



RDECOM



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Trajectory Simulations of the Ejected Vent Plugs during Premature Fuze Detonation of the 81mm, M879 Full Range Practice Mortar Cartridge

Seungeuk Han

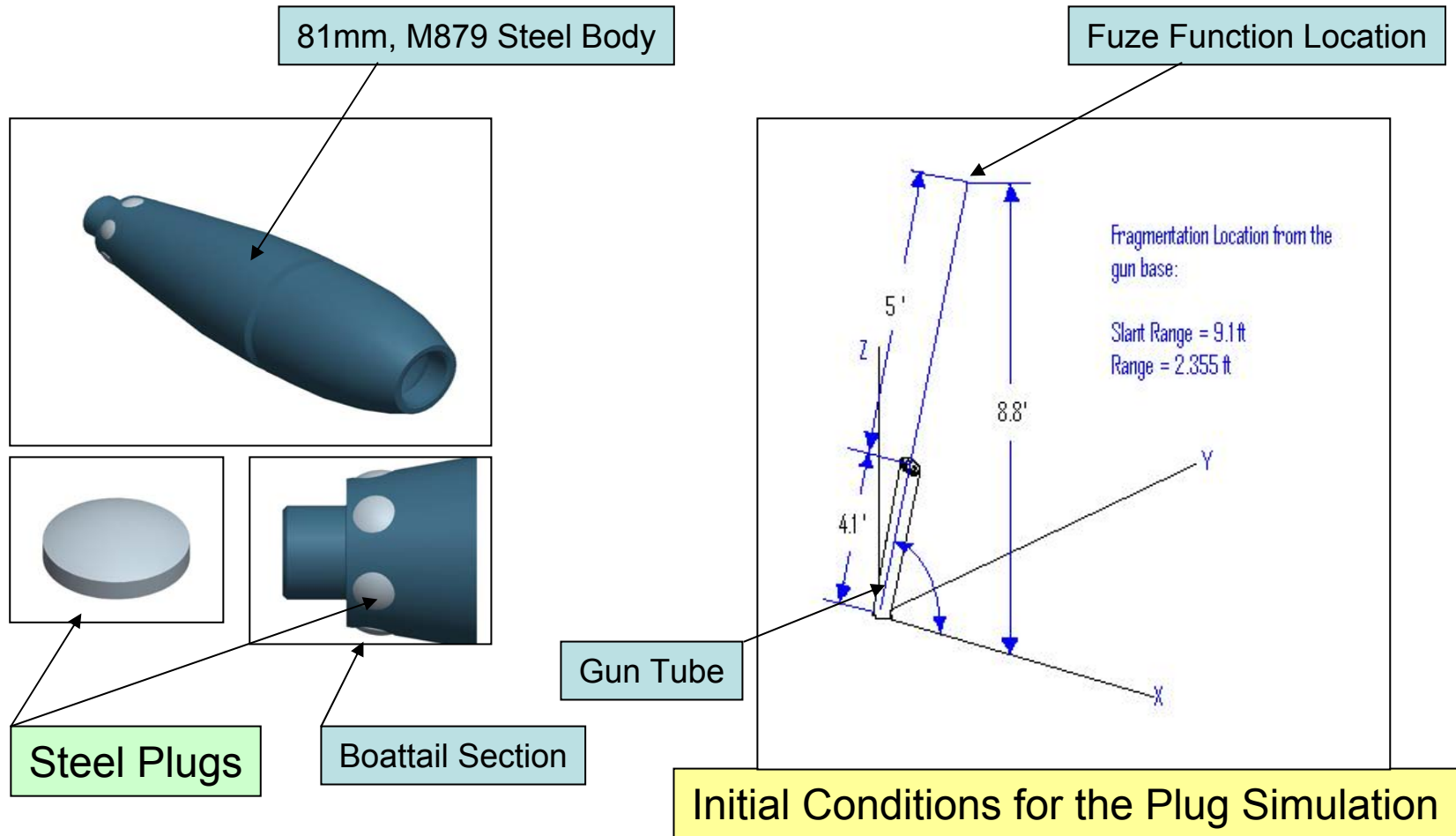
AMSRD-AAR-MEM-A

Aeroballistics Division

Munitions Systems & Technology Directorate

- The 81mm, M879 Full Range Practice Mortar Cartridge (FRPC) has six (6) steel plugs (0.5 inch diameter each - uncompressed) located on the boattail that are designed to eject and vent out pyrotechnic smoke generated by the fuze upon its function.
- The fuze can function prematurely; as close as 5 feet slant range from the gun muzzle.
- Although the possibility of occurrence is extremely low, soldier safety in the event of premature fuze functioning was studied.

