

# **DoD Blast Overpressure Reference and Information Guide (D-BOP RIG)**

May 2024

# DoD Requirements for Managing Brain Health Risks from Blast Overpressure (BOP) / D-BOP RIG

- Specifies recommended stand-off distances for those (1) involved in training (e.g., instructors, range safety officers) and (2) involved in operations of the weapon system (e.g., assistant gunners, spotters and loaders) if there are options pertaining to their proximity to the weapons system, with consideration given to safe training and operations
- The stand-off distances will be updated as additional characterizations are completed, including additional weapons systems and/or variations in ammunition or charges, configuration (e.g., non-open terrain, shipboard)

# As Low as Reasonably Achievable (ALARA)

1 **Minimize number of personnel** in vicinity of BOP event

2 **Increase standoff distances** from weapons

3 **Minimize the duration of live-fire events**

4 Adhere to the **maximum allowable number of rounds that may be fired** during each event or time period

5 Ensure appropriate **use of personal protective gear and equipment (PPE)**

6 **Train and educate others** on BOP hazards and risk management actions

Avoid unnecessary exposure

Fewer personnel

Increased distances

Shorter durations

Limit number of rounds

Use PPE

Educate others

# Contents—Examined Tier 1 Weapon Systems

## Shoulder Launched Munitions



M3, MAAWS



M136, AT4



LAW

## .50 Caliber Weapons



M107 sniper rifle



M2A1 machine gun



MK15



GAU21

## Indirect Fire System – Howitzers



M119 A3



M777 A2



M109 A6

## Indirect Fire System – Mortars



120mm



81mm



60mm

## Explosive Breachers



Breacher Open Space



Breacher Door



Breacher Wall

# How to use this guide

This Flipbook leverages data collection efforts performed by the USUHS CONQUER program.

## Title:

- Weapon system name and type

M3 Multi-role Anti-Armor Antipersonnel Weapon System (MAAWS) (Carl Gustav)



STANDING

Position

## DoD Personal Protective Equipment Guidance

- Personal protective gear and equipment (PPE) level. Protections associated with each PPE level

### DoD Personal Protective Equipment Guidance

**Hearing protection** Within a 100-m radius must wear properly inserted foam earplugs as well as earmuffs (double hearing protection), single hearing protection within 500m while firing HE, HEAT, TP, smoke, and illumination.

**Eye protection** all personnel on the range.

**Helmet and flak jacket** required when firing.

### Data Collection Information and Recommended Stand-off Distances

Weapons System: M3 MAAWS (Carl Gustav)

Ammunition: DODIC: AS57

Round Type: 84mm HEAT TP S52

Data Collection: 1 shot

BOP Sensor: 5.2 ft above ground



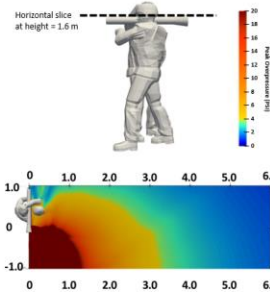
Approx. 15/16 ft

Minimum Stand-off Distance:

Based on collected data, minimum stand-off distance for observers and non-essential personnel to minimize exposure to 4psi:

**16 ft approximately the length of a HMMWV**

### Blast Overpressure Measurement Data



**Graph:** A bird's eye view of blast overpressure zones color-coded based on pounds per square inch (psi) levels collected around the weapon.

## Data Collection Information and Recommended Stand-off Distances:

Weapon system, ammunition, and sensor information under which BOP data was collected

Minimum standoff distance for personnel in vicinity of the stationary weapon system based off 4psi contour.

Output graph key;  
Grid is in meters

# Shoulder Launched Munitions



**M3, MAAWS**

**M3 Multi-role Anti-Armor Antipersonnel  
Weapon System (MAAWS) (Carl Gustav)**



**M136, AT4**

**M-136A1 AT4 Confined Space (AT-4CS)**



**LAW**

**M72 Light Antitank Weapon (LAW)**

# M3 Multi-role Anti-Armor Antipersonnel Weapon System (MAAWS) (Carl Gustav)



STANDING

## DoD Personal Protective Equipment Guidance

**Hearing protection** Within a 100-m radius must wear properly inserted foam earplugs as well as earmuffs (double hearing protection), single hearing protection within 500m while firing HE, HEAT, TP, smoke, and illumination.

