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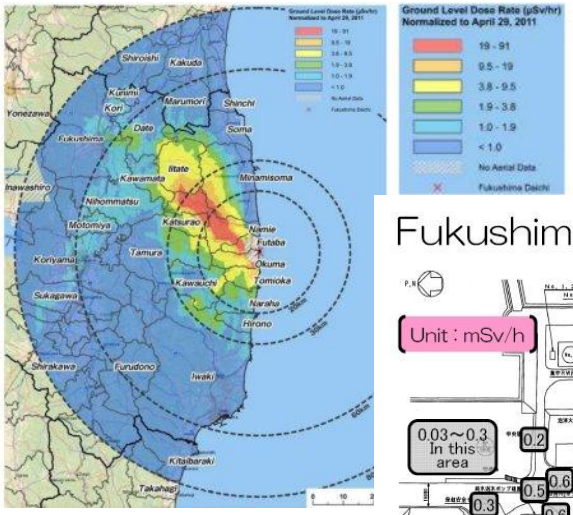
Robots That Make A Difference

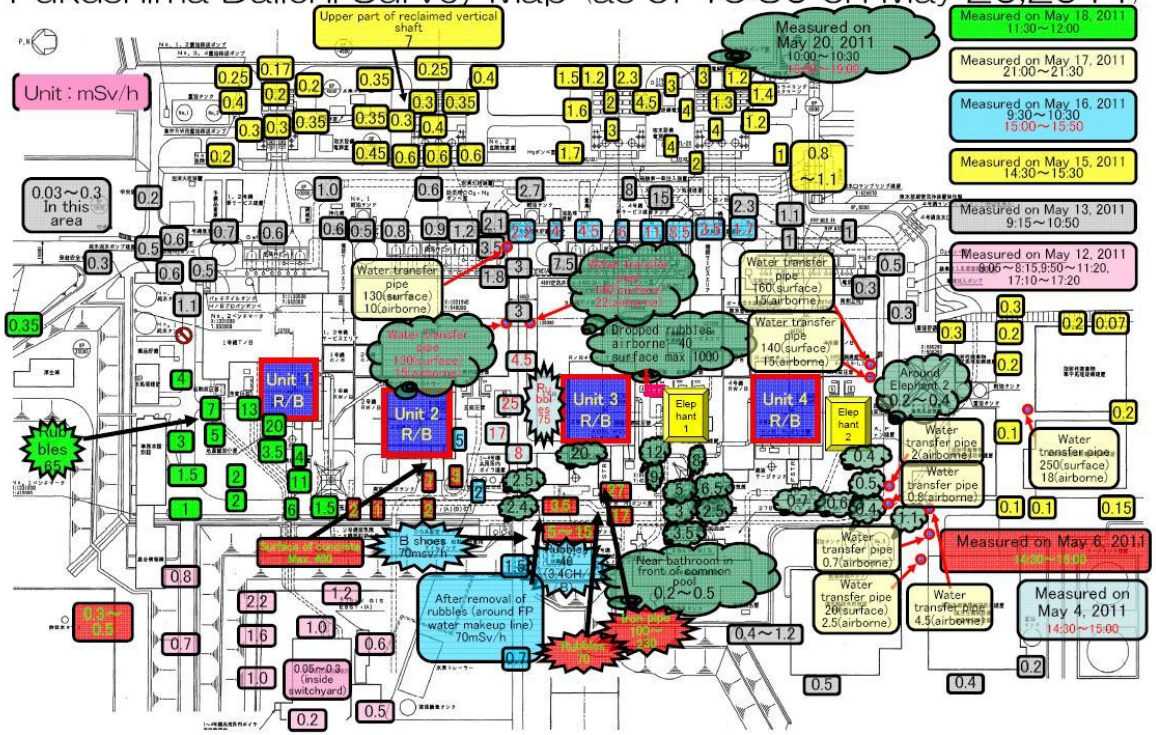
iRobot at Fukushima Accident

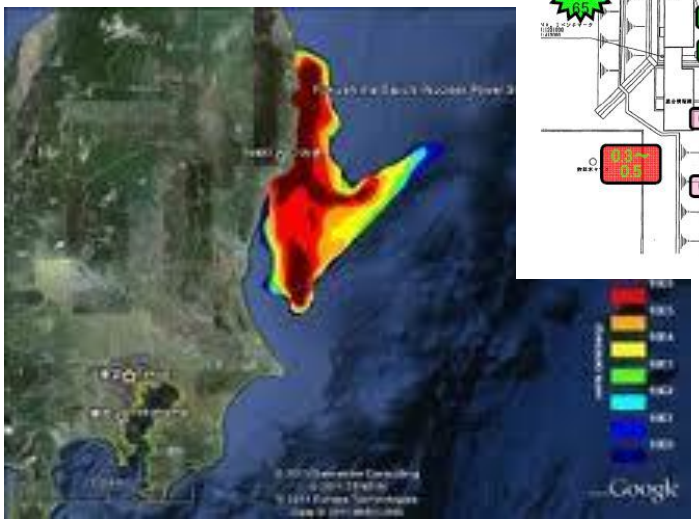
Mike B Edis iRobot Europe 2013

