



# Use of Robotics and Remote Monitoring Equipment for Reducing Dose and Risk Associated with Radiological Work at Ontario Power Generation

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**ONTARIO** **POWER**  
GENERATION



# Ontario Power Generation

- 10 Operating Nuclear Stations at 2 sites
- 2 Shut Down Nuclear Stations in Safe Storage
- 2 Dry Fuel Storage Sites
- 1 Nuclear Waste Facility
- 66 Hydroelectric Stations
- 3 Thermal Generating Stations
- 2 Wind Power Turbines
- Generating Capacity >16,000 MW





# OPG Nuclear

- Pickering Nuclear Generating Station
- Darlington Nuclear Generating Station
- Health Physics Laboratories
- Western Waste Management Facility



- Darlington Refurbishment
- Pickering Extension of Commercial Operations
- Deep Geological Repository



# High Activity Debris Identification

- Radiation

Technician discovers gamma radiation field of 500 mrem/h in an area that is typically 2 mrem/h.

- ALARA later discovers that a worker doing a leak search under the boilers had a peak dose rate of 4,900 mrem/h on their EPD.





# High Activity Debris Identification

- A high hazard work plan was written to identify the source of the high radiation dose rates.
- Armed with a 14' Automess extension gamma meter the technicians looked for the source in the 80' by 20' maze of pipe work under the boilers.



• Surveys identified that the source of the unusually high dose rate was the Boiler 6 cold leg drain line.



# High Activity Debris in Boiler Cold Leg Drain Lines

- High activity debris (~35 Ci of Co-60) in the Boiler 6 Cold Leg Drain Line of Unit 4.
  - 500 rem/h working distance
  - 3.5 rem/h at 10'
  - 500 mrem/h at 20'
- Drain line located in very congested area





# Path Forward?

How do we retrieve the High Activity Debris?

How do we control the area around the Source?

Where exactly are the High Activity Debris?

Will the Source Move During Reactor Operation?

When will we be Ready to Execute Recovery Plan?

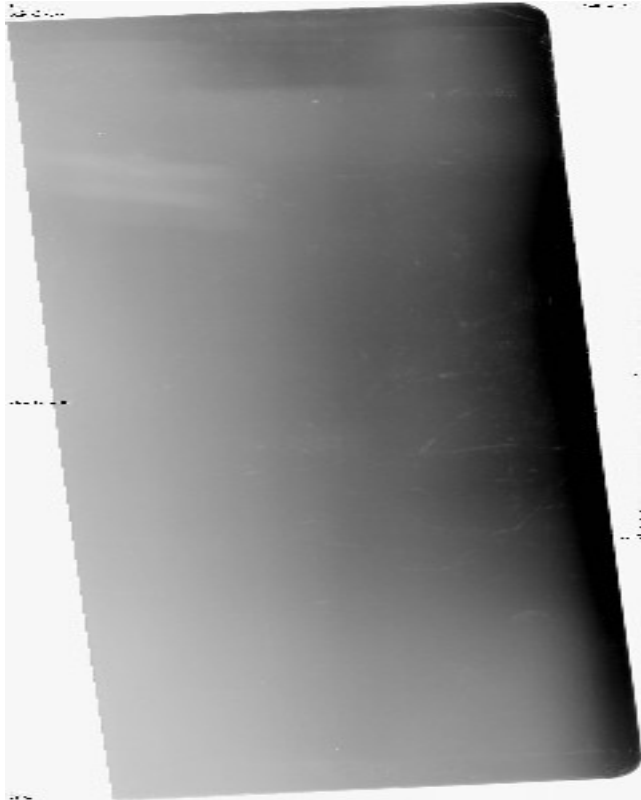
How will we make sure the robots work?

What are we going to do with it when it is Captured?

