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

Presented by

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Outline

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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
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
Wall Targets

Brick-over-Block

Concrete Masonry Unit
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
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)
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.
Probability Of Incapacitation

• Probability of incapacitation ($P_{\text{inc}}$) as a function of the number of lethal hits ($N_{\text{Lethal}}$):

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

• 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:

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

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

• 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
WarheadView Target Configuration
46 Personnel Targets

16x16-foot room
(Front wall not shown)

Projectile fragment paths

Projectile path

h burst = 2.33 ft
angle = 0.00 deg
velocity = 1365.0 ft/s
Time = 0.021 500

distance = 38.94 ft
azimuth = -16.00
elevation = 32.00
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)
• 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)
### Summary of Test Shots
PGU-47/U

<table>
<thead>
<tr>
<th>Shot</th>
<th>Wall Target</th>
<th>Type</th>
<th>Angle</th>
<th>Velocity (ft/s)</th>
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<tr>
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</table>
Fragment Trajectories: Shot 5

Fragment trajectory simulations in WarheadView
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
Questions