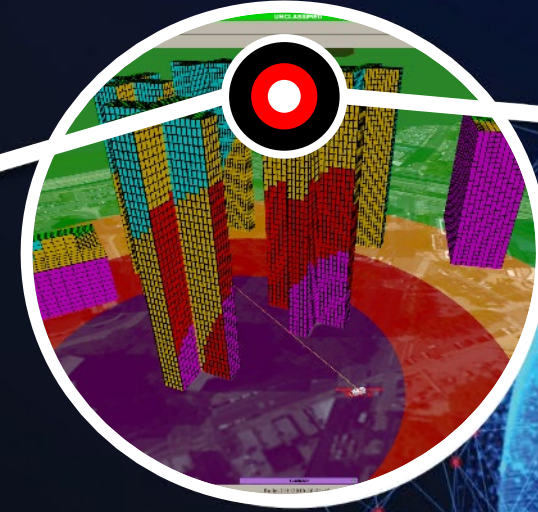
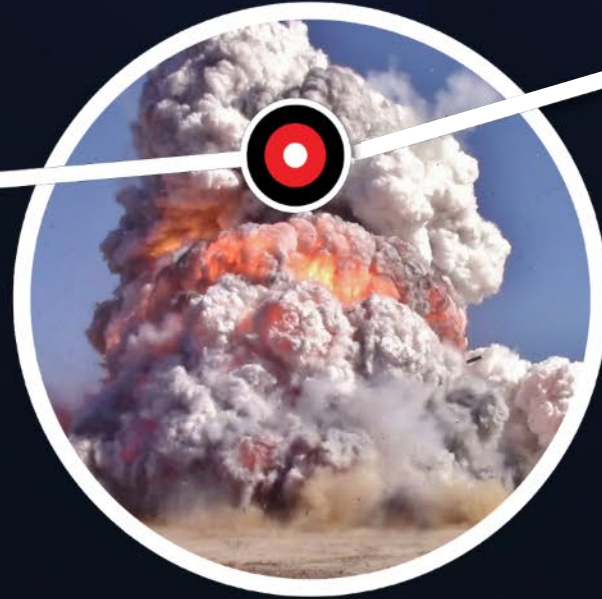


CONNECTING THE DOTS TO INNOVATION



# Force Protection and Weapons Effects

Category: Approved for Public Release  
Distribution Statement: A

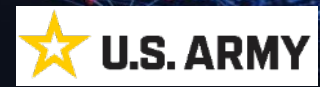
Genevieve Pezzola, PhD

Jason Roth, PhD, Andy Frank, PhD, and Bill Heard, PhD,

Tracey Waddell - Graphics

U.S. ARMY CORPS OF ENGINEERS  
ENGINEER RESEARCH AND DEVELOPMENT CENTER (ERDC)

13 Mar 2024





# History in Blast and Ballistics Research



TRINITY 1945

1960: Early WES research for Defense Nuclear Agency

1960

Original WES blast load generator built to simulate nuclear blast loads

Pioneering research on ground shock and cratering

Structure and equipment survivability from nuclear effects

Early mechanics for earth penetrating weapons

Conventional weapons effects: Prediction standards

Penetrator effects against hardened structures

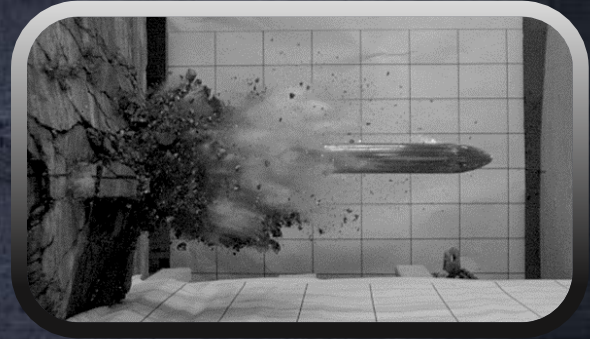
Structure protection against terrorist attack

Field fortifications for battlefield protection

RAM basecamp protection

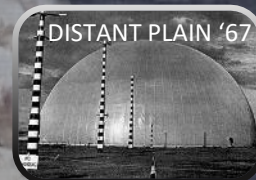
Buried IEDs and VBIEDs

Advanced weapons effects



SNOWBALL '64

1980



DISTANT PLAIN '67



WTC '93

1992: WES named S&PS Lead in RELIANCE 21

2000



SEPT 11<sup>TH</sup> ATTACKS

2020



IED SIMULATIONS



SAFGUARD '60s-'70s



KHOBAR TOWERS '96

References: Fatheree. 2006. The History of Geotechnical Engineering at the Waterways Experiment Station, 1932-2000. Robert E. Walker, verbal communication