Marseilles Safety Ground Robotics' International Conference 2013

Fukushima – **The Problem**







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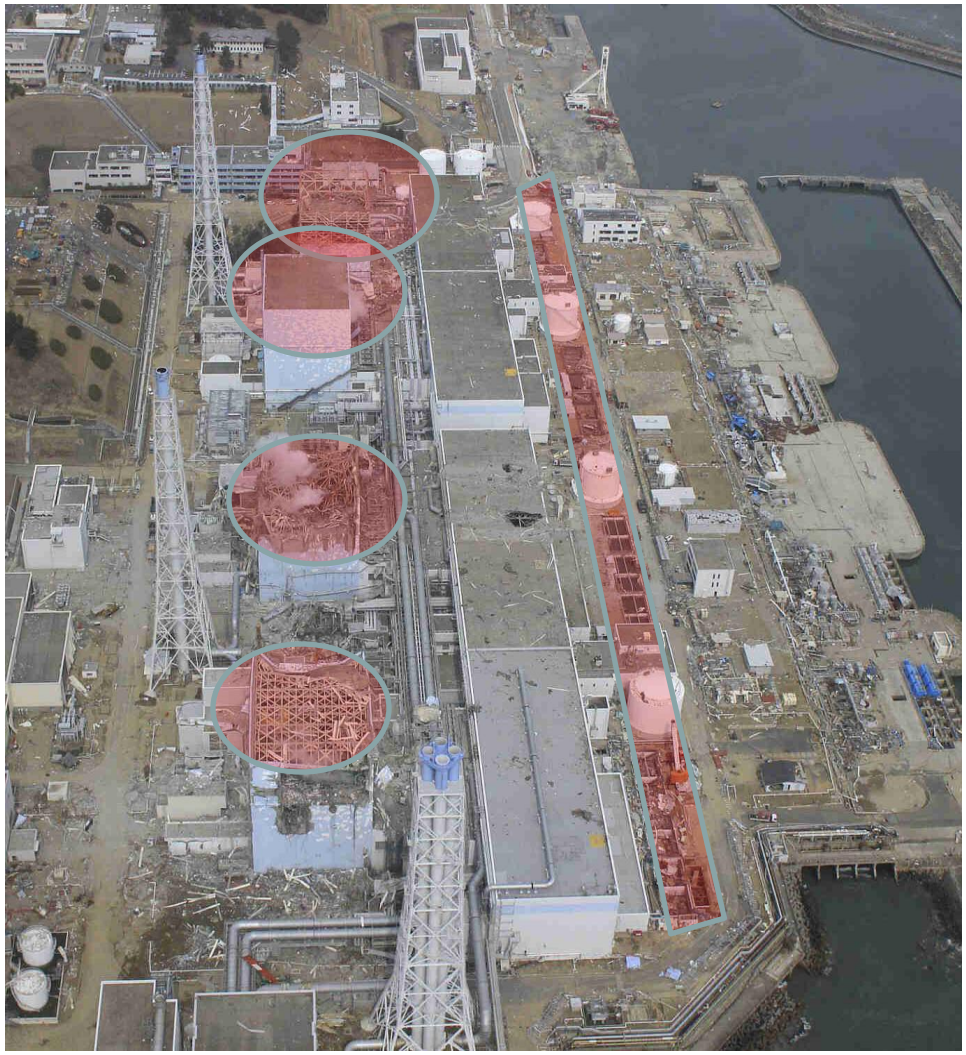
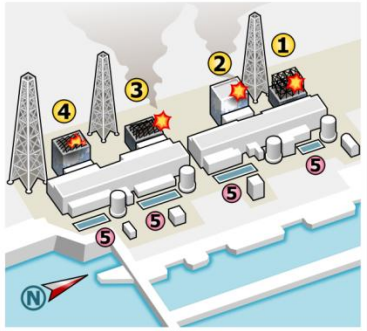
Fukushima – **Direct Impact**





