The BROOM System

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Outline

- Objectives of the BROOM System
- Technical Features of the BROOM System
- Operational Features of the BROOM System
- The WITS System for the Mobile Lab
- BROOM Deployment for VSP WG Efforts

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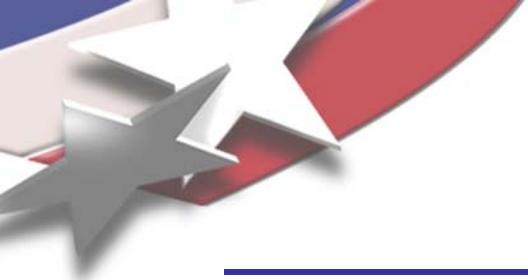
Acknowledgements

- **Funding Sources for the Development and Deployment of BROOM**
  - **US Department of Homeland Security**
  - **US Environmental Protection Agency**

2001 Anthrax Letters and National Response Lead to the Development of BROOM

- Postal facilities, senate buildings, and news organizations were contaminated

- Very little experience decontaminating large indoor facilities

- CDC reports that over 125,000 samples were tested at LRN laboratories costing $25-30 mil.

- Many facilities were closed for years and restored at great cost
  - Capitol Hill (4 mo, $42 mil.)
  - Brentwood (26 mo, $130 mil.)
  - US Postal Facilities (3+ yr, $800M)

National response revealed significant capability gaps

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A biological or chemical agent release in key transportation facilities could be devastating

- Severe economic impact if closed for even short periods

- Highly vulnerable to biological or chemical terrorism

- Wide range of decon and remediation challenges

- The primary focus of the Facility Restoration projects was on major airports, with an emphasis on facilitating rapid restoration of the facilities

- Airports could lose $80M+ revenue per day of shutdown, a major economic impact

We worked in close collaboration with two partner airports, SFO and LAX, and regulatory agencies

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Response and Recovery Activities					
Crisis Management		**Consequence Management**			
Notification	First Response	Remediation/Cleanup			Restoration (Recovery)
		Characterization	Decontamination	Clearance	
Receive and assess information Identify suspect release sites Relay key information and potential risks to appropriate agencies	HAZMAT and emergency actions Forensic investigation Public health actions Screening sampling Determination of agent type and concentration Risk communication	Detailed characterization of agent Characterization of affected site Site containment Continue risk communication Characterization environmental sampling and analysis Initial risk assessment Clearance goals	Worker health and safety Source reduction Decontamination strategy Remediation Action Plan Site preparation Waste disposal Decontamination of sites, items, or both Verification of decontamination parameters	Clearance sampling and analysis Clearance decision	Renovation Reoccupation decision Long-term environmental and public health monitoring
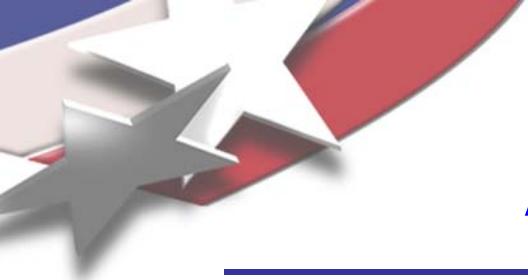
Additional Needs Identified

- GAO (2005) identified a number of deficiencies in the response actions to the 2001 anthrax attacks on the USPS facilities and the Hart Senate Building
  - Need for probability-based sampling methods to quantify confidence in the results
  - Need to quantify sampling efficiencies
 - Need to manage data more effectively

GAO

United States Government Accountability Office
Report to the Chairman, Subcommittee on National Security, Emerging Threats, and International Relations, House Committee on Government Reform, House of Representatives

March 2005

ANTHRAX DETECTION

Agencies Need to Validate Sampling Activities in Order to Increase Confidence in Negative Results

GAO

GAO-05-251

The combined needs of the Facility Restoration Projects and the GAO recommendations lead to the development of the BROOM Decision Support Tool

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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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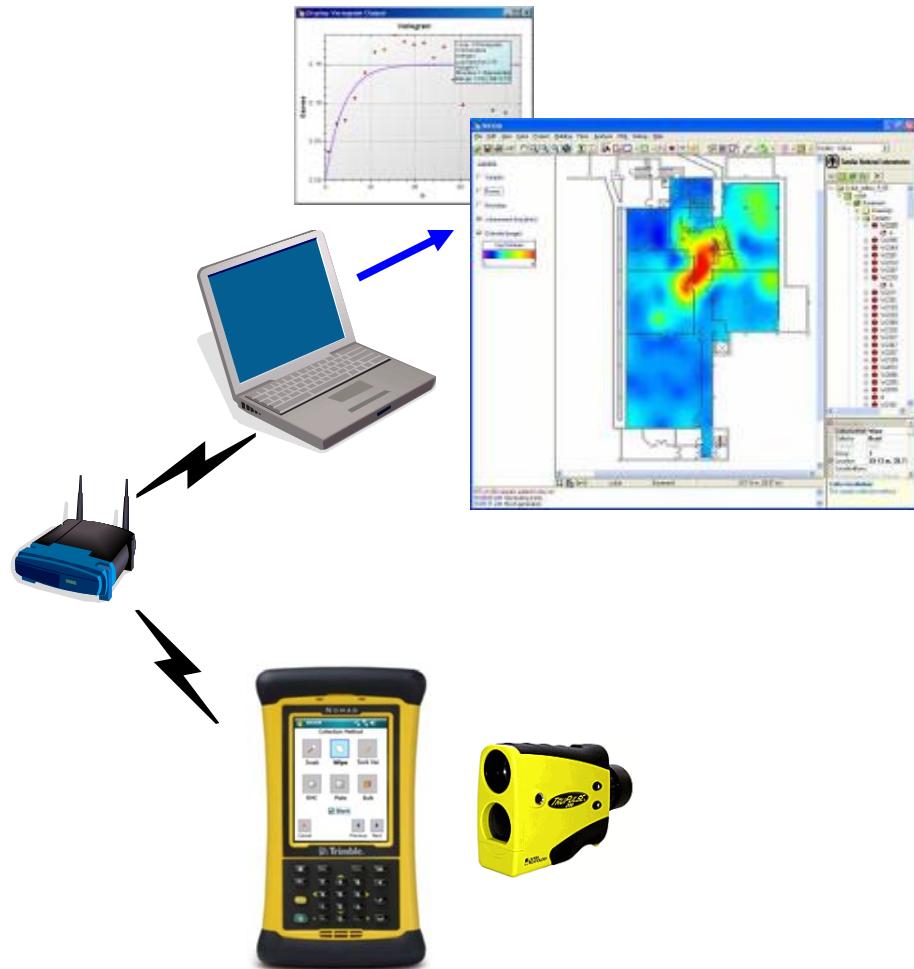
Conceptual Use of the BROOM System
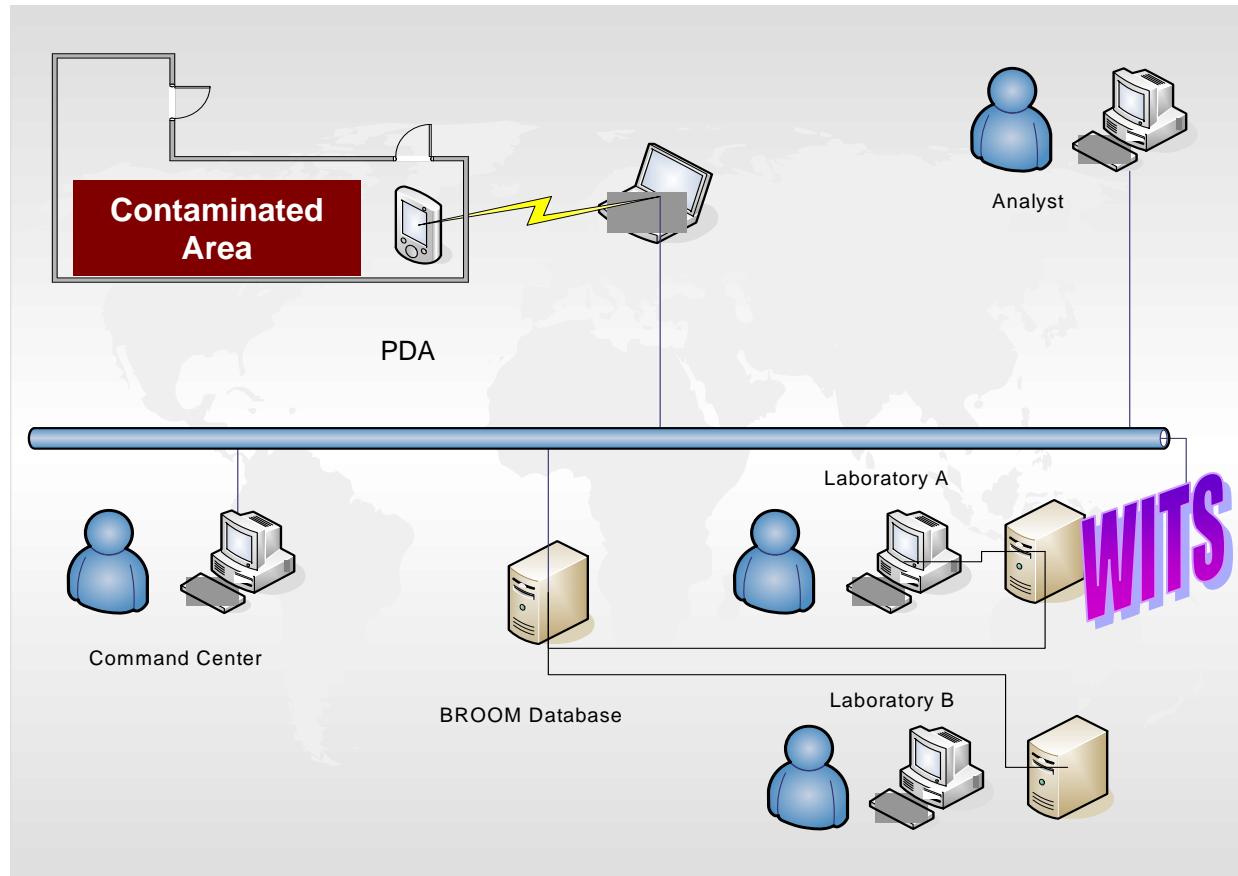
BROOM can be used for pre-event planning and post-event operations