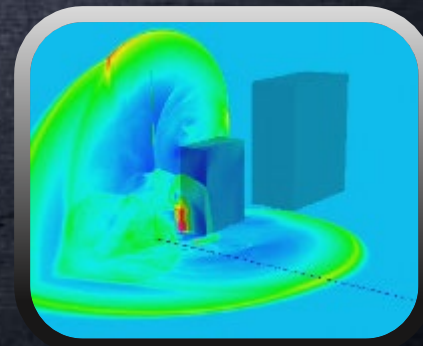
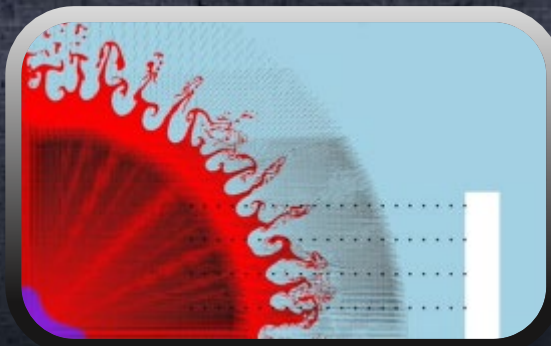
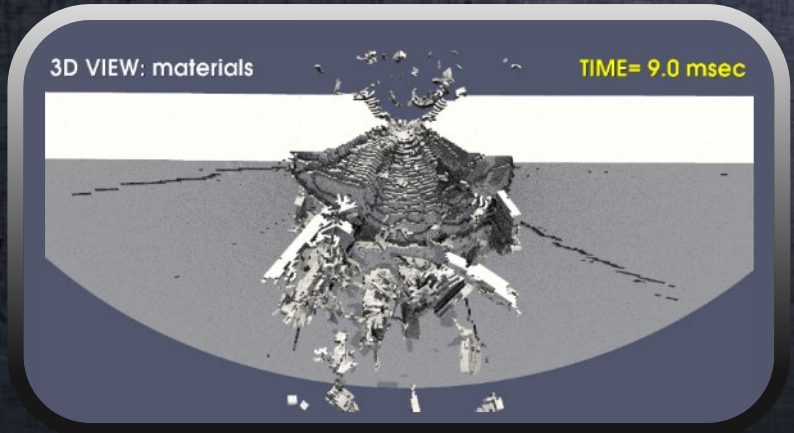


# Military Research Mission

Utilize State-of-the-Art Modeling and Experimentation to

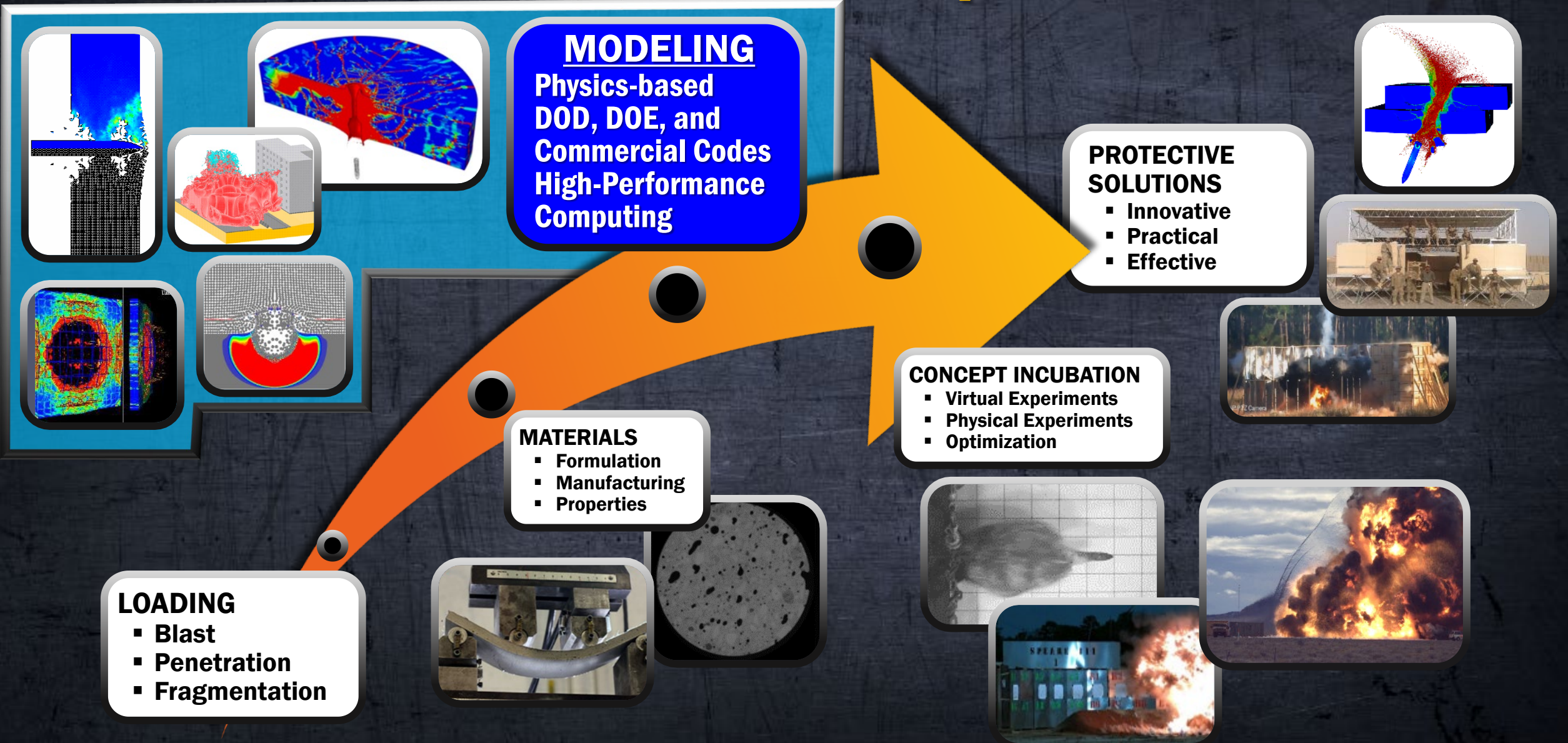
*Investigate Complex Military Challenges and*

