SAND2011-3008C

Systems Engineering Approach to Remediating Large Burial Sites

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

Large Burial Sites Present a Major Remediation Challenge

- USA
  - Alabama, Utah, Colorado, South Dakota, Maryland, and others
  - Large disposal pits and trenches
  - Contents largely undocumented
- China
  - Haerbaling and others
  - Hundreds of thousands of Abandoned Chemical Weapons
  - Other items might be buried with them
  - Remote locations
- Al Muthanna, Iraq
  - Former weapons bunker
  - Sealed by UNSCOM after gulf war
  - Partially destroyed munitions and bulk chemicals

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Existing US Army Technologies and Methods Are Not Sufficient

- Stockpile systems lack sufficient flexibility
  - Many different types of munitions, containers, and other items
  - Multiple agents including experimental chemistries
  - Degraded and unknown condition
- Non-stockpile destruction systems lack sufficient capacity
- Recovery methods are slow, costly, and labor intensive
- New and increased hazards must be considered
  - Items are concentrated in a much smaller area
  - Potential for spills, releases, or widespread contamination
  - Non-ideal working conditions
  - Concurrent operations

Systems Engineering Approach

- The remediation operation will be complex with multiple operations in close proximity
- All aspects of the process are interrelated
  - Detector response time affects emergency response plans
  - Destruction methods will drive storage requirements and monitoring requirements
  - Ability to isolate hazards impacts PPE requirements
  - Munition recovery, characterization, and destruction capacity must be matched
  - Etc.
- A systems engineering approach is required
  - New technology development must be done in the context of the complete system

Examples of Areas Where New Approaches Are Needed

- Air monitoring and sampling
- Safety and accident mitigation
- Excavation and debris sorting
- Triage and munition stabilization
- Storage
- Munition destruction
- Decontamination and closure

Planning Software Tools

- Software planning tools developed for US Dept. of Homeland Security could be adapted
  - PATH (Prioritization Analysis Tool for all-Hazards)
    - Spreadsheet based analysis and decision support tool
    - Restoration prioritization following widespread contamination
  - RESTORe (Resource Estimation and Scheduling Tool for Optimized Recovery)
    - Estimates resources, time, and cost for remediation

Air Monitoring and Agent Detection

- Large burial sites will require simultaneous monitoring for multiple agents and chemicals
- Rapid detection will be important
  - Allow prompt response to abnormal conditions
  - Minimize PPE requirements
- Use of multiple detection methods could improve confidence
- Autonomous, self calibrating detectors would decrease costs
- Monitors should be networked
  - Allow better utilization of data
  - Increased confidence by comparing adjacent detectors
  - Plume tracking and source location
- Sample tracking and data management will be complicated

Air Monitoring and Agent Detection

- Depot and site boundary monitoring
  - DAAMS and continuous air monitoring at multiple locations
  - Stand-off detection to cover large areas
- Localized monitoring at the excavation site
  - Continuous air monitoring
  - Handheld detectors
  - Soil sample analysis
  - Surface detection
- Localized monitoring at the destruction facility or other process steps
  - Continuous air monitoring

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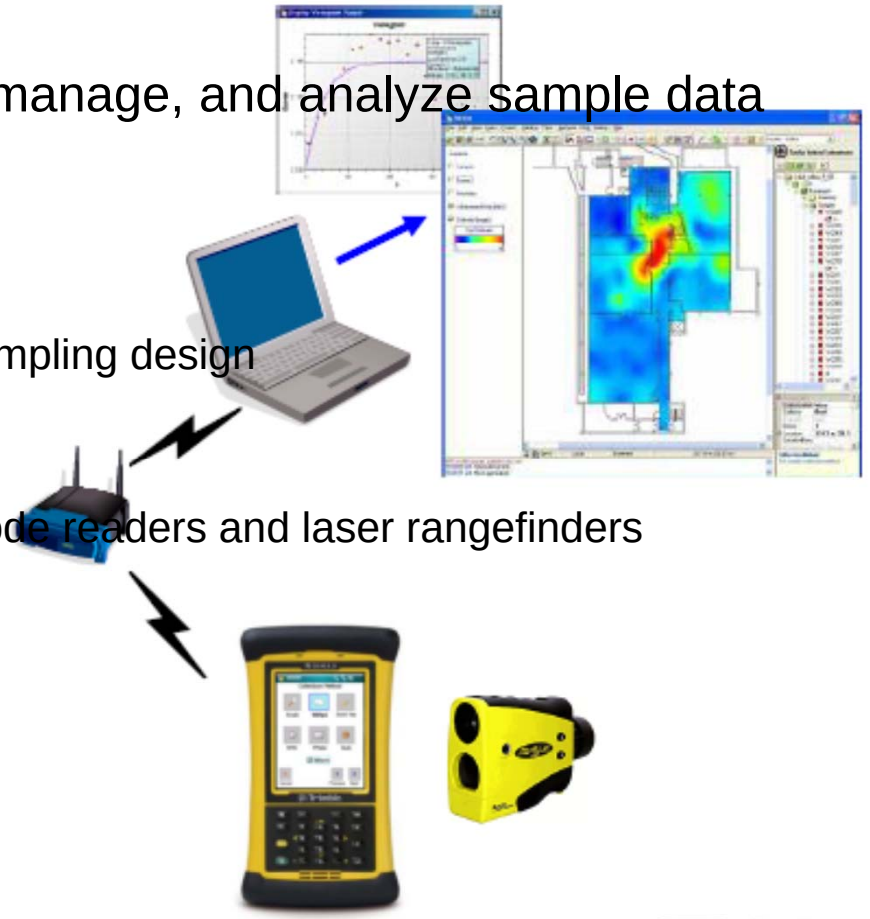
Building Restoration Operations Optimization Model - BROOM

