# Development and Fielding of the Excalibur XM982 Warhead

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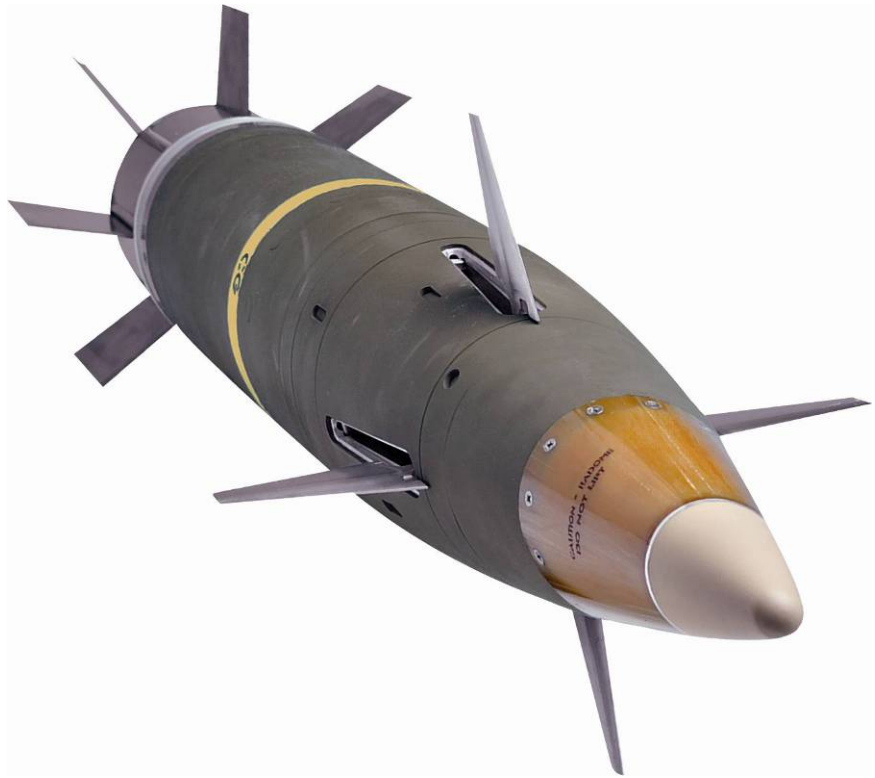
# Excalibur Team

- Prime Contractor: Raytheon
- BAE Systems Bofors
- GD-OTS
- PM-CAS



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# XM982 Excalibur

## GPS-Guided, Precision Long-Range Artillery Projectile

- Accuracy of Less Than 10M CEP
- Minimizes Collateral Damage
- Employment Flexibility
  - Danger Close
  - Restrictive Environment
  - Limits House Clearing
  - Off-Axis Capable Maneuvering Airframe
- High Impact Angle
  - Ideal For Urban Terrain
  - Optimal Effects
- Increased Effects With Fewer Rounds
- Responsive & Available to the Close-Combat Soldiers/Marines

M109A6 Paladin
- US Army

M777A2 LW155
- US Army
- USMC

Archer

**Excalibur is Transforming Cannon Artillery on the Battlefield Today**

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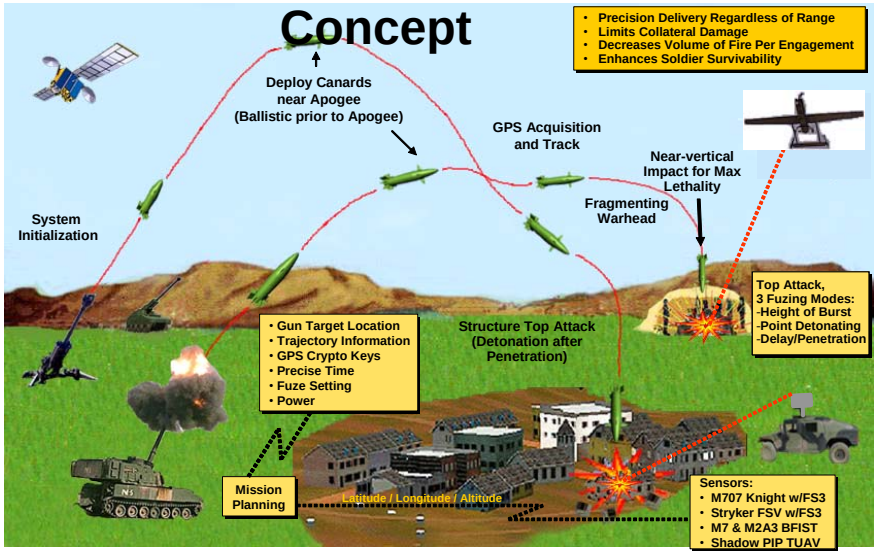
# Precision Cannon Munition Capability

