Advancements in Personnel Incapacitation Methodologies for Multiple Cartridge Projectiles (MPCs)

NDIA – Joint Armaments: Conference, Exhibition, and Firing Demonstration
19 May 2010

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• Background – Close-In Anti-Personnel (CIAP) Study
• Modeling methodology
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    • MUVES-S2
    • Modeling MPCs
    • ORCA
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  • Incapacitation
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The intent of the CIAP program is to replace the current 40mm Multiple Projectile (M576) cartridge with modern alternative.

ARL conducted a 3 phase effort to assist in the design:

- Phase 1 – Characterize the M576
- Phase 2 – Characterize the Mossberg 590A Tactical Shotgun System w/ standard configuration
- Phase 3 – Concept evaluation and optimization

Each phase considered:

- Pellet mass/velocity/quantity
- Pellet shape and in shot dispersion
- In addition, as a part of phase 2, ARL evaluated and compared the Probability of Incapacitation (P(I) =1) values of the M576 and the 590A

All modeling and simulation were performed with ARL-SLAD’s MUVES/ORCA software
Modeling is composed of three stages:
- Delivery
- Damage to target (injury)
- Incapacitation (assessment of target’s reduced capability to accomplish tasks)

### Delivery
- Target posture
- Aim point
- Aim error
- Trajectory
- Velocity decay
- Air drag
- Dispersion

### Damage to Target
- Hit location
- Shot line in target
- Striking velocity
- Fragmentation effects
- Anatomical model
- Deleterious processes
- Tissue retardation
- Resulting hole sizes

### Incapacitation
- Assess target’s reduced ability to accomplish tasks, using Operation Requirement based Casualty Assessment (ORCA)
A Survivability/Lethality/Vulnerability (SLV) computer model capable of analyzing the effects of one or more munitions against aircraft, ground-mobile targets and/or personnel.

**ORCA Methodology** allows for:
- discrete shot lines through anatomy based on orientation of threat trajectory to personnel
- projectile penetration mechanics through various anatomic structures
- velocity retardation of threat through wound track
- injury description by type, severity, and frequency
- in-depth description of operational effectiveness

**Analysis Outputs**
- personnel injury and incapacitation
- system-level kills / loss of function
- residual penetration & velocity
- component damage
- subsystem capabilities
- remaining system utility
- user-defined criteria
- tabular & graphical products

**Vehicular SLV Analysis**
- Threat Characterization
- Behind-Armor Debris
- Target Geometry
- Crew Casualty
- Component Defeat Criteria
- Engagement Conditions
- Criticality Analysis of Components and Subsystems
How MPC’s are modeled in MUVES-S2

Each run within MUVES-S2 modeled 250 iterations of a unique shot configuration using a specified angular dispersion.

Each iteration modeled:
- A circular uniform dispersion of impacts around an aim point
- Injuries for each pellet that impacts personnel
- The cumulative damage of all pellets is assessed to calculate impairment
• ORCA is a high-resolution computerized human vulnerability model that is used to assess the impact of various casualty-causing insults on personnel.

• ORCA calculates several injury severity trauma metrics that may be used to characterize both an individual injury as well as multiple injuries to a single person.

• Incapacitation:
  • The inability to perform, at a level required for combat effectiveness, a predefined combat role at a specific time after wounding:
    • Physical capabilities
    • Mental capabilities

  • A combat role is a specific list of individual tasks that personnel must be able to perform at a pre-designated level.

  • Personnel are considered incapacitated if they cannot perform their given combat role at the minimum capability level, and are considered an Operational Casualty.
Dispersion provides the means for MPCs to affect damage to multiple critical tissues at once but diminishes the incapacitation potential of a cartridge when it causes an insufficient number of projectiles to impact the target.
Target Profile: Insurgent
Armor: Light to none
Environment: Close quarters
Capabilities:
  • Stand
  • Aim
  • Shoot
Time Period of Interest: \( \leq 1 \) second

Job Description Chosen: Armed Adversary
  • Most difficult job to incapacitate
    • Pro: Provides worst case scenario
    • Con: May underestimate incapacitation potential of a given round

- Incapacitation is achieved by damaging the central nervous system, cardiovascular system, and the skeletomuscular system
- This job description was approved by Director of Combat Development, Infantry Center
- It was used by ARL in lethality and small arm characterization studies (FY09-Present)
Characterizing a Sample Shot Configuration

Probability of Incapacitation vs. Projectile Count

Shot Configuration Variables
- Mass
- Shape
  - Sphere
  - Cube
  - Cylinder
- Velocity
- Count
- Dispersion Angle
- Material
  - Steel
  - Lead
  - Tungsten

Target Configuration Variables
- Range
- Posture
- Armored vs. Armored
- Job Description

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Probability of P(I) = 1 for given projectile count @ given ranges

May 2010
These incapacitation plots were modeled using a single projectile from a given shot configuration. Uniform grid of shot lines in a front-only view with zero degrees azimuth and elevation.
Observations

- Driving factors of incapacitation:
  - Penetration/tissue damage (KE of the system)
  - Hit location (dispersion)
  - Quantity of tissues damaged (pellet count)

- Without sufficient penetration, incapacitation is unlikely regardless of hit location

- With an increase in dispersion, pellet count is a greater factor

- A high energy, optimally dispersed system with the maximum number of projectiles provides the greatest potential for complete incapacitation

Summary
Without sufficient penetration, an increase in dispersion/pellet count will result in a minimal increase in incapacitation. However, as range increases, dispersion and pellet count amplify a MPC’s ability to incapacitate by damaging more than one physiological region at once.
Optimization Analysis

245 Mass/Velocity/Dispersion Configurations

Optimization Methodologies:
- Trend analysis via frequency histograms
- Legacy constraints:
  - Velocity
  - Mass
  - Dispersion
  - Geometric optimization

Results: 8 final configurations
MUVES-S2/ORCA provides inputs for dynamic modeling software such as The Infantry Warrior Simulation (IWARS)

Tailored to the specific analysis:
- Scope
  - System based
  - Single projectile based
- Casualty based P(I) values
  - Entire body
  - Per body region
  - With or without aim error

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Images provided by ARL/WMRD
Questions
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