*Develop New Solutions for Fielding*





# Framework for Solution Development



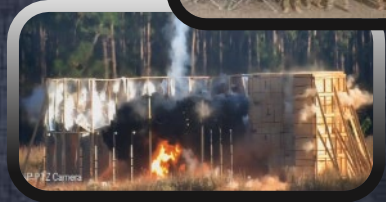
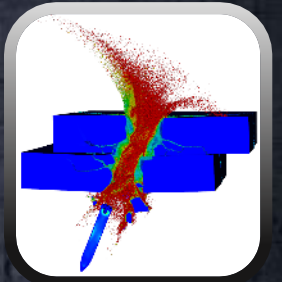
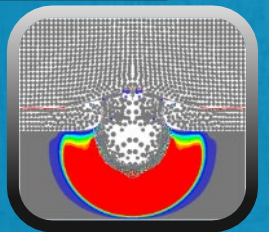
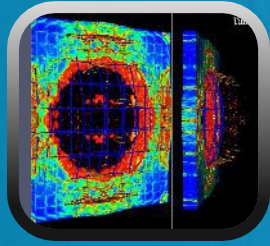
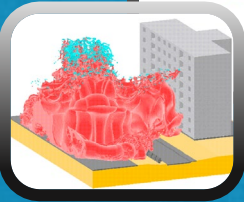
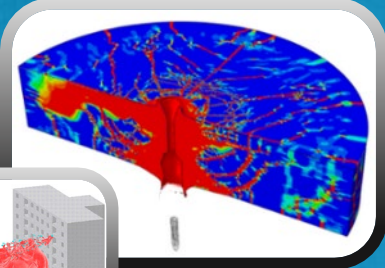
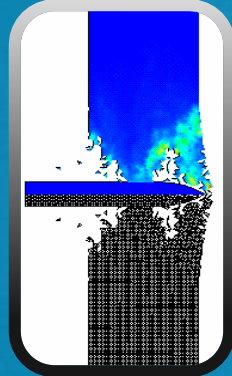
**MODELING**  
 Physics-based  
 DOD, DOE, and  
 Commercial Codes  
 High-Performance  
 Computing

**PROTECTIVE SOLUTIONS**  
 ▪ Innovative  
 ▪ Practical  
 ▪ Effective

**CONCEPT INCUBATION**  
 ▪ Virtual Experiments  
 ▪ Physical Experiments  
 ▪ Optimization

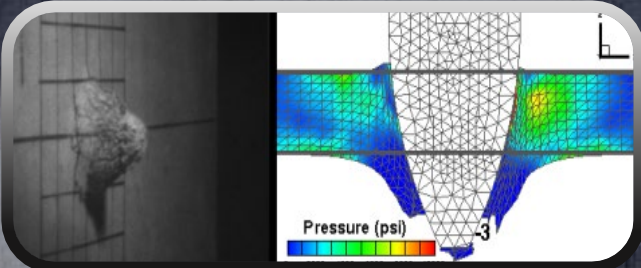
**MATERIALS**  
 ▪ Formulation  
 ▪ Manufacturing  
 ▪ Properties

