DEFENSE THREAT REDUCTION AGENCY
8725 JOHN J. KINGMAN ROAD, STOP 6201
FORT BELVOIR, VA 22060-6201

December 30, 2022

John Greenewald, Jr.
27305 W. Live Oak Rd
Suite #1203
Castaic, CA 91384

Re: FOIA Case No.: 18-054

Dear Mr. Greenewald:

This is the final response to your Freedom of Information Act (FOIA) request perfected on May 28, 2018, and assigned FOIA case number 18-054 by the Defense Threat Reduction Agency (DTRA). You requested a copy of records, electronic or otherwise, of all manuals, operating procedures, instruction booklets, information pamphlets, etc. for Discreet Oculus network and sensors.

Enclosed are copies of documents responsive to your request totaling 85 pages. Some information is being withheld under FOIA Exemption 3. Exemption 3 applies to information specifically exempted from disclosure by a statue. In this case, the information is withheld under 10 USC 130, authority to withhold unclassified technical data with military or space application. No fees are due as the assessable costs total $25.00 or less.

Responsibility for the Discreet Oculus Program was transferred to the Air Force Technical Application Center (AFTAC). Therefore, it is recommended that you contact the Air Force for copies of the other documents you requested.

Determinations for this release were made by the Initial Denial Authority (IDA), Mr. Earl Washington, Chief, Records Management, FOIA, and Privacy Act Division / DTRA Records Officer, Information Management and Technology Directorate, on behalf of DTRA. If you consider this decision to be an adverse determination, you may file a written appeal that is postmarked no later than 90 calendar days after the date of this letter to the Deputy Director, Defense Threat Reduction Agency, Information Management and Technology Directorate, ATTN: FOIA/PA Office, 8725 John J. Kingman Road, MSC 6201, Fort Belvoir, Virginia 22060. The appeal should reference the FOIA/Privacy Act case number, contain a concise statement of the grounds upon which the appeal is brought, and a description of the relief sought. A copy of this letter should also accompany your appeal. Both the envelope and your letter should clearly identify that a Freedom of Information Act and/or a Privacy Act Appeal is being made.

Should you have additional questions or concerns regarding this case, you may seek dispute resolution services from the DTRA FOIA Public Liaison or the Office of Government Information Services (OGIS). The DTRA FOIA Public Liaison, Mr. Mario Vizcarra, may be contacted by phone at (703)767-1792 or by email at dtrafoiaprivacy@mail.mil. The contact information for OGIS can be found at www.archives.gov/ogis.

Sincerely,

Eugene McGirt

Eugene McGirt
FOIA/Privacy Act Specialist
Freedom of Information/Privacy Act Office

Enclosure(s):
As stated

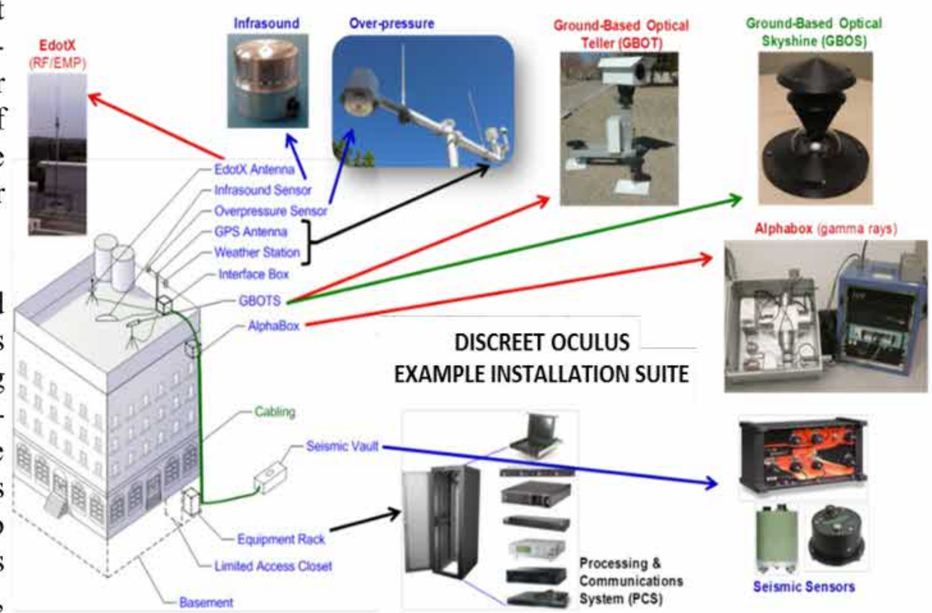
DTRA Installing Sensor Stations to Detect, Analyze Nuclear Attacks

DTRA has installed prompt nuclear effects sensor stations, such as the ones above, in U.S. metropolitan areas as part of Discreet Oculus, a prototype sensor network. Before installing the stations, DTRA conducted explosive-based yield estimation sensor tests, including the one above, to validate the functionality of the sensors. DTRA also conducted a nuclear forensics demonstration in mid-2015 called Mighty Saber that validated the capabilities of Discreet Oculus.

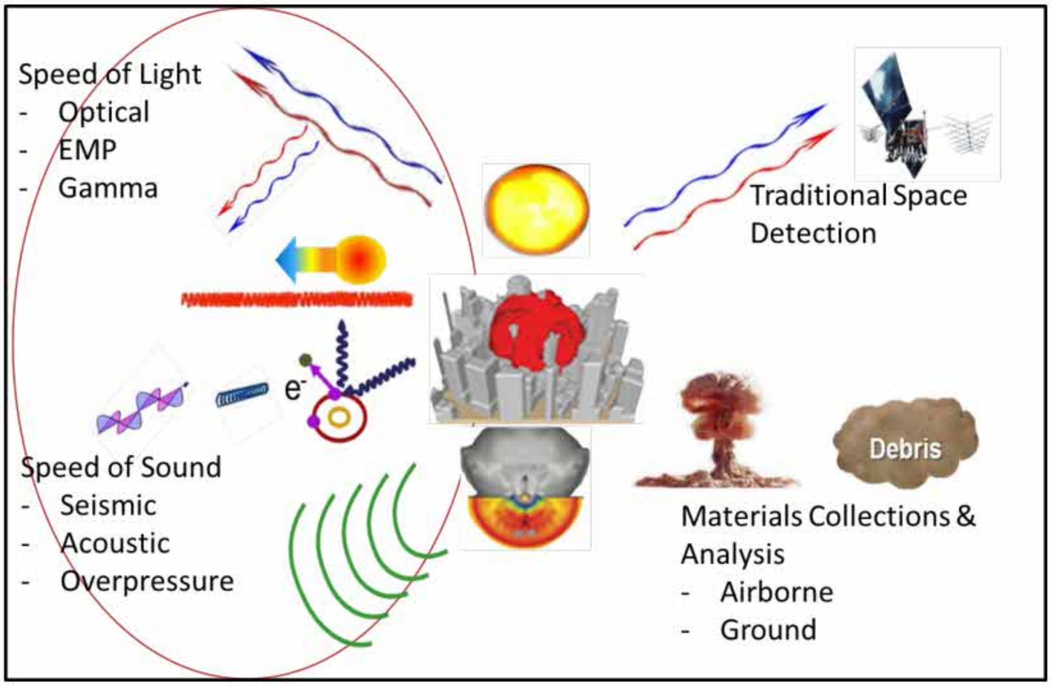
The Discreet Oculus Prompt Diagnostics Sensor System is a research and development effort to create a ground-based prompt detection and diagnostics system. The system complements current global- and space-based prompt nuclear effects monitoring systems. It is designed to support the United States Government's efforts to develop timely and accurate technical nuclear forensics conclusions after a nuclear attack on the U.S.

Information collected by this system after an attack will be used to help national and military leaders identify what was detonated, where the materials came from, and who launched or supported the attack. The system has been installed in two metropolitan areas and an installation in a third metropolitan area has begun.

To validate Discreet Oculus' capabilities, DTRA conducted a first-of-its-kind interagency nuclear forensics demonstration in 2015 called Mighty Saber. The demonstration, executed by 16 organizations over 21 days in July and August 2015, successfully met each of its objectives, including demonstrating U.S post-detonation nuclear forensics processes and the value of prompt diagnostics data provided by the Discreet Oculus ground-based sensor network.



The demonstration additionally showed how prompt diagnostics complements traditional radiochemistry in providing a robust post-detonation nuclear forensics capability. It also established the first-ever nuclear forensics process baseline and provided opportunities to explore nuclear forensics interactions with intelligence, law enforcement, and policy communities.



Discreet Oculus monitors and collects prompt nuclear signals such as seismic, acoustic, air pressure, radiation, optical and radio frequency waves, as illustrated on the far left of the figure, and is part of a complete technical nuclear forensics capability that includes traditional space detection capabilities and material collections and analysis technologies.

Develop Initial Capability

Discreet Oculus monitors and collects seismic, acoustic, air pressure, radiation, optical, and radio frequency waves to help weapons of mass destruction experts determine the yield, geolocation and other device characteristics of a nuclear attack to enable the attribution process.

Test, Demonstrate and Evaluate

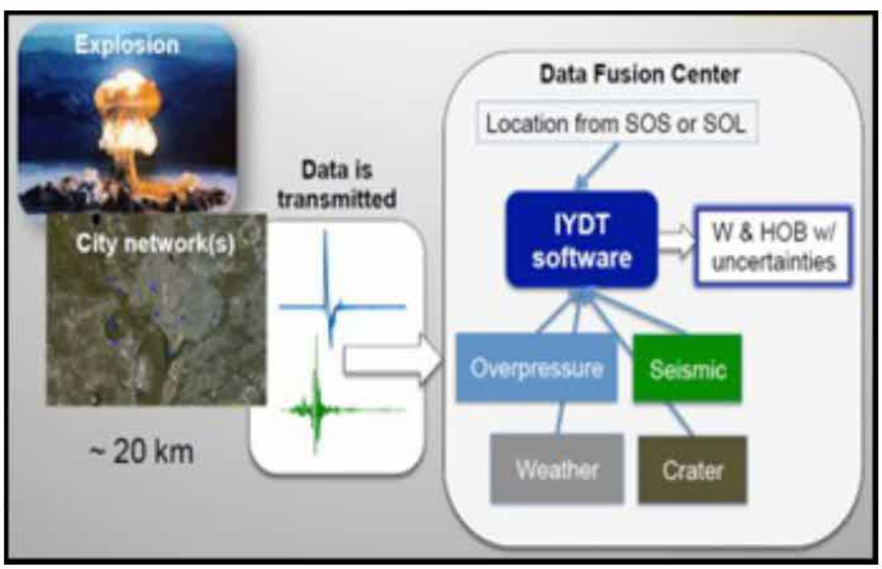
Extensive sensor performance testing, several modeling and simulation, and technology demonstrations continue to be leveraged to verify system performance and achieve necessary technology readiness levels to transition Discreet Oculus' capability to the United States Air Force starting in 2018.

Process Data

Discreet Oculus integrates data from up to nine different sensor types to create actionable information that can be used by senior leaders in the attribution and law enforcement communities.

Recent Accomplishments

The recently installed sensors will become part of a growing nationwide network to instantly send information to a data fusion center at the Air Force Technical Applications Center located on Patrick Air Force Base, Florida. Additional sensor stations near large metropolitan areas will ensure robust sensor network coverage.



Integrated yield determination tool data flow

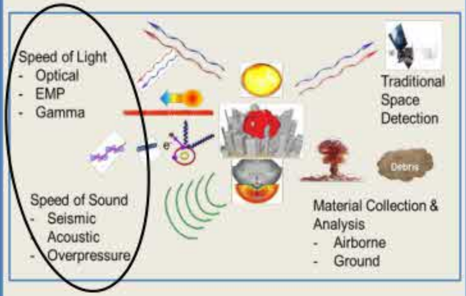
DTRA-J9 Research, Development, Testing and Evaluation

Managing research, development and technology integration to overcome capability gaps and protect the warfighter in a CBRNE environment

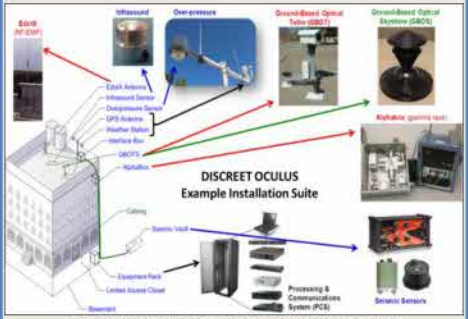
Nuclear Technologies

DISCREET OCULUS (DO) is a research and development effort to create a ground-based prompt detection and diagnostics system designed to characterize urban nuclear events to support US government's attribution efforts. DISCREET OCULUS complements current global- and space-based systems and is scheduled to transition to the USAF under the U.S. Prompt Diagnostics System (USPDS) starting in 2018.

Develop Initial Capability



DO monitors and collects seismic, acoustic, air pressure, radiation, optical, and radio frequency waves to help WMD experts determine the yield, geolocation, and other characteristics of a nuclear attack to enable the attribution process.



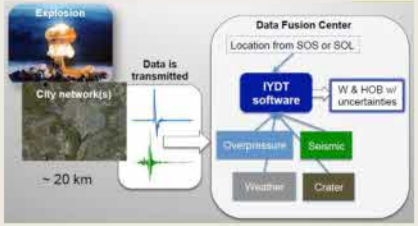
DISCREET OCULUS Prompt Diagnostics Ground-Based Sensor System

Test, Demonstrate, & Evaluate

Extensive sensor performance testing, modeling & simulation, and technology demonstrations continue to be leveraged to verify system performance and achieve necessary technology readiness levels to transition this initial prototype capability to USAF.

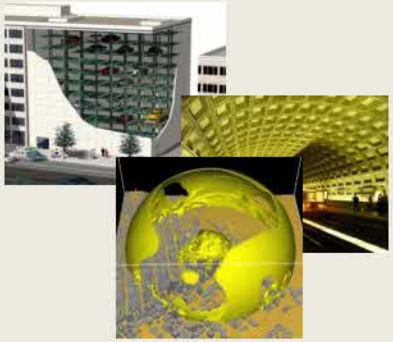
10-ton ANFO on Alluvium Lithology (top) and Tunnel Shot (bottom) Yield Estimation Sensor Tests

Process Data



Data flow for Integrated Yield Determination Tool

DO integrates data from up to nine different sensors types to create actionable information that can be used by senior leaders in the attribution and law enforcement communities.



System modeling for sensor and system performance evaluation

Recent Accomplishments

Recently installed sensors will become part of a growing nationwide network to instantly send information to a data fusion center at the Air Force Technical Applications Center (AFTAC) located on Patrick Air Force Base, FL. Additional sensor stations near large metropolitan areas will ensure robust sensor network coverage.

Mr. Kenneth A. Myers III, Director, DTRA/SCC-WMD, Observes Installation (top) and Conducts a Ribbon Cutting (bottom) for Completion of a DISCREET OCULUS Site Prototype

DTRA PA# NT-15-552

Improved transport modeling to support post-detonation nuclear forensics

Thomas Cartledge*, Michael Pochet, Kevin Mueller, Roger Roberts

Defense Threat Reduction Agency, 8725 John J. Kingman Road, Fort Belvoir, VA 22060
**Thomas.e.cartledge.civ@mail.mil*

INTRODUCTION

Following a nuclear attack, the timely and accurate determination of the weapon design origin is necessary to support attribution. The signals generated at the time of a nuclear weapon's detonation, collected using various sensor types to enable *prompt diagnostics*, are key to deducing weapon design.

The Defense Threat Reduction Agency (DTRA) is developing improved capabilities to model the propagation of prompt nuclear signals in the urban environment. The understanding of how these signals propagate in the urban environment is necessary to support accurate conclusions.

In President Barack Obama's 2009 speech in Prague, Czech Republic, he stated that "black market trade in nuclear secrets and nuclear materials abound. The technology to build a bomb has spread [1]." The changing threat has created new information requirements in order to attribute responsibility and hold any state involved accountable. In addition to faster response time, the ability to determine the design origin of a weapon used in a nuclear attack is necessary to deter the proliferation of nuclear weapon designs, materials, and technologies, as well as their use. With the most likely use of nuclear weapon being a terrorist attack on a key U.S population center, understanding how nuclear weapon effects transit through an urban environment is essential to determine the design origin.

Nuclear forensics analysis has been primarily focused on materials analysis, where the goal is to provide information on the source of the nuclear material and the route it followed before its interception by authorities [2]. The spectrum of post-detonation nuclear forensics analysis is described in reference [3].

The ability to collect the time-of-detonation prompt signals (optical, radio frequency, gamma, seismic, acoustic, and overpressure), coupled with an understanding of how the signals propagate from the weapon location to distant sensors, is fundamental to decreasing analysis timelines and determining design attributes indicative of the weapon's developmental origin. The propagation of the detonation signals in the urban environment presents a complicated problem, amplified by the fact that experimental data is limited due to the cessation of above ground tests in 1962 and cessation of all nuclear weapon tests and yield-producing nuclear weapons experiments since 1992. While there is a wealth of historic nuclear weapons test data, very little of that data is applicable to understanding how the outputs of nuclear weapons transit through an urban environment with significant reflection and obscuration.

This paper describes DTRA's approach to modeling the influence of the cityscape from signals generated by a nuclear weapon's detonation.

URBAN IMPACTS ON DETONATION SIGNALS

The simulated transport of signals through a cityscape following a nuclear detonation is dominated by the interactions of particles with the environment. In most cases the transport and simulation of particles through a cityscape following a nuclear detonation is computationally intensive, requiring hundreds of hours. This lengthy computational time results from including signal interactions not only with buildings, but also the soil, air, and all other media that lie along the path of travel.

DTRA is developing Monte Carlo and finite element modeling capabilities for various speed-of-light (gamma, radio-frequency, photonic) and speed-of-sound (seismic, overpressure, infrasound) signal phenomena generated at the time of a nuclear weapon's detonation.

Speed-of-Light Detonation Signals

DTRA's comprehensive approach to the urban transport problem for speed-of-light signals involves the integration of cityscape layout data using U.S. Government geospatial data (Light Detection and Ranging (LIDAR) shapefiles), FEMA's Hazus database, and individual building characteristics (i.e., concrete vs. steel construction). Figure 1 illustrates the geospatial data for New York City, where a 2m x 2m x 1m mesh resolution is used in modeling the propagation of signals from nuclear weapon source to sensor.

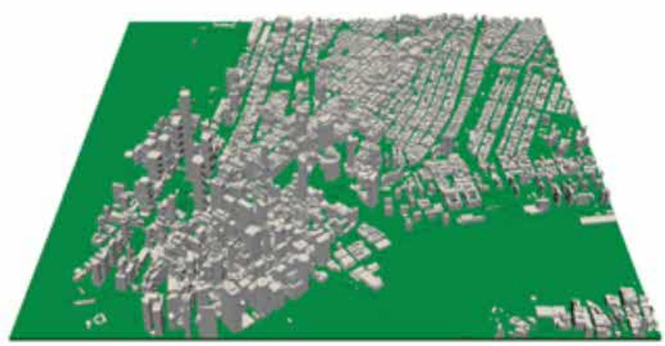


Fig. 1. 3x3 km^2 section of New York in a 2x2x1 m^2 mesh.

With the understanding that buildings of varied exterior type (i.e., concrete, steel, glass) have a varied impact on the propagation of neutrons, photons, and electrons, DTRA has characterized buildings within the geospatial data illustrated in Figure 1. DTRA has added internal building features to its modeling, to include doorways, inner walls, and floors/ceilings, as shown in Figure 2. Atmospheric features are also added to urban models to account for the varied refractory properties above the city, as depicted in Figure 3. At this time DTRA is uncertain whether this level of fidelity is necessary to support its analysis. Comparisons will be made with cases where buildings are simple, homogeneous structures.

The Monte Carlo N-Particle (MCNP) code from Los Alamos National Laboratory is the primary tool for transporting particles through the urban environment [4]. For this endeavor the cityscape shown in Figure 1, along with numerous other cities with LIDAR data available, is implemented within MCNP.

The MCNP simulation results for high energy photons commensurate with the output of a nuclear detonation and their propagation in the cityscape are given in Figure 4.

Additional areas where DTRA's work has improved capabilities include modeling electromagnetic pulse (EMP) and photon energy ranges. To improve the capability to simulate Teller-Light, the range of photons energies that can be simulated has been extended down to approximately 100 electronvolts.