Unit 1: Explosion, (12 March) roof blown off

Unit 3: Explosion, most of concrete building destroyed (14 March), Possible plutonium leak

Unit 2: Explosion (15 March), Contaminated water in underground trench, possible leak from suppression chamber

Unit 4: Fire (15 March), Water level in spent fuel pools partly restored

Multiple trenches: probable source of contaminated water, partly underground, leaked stopped (6 April)

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Fukushima – **Tsunami**

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iRobot's Response to March 11th Earthquake & Tsunami Relief

- Motivated by humanitarian outreach based on a history of iRobot providing robots when disasters occur.

iRobot's Response to March 11th Earthquake & Tsunami Relief

- 3/17/2011: Two (2) 510 PackBots and two (2) 710 Warrior systems provided – plus supporting spare parts, accessories, tools and modifications.

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710 Warrior

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510 PackBot

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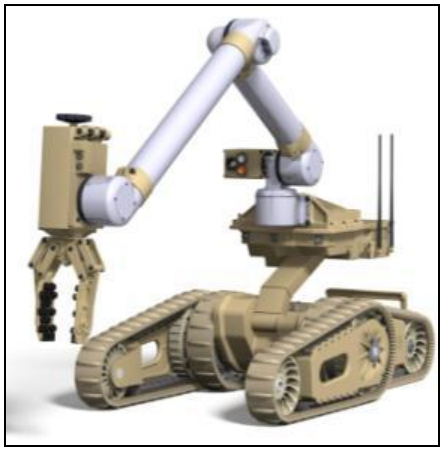
iRobot's Response to March 11th Earthquake & Tsunami Relief



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710 Warrior ®
Demonstration Video

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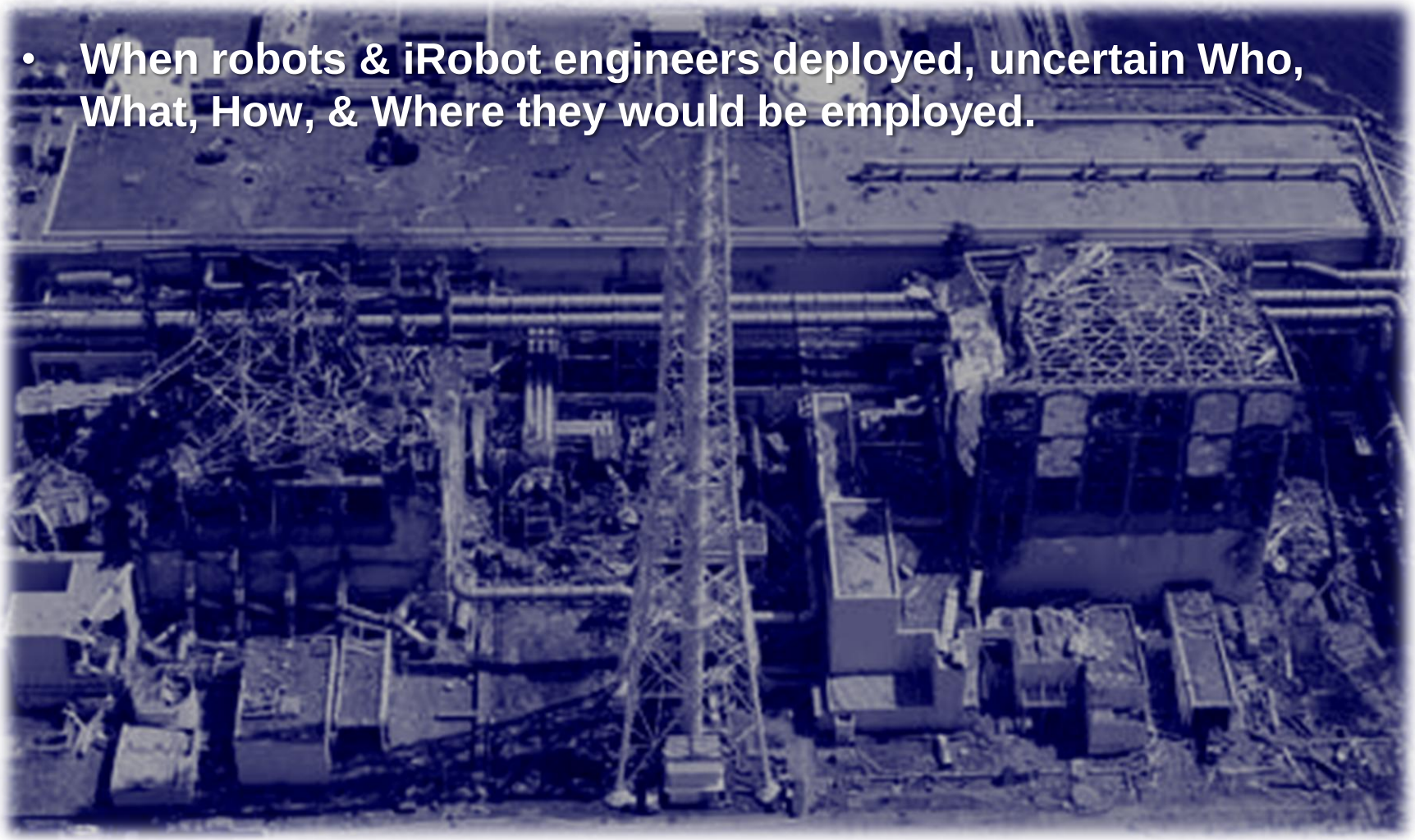
iRobot's Response to March 11th Earthquake & Tsunami Relief



