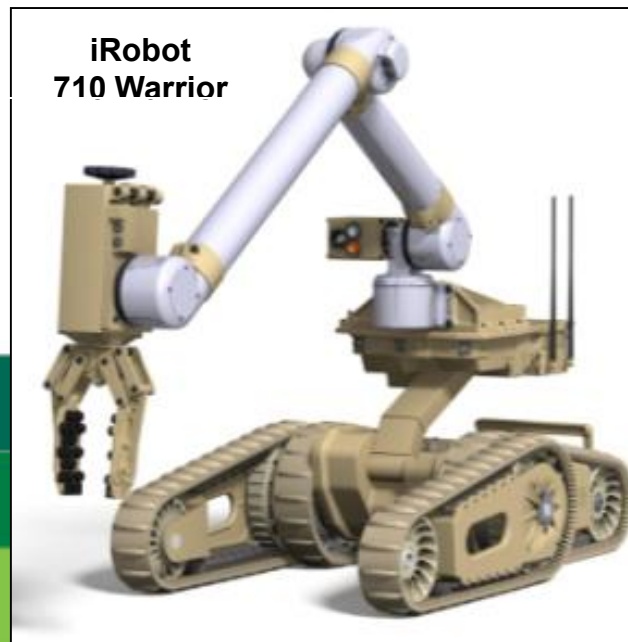


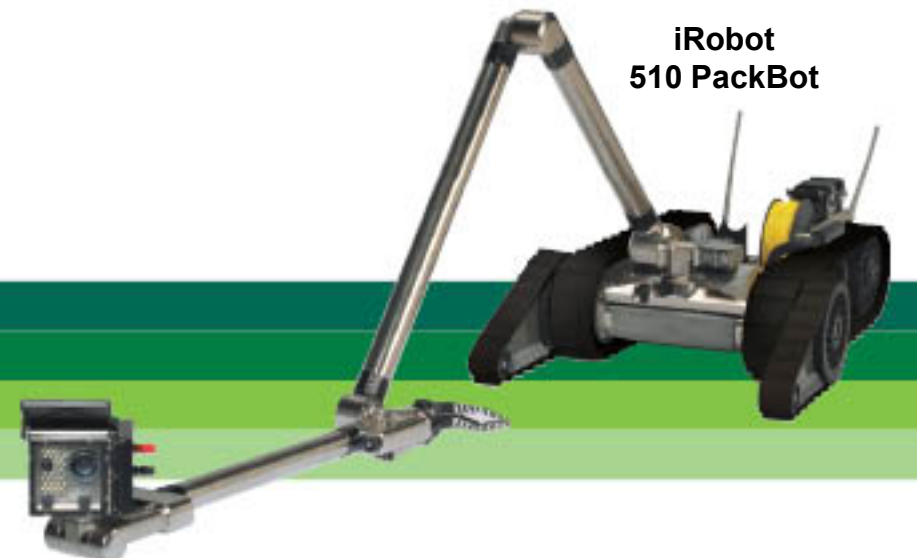
iRobot®

Robots That Make A Difference

Japan Institute of International Affairs Symposium – Tokyo, Japan



July 12, 2011



iRobot Corporation Overview

- **2010 Revenue \$390M***
- **Approximately 750 Employees**
- **Founded in 1990 by three MIT Roboticists**
 - Colin Angle, (Current CEO)
 - Helen Greiner
 - Rodney Brooks
- **Global Distribution & Customer Service**



Bedford Headquarters



Raleigh-Durham



San Luis Obispo



India



Hong Kong

iRobot®

* Guidance provided 7/24/08

Two Vertical Markets

**Home Robots Division:
6 Million Home Robots
Sold**

“Best thing I have ever bought. Works great and saves me a lot of time.”

“Love it—I have it working every day. Now my dark carpet always looks clean.”



**Government & Industrial
Division:
4,000 PackBot Robots
Delivered**

“You have saved lives today!”

“When a robot dies you don’t have to write a letter to its mother.”