**LOADING**  
 ▪ Blast  
 ▪ Penetration  
 ▪ Fragmentation

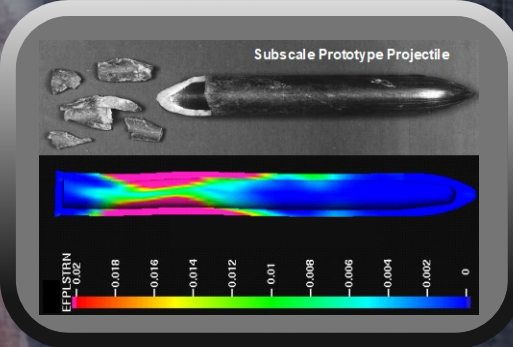




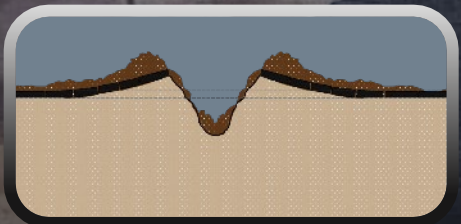
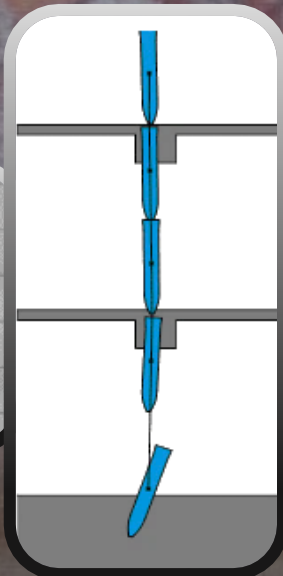
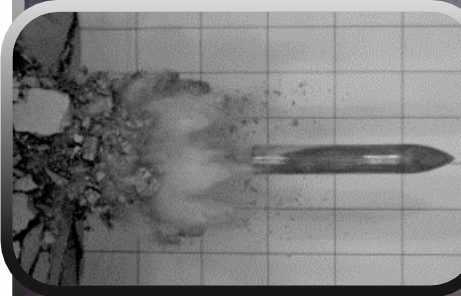
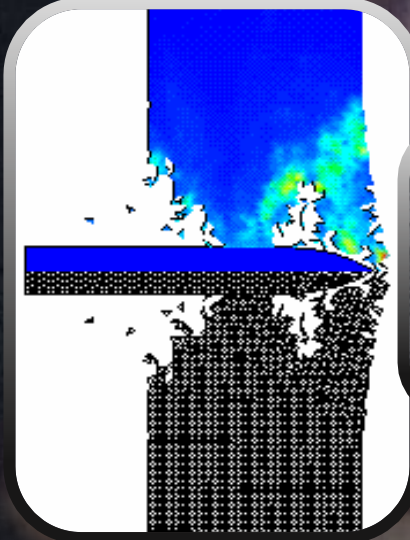
# Blast Effects and Penetration Mechanics



**PURPOSE**  
Investigate fundamental mechanics to grow knowledge on event phenomena



**PRODUCTS**  
Meaningful data, insight and knowledge; validation / development experiments, hypotheses on system solutions, decision support tools