- There are six (6) identical steel plugs on the body:
 - Thickness = 0.062 in (1.575 mm)
 - Weight = 0.00342 lbm (1.55 g)
 - Diameter = 0.5 in (12.7 mm)
- The internal pressure inside the projectile body is 6,000 psi.
- Projectile launching conditions:
 - Propellant Charge 0 (muzzle velocity of 216.5 ft/sec)
 - QE of 75 degrees



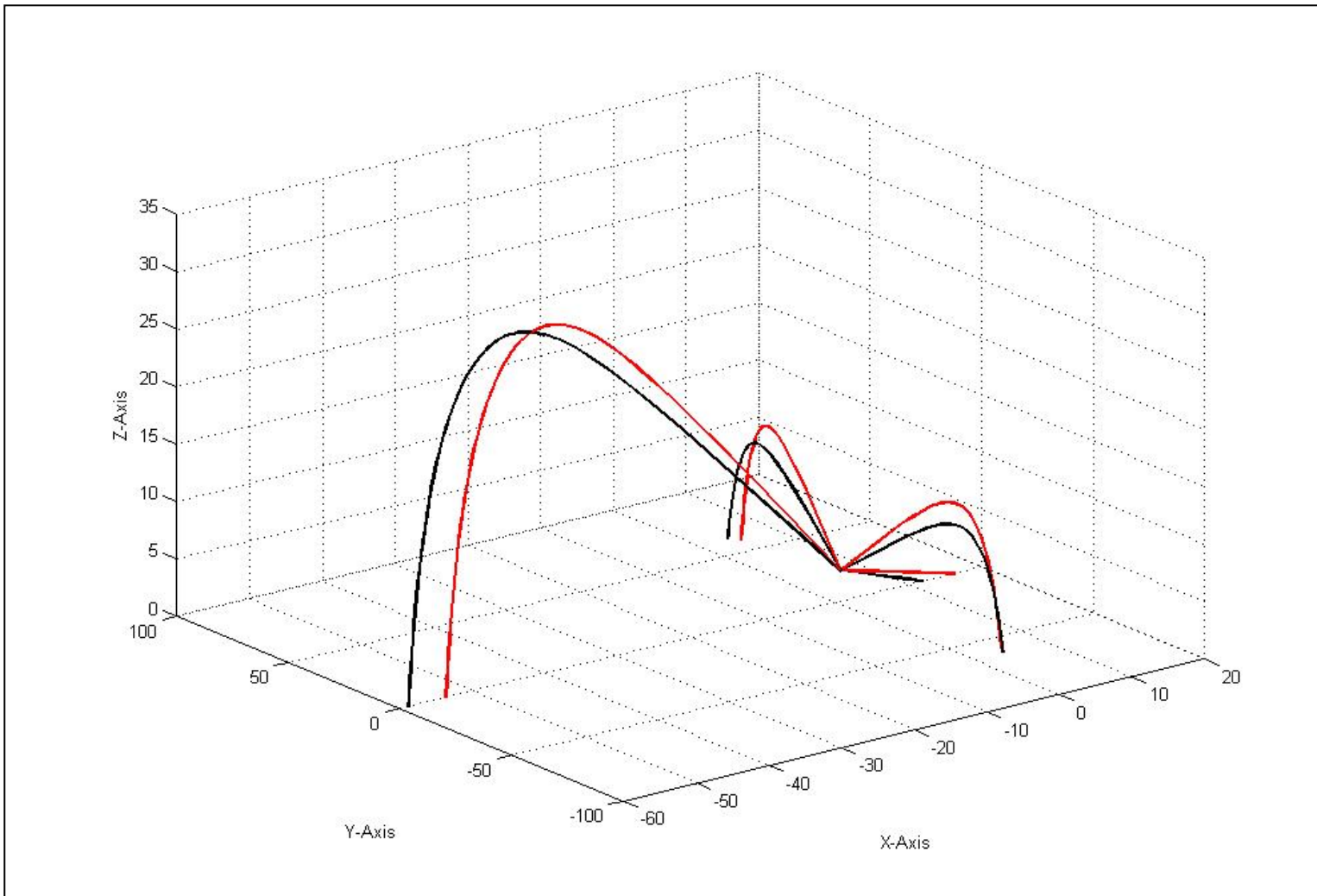
- Do the plugs hit an average height soldier (5',6" – 6', 2").
- If the plugs hit anything direct at ejection, will it hit with greater impact energy than the Less-Than-Lethal (LTL) criteria of 58 ft-lb?
- If the plugs hit indirectly by falling to the ground, will it hit with greater impact energy than the LTL criteria of 58 ft-lb?
- If the plugs falling, will it hit the vulnerable human body parts like ears and eyes, etc?

