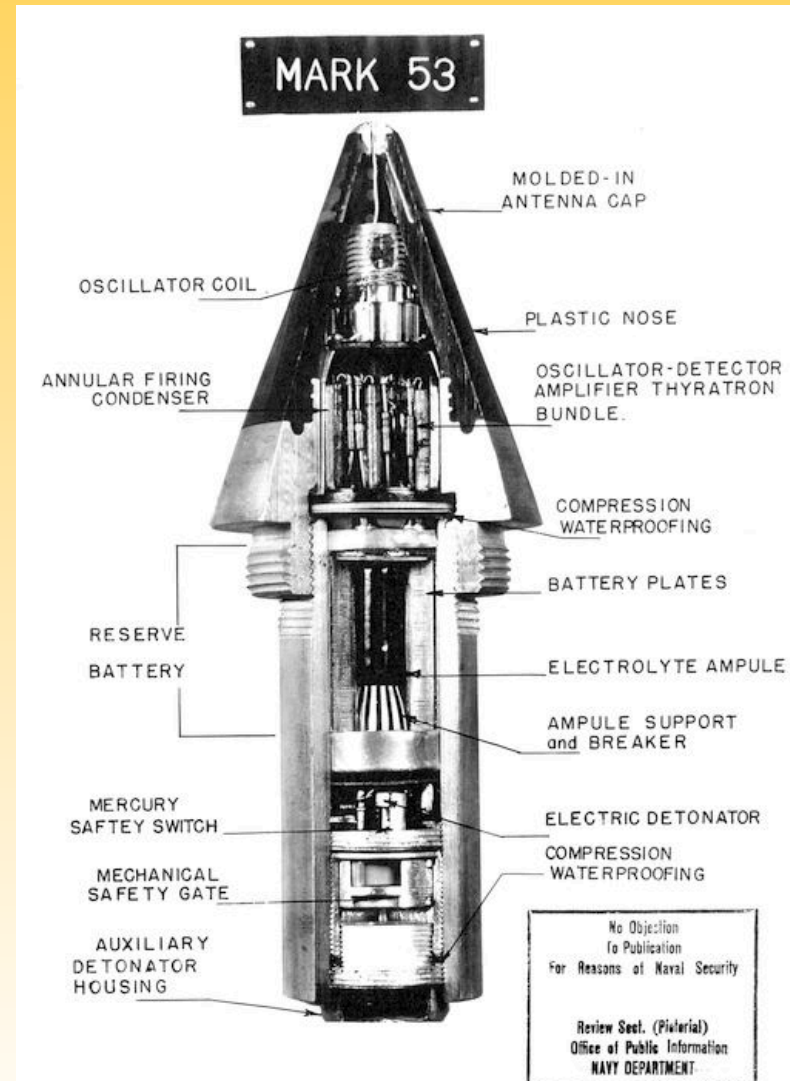




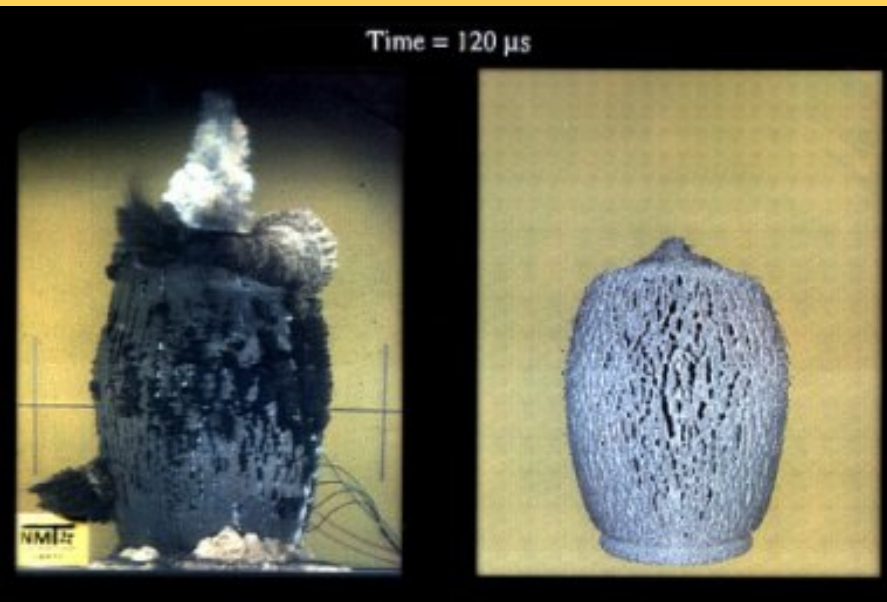
# RESEARCH & ECONOMIC DEVELOPMENT

Dr. Van D. Romero  
Vice President

# Proximity Fuse



# Weapons Systems to Technology Development



| 20mm/30mm | Tomahawk   | Patriot |
|-----------|------------|---------|
| Phalanx   | 90 mm      | 155 mm  |
| Hel Fire  | 4.2 mortar |         |
| 40 mm     | 120 mm     | Sat Arm |
| Tow       | Standard   | Ammram  |
| Tow2B     | Missile    | 105 mm  |
| Tow2A     | Side       |         |
| Roded     | Winder     | Hawk    |
| Warheads  |            |         |
| Chaparral |            |         |

