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NDIA Armaments Forum
Indianapolis, Indiana
Analysis of 25mm PGU-47 APHEI-T Projectile Against Wall Targets

Presented by

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GUN & ELECTRIC WEAPON SYSTEMS DEPARTMENT (E)

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Analysis Approach

- Assemble warhead characterization file (ZDATA) for each test shot
  - Obtain projectile fragment impact data from E40
  - Determine fragment mass for non-recovered fragments using PMAT
  - Determine impact velocity using velocity screen data or PMAT
  - Compute fragment initial conditions based on impact state and estimated average drag coefficient
- Use WarheadView to compute probability of incapacitation (P_{inc}) of projectile fragments for a matrix of personnel targets
  - 46 personnel targets located in 16x16-foot room
  - Projectile impact point on wall varied using a grid of 468 points
  - Serious and Lethal wounding casualty criteria used
    - Include summer uniform fragment velocity cut-off

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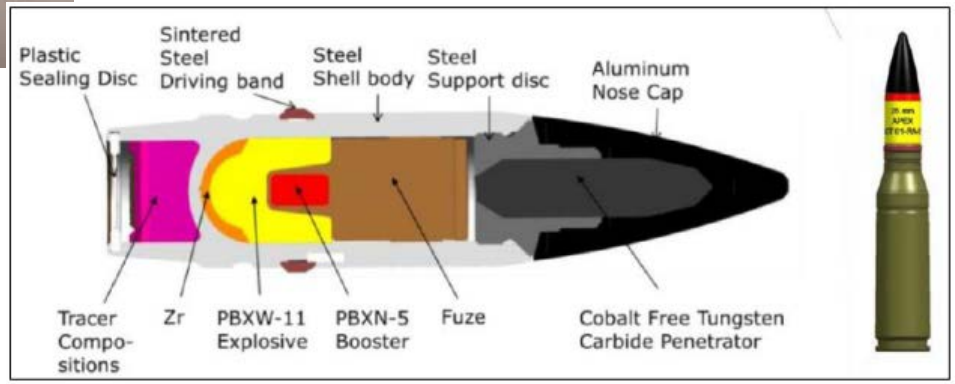
Test Description

- Wall target placed in front of 12x16x8-foot plywood room
  - Brick-over-block wall
  - Concrete Masonry wall
- Fragment impact locations on plywood sheets were recorded
- Velocity screens covered back wall and both side walls
- Projectile: PGU-47/U



