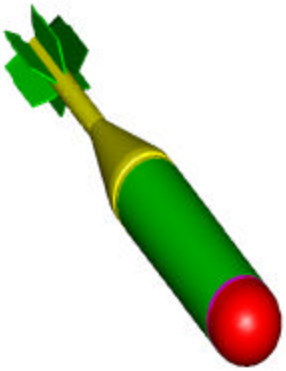
United Defense

Design and Development of an 81mm Non-Lethal Mortar Cartridge

David H. Lyon - ARL
Richard F. Johnson - UDLP
Joseph Domanico - SBCCOM

Presented to:
Non-Lethal Defense IV
March 20-22, 2000



Program Requirements

- Accurately deliver non-lethal payloads at long ranges (400 - 1,500 meters)
- Projectile components and payload must reach ground with non-lethal energy
- Utilize fielded weapon system indigenous to light force units
- Strive for cost effectiveness and scalability
- Design with focus on minimal logistics tail
  - Ease of introduction
  - Minimize training burden

Concept of Operation

- Call For Fire
- Quadrant Elevation and Azimuth Determined by Ballistic Computer (Firing Table)
- Cartridge Drop Fired in Standard Fashion
- Subsonic Ballistic Flight
- Dispense Payload 50m Above Target Area
- Low Mass Submunitions Free Fall into Target Area
- Projectile Components Parachuted to Ground

Program Plan

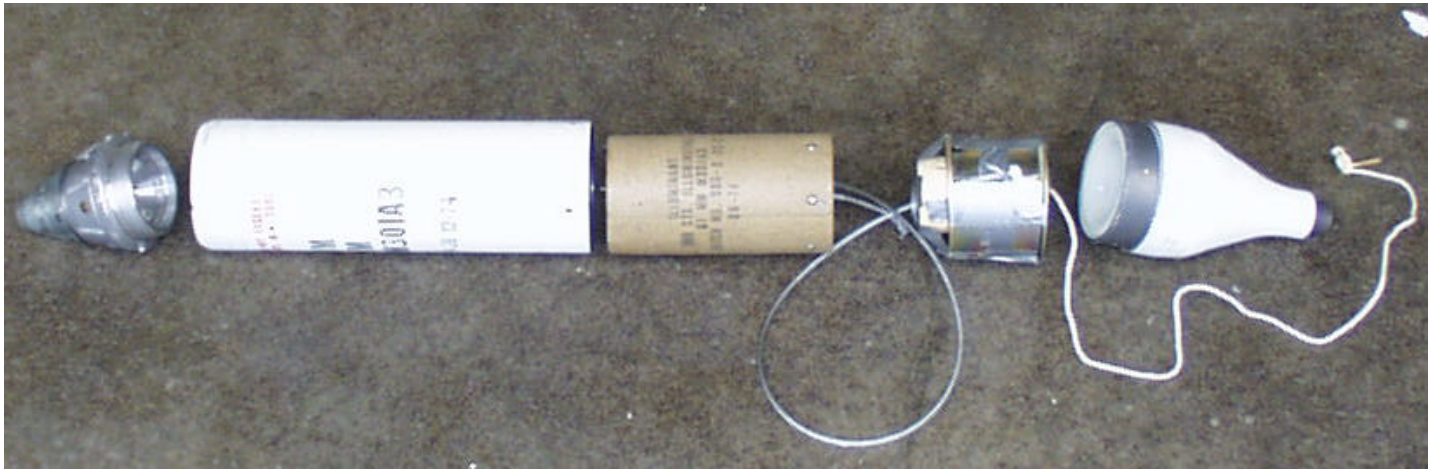
- Examine Existing Rounds for Applicability/Mods
- Design Prototype Based Upon Predictions
- Conduct Interior Ballistic and Preliminary Flight Test of Prototype
- Optimize Stability Parameters in Wind Tunnel
- Configure Interior Volume (Payload/Dispense)
- Conduct Parachute and Dispersal Testing
- Incorporate Light Weight Materials (Composites)
- Perform Interior Ballistic and Flight Test of Final Design
- Conduct Proof-of-Principle Demonstration

