Test Information Building	Completed (4/6～4/7)	3
Sys1-1 Shiomisaka Kosei Building	Completed (4/11～17)	11
Sys1-2 1R/B North Side	Completed (4/18～21)	6
Sys1-3 1R/B West Side	Completed (4/22～26)	8
Sys1-4 3R/B South Side	Under Construction (4/27～)	1
Sys1-5 3T/B East Side	Planned (4/30～)	

Site	Status	No. of Container
Sys2-1 Unit 3/4 Switch Yard	Completed (4/10～21)	20
Sys2-2 3R/B West Side	Under Construction (4/22～)	10
Sys2-3 3R/B North Side	Planned (5/1～)	

Total 59 Containers
(As of 4/27)

Flow of Introduction of Robots

Proposed or Provided Robots
（Quince, Packbot, Talon, etc.）

Evaluation/Workability Confirmation
（Confirmation of Revision）

Study and Establishment
of Operation System

- Considering countermeasures including utilization of robots in accordance with the site situation and needs
- If necessary, the robots will be revised for adjustment

Quince (Current Status)

Talon (Current Status)

Packbot (Current Status)

Robot and monitoring equipment will be installed

Transport to Fukushima
（Onahama, Hirono, etc.）

Test Operation, Training

- Before bringing into the site, test operation and training are necessary in non-control area.

Remote Control Robot Car
（TEAM NIPPON）
is under preparation

Bringing into Fukushima Daiichi NPS

Simulation for Unit 5, etc.

- Implementation of mock-up in advance, using Unit 5 that has a similar structure (in order to reduce exposure in high radioactive area)

Waiting

Utilization on Site (Unit 1-3, etc.)

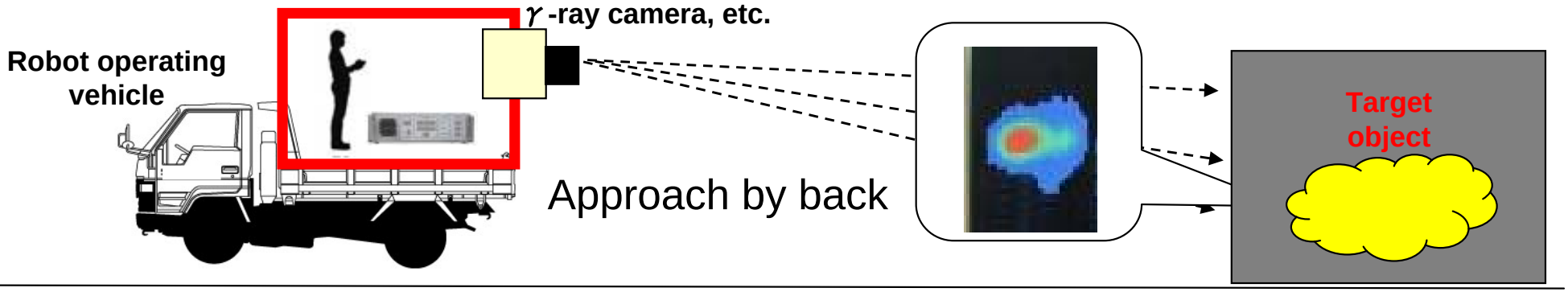
Examples of how the small robots are used

Manufa-cture	Name			April	May	Purposes of operations
iRobot	Packbot		①	Currently operated at the site <Results of the operations> 4/1：Took photos of debris around the building of Unit 3 4/17・18：Examined inside of the reactor buildings of Unit1,2 and 3 4/26：Examined inside of the reactor building of Unit1		To monitor the situations of inside/outside the buildings,etc.
			②			
QinetiQ（DOE）	Talon		①	Trainings/adjustments at Onahama	→Go into operations	Planned to use for outside survey, etc. (This robot has mapping functions)
				4/14:Receipt at AIST(Tsukuba) 4/22:Trainings of operation at Onahama 4/27:Combination with robot operating vehicle Late April: Final adjustment to go into operations		
C.I.T., Touhoku U.,etc.	Quince			Trainings/adjustments at Chiba	→Preparation for going into operations	Planned to use to monitor the situations of inside/outside the buildings,etc
				Confirmation of manipulation performance, adjustments（4/11,15,21,26）		