- A decision support tool to collect, manage, and analyze sample data
  - Secure SQL Server database
  - GIS mapping & 3D visualization
  - Geostatistical analysis tools
  - Uncertainty analysis
  - Interfaces with VSP for statistical sampling design

- Data collection
  - Hand-held wireless PDAs with barcode readers and laser rangefinders
  - GPS for outdoors
  - Camera for photo documentation
  - Paperless data transfer
  - Secure transmission of data
  - Chain of custody report



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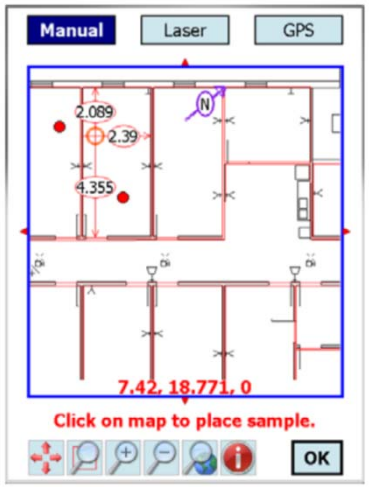
More Features of BROOM

- Maps of the facility are uploaded to the PDA for r within the facility
- Pre-defined sampling locations can be displayed map
- Pan & zoom capabilities
- Laser positioning or manual locating of sample lo (GPS is not reliable indoors)
- Barcode reader reduces transcription (ole numbers
- Wireless connection allows tracking of ess and uploading of sample collection dat e BROOM server



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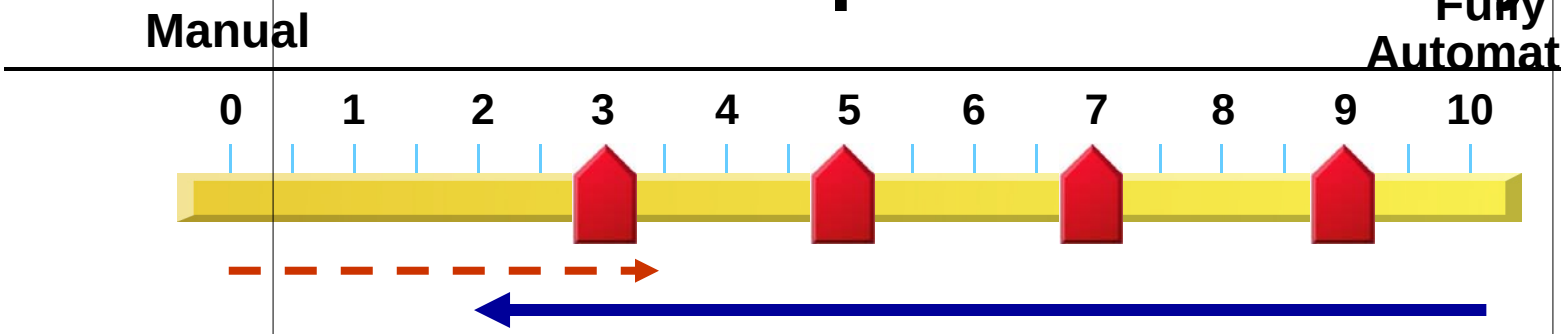
Safety and Accident Mitigation

