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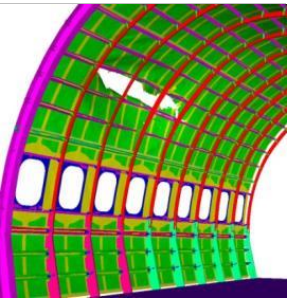

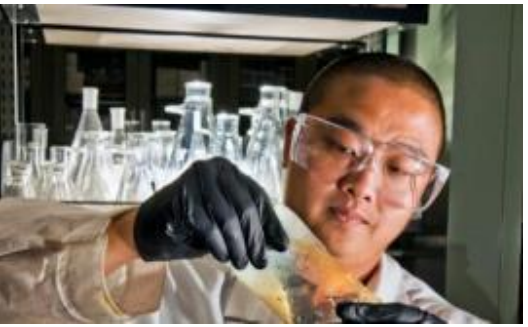

Advances in Sampling and Situational Awareness Using Augmented and Virtual Reality Devices

Bob Knowlton, Scott Olson, & Kurt Hollowell

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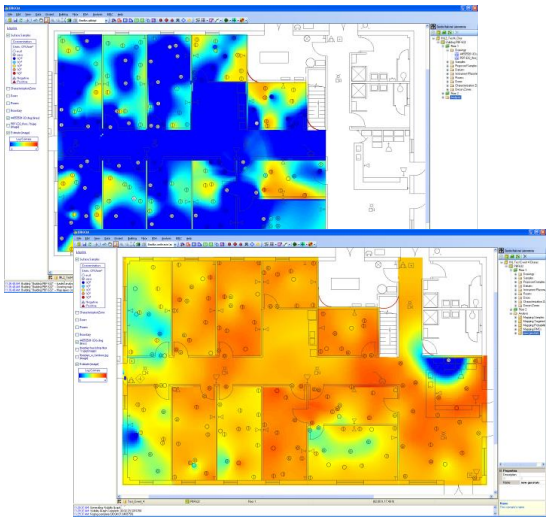
Topics

- Review of sampling practices and tools
- SESSA Capabilities
- 3D Virtual and Augmented Reality Techniques

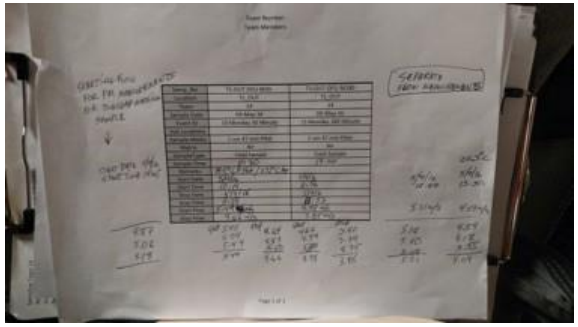
Sampling & Situational Awareness

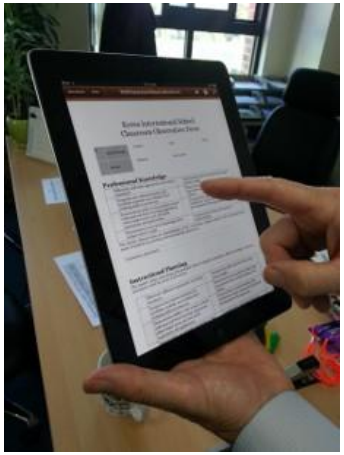
- A need exists for a comprehensive decision support system to aid with sampling design, sample collection, data management, and data analysis (e.g., contamination mapping)
- This need is for chemical, biological, radiological, nuclear, explosives (CBRNE) response and recovery actions (e.g., characterization and clearance sampling), as well as forensic data gathering and sensitive site exploitation
- A comprehensive decision support system has the potential to reduce time and effort with sampling activities and data interpretation, as well as providing rapid situational awareness