Enabling Technologies

- **Composite Materials**
  - **Light Weight**
  - **High Strength**
  - **Low Unit Cost**
- **COTS Fireworks Fuze or Innovative MEMS Design**
  - **Expel Cargo at Optimal Point in Trajectory**
  - **Reduced KE Due to Low Fuze Mass**
  - **Low Unit Cost**
- **Optimal Aerodynamic Stability**
  - **High Lift / Low Drag Shape**
  - **Steady State Roll Rate to Assist Payload Dispersal**

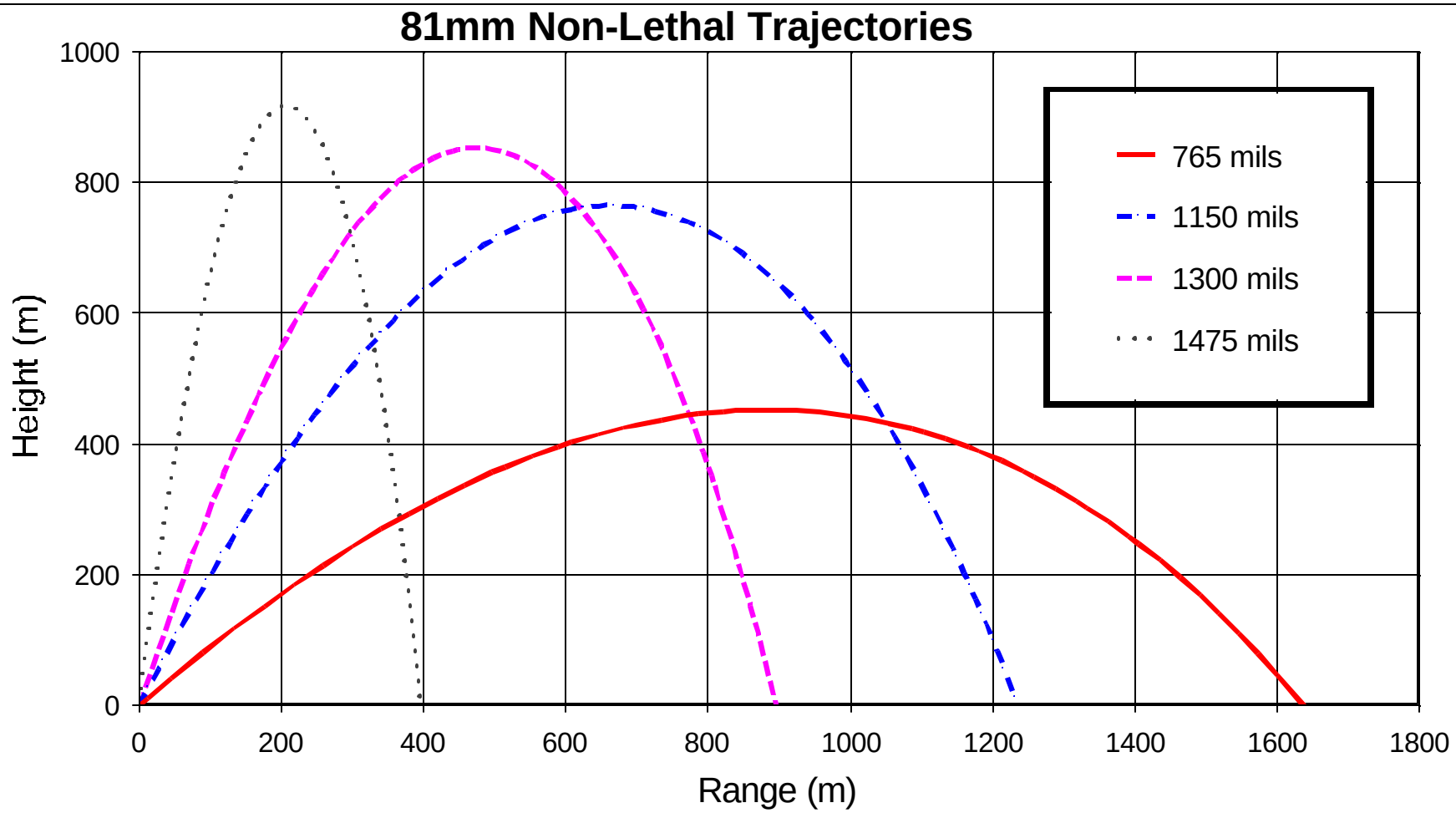
United Defense