**Eye protection** all personnel on the range.

**Helmet and flak jacket** required when firing.

## Data Collection Information and Recommended Stand-off Distances

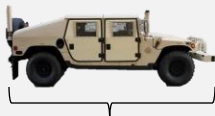
Weapons System: M3 MAAWS (Carl Gustav)

Ammunition: DODIC: A557

Round Type: 84mm HEAT TP 552

Data Collection: 1 shot

BOP Sensor: 5.2 ft above ground



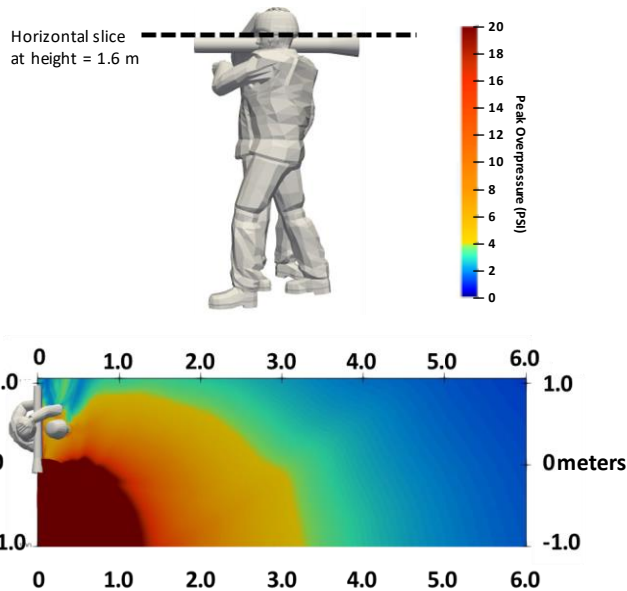
Approx. 15/16 ft

Minimum Stand-off Distance:

Based on collected data, minimum stand-off distance for observers and non-essential personnel to minimize exposure to 4psi:

**16 ft or approximately the length of a HMMWV**

## Blast Overpressure Measurement Data



# M-136A1 AT4 Confined Space (AT-4CS)



**STANDING**

## DoD Personal Protective Equipment Guidance

**Hearing protection** Double hearing protection must be worn within a 100m radius (inserted foam earplugs as well as earmuffs), single hearing protection will be worn by personnel within 390m of the firing point.

**Eye protection** all personnel on the range.

**Helmet and flak jacket** required when firing.

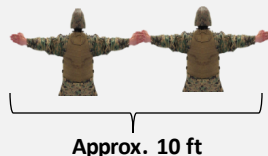
## Data Collection Information and Recommended Stand-off Distances

Weapons System: M136A1 AT4 Confined Space (AT4CS)

Round Type: 84mm AT4CS-RS TP 552

Data Collection: 1 shot

BOP Sensor: 5.2 ft above ground

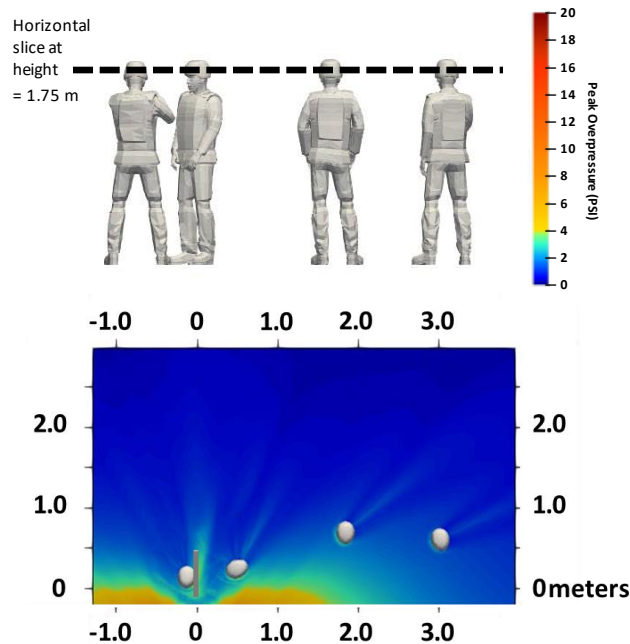


Minimum Stand-off Distance:

Based on collected data, minimum stand-off distance for observers and non-essential personnel to minimize exposure to 4psi:

**10 ft or approximately 2 people 2-arms length**

## Blast Overpressure Measurement Data





# M72 Light Antitank Weapon (LAW)



STANDING

## DoD Personal Protective Equipment Guidance

**Hearing protection** single hearing protection will be worn by personnel within 390 m of the firing point. Gunners and other personnel within 20m will wear personal protective gear such as improved body armor. Sleeves should be down and collars up.

**Eye protection** all personnel on the range.

**Helmet and flak jacket** required when firing.

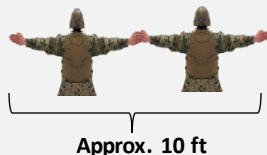
## Data Collection Information and Recommended Stand-off Distances

Weapons System: M72 LAW - Standing

Round Type: 66mm HEAT

Data Collection: 1 shot

BOP Sensor: 5.2 ft above ground



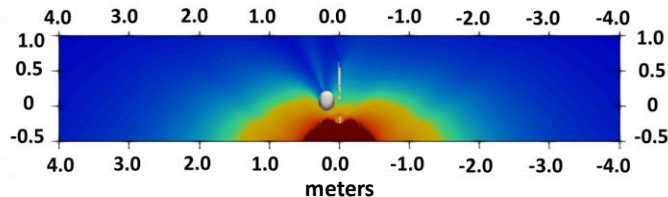
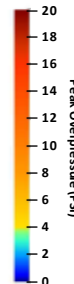
Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-sensational personnel to minimize exposure to 4psi:

**10 ft or approximately 2 people 2-arms length**

## Blast Overpressure Measurement Data

Horizontal slice at height = 1.68 m



# . 50 Caliber Weapons



M107 sniper rifle

M107 Sniper Rifle



M2A1 machine gun

M2A1 Machine Gun



MK15

MK 15 MOD 1



GAU21

GAU-21 Machine Gun

# M107 Sniper Rifle



**PRONE**

## DoD Personal Protective Equipment Guidance

**Hearing protection** 180 ft to the side of the weapon, and 39 ft to the rear.

**Eye protection** for those on the range.

## Data Collection Information and Recommended Stand-off Distances

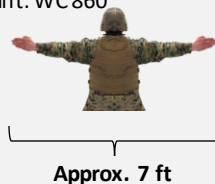
Weapons System: .50 cal blow-back operated semi-automatic sniper rifle with dual chamber detachable muzzle brake

Ammunition: DODIC: A557

Round Type: .50 BMG – M33 Ball with Propellant: WC 860

Data Collection: 10 shots

BOP Sensor: 0.3 ft above ground



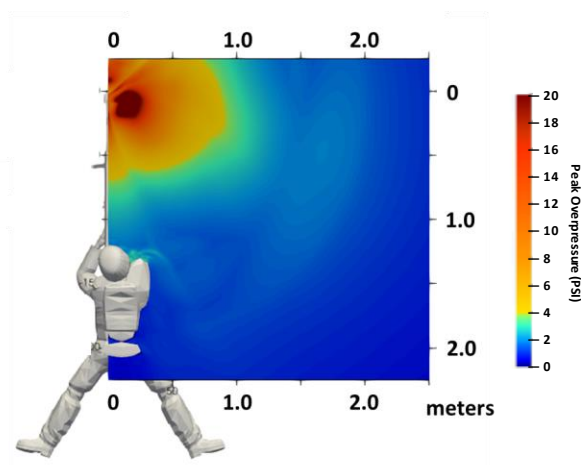
Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4psi:

**7 ft or approximately 2-arms length**

## Blast Overpressure Measurement Data

Horizontal slice at height = 0.32 m



# M2A1 Machine Gun



STANDING

## DoD Personal Protective Equipment Guidance

**Hearing protection** single hearing protection will be worn by personnel within 390 m of the firing point.

**Eye protection** all personnel on the range.

**Helmet and flak jacket** required when firing.

## Data Collection Information and Recommended Stand-off Distances

Weapons System: .50 caliber semi-automatic machine gun

Round Type: .50 cal M8 API

Data Collection: 4 firing bursts

BOP Sensor: 5.2 ft above ground

Minimum Stand-off Distance:

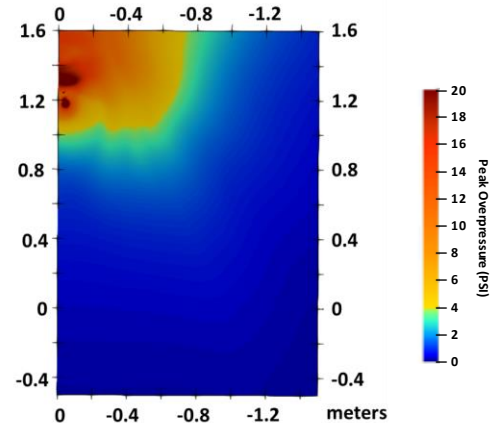
Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4psi: **7 ft or approximately 2-arms length**



Approx. 7 ft

## Blast Overpressure Measurement Data

Horizontal slice  
at height = 2.0 m





**PRONE**

## DoD Personal Protective Equipment Guidance

**Hearing protection** single hearing protection will be worn by personnel within 390 m of the firing point.

**Eye protection** all personnel on the range.

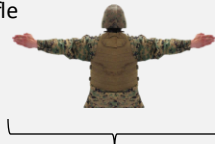
## Data Collection Information and Recommended Stand-off Distances

Weapons System: .50 cal bolt action sniper rifle

Round Type: .50 cal M33 Ball

Data Collection: 8 shots

BOP Sensor: 4" above ground

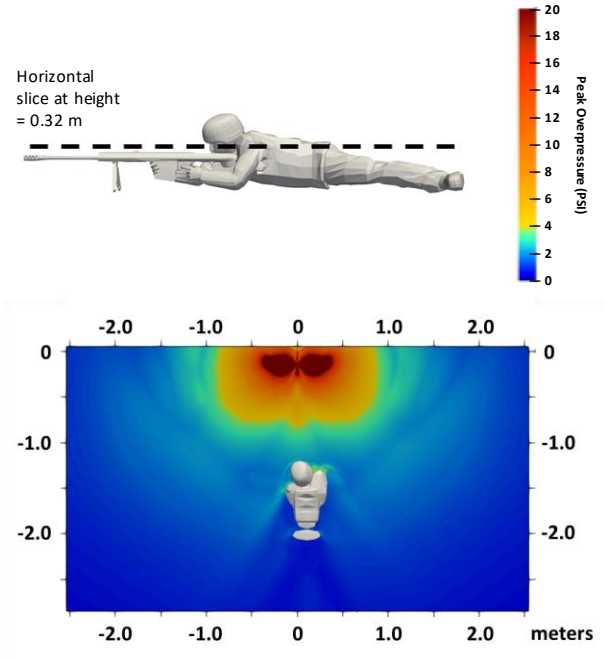


**Approx. 7 ft**

Minimum Stand-off Distance:

Based on collected data, Recommended minimum distance for observers and non-essential personnel to minimize exposure to 4psi: **7 ft or approximately 2-arms length**