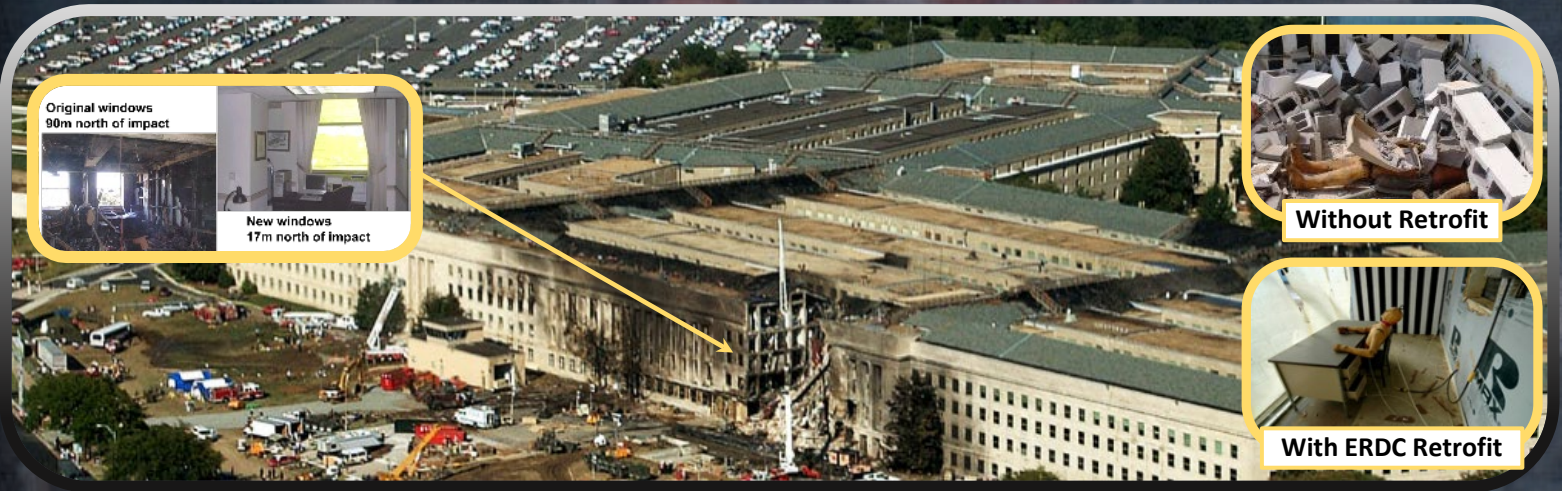


# Weapons Effects on Existing & New Facilities



**PURPOSE**  
Develop hardening solutions to protect facilities against emerging weapons

**PRODUCTS**  
New design concepts, hardening strategies, component solutions, criteria, guidance for system solutions

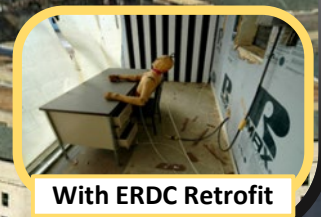


Original windows  
90m north of impact

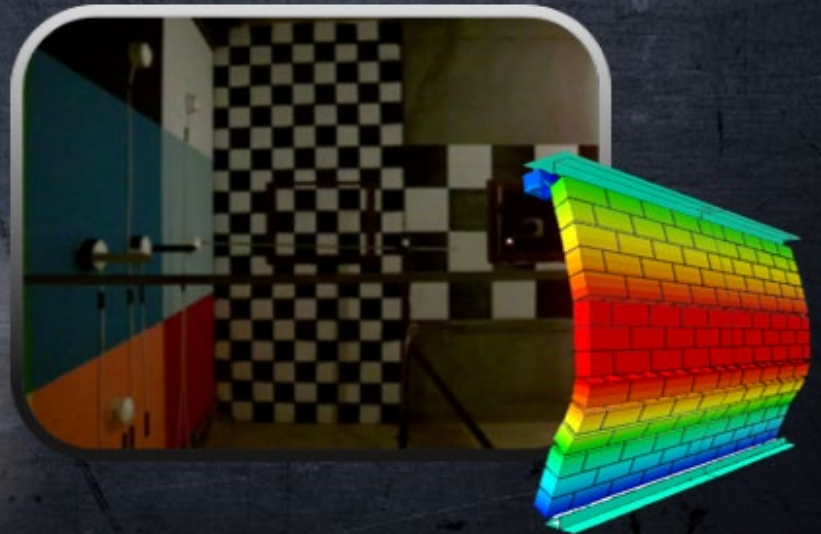
New windows  
17m north of impact



Without Retrofit



With ERDC Retrofit







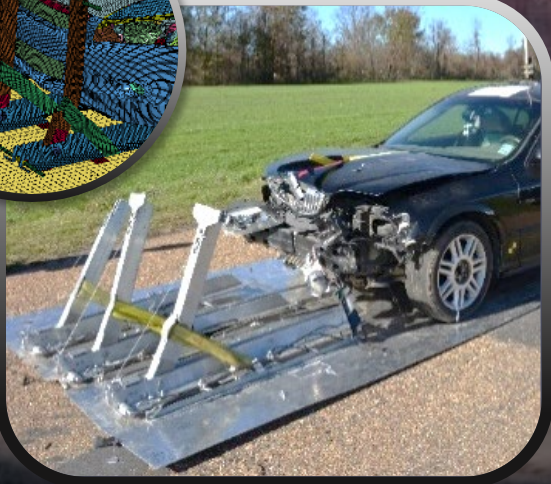
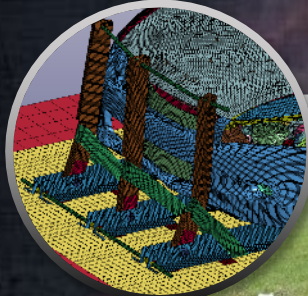
# Expedient Protection for Deployed Forces



**PURPOSE**  
Develop protective solutions for battlefield and expeditionary environments



**PRODUCTS**  
New fortification designs, expedient systems, guidance / strategies for forward forces





# Example: Traumatic Brain Injury

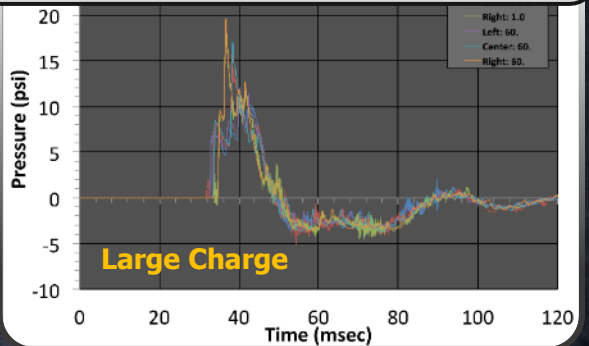
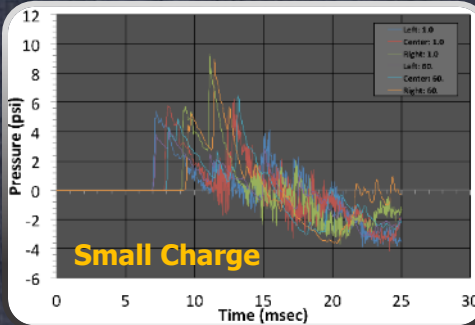
**PROBLEM**  
Unknown cause(s) of TBI due to blast

**HYPOTHESIS**  
Subtle characteristics of the shock wave environment can be important to TBI potential, especially for personnel inside of structures

- Mechanics of low amplitude, attenuated blast wave
- Dynamic pressure
- Homogeneity
- Time scales

$$p^{dyn} = f(\rho, u_{part}^2)$$

$$p^{reflect} = f(p^{dyn}, P^{SO}) = f(\rho, u_{part}^2, P^{SO})$$



Theoretical, Experimental, and Applied Mechanics

## Computational Mechanics

• Loads and mapping

• Simple shock tube vs. complex wave

• Biomechanical response to insult

## Large-Scale Evaluation



Measures: Flow Field • Torso and Cranial Surface Pressure • Intracranial Pressure • Acceleration

Subramaniam, D.R., G. Unnikrishnan, A. Sundaramurthy, J. E. Rubio, V.B. Kote, and J. Reifman. 2021. The Importance Of Modeling The Human Cerebral Vasculature In Blunt Trauma. Biomedical Engineering Online, 20:11.