Baseline Projectile - M301A3



United Defense

Trajectory Plots



Arrow Tech-PRODAS2000 Cross Plots 03/16/2000

United Defense

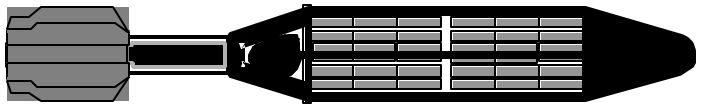
Interior Ballistic Solution

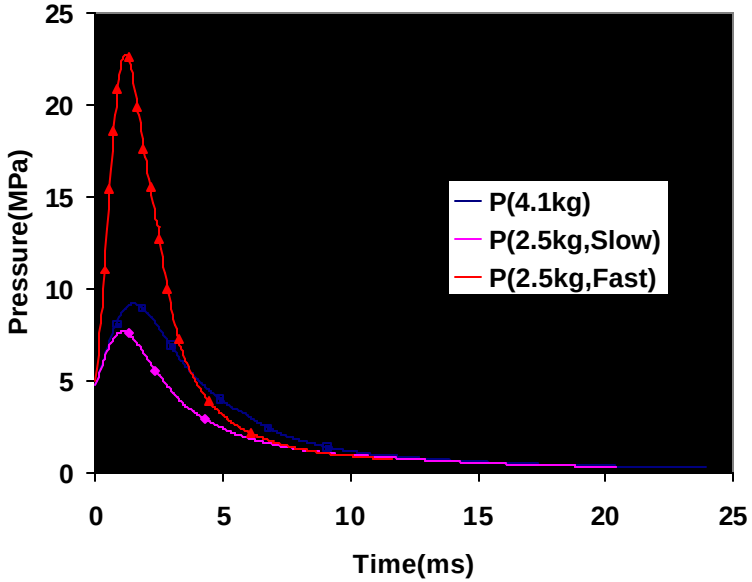
Issues

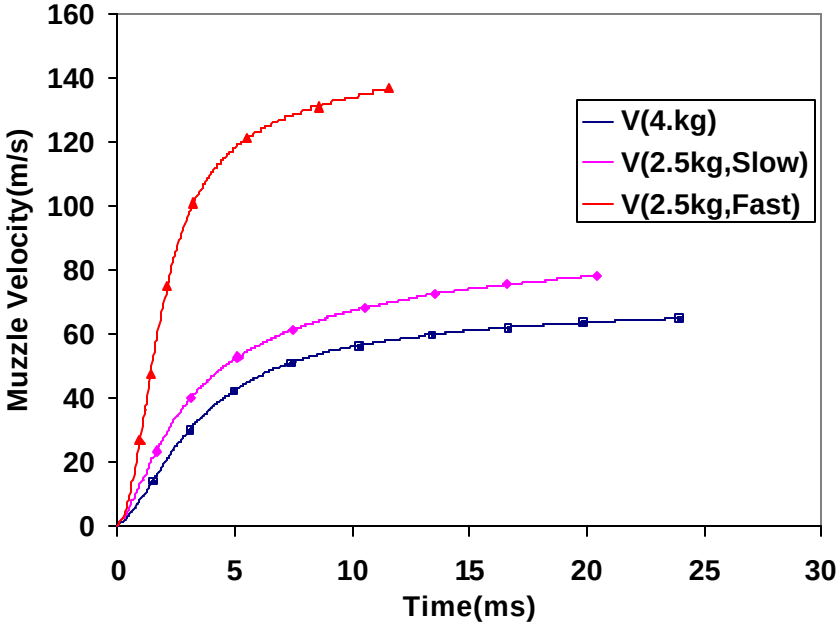
- Muzzle velocity of ~ 130 m/s or higher to obtain maximum range
- Peak pressure for lighter structure
- Minimize cost of modifications to ignition/propulsion system