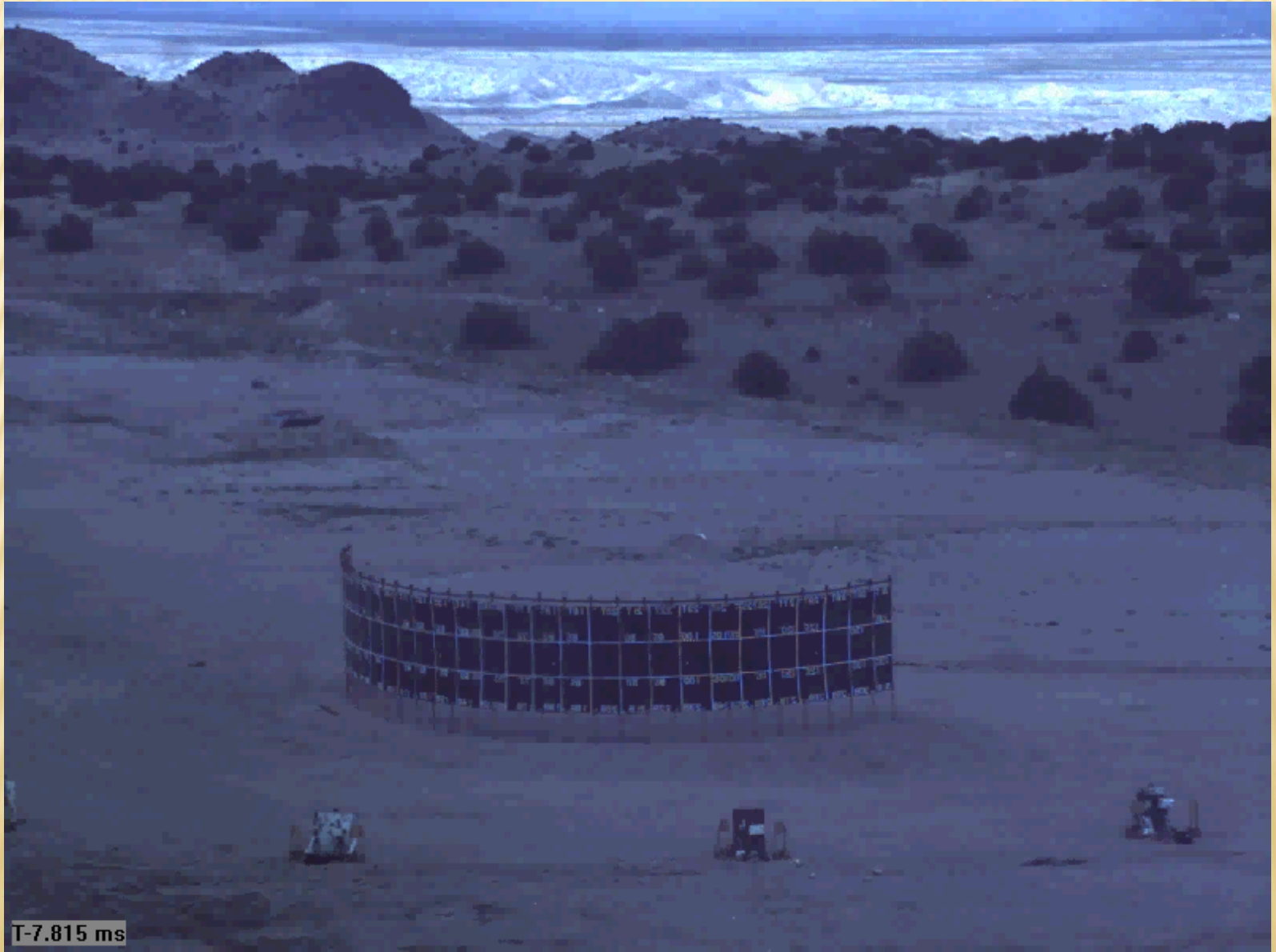
- Detection
- Investigations
- Improved Construction Techniques
- Windows
- Earthquake Protection