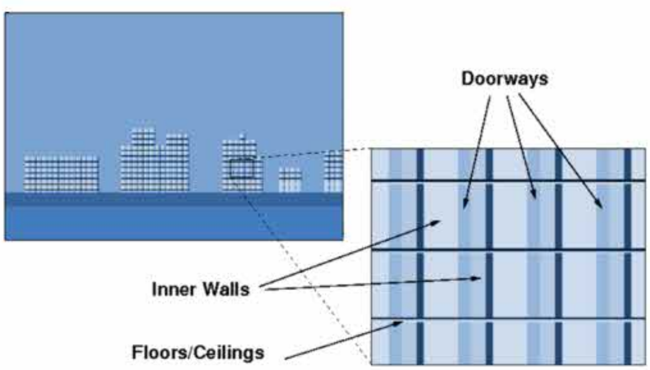


Fig. 2. Depiction of the level of detail for MCNP modeling of buildings, which captures interior features including inner walls, doorways, and floors/ceilings.

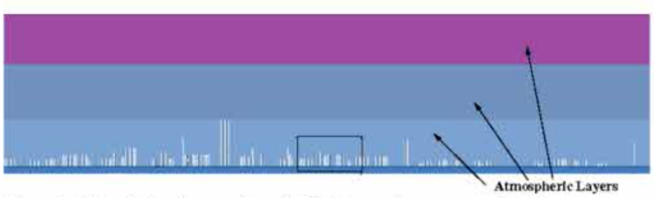


Fig. 3. Depicts atmospheric features incorporated in transmission modeling. Each layer is given the appropriate refractory characteristics in the MCNP model.

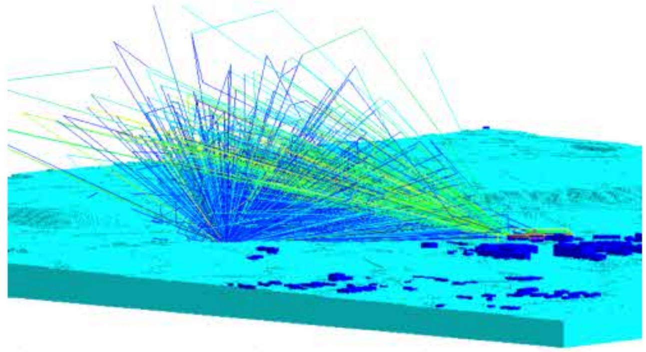


Fig. 4. Example transmission tracks of high energy photons from a nuclear detonation source to a sensor, modeled using MCNP. Blue tracks represent unscattered photons. A color change represents a scattering event due to the varied refractory properties of the atmosphere.

The ability to model RF signals in the complex urban environment has benefited from advancement in high performance computing capabilities, where entire cities can be resolved in mesh sizes never thought possible in the nuclear testing days. This effort leverages historic nuclear test data to develop and validate expertise in prompt signals propagation. The simulation of EMP has been improved with the addition of a three-dimensional first-principles capability based on MCNP and FDTD (finite-difference time-domain). These approaches improve accuracy and reduce the uncertainties of simulations performed in the cityscape.

To validate our models and transport calculation we have implemented a progressive test campaign. Up until October 2015 our test focused on independent validation of sensor performance and transport calculation for each speed of light phenomenology (gamma, radio-frequency, photonic). In October, with support from NNSA NA-22, Sandia National Labs, Los Alamos National Labs, and Livermore National Labs, we set up a three week test program at the HERMES facility at Kirtland Airforce Base. For the HERMES test we had all the speed of light sensor in the surrounding field collecting against a common source. This is the first opportunity where we will be able to compare results of all the sensors. Idealistically they should all come back to a common analysis of the source, but environmental influences and uncertainties will like create some challenges. The HERMES test collected approximately 46 sets of shot data. We're currently analyzing the data and plan to publish a final report in October 2016.

There are two future tests planned. The first is a test of all sensors at the White Sands Fast Burst Reactor in late 2017 where we have a difference source that provides a rise time different than HERMES. The second test is to use the models and transport calculations that were validated at

HERMES test and using our historic nuclear weapon test data, swap out the source and re-run our transport calculations to see how well our results compare to historic test data.

Unfortunately, most of our work with speed of light is associated with nuclear weapon output and not available for open discussion.

Speed-of-Sound Detonation Signals

Analogous to the speed-of-light signal propagation through an urban environment, the propagation of seismic and overpressure signals are heavily impacted by the urban landscape. For the purposes of seismic analysis, effects of a city's underground structure (buildings, utilities, mass transit, etc.) results in changes to the coupled signals. To accomplish such analysis, geological models are overlaid with information from various databases.

The seismic and overpressure signals that are measured can be compared with existing models that help to derive yield estimates and location information.

Three-dimensional Eulerian computational fluid dynamics codes leverage the three-dimensional terrain and buildings used in speed-of-light signal modeling. The numerically modeled air blast/overpressure wave, pictured two-dimensionally in Figure 5, provides insight into how such signals travel through the cityscape environment. The improved understanding of the cityscape's impact helps improve fidelity of weapon yield assessments.

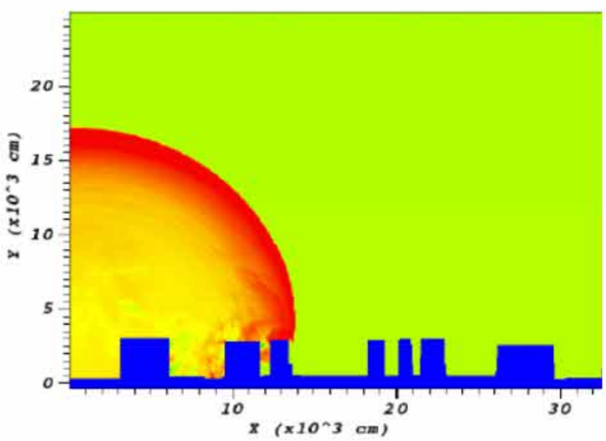


Fig. 5. Snapshot of a representative airblast signal as it interacts with building structures, shown in 2D.

Our test program to validate our speed of sound transport is much more advanced than what has been done for speed of light. DTRA has conducted a variety of tests nsince 2012 that looked at de-coupling, unique urban structures (parking garages and tunnels), different soil geologies, and near surface interaction of seismic and infrasound signals. Modeling and signal transport calculation have been used for every test to validate detector response and algorithms. These results have been used by the national laboratories and DTRA contractors to improve our ability to characterize the yield and location of a nuclear weapon detonation in an urban environment.

Later in 2016 DTRA will host another test for speed of sound sensors. The test scenario involves a weapon detonated in water (e.g. hull of a ship in a harbor). There will be a series of test shots focused at understanding the influence of the water barrier on land based sensors as the shock wave passes though the water and couples with the ground.

Existing treaties and agreements have helped eased the sensitivities associated with sharing or speed of sound data associated with characterization of a weapon's yield and location. May of the organizations supporting DTRA's research have published papers on improved algorithms and transport calculation. The vast majority of research has been associated with localized (urban centers) signals, but starting in 2016 DTRA has expanded some research into regional applications to monitor multiple urban centers.

CONCLUSIONS

The 21st Century threat has generated different information needs within the U.S. government to attribute responsibility. The technical nuclear forensics process that supports attribution has created new capabilities that complement traditional capabilities and improve both the timeliness and fidelity of information. Critical to these capabilities and process is the ability to understand and model how post-detonation nuclear weapon phenomenology transports through an urban environment. The detailed fidelity of speed-of-light and speed-of-sound signal simulation requires high performance computers to produce results in a reasonable and realistic time period. The isotopic interactions of these simulation are dependent on the accuracy of the cross-sections and other data used to describe the cityscape environment.

To support this effort, DTRA is working closely with the Department of Energy's National Nuclear Security Administration (NNSA) to thoroughly understand the signals received with high-confidence and to quantify the sources of uncertainty.

REFERENCES

1. Speech delivered by President Barack Obama, Prague, Czech Republic, April, 2009.

2. K. MOODY, I. HUTCHEON, P. GRANT, *Nuclear Forensic Analysis*, Taylor & Francis, Boca Raton, 2005.

3. R. STONE, "Who Dropped The Bomb," Science, **351**, *6278*, 1138 (2016)

4. J. BREISMEISTER; *"MCNP - A General Purpose Monte Carlo N-Particle Transport Code, Version 5,"* LA-UR-03-1987, Los Alamos National Laboratory (2003).

Technical Nuclear Forensics (TNF)

Office of Nuclear Forensics

DISTRIBUTION STATEMENT A. Distribution unlimited

Problem: The Threat has Changed – Leaders have Different Information Needs

- Cold War Threat (Adversary Known)Global nuclear exchange with Soviet UnionMassive first strikeHigh consequence, low probabilityUncertainties were overcome with yield and quantity21st Century Threat (Unknown Adversary)Increased probability of some level of nuclear exchange due to proliferationNuclear threat from non-state actorsLimited exchange, likely from escalation of conventional warPre-emptive attack on critical infrastructure

New Information Requirements: Identification: What was it?Are there more?Who did it?Where did it come from?

DTRA's Role in Nuclear Forensics

Annex IV to NSPD-17/HSPD-4 "National Technical Nuclear Forensics" (NTNF)USG policy to "…improve the global capacity for forensic and technical attribution of WMD… and develop and maintain effective capability to conduct TNF…"Roles and Responsibilities – in coordination with Attorney General and consultation with other Departments:DoD: Develop post-detonation nuclear sample collection capabilities and ensure lab capabilities support TNF analysis requirements.DoDD 2060.04 "DoD Support to the NTNF Program"DoD further tasks DTRA to manage DoD NTNF R&D programs and coordinate them with the Services and other non-DOD National Technical Nuclear Forensics (NTNF)-relevant R&D

DTRA's Office of Nuclear Forensics

- **Nuclear forensics is an integral component of the broader process of attribution, which fuses investigation, intelligence, and nuclear forensics information, to identify the source of the material or device and the persons or groups responsible for its use in planned or actual acts of terrorism. Mission: Design, develop, demonstrate, and transition advanced technologies and methodologies that improve the interagency operational capability to provide forensics conclusions after the detonation of a nuclear device.Goal: Determine the characteristics of the nuclear material or device and whether associations exist among people, places, things, and events.**

(U) Dog; 1951 @ Nevada Test Site

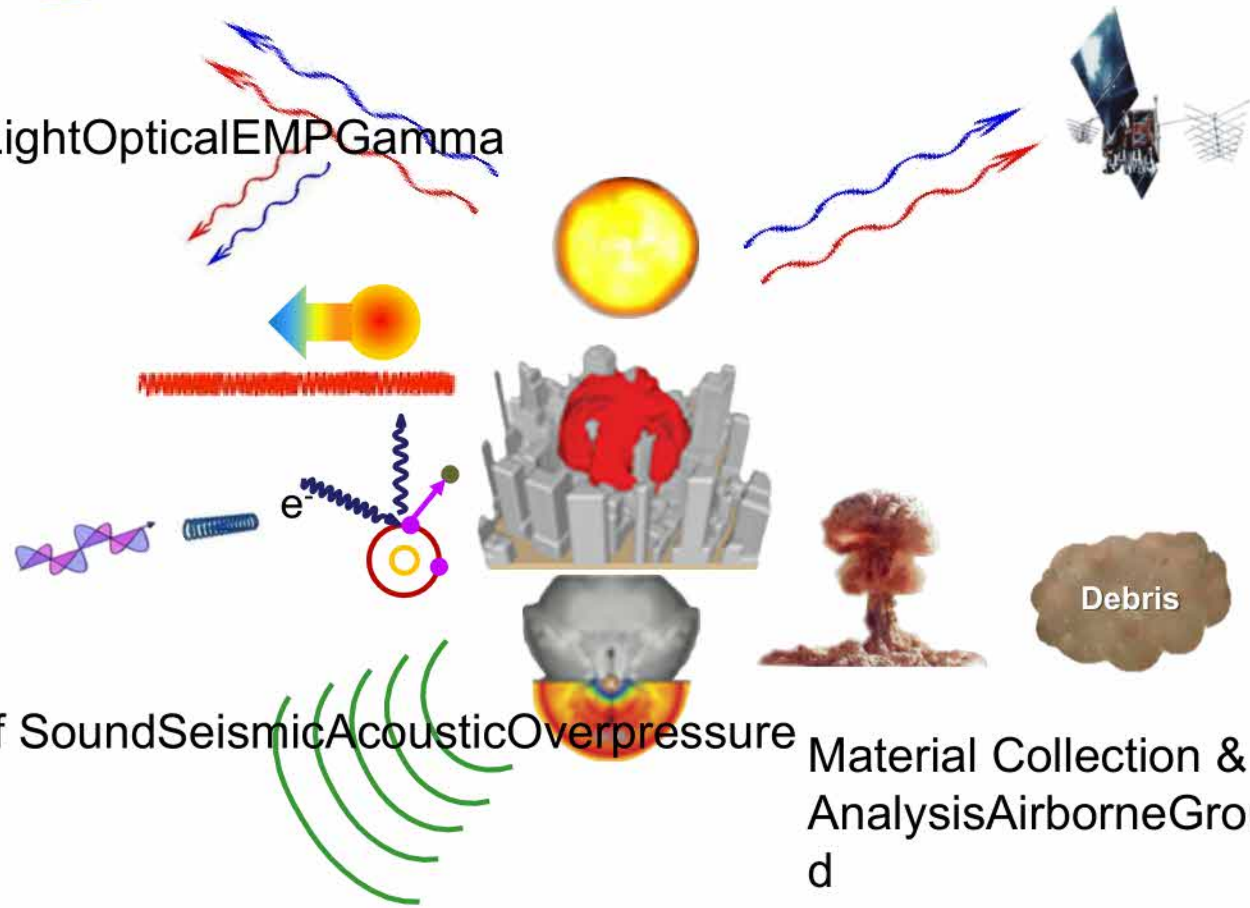
(U) Grable; 1953 @ Nevada Test Site

Office of Nuclear Forensics

- Three Programs addressing the span of the TNF process to enable strategic decision-making (attribution)Nuclear Forensic Materials Exploitation for Attribution Prompt Nuclear Forensics Exploitation for Attribution Nuclear Device Characterization for Forensics Lead a coordinated interagency and international effort to decrease process timeline, increase results confidence and decrease uncertainties

Goal: provide direct answers to the attribution community and decision makers

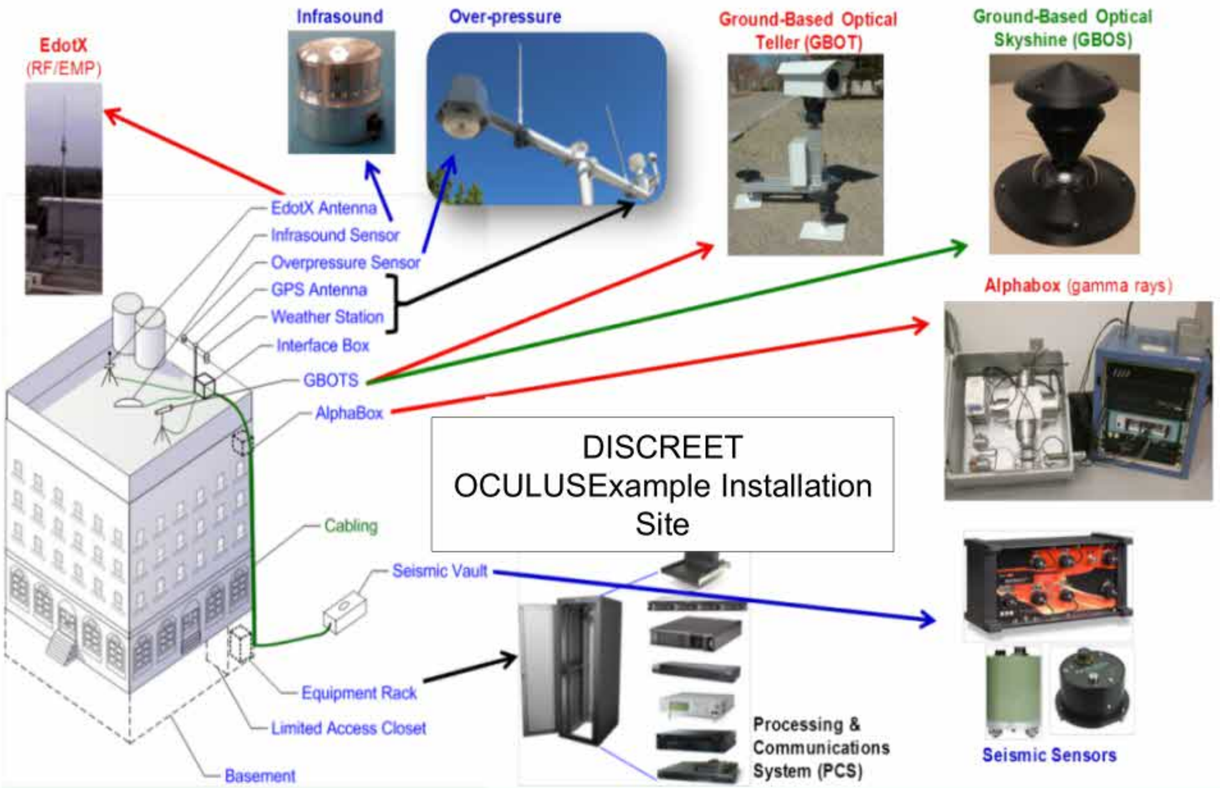
Post-Detonation Nuclear Forensics Attributes



Airborne and Ground Particulate Collection Capabilities

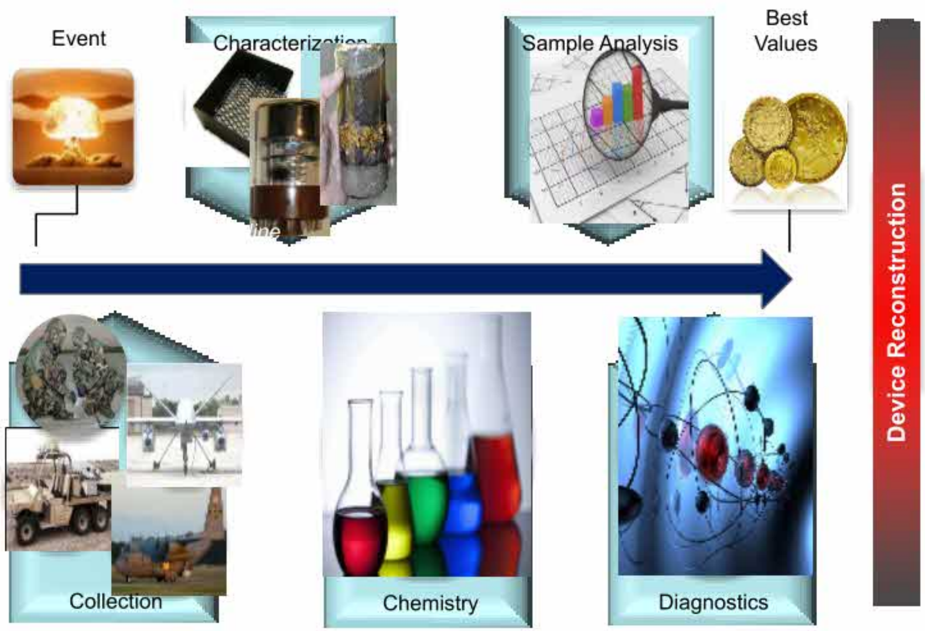
DISCREET OCULUS Prompt Diagnostics Ground Based Sensor Installation

DISCREET OCULUS will become part of a growing nationwide network to instantly send information to a data fusion center at the Air Force Technical Applications Center (AFTAC) located on Patrick Air Force Base, FL. Additional sensor stations near large metropolitan areas will ensure robust sensor network coverage.



DO integrates data from up to nine different sensor types to create actionable information that can be used by senior leaders in the attribution and law enforcement communities.

Materials Identification and Debris Analysis Solution (MIDAS)



Goal: Develop ***targeted*** technologies, methodologies, and tools to enable the collection, analysis, and interpretation of the composition of detonation materials ***relevant*** to nuclear forensics assessment and policy decision makers within a ***designated timeframe*** after the initial event.