- Minimize exposure
- Isolate the hazards
- Utilize a triage approach to prioritize treatment
- Include release mitigation systems

Minimize Exposure

- Robots can remove humans from hazardous environments
- Mobile robots can be effective in highly unstructured situations
  - IED/UXO removal
  - Radioactive material cleanup
- Robotics for high consequence applications are different than robotics for repetitive tasks
  - Lot size of one
  - Strict process constraints in quality and safety
  - Continuous interaction between the machine and the operator
- Requires the correct balance of human interaction and machine autonomy

A Philosophical Approach To Robotics: Operator Flexibility




Hot Cell Facility Confinement Boxes and Manipulators

- Automated Planning and Programming
- Model- and sensor-based control
- Rapid, efficient integration

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Robotic Platforms

- Pedestal
  - Highly repetitive tasks
  - Complex mechanical motion
- Tracked/Wheeled
  - Provide greatest mobility
- Gantry
  - Cover large workspaces
  - Pure vertical approach
  - High load capacity
  - Well suited for recovering munitions from a pit or trench

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Robotic End-Effectors

- Mount at the end of the manipulator system
- Can be changed without human interventions
  - Grippers
  - Cutters
  - Vacuums
  - Shovels (with sensors)
  - Sensors

Isolation of Hazards

- The excavation site should be partitioned
  - Allow separate crews to work independently
  - Minimize extent of potential contamination
- Processes should be separated to allow concurrent operations
- Explosive hazardous should be separated from chemical hazards where possible
- Isolation can be achieved by distance
  - Less efficient operation
  - Increased risk from handling and transportation
- Isolation can also be achieved with barriers
  - Bunker design methodologies
  - Foams or gels to mitigate blasts and agent dispersion
  - Layered armor or concrete fragment mitigation

An Approach Is Needed to Rapidly Assess Each Item - Triage

- Determine condition
  - Leaking or external contamination
  - Suitable for handling or storage
- Stabilize, decontaminate, place in secondary containment
- Characterize fill
  - Conventional munition/chemical munition/other CWM
  - Burster/no burster
  - ID chemical agent
- Identify treatment requirements and priority
- Catalogue, label, track, and document

What is Needed for Triage

- Rapid, hand-held multi-agent detectors
- Suitable decontamination methods
- Improved secondary containers
  - Matched to the destruction method
  - Compatible with x-ray and PINS
  - Easy to load and seal
- In-situ x-ray and PINS capability
- Methodology for making decisions
  - Meet regulatory requirements
  - Transparent to public
- Automated system to catalogue, label, and track each item
  - Variant of BROOM?

Sandia Decon Formulation (DF-200)

How Does it Work?

Components

Foam Component (Surfactants, mild solvents, buffers)

Peroxide (7.9% Solution)

Novel Activator

Mix

Formulation

Synergistic formulation (multiple reactive species)

Spray, Foam, Mist, or Gel

Multiple Uses

Neutralization of CW Agents

Neutralization of TICs

Kill of BW Agents

Kill of Bio Pathogens

Final peroxide concentration is ~3.6%

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Sandia Decon Formulation (DF-200)

Surface Decontamination

Small-scale Foam System

Large-scale Foam System

Indoor Foam Application

Medium-scale Foam System

Fog/Mist Application

Liquid Spray Application

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Efficacy of Sandia DF-200 Formulation in DoD Testing (CW)

Agent	Type of Decon	Decontamination Process	Average Residual Results (g/m²)	Contamination Removal (%)	Objective (%)
HD	EasyDECON	Operational	0.017	**99.83**	**99.0**
HD	EasyDECON	Thorough	0.013	**99.87**	**99.0**
GD	EasyDECON	Operational	<0.005	**>99.95**	**99.9**
GD	EasyDECON	Thorough	<0.005	**>99.95**	**99.9**
VX	EasyDECON	Operational	0.022	**99.78**	**99.9**
VX	EasyDECON	Thorough	0.007	**99.93**	**99.9**

Summary of results of residual agent on CARC decontamination tests (DF-200 [EasyDECON] deployed as a spray with the Intelagard Merlin™ system; Agent loading: 10 g/m²; Challenge ratio: 120:1, Contact time: 30 minutes).