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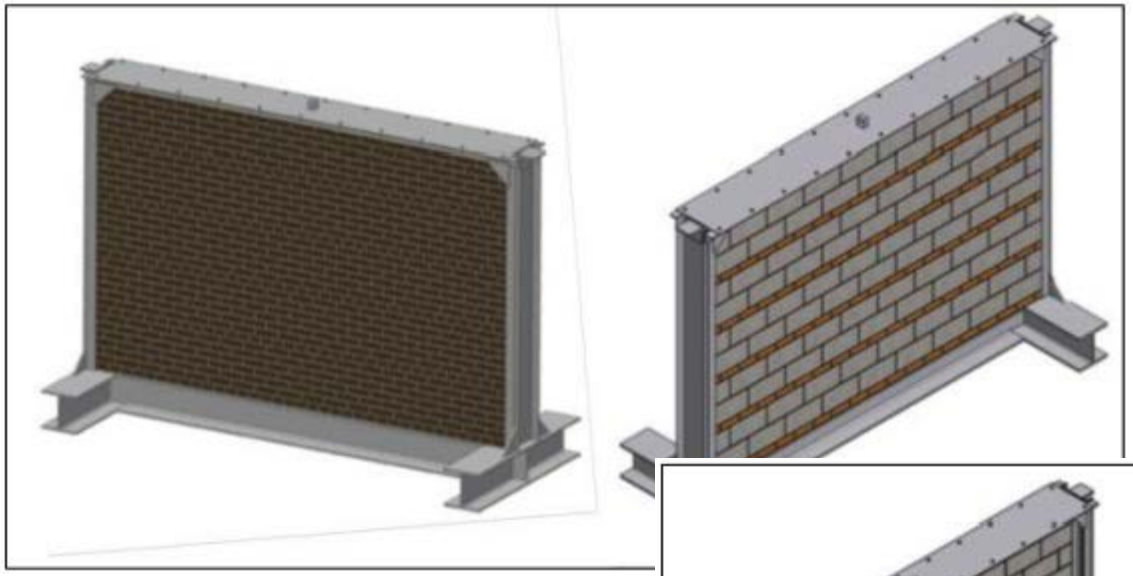
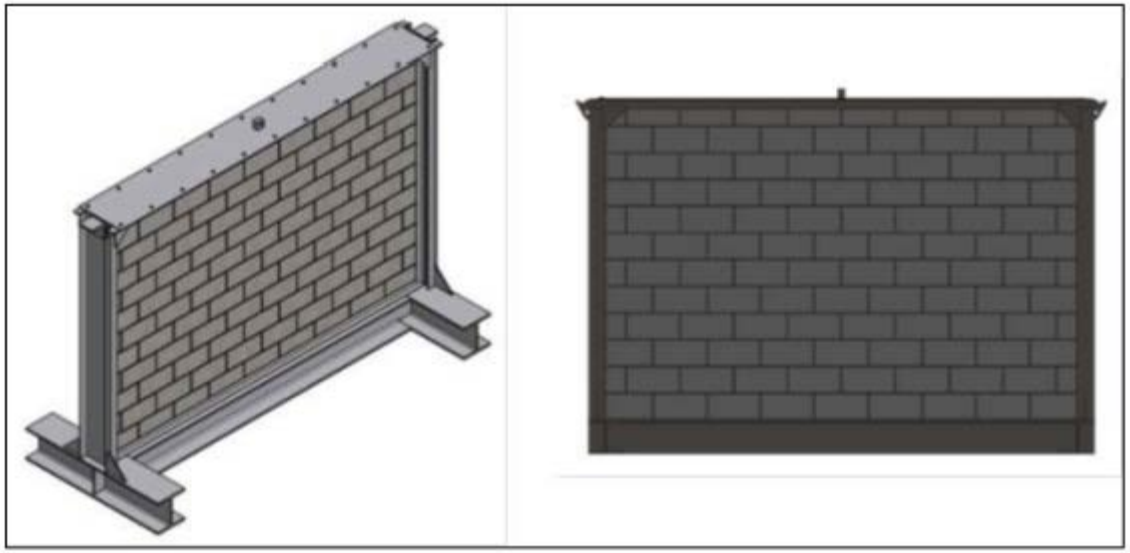
Wall Targets

Brick-over-Block



Concrete Masonry Unit



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ZDATA Construction

- Fragment polar angle and azimuth angle determined from fragment impact location (relative to burst point)
- Fragment impact velocity:
  - For fragments that completely perforated the plywood (non-recovered), velocity screen data was used
  - Otherwise, the lower of velocity screen or PMAT value was used
  - JTCG drag curve used to compute initial velocity
- Fragment mass:
  - Mass was measured for all recovered fragments
  - Otherwise, use PMAT to estimate mass
- Fragment shape assumed to be irregular
- Used ETB format for ZDATA file
  - Allows deterministic analysis
  - Standard JTCG ZDATA format could be constructed if desired