Common Sampling Practices

- Traditionally, documentation of sampling activities (e.g., surface wipe sampling, air filter collection) was done with handwritten forms on a clipboard
  - Transcription errors are more prevalent with handwritten forms
  - If the sampling regime has contamination, the forms are placed in plastic sleeves and decontaminated prior to removing them from the area, possibly leading to compromises in the paper media
- More recently, the US Environmental Protection Agency (USEPA) and others have been using Apple iPads with custom forms to document the sampling process through electronic means
- With both of these protocols, the data need to be transcribed or imported into a spreadsheet or database in order to manipulate the data
- Typically, if mapping of the data is desired, a separate software package, such as a Geographical Information System, (GIS) is used





Software for Sampling and Analysis

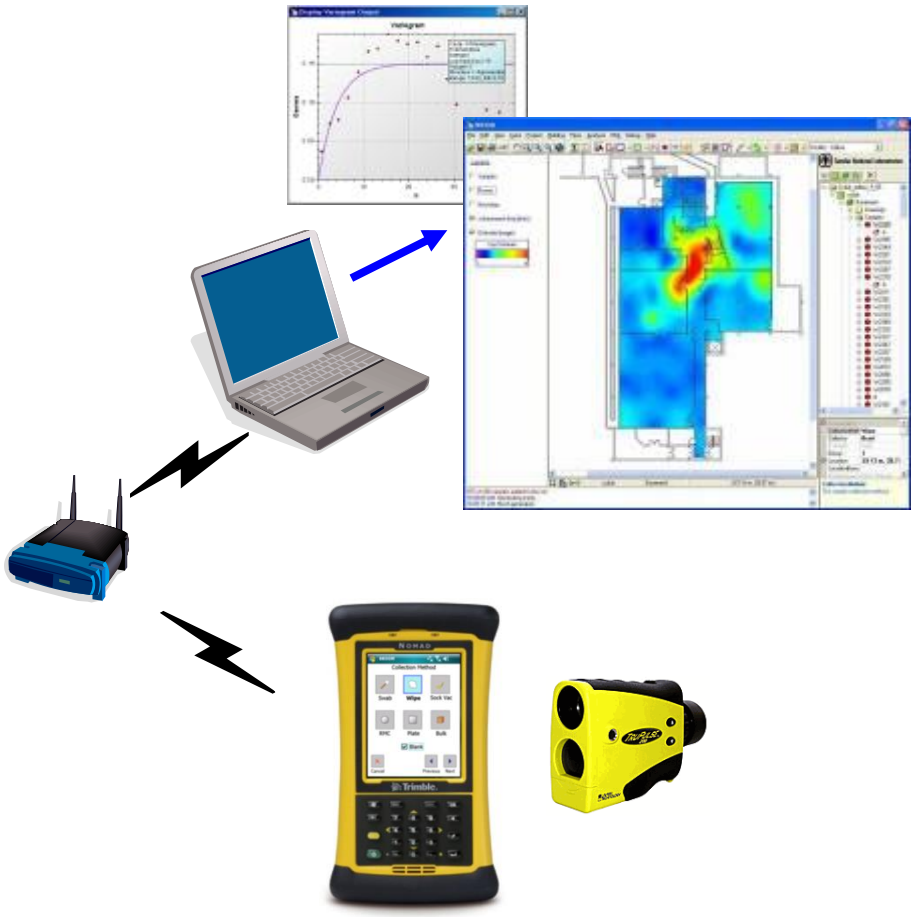
Sandia National Laboratories

- As part of the Department of Homeland Security (DHS) Underground Transport Restoration (UTR) Project, the Sampling & Analysis Working Group surveyed available software to aid with sampling design, sample collection, data management and data analysis
- This summary in no way constitutes a recommendation for use of one or more of these software packages, and may not be a complete list of available systems
- In addition, each software application was evaluated against a set of need statements (e.g., WiFi enabled, GPS enabled/capable, Android/Apple/Windows operating system, mapping, GIS, SQL database, etc.)