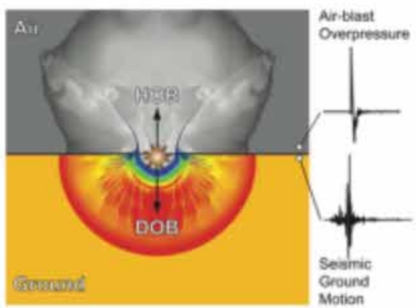
MIDAS targets technologies and methodologies to significantly impact operations and enhance accuracy and timeliness for materials forensics conclusions.

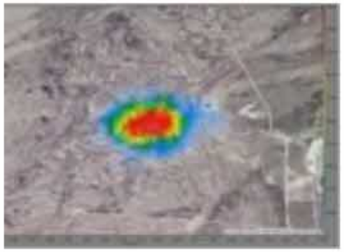
National Technical Nuclear Forensics (NTNF) Joint Capability Technology Demonstration

Three New Capabilities to the USAF and US Army

- Improved yield estimation of nuclear detonation phenomenology. Integrated advanced air and ground particle sample collection (manned & unmanned platforms).Ground collection team video reconnaissance, 3D terrain visualization, and radiation mapping and survey.

Integrated Yield Determination Tool (IYDT) Software





Mission Module Payloads (MMP) for Situational Awareness

Harvester Particulate Airborne Collection System (PACS)

Ground Particle Sampling System

Summary

- Cutting-edge R&D efforts continue to improve technology and capability across the nuclear forensics spectrum. Major R&D priorities today are to improve the speed at which nuclear forensic analytical results are obtained, while increasing their precision and accuracy. The existence of nuclear forensics capabilities promotes nuclear security by encouraging other governments to secure their nuclear materials to help prevent their unwitting transfer to third parties through loss of control.Need to continue to expand capability - Partnerships with Allies:Mostly COTs/GOTs systems – should be sharable with international partners.Peer review and co-sponsored tests and demonstrations.

Questions

Improved Transport Modeling to Support Post-Detonation Nuclear Forensics

Thomas E. Cartledge
Defense Threat Reduction Agency

The post-detonation nuclear forensics community needs better capabilities to model the urban transport of nuclear explosion signals

Phenomenon

Electro-Magnetic Pulse

Teller Light

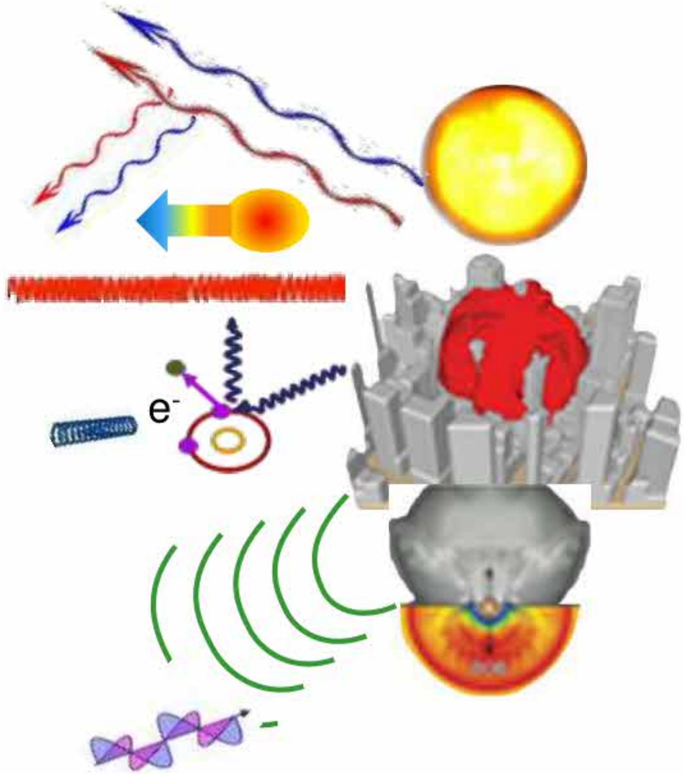
Optical Skyshine

Gamma Rays

Overpressure

Infrasound

Seismic



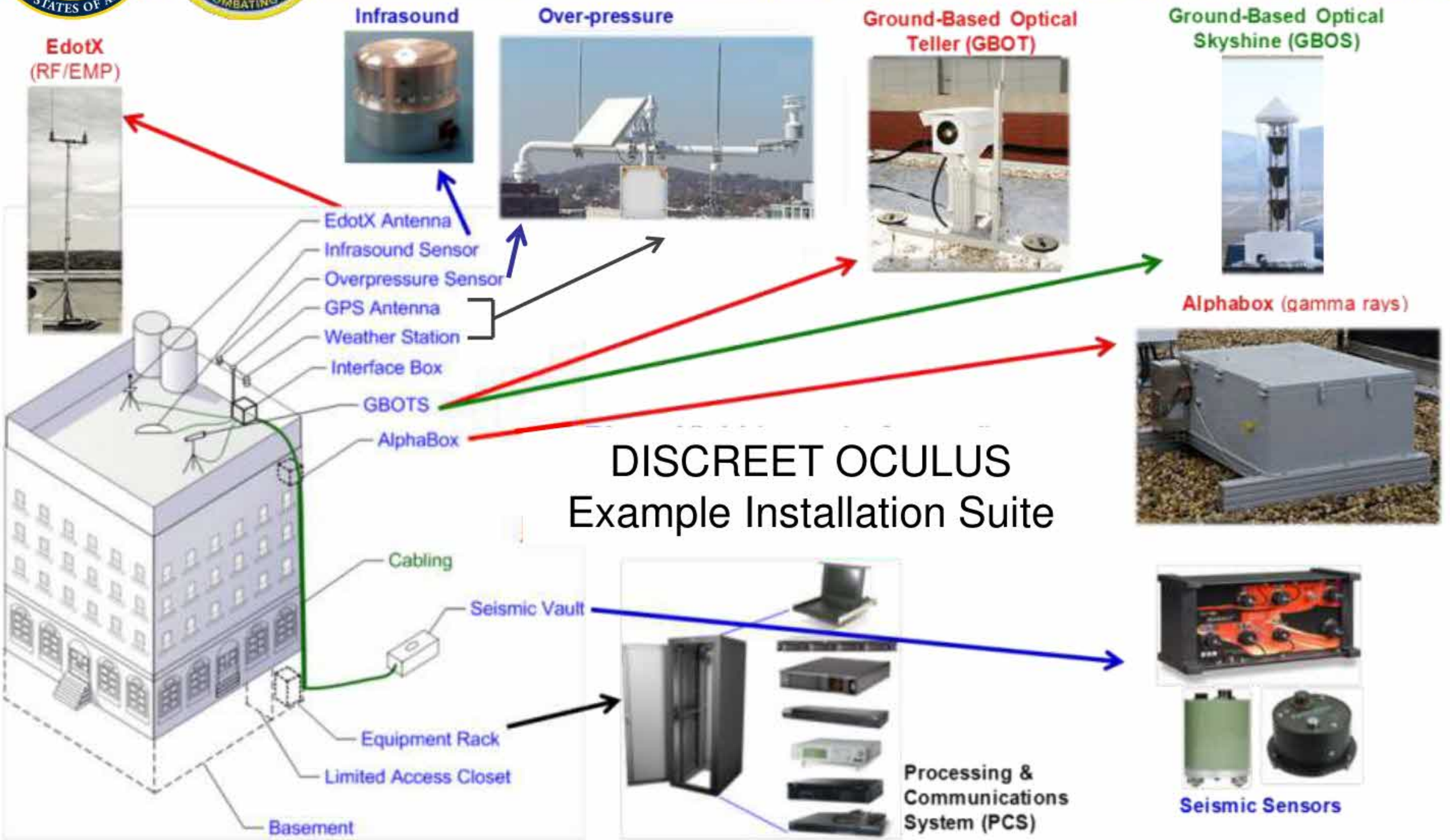
Detonation Location

Above Ground

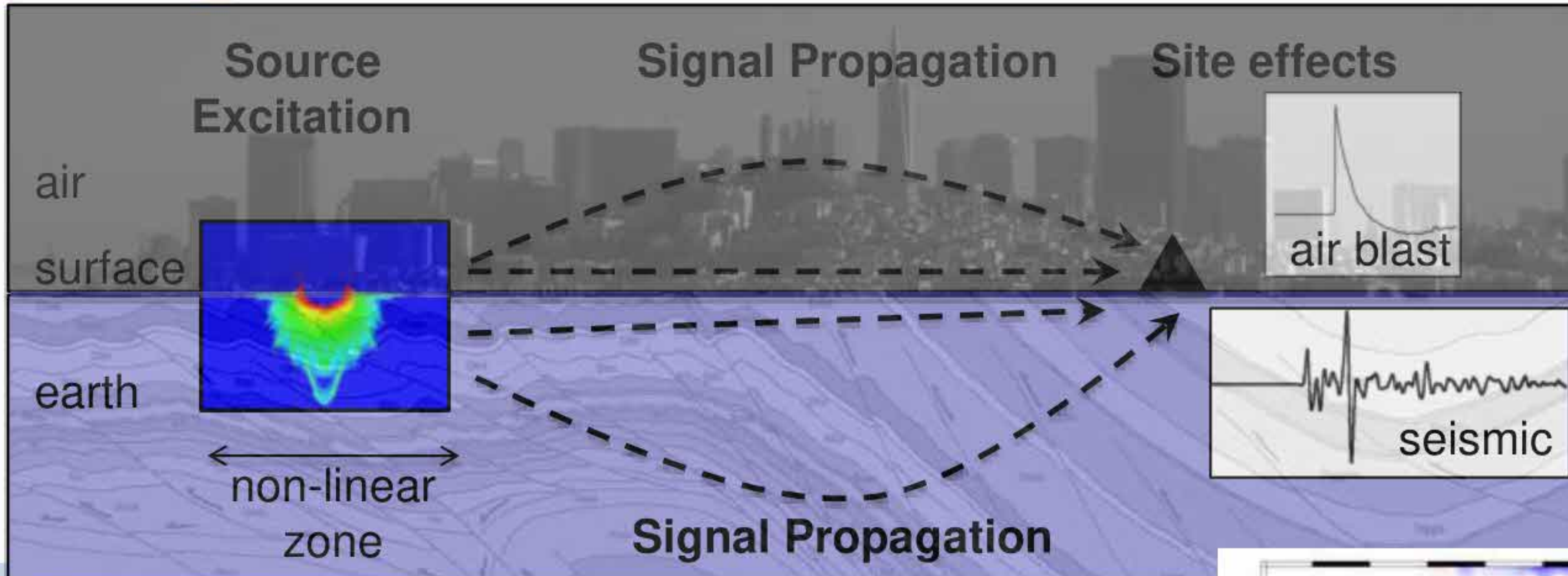
On-Surface

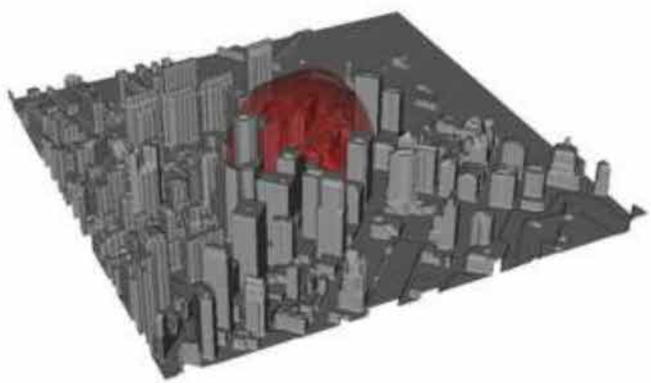
Partially-Buried

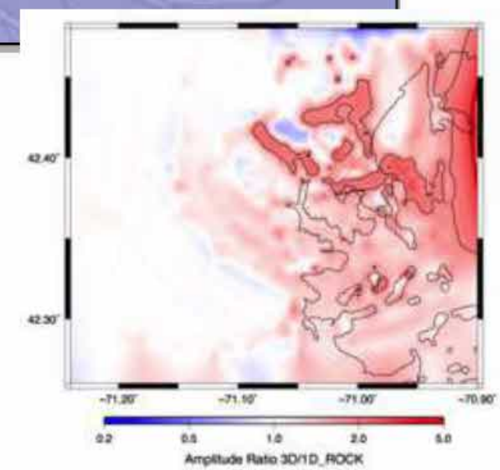
Improved modeling capabilities will directly support the analysis of data from nuclear forensics sensors we are deploying in U.S. cities



Our technical challenges in transport are opportunities for new research







DTRA has sponsored a lot of experiments and research[1-23] to improve seismic, overpressure, and infrasound transport

HUMMING ALBATROSS:
- Quarry shots
- September 7-8, 2011
- ***Observed directivity, wind, & weather effects***

HUMMING COYOTE:
- 13 explosions (100-2000 lbs) May 7-18, 2012
- ***Observed impact of geology, simulated urban structures, weather, winds***

HUMMING ROADRUNNER:
- August 10-30, 2012
- 6 explosions (10-50 tons)
- ***Observed impact of lithology variations, urban structures, directivity, weather at higher yields***

HUMMING SKUNK:
- April 2014
- 8 calibration explosions
- ***Objectives: Calibrate sensor network***

HUMMING TARANTULA:
- June 2014
- Low yield explosions at varying burst heights/burial depths in hard rock
- ***Objective: Develop seismo-acoustic coupling curves for granite***

HUMMING WOMBAT:
- DEC ‘13, MAR, JUN, SEP ‘14
- Rocket motor explosions in all four seasons
- ***Objective: Look at seasonal effects on infrasound transport***

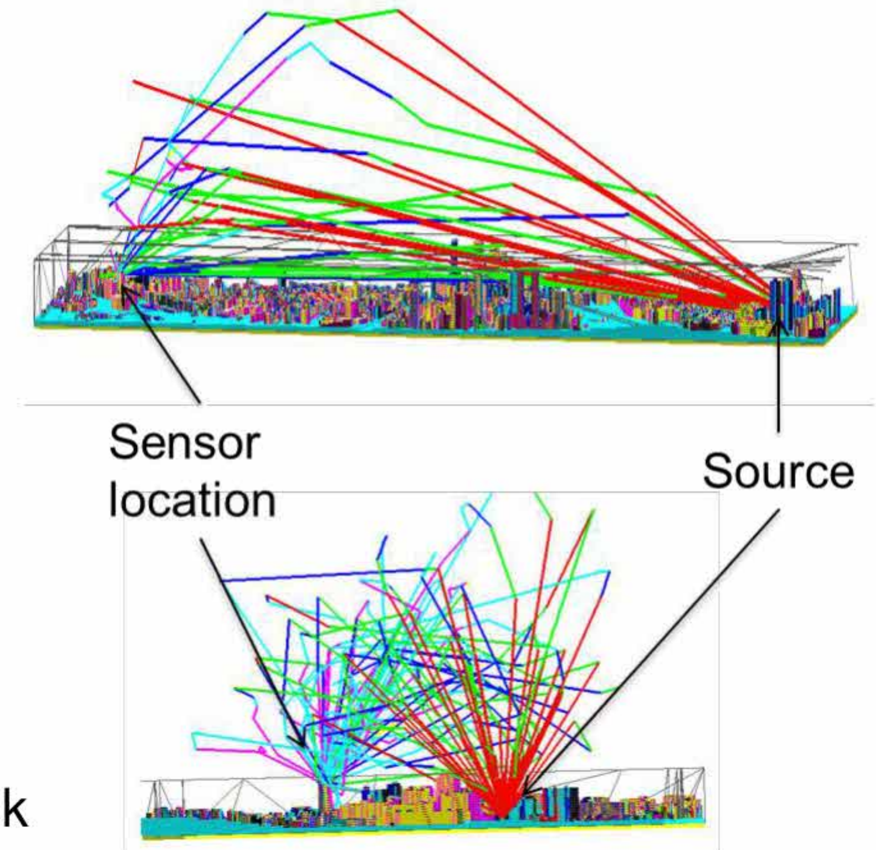
MIGHTY SABER 2015:
- Oct 2013 – Aug 2015
- High-fidelity 3D urban modeling of all relevant nuclear explosion signals

Demo 2016:
- Jan 2014 – Aug 2016
- High-fidelity 3D urban modeling of all relevant nuclear explosion signals

HUMMING TERRAPIN:
- Oct 2016
- Low yield explosions at varying burst heights/depth in water
- ***Objectives: Develop seismo-acoustic coupling curves for water***

However, little research has been done on urban transport of gamma rays, EMP, and optical signals

- HYPER ACTIVE Test
  - Conducted in Oct 2015 at HERMES facility
  - Allowed comparison of measurements across sensor phenomenology against a common source
- Need to understand:
  - Spectral transport effects
  - Temporal transport effects (i.e. what does a signal injected at location A as a delta function look like at location B)



Particle tracks from urban MCNP calculation

Almost no experimental data exists to benchmark codes

Conclusions

- Improvements in understanding urban transport of seismic, overpressure, infrasound and optical signals help improve nuclear forensics weapon yield assessments
  - A lot of research has been done in this area, but more is needed to address evolving threat
- Improvements in understanding what urban transport of gamma, EMP, and optical signals can provide is equally important
  - Additional information will assist in identifying characteristics of the nuclear weapon and attributing responsibility

References

1. Blom, P., & Arrowsmith, S. (2014). Predictions and Analysis of Infrasound from a Large Explosion at Regional and Global Distances. *Review of Monitoring Research.*
2. Blom, P., & Waxler, R. (2013). Eigenray Identification for Non-Planar Propagation. *166th Meeting of the Acoustical Society of America.*
3. Bonner, J., Landry, S., & Russell, D. (2012). Effects of Delay Firing on Surface Waves. *Bulletin of the Seismological Society of America.*
4. Bonner, J., Russell, D., & Reinke, R. (2013). Modeling Surface Waves from Aboveground and Underground Explosions in Alluvium and Limestone. *Bulletin of the Seismological Society of America*.
5. Bonner, J., Waxler, R., Gitterman, Y., & Hofstetter, R. (2012). Seismo-Acoustic Energy Partitioning at Near-Source and Local Distances from the 2011 Sayarim Explosions in the Negev Desert, Israel. *Bulletin of the Seismological Society of America*.
6. Bonner, J., Waxler, R., Reinke, R., Lenox, E., & Cole, P. (2013). Seismic and Acoustic Signal Generation and Propagation at Local Distances: New Datasets from Surface and Shallow Explosions. *Seismological Society of America.*

References

7. Bulaevskaya, V., Ford, S., Johannesson, G., Ramirez, A., & Rodgers, A. (2016). Joint Bayesian inference for near-surface explosion yield. *American Geophysical Union.*

8. Chiang, A., Dreger, D., Ford, S., Walter, W., & Seung, H. (2013). Moment Tensor Analysis of Shallow Sources. *American Geophysical Union.*

9. Ford, S., Ramirez, A., Rodgers, A., & Lenox, L. (2014). Crater Dimensions for Near-Surface and Buried Explosions. *Journal of Geophysical Research*.

10. Ford, S., Rodgers, A., Xu, H., Templeton, D., Harben, P., Foxall, W., et al. (2013). Partitioning of Seismo-Acoustic Energy and Estimation of Yield and Height-of-Burst/Depth-of-Burial for Near-Surface Explosions. *Bulletin of the Seismological Society of America*.