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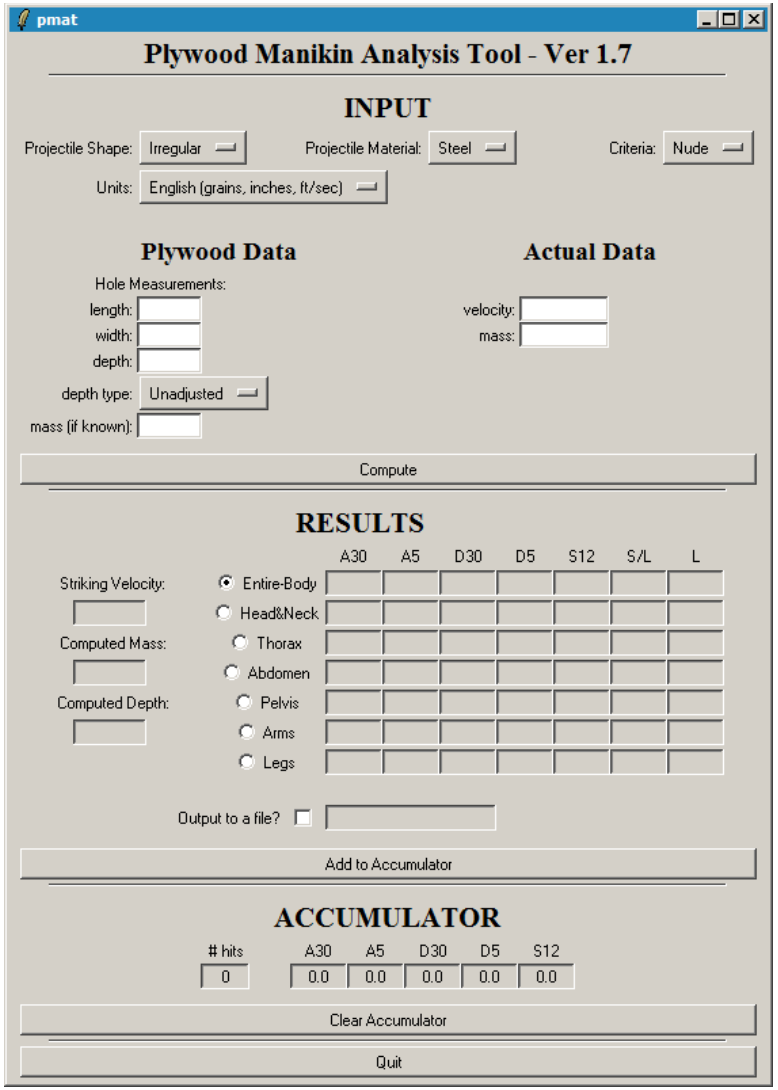
PMAT Tool



- Computes fragment mass and impact velocity based on size of hole in plywood (L,W,D)
  - Four fragment material options (steel, tungsten, etc.)
  - Four fragment shapes
- Fragment hole size measured for all fragments that completely perforated plywood layers
- Program can also compute resulting P_{inc} (not used)

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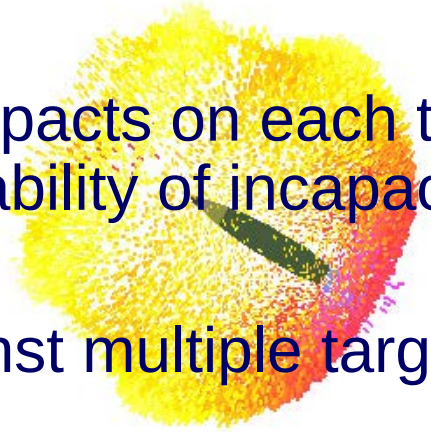
WarheadView Description

Warhead Fragment Trajectory Visualization Program

- Program to visually display the trajectories of warhead fragments resulting from the detonation of single or multiple blast-fragment warheads or projectiles.
- Fragment initial positions and velocities are computed according to the warhead characterization (ZDATA) file and combined with the weapon position and velocity
- Each fragment trajectory is simulated until impact and includes effects of drag and gravity (JTCG drag curves are used)
- Number of fragment impacts on each target object is recorded and the probability of incapacitation is computed for each hit
- Multiple weapons against multiple targets can be simulated



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Probability Of Incapacitation