Name of tool	Provider
Building Restoration Operations Optimization Model (BROOM)	Sandia National Laboratories (SNL)
Site Exploitation System for Situational Analysis (SESSA)	Sandia National Laboratories (SNL)
Visual Sample Plan (VSP)	Pacific Northwest National Laboratory (PNNL)
Tactical Dynamic Operational Guided Sampling (TacDOGS)	Johns Hopkins University (JHU), Applied Physics Lab (APL)
SCRIBE	U.S. Environmental Protection Agency (U.S. EPA)
EQuIS	EarthSoft
Spatial Analysis and Decision Assistance (SADA)	University of Tennessee

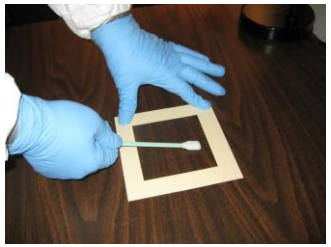
Lessons Learned From Previous Sampling Events

- Sandia National Laboratories (SNL) developed a comprehensive decision support tool called the Building Restoration Operations Optimization Model (BROOM) for the CBRNE need set, and deployed it on numerous government-sponsored release tests, logging thousands of samples
- BROOM was a comprehensive decision support tool that facilitated sampling design, data acquisition (including accurate indoor locations), real-time monitoring of personnel locations, data management, and data analysis (e.g., mapping)



Major Projects Supporting Data Collection, Data Management, and Data Analysis

- SNL supported two separate projects at the Idaho National Laboratory (INL) for the Validated Sampling Plan Working Group (VSPWG) to address GAO (2005) concerns about sampling
  - Each of these two projects had 5 separate releases of Bg in a 2-story building, followed by characterization sampling, decontamination (with chlorine dioxide) and clearance sampling
- SNL supported the EPA's Biological Operational Test and Evaluation (BOTE) project
  - BOTE was a two-phased project, where the first phase evaluated 3 different decontamination methods and the second phase was an operational demonstration
- SNL has supported several other projects with BROOM as well
- In all, BROOM logged on the order of 8,000 samples, never losing a single sample



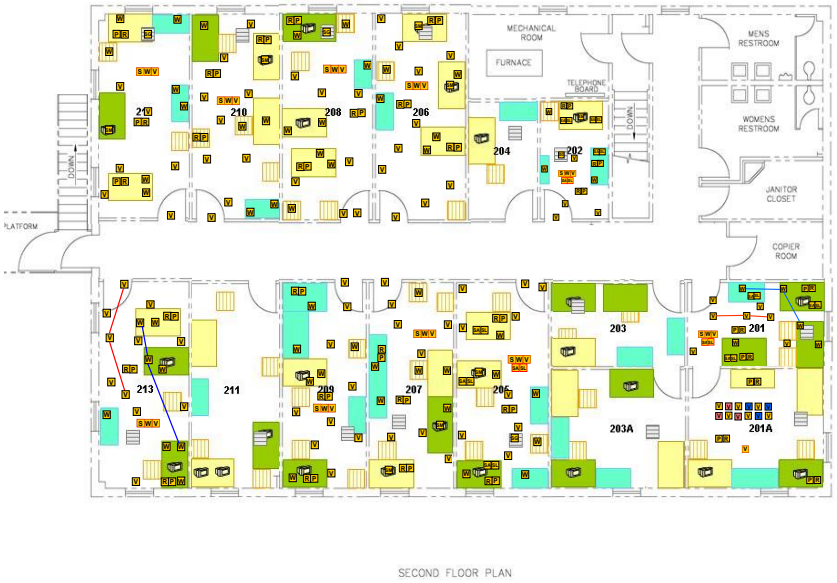
Surface sampling

On-site mobile lab

Sampling team

Lessons Learned From Previous Sampling Events

- Significant effort was employed on these projects to develop accurate building maps (with furniture placement) and sampling designs (with both judgmental and statistical sampling protocols)
- Accurately positioning indoor sampling locations is a significant challenge
- There was a desire to create plume maps as soon as data were available from the lab, which was done within minutes using the BROOM system
- During forensic investigations, significant effort is employed to capture scene measurements and photo documentation before any evidence is collected or samples taken
- Methods to streamline these activities are desired