➤ **Robots that tackle dull, dirty & dangerous tasks**

iRobot®

G&I Division Products



110
FirstLook™



310
SUGV



320
SUGV



510
FasTac™



510
PackBot®



710
Warrior®

Ground Robots (UGV)

Maritime Robots (UUV)



1KA Seaglider™



15A Ranger





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

- iRobot's response to March 11th, 2011 disaster motivated by humanitarian outreach to the people of Japan.
- iRobot has a history of providing robots when disasters occur
- Provided two (2) 510 PackBots and two (2) 710 Warrior systems with supporting spare parts, accessories, and tools on March 17th, 2011.
- When robots & iRobot engineers were deployed, there was uncertainty as to Who?, How?, & Where? the robots would be used.
- Robots were assigned to a team of TEPCO engineers.
- Training of the TEPCO team commenced on March 24th, 2011.

iRobot Humanitarian Missions

Ground Zero, Sept. 11, 2001 - NYC



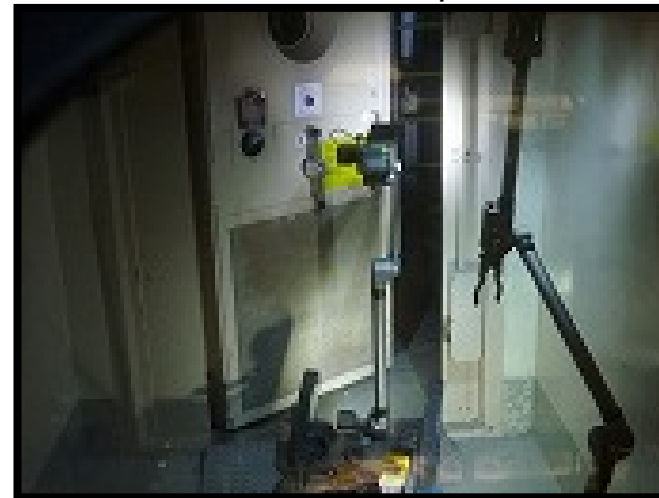
Law Enforcement (Bomb Threat) - 2009



Gulf of Mexico Oil Spill - 2010



Fukushima Daiichi, Japan - 2011



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iRobot 510 PackBot Multi-Mission Robot

• Highly Robust

- Man-portable robot weight 29.5 kg [65 lbs]
- All weather operation
- QuickFlip™ flippers used to get over obstacles
- Rugged, shock resistant chassis
- Lifts up to 13.6 kg [30 lbs.]

• Mobile and Agile

- Speeds of up to 9.3 km/h [5.8 mph]
- Maneuver all types of terrain – rocks, mud, snow, gravel, sand
- Climbs stairs in most commercial, industrial, and residential buildings

• Modular

- Multi-Mission capability handles a wide range of missions such as explosive ordnance disposal, reconnaissance & search-and-rescue
- Eight (8) separate ports facilitate the addition of:
 - Variety of Manipulator Arms
 - Multiple cameras (Daylight Zoom & Wide Angle, IR, Thermal)
 - Sensors (ex. Radiation detection, HazMat, Explosive),
 - Fiber-optic spooler
 - Variety of wireless communications packages
 - Power payloads (extended operating time up to 8 hrs)



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510 PackBot Equipped with HazMat System

MultiRae Sensor (Multi-RAE Plus)

Detects

- Any 2 of 3 specific toxic chemicals at 1 time:
 - Ammonia (NH₃)
 - Carbon Monoxide (CO)
 - Chlorine (Cl₂)
- Oxygen (O₂) levels
- Volatile Organic Compounds (VOCs):
- Combustible gases

DAPPA Sensor (Dual Accessory Port Adapter)