- Probability of incapacitation (P_{inc}) as a function of the number of lethal hits (N_{Lethal}):

$$P_{inc} = 1 - e^{-N_{Lethal}}$$

- The number of lethal hits is the summation of the probability of incapacitation ($P_{I/H}$) of each hit, which is computed using the Sperrazza-Kokinakis (S-K) equation:

$$N_{Lethal} = \sum P_{I/H}$$

$$P_{I/H} = 1 - e^{-a\left(mV^{3/2} - b\right)^{n}}$$

- Summer uniform velocity cut-off included:

$$V_{50} = \sqrt{kA/M}$$

$$k = (-1.7942 \log M + 7.543) \times 10^{6}$$

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Personnel Model

6-Pt Standing Man

- Personnel model divided into six segments
  - Head/Neck
  - Thorax
  - Abdomen
  - Pelvis
  - Arm
  - Leg
- Separate S-K coefficients for each segment
  - Serious wounding
  - Lethal wounding

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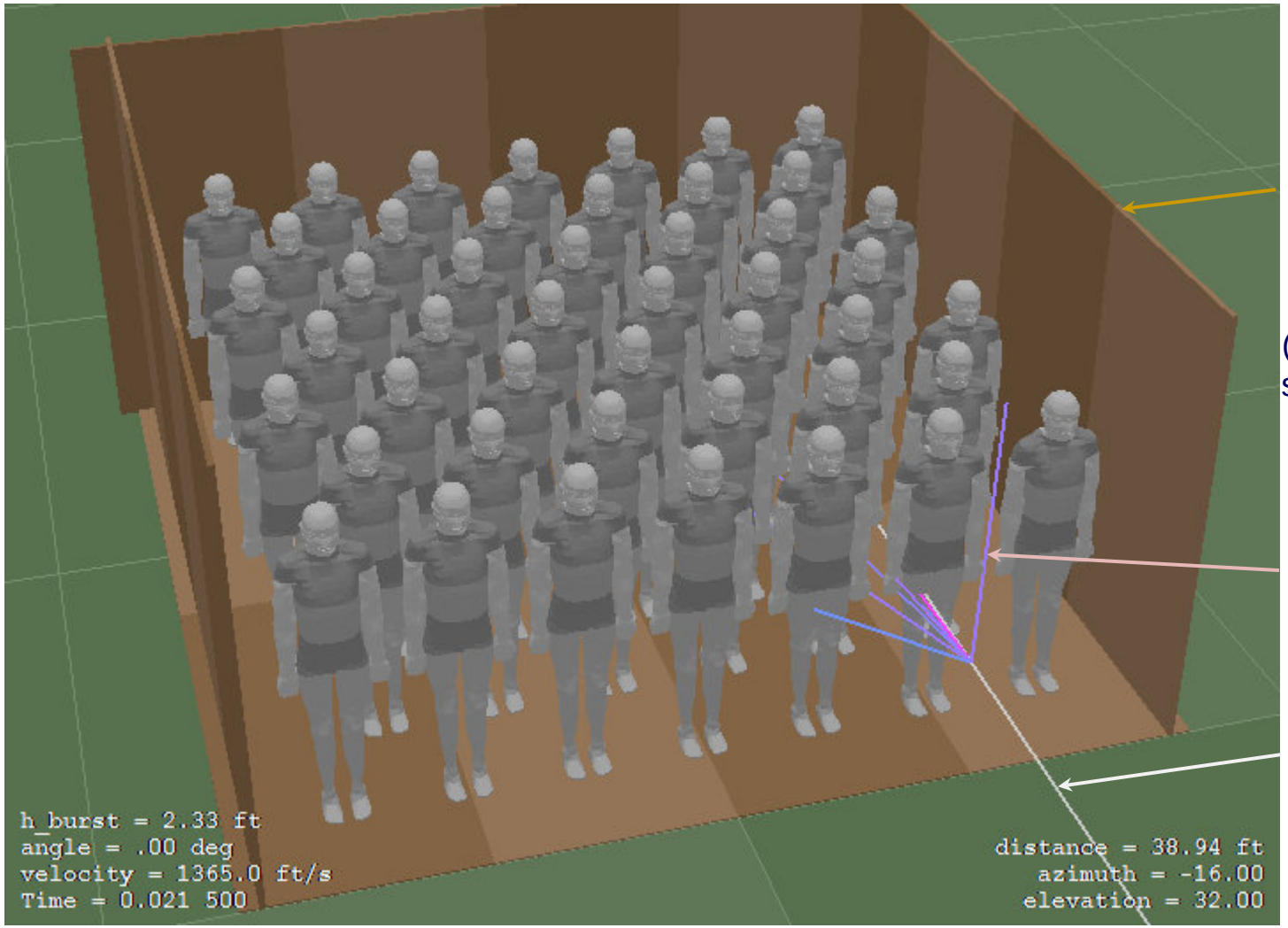
WarheadView Target Configuration