11. Frazier, W. G. (2014). Application of parametric empirical Bayes estimation to enhance detection of infrasound transients. *Infrasound Technology Workshop.*

12. Green, D., & Waxler, R. (2014). Overview of Infrasound Signal Detection and Phase Identification for the Humming Roadrunner Ground Truth Experiments. *Infrasound Technology Workshop.*

References

13. Lonzaga, J., & Waxler, R. (2013). An Exact Solution of a Burgers' Equation Governing Infrasound Propagation in a Range-Dependent, Windy Atmosphere. *166th Meeting of the Acoustical Society of America.*

14. Lonzaga, J., Waxler, R., Frazier, W. G., & Assink, J. (2013). Uncertainties Due to Atmospheric Winds in the Estimation of Event Yield from Thermospheric Pulse Lengthening. *EGU General Assembly.*

15. Napoli, V., Bonner, J., & Reinke, R. (2014). Characterization of S-Waves Generated from Aboveground and Underground Explosions in Alluvium. *American Geophysical Union Poster.*

16. Rodgers, A., Bonner, J., Ford, S., Templeton, D., Ramirez, A., & Dodge, D. (2014). Improving Yield Estimation for Near-Surface Explosions using Seismic and Overpressure Data. *Seismolofical Society of America Annual Meeting.*

17. Rodgers, A., Ford, S., Ezzedine, S., Vorobiev, O., Pitarka, A., Templeton, D., et al. (2014). Analysis and Simulation of Seismic and Overpressure Data from Near-Surface Explosions for Yield and Height-of-Burst/Depth-of-Burial Estimation. *Review of Monitoring Research.*

18. Rodgers, A., Ford, S., Ramirez, A., Xu, H., Templeton, D., & Dodge, D. (2013). Estimation of Yield and Height-of-Burst for Near-Surface Explosions from Seismoacoustic Data. *Seismological Society of America Annual Meeting.*

References

19. Rodgers, A., Sjogreen, B., & Petersson, A. (2015). Simulation of Coupled Seismoacoustic Wave Propagation in Three-Dimensions with a Summation-by-Parts Finite Difference Method. *Seismological Society of America.*

20. Waxler, R., & Velea, D. (2013). Refraction of Impulsive Signals by a Mountain Slope. *Acoustical Society of America Fall Meeting.*

21. Waxler, R., Bonner, J., Reinke, R., Talmadge, C., Kleinert, D., Alberts, K., et al. (2012). Acoustic Source Signal and Directivity for Explosive Sources in Complex Environments. *Meeting of the American Geophysical Union.*

22. Waxler, R., Green, D., & Lalande, J.-M. (2014). Propagation model based explosive yield determination from stratospheric infrasound arrivals: Humming Roadrunner data analysis. *Infrasound Technology Workshop.*

23. Weber, P. W., Millage, K. K., Crepeau, J. E., Happ, H. J., Gintterman, Y., & Needham, C. E. (2012). Numerical Simulation of a 100-ton ANFO Detonation. *Shock Waves*, 127-140.

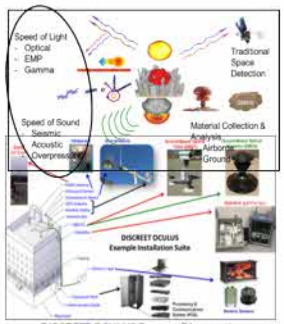
Fact Sheet

Defense Threat Reduction Agency
U.S. Strategic Command Center for Combating Weapons of Mass Destruction

Defense Threat Reduction Agency (DTRA) Prompt Nuclear Effects Exploitation for Attribution
DISCREET OCULUS Program

The goal of DTRA's nuclear forensics program is to support and improve the interagency capability to provide forensics conclusions after the detonation of a nuclear device through the design, development, demonstration, and transition of advanced post-detonation National Technical Nuclear Forensics (NTNF) operational capabilities.

A major thrust area of DTRA's NTNF R&D effort is DISCREET OCULUS, a program to create a ground-based prompt detection and diagnostics system designed to characterize urban nuclear events to support the U.S. government's attribution efforts. DISCREET OCULUS complements current global- and space-based systems.



DISCREET OCULUS Prompt Diagnostics Ground-Based Sensor System

(FOUO) DISCREET OCULUS monitors and collects seismic, acoustic, air pressure, radiation, optical, and radio frequency waves to help WMD experts determine the yield, geolocation, and other characteristics of a nuclear attack to enable the attribution process. (b)(3):10 USC 130 (b)(3):10 USC 130 und-based prompt diagnostic sensor systems are being installed in four U.S. cites – Boston, MA (completed and transmitting data), Washington DC, and New York City/ Newark, NJ – and will transition to the USAF US Prompt Diagnostics System (USPDS) beginning in FY2018.

(b)(3):10 USC 130
Commented [DDC1]: DTRA B(3) USC 130


10-ton ANFO on Alluvium Lithology (left) and Tunnel Shot (right) Yield Estimation Sensor Tests

Extensive sensor performance testing, modeling & simulation, and technology demonstrations continue to be leveraged to verify system performance and achieve necessary technology readiness levels to transition this initial prototype capability to the USAF. DO integrates data from up to nine different sensor types to create actionable information that can be used by senior leaders in the attribution and law enforcement communities.

Swift and accurate forensic and attribution capabilities serve as a deterrent to nuclear terrorism, and are vital to the President to make time-sensitive decisions for response and prevention of future attacks. DISCREET OCULUS will become part of a growing nationwide network to instantly send information to a data fusion center at the Air Force Technical Applications Center (AFTAC) located on Patrick Air Force Base, FL and will support the overall attribution process.

Defense Threat Reduction Agency

DTRA safeguards the United States and its allies from the global WMD threats by integrating, synchronizing, and providing expertise, technologies, and capabilities across all operating environments. This Department of Defense combat support agency is located at Fort Belvoir, VA, and operates field offices worldwide.

For more information please contact the DTRA Governmental and Public Affairs (JOXG) Office.
August 2015

For Official Use Only

Discreet Oculus Overpressure Sensor and Common Sensor Mast Installation Manual

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26 August 2013

For
Defense Threat Reduction Agency (DTRA)

Contents

1 Introduction

This document describes installation procedures for the "Overpressure Sensor" (OPS) and "Common Sensor Mast" (CSM) at a Discreet Oculus (DO) field site.

2 Scope

This document provides an overview of the OPS and CSM rooftop components and includes the site requirements, tools needed to perform the installation and the recommended safety equipment. It also covers the installation procedures, the test procedure before and after the OPS is installed at a Discreet Oculus (DO) field site. It also includes the acceptance testing matrix.

It does not include information regarding necessary site preparations such as site access or pre-arrival safety preparations all of which are covered by other documentation.

3 Overpressure Sensor (OPS) System Description

The OPS system consists of the overpressure head assembly, a sensor arm, and a cable that runs through the CSM and into the JAS digitizer box. The head assembly contains the signal conditioning electronics, a turbulence mitigation plate, and the overpressure transducer.

The OPS is designed to measure overpressures from blast waves regardless of the direction to the source. It is capable of measuring blast wave overpressures up to 1 psi. The transducer is located at the center of the turbulence mitigation plate under the OPS head (see Figure 1).

Figure 1 – OPS System Showing Transducer at the Center of the Lower Disk (aka the Turbulence Mitigation Plate).

4 Common Sensor Mast (CSM) Description

The CSM is designed to support a variety of instrumentation and antennas on a common mast. The assembled components of the CSM (see Figure 2) consists of the non-penetrating roof tripod, the vertical mast, a GPS antenna, and a weather arm that holds the weather station. The mast also supports two lightning arrestors and a satellite antenna (not shown).

Figure 2 – Common Sensor Mast (CSM) with JAS Digitizer Box

5 Sensor System Description

The OPS head contains the overpressure transducer and the low-noise electronic subsystem. This subsystem receives power from the JAS digitizer box (on black and red wires) and produces several internal voltages needed to bias the transducer and provide signal conditioning. The highest internal voltage is thirty (30) volts DC. The transducer's output feeds into a signal conditioning circuit that increases the gain by negative two times (-2X). A differential circuit then drives a twisted pair of wires (green and white) that returns to the JAS box as an analog (± 10V) signal ready for digital conversion. The four wires connecting the OPS head with the JAS box run through the tubing on the CSM and through the watertight flexible conduit connecting the two systems.

6 Site Requirements

The Discreet Oculus (DO) OPS and CSM site location should have been determined during the site survey and are summarized below:

- The OPS head needs an unobstructed line of site to the center of the city
- Avoid putting sensor near a wall or where there are other reflective objects behind it
- Avoid noisy locations (i.e. near equipment or at the immediate edge of the building)
- Tripod location must be able to support 375 lbs. (12 lbs. per square foot)
- Site needs to be near a building ground for lightning protection
- Mast should be installed as close to vertical as possible

7 Sensor System Equipment

A list of the OPS and CSM components are listed below.

#	Description	Manufac.	P/N	Qty Each	Supplier
	TRPD-HD Non-Penetrating Tripod				
1	Ballast Tray Weldment - Site Pro 1	Valmont	X-232696	3	NSTEC
2	Formed Plate 60 degrees - Site Pro 1	Valmont	X-232693	3	NSTEC
3	Formed Plate Pipe Clamp - Site Pro 1	Valmont	X-232691	6	NSTEC
4	TRPD-HD Diagonal Angle - Site Pro 1	Valmont	X-232697	6	NSTEC
5	TRPD-HD Support Plate - Site Pro 1	Valmont	X-232698	3	NSTEC
6	1/2"-13 x 2-1/2" HDG Hex Bolts GR5	Valmont	G12212	30	NSTEC
7	1/2" x 4" HDG Hex Bolt GR5 Full Thread	Valmont	G1204	12	NSTEC
8	1/2" HDG USS Flatwasher	Valmont	G12FW	32	NSTEC
9	1/2" HDG Lockwasher	Valmont	G12LW	30	NSTEC
10	1/2"-13 HDG Heavy 2H Hex Nut	Valmont	G12NUT	30	NSTEC
11	1/2” x 18” x 48” Rubber Mats	Site Pro 1	MAT18	6	NSTEC
12	Washer ½” Galvanized	McMaster	98970A13	28	NSTEC
	Weather Station Assembly				
13	2-1/2" x 24" Arm, Weather Station Mount	NSTEC	ZM6366	1	NSTEC
14	Weather Station	Gill Instruments	Met-Pak II	1	SNL
15	Weather Station Power/Data Cable, 22 AWG stranded (7x30) tinned copper conductors, 2 twisted pairs	Belden	8723SB	20'	SNL
16	Crimp Ferrule, White	Wago	771-8992/216-201	4	SNL

#	Description	Manufac.	P/N	Qty Each	Supplier
			Vertical Mast		
17	2-1/2" x 74-3/4" Mast with junction on bottom and tee at top	NSTEC	ZM6365	1	NSTEC
18	Junction Cover, 6" square	NSTEC	ZD6348	1	NSTEC
19	O-Ring, Small, Metal, TBD"	Spira Mfg	IWSSOG-B-041	3	NSTEC
20	O-Ring, Large, Metal, TBD"	Spira Mfg	IWSISS-.070-5.75 ID-.035	1	NSTEC
21	Nyloc Nuts #10-32	McMaster Carr	90715A115	8	NSTEC
22	Washer #10 Stainless Steel	McMaster Carr	90107A011	8	NSTEC
23	Socket Head Cap Screw 1/4"-20 x 1"	McMaster Carr	92196A542	4	NSTEC
24	Socket Cap Screw, Button Head 5/16"-18 x 1-1/4"	McMaster Carr	92949A585	24	NSTEC
25	Socket cap screw, button head $^{5}/_{16}$"-18 x 1"	McMaster Carr	92949A582	4	NSTEC
26	Socket cap screw, button head $^{5}/_{16}$"-18 x ¾"	McMaster Carr	92949A581	4	NSTEC
27	Nyloc Nuts 5/16"-18 Stainless Steel	McMaster Carr	90715A135	32	NSTEC
28	Washer 5/16" Stainless Steel	McMaster Carr	90107A030	64	NSTEC
29	EMI Flex Conduit, 1"	Electri-Flex	ELFHFEMCS-13	10'	NSTEC
30	Liquidtight Flexible Metal Conduit Connector, 1"	Thos. & Betts	5334-TB	2	NSTEC
			Centralized GPS/SATCOM System		
31	GPS Antenna, 5V	Symmetricom	58532A	1	LANL
32	Male/Male N-Type Adapter	RF Industries	RFN-1014-1		LANL
33	GPS Antenna Lightning Arrestor	Symmetricom	58538A	2	LANL
34	Lightning Arrestor Ground Wire			1	LANL
35	Dual shield coax cable, RG223	Alphawire	9223	20'	LANL
36	N Male Crimp-RG55/RG142/RG223	RF Industries	RFN-1005-3C1	1	LANL
37	Right-Angle N-Male Crimp RG223	RF Industries	RFN-1009-C1	1	LANL
38	GPS/SATCOM Mount	NSTEC	ZD6398	1	NSTEC
39	SATCOM Azimuth Bracket	NSTEC	ZD6399	1	NSTEC
40	SATCOM Elevation Bracket	NSTEC	ZD6400	1	NSTEC
41	SATCOM Antenna	Hughes		1	SNL
42	N-type Bulkhead Connector	Pasternack	9128	2	SNL
43	SATCOM Antenna Patch Cable			1	SNL
44	GPS Antenna Patch Cable			1	SNL
45	Lightning Arrestor Patch Cable			2	SNL
			Overpressure Sensor Arm Assembly		
46	Overpressure Sensor Arm Assembly	NSTEC	ZM6367	1	NSTEC
47	Overpressure Sensor Power/Signal Cable, 20 AWG stranded (7x28) TC conductors, semi-rigid PVC insulation, 2 twisted pairs	Belden	9402	25'	NSTEC
48	Crimp Ferrule, White	Wago	771-8992/216-201	4	SNL

Table 1 Overpressure Sensor (OPS) and Common Sensor Mast (CSM) Component List

8 Installation Tools and Equipment

A list of installation tools and equipment is provided in the following list.

Item #	Description
1	¾" combination wrench
2	½" combination wrench
3	$^{7}/_{8}$" combination wrench
4	½" combination wrench
5	$^{7}/_{16}$" combination wrench
6	½" drive ratchet
7	$^{3}/_{8}$" drive ratchet
8	$^{7}/_{8}$" deep well socket, ½" drive
9	¾" deep well socket, ½" drive
10	½" socket, 3/8" drive
11	$^{7}/_{16}$" deep well socket, $^{3}/_{8}$" drive
12	$^{3}/_{8}$" deep well socket, $^{3}/_{8}$" drive
13	$^{3}/_{8}$" drive torque wrench, 240 in-lb capacity
14	½" drive torque wrench, 120 ft-lb capacity
15	flat blade screwdriver assortment
16	phillips screwdriver assortment
17	$^{3}/_{8}$" nut-driver
18	¼" hex driver
19	¼" L hex key
20	$^{3}/_{16}$" hex driver
21	$^{3}/_{16}$" L hex key
22	2 pair of large channel-lock pliers
23	diagonal cutters
24	wire strippers
25	wire crimpers
26	electrical tape
27	sealing heat shrink OR self-vulcanizing weatherproofing tape
28	heat gun
29	scissors
30	small 'precision' scissors
31	cordage OR wire snake (for pulling cable)
32	small bubble level
33	analog compass
34	voltage meter (DC up to 20 volts) with leads that clip-on

Table 2 List of installation tools and equipment

9 Safety Equipment

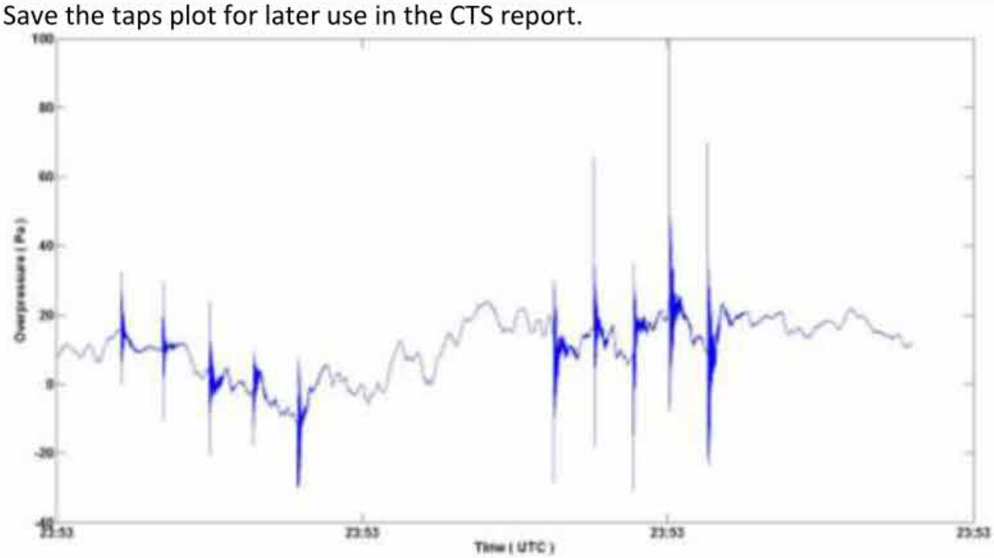
Below is a list of recommended safety equipment.

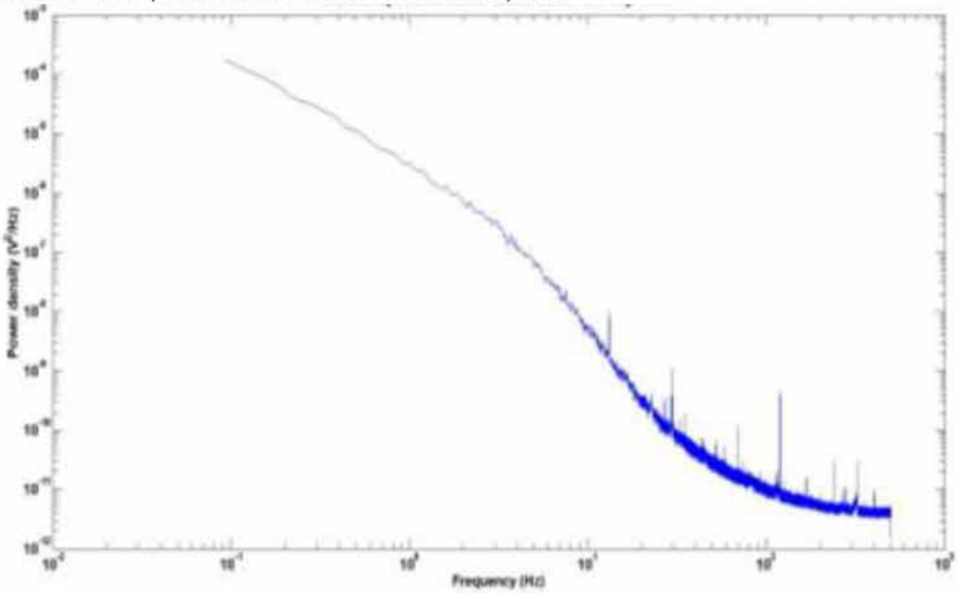
Item #	Description
1	Safety glasses
2	Safety shoes
3	Hard hat
4	Ear plugs
5	Knee pads
6	Gloves
7	Proper attire for weather conditions (sunscreen if necessary)
8	Bottled Water

Table 3 Safety equipment

10 Overpressure Sensor Consent to Ship (CTS) Test – Before Installation

Before the OPS system can be authorized for field deployment it should be fully assembled and tested to verify that it is operational as a system. This section outlines the procedure to use to validate the overpressure system performance before shipment to the site location. This test can be performed indoors or outdoors.

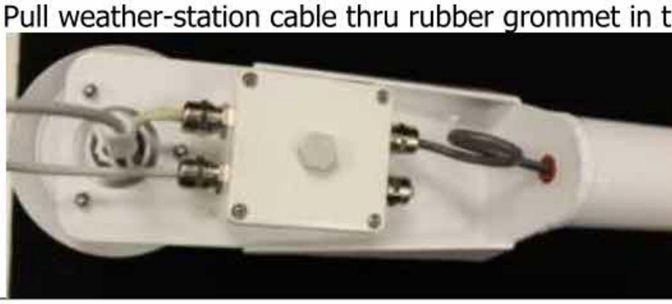
Step	Instructions	Initials
1	Verify that all system components are installed and connected properly.	
2	Verify that JAS digitizer system is powered on and operating.	
3	Wait 5 minutes to allow the JAS digitizer to settle and for GPS clocks to synchronize.	
4	Gently tap the center of the Over pressure sensor 5 times (softly). Allow one second between taps.	
5	Tap the center of the Overpressure sensor 5 more times (firmly). Allow one second between taps.	
6	Record the time when the taps were performed.	
7	Wait 25 minutes and allow the JAS digitizer to collect background data.	
8	Use the recorded time to obtain JAS digitizer data from 5 minutes before the taps to 25 minutes after using the JAS data extraction procedure (provided by others).	
9	Read / Import data into 'CTS Overpressure Test' software. Entire time series data record will now be graphed.	
10	Using the Zoom controls, zoom in until you can clearly see and count all 10 taps.	
11	Save the taps plot for later use in the CTS report.  Typical tap test results	
12	Depending on how hard the taps were, the first five taps should be smaller and will generally range from 30 to 100 Pa. The second five should be larger and range from 100 to 300 Pa. If all ten taps are discernible then the overpressure system is operating properly. If not return to step 1.	
13	Using the Zoom controls select the data after the last tap through to the end of the data record (about 25 minutes).	
14	Save the Time series plot for later use in the CTS report.	