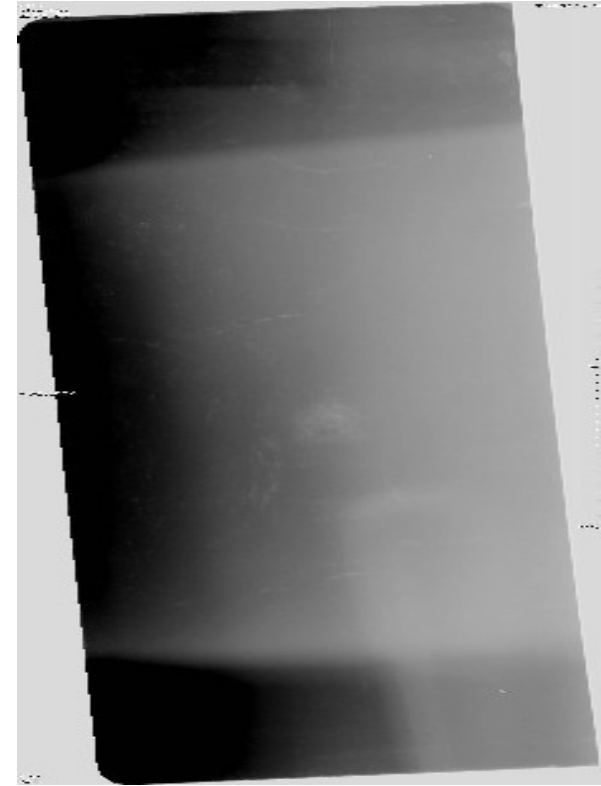
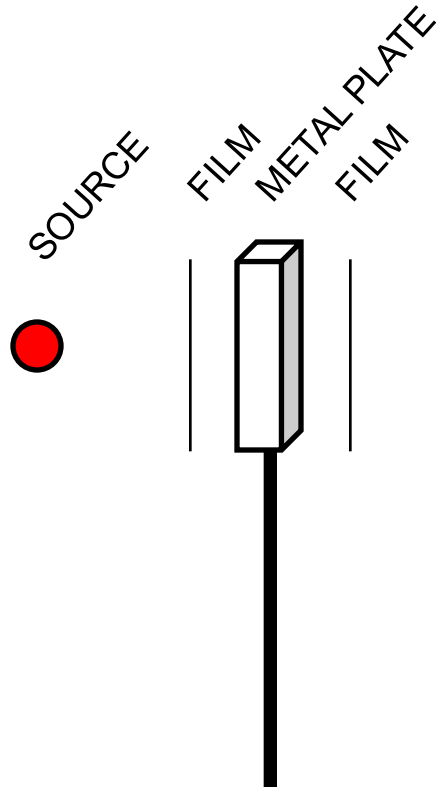


# High Activity Debris Location

The best indication of the location of the source, prior to execution, came from using radiography film.



COLD LEG



BOILER BOWL

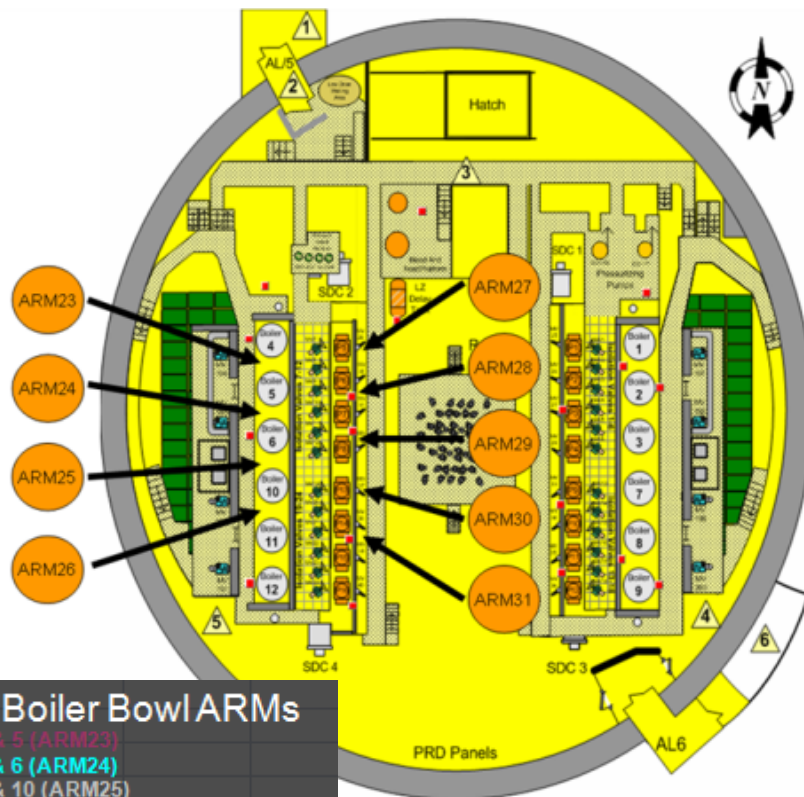
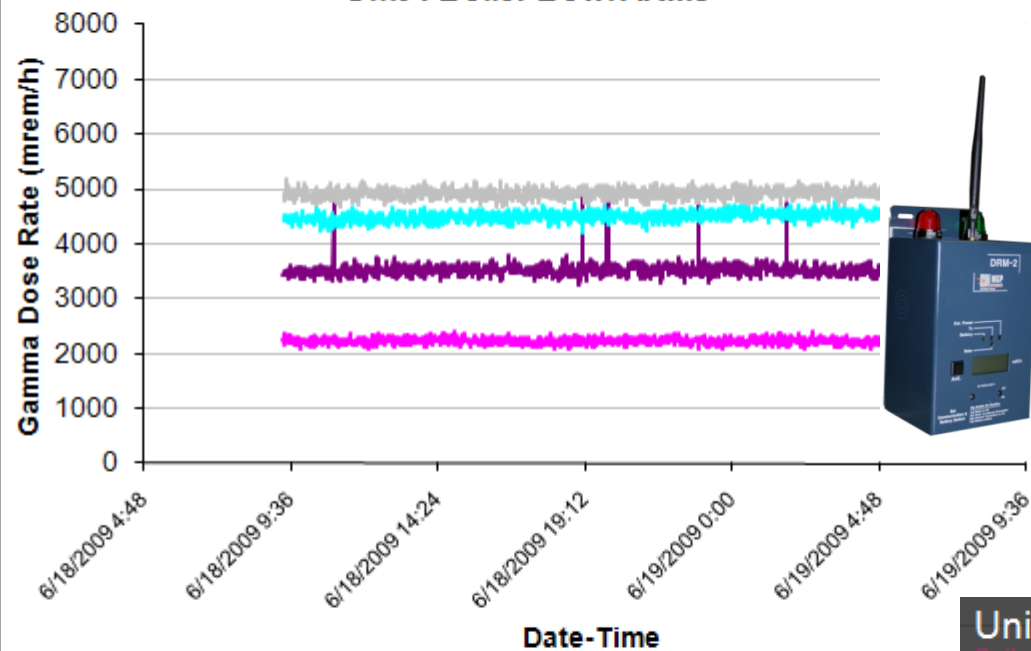