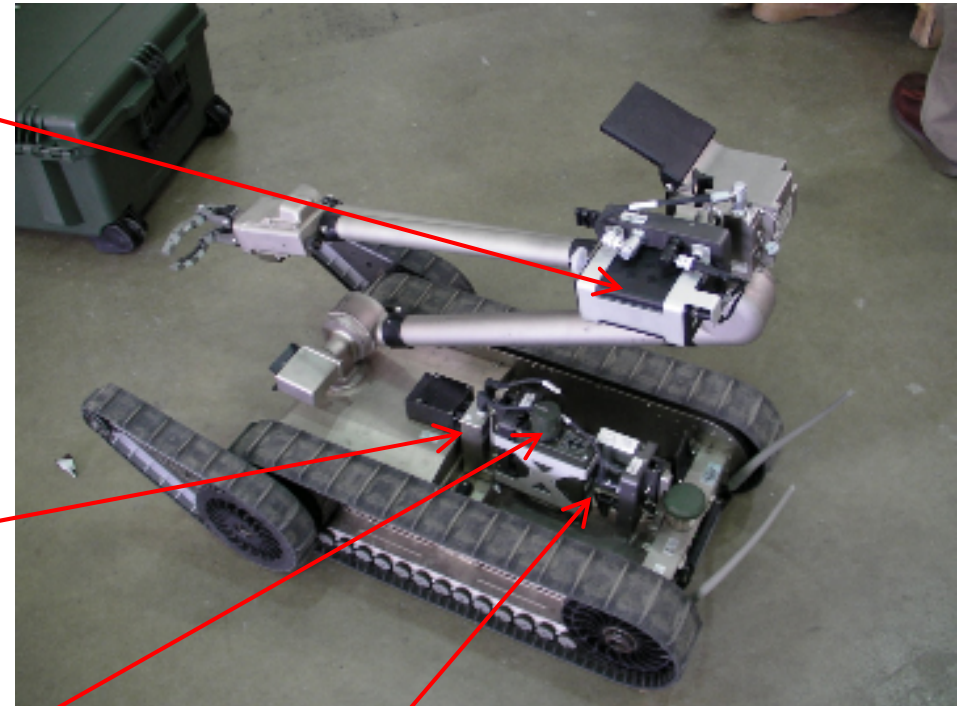
Measures

- Temperature
- Humidity

LCD Sensor (LCD 3.2E)

Detects

- Detects Chemical Warfare Agents (CWAs) in the surrounding environment. G and H agent levels are detected and displayed:
 - G levels represent the detection of a nerve agent
 - H levels represent the detection of blood, blister, or choking agents



Radiac Sensor (AN/UDR-54)

Detects

- Detects background level gamma radiation and neutron/gamma dose accumulation, and displays the data in Gray (Gy), CentiGray (cGy) or MicroGray (μGy).

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iRobot 710 Warrior

- **Powerful and Rugged Multi-Mission Robot**

- Weighs approximately 136 Kg
- Carries heavy payloads of up to 68 Kg
- Lifts up to 91 Kg
- Speeds of up to 13 Km/hr

- **Features**

- Extreme mobility in aggressive terrain and urban environments
- Performs explosive ordnance disposal, reconnaissance and search-and-rescue
- Expandable to accommodate a wide range of payloads
 - 2-Link Manipulator Arm
 - Multiple cameras (Daylight Zoom & Wide Angle, IR, Thermal)
 - Fiber-optic spooler
 - Variety of wireless communications packages
- Third-party payload integration available



Warrior in use at Fukushima Daiichi July 2, 2011





Challenges Faced

- Impossible to anticipate what was going to be required at the Fukushima site.
- Inability of iRobot personnel to have direct access to the Fukushima site.
- Training a team of eight (8) people who had no experience using robots.
- Language barriers had to be overcome.
- Other than being able to measure radiation levels no specific requirements were known prior to engaging with the TEPCO team.
- Mission objectives changed frequently depending on what is happening at the site.
- Uncertainty about how the robots would withstand high radiation environments.

Timeline of Events

Deploying iRobot 510 PackBot & 710 Warrior systems to TEPCO

- 4/17 – First pictures & video taken from (2) 510 PackBots operating in Reactor Units 1, 2, & 3. Released on 4/19.

(Source Link: <http://www.tepco.co.jp/en/news/110311/index-e.html>)



(3) Pictures from Reactor Unit 3

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Timeline of Events

Deploying iRobot 510 PackBot & 710 Warrior systems to TEPCO

- **4/17 – First pictures & video taken from (2) 510 PackBots operating in Reactor Units 1, 2, & 3. Released on 4/19.**

(Source Link: <http://www.tepco.co.jp/en/news/110311/index-e.html>)



Picture from 1st Floor Reactor Unit 1



Picture from 1st Floor Reactor Unit 2



Picture from 1st Floor Reactor Unit 3

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PackBot at Fukushima Daiichi Nuclear Power Plant