- When robots & iRobot engineers deployed, uncertain Who, What, How, & Where they would be employed.

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iRobot's Response to March 11th Earthquake & Tsunami Relief

- Ultimately robots assigned to a team of TEPCO engineers.
- Training of the TEPCO team commenced on March 24th, 2011.
- Commenced with Experienced Managers – Rapidly changed to young Engineers

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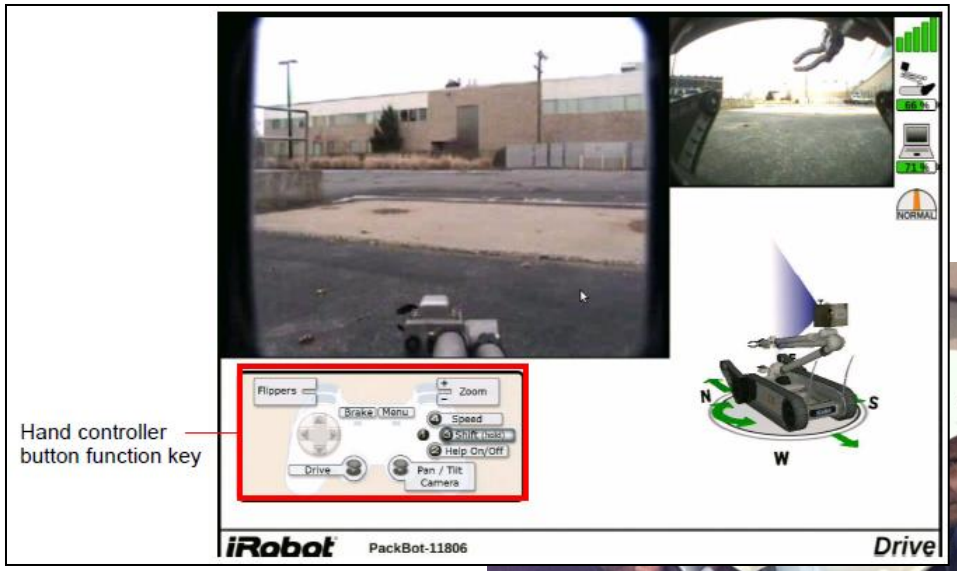
iRobot Training the TEPCO Engineers on 510 & 710

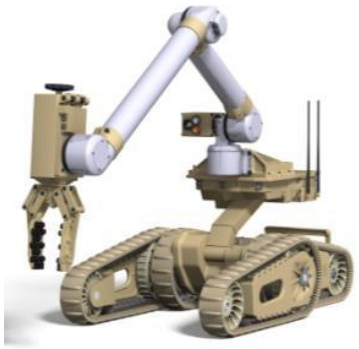
Training Challenges Encountered

- Language Barriers
- No prior robot experience
- Needed Rapid Response to Critical Situation