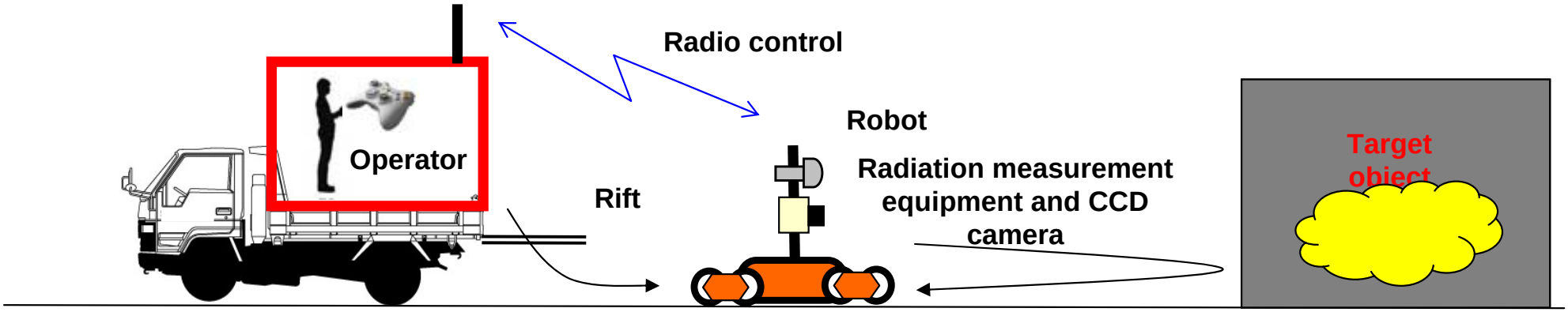
Robot operating vehicle system
（「TEAM NIPPON」）

Developed at Japan Atomic Energy Agency

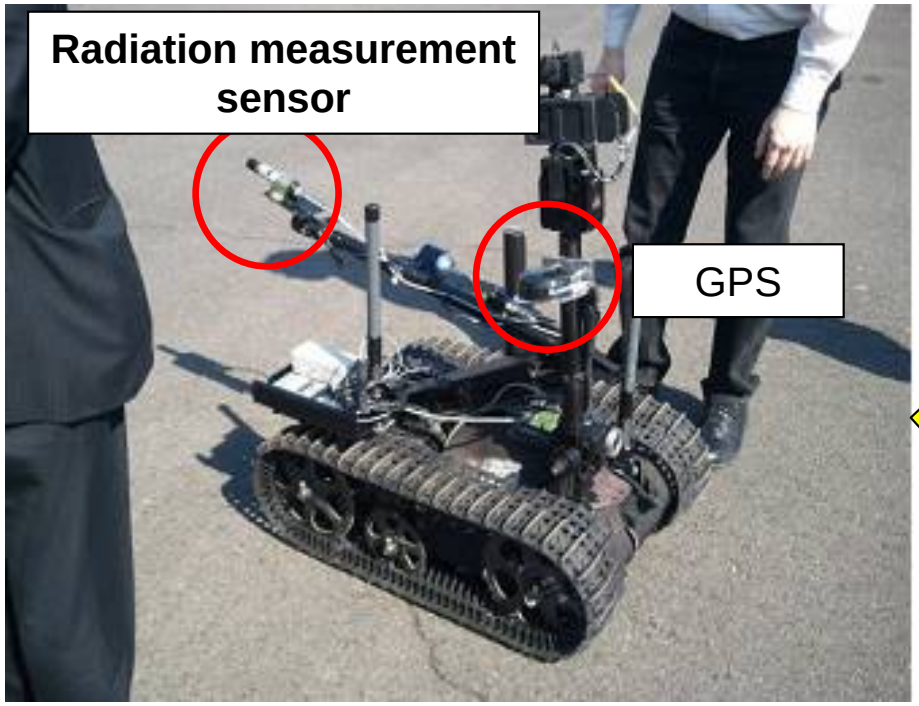
1. **Identify the source of radiation by γ-ray camera, etc.**



2. **Measure the dose of radiation and monitor the situation**



Talon（offered by DOE, Manufactured by QinetiQ）（w/Automatic radiation quantity mapping function）