EXCALIBUR XM982

## Concept




## System Description

- Precision guided, extended range 155mm High Explosive cannon ammunition
- All weather, day/night, fire & forget capability, optimized for urban/complex terrain
- GPS-Inertial Navigation System guidance w/anti-jam technology
- <10 meter CEP Accuracy at all Ranges
- Lethality comparable to M107 HE

## Value to Warfighter

- Allows for destruction of high-payoff targets in urban and complex terrain
- Minimizes collateral damage; reduces risk to friendly forces in the close fight
- Responsive; organic to UA & Stryker BCT
- All weather capability
- Fully autonomous; no laser required

| | Block Ia-1: Early Fielding | | ORD Requirements | |
|---|---|---|---|---|
| | User's Minimum Capability | Expected Performance | Block Ia2 *Threshold* | Block Ia2 *Objective* |
| *Accuracy (CEP) | =20 Meter | =6 Meter | =20 Meter | =10 Meter |
| *Effectiveness | =M107 HE | =M107 HE | =M107 HE | =M107 HE |
| *Reliability | =60% | =74% | =85% | = 96% |
| *Interoperability | All critical top level IERs | All critical top level IERs | All critical top level IERs | All top-level IERs |
| Range | =24 km | =24 km | =30 km | =40 km |
| Concrete Penetration | 4” | =4” | 4” | 8” |
| ** Anti-Jam | No | Yes | =30 Meter | =20 Meter |

* Key Performance Parameter
** Block Ia-1 Configuration will have Anti-Jam electronics, but will only have limited testing prior to Fielding

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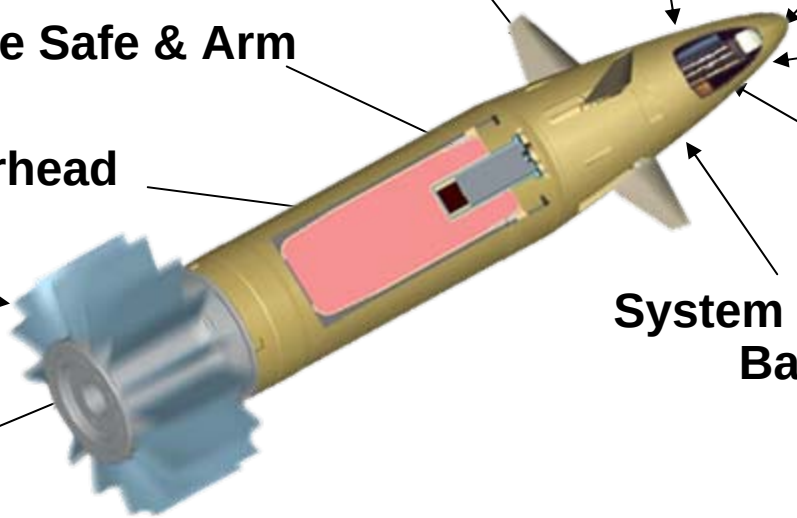
# Major Components & Functions



GPS Receiver
Inertial Measurement Unit – IMU

Height of Burst, Point Detonating & Delay Sensors

Canard Actuation System - CAS

Internal Fuze Safe & Arm

GPS SAASM (Selective Availability-Anti Spoofing Module)

Unitary Warhead

GPS Antennas

Spinning Base

System & Data Hold Batteries

Base Bleed

EPIAFS - Enhanced Portable Inductive Artillery Fuze Setter

# Effectiveness Against Unitary Targets

**Infantry Platoon**
M549: 25 rounds
M107: 43 rounds
Excalibur: 3 rounds

**Command Post**
M549: 54 rounds
M107: 78 rounds
Excalibur: 6 rounds

**Effects Comparison:**
M107 at 15Km
M549 at 20Km
Excalibur at any range

**Radar**
M549: 10 rounds
M107: 11 rounds
Excalibur: 1 round

**Structures**
M549: 147 rounds
M107: 110 rounds
Excalibur: 3 rounds

Excalibur is used in a complex target environment!