Approach

- Start with modified M752 cartridge as baseline (Charge 0) propulsion system
- Increase M9 charge mass at constant loading density
- Achieves muzzle velocity of 130 m/s or higher with peak pressure ~ 3,300 psi





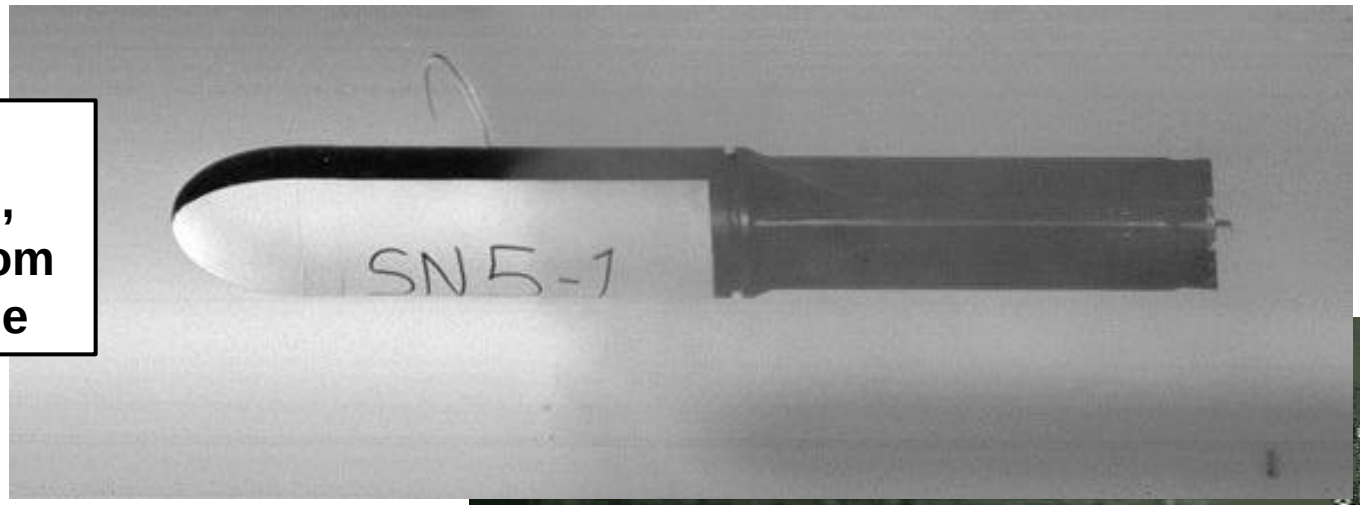


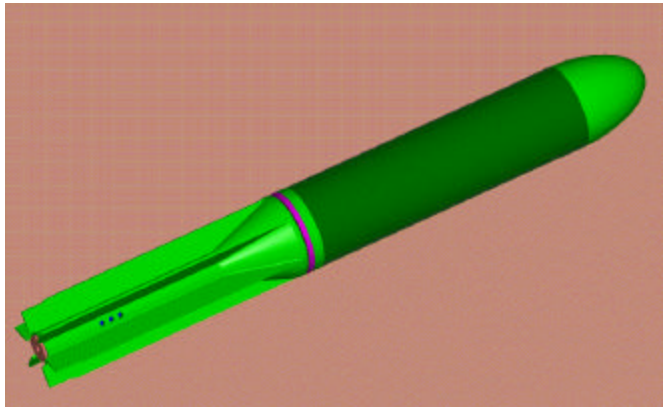
Modified Charge 0 achieved the desired muzzle velocity