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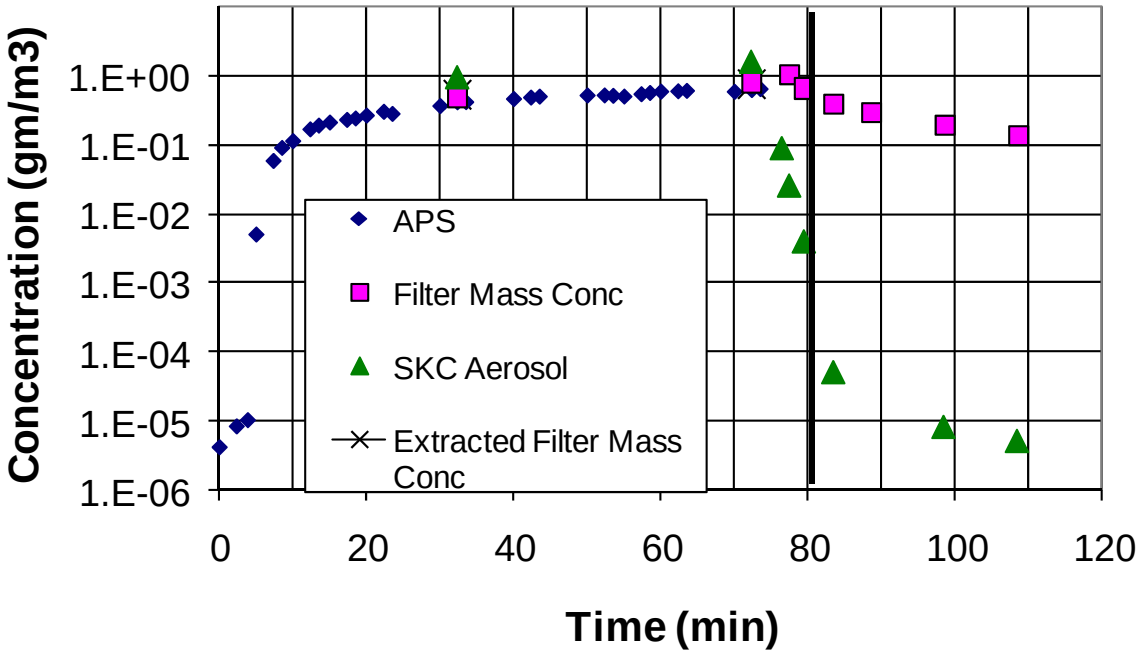
Cloud Knockdown System

- Decontaminant spray is dispersed as charged droplets
- Droplets collect vapor and particles as they fall through the air
- Neutralizes and removes airborne agent releases
- Protects personnel, limits contamination, prevents off-site transport
- Demonstrated >5 orders of magnitude knockdown



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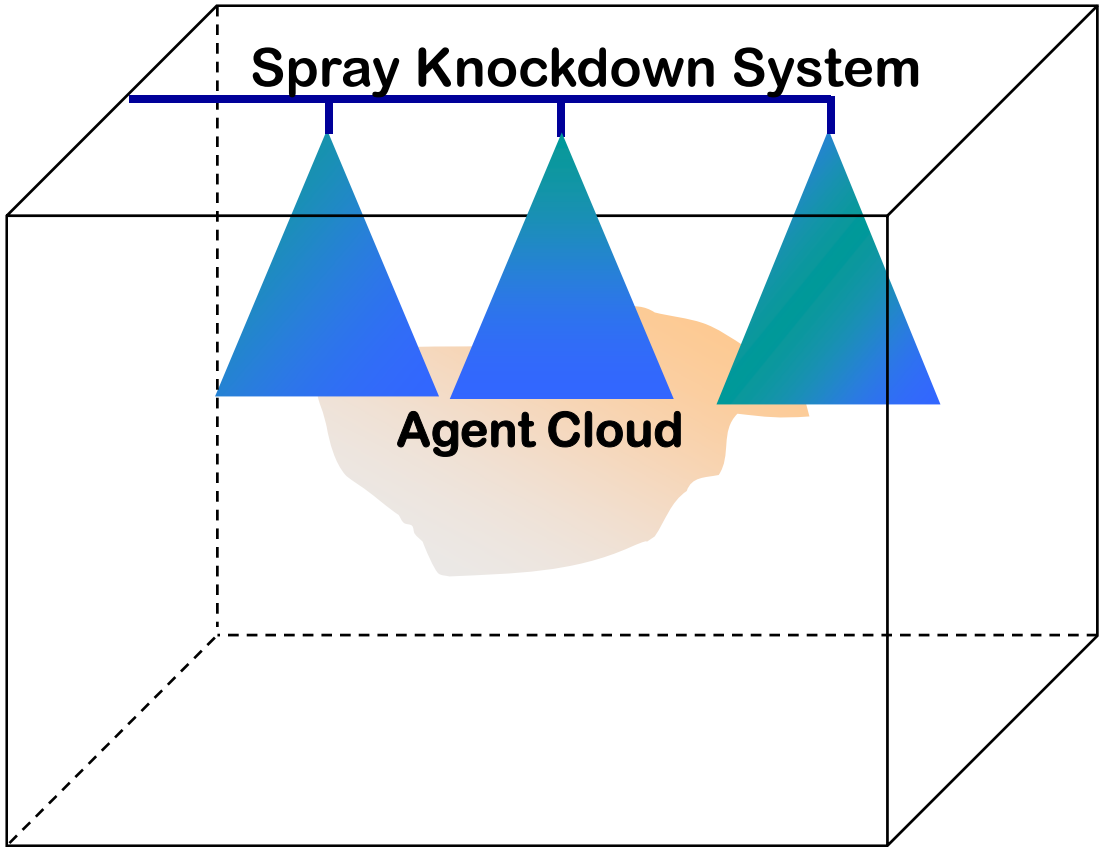
Cloud Knockdown Concept