# Example: Localized Blast Effects on Glazing

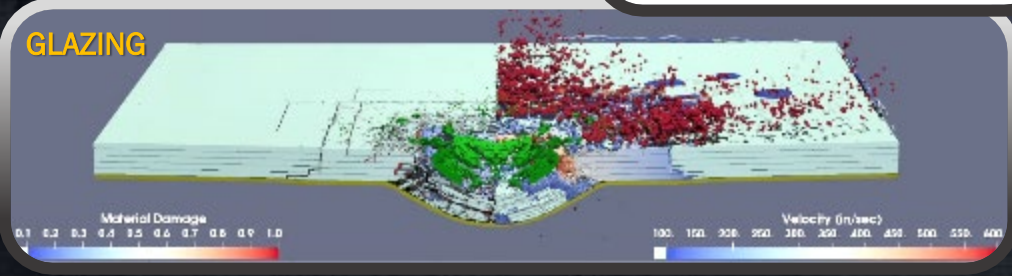
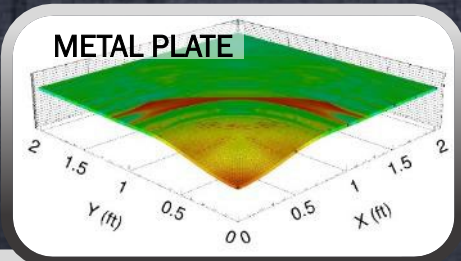
## PROBLEM

Mechanics of ballistic glazing failure due to close-in (localized) blast not understood

## HYPOTHESIS

Critical failure mechanisms in ballistic glazing exposed to localized blast differ from far-field planar loads; better understanding will drive improved performance

- Metal Plate Simulations: Quantify load
- Glazing Simulations: Study mechanical response to definable explosive load

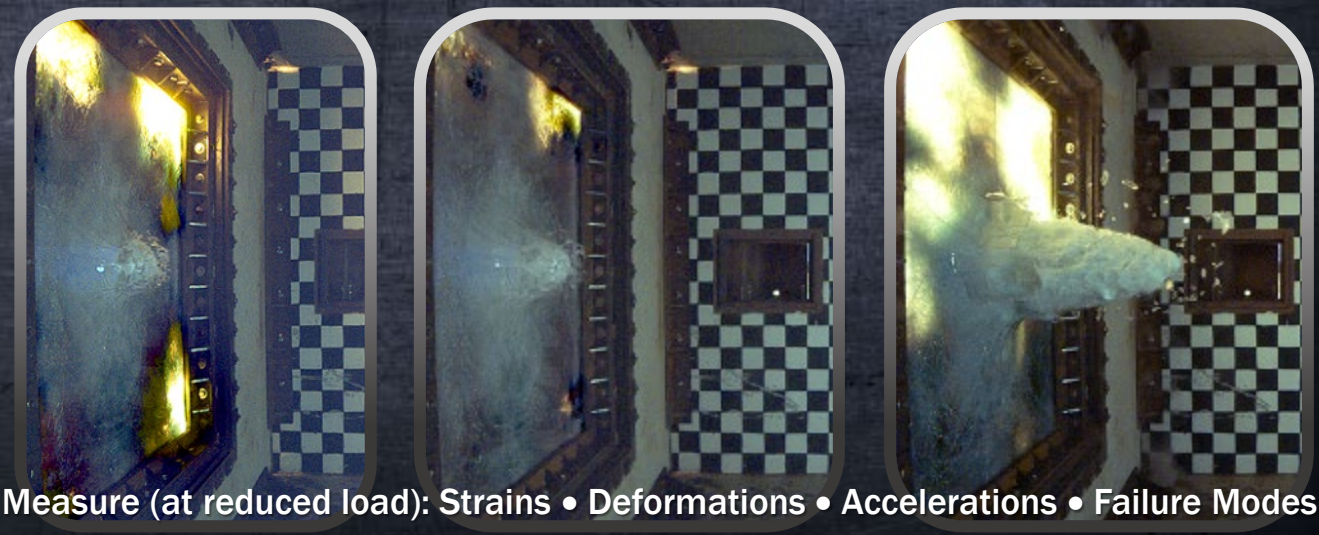


Computational Mechanics

- Study on metal plates
- Induce various deformations
- Deduce load from "predictable" material response
- Result: Derive a well-controlled, localized explosive loading protocol for glazing samples