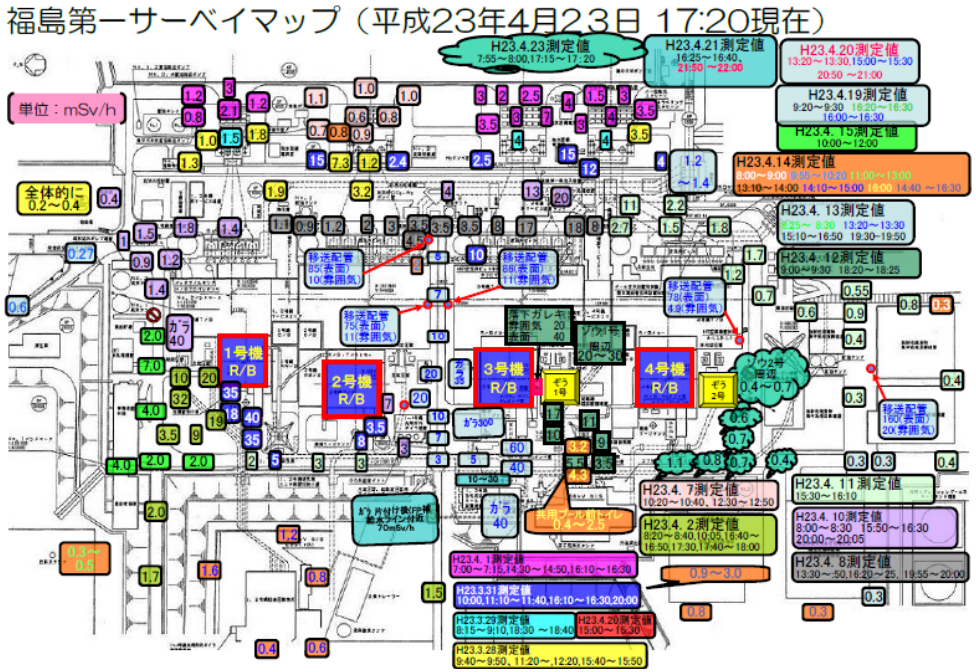


”Talon” offered by DOE

■Position measurement by GPS

■Dose of radiation measured by radiation measurement equipment

Measured radiation data may be visually identifiable



Planned to use to measure the dose of radiation at outside of the buildings, etc.

（Studying to operate with robot operation vehicle）

Quince (Jointly developed by Chiba Institute of Technology, Tohoku University, International Rescue System, etc.)

スペック

ハードウェア装備

仕様

全長	565～1099[mm]
全幅	480 [mm]
高さ	225 [mm]
体重	26.4 [kg]
最高速度	1.8 [m/秒]
最大搭載重量	90kg
防塵・防水(IP67)	あり
耐衝撃	2m落下
標準装備	3chカメラ(前後、俯瞰)、マイクロフォン・スピーカ、PSDセンサ
オプション装備	パンチルトズームカメラ、6DOFマニピュレータ、赤外線サーモグラフィ、CO2センサ・3Dレーザーレンジファインダ

High mobility is the main feature

- Having a low center of gravity with four sub crawlers
  - Overcame debris（concrete of 40 sq. meter and wooden debris）
  - It may go up and down wet and slippery staircases
- It is developed for the purposes of survey the closed room where such as chemical material is leaked and explosion occurred.
- It has world class track record such as winning the championship twice at RoboCup World mobility competition.

Image from C.I.T. website

✓Confirmation of manipulation performance
✓Radiation-proof: Confirmed over 100mSv
✓Confirmed mobility at dark area
✓Attached radiation measurement equipment
・・・

Planned to use to measure the dose of radiation at outside/inside of the buildings, etc.
（Studying to operate with robot operation vehicle）

(Reference) Operation record of the small robots

The site survey was conducted inside the reactor buildings of Unit 1 to 3 on the followings: photos, radiation dose, temperature, humidity, and oxygen density. (4/17, 18, 26)

- Packbot: 2 robots
  - Size: 0.7 × 0.53 × 0.18[m]
  - Weight: 35[kg]
- Running Performance
  - Maximum speed: 9.3[km/h]
- Possible uninterrupted operation hour: 4h