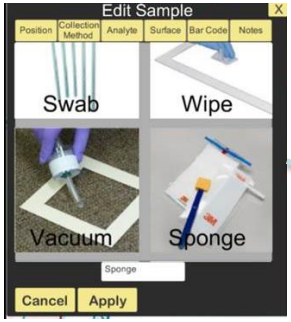


SECOND FLOOR PLAN

SESSA

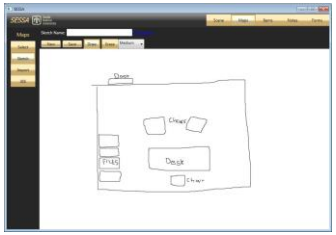
- BROOM became dated, and lessons learned from it were used as the foundation for development of the SNL's Site Exploitation System for Situational Awareness (SESSA)
- SESSA's architecture has been modernized:
  - Web services module for data storage in the Cloud or a secure server, including track changes
  - Tablet computers or smart phones that facilitate scenario design, sample collection, and data analysis on Windows and Android platforms (could add iOS)
- SESSA also includes 3D Virtual Reality (VR) and Augmented Reality (AR) techniques
  - Utilizing new commercial hardware and custom software applications

SESSA (continued)



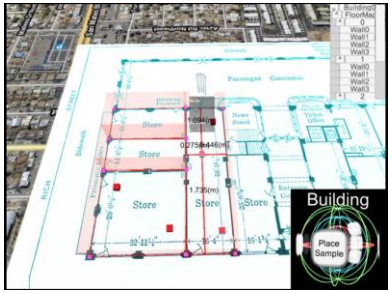
Data collection

3D virtual scene walk-thru & photos

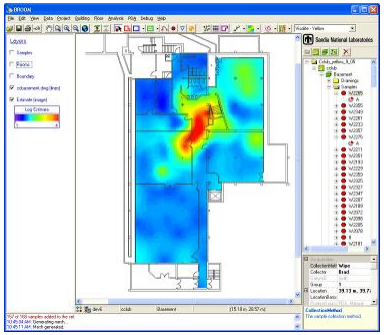


Sketch pad

Barcode scanning



Mapping & sample placement

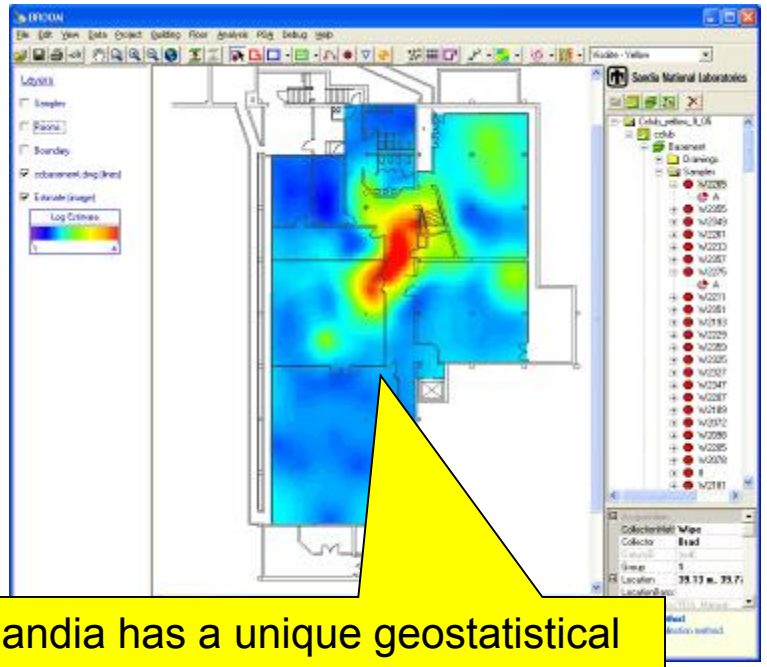


Heat map generation

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
- The tool can also provide contour maps using conventional contouring techniques

Expected Value Map



Sandia has a unique geostatistical technique that accounts for walls and doorways