15	Run the Power Spectral Density (PSD) tool on this selected data.	
16	Save the PSD plot for later use in the CTS report.  Typical PSD plot.	
17	Verify that the trend on the plot gets continually smaller as the frequency goes higher. If not, then return to step 1. *Note: It's okay to have single frequency spikes above 10 Hz (as shown above)*	
18	Accept the overpressure system as operational.	

11 Sensor System Installation

The procedure for installing the sensor system at the site is listed below.

11.1 Weather-station Arm Assembly

Step	Instructions	Initials
1	Unpack weather-station from box	
2	Remove weather station from factory mount a. Make note of wiring code	
3	Attach weather-station to weather-station arm a. Re-use mounting hardware supplied with the weather-station 	
4	Pull weather-station cable thru rubber grommet in the end of the mount 	

11.2 GPS Assembly

Step	Instructions	Initials
1	Unpack GPS & lightning arrestor parts	
2	Connect the in-line lightning arrestor to the GPS antenna with the N-type adapter  a. Connect the antenna to the correct side of the lightning arrestor b. Be sure to weather proof all connections with sealing heat shrink or self vulcanizing tape	
3	Attach the supplied GPS tube adapter mount for additional environmental protection 	
4	Attach the lightning GPS & arrestor assembly to the GPS/SATCOM mounting plate following the manufacturer's instructions 	

5	Attach SATCOM brackets to the GPS/SATCOM mounting plate a. Attach SATCOM azimuth bracket to GPS/SATCOM mounting plate using four (4) $^{5}/_{16}$"-18 x 1" bolts, snug bolts but leave loose enough to adjust bracket b. Attach SATCOM elevation brackets to the SATCOM antenna c. Attach SATCOM antenna to azimuth bracket using four (4) $^{5}/_{16}$" -18 x ¾" bolts, snug bolts but leave loose enough to adjust bracket 	
6	Attach SATCOM and GPS cables to their respective bulkhead connectors on the bottom of GPS/SATCOM mounting bracket a. Attach GPS & SATCOM patch cables to their proper places on the antennas, lightning arrestors and top of bulkhead feedthru connectors	

11.3 Mast Assembly

Step	Instructions	Initials
1	Install the flexible conduit fitting onto the large hole in the box at the bottom of the mast 	
2	Install the compression nut, seal sleeve and internal conduit fitting onto each end of the flexible conduit a. Trim any small wire 'hairs' protruding from the end of the conduit	
3	Attach the prepared conduit to the fitting on the box	
4	Pull a cord or a suitable 'wire snake' thru sensor tree & conduit, leaving running end protruding from top flange	
5	Install EMI O-rings in each flange groove 	
6	Feed O/P cable thru flange on one side of mast and up thru top flange 	
7	Bolt O/P arm to mast using eight (8) $^{5}/_{16}$-18 x 1¼" socket cap screws, washers and nylon locking nuts *Note: Make sure O-ring is still in its proper place in the O-ring groove*	

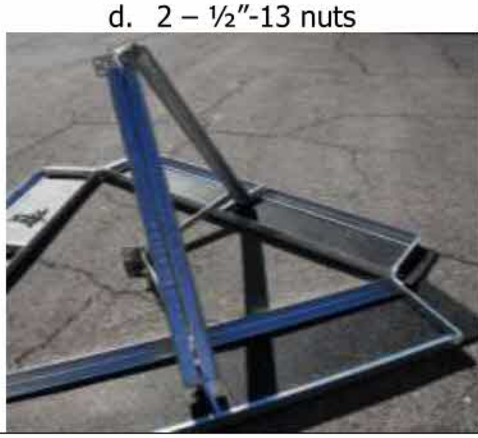
8	Feed weather-station cable thru flange opposite of O/P arm and up thru top flange	
9	Bolt weather-station arm to mast using eight (8) $^{5}/_{16}$-18 x 1¼" socket cap screws, washers and nylon locking nuts *Note: Make sure O-ring is still in its proper place in the O-ring groove*	
10	Attach all four cables (O/P, GPS, SATCOM & weather-station) to running end of cord/wire snake	
11	Pull cables thru sensor tree to box at bottom of sensor tree and thru conduit  a. Leave enough cable in the electrical box at bottom of tree to make a suitable 'service loop'	
13	Bolt mounted GPS/SATCOM to mast using eight (8) $^{5}/_{16}$-18 x 1¼" socket cap screws, washers and nylon locking nuts *Note: Make sure O-ring is still in its proper place in the O-ring groove*	
14	Double check to make sure the EMI gasket has not fallen out of the box lid, replace the box lid and secure with eight (8) #10-32 nuts and washers 	

15	Bend and attach lightning arrestor brackets onto each arm of the sensor tree a. Secure bracket with cable in position using two (2) ¼″-20 x 1″ socket head cap screws on each bracket 	
16	Cut grounding cable on one arm in a suitable location for the cable splice 	
17	Attach cable splice and route grounding cable down the mast	
18	Install an air terminal on each air terminal bracket	

11.4 Tripod Assembly

Step	Instructions	Initials
1	Layout tripod base trays to verify fitment at desired location	
2	Slide buffer mats underneath each base tray 	
3	Bolt base trays together using the following: (torque to appropriate value) a. 1 – 2″ x 3/8″ angle bracket b. 2 – ½″-13 x 2½″ cap screws c. 4 – ½″ flat washer d. 2 – ½″ split lock washer e. 2 – ½″-13 nuts 	
4	Bolt mast clamp together using the following:[1] a. 2 – 6″ x ¼″ mast clamp brackets b. 3 – ½″-13 x 2½″ cap screws c. 6 – ½″ flat washers d. 3 – ½″ split lock washers e. 3 – ½″-13 nuts f. Leave a gap of at least 1″ between flat faces of brackets, DO NOT tighten completely at this time g. Repeat 1x 	

[1] Always put the flat washer on the part with a slot (where applicable)

<table>
<tr><td>5</td><td>Bolt tripod legs to center bar of base tray using the following:[2]
a. 2 – 2″ x 2″ x ¼″ leg brackets
b. 1 – ½″-13 x 2½″ cap screws
c. 2 – ½″ flat washers
d. 1 – ½″ split lock washers
e. 1 – ½″-13 nuts
f. Repeat 2x</td><td></td></tr>
<tr><td>6</td><td>Bolt stabilizer bar in between tripod leg brackets with a single ½″ bolt assembly[2]
a. Repeat 2x
</td><td></td></tr>
<tr><td>7</td><td>Bolt one (1) mast clamp assembly from step 4 to two (2) of the tripod leg assemblies from step 5 (mast clamp bracket bolts between the 2 angle iron leg brackets). Rotate the third leg assembly back out of the way for the time being[2]
a. 2 – ½″-13 x 2½″ cap screws
b. 4 – ½″ flat washers
c. 2 – ½″ split lock washers
d. 2 – ½″-13 nuts
</td><td></td></tr>
</table>

[2] Leave hand tight for now, will be tightened later

<table>
<tr><td>8</td><td>Bolt second mast clamp assembly to the stabilizer bars. Make sure to bolt the mast clamp brackets to the same side of the stabilizer bars (i.e. if you bolt one clamp bracket to the left face of one stabilizer bar then bolt the other clamp bracket to the left face of the other stabilizer bar)
</td><td></td></tr>
<tr><td>9</td><td>Very loosely bolt the remaining two (2) mast clamp brackets in their respective places on the remaining tripod legs and stabilizer bar</td><td></td></tr>
<tr><td>10</td><td>Place the sensor mast in position between the 2 mast clamp brackets and have someone hold the mast in position

Note: it is beneficial to keep the bottom of the mast above the roof surface. Do so by resting the mast on a block of wood or other soft material ~1" tall until the mast is firmly clamped into the tripod. REMOVE the block once installation is complete.</td><td></td></tr>
<tr><td>11</td><td>Carefully swing the last tripod leg and stabilizer bar, with clamp brackets loosely attached, into position. Insert remaining screws into positions in the mast clamp bracket</td><td></td></tr>
<tr><td>12</td><td>Check the tripod for level. The sensor does not have to be perfectly level, but it should be close, shim tripod as needed</td><td></td></tr>
<tr><td>13</td><td>Orient the weather-station to align the 'north' mark on it with true north. This is done by rotating the weather station in its mount</td><td></td></tr>
<tr><td>14</td><td>Tighten all of the bolts on the two (2) mast clamps to secure the mast in the tripod</td><td></td></tr>
</table>

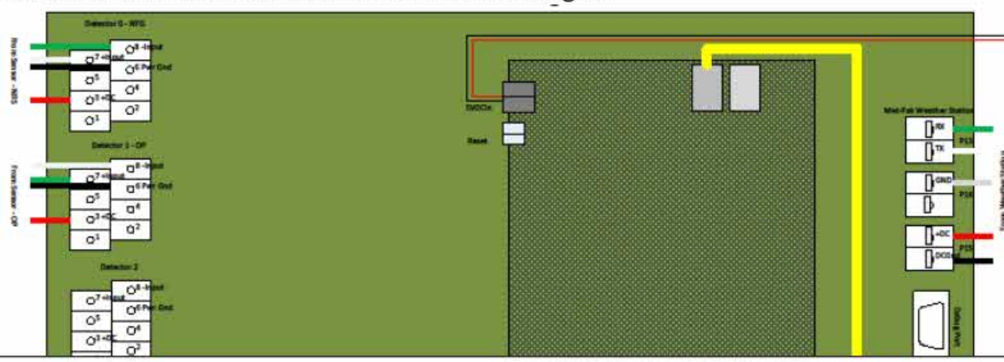
15	Tighten all remaining bolts to their appropriate torque values 	
16.	Set JAS digitizer enclosure in a convenient location inside one of the tripod base trays	
17.	Drill holes in the tray to allow a suitable mounting bracket to be used to attach the JAS enclosure (supplied by SNL) to the tripod base 	
18.	Attach the JAS enclosure to the base using hardware and brackets provided by SNL	
19.	Install flexible conduit fitting into JAS digitizer enclosure	
20.	Route flexible conduit (with cables pulled) conveniently to the JAS digitizer enclosure and route cables thru fitting until conduit is bottomed out in fitting	
21.	Tighten conduit fitting nut	

22\. Connect each cable to its proper location on the JAS digitizer board:

The OPS cable is connected to the second set of input screw-down blocks on the left side of above photo (below near-field infrasound).

Slot	Wire	Description
3	Red	DC Power (+)
6	Black	DC Power (-)
7	Green	Differential (+) OPS signal
8	White	Differential (-) OPS signal

The weather station is shown attached on the right.



23.	Install lightning arrestor grounding cable clamps along the mast and tighten. Align the clamp such that the cable is routed on the opposite side of the mast from the over-pressure sensor  *Note: it is imperative that the tube clamps be placed out of 'view' of the over-pressure sensor. DO NOT place any clamps on the mast within 4" vertically (above or below) of the horizontal plane of the over-pressure sensor disc!* *Note: Lightning arrestor cable clamp spacing cannot exceed 3' center-to-center. Cable can be clamped between the tripod leg brackets on one leg to aid in keeping the cable routing clean. If this is done, be sure to isolate the cable from the mast to prevent galvanic corrosion.*	
24	Attach the loose end of the lightning arrestor cable to an adequate building ground terminal 	
25	Adjust SATCOM antenna to optimal position and tighten SATCOM bracket bolts	
26	Double check that all bolts are correctly tightened to their appropriate torque	

12 Overpressure Sensor Operational Test – After Installation

After the sensor system is installed at the site, the system must be tested to ensure that all connections have been made successfully using the following procedure.

Step	Instructions	Initials
1	Verify that all electrical system components are installed and connected properly.	
2	Turn on power to the JAS digitizer, if system is off.	
3	Verify that indicators show the correct status and that JAS digitizer is operating properly.	
4	Using a volt meter (VM) measure the DC voltage at the overpressure terminal on the JAS digitizer board – [Slot 3 Red +] and [Slot 6 Black -]. The acceptable voltage range is between 9 and 18 VDC.	
5	Attach the VM to the differential output of the OPS on the same terminal block as step 4 – [Slot 8 Green +] and [Slot 7 White -]. *Note: You may need to use clip-on leads.*	
6	Set the VM to measure up to 1 volt DC. *Note: Actual output range of the OPS is ± 10V or 20V total.*	
7	Adjust the VM so that it is visible from the over pressure sensor head on the mast.	
8	Lightly tap the center of the overpressure sensor and watch the response on the VM. It should jump up with each tap. Typical jump should be between 50 and 400 mV.	
9	If there is no response when taping the OPS then return to step 1.	
10	Remove the VM connections	
11	Verify that all electrical connections are still tight.	
12	Accept the OPS system as functional	

13 Acceptance Matrix

After running the tests in Sections 10 and 12, this matrix provides the individual test measures that need to be checked in order to accept or reject the OPS functionality.

Test	Acceptance Measures	Acceptance Date
Tap Test (Section 10, steps 1-12)	10 individual taps recorded.	
	10 individual taps are easily distinguishable from each other.	
	Each tap should go positive above the baseline as well as go negative below the baseline then return to the baseline.	
Power Spectral Density (Section 10, steps 13-17)	At 0.1 Hz – PSD should be less than 10E-2 V^2/Hz.	
	At 1 Hz – PSD should be less than 10E-4 V^2/Hz.	
	At 10 Hz – PSD should be less than 10E-6 V^2/Hz.	
	At 100 Hz – PSD should be less than 10E-9 V^2/Hz.	
	At 500 Hz – PSD should be less than 10E-10 V^2/Hz.	
	From 0.1 Hz to 10 Hz the PSD forms a reasonably smooth curve (no significant discontinuities).	
	From 10 Hz to 500 Hz the PSD base curve is reasonably smooth (but this section may have frequency spikes).	
Correct Wiring (Section 12, steps 4,5)	Slot 3 has Red wire attached. Slot 6 has Black wire attached. Slot 7 has White wire attached. Slot 8 has Green wire attached.	
Power Test (Section 12, step 4)	Voltage between Red (+) and Black (-) must be between 9 and 18 VDC.	
Signal Test (Section 12, steps 5-8)	Voltage between Green (+) and White (-) must jump when OPS is tapped. (Typical voltage jump is between 50 and 400 mV)	

14 Appendix A – Fastener Torque and Sequence

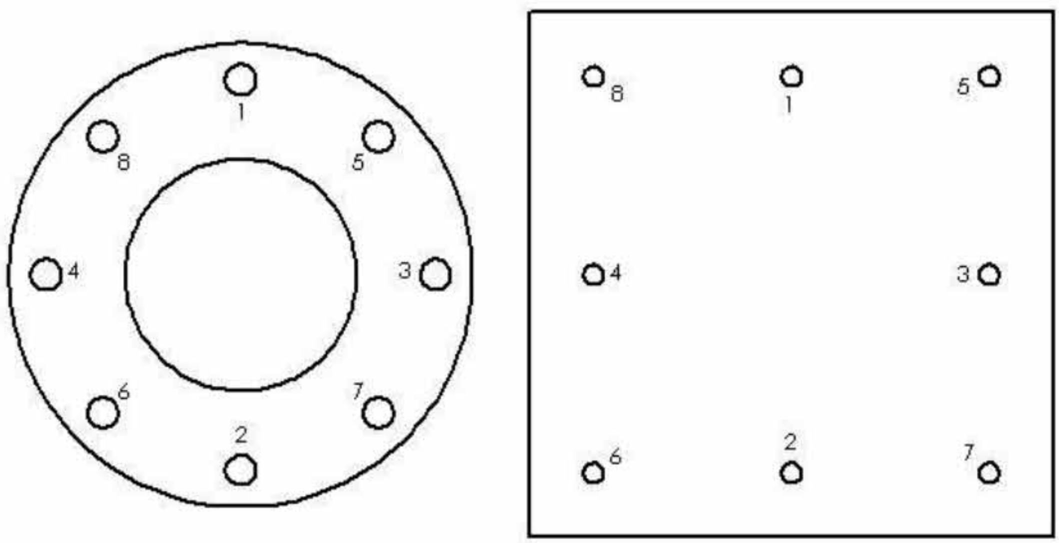
14.1 Torque Values

Always use the appropriate torque when tightening these fastener sizes:

Fastener size	Torque value
#10-32 (stainless steel)	32 in-lbs
¼"-20 (stainless steel)	75 in-lbs
$^{5}/_{16}$"-18 (stainless steel)	132 in-lbs
½"-13 (grade 5, galvanized)	75 ft-lbs

14.2 Fastener Sequence Order

Use these sequence orders when tightening these flanges. This will ensure that the EMI O-rings are properly compressed.



DTRA Installing Sensor Stations to Detect, Analyze Nuclear Attacks

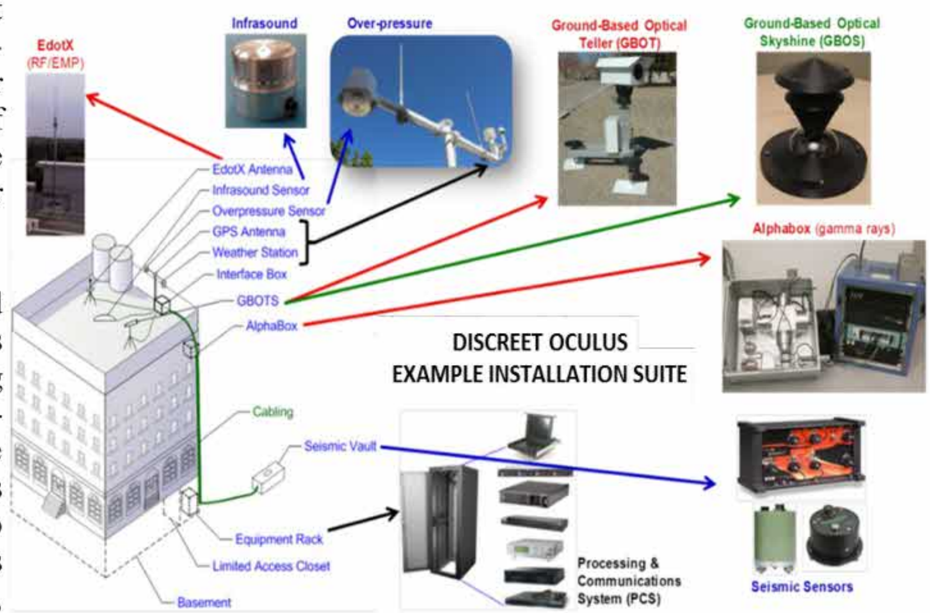
DTRA has installed prompt nuclear effects sensor stations, such as the ones above, in U.S. metropolitan areas as part of Discreet Oculus, a prototype sensor network. Before installing the stations, DTRA conducted explosive-based yield estimation sensor tests, including the one above, to validate the functionality of the sensors. DTRA also conducted a nuclear forensics demonstration in mid-2015 called Mighty Saber that validated the capabilities of Discreet Oculus.