PDA Application

Sample Collection Hardware

Trimble Nomad 800LE PDA:
- Fully programmable with color screen
- Barcode reader
- Bluetooth and 802.11g wireless
- GPS
- Camera
- Essentially dust-proof and submersible

$2300

TruPulse 360 Laser Rangefinder:
- Distance measuring
- Digital compass
- Tilt sensor
- Bluetooth link to PDA

$1600

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More Features of the PDA Application

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

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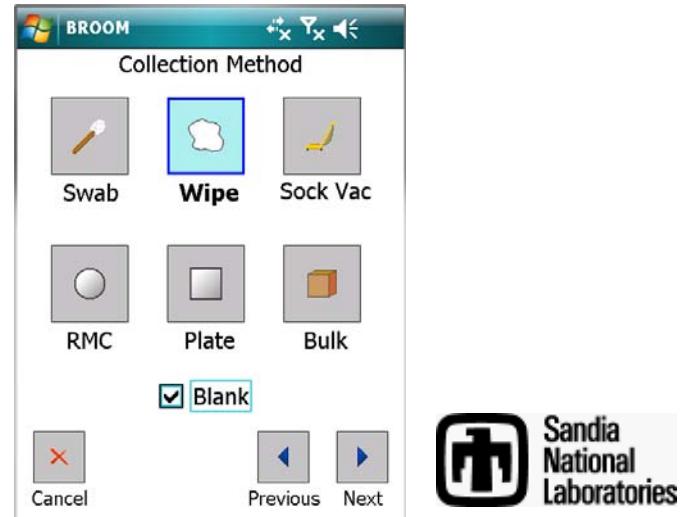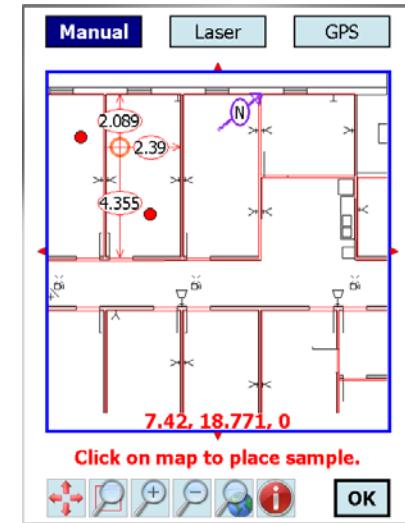
Chain of Custody Report

- Chain of Custody reports can be generated for each batch of samples uploaded from a PDA.

- The sample collector's signature is captured on the PDA and is included on the report.

Company:
SNL

Address:
PO Box 0853

Albuquerque, NM 87123

Phone:
505-555-1111

Sampled by:
Bob Smith

*Sample Types:

SW = Swab
WI = Wipe
MV = Mini Vacuum
SV = Sock Vacuum
HF = HVAC Filter
BI = Biological Indicator

Sample ID	Date Sampled	Time Sampled	Sample Type*	Analysis Requested
SNL3105	1/25/2006	3:48 PM	BI	
SNL3102	1/25/2006	3:48 PM	BI	
SNL3045	1/25/2006	3:48 PM	BI	
S4271	1/25/2006	3:48 PM	BI	
SNL3090	1/25/2006	3:49 PM	BI	
SNL3093	1/25/2006	3:49 PM	BI	
SNL3096	1/25/2006	3:49 PM	BI	
SNL3099	1/25/2006	3:49 PM	BI	
SNL3036	1/25/2006	3:51 PM	BI	
S4274	1/25/2006	3:51 PM	BI	
SNL3088	1/25/2006	3:52 PM	BI	
SNL3062	1/25/2006	3:52 PM	BI	
SNL3047	1/25/2006	3:53 PM	BI	
SNL3028	1/25/2006	3:53 PM	BI	
SNL3132	1/25/2006	3:56 PM	BI	

Chain Of Custody Report

Current Building: Terminal 2

Sampling Organization
SNL

Sample Batch
Time received:
1/25/2006 3:20:58 PM
1/25/2006 3:32:23 PM
1/25/2006 3:32:36 PM
1/25/2006 3:36:34 PM
1/25/2006 3:47:24 PM
1/25/2006 3:47:53 PM
1/25/2006 3:49:57 PM
1/25/2006 4:02:47 PM
1/25/2006 4:03:48 PM
1/25/2006 4:04:02 PM

Number of samples:
31

Collector:
Bob Smith

Signature:
Bob Smith

View   Close

Custody				
Name	Signature	Company	Date	Time
Relinquished by:				
Received by:				
Relinquished by:				
Received by:				
Relinquished by:				
Received by:				

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BROOM Software Features

- BROOM has built-in Geographical Information System (GIS) module that allows management of multiple layers of visual imagery and consistent spatial orientation

- Maps of the facility are easily imported as CAD drawings (preferable) or bitmap images