Key Success Drivers

- Easy to Learn Controls
  - Game-style Controller
- Menu Driven SW Features
- Common SW Across All Platforms



iRobot Training the TEPCO Engineers on 710

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iRobot Training the TEPCO Engineers on 510 & 710

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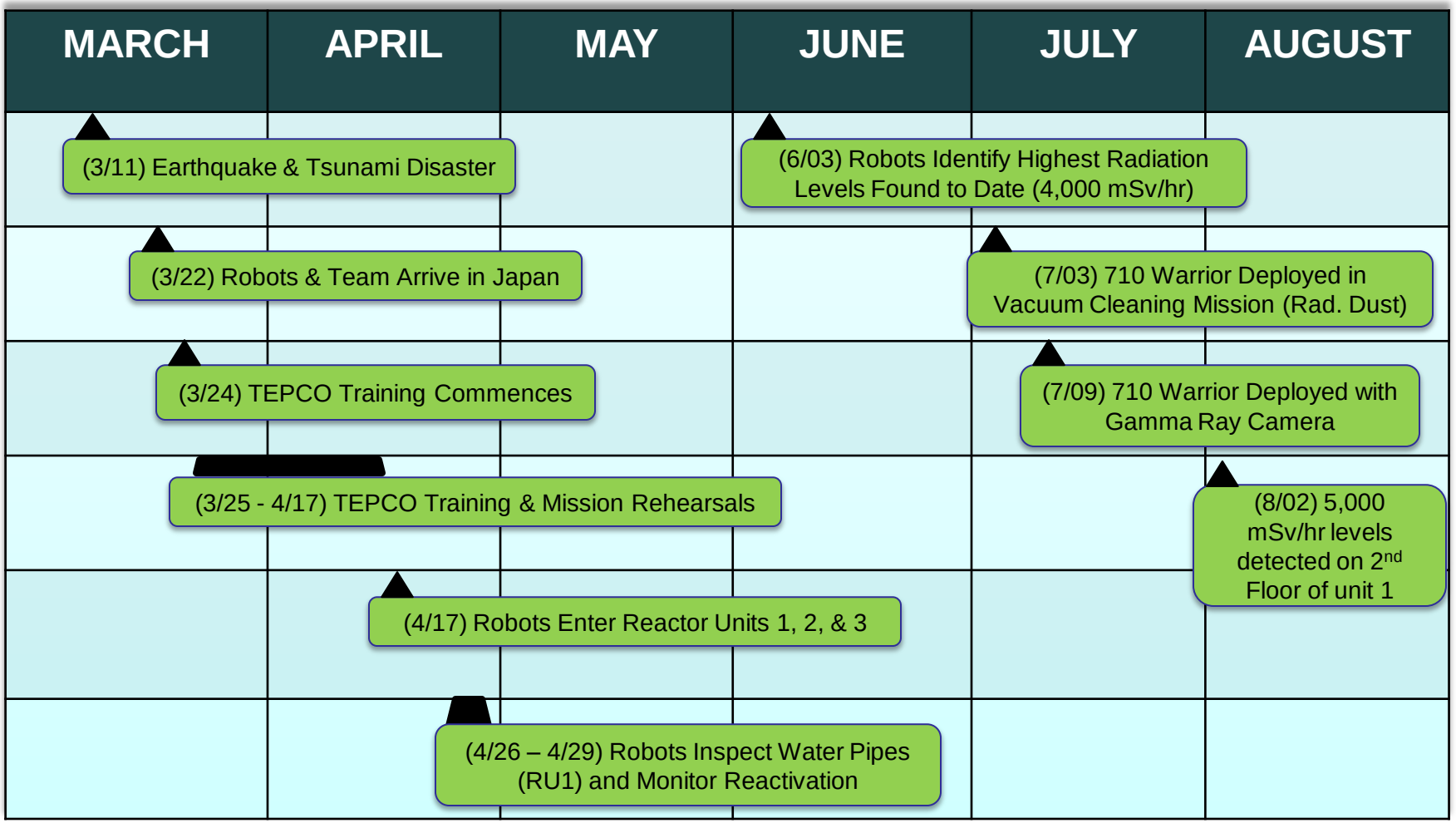
Timeline of Events - 2011

Deploying iRobot 510 PackBot & 710 Warrior systems to TEPCO



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Fukushima – **User Feedback**

“Around the No. 3 reactor, the radiation is very high, and the hydrogen explosion did a lot of damage, so the destruction is the worst.”