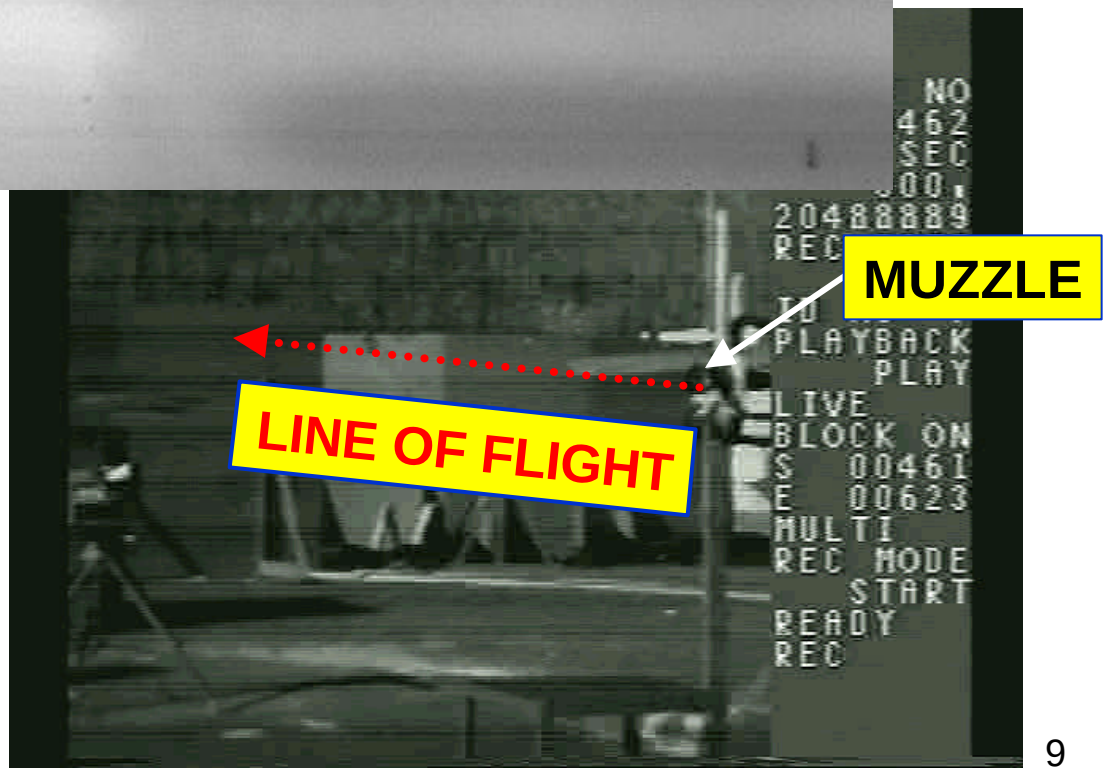
United Defense

Prototype Testing

Rd 35207, 1m from muzzle







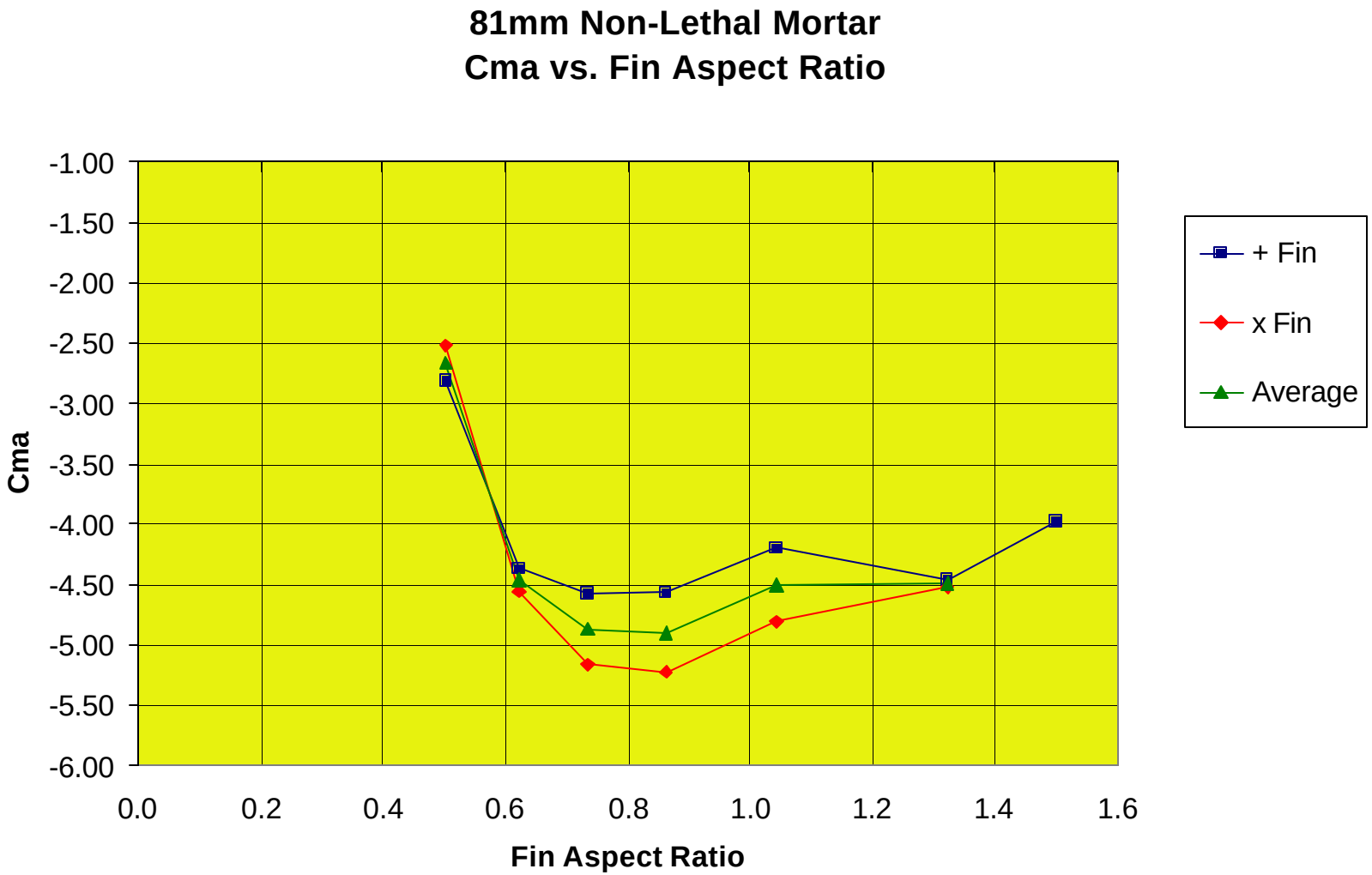
Wind Tunnel Tests

SBCCOM Vertical Wind Tunnel

Wind Tunnel Models

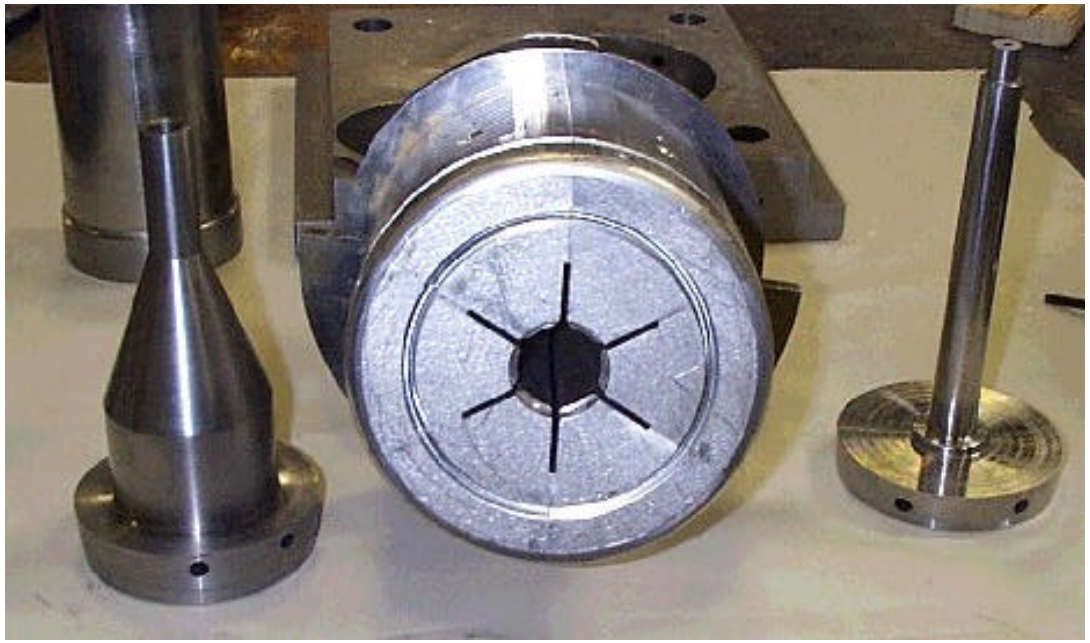
United Defense

Wind Tunnel Results



Composite Material Integration

- Tail Cone/Fin Assembly - Compression molded from PEEK with chopped glass reinforcement