46 Personnel Targets



16x16-foot room

(Front wall not shown)

Projectile fragment paths

Projectile path

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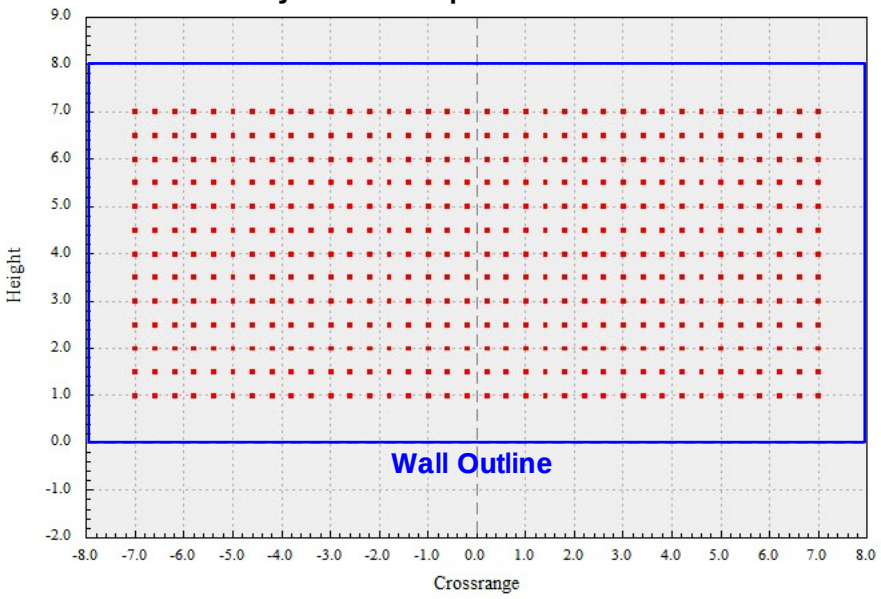
WarheadView Analysis

- Projectile impact point varied across height and width of front wall
  - Horizontal: -7 to +7 feet, every 0.4 feet
  - Vertical: 1 to 7 feet, every 0.5 feet
- Probability of incapacitation (P_{inc}) computed for each personnel target
  - Serious wounding criteria
  - Lethal wounding criteria
- For each impact point:
  - Average P_{inc} of all personnel targets
  - Maximum P_{inc} for all personnel targets
- 8 test shots analyzed
  - Shots 2, 4, 10, 12 (Brick-over-block wall)
  - Shots 5, 8, 13, 14 (Concrete masonry wall)

Projectile Impact Point Grid



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WarheadView Analysis

Interpretation of Results

- Average P_{inc} of all personnel targets:
  - This is the expected value of P_{inc} for a single projectile against a single personnel located at a random point in the room
  - The reported average value (in the summary table) is the average for all personnel and all impact points
    - This includes the assumption that the projectile impact point is random and uniformly distributed on the wall
  - The power-rule could be used to combine the average P_{inc} in order to get a corresponding value for multiple shots
  - The maximum value of average-P_{inc} (included with plots) represents the best-case impact point (for a single personnel at a random location)
- Maximum P_{inc} for all personnel targets:
  - The reported value represents the maximum across all personnel and all impact points
  - This is the best-case P_{inc} for a single projectile against a single personnel in the room (at the best-case impact location)