# High Activity Debris in Boiler Cold Leg Drain Lines (Cont.)

- Real-time monitoring during Unit operation (DRM-2)

Unit 4 Boiler Bowl ARMs



## Unit 4 Boiler Bowl ARMs

- Boilers 4 & 5 (ARM23)
- Boilers 5 & 6 (ARM24)
- Boilers 6 & 10 (ARM25)
- Boilers 10 & 11 (ARM26)

## Unit 4 PHT Pit ARMs

- PHT Pit MV29 (ARM27)
- PHT Pit MV30 (ARM28)
- PHT Pit MV31 (ARM29)
- PHT Pit MV32 (ARM30)
- PHT Pit MV37 (ARM31)



# High Activity Debris in Boiler Cold Leg Drain Lines (Cont.)

- Gamma Camera Robot



WALL-E



06.27.08  
Disney PIXAR

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# High Activity Debris in Boiler Cold Leg Drain Lines (Cont.)

- Insulation Removal Robot



MATER

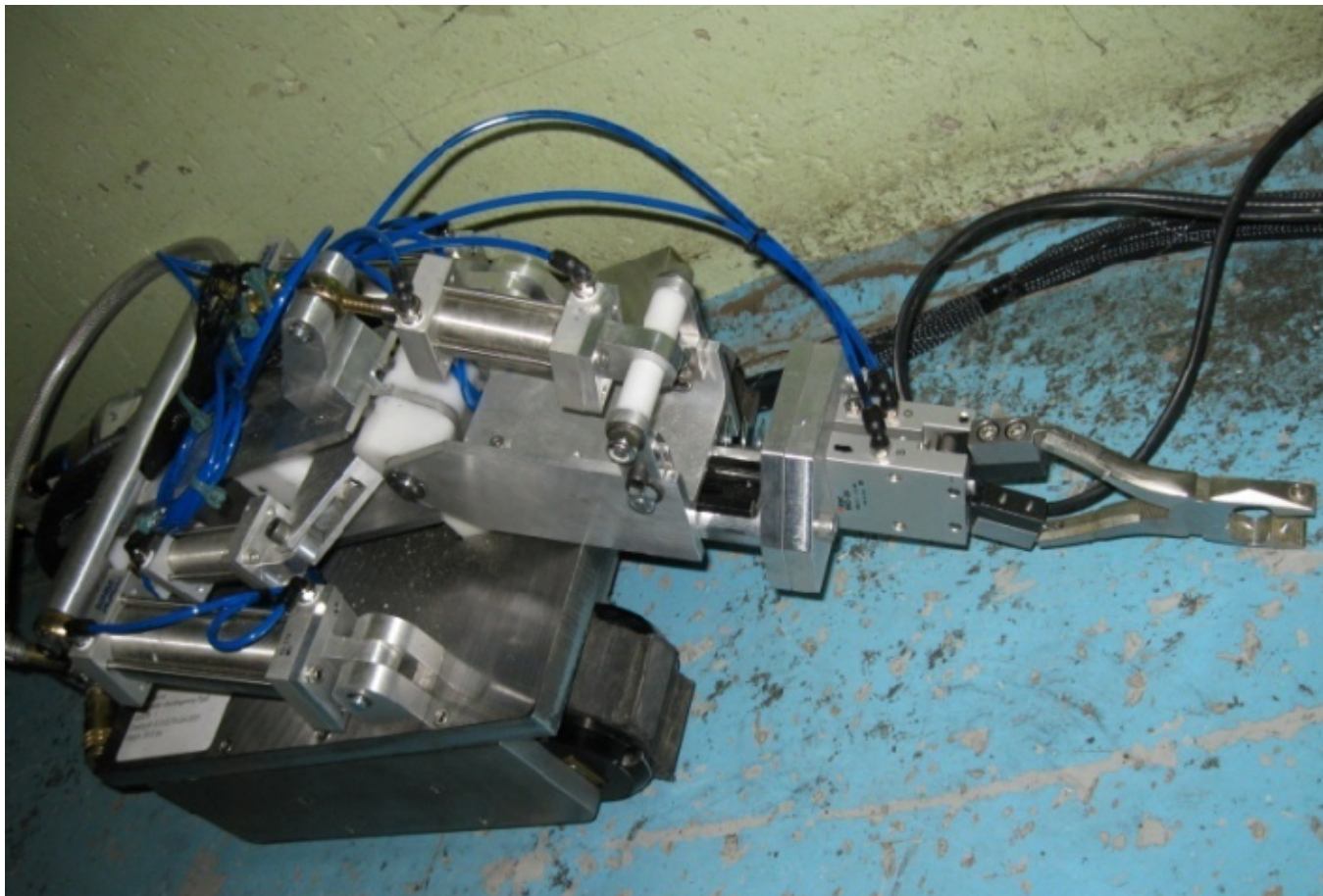


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# High Activity Debris in Boiler Cold Leg Drain Lines (Cont.)

