



# Nuclearized Robotics

- Lessons Learned and perspectives

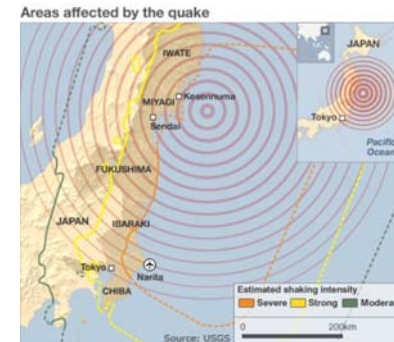
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# Background

- “Off the Pacific coast of Tōhoku earthquake”, Magnitude 9.0, was occurred at 14:46 on Mar. 11<sup>th</sup>, 2011
- And then, huge tsunamis attacked Fukushima daiichi NPPs.
- Fukushima daiichi NPPs lost electrical power and became severely damaged



[http://ichef.bbci.co.uk/news/624/media/images/51641000/gif/\\_51641143\\_japan\\_quake\\_sendai\\_464.gif](http://ichef.bbci.co.uk/news/624/media/images/51641000/gif/_51641143_japan_quake_sendai_464.gif)



Unit 1 to 4 from right to left(16 March, 2011)



<http://photo.tepco.co.jp/date/2011/201104-j/110409-01j.html>



# Review on the tasks with the robots

- More than 20 robots deployed during emergency response
- Several tens operation conducted
- 2 robots, not returned
- Robots, wired, limited for mobility
- No accidents from radiation effects



Missions		Type	
Rubble removal	outdoor use	Unmanned machine	8
	indoor use	BROKK	5
		Talon	1
Reconnaissance (+door opening)	Ground floor of reactor buildings	T-Hawk	2
		PackBot	2
		Talon	1
		QUINCE-1	1
		JAEA-3	1
deconstruction		Warrior	1





# Lessons learned

## Conformity

- Specialized organization required ⇐ training utilizing mock-up
- System, not robot, needed
- Unitization needed, in case

## Reliability

- Radiation resistance

## Maintainability and Decontaminability

- Robot must be maintained under radiation environment
- Contaminated Robots were radiation source for operator





# Perspective and Expectation

Application to Fukushima daiichi decommissioning could be meaningful lessons to other robotics in nuclear field.

- Miniaturization
- Systemization
- Radiation Hardening
- Decontaminability or anti-contamination
- Easy Maintainability





Thank you for your attention !  
We shall overcome !!



# Remote & Robotics Activity for Emergency Response for Fukushima Daiichi NPP

- **JAEA-1:**

Features : Rubbles removable Robot modified with BROKK-40  
 Carrying: Rad. Hardened Camera, Radiation Sensor  
 Status : Standby at JAEA



JAEA-1

- **JAEA-2**

Features : Decontamination Robot modified with RESQ-A  
 Carrying: Rad. Hardened Camera, Water Spray  
 Status : Standby at JAEA



JAEA-2

- **JAEA-3**

Features :  $\gamma$  Imaging Camera Robot modified with RESQ-A  
 Carrying:  $\gamma$  Imaging Camera, Dust Sampler, etc  
 Status : Installed into Fukushima NPP site



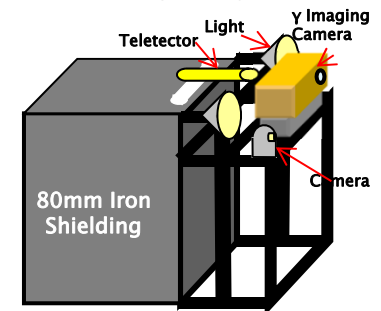
JAEA-3

- **Robot Control Vehicle**

Feature : Mobile control base for nuclear emergency for operator safety  
 Carrying: Shielding BOX,  $\gamma$  Imaging camera, Camera. Tele tector, Generator  
 Status : Installed into Fukushima NPP site



Robot Control Vehicle



Shielding BOX

- **Shielding BOX**

Feature : Shielding Box to reduce exposure for operator for safety  
 Carrying : Installed into Robot Control Vehicle,  
 80mm Iron Shielding ( $^{137}\text{Cs}$ )  
 Status : Installed into Fukushima NPP site