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# Gun Compatibility and Range with Base Bleed

| | | |
|---|---|---|
| **Current US 39-caliber systems (M777, M109A6, M198)** | **40km** | **MACS-5** |
| **NLOS-C US Army** | **>36km** | **MACS-4** |
| **FH77BD* Swedish Army** | **50km** | **Swedish *Uni-Flex* Charge** |

*** 52 Caliber Howitzers Will Achieve the 50km Range**


M777 Joint Light Weight Howitzer (LW155)


M109A6 Paladin Howitzer and M992A2 FAASV


FH77BD "Archer"


M198 Towed Howitzer


Non-Line-of-Sight Cannon (NLOS-C)

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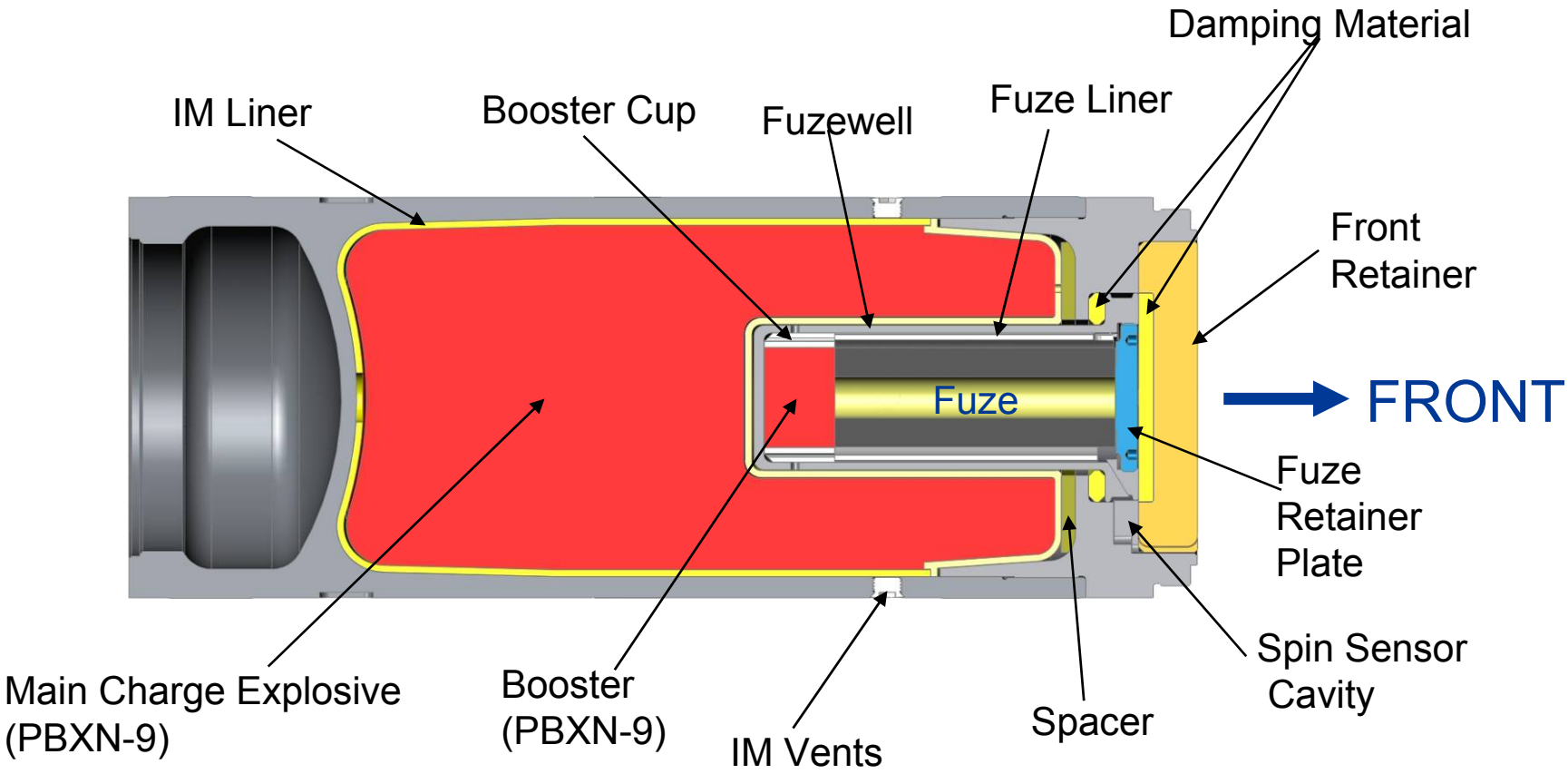
# Design Challenges