# Artillery Testing



# Arena Test



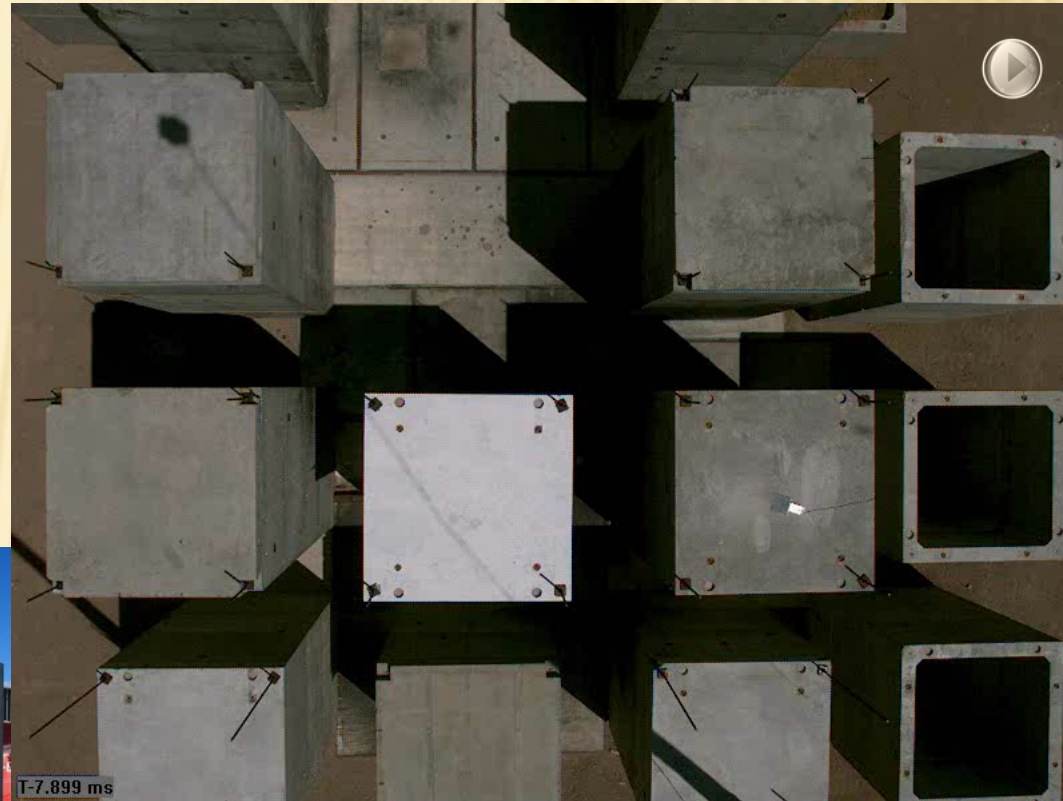
# Reactive Armor



# Enhanced Novel Explosives (ENE) in a Scaled Urban Environment

## Program Objectives

- Evaluate blast overpressures and damage from an ENE in an urban setting
- Design and construct a scaled urban environment
- Use data from TSWG sponsored research at DRDC Canada to develop a detailed computational fluid dynamics computer model
- Perform calibration tests at EMRTC
- Combine all results into a comprehensive data base
- Deliver a software tool that will predict damage in an urban environment from ENE's



# 3-1-1 RULE

**THE Sun** THE DAY BRITAIN WAS GROUNDED

Friday, August 11, 2006 35p www.thesun.co.uk SEE PAGES 2, 3, 4, 5, 6, 7, 8, 9, 10 & 11

- Plot to blow up 9 jets foiled
- 24 Brit Muslims held in raids
- 400,000 in airport chaos

# BOTTLE BOMBERS



**A TERROR plot to blow up nine jets using explosives in drinks bottles was smashed yesterday.**

● **ASIAN MAY** and **BRITAIN** ... the first attack - due on those planes departing tomorrow. Chase the British, disrupting ... Twenty-four Muslims ... were arrested in anti-terror raids in London, Birmingham and High Wycombe, Bucks. They included secret Islam ... Chase ... Gatwick passenger

**Sensation as McClaren drops Becks** SEE BACK PAGE

## 3-1-1 for Your Carry-Ons

Play Your Part →

|  |   |  |
|--|---|--|
| <p><b>3</b> 3.4 ounces* or less size containers of liquid or gel.</p> <p><small>*See this 3 ounces permitted in checked baggage.</small></p> <p>Containers like a security canister.</p>  | <p><b>1</b> 1 quart-size, clear plastic, zip-top bag holding 3.4 ounces or less containers.</p> <p>Bag limits: total volume per person.</p>  | <p><b>1</b> 1 bag per traveler placed in the security bin.</p> <p>Handing liquids through screening.</p>  |
|--|---|--|

Transportation Security Administration [www.tsa.gov](http://www.tsa.gov)





# INDUSTRIAL DIAMONDS



The background image shows a large-scale demolition of a multi-story building. The structure is partially destroyed, with a dense network of rebar and concrete fragments visible. Several large yellow and red excavators are positioned around the site, actively engaged in the demolition process. The ground is covered in a thick layer of rubble and debris. The overall scene is one of significant industrial activity and destruction.

# ***Developing Technology for Agencies***

**Can We Help First Responders?**

# RESPONDER TRAINING BENEFITS THREAT REDUCTION

15 POUNDS OUTSIDE BUS

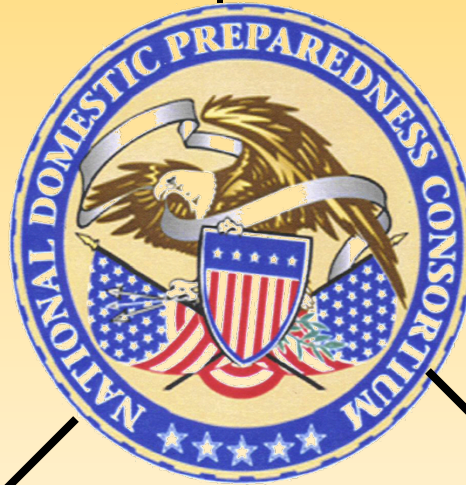


15 POUNDS INSIDE BUS



# New Mexico Tech

**Center for  
Domestic  
Preparedness**



# SHORT COURSES

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- ✘ Incident Response to Terrorist Bombings
- ✘ Prevention and Response to Suicide Bombings
- ✘ Explosive Principles and Interactions: Safety and Applications
- ✘ Fundamentals of Explosives Engineering
- ✘ Improvised Explosives Awareness and Recognition
- ✘ Border Security

# EMRTC EXISTING BUSINESS UNITS

- **Energetic materials**  
Explosives & ballistics research, test & evaluation programs
- **Cyber security**  
Development of cyber intrusion & detection methods & tools
- **Training programs**  
Customer awareness, recognition, safety & training for full-scale explosive environments