You are here!
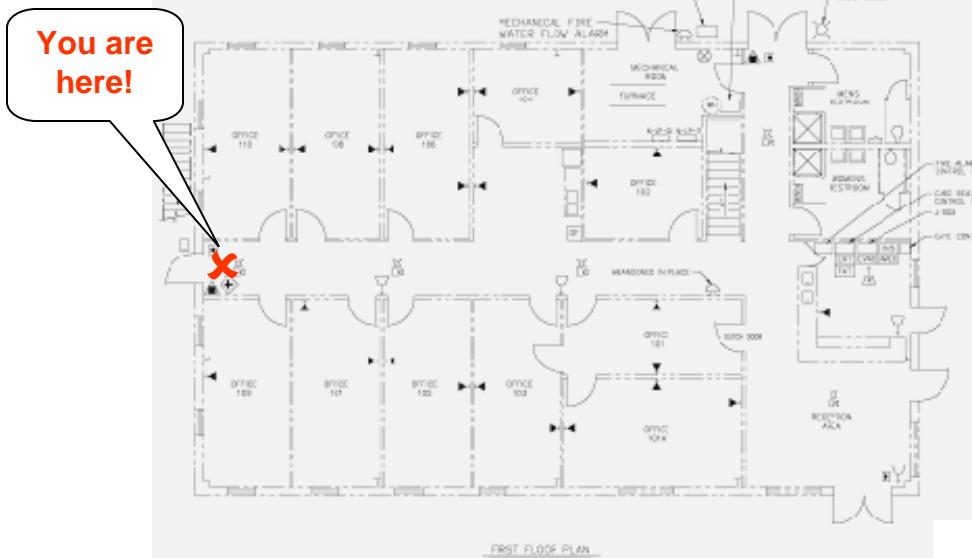
**BROOM can easily register a scanned image of a building map to use as the facility drawing**

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BROOM Software Features

Menus and toolbars for map control, editing, and analysis

Map layer management

Map showing facility layout and sample locations

Details of selected object

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Tracking the Progress of Sampling Effort

Uploaded sample locations

Different color coding for each sampling team

Icon with square represents latest location, other color icons are not-yet uploaded sample data
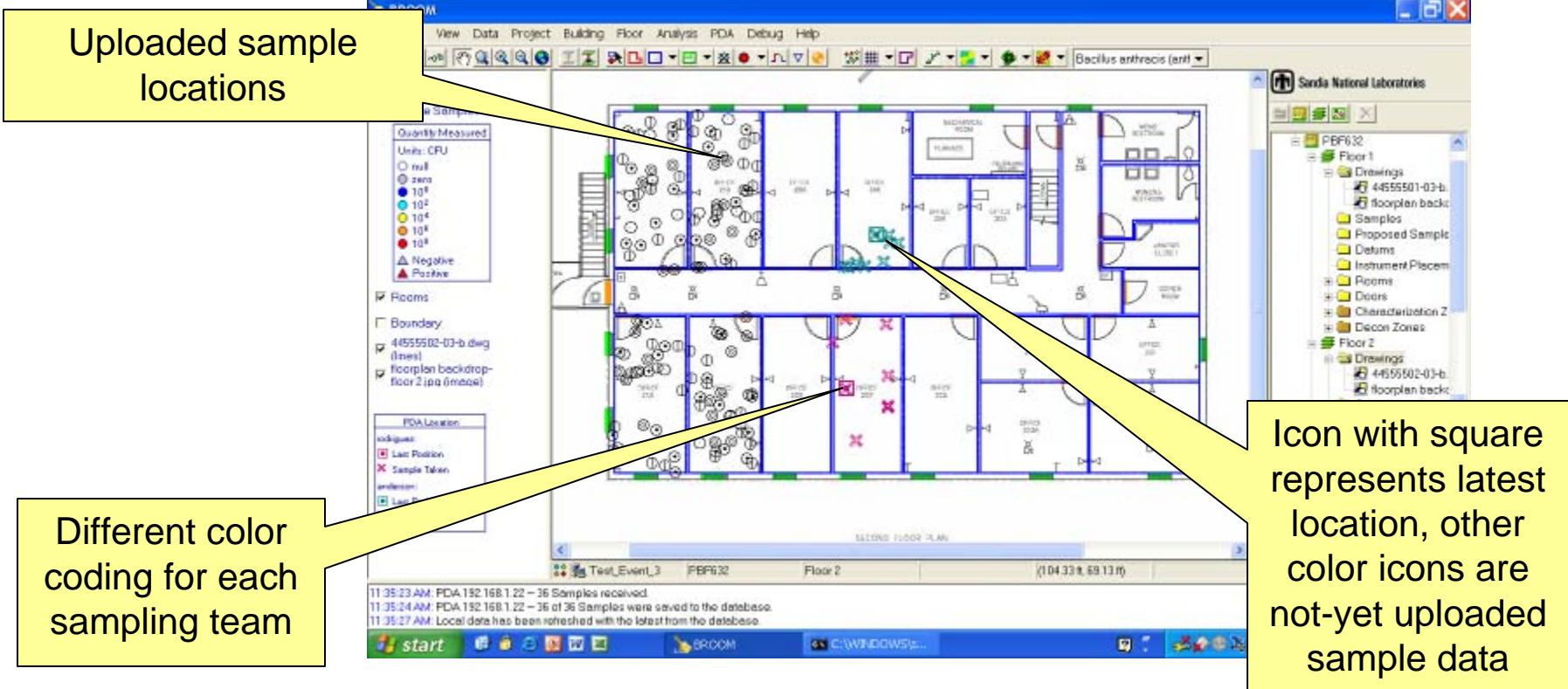
With the BROOM wireless connectivity, the progress of the sampling teams can be viewed in real time on the server computer outside the exclusion zone

BROOM Software Features

Placing cursor over sample icon reveals data synopsis

Project tree allows access to summary information from database
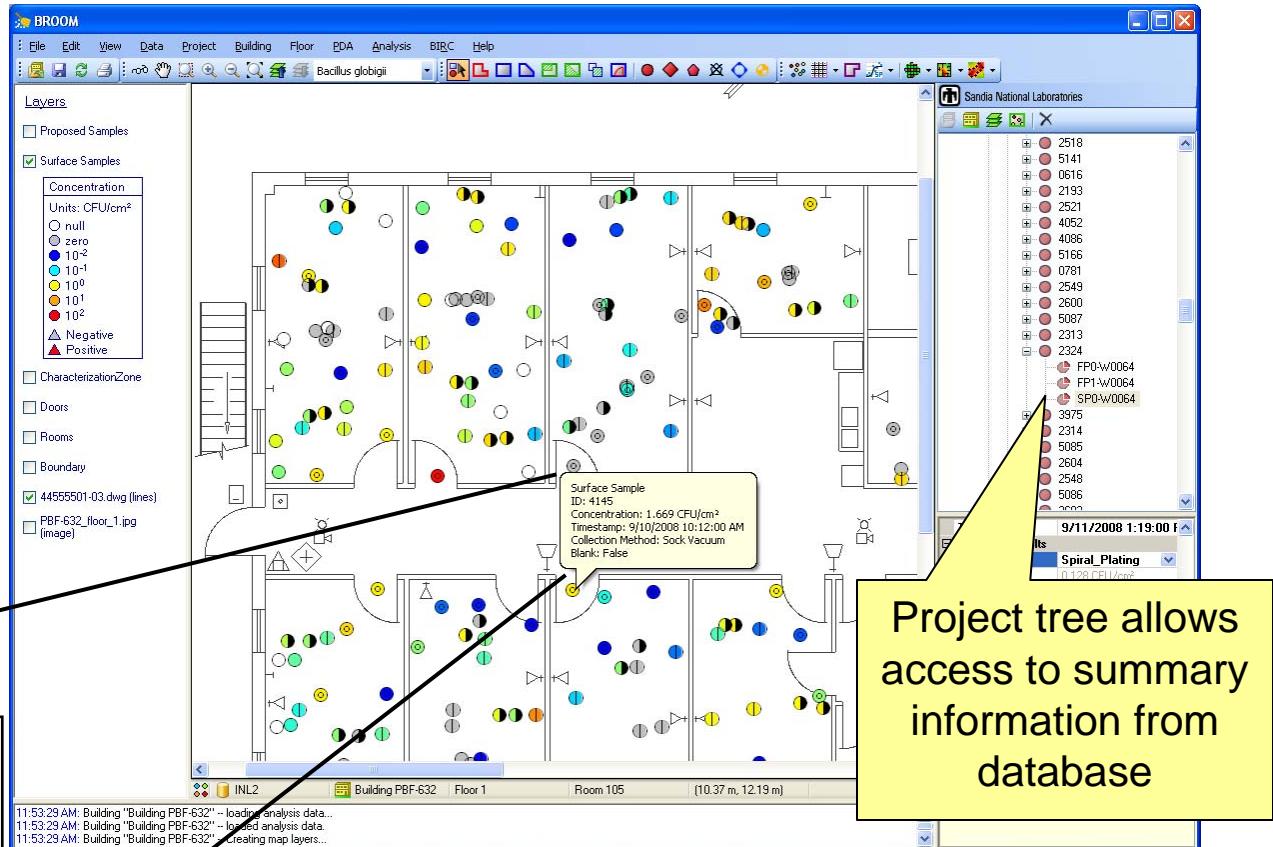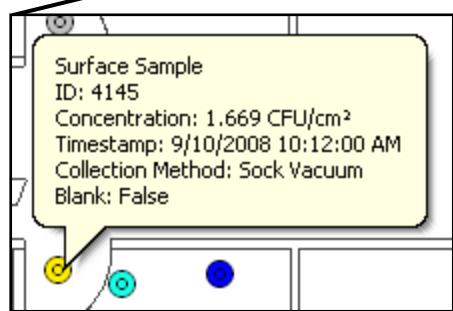
Different sample icons represent different sample types (swab, wipe, etc.)