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Summary of Test Shots
PGU-47/U

Shot	Wall Target	Projectile		
		Type	Angle	Velocity (ft/s)
2	Brick	PGU-47	0	3086.9
3	Brick	PGU-47	0	1993.1
4	Brick	PGU-47	0	3104.0
5	CMU	PGU-47	0	3113.5
8	CMU	PGU-47	0	2128.3
9	Brick	PGU-47	0	2181.1
10	Brick	PGU-47	0	3100.1
11	Brick	PGU-47	45°	1943.2
12	Brick	PGU-47	45°	3110.9
13	CMU	PGU-47	45°	1955.1
14	CMU	PGU-47	45°	3105.6

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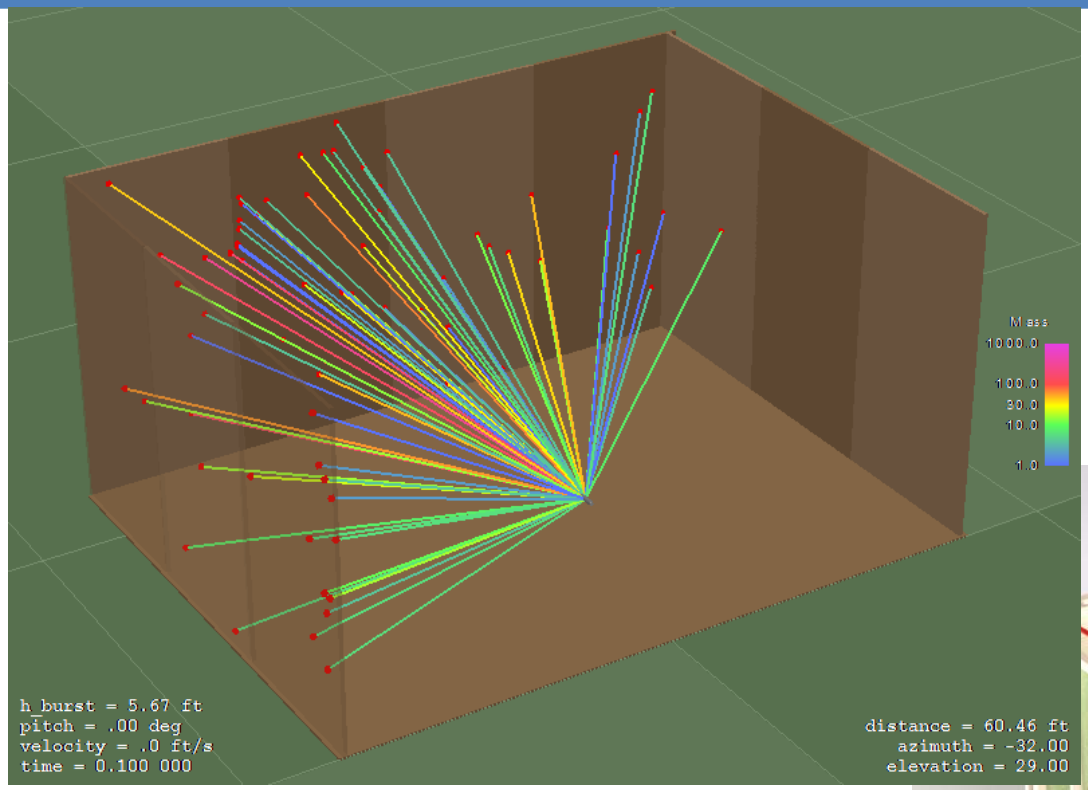
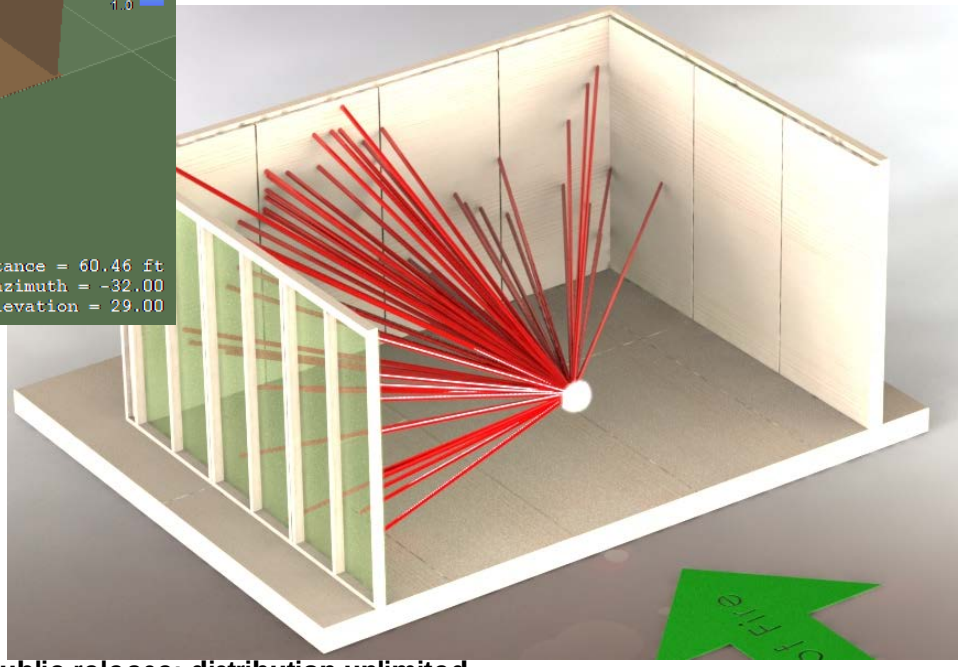
Fragment Trajectories: Shot 5