- Strict IM requirements
- Gun Hardening
- Concrete Penetration
- Evolving Requirements (System Level Trades)
- Long Storage Life

# Warhead Development

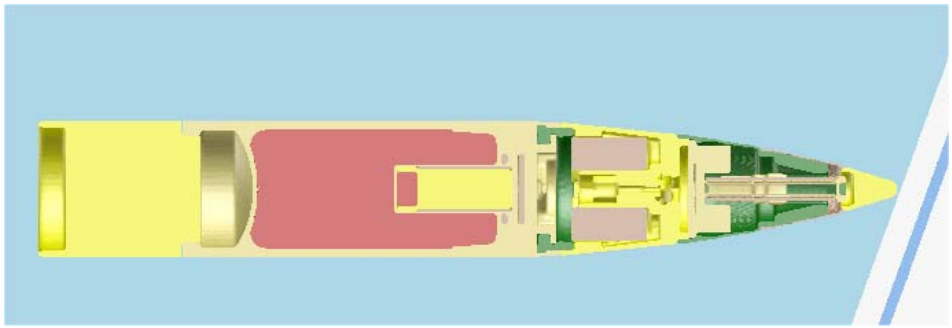
- SDD Program
  - Trade Studies
    - Explosive Material (Gun Safety, Reliability, IM, and Lethality)
    - Protection of Fuze (Gun Launch and Penetration)
    - IM Liner and Vent Material Study
  - Analysis
    - Finite Element Analysis
    - Hydrocode (Concrete Penetration, BI, FI, and SD)
    - Weapon Effectiveness
  - Testing
    - Insensitive Munitions
    - JMEM Arena Testing
    - Concrete Penetration Testing
    - Proof Load Gun Testing
    - Environmental Testing
- Early Fielding to Fulfill Need for Precision Fire Support (Approx. 800 Warheads Delivered)