- Body Tube - Filament wound carbon fiber pre-preg
- Nose - Aluminum windscreen with potted fuze

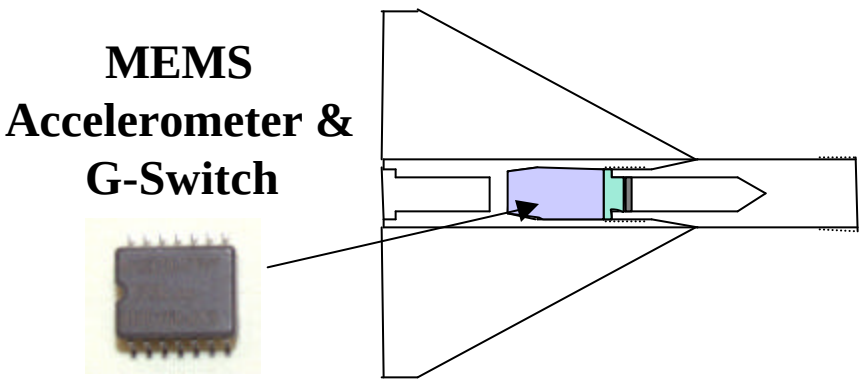


Fuze Option A

- **Time fuze from fireworks industry**
  - **Dual Squib Output (lifting charge and burst charge)**
  - **Function Time Pre-Selected (non-tactical solution)**
  - **Hard Wire Initiated (non-tactical solution)**
  - **Lightweight and Simple Design (RC Circuit)**
  - **Cheap ($10/copy) COTS Item**

Fuze Option B

- **Repackage MEMS Fuze Demoed for Tank Ammo**
  - **Leverage existing program (DARPA, ARDEC, ARL)**
  - **Utilizes COTS MEMS components (G-switch and accelerometer)**
  - **Self-contained fuze (Battery, Dual Safe & Arm, Squib)**
  - **Function Time Pre-Selected, Semi-Tactical Solution**
  - **Very Lightweight**
  - **Extremely Rugged (Demonstrated at 60,000 g's)**
  - **Medium Cost**