- **$\gamma$ -eye**

Feature : Gamma ray imaging camera  
 to search higher contaminated object  
 Status : Installed into Fukushima NPP site



$\gamma$ -eye



“JAEA-3 goes into Unit-2”  
 (Sep. 23<sup>rd</sup>: by TEPCO)



# Operation using robot(s) during emergency response

Date	Location	Robots	Tasks
4/6-	Outdoor in the Fukushima Daiichi site.	Unmanned Heavy Construction Machines	Removal of high contaminated debris scattered by hydrogen explosion to surroundings of reactor buildings.
4/14	1u	T-Hawk	Reconnaissance from the air, using video camera.
4/15	1u,3u,4u	T-Hawk	Reconnaissance from the air, using video camera.
4/17	1u, 1F	PackBots	Reconnaissance, using video camera and dose meter.
4/17	3u, 1F	PackBots	Reconnaissance, using video camera and dose meter.
4/18	2u, 1F	PackBots	Reconnaissance, using video camera and dose meter.
4/21	1u	T-Hawk	Reconnaissance from the air, using video camera.
4/26	1u-1F	PackBots	Reconnaissance, using video camera and dose meter.
4/29	1u, 1F	PackBots	Reconnaissance, using video camera and dose meter.
5/2-	Around 1u-3u	Talon with RC-1	Radiation mapping and finding hotspot
5/10-	3u, Truck Lock	Talon Bobcat Brokk-90 2*Brokk330 Brokk-800	Removal of high contaminated concrete debris and clean-up of damaged truck of unit 3.
5/10	3u, 1F North	PackBots	Reconnaissance, using video camera and dose meter.
5/13	1u, 1F South	PackBots	Reconnaissance, using video camera and dose meter.
6/3	1u, 1F South	PackBots	Reconnaissance, using video camera and dose meter.
6/24	2u	T-Hawk	Reconnaissance from the air, using video camera. Engine control troubled.
6/24	3u, 1F South	PackBots	Reconnaissance, using video camera and dose meter.
6/24	3u, 1F South	Quince	Installation of water depth meter on the under- ground floor. Robot was optimized to meet the situation. First trial to go stairs. The operation was failed.
7/1	3u, 1F South	Warrior	Clean-up of dust (decontamination) on floor.
7/2	3u, 1F South	PackBots	Reconnaissance, using video camera and dose meter.
7/6	3u, 1F South	Warrior PackBots	Observation of the other operation.
7/8	3u, 1F South	PackBots	Previous observation.
7/8	2u, 1-3F	Quince	Reconnaissance, using video camera and dose meter. Stairs.
7/12	3u, 1F South	PackBots	Observation of the other operation.
7/22	3u, 1F North East	PackBots	Reconnaissance, using video camera and dose meter.
7/26	3u, 1-2F	Quince	Reconnaissance, using video camera and dose meter. Stairs. Operation imcompleted because of obstructs on the stairs.
9/22	2u, 1F	Quince	Reconnaissance, using video camera and dose meter.
9/23	2u,1F	JAEA3 PackBot	Reconnaissance, using gamma ray imaging device.
9/23	3u, 1F	PackBots	Reconnaissance, using video camera and dose meter.
9/24	3u,1F	Quince	Reconnaissance, using video camera and dose meter.
10/13	1u,1F	PackBots	Reconnaissance, using video camera and dose meter.
10/20	2u, 1-5F	Quince	Reconnaissance, using video camera and dose meter.
11/2	3u,1F	Warrior PackBot	Reconnaissance and observation of obstacles.
11/3	3u,1F	Warrior PackBot	Reconnaissance and observation of obstacles.
11/14	3u, 1F North East	PackBots	Reconnaissance and Contaminated water wipe out etc.
11/17	3u, 1F North East	PackBots	Reconnaissance and Contaminated water wipe out etc.
11/18	3u, 1F North East	PackBots	Reconnaissance and Contaminated water wipe out etc.
11/19	3u, 1F North East	PackBots	Reconnaissance and Contaminated water wipe out etc.

Note: Emergency response operations were tentatively determined operations done till Dec. 16<sup>th</sup> when Prime Minister Noda declared no criticalities, cool and no major release of radioactive materials.