# EMRTC BUSINESS DEVELOPMENT THRUSTS

## EMBRACE STRATEGIC PARTNERSHIPS

- **Cyber kinetic test range** (Playas site)  
National resource to characterize integrity, speed, accuracy & reliability of electronic systems challenged by cyber-warfare tactics of the global battlefield environment
- **Data center threat protection** (Socorro site)  
National training, development, test & evaluation center that is responsive to physical & cyber threats (accidental, malevolent) to commercial & Government data centers
- **Border security** (Socorro & Playas sites)  
National training, development, test & evaluation center that is responsive to border threats that challenge the *health, security, safety & financial* interests of the United States

# EMRTC BUSINESS DEVELOPMENT THRUSTS

## EMBRACE STRATEGIC PARTNERSHIPS

- **Electronic infrastructure security** (Socorro site)  
Perform original RDT&E responsive to electronic system vulnerabilities to severe environments (triggered by accidents, attacks & acts-of-nature)
- **Electromagnetic resilience of cyberspace assets** (Socorro & Playas sites)  
Perform original RDT&E responsive to electronic systems (space, ground, air & naval) vulnerabilities when subjected to advanced adversarial electromagnetic illumination conditions
- **Home-made** (“improvised”) **explosives** (Socorro site)  
Perform original RDT&E responsive to fabrication, recognition, effects, neutralization & training of explosives assembled with easily-accessible commercial chemicals



# ACADEMIC PROGRAMS

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- ✘ Explosive Chemistry
- ✘ Materials Engineering
- ✘ Mechanical Engineering  
(Distance Education)

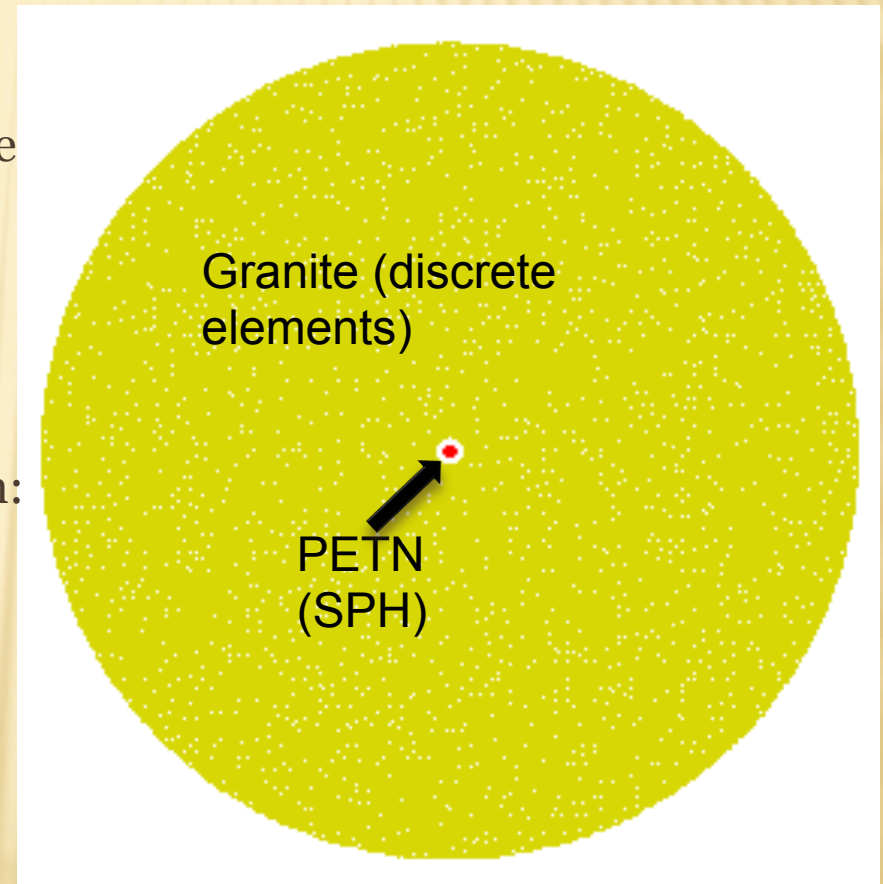
# OVERVIEW OF THE SIMULATION CONFIGURATION

Simulating a cylindrical sample of Barre granite:

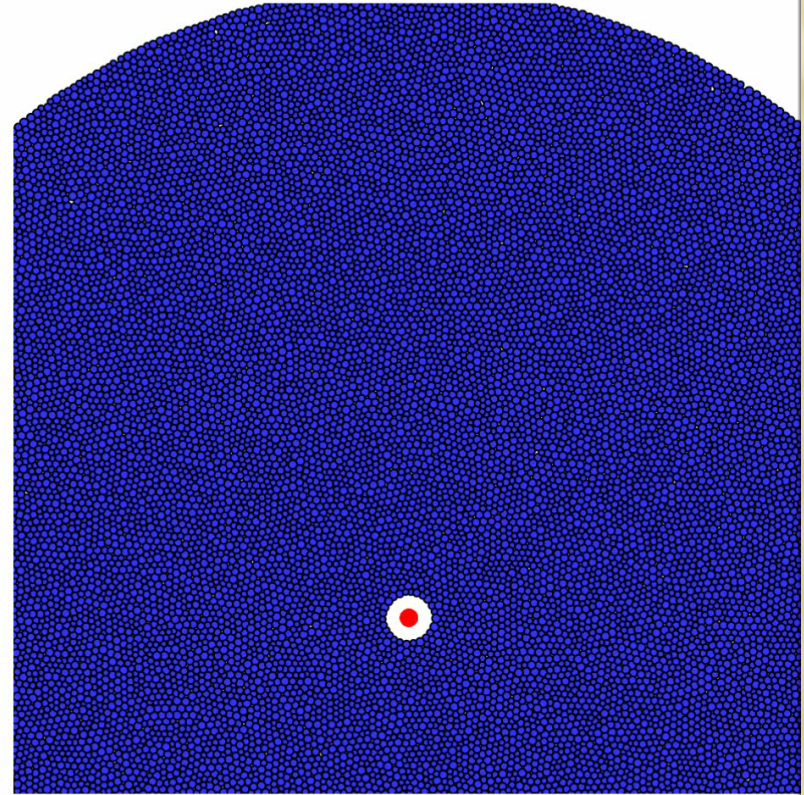
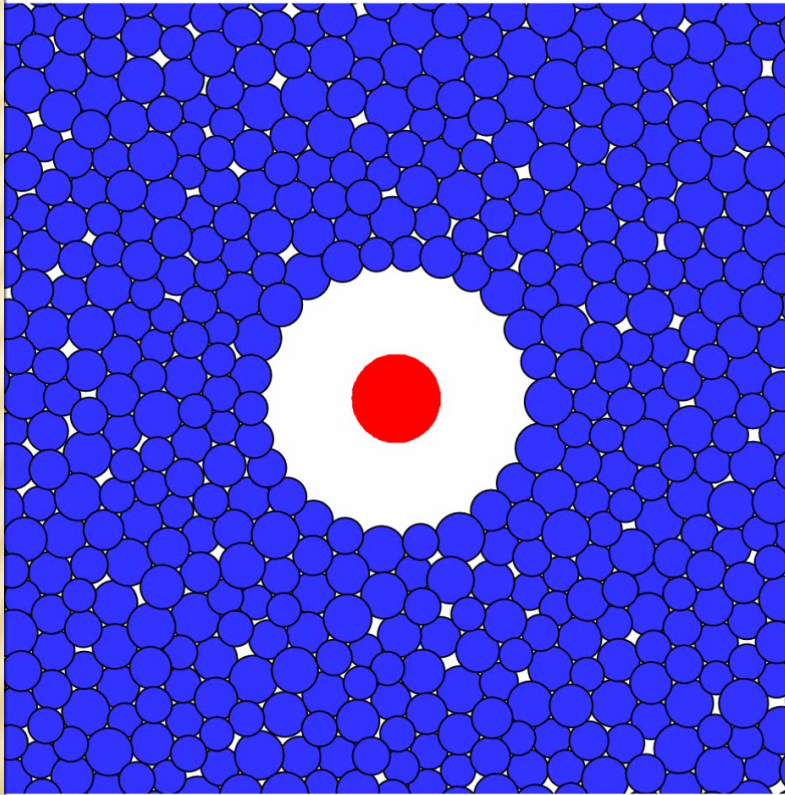
|                  |                         |
|------------------|-------------------------|
| Tensile strength | 7.37 MPa (1x/2x/5x/10x) |
| Poisson ratio    | 0.12                    |
| Diameter         | 144 mm                  |
| Borehole dia.    | 6.25 mm                 |

PETN in the center of the borehole with:

|                   |   |
|-------------------|---|
| Vacuum “coupling” |   |
| Diameter          | 1.65 mm   |
| Density           | 1.32 g/cm <sup>3</sup>  |
| Energy            | 5.73x10 <sup>6</sup> MJ/kg<br>(approx. 16 kJ/m total energy here) |





# GAS PENETRATION – 10X STRENGTH ROCK



**CA2 is able to fully model gas flowing through rock cracks.**

# SPECTRAL SIGNATURES OF THE HIDDEN BOMB FROM INSPIRE ISSUE 13

- ✘ Terrorist Literature on making a suicide bomb from commonplace materials
- ✘ “Undetectable”
  - + No metallics
  - + Silicone coating
- ✘ Unique spectral signatures for detection methods



## Spectral signatures of the hidden bomb from Inspire Issue 13

Melissa S. Candelaria-Lyons, Van D. Romero, Nikolai G. Kalugin  
Energetic Materials Research and Testing Center, Research and Economic Development Office, and Department of Materials and Metallurgical Engineering of New Mexico Tech

### Introduction

Inspire Magazine is an English language publication dedicated to educating aspiring terrorists. Each issue of Inspire contains step-by-step directions for assembling a device that will arm terrorists in their conflict with America. Inspire Issue 13 delivers a covert bomb that can easily be prepared at home [1]. All components for this device are common household items such as matches, black cummin seed, hydrogen peroxide, eggshells and vinegar. The illustrated, step-by-step instructions aid in assembly of the device. The finished bomb is difficult to detect because it does not contain metallic components. Additionally, it is coated in a thick layer of silicon, making canine detection challenging [1].

### Materials & Methods

Searching for efficient detection method for this bomb, we performed spectroscopic analysis of the key components of the main charge: black cummin seeds,  $KClO_3$ , and match heads. We looked for spectral signatures in different wavelength regions, including Far-Infrared and visible range techniques.