- Contingency Robot



OPTIMUS  
PRIME

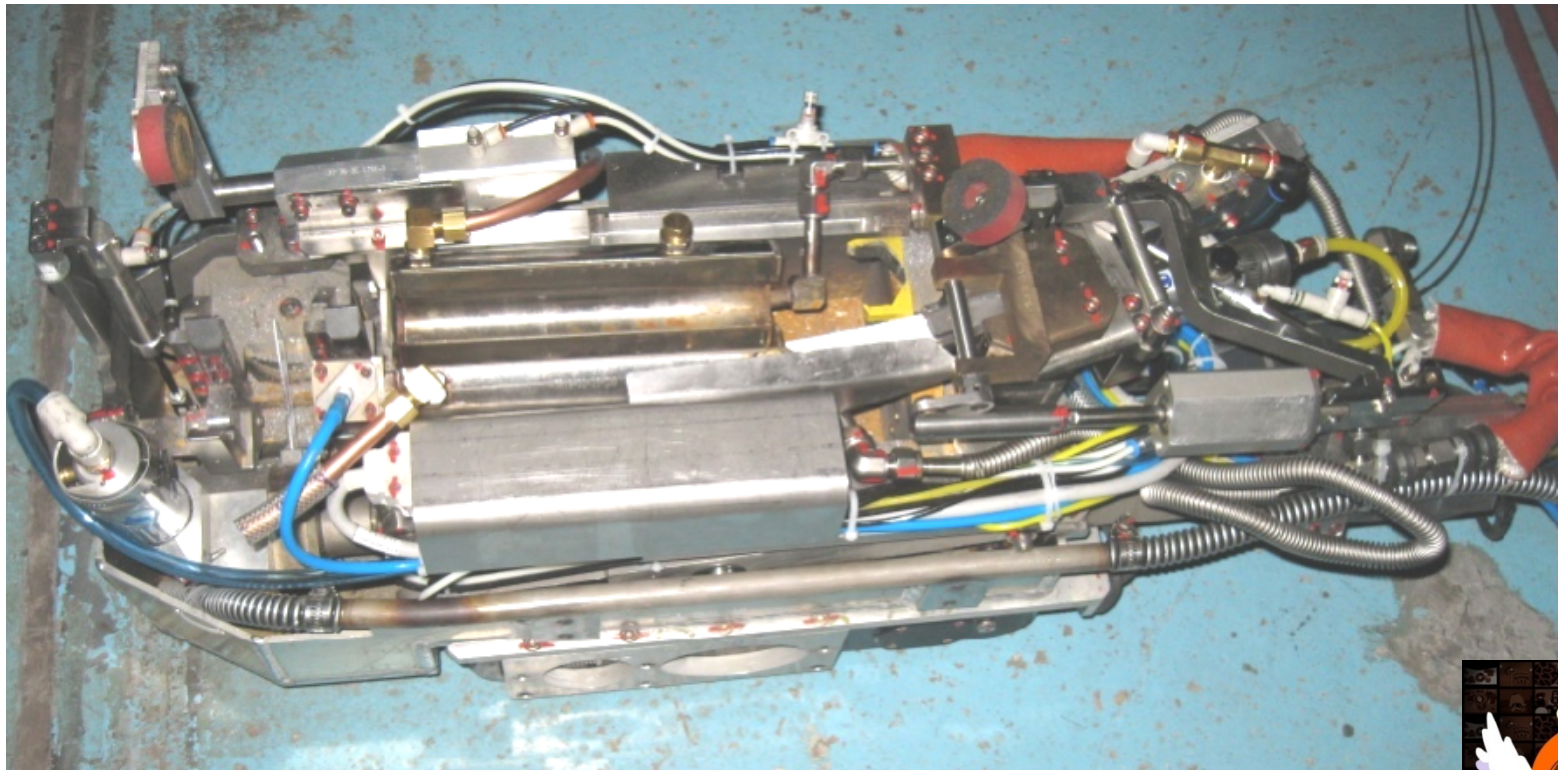


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# High Activity Debris in Boiler Cold Leg Drain Lines (Cont.)