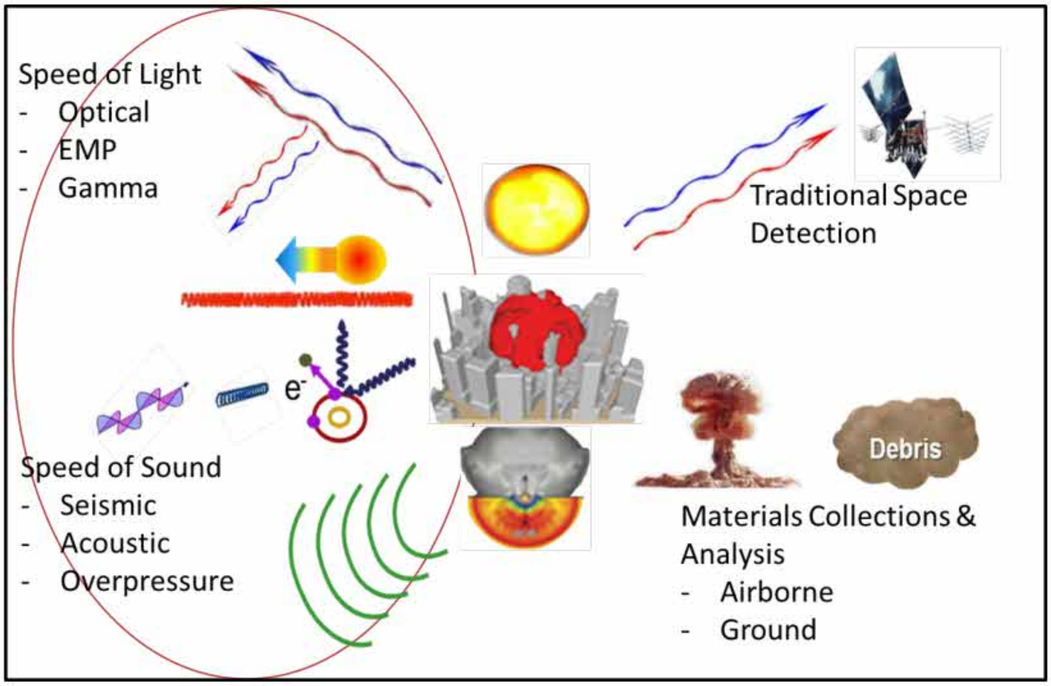
The Discreet Oculus Prompt Diagnostics Sensor System is a research and development effort to create a ground-based prompt detection and diagnostics system. The system complements current global- and space-based prompt nuclear effects monitoring systems. It is designed to support the United States Government's efforts to develop timely and accurate technical nuclear forensics conclusions after a nuclear attack on the U.S.

Information collected by this system after an attack will be used to help national and military leaders identify what was detonated, where the materials came from, and who launched or supported the attack. The system has been installed in two metropolitan areas and an installation in a third metropolitan area has begun.

To validate Discreet Oculus' capabilities, DTRA conducted a first-of-its-kind interagency nuclear forensics demonstration in 2015 called Mighty Saber. The demonstration, executed by 16 organizations over 21 days in July and August 2015, successfully met each of its objectives, including demonstrating U.S post-detonation nuclear forensics processes and the value of prompt diagnostics data provided by the Discreet Oculus ground-based sensor network.

The demonstration additionally showed how prompt diagnostics complements traditional radiochemistry in providing a robust post-detonation nuclear forensics capability. It also established the first-ever nuclear forensics process baseline and provided opportunities to explore nuclear forensics interactions with intelligence, law enforcement, and policy communities.





Discreet Oculus monitors and collects prompt nuclear signals such as seismic, acoustic, air pressure, radiation, optical and radio frequency waves, as illustrated on the far left of the figure, and is part of a complete technical nuclear forensics capability that includes traditional space detection capabilities and material collections and analysis technologies.

Develop Initial Capability

Discreet Oculus monitors and collects seismic, acoustic, air pressure, radiation, optical, and radio frequency waves to help weapons of mass destruction experts determine the yield, geolocation and other device characteristics of a nuclear attack to enable the attribution process.

Test, Demonstrate and Evaluate

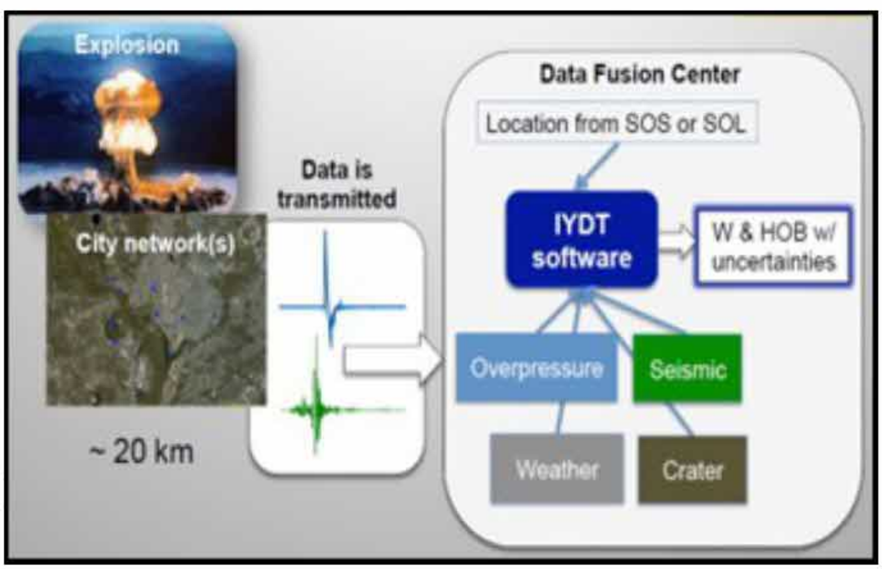
Extensive sensor performance testing, several modeling and simulation, and technology demonstrations continue to be leveraged to verify system performance and achieve necessary technology readiness levels to transition Discreet Oculus' capability to the United States Air Force starting in 2018.

Process Data

Discreet Oculus integrates data from up to nine different sensor types to create actionable information that can be used by senior leaders in the attribution and law enforcement communities.

Recent Accomplishments

The recently installed sensors will become part of a growing nationwide network to instantly send information to a data fusion center at the Air Force Technical Applications Center located on Patrick Air Force Base, Florida. Additional sensor stations near large metropolitan areas will ensure robust sensor network coverage.



Integrated yield determination tool data flow

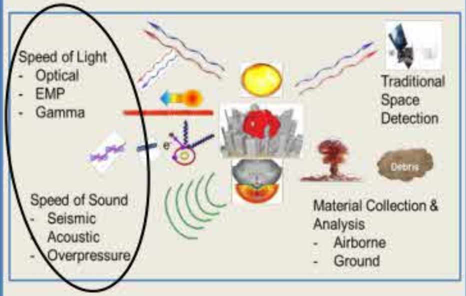
DTRA-J9 Research, Development, Testing and Evaluation

Managing research, development and technology integration to overcome capability gaps and protect the warfighter in a CBRNE environment

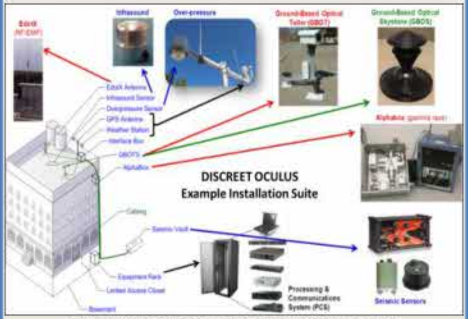
Nuclear Technologies

DISCREET OCULUS (DO) is a research and development effort to create a ground-based prompt detection and diagnostics system designed to characterize urban nuclear events to support US government's attribution efforts. DISCREET OCULUS complements current global- and space-based systems and is scheduled to transition to the USAF under the U.S. Prompt Diagnostics System (USPDS) starting in 2018.

Develop Initial Capability



DO monitors and collects seismic, acoustic, air pressure, radiation, optical, and radio frequency waves to help WMD experts determine the yield, geolocation, and other characteristics of a nuclear attack to enable the attribution process.



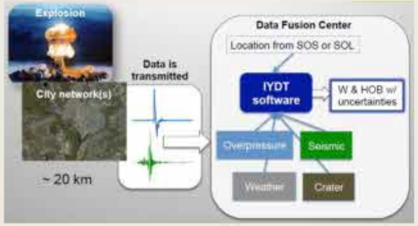
DISCREET OCULUS Prompt Diagnostics Ground-Based Sensor System

Test, Demonstrate, & Evaluate

Extensive sensor performance testing, modeling & simulation, and technology demonstrations continue to be leveraged to verify system performance and achieve necessary technology readiness levels to transition this initial prototype capability to USAF.

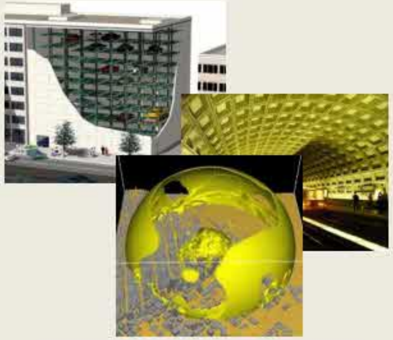
10-ton ANFO on Alluvium Lithology (top) and Tunnel Shot (bottom) Yield Estimation Sensor Tests

Process Data



Data flow for Integrated Yield Determination Tool

DO integrates data from up to nine different sensors types to create actionable information that can be used by senior leaders in the attribution and law enforcement communities.



System modeling for sensor and system performance evaluation

Recent Accomplishments

Recently installed sensors will become part of a growing nationwide network to instantly send information to a data fusion center at the Air Force Technical Applications Center (AFTAC) located on Patrick Air Force Base, FL. Additional sensor stations near large metropolitan areas will ensure robust sensor network coverage.

Mr. Kenneth A. Myers III, Director, DTRA/SCC-WMD, Observes Installation (top) and Conducts a Ribbon Cutting (bottom) for Completion of a DISCREET OCULUS Site Prototype

Improved transport modeling to support post-detonation nuclear forensics

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INTRODUCTION

Following a nuclear attack, the timely and accurate determination of the weapon design origin is necessary to support attribution. The signals generated at the time of a nuclear weapon's detonation, collected using various sensor types to enable *prompt diagnostics*, are key to deducing weapon design.

The Defense Threat Reduction Agency (DTRA) is developing improved capabilities to model the propagation of prompt nuclear signals in the urban environment. The understanding of how these signals propagate in the urban environment is necessary to support accurate conclusions.

In President Barack Obama's 2009 speech in Prague, Czech Republic, he stated that "black market trade in nuclear secrets and nuclear materials abound. The technology to build a bomb has spread [1]." The changing threat has created new information requirements in order to attribute responsibility and hold any state involved accountable. In addition to faster response time, the ability to determine the design origin of a weapon used in a nuclear attack is necessary to deter the proliferation of nuclear weapon designs, materials, and technologies, as well as their use. With the most likely use of nuclear weapon being a terrorist attack on a key U.S population center, understanding how nuclear weapon effects transit through an urban environment is essential to determine the design origin.

Nuclear forensics analysis has been primarily focused on materials analysis, where the goal is to provide information on the source of the nuclear material and the route it followed before its interception by authorities [2]. The spectrum of post-detonation nuclear forensics analysis is described in reference [3].

The ability to collect the time-of-detonation prompt signals (optical, radio frequency, gamma, seismic, acoustic, and overpressure), coupled with an understanding of how the signals propagate from the weapon location to distant sensors, is fundamental to decreasing analysis timelines and determining design attributes indicative of the weapon's developmental origin. The propagation of the detonation signals in the urban environment presents a complicated problem, amplified by the fact that experimental data is limited due to the cessation of above ground tests in 1962 and cessation of all nuclear weapon tests and yield-producing nuclear weapons experiments since 1992. While there is a wealth of historic nuclear weapons test data, very little of that data is applicable to understanding how the outputs of nuclear weapons transit through an urban environment with significant reflection and obscuration.

This paper describes DTRA's approach to modeling the influence of the cityscape from signals generated by a nuclear weapon's detonation.

URBAN IMPACTS ON DETONATION SIGNALS

The simulated transport of signals through a cityscape following a nuclear detonation is dominated by the interactions of particles with the environment. In most cases the transport and simulation of particles through a cityscape following a nuclear detonation is computationally intensive, requiring hundreds of hours. This lengthy computational time results from including signal interactions not only with buildings, but also the soil, air, and all other media that lie along the path of travel.

DTRA is developing Monte Carlo and finite element modeling capabilities for various speed-of-light (gamma, radio-frequency, photonic) and speed-of-sound (seismic, overpressure, infrasound) signal phenomena generated at the time of a nuclear weapon's detonation.

Speed-of-Light Detonation Signals

DTRA's comprehensive approach to the urban transport problem for speed-of-light signals involves the integration of cityscape layout data using U.S. Government geospatial data (Light Detection and Ranging (LIDAR) shapefiles), FEMA's Hazus database, and individual building characteristics (i.e., concrete vs. steel construction). Figure 1 illustrates the geospatial data for New York City, where a 2m x 2m x 1m mesh resolution is used in modeling the propagation of signals from nuclear weapon source to sensor.

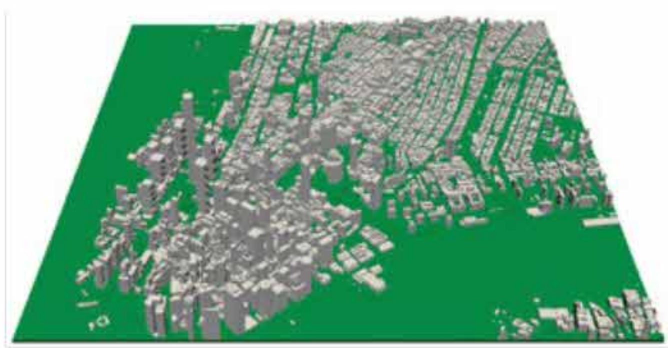


Fig. 1. 3x3 km^2 section of New York in a 2x2x1 m^2 mesh.

With the understanding that buildings of varied exterior type (i.e., concrete, steel, glass) have a varied impact on the propagation of neutrons, photons, and electrons, DTRA has characterized buildings within the geospatial data illustrated in Figure 1. DTRA has added internal building features to its modeling, to include doorways, inner walls, and floors/ceilings, as shown in Figure 2. Atmospheric features are also added to urban models to account for the varied refractory properties above the city, as depicted in Figure 3. At this time DTRA is uncertain whether this level of fidelity is necessary to support its analysis. Comparisons will be made with cases where buildings are simple, homogeneous structures.

The Monte Carlo N-Particle (MCNP) code from Los Alamos National Laboratory is the primary tool for transporting particles through the urban environment [4]. For this endeavor the cityscape shown in Figure 1, along with numerous other cities with LIDAR data available, is implemented within MCNP.

The MCNP simulation results for high energy photons commensurate with the output of a nuclear detonation and their propagation in the cityscape are given in Figure 4.

Additional areas where DTRA's work has improved capabilities include modeling electromagnetic pulse (EMP) and photon energy ranges. To improve the capability to simulate Teller-Light, the range of photons energies that can be simulated has been extended down to approximately 100 electronvolts.

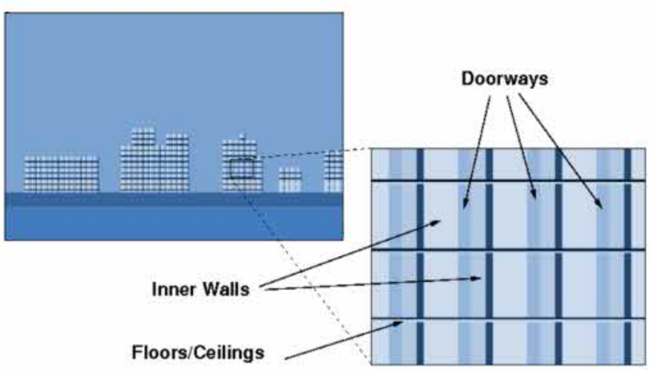


Fig. 2. Depiction of the level of detail for MCNP modeling of buildings, which captures interior features including inner walls, doorways, and floors/ceilings.

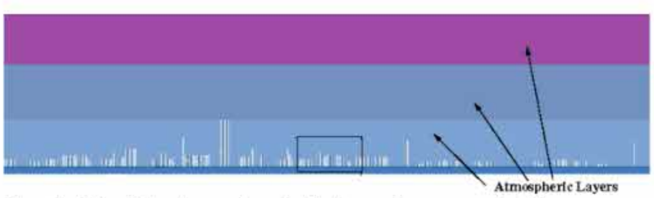


Fig. 3. Depicts atmospheric features incorporated in transmission modeling. Each layer is given the appropriate refractory characteristics in the MCNP model.

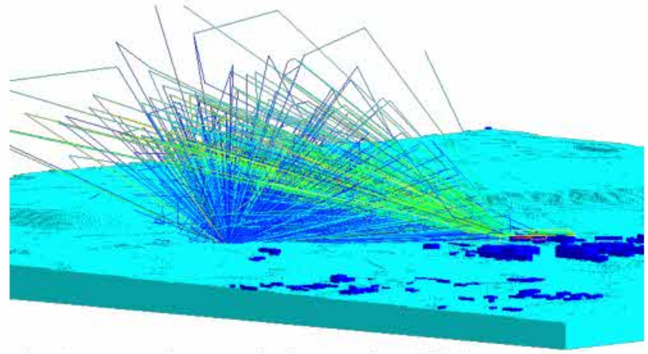


Fig. 4. Example transmission tracks of high energy photons from a nuclear detonation source to a sensor, modeled using MCNP. Blue tracks represent unscattered photons. A color change represents a scattering event due to the varied refractory properties of the atmosphere.

The ability to model RF signals in the complex urban environment has benefited from advancement in high performance computing capabilities, where entire cities can be resolved in mesh sizes never thought possible in the nuclear testing days. This effort leverages historic nuclear test data to develop and validate expertise in prompt signals propagation. The simulation of EMP has been improved with the addition of a three-dimensional first-principles capability based on MCNP and FDTD (finite-difference time-domain). These approaches improve accuracy and reduce the uncertainties of simulations performed in the cityscape.

To validate our models and transport calculation we have implemented a progressive test campaign. Up until October 2015 our test focused on independent validation of sensor performance and transport calculation for each speed of light phenomenology (gamma, radio-frequency, photonic). In October, with support from NNSA NA-22, Sandia National Labs, Los Alamos National Labs, and Livermore National Labs, we set up a three week test program at the HERMES facility at Kirtland Airforce Base. For the HERMES test we had all the speed of light sensor in the surrounding field collecting against a common source. This is the first opportunity where we will be able to compare results of all the sensors. Idealistically they should all come back to a common analysis of the source, but environmental influences and uncertainties will like create some challenges. The HERMES test collected approximately 46 sets of shot data. We're currently analyzing the data and plan to publish a final report in October 2016.

There are two future tests planned. The first is a test of all sensors at the White Sands Fast Burst Reactor in late 2017 where we have a difference source that provides a rise time different than HERMES. The second test is to use the models and transport calculations that were validated at

HERMES test and using our historic nuclear weapon test data, swap out the source and re-run our transport calculations to see how well our results compare to historic test data.

Unfortunately, most of our work with speed of light is associated with nuclear weapon output and not available for open discussion.

Speed-of-Sound Detonation Signals

Analogous to the speed-of-light signal propagation through an urban environment, the propagation of seismic and overpressure signals are heavily impacted by the urban landscape. For the purposes of seismic analysis, effects of a city's underground structure (buildings, utilities, mass transit, etc.) results in changes to the coupled signals. To accomplish such analysis, geological models are overlaid with information from various databases.

The seismic and overpressure signals that are measured can be compared with existing models that help to derive yield estimates and location information.

Three-dimensional Eulerian computational fluid dynamics codes leverage the three-dimensional terrain and buildings used in speed-of-light signal modeling. The numerically modeled air blast/overpressure wave, pictured two-dimensionally in Figure 5, provides insight into how such signals travel through the cityscape environment. The improved understanding of the cityscape's impact helps improve fidelity of weapon yield assessments.

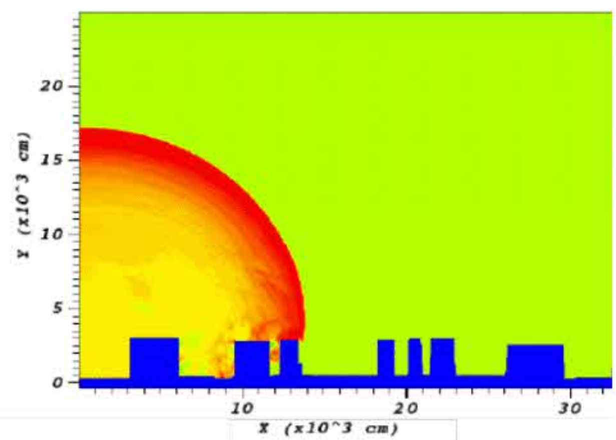


Fig. 5. Snapshot of a representative airblast signal as it interacts with building structures, shown in 2D.

Our test program to validate our speed of sound transport is much more advanced than what has been done for speed of light. DTRA has conducted a variety of tests nsince 2012 that looked at de-coupling, unique urban structures (parking garages and tunnels), different soil geologies, and near surface interaction of seismic and infrasound signals. Modeling and signal transport calculation have been used for every test to validate detector response and algorithms. These results have been used by the national laboratories and DTRA contractors to improve our ability to characterize the yield and location of a nuclear weapon detonation in an urban environment.