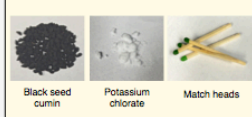


Fig. 1. Photos of tested samples




Fig. 2 FTIR and Raman spectrometers used in our experiments

### Results

#### Far- and Mid-Infrared transmission results:

The Far-IR transmission and attenuated total reflection measurements [2] have revealed that the major signatures for the oxidizer and for one of the components of the initiator are in the range below  $1500\text{ cm}^{-1}$ .

#### Raman and Photoluminescence results

##### Black cummin seeds

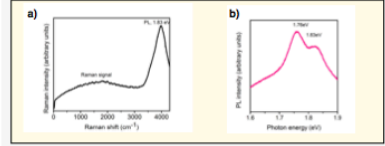


Fig. 3. a) Raman spectrum of black cummin seeds, 532 nm excitation. b) PL spectrum of black cummin seeds, 633nm excitation.

##### Match heads

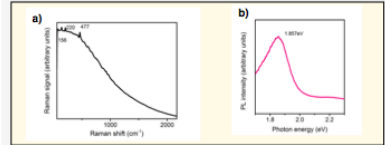


Fig. 4. a) Raman spectrum of match head, 785 nm excitation. b) PL spectrum of match head, 532nm excitation.

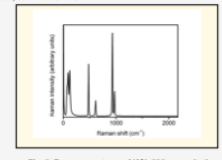


Fig. 5. Raman spectrum of  $KClO_3$ , 785nm excitation

### Conclusions

The components of the hidden bomb from Inspire 13 are detectable by vibrational and photoluminescence (PL) spectroscopies. In particular:

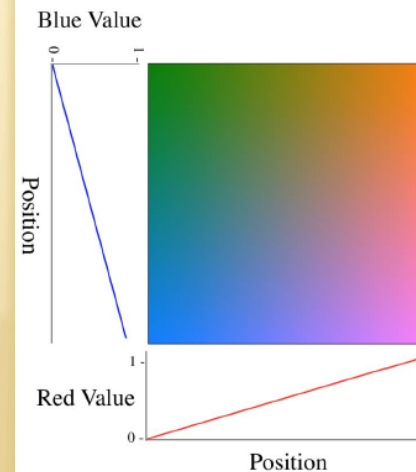
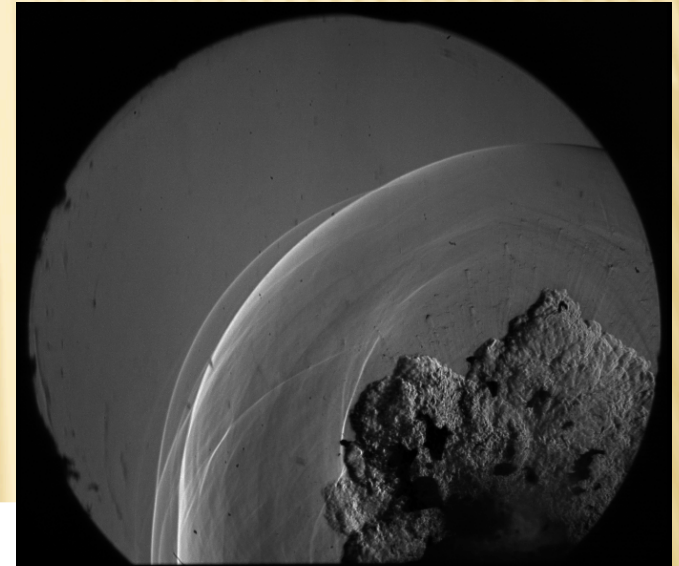
- The black cummin seeds may be detected via PL measurements using characteristic PL peaks at 1.76 eV and 1.83 eV
- Match heads have distinct spectral features in Raman and PL spectra: PL peak at 1.857 eV, and Raman lines at 156, 220, and  $477\text{ cm}^{-1}$ .
- Potassium Chlorate is detectable by Raman and Far-Infrared spectroscopy

### References

- [1]. Inspire 13
- [2]. Möller KD and Rothschild WG (1971) Far Infrared Spectroscopy. New York: Wiley-Interscience.
- [3]. Gardiner, D.J. (1989). Practical Raman spectroscopy. Springer-Verlag. ISBN 978-0-387-50254-0