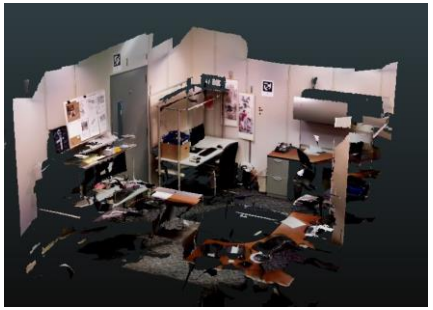
Maps can be produced within minutes of the data uploads for real-time situational awareness

VR & AR Capabilities

- New SESSA capabilities:
  - New hardware for virtual reality (VR) and augmented reality (AR) capabilities is truly modernizing our SESSA functionality and should revolutionize our ability to provide rapid situational awareness for first responders and decision makers
  - VR capability
    - A 3D synthetic representation of a scene (e.g., point cloud data) or computer generated imagery that can provide a virtual walk-through capability
  - AR capability
    - A wearable headset that allows the user to see his/her surroundings with holographic insertions of synthetic data

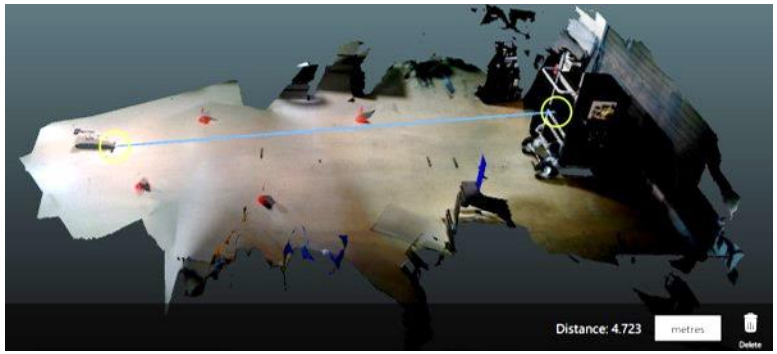
VR Capabilities

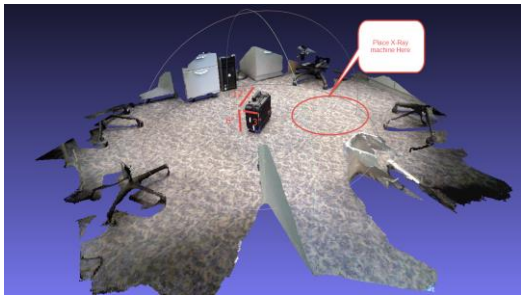
- New VR capabilities:
  - SNL developed a prototype VR device for SESSA several years ago based around the Microsoft Kinect visual-depth sensor to capture 3D point cloud data
  - The Kinect platform provides a low-cost alternative to conventional laser-based VR scanners that cost between $45K and $100K+, and tend to be too fragile for many applications, have significant processing time, and result in large file sizes that are difficult to share remotely
  - Recently several commercial entities have developed better variants of the Kinect sensor platform
  - The DotProduct VR device was chosen for integration with SESSA, which costs ~$5,100
  - Spatial dimensioning and measurements with a 3D scan have centimeter level accuracy
  - The DotProduct device produces real-time 3D point-cloud results with manageable file sizes (e.g., 4Mb to 12Mb file for a typical office space)



VR Capabilities

- DotProduct VR applications :
  - Mapping and measuring interior spaces, sharing that information with a Home Team or Incident Command
  - Facilitating more rapid Xray Tool Kit (XTK) explosive/radiation device scans, sharing that situational awareness with remote team members
  - Facilitating situational awareness of environmental sampling and forensic sampling, with an emphasis on sharing that information through 3D virtual walk-throughs by remote decision makers
  - Training and exercise aid