Theoretical, Experimental, and Applied Mechanics



Measure (at reduced load): Strains • Deformations • Accelerations • Failure Modes  
Large Scale Evaluation

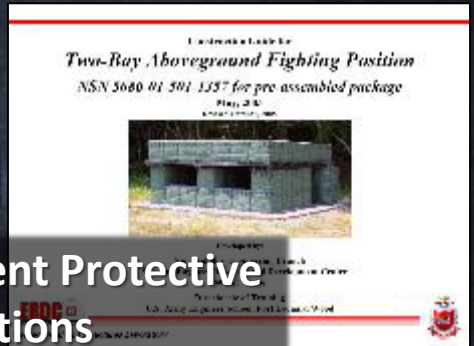


# Expedient Forward Operating Base Protection



### Modular Protective System (MPS)

- Wall
- Guard Tower
- Overhead Cover
- Mortar Pit



### Field Expedient Protective Positions



- Large Observation Post
- Small Observation Post
- Single-Bay Aboveground Fighting Position
- Two-Bay Aboveground Fighting Position
- Helicopter Revetment
- Aboveground 20' Milvan Bunker
- PLS Cargo Bunker
- HEMTT-LHS/PLS Bunker



### Storage Container Usage as Buried Bunkers



### Modular Concrete Bunker for Indirect Fire







# Force Protection in the Urban Environment



Go/No-Go  
Survivability Assessments

Rapid LOP  
Improvements



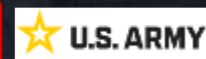
Rapidly Deployable  
Protection



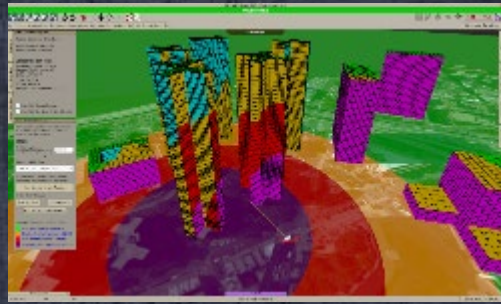
Existing Structure  
Identification and Assessment



# Force Protection in the Urban Environment



Ready Armor Protection for Instant Deployment (RAPID)



Protection, Planning, and Visualization Assessment Tool (PPVAT)

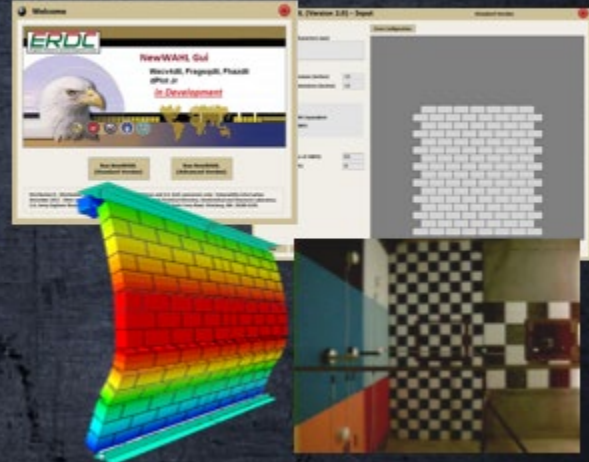
Deployable Expedient Traffic Entry Regulator (DETER)



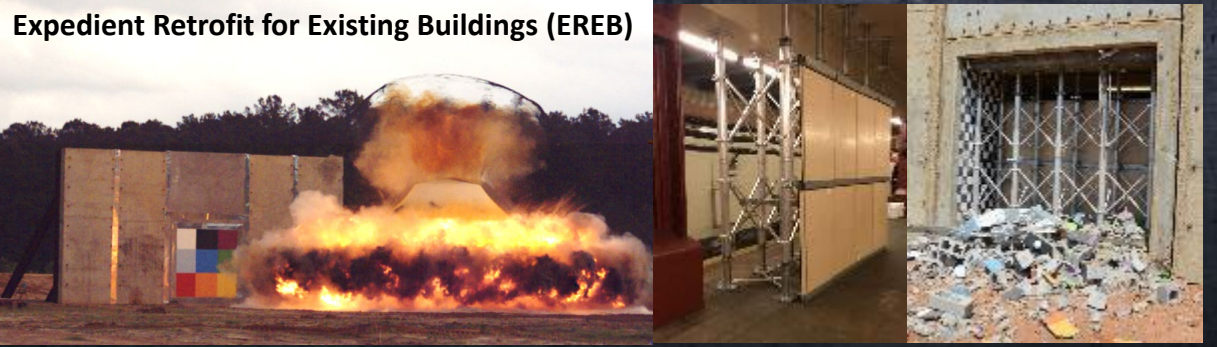
Ballistic Resistance Assessment Tool (BRAT)



Wall Assessment for Hazard Level Application (WAHL)



Expedient Retrofit for Existing Buildings (EREB)