“There is almost no area where workers can protect themselves from the radiation, so we hunkered down in a 15-ton vehicle converted to a shielded vehicle to operate the robot.”

“In the shielded vehicle, there is a rather large generator that works with 200 V, and there is even air conditioning inside. In the vehicle, there is also a pipe system (localized air-filtering machine) that collects the radioactive substances. On top of the shielded vehicle there is an ITV (monitoring camera), set up so that we can verify surrounding conditions.”

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Fukushima – **User Feedback**

23 JUNE 2011

“The cooling vest I got now is better than the previous model.It is comfortable and the cooling packs lasts longer.”
“The previous model used two cooling packs; this one uses five.”

28 JUNE 2011

“They are planning on sealing the pressure vessel (in the dry well) of the No. 3 reactor and adding nitrogen gas (N2), but the radiation levels are high near the instrumentation rack on the floor.”
“From our previous exploration mission, we know that rubble and fine sand/dust particles are still in that area, so our mission is to collect this dust.”

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Fukushima – **User Feedback**

“The PackBot is going to pull along the Ethernet and boost the radio signal for the Warrior. “

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Fukushima – **User Feedback**

3 JULY 2011
Results From the Cleanup

“there is an element of compounded complex issues that come into play with regard to radiation and contamination, so it’s not that the radiation levels will drop drastically with this one clean-up “
However, I think it can be said that it had a certain effectiveness in that [the radiation levels] dropped an average of 10% (maximum 80 mSv/h).

“As of early July 2011, 90% of external clean-up of debris surrounding the reactor buildings has been completed
- Due to the work being near complete, the large robotic construction vehicles are no longer being used “

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Fukushima – QUINCE - **Not ready to go !**
“Tried and Failed !”

Quince is a **rescuer robot** prototype ready to respond to natural catastrophes (earthquakes, landslides, etc.) or work in buildings which have been damaged following explosions (gas, for example), terrorist or biochemical attacks.
This robot can go on practically any terrain thanks to its 4 independent tracked legs and its body which also provides traction.
Quince is 65 cm long, 48 wide and 22.5 cm tall. It weighs 26.4 kg.
The prototype has a wide-angle camera for vision, microphones and speakers, as well as sensors to move forward while evaluating the terrain. It moves at a speed of 1.6 m per second. Quince is even capable of going up and down stairs. It’s also resistant to water (watertight) and shocks (some patents are pending approval).
Developed in Japan by the Chiba Institute of Technology and fuRo, this concept is intended to be on the market as soon as it’s completely finalised

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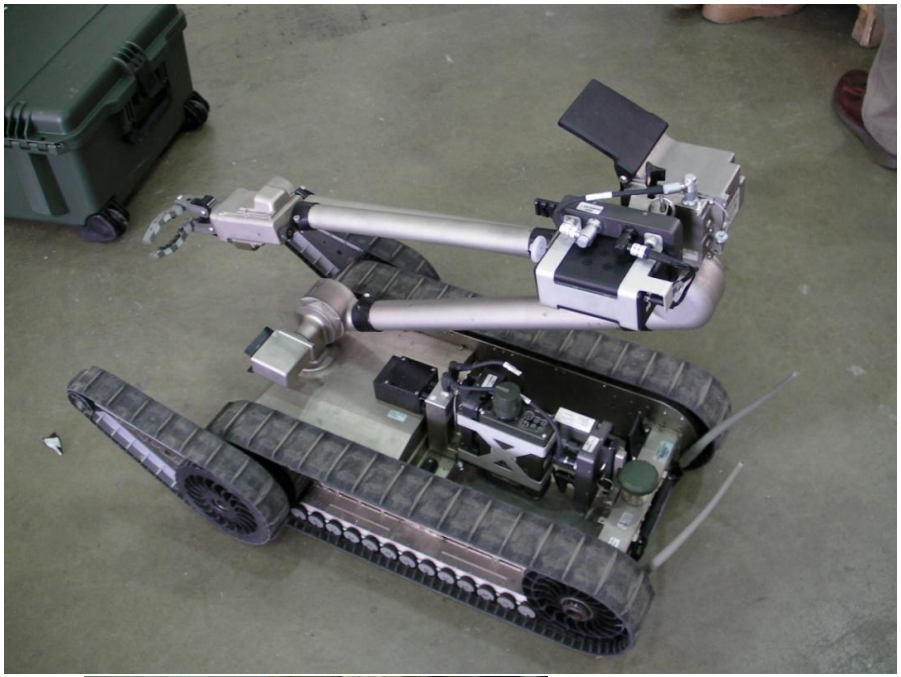
Rapid Response Requirements