Surface Sample
ID: 4145
Concentration: 1.669 CFU/cm²
Timestamp: 9/10/2008 10:12:00 AM
Collection Method: Sock Vacuum
Blank: False

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Secure SQL Server Database

- Sample information is automatically populated into the SQL database once uploaded from a PDA

- Lab data results are uploaded separately, when available

- All data associated with the project, including drawings, is stored in the database
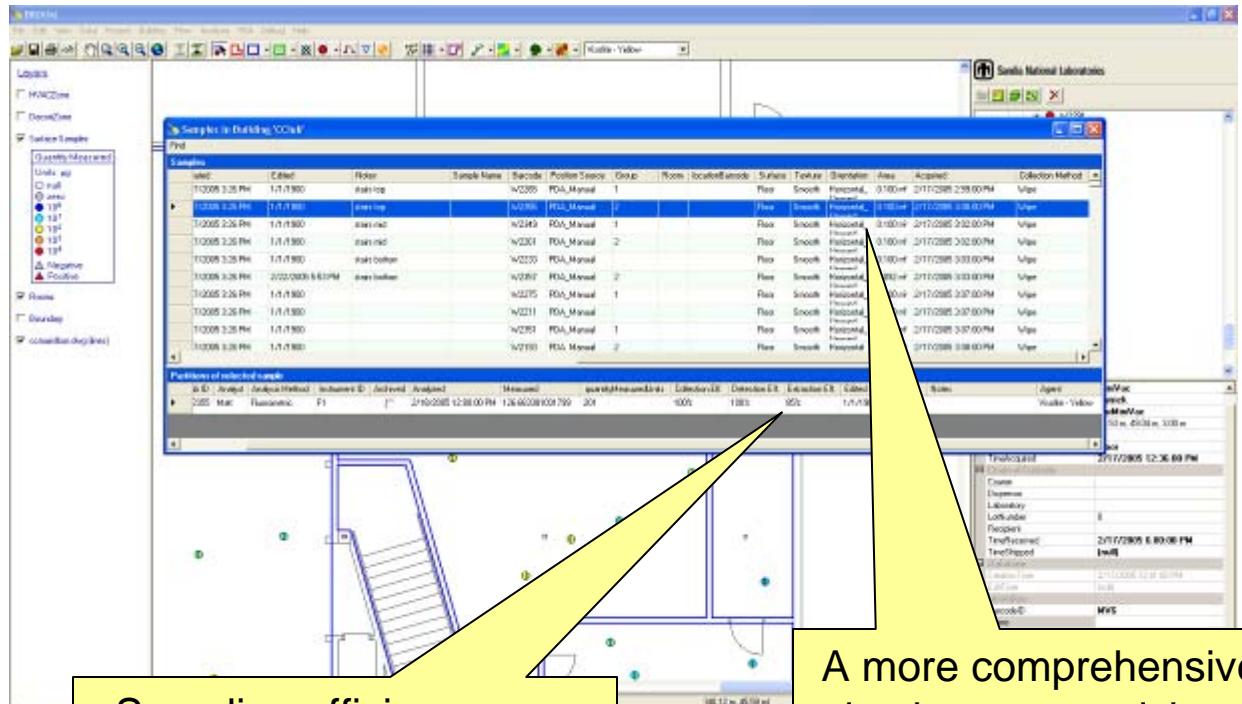
Sampling efficiency may be accounted for in database formulation for sample concentration

A more comprehensive database spreadsheet window is available, with sorting features

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Mapping Spatial Variability

- Geostatistical methods explicitly account for spatial variability and spatial correlation of the data, traditional statistical methods do not

- These methods can quantify uncertainty and variability in the distribution of contamination

- Maps showing the probability of exceeding a specified concentration can also be made with geostatistics

- BROOM can also provide contour maps using conventional contouring techniques

Expected Value Map

Unique geostatistical technique that accounts for walls and doorways

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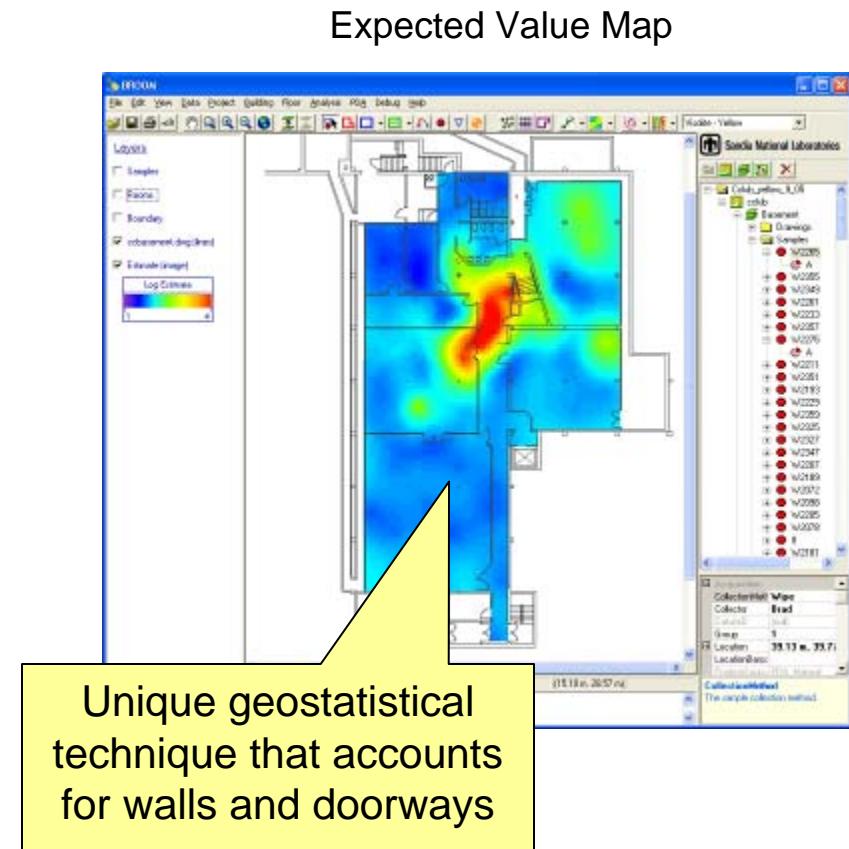
Sampling Design

- Integration with the **Visual Sample Plan (VSP)** tool to import sample design plans and share data/info
  - Establish Data Quality Objectives (DQOs)
  - Statistical (probability-based) sampling designs to explicitly account for confidence in sampling goals
- Geostatistical methods are coupled with optimization techniques for iterative sampling designs to reduce uncertainty in the spatial variability. These methods may prove quite efficient for sampling design.