## Blast Overpressure Measurement Data



# GAU-21 Machine Gun



## DoD Personal Protective Equipment Guidance

**Hearing protection** single hearing protection will be worn by personnel within 390 m of the firing point.

**Eye protection** all personnel on the range.

## Data Collection Information and Recommended Stand-off Distances

Weapons System: .50 caliber automatic machine gun

Round Type: .50 BMG M33 Ball w/ WC 860 Propellant

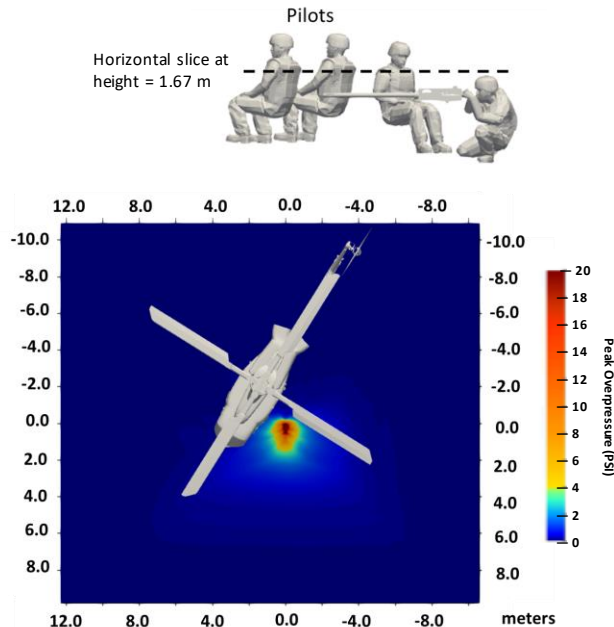
Data Collection: 8 firing bursts

BOP Sensor: 3.3ft above ground

Minimum Stand-off Distance (Ground):

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4psi: **Measurements are < 4 pounds per square inch; maximize stand-off distances to the greatest extent possible (i.e., As Low As Reasonably Achievable principle) while balancing training requirements**

## Blast Overpressure Measurement Data



# Indirect Fire System – Howitzers



**M109 A6**

**M109 A6/A7 155MM Paladin Howitzer**



**M119 A3**

**M119A1-A3 105MM Howitzer**



**M777 A2**

**M777A2 155MM Howitzer**

# M109 A6/A7 155MM Paladin Howitzer



## DoD Personal Protective Equipment Guidance

**Hearing protection** will be required within 800m.

**Eye protection** all personnel on the range.

## Data Collection Information and Recommended Stand-off Distances

Weapons System: M72 LAW Light Antitank Weapon

Round Type: 66mm HEAT

Data Collection: 1 shot

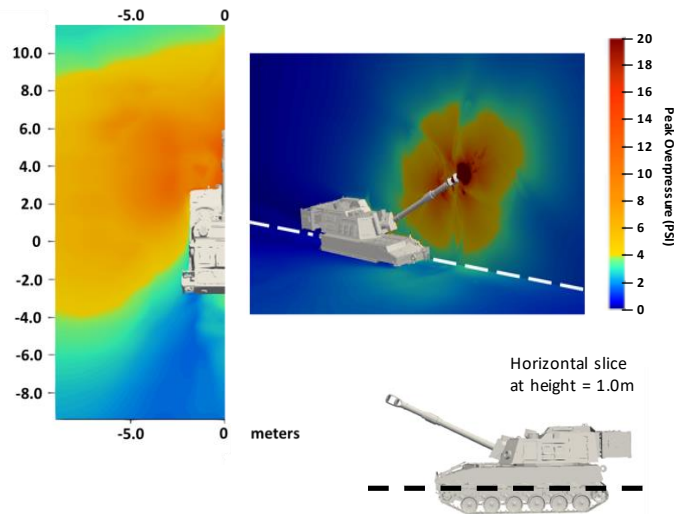
BOP Sensor: 2.3 ft above ground

### Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4psi:

**Measurements are < 4 pounds per square inch; maximize stand-off distances to the greatest extent possible (i.e., As Low As Reasonably Achievable principle) while balancing training requirements**