- Freeze-Cut Robot



KENNY



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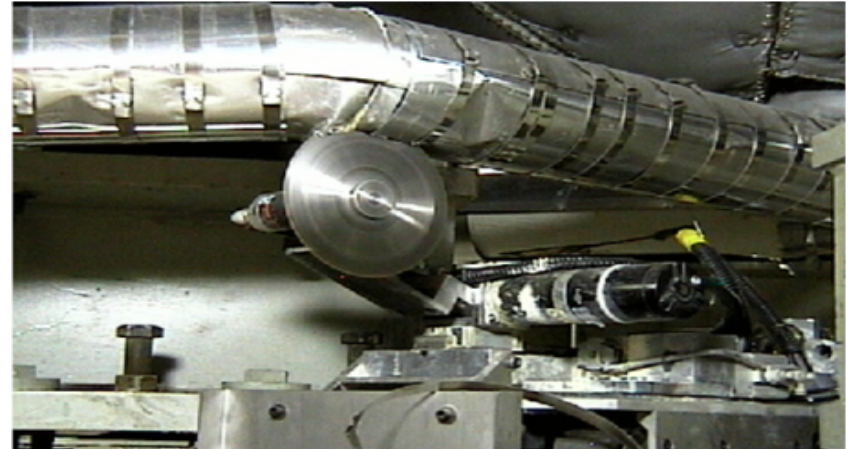
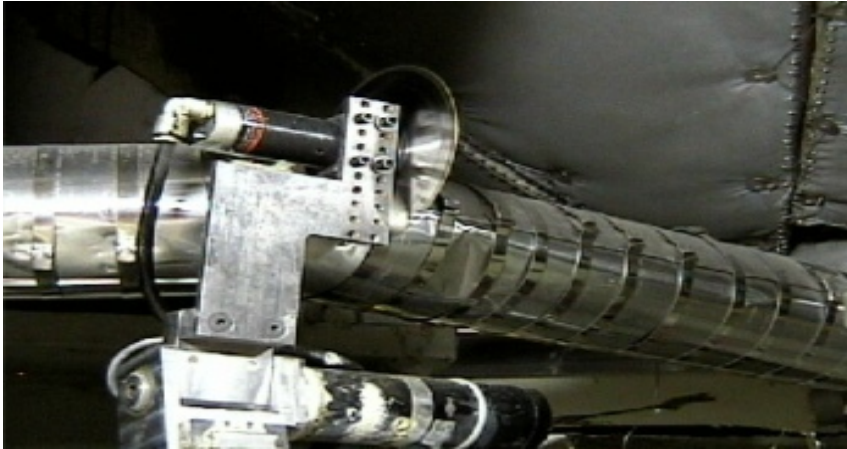
# Mock-Up

- Performing a Mock-Up is part of the High Hazard Radiological Work Process
- Unit 2 is in a Safe State and was the best “playground” to practice executing the work plan
- Confirmed that work plan could be executed
- Coordinated location of staff with respect to high activity debris
- Optimized camera locations and views
- Tested Communications
- Convince the senior management team and our regulator that the robotic retrieval method was the best path forward