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Photo Documentation

- The PDAs have the capability to take photos, which in turn are stored in the database and accessible in the BROOM software.
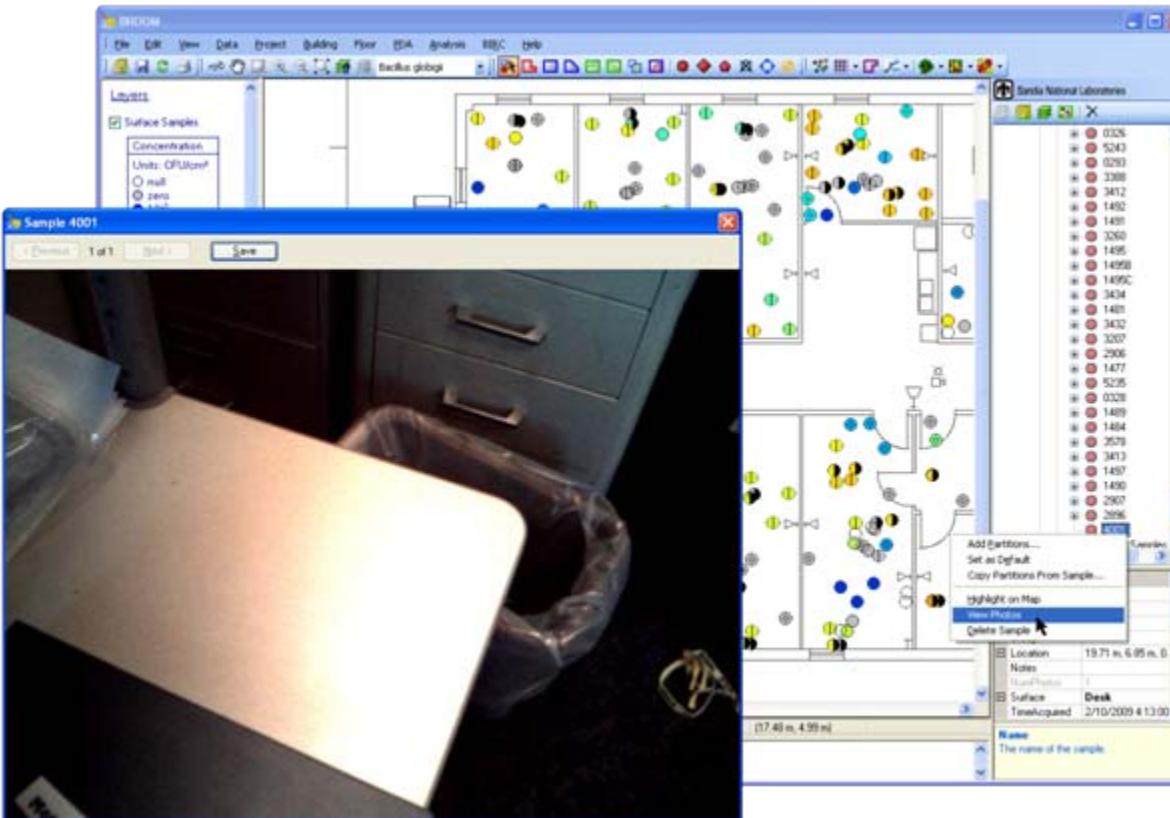
Electronic Playbooks for Sampling

Dynamically generated sampling plans specifically tailored to the characteristics of an event, designed to maximize the amount of information obtained from sampling

- Electronically generated playbooks potential benefits include:

    – More efficient use of resources, time, and money
    – Defensible confidence statements and sampling strategies during natural environmental events.
    – Adaptable to facility-specific response goals and constraints
   – Relatively easy to update and maintain over time

Facility "X"
Initial Characterization
Sampling Playbook

*Playbook generated 12/1/2008 @ 11:02 am*

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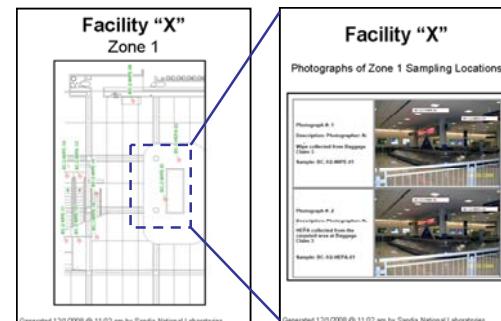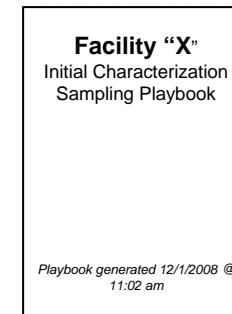
Other Features of the BROOM System

- 3-D visualization option, with game-style navigation

- Integration with **EPA's SCRIBE** database

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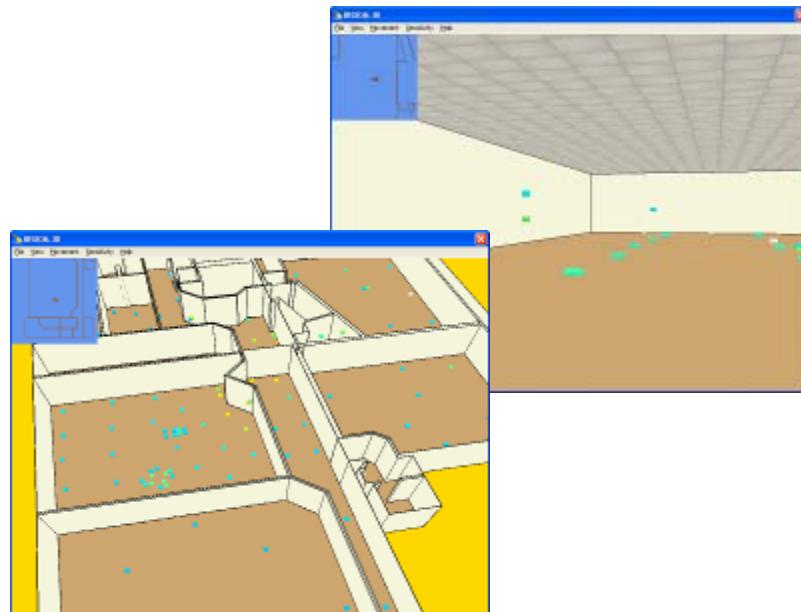
Other Features of the BROOM System

- BROOM can save data to a format that can be viewed in Google Earth
  - Spatial representation of the data overlain on a satellite image of the site
  - Color-coded sample icons to show concentration
 - Sample number, type and concentration listing

