SAND2008-1476C

American Nuclear Society

Utilizing A Robotic Vehicle To Access and Clean A Hazardous Underground Tank

March 10, 2008

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Agenda

- Review of Presentation Aids
- The Problem
- The Goal
- Trial and Error
- Solution SWARMY
- Success
- Conclusion

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Presentation Aids

- (1) Swarmy the Robot
- (2) Video of Tank and Sludge
- (3) Video of Swarmy in Sludge
- (4) Video of Swarmy Cleaning the Tank
- (5) Video of the Cleaned Tank
- (6) Bucket and Rope

The Problem

- Leaking Concrete tank
  - 26 feet below grade
  - 36 inch diameter manhole at grade
  - 18 inch diameter tank entrance
  - Oxygen concentration less than 19.5 %
  - Radioactive contaminates – Co-60, U-238, Cs-137
  - Hazardous constituents – cadmium, lead, arsenic

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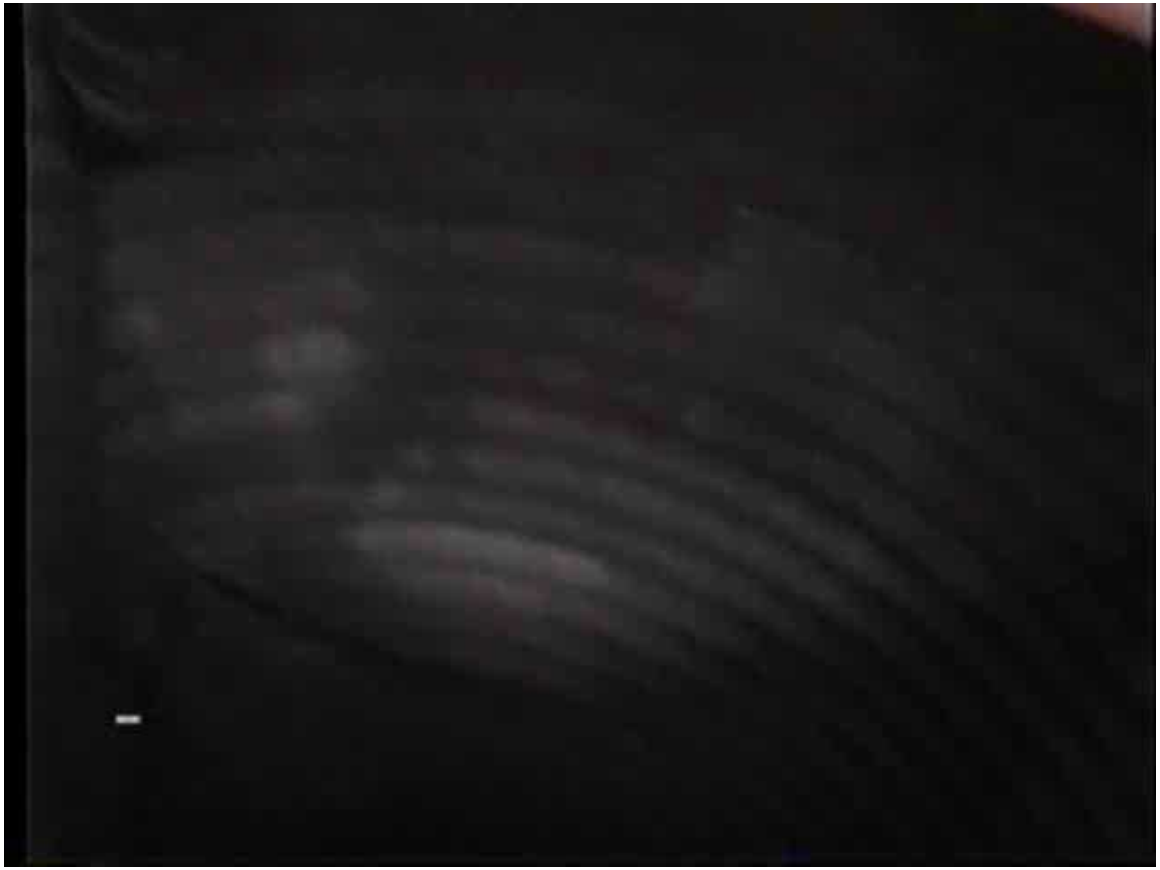
Video of Tank Initial Conditions



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The Problem

- Personnel entry was not allowed due to atmospheric concerns and unknown structural integrity
- Prohibition from adding water by regulating authority
- How to manage both vertical and horizontal sludge removal
- Avoid excessive cleanup costs; i.e. “The Big Dig”

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The Goal

- Remove obstructions for tank access
- Remove 90 % of the sludge
- Initial $5000 budget to demonstrate a solution methodology

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Trial and Error and Trial Again

- Pump
- Pump and eductor combination
- Septic truck
- Vacuuming
- Auger
- Commercial Robot (not Swarmy)
- External Contractors - “Hitting the Wall”

Introduction to Swarmy

- The Intelligent Systems Controls Department at SNL had a small used tracked vehicle robot that could be modified at reasonable cost (~$5000) to be operated from grade level.