# High Activity Debris in Boiler Cold Leg Drain Lines (Cont.)

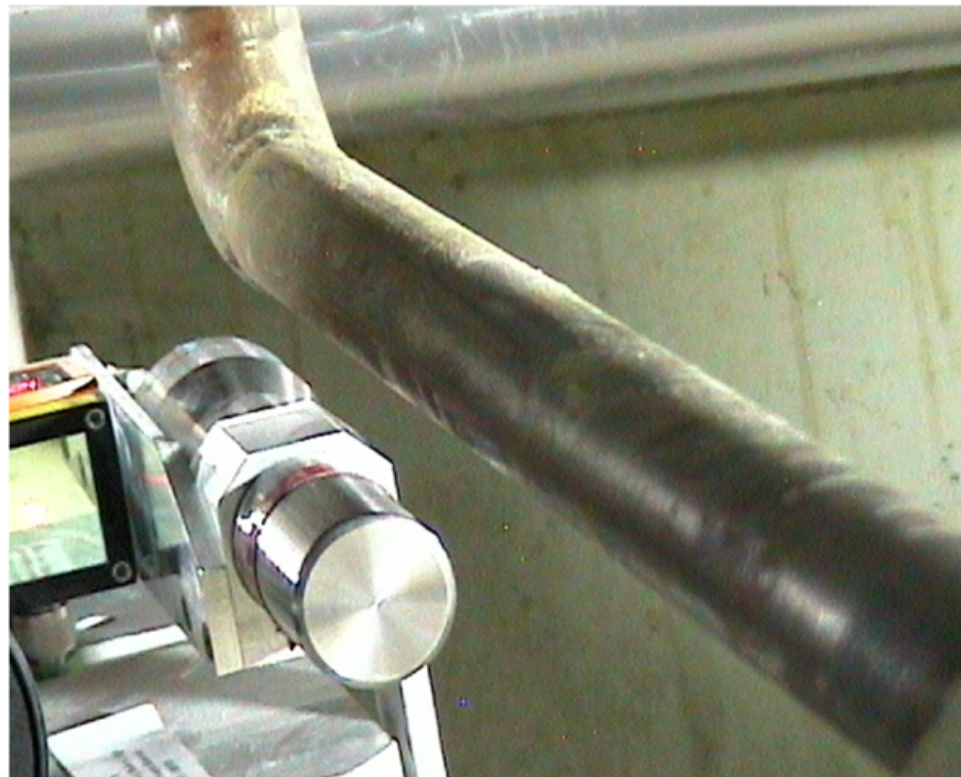
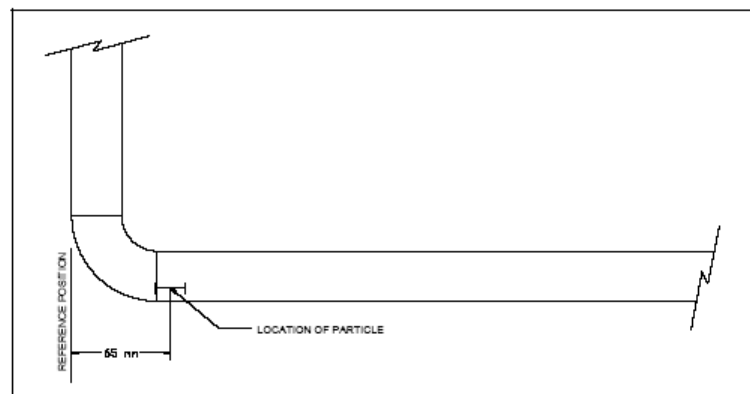
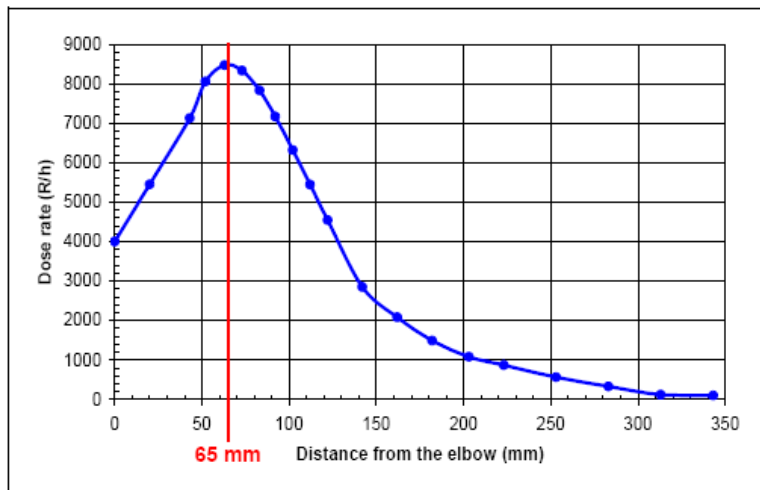
- Insulation Removal





# High Activity Debris in Boiler Cold Leg Drain Lines (Cont.)

## ■ Verifying Source Location

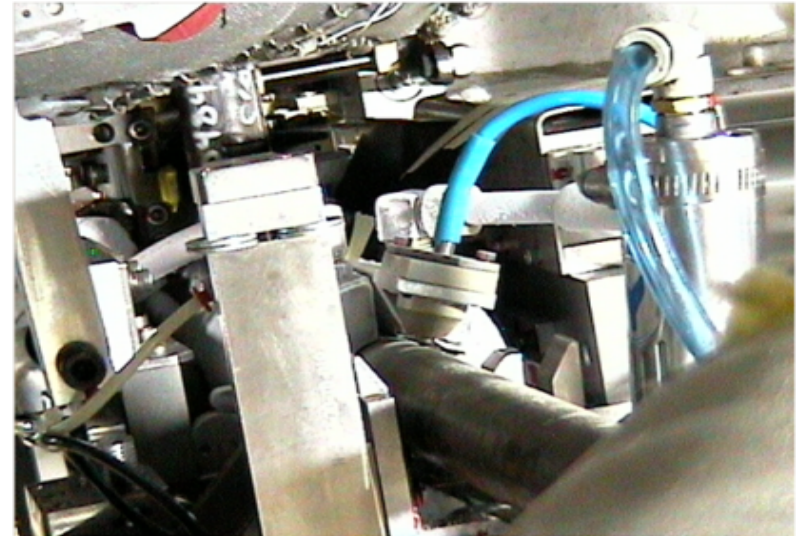
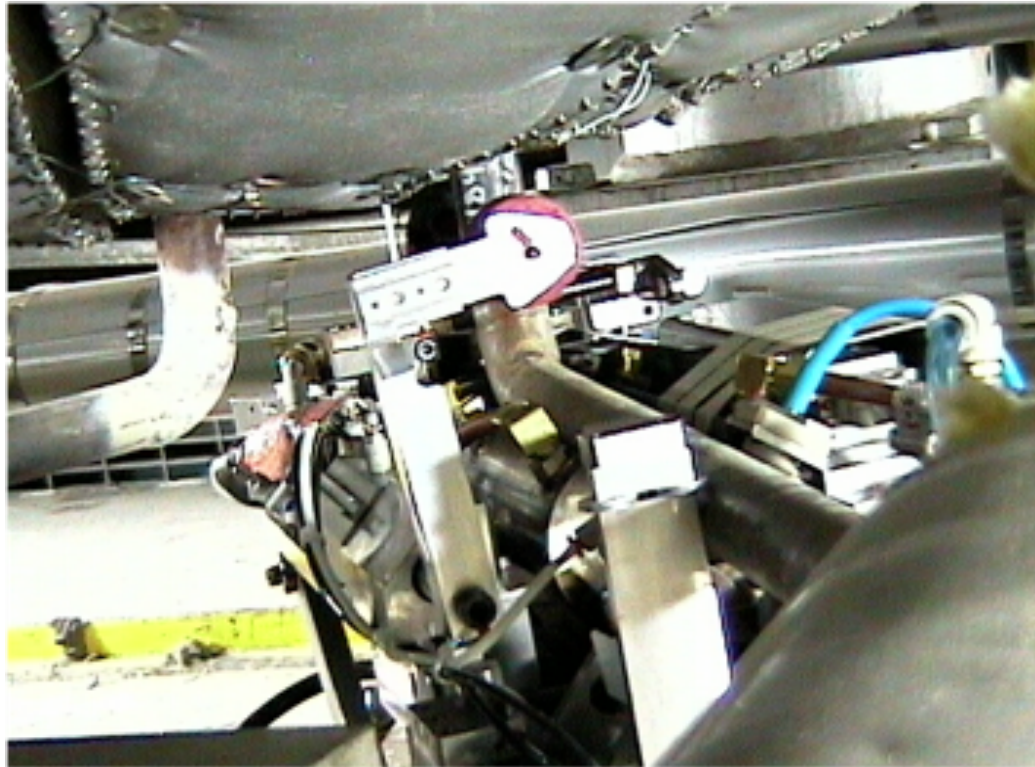