Interior Protection



Protected Facility

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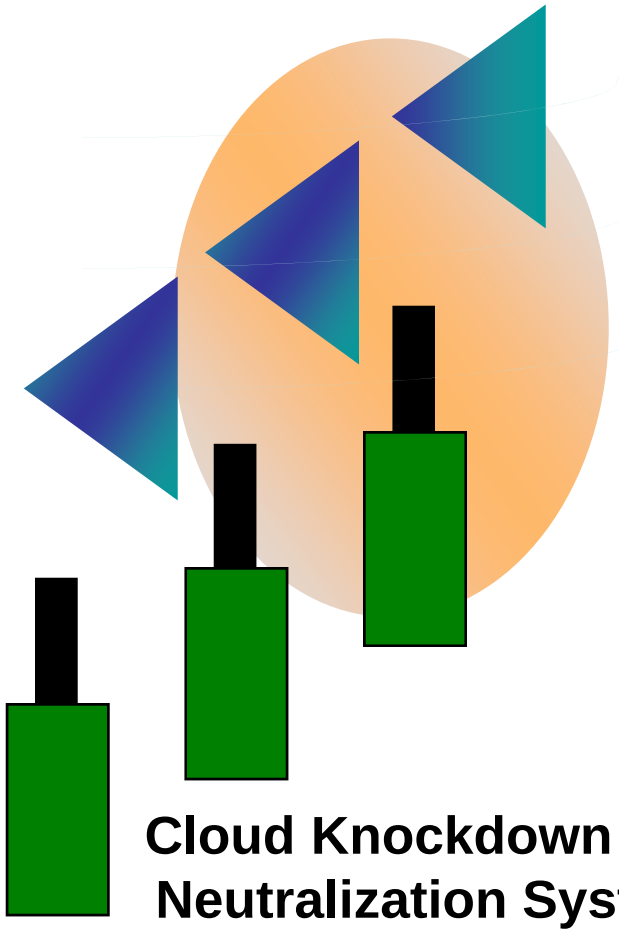
Cloud Knockdown Concept

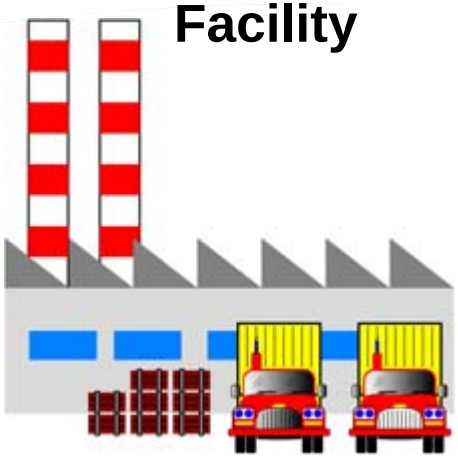
Protection of Exterior Environment



Protection for exterior environment

Cloud Knockdown and Neutralization System

Chem Demil Facility



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Conclusions

- Large burials sites present a major challenge
  - Scope
  - Complexity
  - Hazards
- New technologies and approaches are required
- Technologies are being developed for some aspects of the problem
- A systems engineering approach is needed to integrate the pieces
- The demil community should begin preparing for the challenge