- Swarmy would fit into the enlarged tank entrance (30 inch)

The Solution

- First attempt:
  - Swarmy was fitted with a plow and weight. Swarmy was to plow the sludge below the tank access where a scoop would lift the sludge.
  - But the sludge was wet and the robot heavy and the plow set low. So the robot became trapped in the sludge and churned to a halt.

The Solution

- Second attempt
  - The plow and weight was removed.
  - Ice screws added to treads to increase traction.
  - With the lid of the robot removed to allow adjusting the weight with bags of steel shot, the robot navigated over the sludge (now relatively dried out).

Video of Swarmy's Initial Entry

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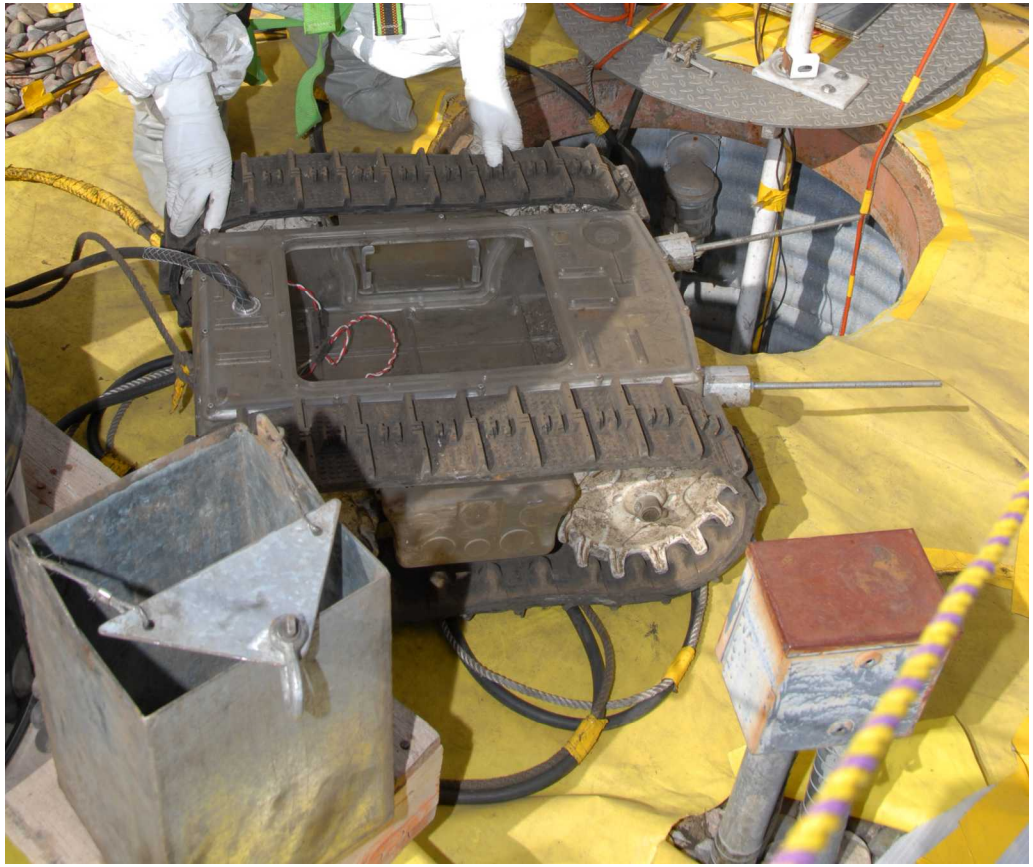
The Solution

- Now that we could navigate to all areas of the tank, the breakthrough idea was to use Swarmy as a pickup truck to carry a bucket on a rope into the tank and then the bucket was pulled from above grade, quickly filling with sludge and pulled to the surface by the operators.

The Solution



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The Solution

- The process was repeated and improved by the operators solving both the vertical and horizontal problems.
- With the sludge scraped down to the concrete, Swarmy was modified to push around a small shop-vac.

Swarmy Vacuuming

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Success

- With the use of Swarmy, the bucket and the shop-vac, the robot was able to remove 14 – 55 gallon drums filled to about 80%.
- Over 99% of the sludge was removed.

Success

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Team SWARMY

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Conclusions

- Accurately define the problem by understanding the characteristics of the sludge
- Build a team with people who are either uninformed of all of the obstacles or who are too stubborn to believe they can't get the job done
- Demand effective communications between the various regulating authorities
- Appeal to experts
- Experiment
- Above all, persistence counts – Surrender is not an option