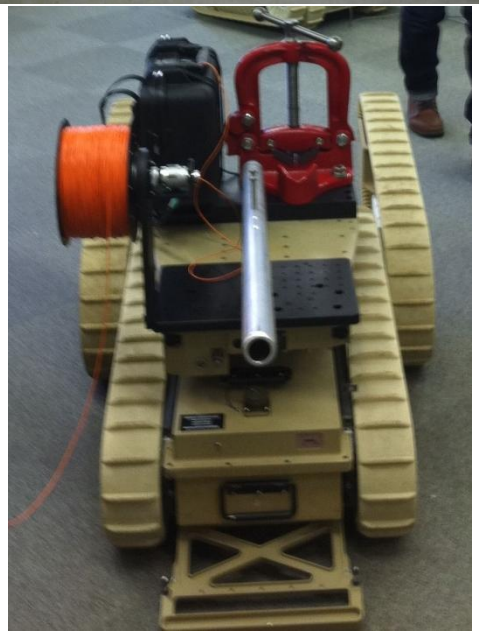
Deployment Challenges

- **No Direct Access to Disaster Site**
- **Specific Mission Objectives Unknown**
- **Radiation Impact to Robots Unknown**

Key Success Drivers

- **Multi-Mission Capability**
  - Aware 2 Common Software Architecture
  - Over 65 different Accessories, Payloads, & Tool Options
- **Flexible Communications Packages**





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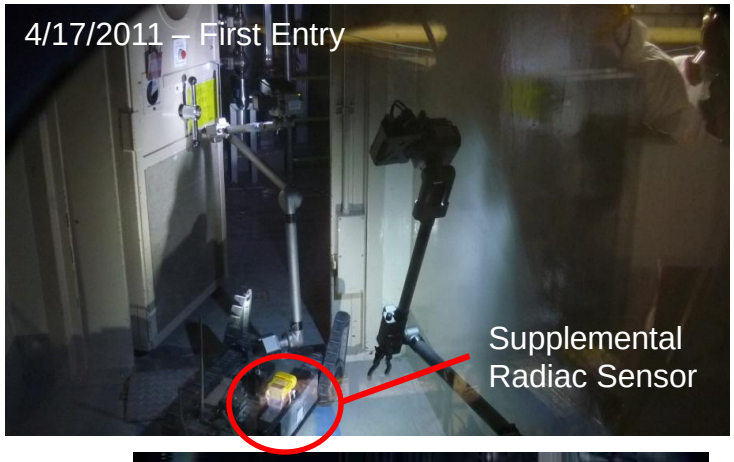
TEPCO CONOPS

TEPCO Priorities

1. **Radiation Detection / Mapping**
2. **Survey Damage / Gain SA**
3. **Debris Removal**
4. **Monitor Facility Recovery Efforts**

CONOPS Implementation

- **Extensive rehearsals prior to mission execution**
- **Missions executed on a tight timetable**
  - Missions: 2 - 3 per day, biweekly
  - Duration: ~2 hours
- **Day-to-Day objectives change frequently**



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Reactor Environment

Disaster Site Challenges

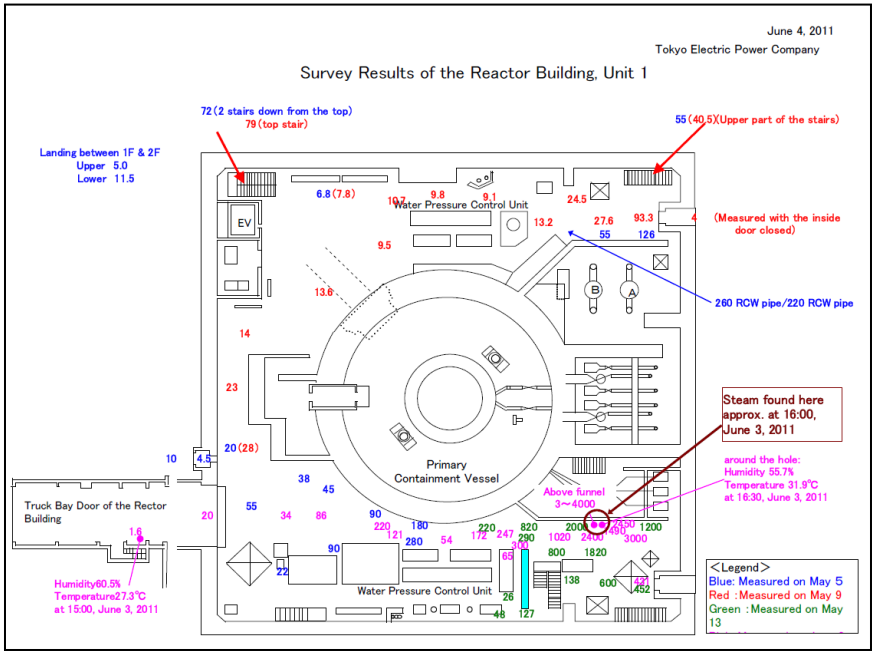
- High Levels of Radiation
- High Temperature & Humidity
- Limited Visibility in Steam
- Floor-to-Floor Access & Comms
- Compliance w/ Japan RF regulations