- Trajectory of the plugs were estimated by using 3 DoF computer program.
 - Initial conditions of the plugs were set at the projectile conditions at 5 ft slant range from the muzzle.
 - Constant drag coefficient had been used.
 - The plug was assumed tumble throughout the entire trajectory.

- An equivalent aerodynamic drag coefficient and its respective reference area were estimated for the simulation.
 - $A_{eq} = 0.126 \text{ in}^2$
 - $CD_{eq} = 2.0$

- Internal chamber pressure due to the fuze detonation is up to 6,000 psi.
- The firing condition of charge 0 at QE of 75 degrees is assumed to be the worst case.
- The rectangular coordinate system had been used.
- The plugs are tumbling during their entire trajectories.
- There is no energy loss during the plug ejection process.

- The ejection velocity for this pressure is estimated at 1070 ft/sec (326 m/sec), which is higher than the 58 ft-lb cutoff velocity of 1047.5 ft/sec for the plug.
- According to the Lam's Equation, a force estimation equation to press fit a pin, the lowest pressure the plug will eject is 3800 psi.
- The ejection velocity for this pressure is estimated at 810 ft/sec (247 m/sec)



- The plugs are ejected at 8.8 feet which is beyond the reasonable heights of soldiers enlisted in the US Army (about 6 feet).
- All plugs behind and to the side of the gun position are falling near vertically with the velocities approx 36 – 41 ft/sec (i.e. ≈ 0.1 lbs-ft).
- All plugs front of the gun position are hitting the ground directly with 300 – 520 ft/sec (eq. 4.8 – 14.3 lbs-ft), but no one allowed to be in this area during firing.

- Possibility of the plug hitting the operator is extremely low.
 - Fuze detonates beyond the reasonable heights of soldiers.
 - No one allowed to be in front of the gun during firing.
- Kinetic energy of the plug hitting the operator is negligible compare to the LTL criteria of 58 ft-lbs.
 - Each plug can reach the ground around 40 ft/sec which is about 0.1 ft-lbs.
- Impact angle of the plugs on the operator near the ground level is vertical.
 - The plugs behind the gun position are falling to the ground near vertical (90 degree from horizon), it is not likely to impact the vulnerable human body parts like ears, eyes, and mouth.

Seungeuk Han

Aerospace Engineer
US Army, RDECOM-ARDEC
seungeuk.han@us.army.mil
973 – 724 – 2978