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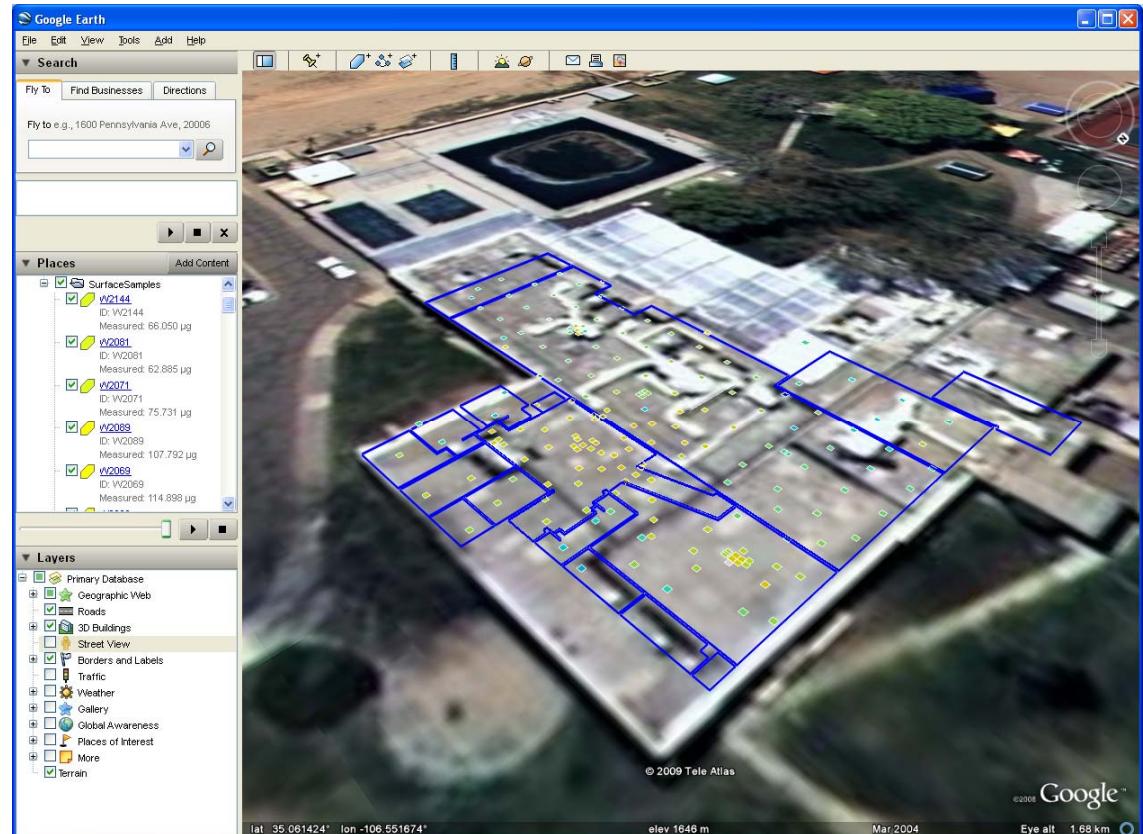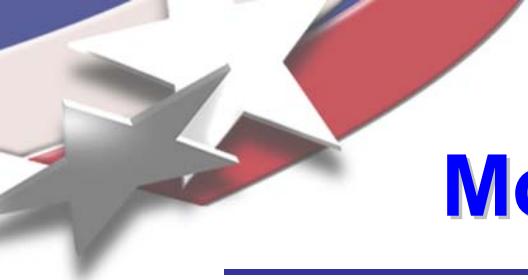
Mobile Lab Integration - WITS

- A sample tracking module called Where Is That Sample? (WITS) can:

  - Scan barcodes with PDAs at each step in the sample analysis process in the mobile laboratory and track progress through these steps:

    - Sample kit preparation; Inventory unused and discarded sample containers; Sample receipt in mobile laboratory, including QC samples, ALS samples, and LRN samples; Extraction step; Spiral plate step; Filter plate step; RV-PCR; and Incubation

  - Scan consumables used in lab processing (e.g., buffer solution)

  - Structured input of sample analysis results from the mobile laboratory on a laptop PC in the mobile laboratory

  - Wireless transfer of mobile laboratory data to the BROOM server application for analysis and review

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Integration of BROOM & WITS
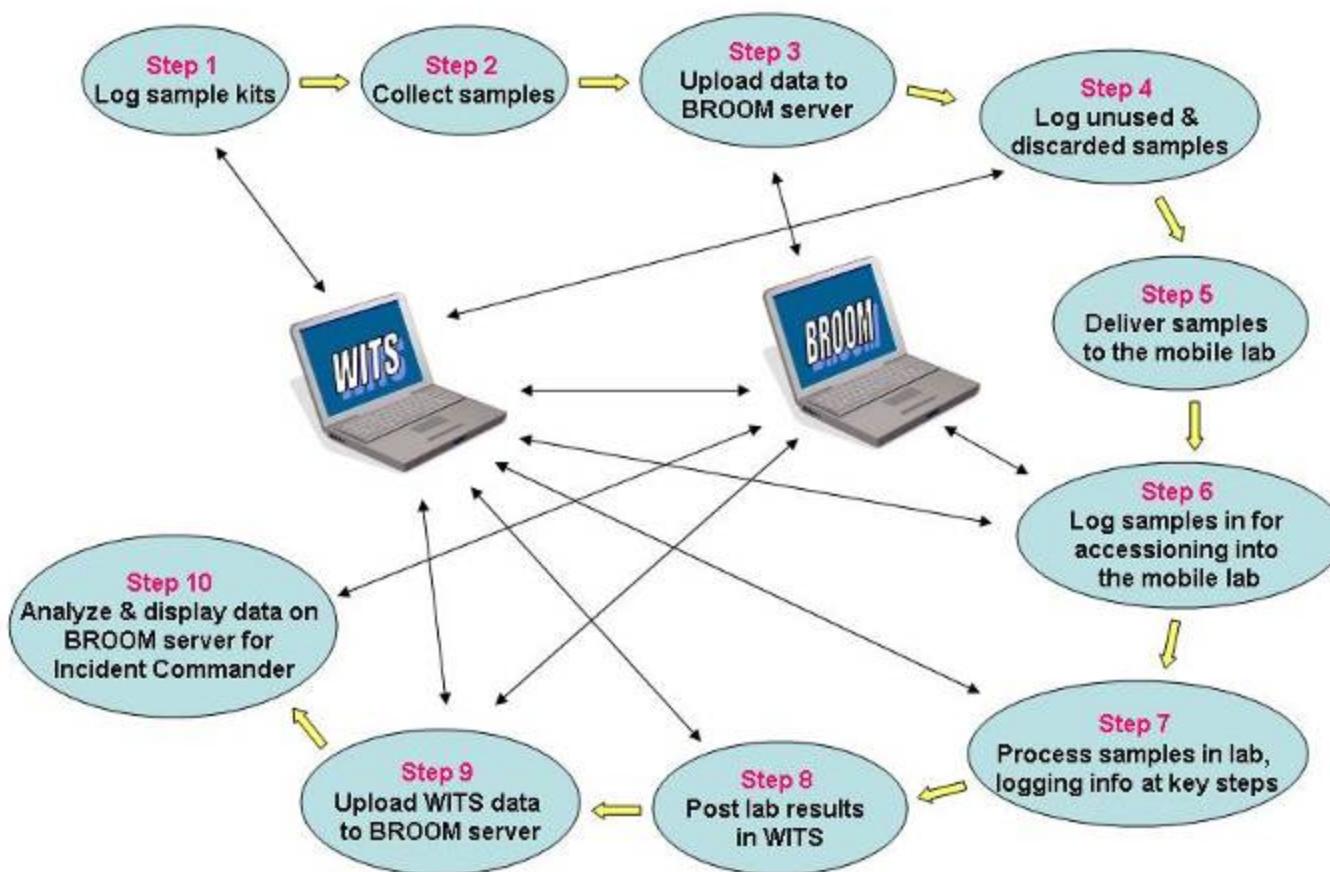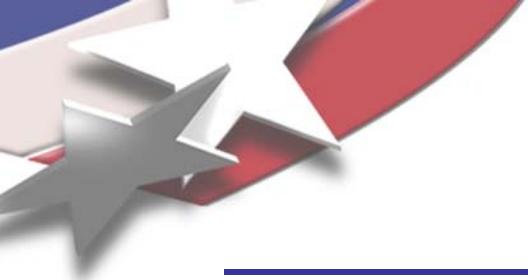
BROOM Deployment for Sample Collection Test Efforts

- A multi-agency committee was established to address the concerns of the GAO report regarding sample validation issues

- The Validated Sampling Plan Working Group (VSP WG) has members from DHS, DoD, EPA, FBI, CDC, and other organizations

- The VSP WG has funded several studies to address validation needs, including two field tests at the Idaho National Laboratory (INL), one in 2007 and one in 2008

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The INL Sample Collection Test Deployment

- The INL field tests had the following objectives:
  - Collect data to evaluate probability-based sampling designs
  - Collect data to evaluate a new hybrid probability-judgmental design method for clearance sampling
  - Evaluate sampling protocols
- To achieve these objectives a series of 5 separate release tests were performed, both covert and overt, with an anthrax simulant in an unused building at INL that was representative of typical office space