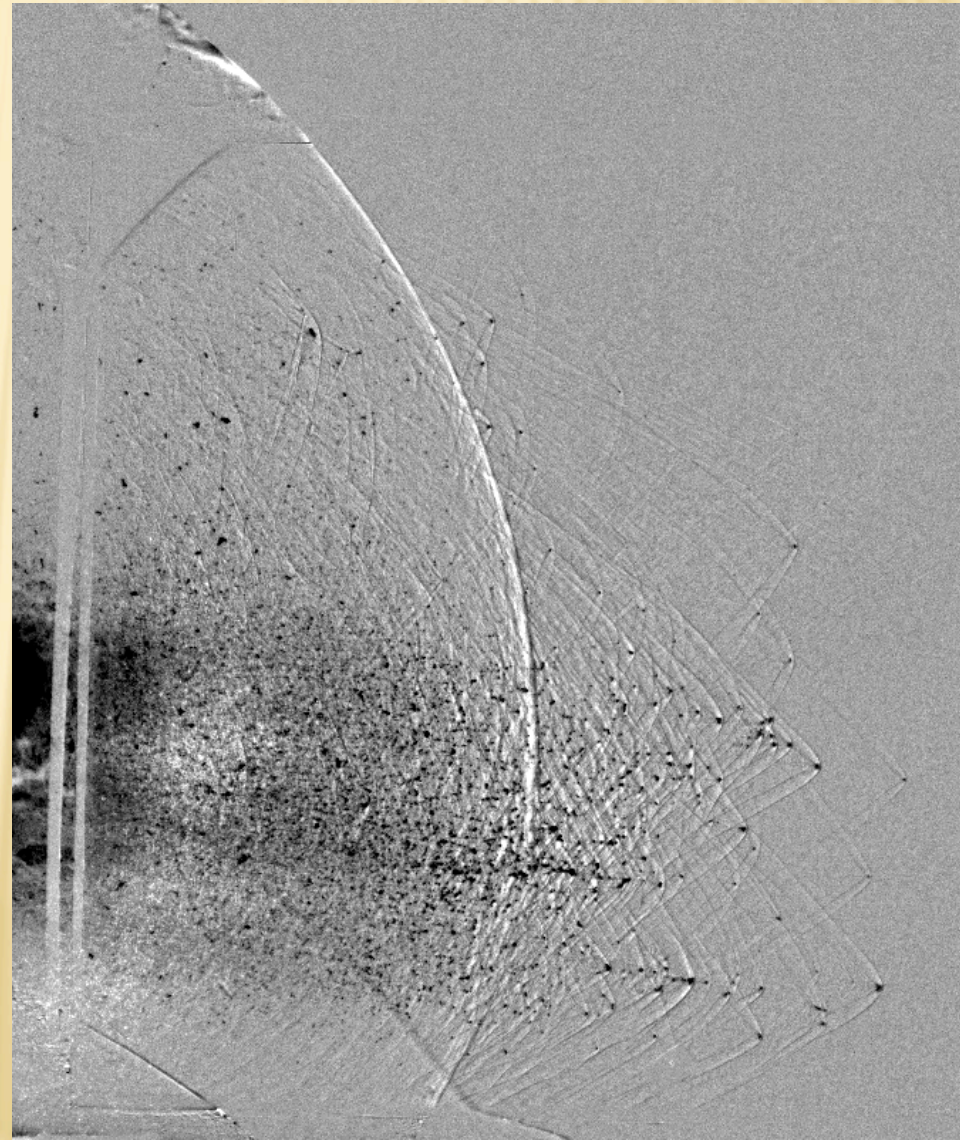
# OPTICAL DIAGNOSTICS FOR ENERGETIC MATERIALS RESEARCH – ANDERSON, SMITH, MIER, HARGATHER

- ✘ Refractive imaging techniques used to study energetic events
  - + Schlieren
  - + Shadowgraph
  - + Background Oriented Schlieren (BOS)
- ✘ Quantitative and qualitative measurements
  - + Shock speed
  - + Quantitative density fields
  - + Turbulence measurement and flow visualization
- ✘ Laboratory and field-scale techniques



# THREE-DIMENSIONAL SHOCK WAVE AND FRAGMENT TRACKING FOR WARHEAD CHARACTERIZATION

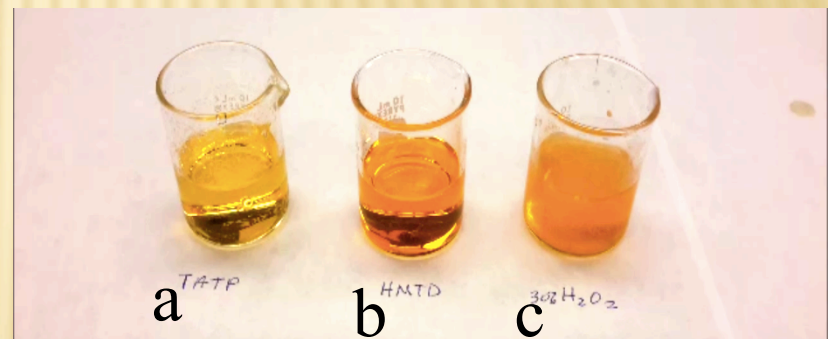
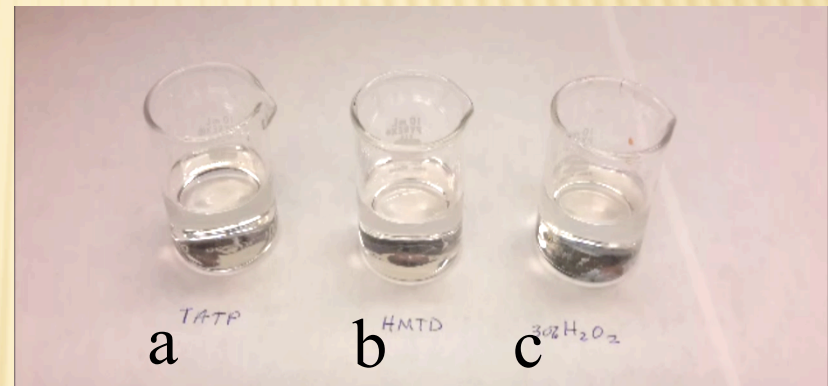
- ✘ Stereoscopic imaging to identify three-dimensional positions
- ✘ Retroreflective shadowgraph and background oriented schlieren imaging to image shock waves
- ✘ Measurement of three-dimensional position, velocity, acceleration for fragments and shock waves
- ✘ Authors: Winter, Locke, Hargather