← Fragment trajectory simulations in WarheadView



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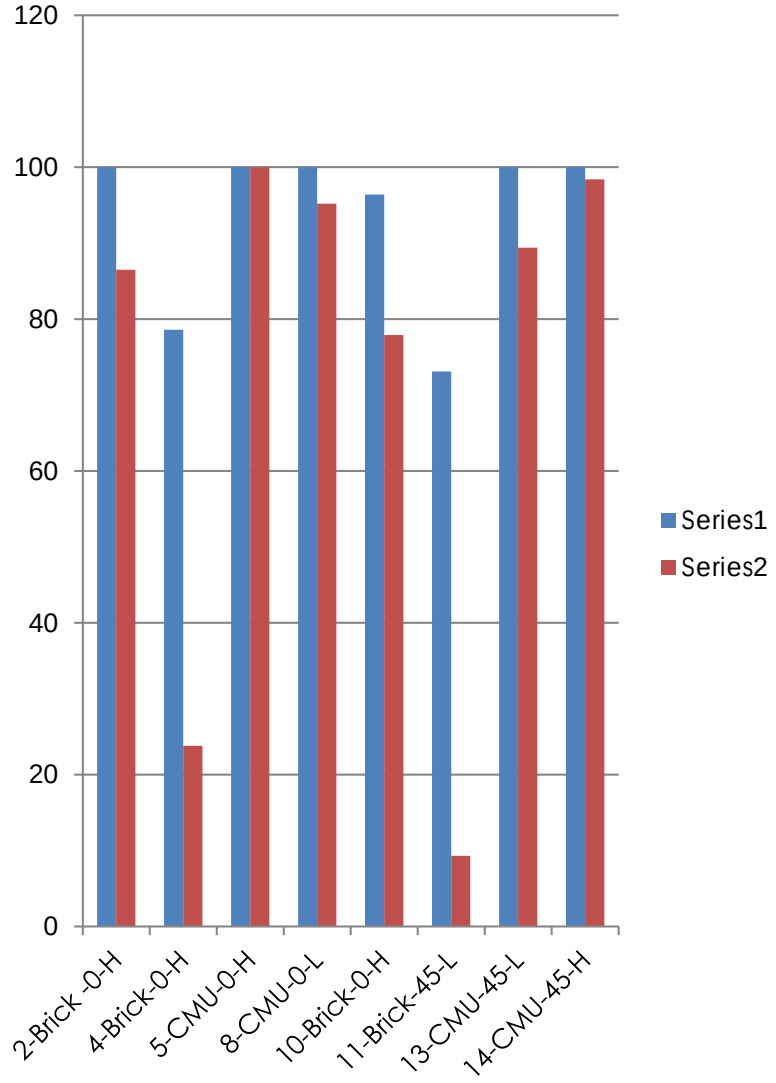
Summary of Test Shots and Results