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The INL Sample Collection Test Deployment

- For each of the 5 test releases, the following occurred:
  - Bacillus atrophaeus (BG), an anthrax simulant, was released inside the building as either a covert or overt attack
  - The HVAC system was activated for a short time to distribute the BG throughout the facility
  - Sampling teams collected data for characterization purposes
  - Samples were analyzed on-site with a mobile laboratory, with results available the next morning
  - The facility was decontaminated overnight using the chlorine-dioxide fumigation method
  - The next day, sampling teams collected data for clearance purposes
  - Samples were analyzed on-site with a mobile laboratory

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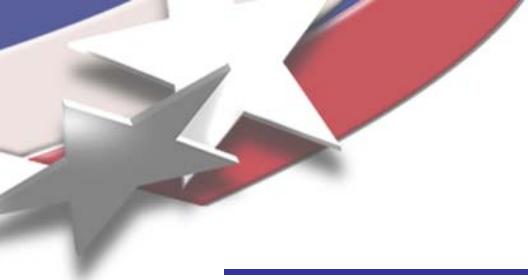
Participants

- DoD's Joint Programs Executive Office (JPEO) provided test direction
- DHS provided support for several entities
- EPA provided support and the Incident Commander (who was responsible for judgmental sampling designs)
- Johns Hopkins University Applied Physics Lab provided logistical support, as well as sampling and analysis protocols
- The Army's 1st and 9th Area Medical Labs (AMLs) provided onsite mobile laboratory analyses
- National Guard Civil Support Teams (CSTs) and several first-responder organizations performed surface sampling
- The CST Army Laboratory System (ALS) mobile lab also provided support
- SNL provided support with BROOM and WITS
- PNNL provided the probability-based and hybrid method sampling designs
- SabreTech performed the chlorine-dioxide fumigation

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The INL Sample Collection
Test Deployment

INL Building PBF-632 before and after tent installation

Personnel decon after every entry

On-site mobile laboratory

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BROOM Deployment at the INL Test

- Several dry runs performed the first week, followed by 5 separate BG release events over a 3 week period

- Training provided weekly to the CSTs and first responders as new teams engaged

- Up to 4 sampling teams deployed simultaneously

- Collected up to ~340 samples in a day; nearly 3,000 samples collected and analyzed for all events

- Data transfer from the mobile lab accomplished in 15 to 30 minutes to facilitate rapid decision making prior to clearance sampling design

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- Hardcopy maps showing proposed sample locations and furniture layout were provided to each sampling team

- The BROOM PDAs had the same map views on the display, showing furniture layout

- Sampling teams either used the laser positioning system to log the location of the sample or manually placed it on the PDA map
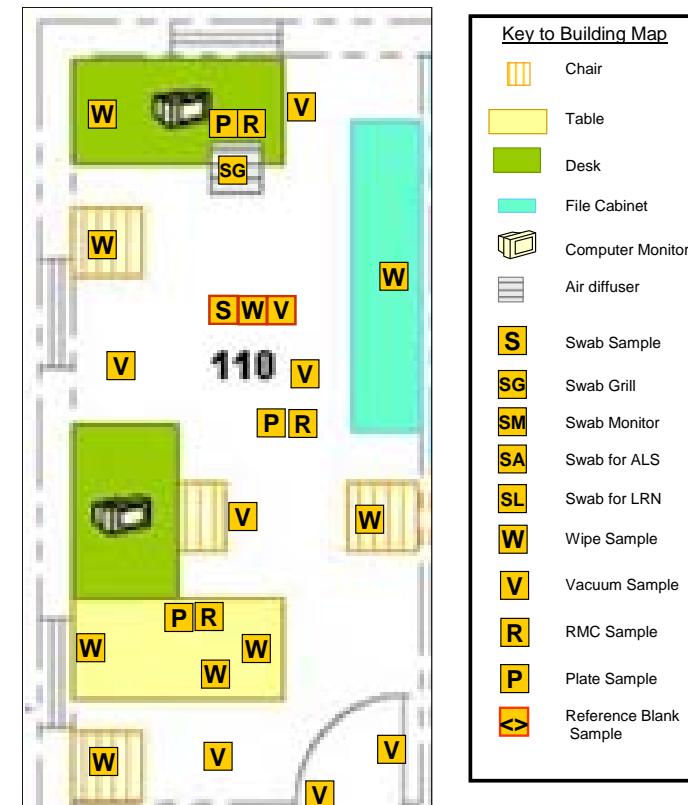
Test Event 4 Characterization – Room 110

Test Event 4 Characterization in 2007

- In 2007, the mass release of Bg for each event was 1 gram.

- The Bg dispersed throughout the facility at relatively high concentrations

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Results from Sample Collection Test
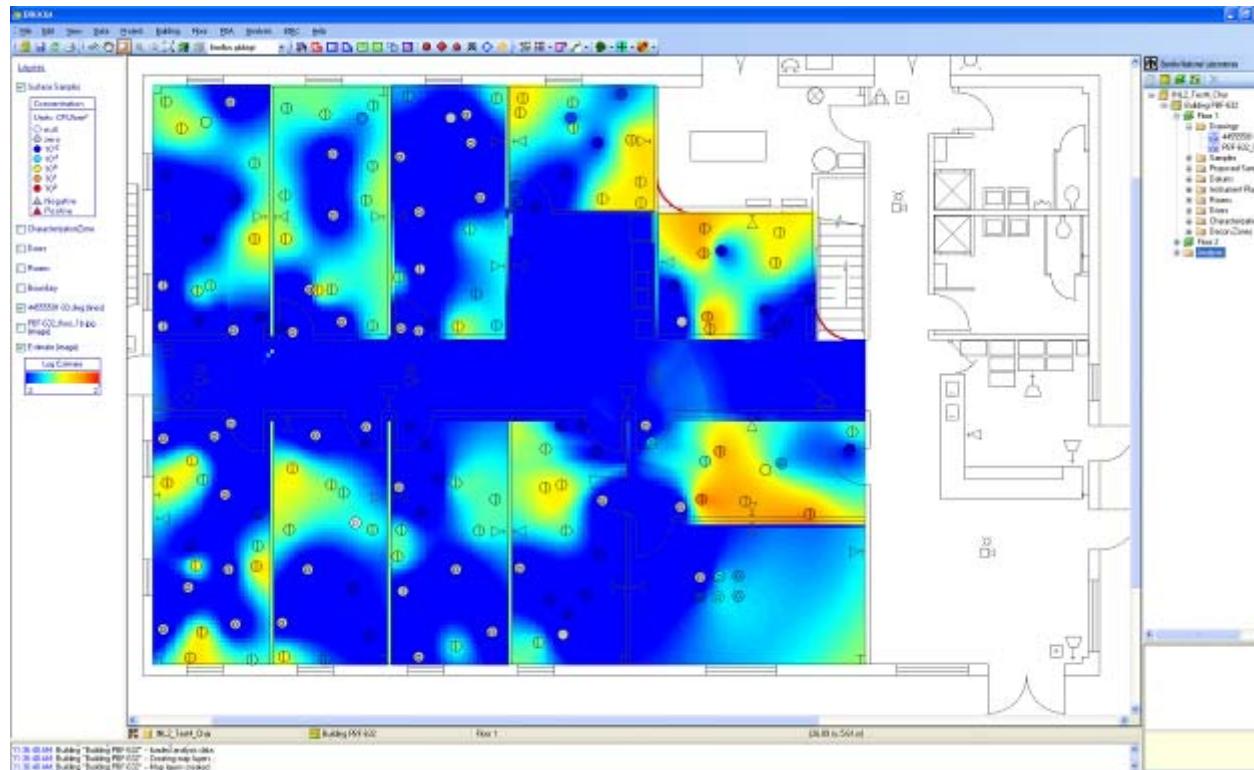
Test Event 4 Characterization in 2008

- In 2008, the mass release of Bg for each event was 1 milligram.