Later in 2016 DTRA will host another test for speed of sound sensors. The test scenario involves a weapon detonated in water (e.g. hull of a ship in a harbor). There will be a series of test shots focused at understanding the influence of the water barrier on land based sensors as the shock wave passes though the water and couples with the ground.

Existing treaties and agreements have helped eased the sensitivities associated with sharing or speed of sound data associated with characterization of a weapon's yield and location. May of the organizations supporting DTRA's research have published papers on improved algorithms and transport calculation. The vast majority of research has been associated with localized (urban centers) signals, but starting in 2016 DTRA has expanded some research into regional applications to monitor multiple urban centers.

CONCLUSIONS

The 21st Century threat has generated different information needs within the U.S. government to attribute responsibility. The technical nuclear forensics process that supports attribution has created new capabilities that complement traditional capabilities and improve both the timeliness and fidelity of information. Critical to these capabilities and process is the ability to understand and model how post-detonation nuclear weapon phenomenology transports through an urban environment. The detailed fidelity of speed-of-light and speed-of-sound signal simulation requires high performance computers to produce results in a reasonable and realistic time period. The isotopic interactions of these simulation are dependent on the accuracy of the cross-sections and other data used to describe the cityscape environment.

To support this effort, DTRA is working closely with the Department of Energy's National Nuclear Security Administration (NNSA) to thoroughly understand the signals received with high-confidence and to quantify the sources of uncertainty.

REFERENCES

1. Speech delivered by President Barack Obama, Prague, Czech Republic, April, 2009.

2. K. MOODY, I. HUTCHEON, P. GRANT, *Nuclear Forensic Analysis*, Taylor & Francis, Boca Raton, 2005.

3. R. STONE, "Who Dropped The Bomb," Science, **351**, *6278*, 1138 (2016)

4. J. BREISMEISTER; *"MCNP - A General Purpose Monte Carlo N-Particle Transport Code, Version 5,"* LA-UR-03-1987, Los Alamos National Laboratory (2003).

Technical Nuclear Forensics (TNF)

Office of Nuclear Forensics

DISTRIBUTION STATEMENT A. Distribution unlimited

Problem: The Threat has Changed – Leaders have Different Information Needs

- Cold War Threat (Adversary Known)
  - Global nuclear exchange with Soviet Union
  - Massive first strike
  - High consequence, low probability
  - Uncertainties were overcome with yield and quantity
- 21st Century Threat (Unknown Adversary)
  - Increased probability of some level of nuclear exchange due to proliferation
  - Nuclear threat from non-state actors
  - Limited exchange, likely from escalation of conventional war
  - Pre-emptive attack on critical infrastructure

New Information Requirements:

- Identification: What was it?
- Are there more?
- Who did it?
- Where did it come from?

DTRA's Role in Nuclear Forensics

Annex IV to NSPD-17/HSPD-4 "National Technical Nuclear Forensics" (NTNF)

- USG policy to "…improve the *global* capacity for forensic and technical attribution of WMD… and develop and maintain effective capability to conduct TNF…"
- Roles and Responsibilities – in coordination with Attorney General and consultation with other Departments:
  - ***DoD: Develop post-detonation nuclear sample collection capabilities and ensure lab capabilities support TNF analysis requirements.***

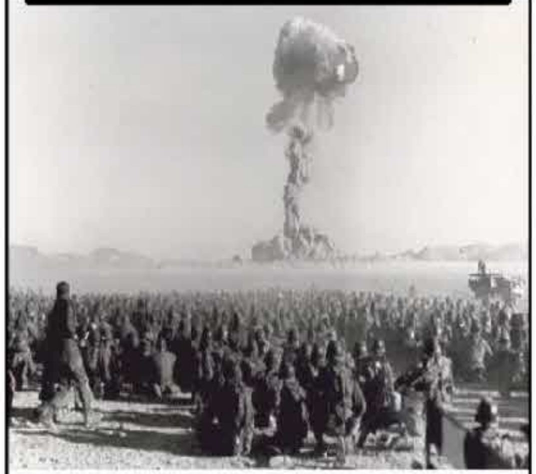
DoDD 2060.04 "DoD Support to the NTNF Program"

- DoD further tasks DTRA to *manage DoD NTNF R&D programs* and *coordinate them* with the Services and other non-DOD National Technical Nuclear Forensics (NTNF)-relevant R&D

DTRA's Office of Nuclear Forensics

- **Nuclear forensics** is an integral component of the broader process of ***attribution***, which fuses investigation, intelligence, and nuclear forensics information, to identify the source of the material or device and the persons or groups responsible for its use in planned or actual acts of terrorism.
- **Mission:** Design, develop, demonstrate, and transition advanced technologies and methodologies that improve the interagency operational capability to provide forensics conclusions after the detonation of a nuclear device.
- **Goal:** Determine the characteristics of the nuclear material or device and whether associations exist among people, places, things, and events.

(U) Dog; 1951 @ Nevada Test Site



(U) Grable; 1953 @ Nevada Test Site

Office of Nuclear Forensics

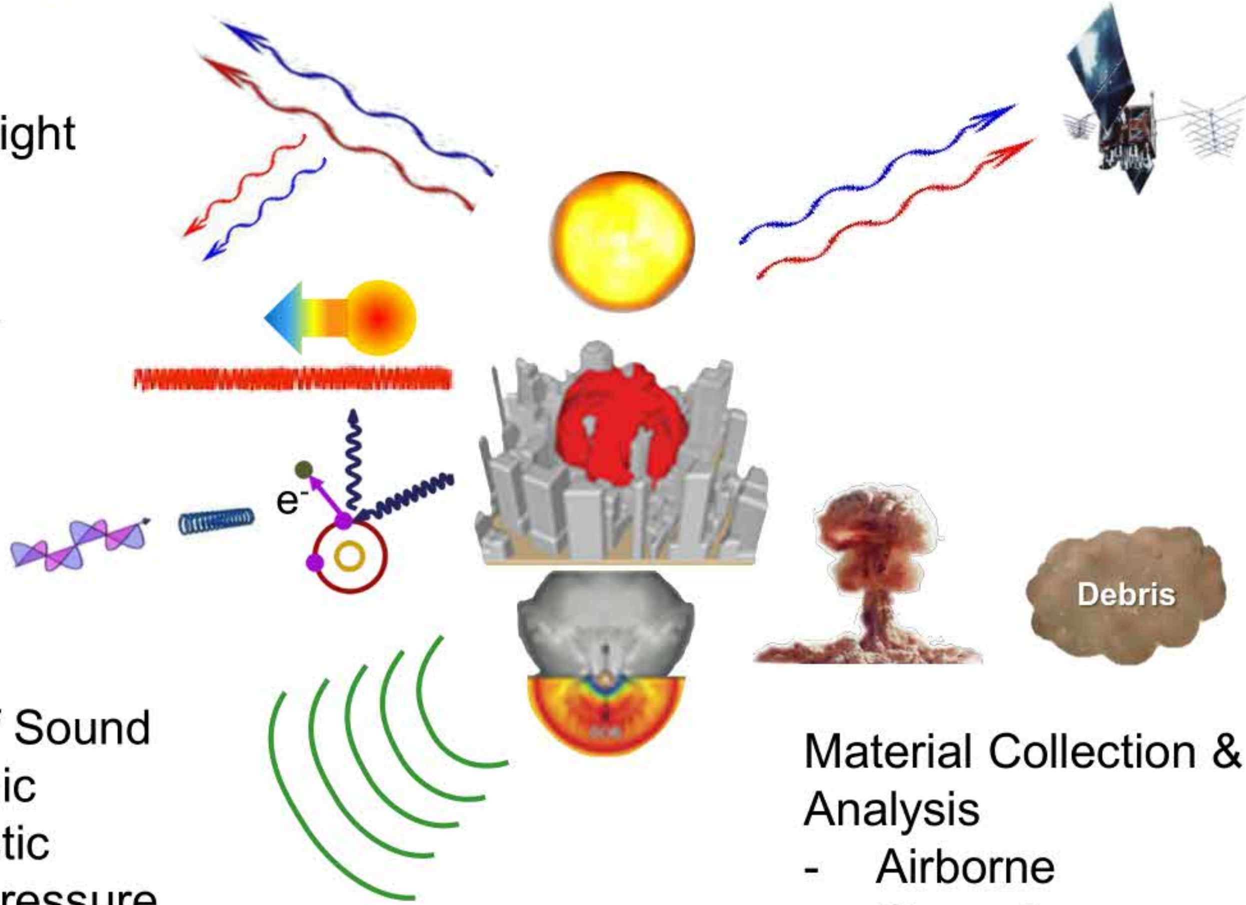
- Three Programs addressing the span of the TNF process to enable strategic decision-making (attribution)
  1. Nuclear Forensic Materials Exploitation for Attribution
  2. Prompt Nuclear Forensics Exploitation for Attribution
  3. Nuclear Device Characterization for Forensics
- Lead a coordinated interagency and international effort to decrease process timeline, increase results confidence and decrease uncertainties

Goal: provide direct answers to the attribution community and decision makers

Post-Detonation Nuclear Forensics Attributes

Speed of Light
- Optical
- EMP
- Gamma

Traditional Space Detection



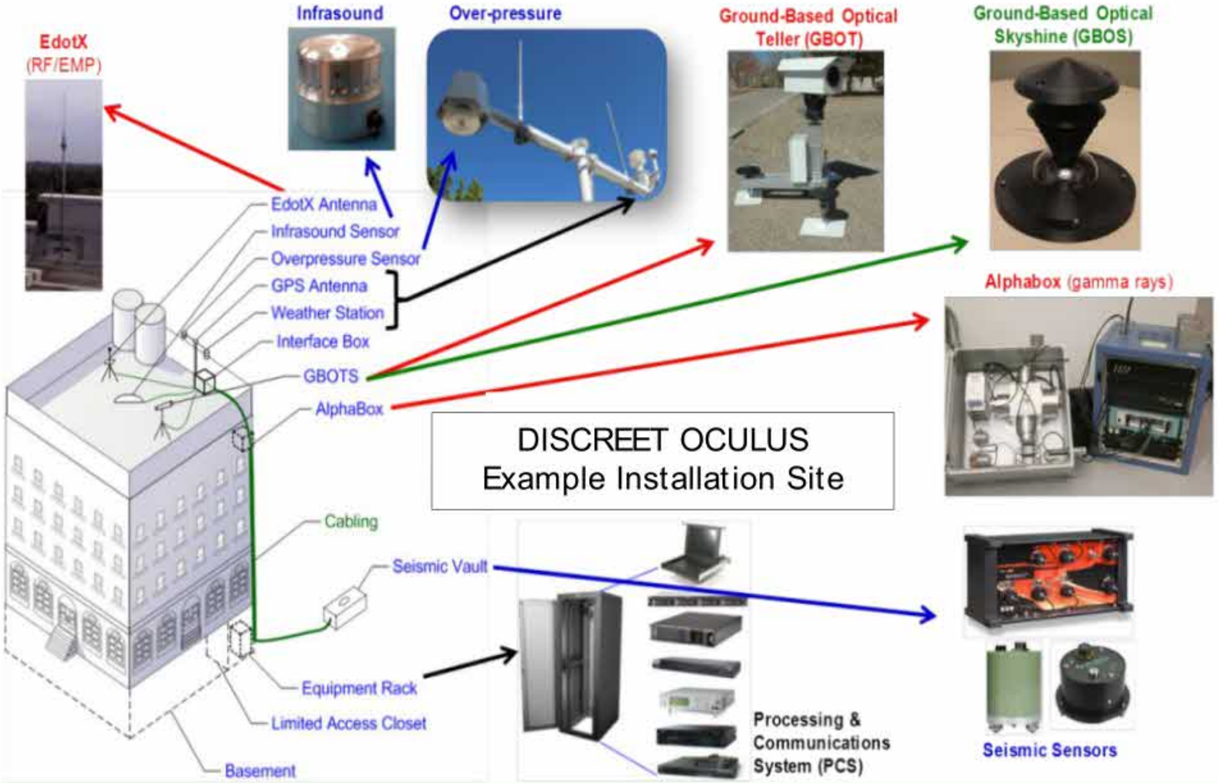
Speed of Sound
- Seismic
- Acoustic
- Overpressure

Material Collection & Analysis
- Airborne
- Ground

Airborne and Ground Particulate Collection Capabilities

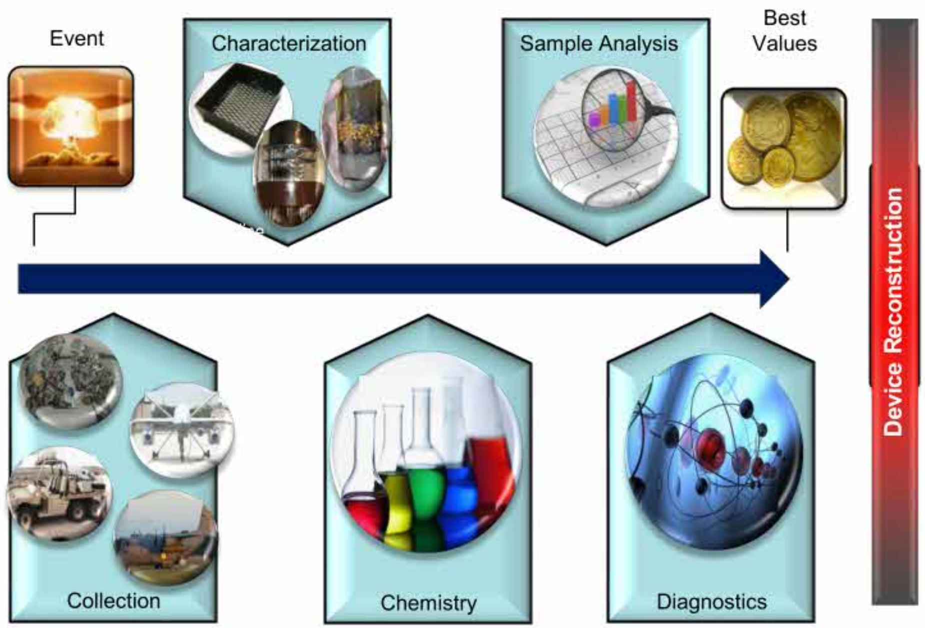
DISCREET OCULUS Prompt Diagnostics Ground Based Sensor Installation

DISCREET OCULUS will become part of a growing nationwide network to instantly send information to a data fusion center at the Air Force Technical Applications Center (AFTAC) located on Patrick Air Force Base, FL. Additional sensor stations near large metropolitan areas will ensure robust sensor network coverage.



DO integrates data from up to nine different sensor types to create actionable information that can be used by senior leaders in the attribution and law enforcement communities.

Materials Identification and Debris Analysis Solution (MIDAS)



Goal: Develop ***targeted*** technologies, methodologies, and tools to enable the collection, analysis, and interpretation of the composition of detonation materials ***relevant*** to nuclear forensics assessment and policy decision makers within a ***designated timeframe*** after the initial event.

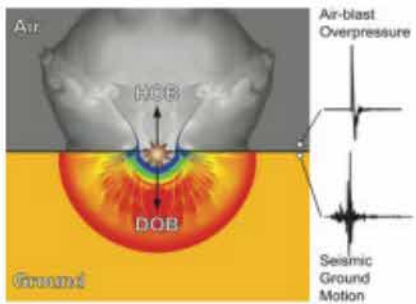
MIDAS targets technologies and methodologies to significantly impact operations and enhance accuracy and timeliness for materials forensics conclusions.

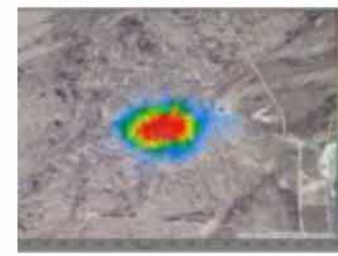
National Technical Nuclear Forensics (NTNF) Joint Capability Technology Demonstration

Three New Capabilities to the USAF and US Army

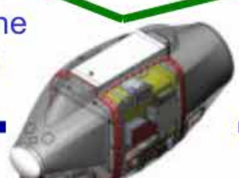
- Improved yield estimation of nuclear detonation phenomenology.
- Integrated advanced air and ground particle sample collection (manned & unmanned platforms).
- Ground collection team video reconnaissance, 3D terrain visualization, and radiation mapping and survey.

Integrated Yield Determination Tool (IYDT) Software

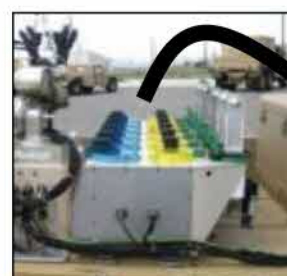




Mission Module Payloads (MMP) for Situational Awareness



Harvester Particulate Airborne Collection System (PACS)



Ground Particle Sampling System

Summary

- Cutting-edge R&D efforts continue to improve technology and capability across the nuclear forensics spectrum.
- Major R&D priorities today are to improve the speed at which nuclear forensic analytical results are obtained, while increasing their precision and accuracy.
- The existence of nuclear forensics capabilities promotes nuclear security by encouraging other governments to secure their nuclear materials to help prevent their unwitting transfer to third parties through loss of control.
- Need to continue to expand capability - Partnerships with Allies:
  - Mostly COTs/GOTs systems – should be sharable with international partners.
  - Peer review and co-sponsored tests and demonstrations.

Questions

Improved Transport Modeling to Support Post-Detonation Nuclear Forensics

Thomas E. Cartledge
Defense Threat Reduction Agency

The post-detonation nuclear forensics community needs better capabilities to model the urban transport of nuclear explosion signals