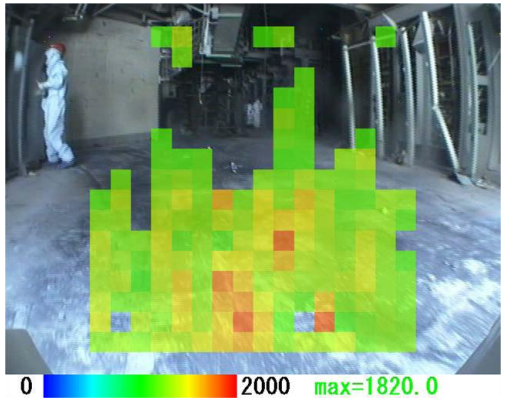
Key Success Drivers

- Robust Robot Design, Field Proven
- Multiple Sensor Capability
  - Cameras
  - Lighting
  - Radiation Detectors
- Multiple Communication Options

  (2.4GHz, 4.9GHz, & Fiber Optic Tether)

Sample Radiation Map Measured by PackBot





Gamma Ray Camera on 710 Warrior

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On-Going Support

Challenges

- Lack of formal agreements
- Limited comms at disaster site prevents contact w/ End-Users
- Export licensing requirements
- Providing service for contaminated robots

Key Success Drivers

- Follow-on training
- Daily Tele-con w/ Japan
- OEM Reach-back for Technical and Logistics Support
- Available spares at or near disaster site
- Established business relationship

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Critical Requirements for Disaster Robots

1. **Flexible Robot – Multi-Mission, Plug & Play compatibility allows the robot to be quickly reconfigured at disaster location to meet mission objectives**
2. **Open Software Architecture – Allows for continuous enhancements and facilitates new payload development**
3. **Operator Friendly – Menu driven, Play Station hand controllers. Easy and intuitive to learn, Supported by a common software across all robot platforms**
4. **Logistics and operation support – Spare Parts, Maintenance, and Field Services ready to be deployed**
5. **Open Institutional Architecture – Knowledge base global reach, Local application payload development**
6. **Field Proven – 4,000 Robots delivered, continual feedback from operation in hostile environments & disaster area usage drives quality and robustness**
7. **Human Protection – Keeping human work force out of harm's way**
   - Robust & Reliable Radio Communications
   - Rechargeable Power Source
   - Remote Surveillance for best situational awareness
   - Worker/Soldier On-site Load Reduction (Reduce human presence of transporting materials, removing debris, and overall exposure time)
8. **Preparedness for Terrorism & Outside Threats – similar incident situation**

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Conclusions

1. Flexible, robust robot that is reconfigurable quickly at the disaster site critical.
2. Ease of use and common software architecture across all platforms is key to efficiently training new operators.
3. Communications challenges, demand robot platforms that offer a variety of communications options.
4. Mature robotic technology based on years of development and use in hostile environments guarantees a higher level of success.
5. Rapid establishment of business relationships critical to supporting on-going technical and logistics needs.
6. When disaster strikes, you go with what you have, not what you wish you had.

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Robots That Make A Difference

“SAVE A LIFE, SEND A ROBOT”

ありがとうございました


HazMat Summary
RAD
RAE
Powered off
ICO
Powered off
RNV
2011.04.17 PM04:52


2011.04.18 PM01:54


2011.04.18 PM01:55
Head Camera Options
Infrared Mode

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