- The Bg exhibited more spatial variability and lower concentrations than the year before

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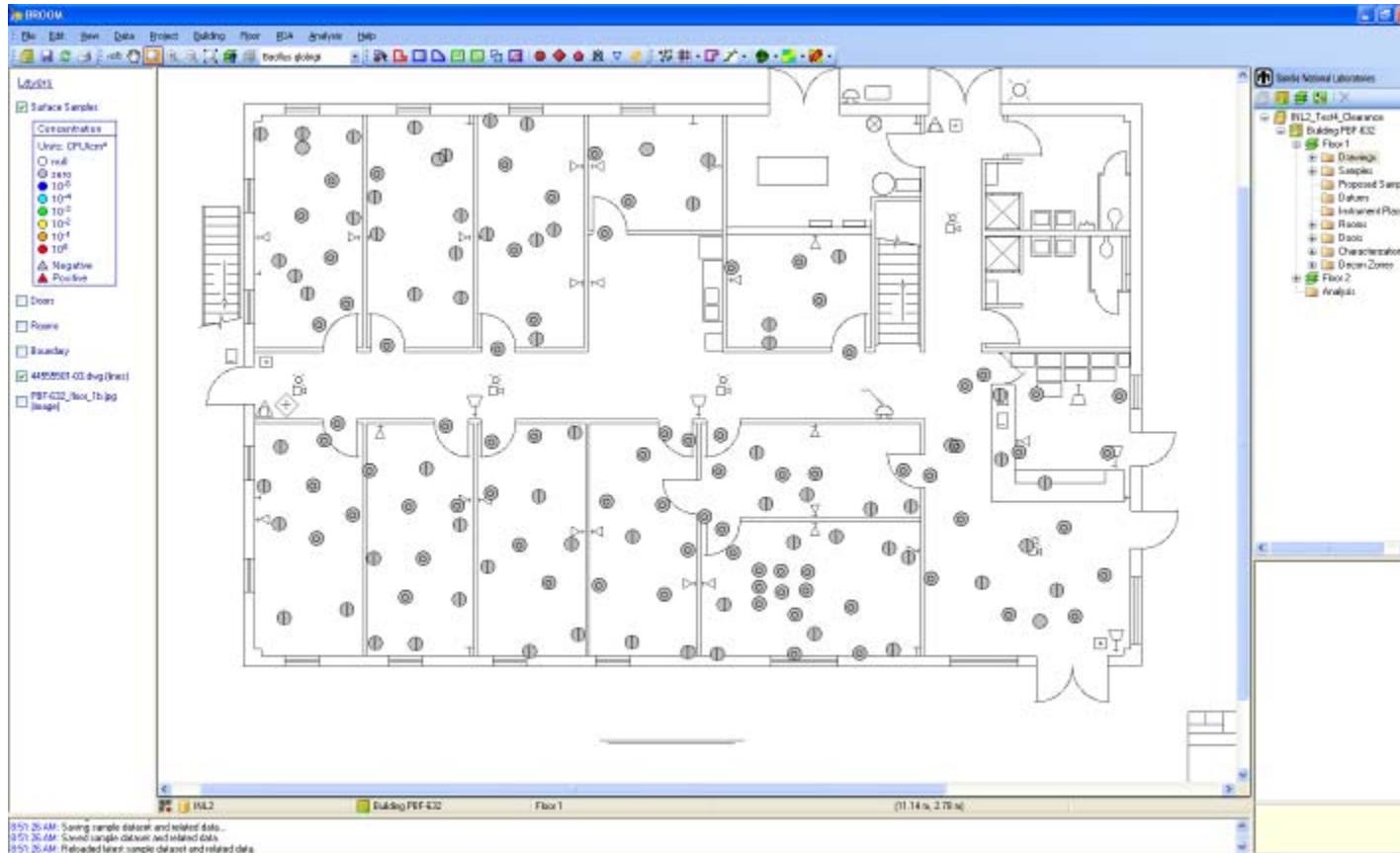
Clearance sampling demonstrated that the chlorine dioxide fumigation was effective at decontaminating the facility

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Civil Support Team (CST) Feedback

- SNL was invited to speak at the CST sampling and survey conference in Las Vegas during December 2008
- CSTs filled out questionnaires regarding the usage of BROOM for the tests
- Feedback included:
  - "Allow quick reference point and sample ID." Morris, John, SFC, 24th CST
  - "No paperwork, know where to sample was taken faster than writing on sample. Manual mode was faster than laser no cross contamination." Arnold Young, 21st CST
  - "Good physical setup for realistic sampling. Good visual tool, help keep things organized and moving." Sandin, Matthew W, 55th CST (WMD)
  - "Quick, accurate sampling recording, big pluses." Mike D. Lubovich, 55th CST (WMD) Minnesota
  - "Getting exact locations of samples on a map and being able to get an electronic view of sample #s and locations." Brent Emery, 55th CST (WMD)
  - "The Broom system shows excellent potential to create a valid system for tracking critical information at these types of incidents." Jeremy Hamrick, 101st CST (ID)

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- Surveys also included numerical evaluations each week of the test

INL-2 Exit Survey: Week C	C-01	C-02	C-03	C-04	C-05	C-06	C-07	C-08	C-09	C-10	C-11	C-12	C-13	C-14	C-15	C-16	C-17	Avg
1. Initial Training Sunday																		**4.0**
a. Quality of Sampling Training	5	4	5	4	5	5	3	3	4	4	4	3	4	3	4	4	4	4.0
b. Training Information Provided	4	3	5	3	5	5	3	4	4	4	3	4	4	3	4	4	4	3.9
c. BROOM Training****	4	4	4	3	5	NA	3	4	4	3	3	4	4	3	4	5	5	3.9
d. Length of Training	4	4	4	3	5	5	3	4	4	4	2	5	2	3	5	4	5	3.9
e. Overall Effectiveness of Training	5	4	5	4	5	5	3	4	4	4	3	4	3	3	5	5	5	4.2
2. Test Conduct																		**4.2**
a. Facility	5	5	5	3	5	5	3	4	5	4	3	4	4	4	3	4	4	4.1
b. Techniques	5	5	5	4	4	5	4	5	5	4	4	4	4	4	3	5	4	4.4
c. Tools Provided	5	5	5	4	5	4	4	5	5	4	4	5	4	3	3	4	4	4.3
d. Usefulness of BROOM***	5	4	5	3	4.5	NA	4	4	4	4	3	4	4	4	3	5	5	4.1
3. Overall Experience																		**4.4**
a. Applicability to your present operations	5	4	5	4	4	3	1	4	4	4	4	4	3	4	4	4	5	3.9
b. Did this training help you improve your sampling techniques*****	4	3	5	4	5	4	5	5	5	5	4	5	3	4	3	4.5	4	4.3
c. Was the BROOM useful*	5	5	5	5	5	NA	5	5	5	5	2.5	5	5	5	5	5	5	4.8
d. Usefulness of the test experience	-	4	5	4	5	5	5	4	5	5	4	5	3	4	5	4	4	4.4

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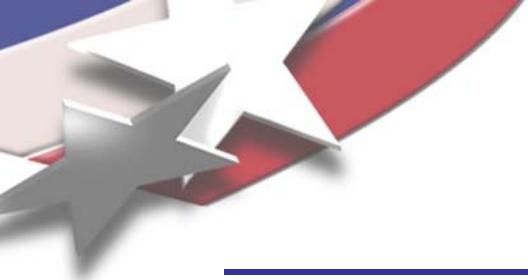
Summary

- The BROOM and WITS systems have the potential to provide the following:
  - Reduce the cost and time of sample collection and data management
  - Eliminate the laborious and error-prone tasks associated with manual data entry
  - Improve decision making through visualization and analysis tools
  - Provide real-time mapping support to incident commanders
  - Sharing of data and analysis results through secure networking
  - Provide a transparent record of what was done
  - Provide a defensible basis for deciding what to do with the facility

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