Pictures taken by TEPCO (Tokyo Electric Power Corporation) and used with their permission



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Timeline of Events

Deploying iRobot 510 PackBot & 710 Warrior systems to TEPCO

- **4/26 – Site observation of inspecting water system & pipes performed by (2) 510 PackBots on Reactor Unit 1. Pictures posted on 4/27, video posted on 4/29.**

(Source Link: <http://www.tepco.co.jp/en/news/110311/index-e.html>)



Nearby the entrance of SHC pump room



Observation of the pressure gauge of the primary containment vessel



Check of the leakage from the electrical penetration



Check of the leakage from the equipment hatch

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June 5, 2011 PackBot used in Reactor #1 to measure 4,000 msv/hr radiation levels.

Lethal four-sievert reading taken by robot; suppression chamber suspect Radiation in No. 1 reactor building at highest level yet

The Japan Times
KYODO, AP Sunday, June 5 2011

Tokyo Electric Power Co. said Saturday it has detected radiation of up to 4,000 millisieverts per hour in the building housing the No. 1 reactor at the Fukushima No. 1 nuclear plant.

The radiation reading, which was taken when Tepco sent a robot into the No. 1 reactor building on Friday, is believed to be the highest detected in the air at the plant so far.

On Friday, Tepco found steam spewing from the basement into the building's first floor. Nationally televised news Saturday showed blurry video of a steady stream of smoky gas curling up from an opening where a pipe rises through the floor.

The radiation is so high now that any worker exposed to it would absorb the maximum

permissible dose of 250 millisieverts in only about four minutes. Tepco said there is no plan to place workers in that area of the plant and said it will carefully monitor any developments.

The utility said it took the reading near the floor at the southeast corner of the building. The steam appears to be entering from a leaking rubber gasket that is supposed to seal the area where the pipe comes up through the first floor. No damage to the pipe was found, Tepco said.

The reactor's suppression chamber is under the building, and highly radioactive water generated from cooling the reactor is believed to have accumulated there, Tepco said, adding that the steam is probably coming from there.

Meanwhile, tanks for storing radioactive water were on their way Saturday to the plant.

Tepco has said radioactive water could start overflowing from temporary storage areas on June 20, or possibly sooner if there is heavy rainfall.

Two of the 370 tanks were due to arrive Saturday from a manufacturer in nearby Tochigi Prefecture, Tepco said. Two hundred of them can store 100 tons, and 170 can store 120 tons.

The tanks will continue arriving through August and will store a total of 40,000 tons of radioactive water, according to Tepco.

Workers have been fighting to get the plant under control since the March 11 tsunami knocked out power, destroyed backup generators and halted the crucial cooling systems for the reactors, causing the world's worst nuclear disaster since Chernobyl in 1986. Several explosions have scattered radioactive debris around the plant, and reactors are spewing radiation into the air and leaking it into the sea.

On Friday, nine workers who entered the building to attach a pressure gauge to the pressure vessel of reactor No. 1 were exposed to around 4 millisieverts of radiation, according to Tepco.

The fuel rods are believed to have melted almost completely and sunk to the bottom of the containment vessels of reactors 1, 2 and 3.

A complete meltdown would have seen the fuel melt entirely through the containment vessels and into the reactor floor.



Where there's smoke: A video image from the Fukushima No. 1 power plant shows steam rising from an opening in the floor of the No. 1 reactor building Friday. TEPCO/AP

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PackBot measuring 4,000 msv steam escaping in reactor #1.

June 3, 2011



iRobot



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**

Conclusions

1. No single robot is perfect for every situation. A variety of sizes and types of robots are required when a disaster occurs
2. Well trained operators are essential to using robots successfully in disaster areas.
3. Robots that offer a variety of communications methods (multiple frequency radios, COFDM, Ethernet Tethers, Mesh Networks and Fiber Optics) will keep the operators safe.
4. Adequate supply of spare parts, accessories and spare robots are required for successful responses when disasters occur.
5. Mature robotic technology based on years of development and use in hostile environments guarantees a higher level of success.
6. The ability to respond rapidly with robots specifically designed for disaster relief is a key factor in the success of the mission



“SAVE A LIFE, SEND A ROBOT”

ありがとうございました