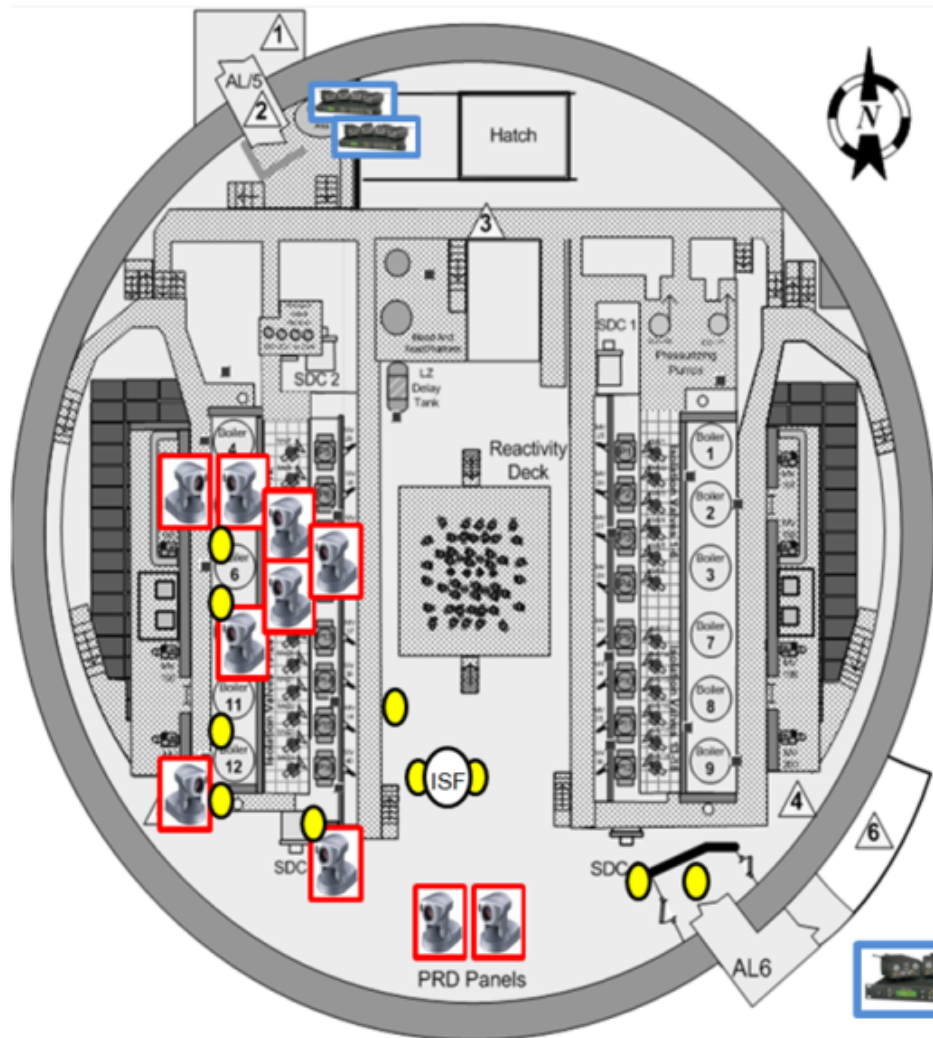
# High Activity Debris in Boiler Cold Leg Drain Lines (Cont.)