Deployed Forces Protection Handbook and Force Protection Portal



# Ready Armor Protection for Instant Deployment (RAPID)

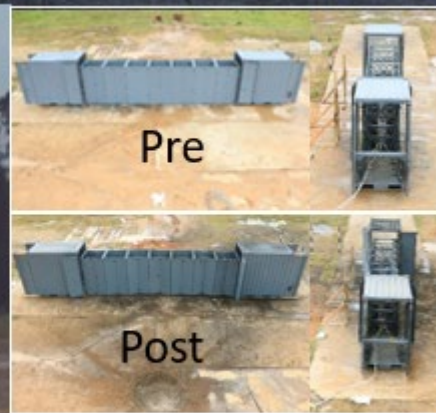


- Rapidly deployable protective barrier for critical asset protection and urban operations
  - Ballistic/fragmentation protection
  - Blast protection
  - Vehicle/personnel intrusion prevention
  - Line-of-sight-denial
- Protection level is tailorable using layered armored panels
- Placement and recovery of 35-ft protective wall in less than 20 minutes
  - Wheels and hydraulic system for easy setup
  - No equipment or special tools required
- Easily recovered and reused



Video

RAPID Deployability



RAPID Blast Experiments



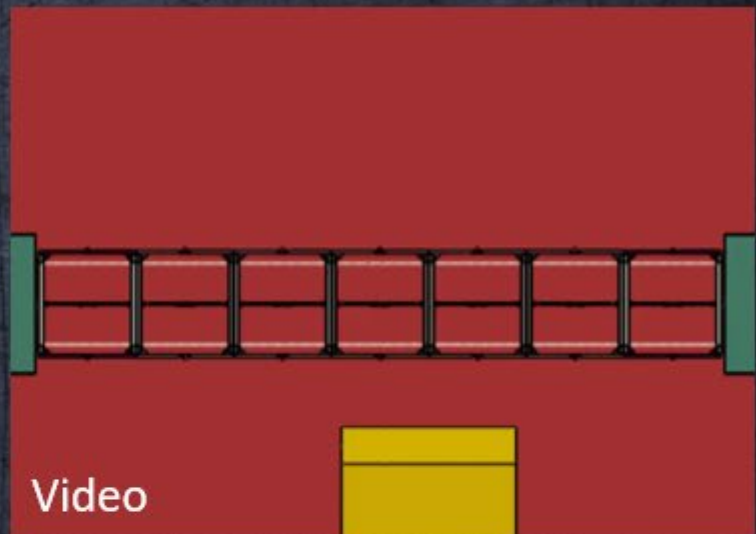
Fragmenting Warhead Arena



# RAPID - Hostile Vehicle Testing



Video



Video



System Fully Recovered Post Event



Video





# Deployable Expedient Traffic Entry Regulator (DETER)

- Expedient access control solution to protect critical assets and soft targets from vehicular attacks
  - Active wedge barrier with friction-based mat design
  - Easily recovered and reused
  - No anchoring required
- Integrated into standard QuadCon ISO container form factor for easy storage, transport, and deployment
- Modular design, incrementally linkable 8-ft width units



Video

DETER deployability



Video

DETER tested to IWA14-1:2013 Impact Test Specification for Vehicle Security Barrier



Video

MIRA





# Expedient Retrofit for Existing Buildings (EREB)

- Modular lightweight retrofit to increase the level of protection provided by existing concrete and masonry buildings
  - Protection from ballistic, fragmentation, and blast threats
  - Protection level is tailorable using layered armor panels and existing building properties
  - Modular for any room width and range of room heights
- Each component is less than 60 lbs. and can be installed quickly
  - No equipment or special tools needed for construction
- Easily disassembled and reused



Video

EREB Deployability



No retrofit



With retrofit



No debris in room  
after large explosion  
damaged entire  
masonry wall

Post-blast views, w/ and w/o EREB



# Threat Spectrum and Perspective Shift

## Counter-Insurgent Threats



Rockets, Artillery, and Mortars



Small Arms

## Near-Peer Threats



Large Rockets and Artillery



Ballistic Missiles



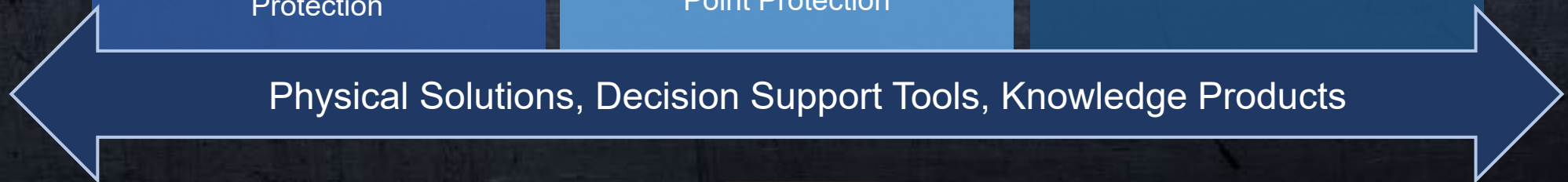
Weaponized UAVs



Weaponized UAV Protection

Expedient Assembly Point Protection

Expeditionary Bunkers





# CONNECT WITH US

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