## Blast Overpressure Measurement Data





# M119A1-A3 105MM Howitzer



STANDING

## DoD Personal Protective Equipment Guidance

**Hearing protection** will be required within the hearing hazard zone or if not available, 800m.

**PPE:** all personnel immediately engaged in firing will wear body armor and helmet, hearing/eye protection.

## Data Collection Information and Recommended Stand-off Distances

Weapon Type: Indirect Fires System Artillery Cannons

Round Type: M1 projectile, 105mm HE M67 propellant system charge-6

Data Collection: 1 shot

BOP Sensor: 5.2 ft above ground

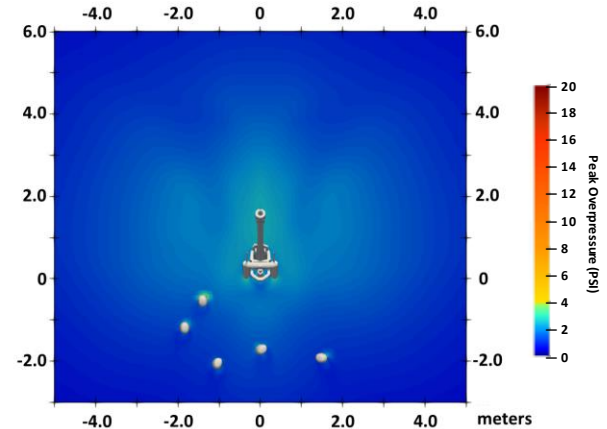
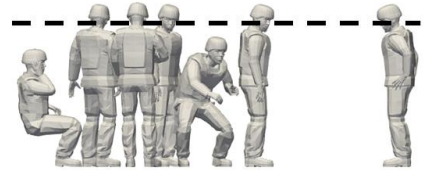
### Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4psi:

**Measurements are < 4 pounds per square inch; maximize stand-off distances to the greatest extent possible (i.e., As Low As Reasonably Achievable principle) while balancing training requirements**

## Blast Overpressure Measurement Data

Horizontal slice  
at height = 1.6 m



# M777A2 155MM Howitzer



STANDING

## DoD Personal Protective Equipment Guidance

**Hearing protection** will be required within the hearing hazard zone or if not available, 800m.

**PPE:** all personnel immediately engaged in firing will wear body armor and helmet, hearing/eye protection.

## Data Collection Information and Recommended Stand-off Distances

Weapon Type: Indirect Fires System Artillery Cannons

Round Type: Round fired w/ 2M231 charges ("2LIMA")

Data Collection: 1 shot

BOP Sensor: 5.2 ft above ground

Minimum Stand-off Distance:

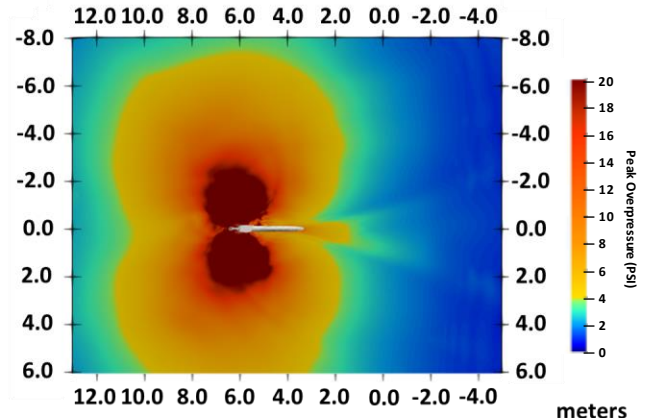
Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4psi:

**Measurements are < 4 pounds per square inch; maximize stand-off distances to the greatest extent possible (i.e., As Low As Reasonably Achievable principle) while balancing training requirements**