<u>Phenomenon</u>

Electro-Magnetic Pulse

Teller Light

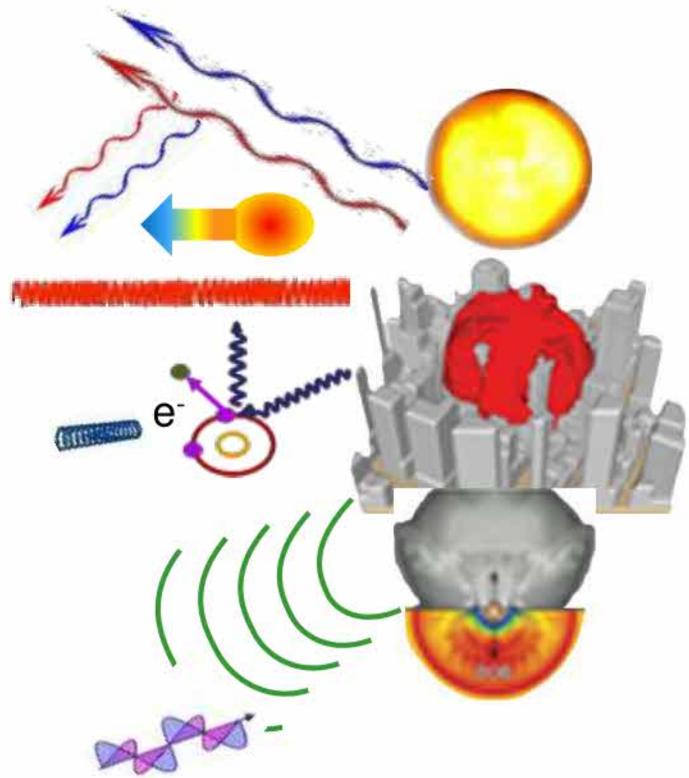
Optical Skyshine

Gamma Rays

Overpressure

Infrasound

Seismic



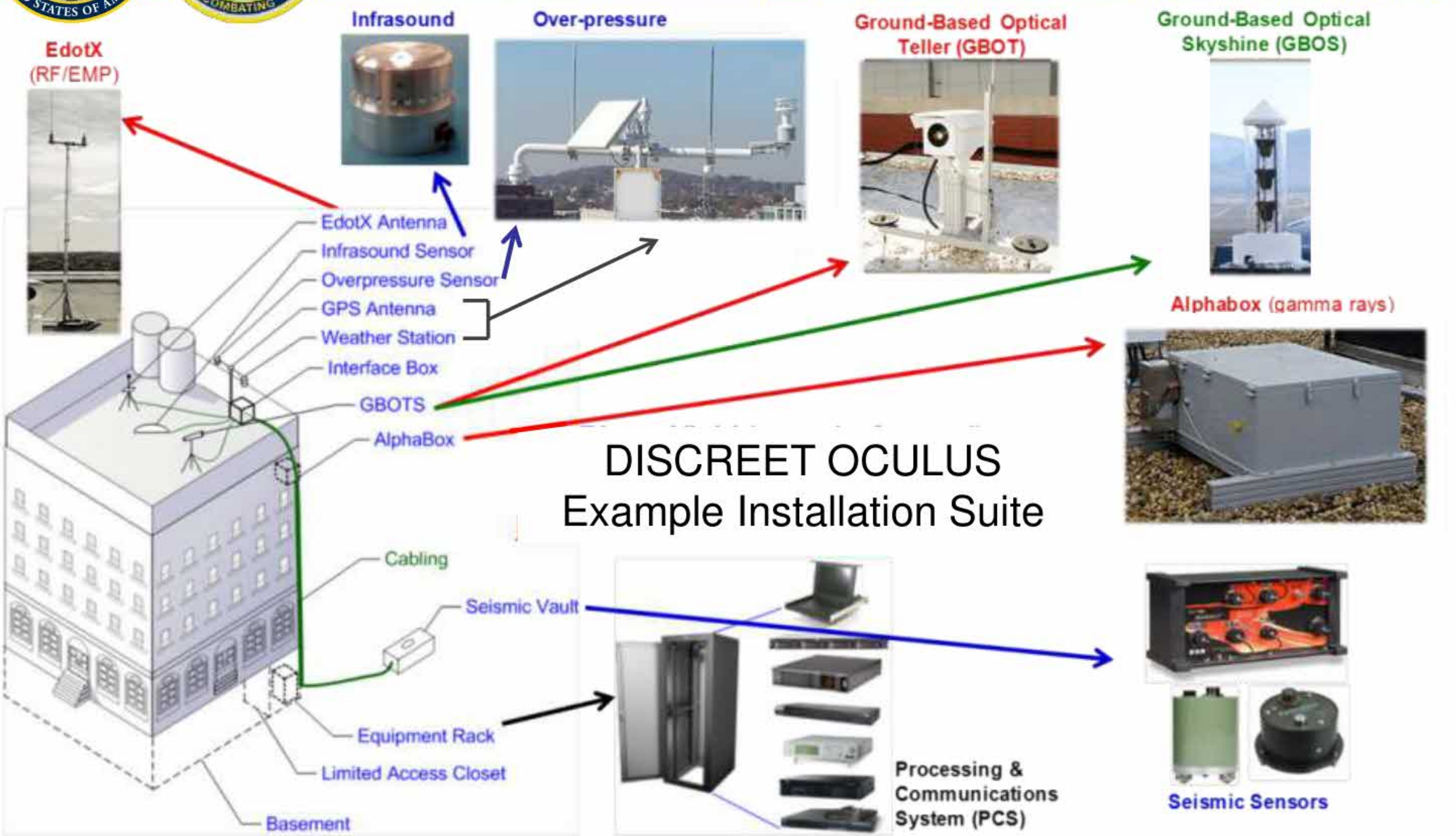
<u>Detonation Location</u>

Above Ground

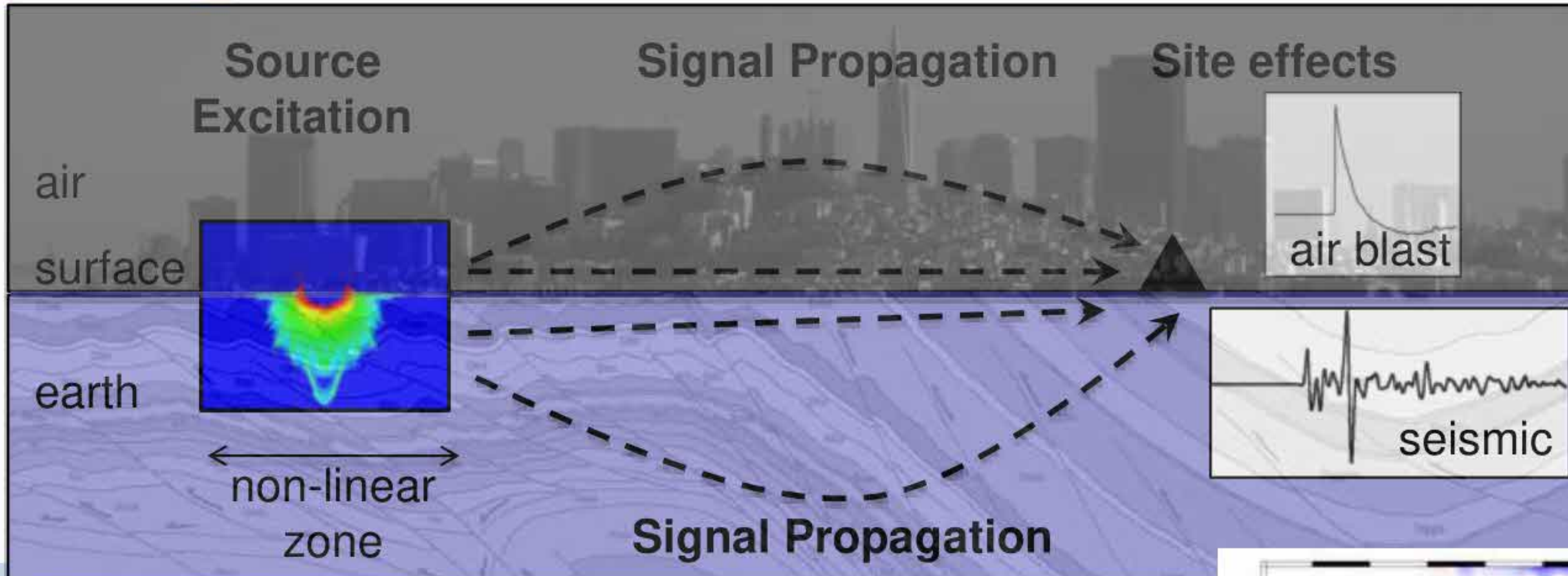
On-Surface

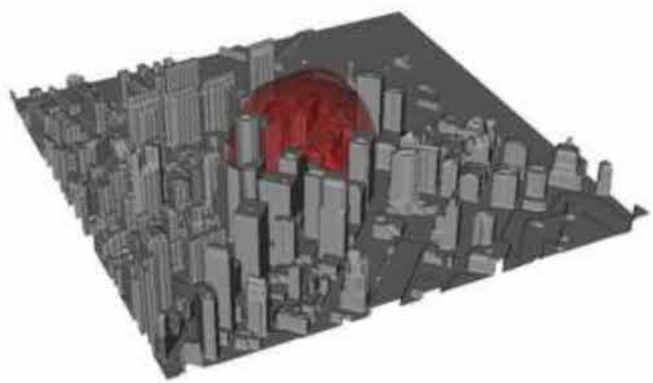
Partially-Buried

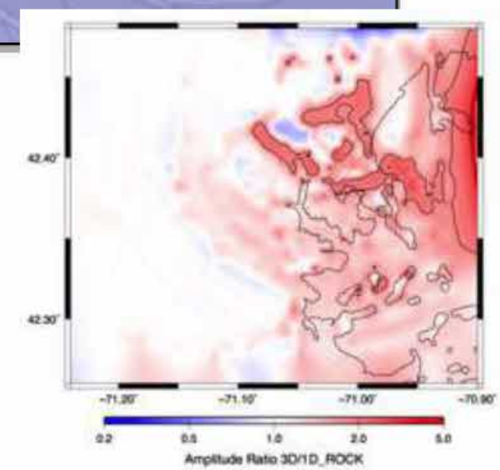
Improved modeling capabilities will directly support the analysis of data from nuclear forensics sensors we are deploying in U.S. cities



Our technical challenges in transport are opportunities for new research







DTRA has sponsored a lot of experiments and research[1-23] to improve seismic, overpressure, and infrasound transport

HUMMING ALBATROSS:
- Quarry shots
- September 7-8, 2011
- ***Observed directivity, wind, & weather effects***

HUMMING COYOTE:
- 13 explosions (100-2000 lbs) May 7-18, 2012
- ***Observed impact of geology, simulated urban structures, weather, winds***

HUMMING ROADRUNNER:
- August 10-30, 2012
- 6 explosions (10-50 tons)
- ***Observed impact of lithology variations, urban structures, directivity, weather at higher yields***

HUMMING SKUNK:
- April 2014
- 8 calibration explosions
- ***Objectives: Calibrate sensor network***

HUMMING TARANTULA:
- June 2014
- Low yield explosions at varying burst heights/burial depths in hard rock
- ***Objective: Develop seismo-acoustic coupling curves for granite***

HUMMING WOMBAT:
- DEC '13, MAR, JUN, SEP '14
- Rocket motor explosions in all four seasons
- ***Objective: Look at seasonal effects on infrasound transport***

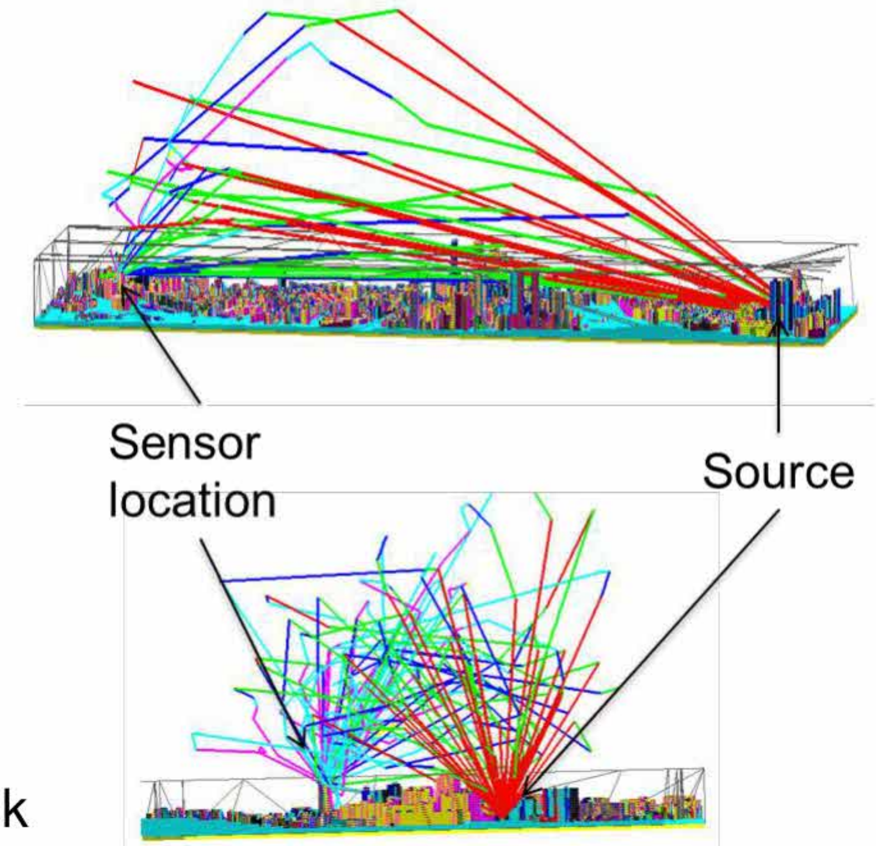
MIGHTY SABER 2015:
- Oct 2013 – Aug 2015
- High-fidelity 3D urban modeling of all relevant nuclear explosion signals

Demo 2016:
- Jan 2014 – Aug 2016
- High-fidelity 3D urban modeling of all relevant nuclear explosion signals

HUMMING TERRAPIN:
- Oct 2016
- Low yield explosions at varying burst heights/depth in water
- ***Objectives: Develop seismo-acoustic coupling curves for water***

However, little research has been done on urban transport of gamma rays, EMP, and optical signals

- HYPER ACTIVE Test
  - Conducted in Oct 2015 at HERMES facility
  - Allowed comparison of measurements across sensor phenomenology against a common source
- Need to understand:
  - Spectral transport effects
  - Temporal transport effects (i.e. what does a signal injected at location A as a delta function look like at location B)



Particle tracks from urban MCNP calculation

Almost no experimental data exists to benchmark codes

Conclusions

- Improvements in understanding urban transport of seismic, overpressure, infrasound and optical signals help improve nuclear forensics weapon yield assessments
  - A lot of research has been done in this area, but more is needed to address evolving threat
- Improvements in understanding what urban transport of gamma, EMP, and optical signals can provide is equally important
  - Additional information will assist in identifying characteristics of the nuclear weapon and attributing responsibility

References

1. Blom, P., & Arrowsmith, S. (2014). Predictions and Analysis of Infrasound from a Large Explosion at Regional and Global Distances. *Review of Monitoring Research.*

2. Blom, P., & Waxler, R. (2013). Eigenray Identification for Non-Planar Propagation. *166th Meeting of the Acoustical Society of America.*

3. Bonner, J., Landry, S., & Russell, D. (2012). Effects of Delay Firing on Surface Waves. *Bulletin of the Seismological Society of America.*

4. Bonner, J., Russell, D., & Reinke, R. (2013). Modeling Surface Waves from Aboveground and Underground Explosions in Alluvium and Limestone. *Bulletin of the Seismological Society of America*.

5. Bonner, J., Waxler, R., Gitterman, Y., & Hofstetter, R. (2012). Seismo-Acoustic Energy Partitioning at Near-Source and Local Distances from the 2011 Sayarim Explosions in the Negev Desert, Israel. *Bulletin of the Seismological Society of America*.

6. Bonner, J., Waxler, R., Reinke, R., Lenox, E., & Cole, P. (2013). Seismic and Acoustic Signal Generation and Propagation at Local Distances: New Datasets from Surface and Shallow Explosions. *Seismological Society of America.*

References

7. Bulaevskaya, V., Ford, S., Johannesson, G., Ramirez, A., & Rodgers, A. (2016). Joint Bayesian inference for near-surface explosion yield. *American Geophysical Union.*

8. Chiang, A., Dreger, D., Ford, S., Walter, W., & Seung, H. (2013). Moment Tensor Analysis of Shallow Sources. *American Geophysical Union.*

9. Ford, S., Ramirez, A., Rodgers, A., & Lenox, L. (2014). Crater Dimensions for Near-Surface and Buried Explosions. *Journal of Geophysical Research*.

10. Ford, S., Rodgers, A., Xu, H., Templeton, D., Harben, P., Foxall, W., et al. (2013). Partitioning of Seismo-Acoustic Energy and Estimation of Yield and Height-of-Burst/Depth-of-Burial for Near-Surface Explosions. *Bulletin of the Seismological Society of America*.

11. Frazier, W. G. (2014). Application of parametric empirical Bayes estimation to enhance detection of infrasound transients. *Infrasound Technology Workshop.*

12. Green, D., & Waxler, R. (2014). Overview of Infrasound Signal Detection and Phase Identification for the Humming Roadrunner Ground Truth Experiments. *Infrasound Technology Workshop.*

References

13. Lonzaga, J., & Waxler, R. (2013). An Exact Solution of a Burgers' Equation Governing Infrasound Propagation in a Range-Dependent, Windy Atmosphere. *166th Meeting of the Acoustical Society of America.*

14. Lonzaga, J., Waxler, R., Frazier, W. G., & Assink, J. (2013). Uncertainties Due to Atmospheric Winds in the Estimation of Event Yield from Thermospheric Pulse Lengthening. *EGU General Assembly.*

15. Napoli, V., Bonner, J., & Reinke, R. (2014). Characterization of S-Waves Generated from Aboveground and Underground Explosions in Alluvium. *American Geophysical Union Poster.*

16. Rodgers, A., Bonner, J., Ford, S., Templeton, D., Ramirez, A., & Dodge, D. (2014). Improving Yield Estimation for Near-Surface Explosions using Seismic and Overpressure Data. *Seismolofical Society of America Annual Meeting.*

17. Rodgers, A., Ford, S., Ezzedine, S., Vorobiev, O., Pitarka, A., Templeton, D., et al. (2014). Analysis and Simulation of Seismic and Overpressure Data from Near-Surface Explosions for Yield and Height-of-Burst/Depth-of-Burial Estimation. *Review of Monitoring Research.*

18. Rodgers, A., Ford, S., Ramirez, A., Xu, H., Templeton, D., & Dodge, D. (2013). Estimation of Yield and Height-of-Burst for Near-Surface Explosions from Seismoacoustic Data. *Seismological Society of America Annual Meeting.*

References

19. Rodgers, A., Sjogreen, B., & Petersson, A. (2015). Simulation of Coupled Seismoacoustic Wave Propagation in Three-Dimensions with a Summation-by-Parts Finite Difference Method. *Seismological Society of America.*

20. Waxler, R., & Velea, D. (2013). Refraction of Impulsive Signals by a Mountain Slope. *Acoustical Society of America Fall Meeting.*

21. Waxler, R., Bonner, J., Reinke, R., Talmadge, C., Kleinert, D., Alberts, K., et al. (2012). Acoustic Source Signal and Directivity for Explosive Sources in Complex Environments. *Meeting of the American Geophysical Union.*

22. Waxler, R., Green, D., & Lalande, J.-M. (2014). Propagation model based explosive yield determination from stratospheric infrasound arrivals: Humming Roadrunner data analysis. *Infrasound Technology Workshop.*

23. Weber, P. W., Millage, K. K., Crepeau, J. E., Happ, H. J., Gintterman, Y., & Needham, C. E. (2012). Numerical Simulation of a 100-ton ANFO Detonation. *Shock Waves*, 127-140.

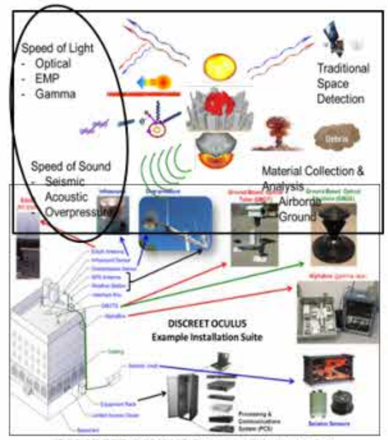
Fact Sheet

Defense Threat Reduction Agency
U.S. Strategic Command Center for Combating Weapons of Mass Destruction

Defense Threat Reduction Agency (DTRA) Prompt Nuclear Effects Exploitation for Attribution DISCREET OCULUS Program

The goal of DTRA's nuclear forensics program is to support and improve the interagency capability to provide forensics conclusions after the detonation of a nuclear device through the design, development, demonstration, and transition of advanced post-detonation National Technical Nuclear Forensics (NTNF) operational capabilities.

A major thrust area of DTRA's NTNF R&D effort is DISCREET OCULUS, a program to create a ground-based prompt detection and diagnostics system designed to characterize urban nuclear events to support the U.S. government's attribution efforts. DISCREET OCULUS complements current global- and space-based systems.



DISCREET OCULUS Prompt Diagnostics Ground-Based Sensor System

(FOUO) DISCREET OCULUS monitors and collects seismic, acoustic, air pressure, radiation, optical, and radio frequency waves to help WMD experts determine the yield, geolocation, and other characteristics of a nuclear attack to enable the attribution process. An initial prototype capability of ground-based prompt diagnostic sensor systems are being installed in four U.S. cites – Boston, MA (completed and transmitting data), Washington DC, and New York City/ Newark, NJ – and will transition to the USAF US Prompt Diagnostics System (USPDS) beginning in FY2018.

10-ton ANFO on Alluvium Lithology (left) and Tunnel Shot (right) Yield Estimation Sensor Tests

Extensive sensor performance testing, modeling & simulation, and technology demonstrations continue to be leveraged to verify system performance and achieve necessary technology readiness levels to transition this initial prototype capability to the USAF. DO integrates data from up to nine different sensor types to create actionable information that can be used by senior leaders in the attribution and law enforcement communities.

Swift and accurate forensic and attribution capabilities serve as a deterrent to nuclear terrorism, and are vital to the President to make time-sensitive decisions for response and prevention of future attacks. DISCREET OCULUS will become part of a growing nationwide network to instantly send information to a data fusion center at the Air Force Technical Applications Center (AFTAC) located on Patrick Air Force Base, FL and will support the overall attribution process.

Defense Threat Reduction Agency

DTRA safeguards the United States and its allies from the global WMD threats by integrating, synchronizing, and providing expertise, technologies, and capabilities across all operating environments. This Department of Defense combat support agency is located at Fort Belvoir, VA, and operates field offices worldwide.

For more information please contact the DTRA Governmental and Public Affairs (JOXG) Office.
August 2015

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