40mm High Explosive Multi-Mode (HEMM) Grenade Concepts

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Briefing Objective

• Project Overview
  – Background
  – Scope
  – Objectives
  – Approach
  – Results
Background & Scope

- **Background**
  - There is a need to more effectively defeat enemies in defilade
  - The lethality of grenades can be increased by launching more, most, or all fragments in a preferred direction – at the target

- **Scope**
  - Phase I was an iterative design and modeling effort
    - Establish baseline performance of working munitions
    - Compare effectiveness of 40mm directed fragmentation munition concepts
Technical Approach

• Requirements & Constraints Development
  – Establish applicable performance requirements: start with the effects on target and work backwards

• Preliminary Concept Development
  – Two design teams
    – Iterative concept development & analyses

• Fuzing Design Development

• Preliminary Design Verification
  – Limited detail of modeling & analyses

• Further Concept Development
  – Refine definition of subsystems & components

• Performance Verification of Concepts
  – Verify design in virtual environment
Functional Analysis

- Eight fundamental functions are basis of concepts
  - Initialize Fuze Logic Circuit
  - Transfer Targeting Data
  - Arm Fuze
  - Sense Target
  - Function Fuze
  - Lethality Enhancement Method
  - Launch Fragments
  - Penetrate/Kill Target

Fuze-related functions
Function Methods

- **Initialize Fuze Circuit**
  - Activate onboard power source
  - Transfer power to munition
  - Electrical contact
  - Inductive contact

- **Transfer targeting data**
  - Electrical signal
  - Inductive signal

- **Arm Fuze**
  - Safety release - setback
  - Safety release - spin

- **Sense Target**
  - Count revolutions
  - Count time
  - Sense proximity
  - Mechanical contact

- **Function Fuze**
  - Electrical
  - Mechanical
  - Pyrotechnic

- **Lethality Enhancement**
  - Explosive
  - Propellant

- **Launch fragments**
  - Perforate / Disrupt
  - Impulse / Blunt Trauma

- **Penetrate / kill target**
Lethality Enhancement Methods

• **Time or Orientation**
  – Control time or orientation at which selected portions of munition detonate

• **Reconfigure Munition**
  – Statically or dynamically rearrange munition configuration so most or all of fragments are projected in a preferred direction

• **Submunitions**
  – Deploy then detonate submunition(s) at appropriate times

• **Redistribute Mass of Baseline Munition**
  – Redistribute mass of baseline munition to increase number of radial fragments

• **Mixed Fragment Masses/Types**
  – Large number of small fragments
  – Limited number of massive fragments (more penetrating capability)
    - Preformed, controlled (scoring/notching), EFPs
Operational Modes

- Directed fragmentation
  - Shooter designates direction of fragments

- Axisymmetric burst
  - Burst on contact
  - Airburst

- Anti-armor mode
Initial Concepts (1 of 2)

- Sequential Segment Detonation
Initial Concepts (2 of 2)

- Counter-rotating Detonation Wave

\[ \omega \approx 20,000 \text{ RPM} \]

- Reconfigured Segments

![Diagram of reconfigured segments](image)
EFI-Based Fuzing

All of the 40mm DFM concepts use EFI-based electronic firing set for multi-functionality, timing precision, and safety.

<table>
<thead>
<tr>
<th>Initiator</th>
<th>Current</th>
<th>Voltage</th>
<th>Energy</th>
<th>Power</th>
<th>Time</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Wire</td>
<td>1A</td>
<td>20V</td>
<td>0.2 J</td>
<td>1 W</td>
<td>1 ms</td>
<td>Initiator to sensitive primary to sensitive secondary explosive</td>
</tr>
<tr>
<td>EFI</td>
<td>2000A</td>
<td>1000V</td>
<td>0.2 J</td>
<td>3 MW</td>
<td>1μs</td>
<td>Initiator to insensitive secondary explosive</td>
</tr>
</tbody>
</table>

Exploding Foil Initiator (EFI)
Deployment Charge COTS Item

Smart ASIC

Nozzle

Grain Trap

Igniter and Charge Sleeve

Propellant

SEA Smart Thruster

SEA Printed Circuit Board Sizing
Fuze Packaging Concept

- LV to HV Conversion Components
- Inductive Communication
- Setback Battery
- Filter
- Piezo Impact
- Supercapacitors
- FETS
- GYROS
  Angular Rate Sensors
- FPGA
Summary

• 40mm High-Explosive Multi-Mode Grenades are Feasible

• Greater lethality
  – In anti-personnel mode: most fragments can be directed at targets in defilade
  – In anti-armor mode: standoff can be increased to optimize shaped charge penetration

• Substantially more reliable performance
  – Ensured through the use of an electronic S&A subsystem

• Lower development costs
  – COTS or COTS-adaptable electronics avoid substantial development time and cost

• Retention of legacy capabilities
  – Multi-mode grenades can be employed the same as current grenades

• Design growth potential
  – Inherent programmability can adapt to emerging needs
  – Tactics can be evolved to take advantage of additional modes of operation
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