## Blast Overpressure Measurement Data



Horizontal slice at height = 1.85 m



# Indirect Fire System – Mortars



**M120/121 120 MM Mortar**



**M252 81 MM Mortar**



**M224 60 MM Mortar**



### DoD Personal Protective Equipment Guidance

**Hearing protection** single hearing protection will be required within 200m.

**PPE:** All personnel who take part in mortar firing will wear a minimum of IBA and helmet (PPE Level 1).

### Data Collection Information and Recommended Stand-off Distances

Charge Type: M224 60 MM Mortar

Round Type: M1061 (B29) HE mortar cartridge, 2 propelling charges

Round fired with Charge 2

Data Collection: 1 shot

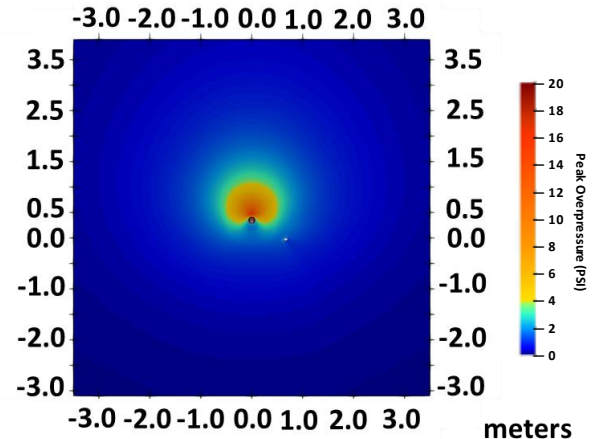
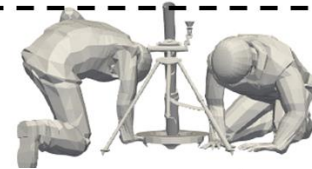
BOP Sensor: 3.2 ft above ground

Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4psi: **3 ft or approximately 1 arm length**

### Blast Overpressure Measurement Data

Horizontal slice  
at height = 0.8 m



# M252 81 MM Mortar



**KNEELING**

## DoD Personal Protective Equipment Guidance

**Hearing protection** hearing protection will be required within 200m.  
**PPE:** All personnel who take part in mortar firing will wear a minimum of IBA and helmet (PPE Level 1).

## Data Collection Information and Recommended Stand-off Distances

Charge Type: M252 81 MM Mortar

Round Type: M889A2 HE mortar cartridge, M223 propelling charge

Round fired with Charge 2

Data Collection: 1 shot

BOP Sensor: 5.2 ft above ground



Approx. 7 ft

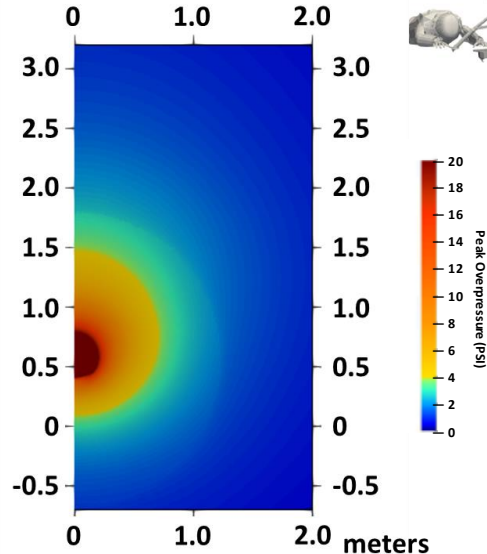
Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4psi:

**7 ft or approximately 2-arms length**

## Blast Overpressure Measurement Data

Horizontal slice  
at height = 1.36m



# M120/121 120 MM Mortar



**KNEELING**

## DoD Personal Protective Equipment Guidance

**Hearing protection** will be required within the hearing hazard zone or if not available, 200m.

**PPE:** All personnel who take part in mortar firing will wear a minimum of IBA and helmet (PPE Level 1).

## Data Collection Information and Recommended Stand-off Distances

Charge Type: M120/121 120 MM Mortar

Round Type: M933 HE mortar cartridge, M230 propelling charge

Round fired with Charge 3

Data Collection: 1 shot

BOP Sensor: 5.2 ft above ground



**Approx. 10 ft**

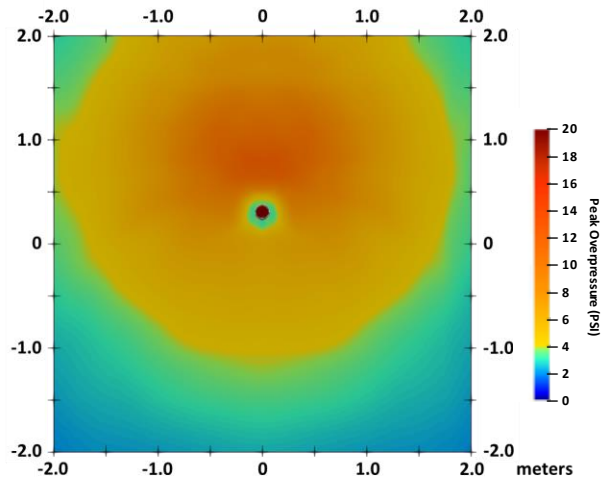
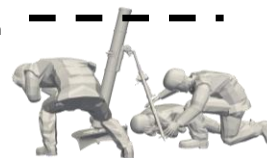
Minimum Stand-off Distance:

Based on collected data, minimum distance for observers and non-essential personnel to minimize exposure to 4psi:

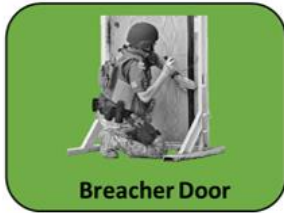
**13 ft or slightly more than 2 people 2-arms length**

## Blast Overpressure Measurement Data

Horizontal slice  
at height = 1.6m



# Explosive Breachers



**Breacher Door**



**Breacher Wall**

### DoD Personal Protective Equipment Guidance

**PPE:** IBA, helmet, and hearing and eye protection will be worn by personnel within the SDZ but outside the missile-proof shelter.

### Data Collection Information and Recommended Stand-off Distances

Charge Type: Explosive Breaching

Charge Type: Door water charge w/ NEW: 0.11lbs

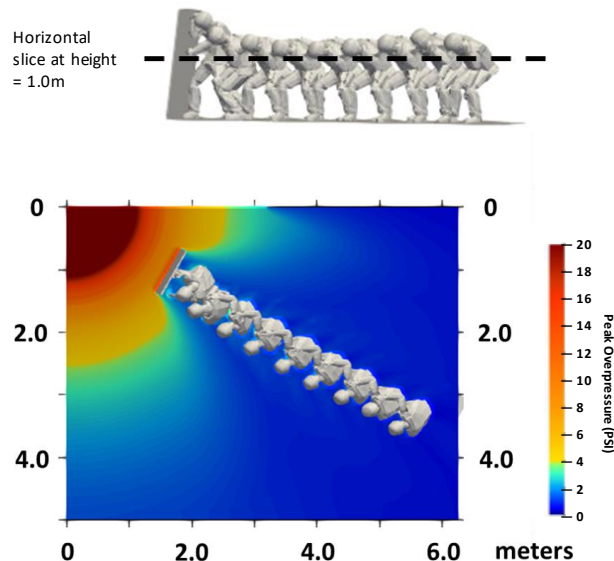
Data Collection: 1 blast

BOP Sensor: 5.24 ft above ground

#### Minimum Stand-off Distance:

Based on collected data, Recommended minimum distance for observers and non-essential personnel to minimize exposure to 4psi: **13 ft or slightly more than 2 people 2-arms length**

### Blast Overpressure Measurement Data





# Methods and Acknowledgements

## Field Data Collection

**Funding Source: OASD Health Affairs/USUHS**

Study Title: CONQUER; PI: CDR Josh L. Duckworth, MD  
Award Numbers: HU0001-18-2-0006, HU0001-19-2-0049

### Measurement & Recording Equipment

- PCB pencil gauges (Model 137B23B)
- Microphones (G.R.A.S.47BX-S7½"CCP)
- BlackBox Biometrics (B3) Gen 7 Blast Gauge System
- Hi-Techniques Ruggedized Echelon Data Acquisition System (DAQ)
- Video: Sony DSC-RXOM2 Mini Cameras & CCB-WD1 Control Boxes; GOPRO MAX 360 Camera

### Data Processing, Reporting & Visualization

- Validated high-fidelity simulations based upon data from both scientific instruments and blast gauges
- Second-Order Hydrodynamic Automatic Mesh Refinement Code (SHAMRC) simulations provided voxel-based maximum peak overpressure estimates to support blast overpressure contour visualization
- Two-dimensional slices of environmental overpressure, based upon high fidelity simulation data, provide visual estimates of maximum peak environmental overpressure.
- Three-dimensional contour plots, also based upon high fidelity simulation, provide visual estimates of maximum peak surface pressure on objects and service members.
- B3 Blast Gauge data as captured on engineering stake-mounted gauges were processed using Stata 17 (StataCorp, College Station, TX) for graphic display.

## Research Team Members

### Neurotactical Research Team (NTRT)

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The Henry M. Jackson Foundation for the Advancement of Military Medicine

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- United States Navy
- United States Marine Corps
- United States Special Operations Command