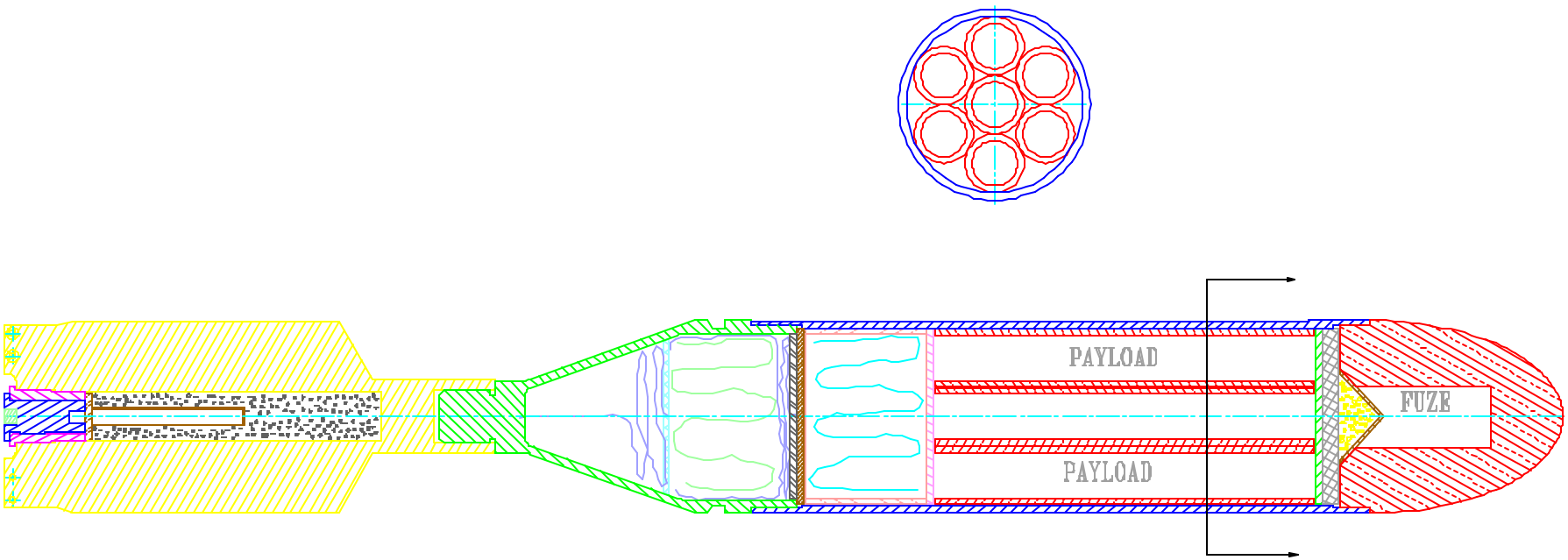


Mode of Operation for MEMS Fuze

- Safety Removed
- Cartridge Drop Fired, Percussion Primer Ignites Propellant
- G-Switch Senses Setback, Starts Timing Circuit
- Accel. Senses Spin, Arms Firing Circuit
- Timer Fires Squib, Ignites Expulsion Charge
- Payload Fuze Ignited and Parachutes Ejected
- Payload Lands in Target Area
- Projectile Components Float to Ground
- Fuze Functions if Impact Sensed (Prevent Battlefield Duds)

United Defense

Final Configuration



Potential Payloads

- **Pyrotechnic Submunitions**
  - **Concussion (Flash/Bang), Smoke, Tear Gas, Strobe, Whistles, Dragon Eggs, etc.**
- **Malodorants**
- **Acoustic Emitters**
- **Liquid Dispenser**
- **Video Imager**
  - **Visible/IR**
- **Sensors**
  - **Microphone**
  - **RF Receiver/Jammer**
  - **Seismic**

Future Program Plan

- Conduct Static Dispersal Testing
- Perform Dynamic Dispersal Testing
- Complete Fuze Design and Fabrication
- Flight Test Composite Round Components
- Conduct Proof-of-Principle Demo
- Complete Final Report and Briefing

Dragon Fire Prototype

M252 81mm Mortar

Engagement Scenario