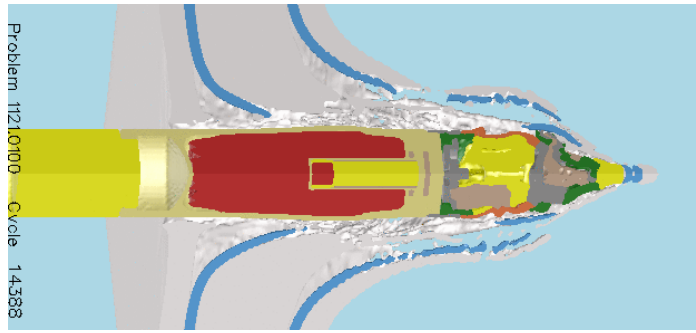
# Warhead Overview

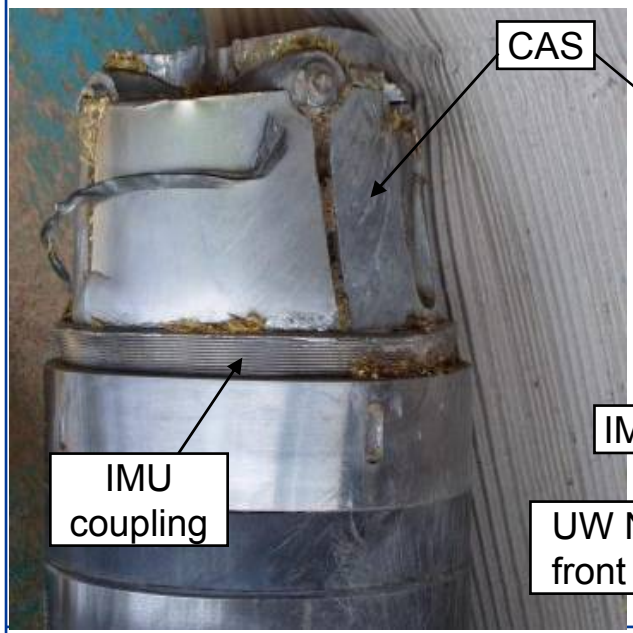


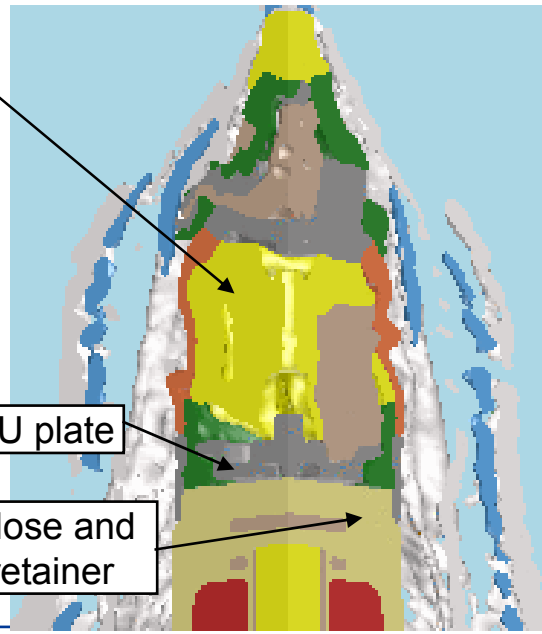
# Modeling & Simulation
# Target Penetration

EXCALIBUR XM982

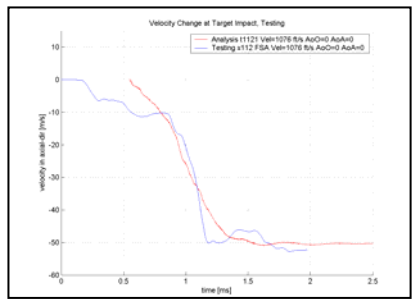





**Correlation of Modeling & Test Results**
Impact velocity = 328 m/s (1,076 ft/s)
Angle of obliquity = 0 deg
Angle of attack = 0 deg
Concrete Comp. strength = 4,200 psi
Exit Velocity (Simulation) = 278 m/s
Exit Velocity (Test) = 276 m/s

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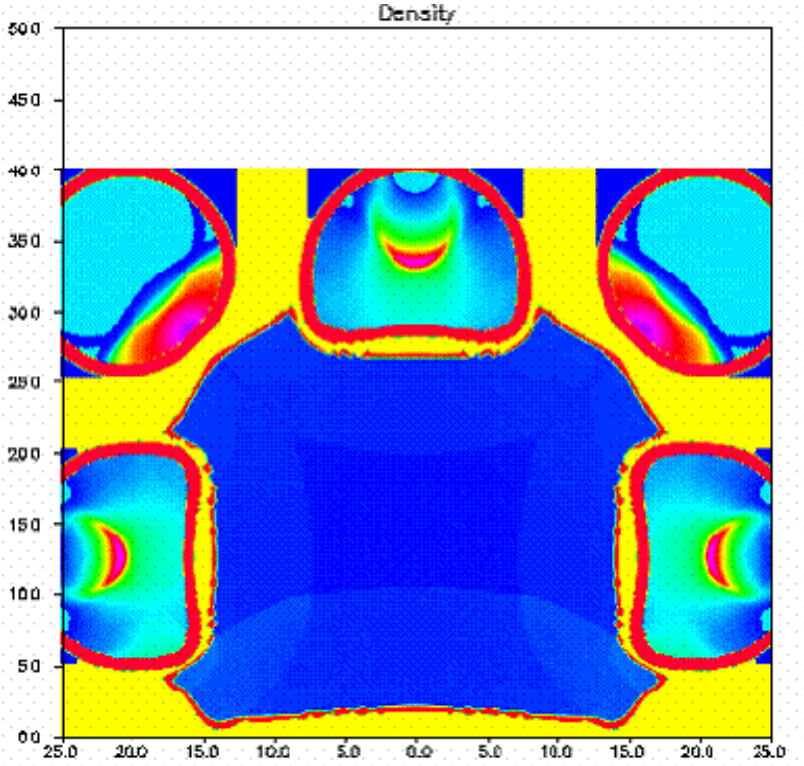
# Modeling & Simulation
# Sympathetic Detonation