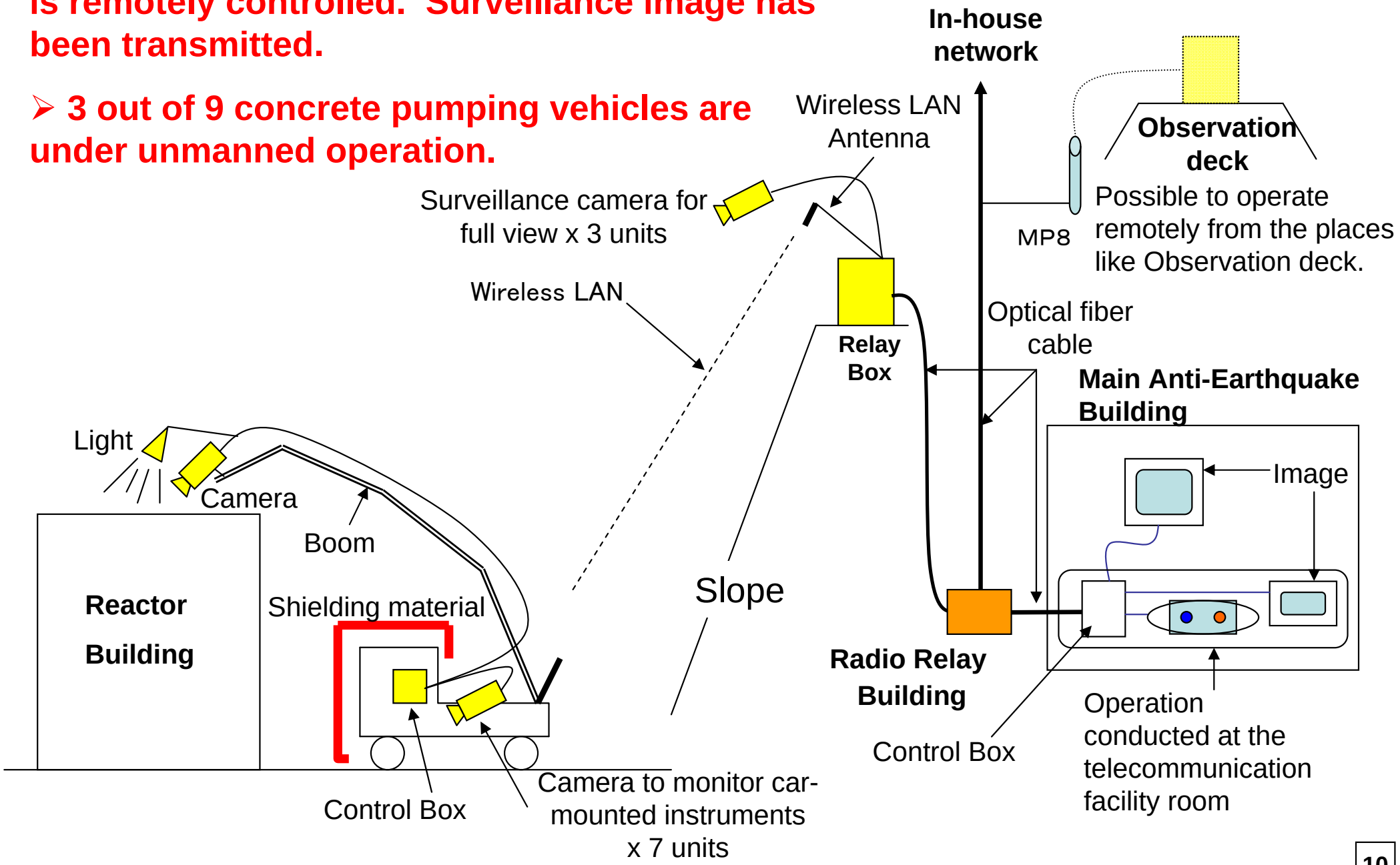
Filmed on April 17th, 2011

Fukushima Daiichi Nuclear Power Station
1 st Floor of Unit 1's Reactor Building

Remote control of concrete pumping vehicle

The operation of boom as well as water injection is remotely controlled. Surveillance image has been transmitted.

- **3 out of 9 concrete pumping vehicles are under unmanned operation.**



Schedule to enable remotely-controlled operation of concrete pumping vehicles.

Made by Putzmeister, Germany

- **Work to enable unmanned operation**
  - **Toshiba: Camera**
  - **Hitachi: Controlling**
  - **Mitsubishi Fuso & MHI: carbody shielding**

	April	May	June
Arm: 62m class	Work to enable unmanned operation Carbody modification (shielding), maintenance		
Arm: 70m class	Work to enable unmanned operation Carbody modification (shielding), maintenance		
Arm: 52m class	Work to enable unmanned operation Carbody modification (shielding), maintenance	Carbody maintenance and repair	
Site		Operation at site (to be finalized)	