# DETECTION OF PEROXIDE-BASED EXPLOSIVE VAPORS BY EXPLOITING TITANIUM OXYSULFATE AS A COLORIMETRIC SENSOR:

Tompkins, Payne, Simitz, Henneke

- ✗ Titanium Oxysulfate  $[\text{TiO}(\text{SO}_4)]$  is a detection solution for peroxide-based explosive (PBE) vapors
- ✗ Color change occurs when PBEs complex with the Titanium (IV) cation:
  - + Vapor detection occurs within ~1 minute
  - + Differentiation between PBEs is possible
- ✗ Method may be adapted to a portable detection device



Titanium oxysulfate before and after the reaction with a) TATP, b) HMTD and c) 30%  $\text{H}_2\text{O}_2$

# SHOCK DRIVEN REACTIONS IN NANO-ALUMINUM AND WATER ROCKET PROPELLANTS:

Schmitt, Bowden, Tappan, Henneke

- ✘ Nanoaluminum (nAl) and water (ALICE) is a potential rocket propellant, but the detonation characteristics need to be understood:
  - + Critical diameter via rate-stick detonation
  - + Detonation velocity for different diameter charges
- ✘ Small-scale sensitivity experiments: ESD, Drop Hammer, Friction



Nanoaluminum and water suspension <sup>31</sup>

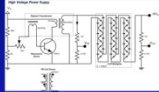


# HIGH-VOLTAGE GENERATOR FOR ENERGETIC MATERIALS (TEARE@EE.NMT.EDU)

- ✘ Current efforts are on understanding the electrical properties of energetic materials under high-voltage stress.
- ✘ PETN is pelletized at densities from 0.6 to 0.95 TMD and thicknesses of 1 to 5mm and stresses up to 30kVDC are used.
- ✘ Punch-through arcs have been obtained on PETN pellets and a full data set covering the ranges of interest is being generated.

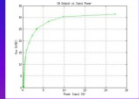
**High-voltage generator for energetic materials**  
A.C. Boston<sup>1,2</sup>, K. Cronin<sup>1</sup>, R. Villegas<sup>1</sup>, R. Schwingle<sup>1</sup>, M. Lyons<sup>1,2</sup>,  
M. Tompkins<sup>1</sup>, T. Wilber<sup>1,2</sup>, S.W. Teare<sup>1,2</sup>  
<sup>1</sup>New Mexico Institute of Mining and Technology  
<sup>2</sup>Energetic Materials Research and Testing Center

**Electrical HV Testing**  
Electrical energy can be used to initiate a reaction in energetic materials so understanding their electrical properties over a wide range of voltages is of interest to many researchers. There are a number of challenges in exploring the electrical properties of energetic materials, not the least of which is the development of a high voltage generator. The test instrument developed for use in our work is described here.




This circuit uses a resonant driven flyback transformer to pump a Cockcroft-Walton (PW) voltage multiplier. The key property of the multiplier is that voltage drops rapidly as current flows. This makes the generator a very sensitive conductivity meter.

The multiplier is shown above with 3 stages each comprised of 4 "voltage doubler" circuits in series. The current system requires only 1 stage to be present to achieve 30kVDC. Notice that after this point considerable power must be added to increase the voltage.





**Abstract**  
The electrical properties of energetic materials are important from the perspective of both intentional and unintentional ignition events. The electrical characteristics of energetic material pellets depend on several factors, including the chemical composition, density, and the physical dimensions of the material. Electrical testing of energetic materials requires careful control of the electric field magnitude and electrode shape as well as the behavior of the high voltage generator during electrical discharge. This paper discusses a high voltage generator that is very sensitive to current flow at voltages greater than 30kVDC. This generator has been used in testing several energetic materials over a range of physical dimensions and densities to investigate electrical punch through events.

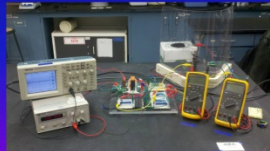
**Construction**  
The flyback transformer is constructed by winding insulated wire onto concentric bobbins and a ferrite core inserted. The flyback and resonator circuit board are mounted together. A single stage of the Cockcroft-Walton multiplier is shown. The bobbins and stand are made using a 3D printer and PET-T filament.



The sample holder/ electrode assembly was also 3D printed and incorporates a self-aligning sample mounting tool. The electrodes contact between high voltage and ground. A pressed PETN pellet (thin thick and 19mm in diameter shows the hole induced by a high voltage punch through arc formed at a voltage of ~30kVDC at ~65% TMD.



**Complete System**



**References**  
J.D. Cockcroft, E.T.S. Walton, Proc. Roy. Soc. A, (129) 477, 1932.  
Presented at the National Energetic Materials Consortium, Texas Tech, Oct 12-14, 2015

**NEW MEXICO TECH**  
SCIENCE • ENGINEERING • RESEARCH UNIVERSITY

- This work has involved undergraduate and graduate students from electrical engineering, mathematics and materials science and combines knowledge of high voltage electronics, explosives and 3D printing.
- The successes from this work are being applied to a wider range of energetic materials in the coming year.

# MYTHBUSTERS