PGU-47/U



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Summary

- Eight PGU-47 25-mm shots analyzed
  - Four against brick-over-block walls
  - Four against concrete masonry unit walls
- Projectile fragment mass and velocities were directly measured or estimated from PMAT
  - For Shots 4 & 12 – only the penetrator was recorded as penetrating the brick-over-block wall and thru the witness room wall. The Fragmentation was trapped in the wall.
- Average and maximum P_{inc} computed for matrix of personnel targets
- Significant difference observed in P_{inc} between brick wall and concrete masonry (CMU) wall
  - Impact/penetration of CMU wall produced large numbers of fragments, resulting in much higher P_{inc} values

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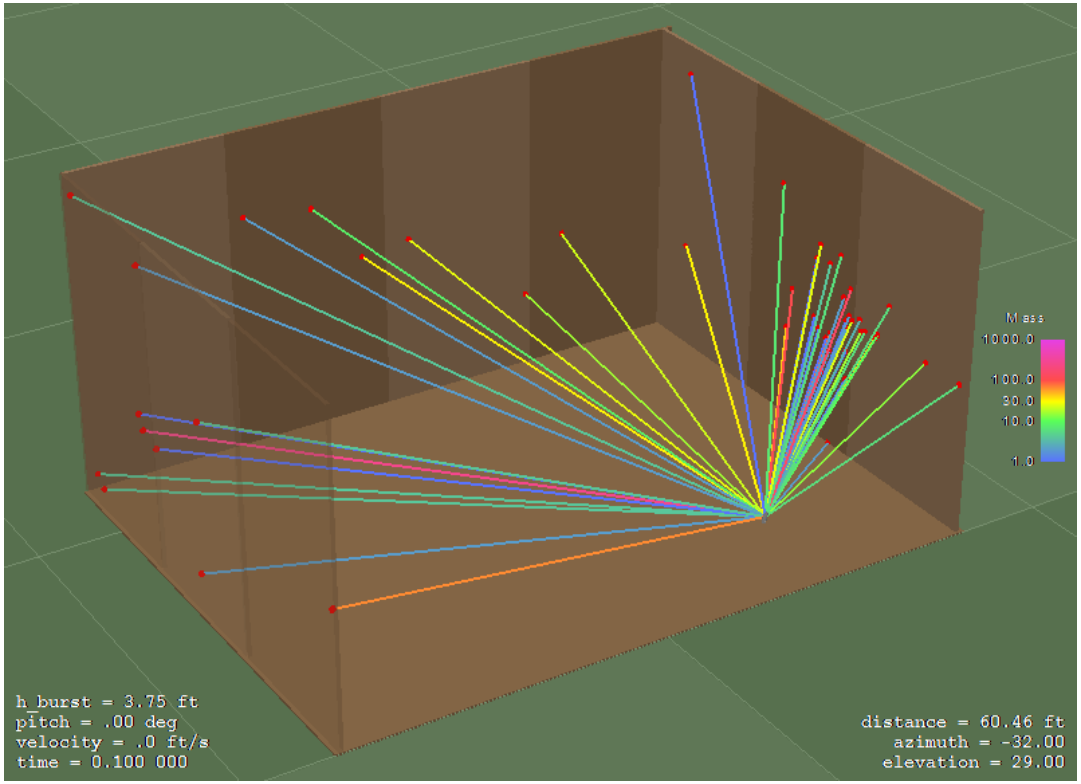
Questions



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