- Freeze Cut and Cap





# High Activity Debris in Boiler Cold Leg Drain Lines (Cont.)



- 10 Video Cameras + 3 Added Later
- 10 Area Radiation Monitors
- 8 Wireless Communication Packs

## PURPOSE

- Minimize number of staff in area
- Maximize safety of execution staff
- Track movement of High Activity Debris

-  Network Camera
-  Area Radiation Monitor
-  Wireless Communications



# Minimizing Airborne Tritium Releases





# High Activity Debris in Boiler Cold Leg Drain Lines (Cont.)

## ■ Results

- Average Dose Rates in Work Areas: 5 mrem/h
  - Highest Peak Dose Rate to a Worker: 200 mrem/h
  - Total Dose for Source Retrieval: 151 mrem
  - Dose for Source Containment and shipping: 12 mrem
- Ended up having to do it again in 2014 on Unit 4 Boiler 8





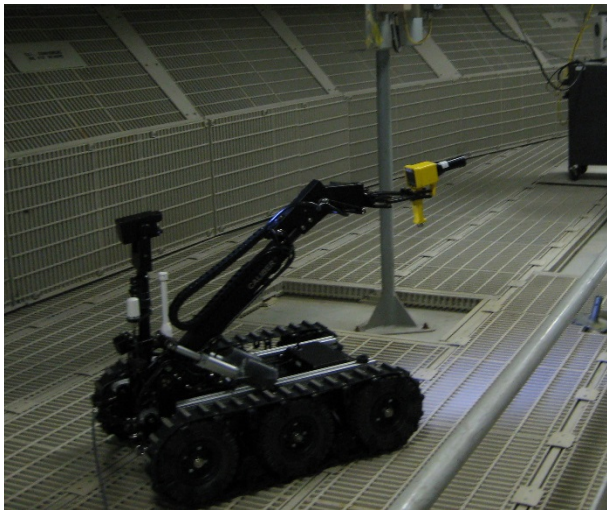
## Challenge from the Management Team

- Routine radiation surveys to be fully automated
- Ability to perform non-routine radiological surveys remotely
- Limit the requirement for Radiation Technicians to be in radiologically controlled areas



# Quick Wins

- Real-Time Routine Surveys
  - Gamma, tritium, beta airborne, alpha airborne, radioiodine
- Non-Radiological Monitoring
  - iCAM filter head changes, HEPA vacuum on/off, temperature, humidity
- Use of robotics to perform surveys, visual / thermal inspections





# Stuck Radiography Source





# Vacuum Building Visual Inspections

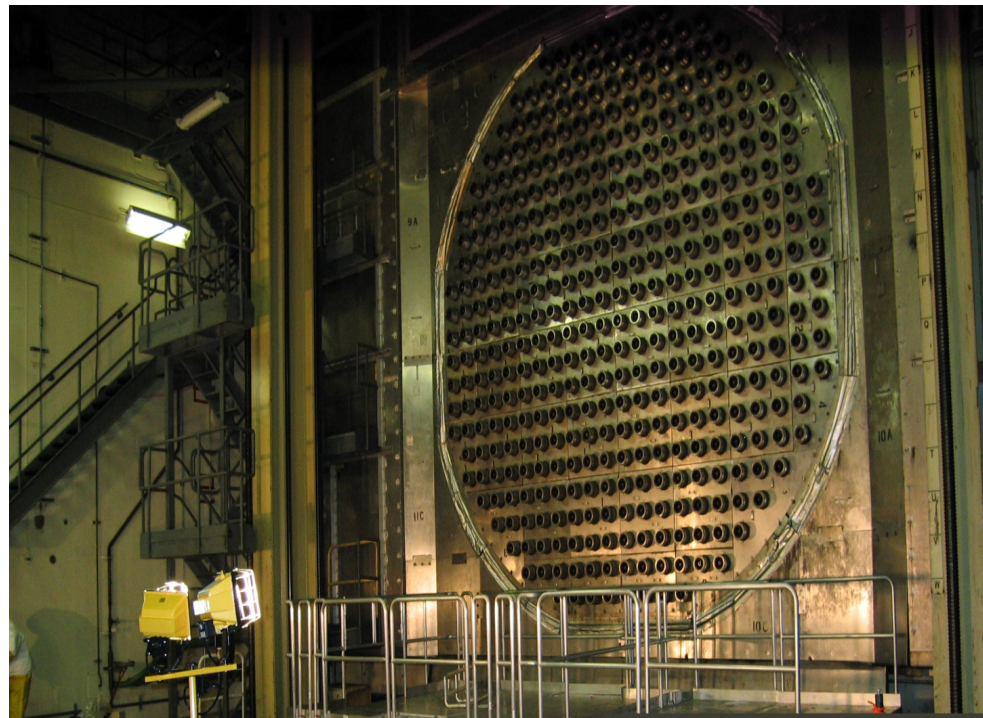






# Automated Reactor Face Survey Initiative

- Current Method:
  - Remote monitors on F/M Bridge
  - 2-3 hours of critical path
- Proposed Method:
  - Automated drones
  - Off-critical path
- Challenges
  - Time required to measure up to 390 channels, with current battery limitations of drones
  - Positioning of drone without GPS
  - Additional weight of gamma detector and transmitter





# Questions?