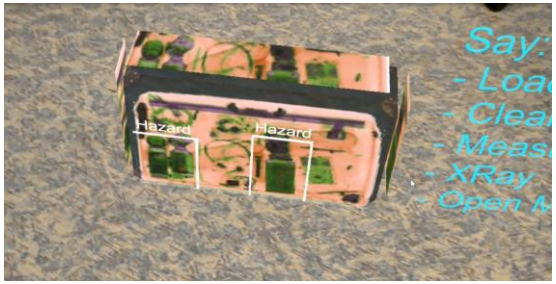


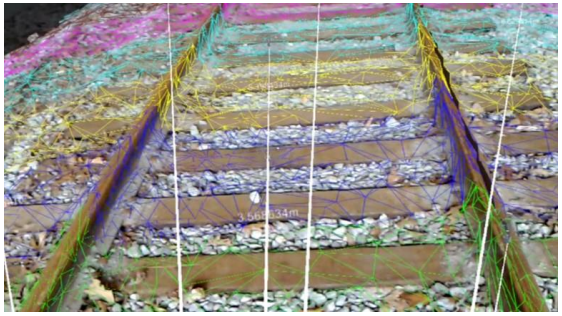
AR Capabilities

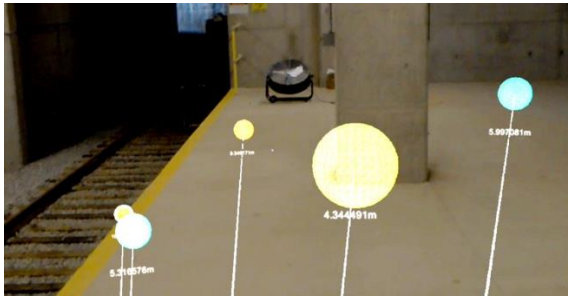
- New AR capabilities:
  - Microsoft HoloLens AR device
    - A wearable heads-up display that projects holographic information on the display
    - The headset has it's own visual-depth sensor, a CPU, data storage, Bluetooth, and WiFi
    - The device can be networked to share information with other users of HoloLens devices
    - Voice and hand-gesture controls allow users hands-free operation
    - Can be worn under Personal Protection Equipment (PPE) head gear (e.g., Powered Air Purifying Respirator (PAPR) hood)
    - Spatial dimensioning and measurements with a 3D scan have centimeter level accuracy
    - The HoloLens costs ~$3,000

AR Capabilities

- HoloLens AR applications :
  - First responder sampling activities, including pre-defined sampling locations, documentation of sample collection, display of sampling results, sharing information in real-time between sampling teams
  - Radiation detection surveys
  - Facilitating more rapid X-ray Tool Kit (XTK) explosive/radiation device scans, sharing that situational awareness with remote team members
  - Mapping and measuring interior spaces
  - Desktop holographic display of situational awareness data (e.g., city view, building interiors, responder locations, etc.)
  - Training and exercise aid

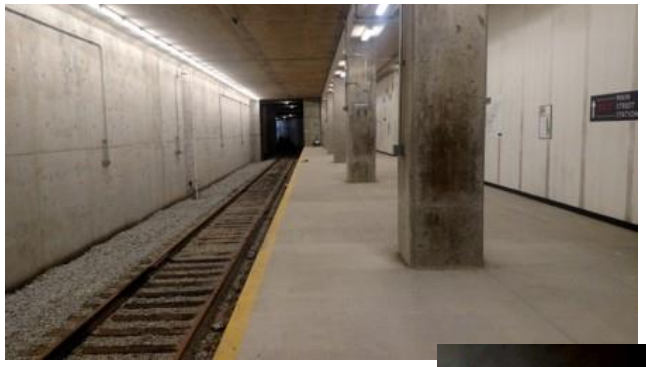


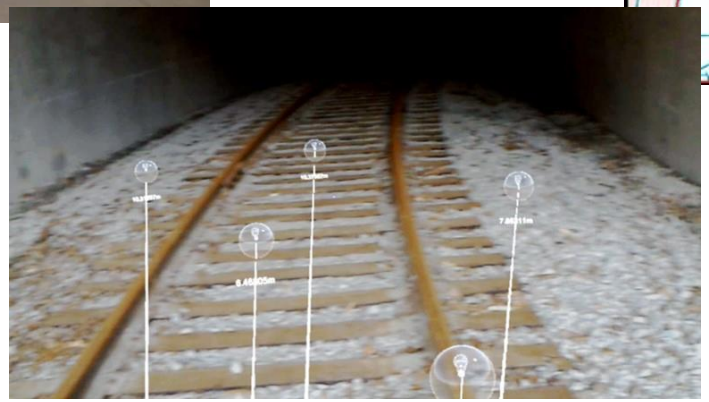


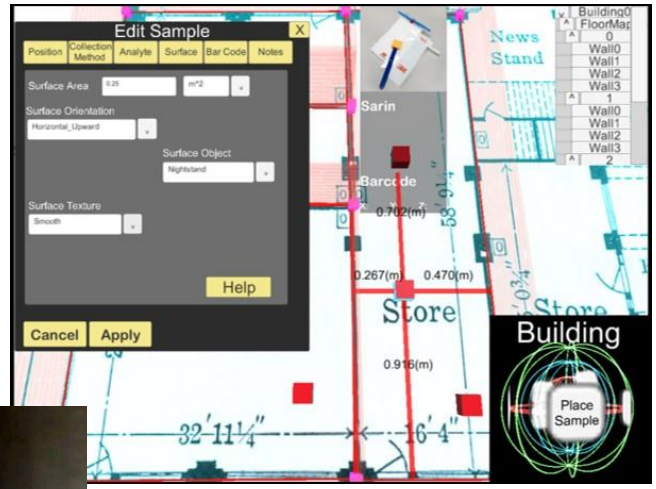


Indoor Geolocations

- SNL has a patented laser range finder technique that provides accurate (down to several cm) coordinates for indoor sample locations where GPS does not work
- SNL tested this method at the recent UTR Operational Test and Demonstration (OTD) venue at the Fort AP Hill mock subway
- The HoloLens and DotProduct devices were also tested at Fort AP Hill

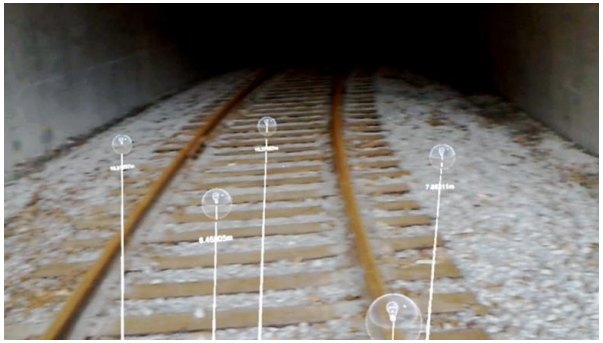


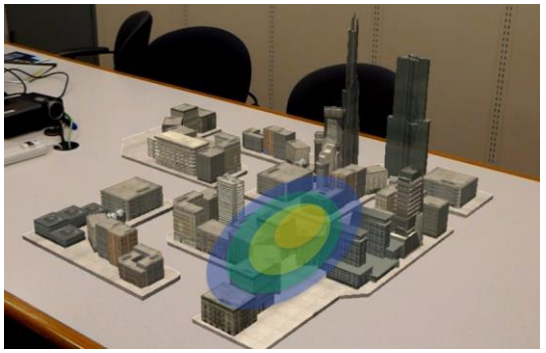




The Future of Sampling & Situational Analysis

- The new VR and AR technologies offer a paradigm shift in the way we approach sampling
- One can envision the following:
  - Samplers enter a building and capture the scene with a VR device and a HoloLens, then send the scans to the Technical Working Group (TWG) and/or the Incident Command
  - A virtual walk-through is performed, sampling locations selected and input within the 3D virtual scene
  - The sampling locations are input to the HoloLens for use by the sampling teams, as well as the VR scene on tablet computers
  - Once sample results are available, plume maps are prepared and displayed in a 3D holographic projection with the HoloLens
  - The same process is proposed for clearance sampling





Summary

- Previous experience with large-scale sampling events have shown a need for rapid situational awareness, measurement capabilities, sampling design, accurate sample locations, electronic data acquisition, data management, and data analysis
- The new VR and AR techniques have the potential to provide a paradigm shift in the way we perform these tasks by reducing time and providing greater accuracy than conventional techniques