Sympathetic Detonation Test

**Prediction: No Detonation of Acceptors**

**Test Results: Type III (Explosion)**

**OTI*HULL Hydrocode Results**

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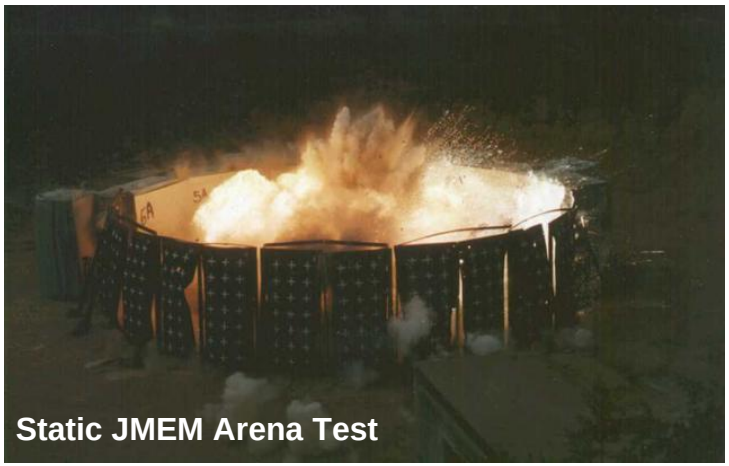
# XM982 Warhead Performance

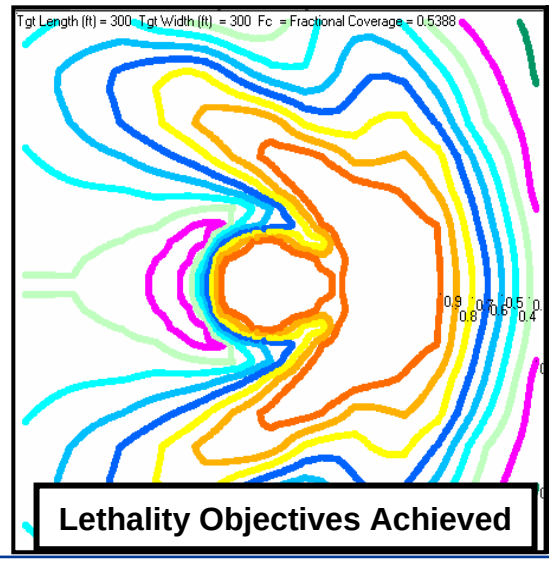
| Performance Measure | Requirement | Result |
|---|---|---|
| Environmental: Gun Launch | PMP + 5% | Meets Requirements |
| Environmental: Hot Gun | Functional After Exposure | Meets Requirements |
| Environmental: Life Cycle | 20 years | Meets Requirements |
| IM: Bullet Impact | ≤ Type V | Type V |
| IM: Fast Cook-Off | ≤ Type V | Type V |
| IM: Fragment Impact | ≤ Type V | Type V |
| IM: Slow Cook-Off | ≤ Type V (Objective)<br>≤ Type II (Threshold) | Type III |
| IM: Sympathetic Detonation | ≤ Type II | Type III |
| Performance: Lethality | Personnel, Command Post, Air Defense Radar | Meets Requirements |
| Performance: Penetration | 8" Reinforced Concrete | Exceeds Requirements |
| Reliability: Initial | ≥ 0.9991 | 0.9998 |
| Reliability: Long Term | ≥ 0.9990 | 0.9993 |

# Performance Test Results

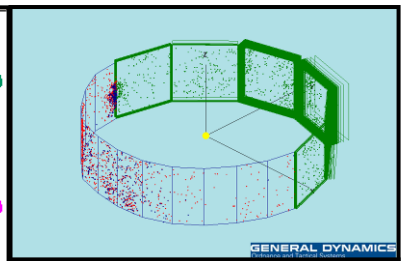

Static JMEM Arena Test


Full Scale Penetration Test (Target Exit)


Live Fire Test



Lethality Objectives Achieved

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# Insensitive Munitions Testing

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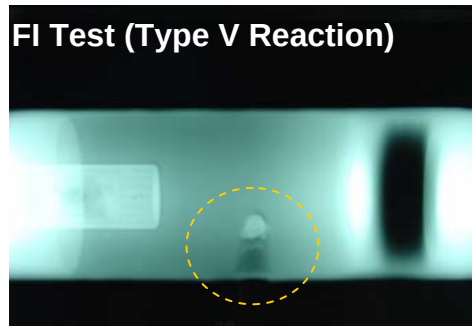
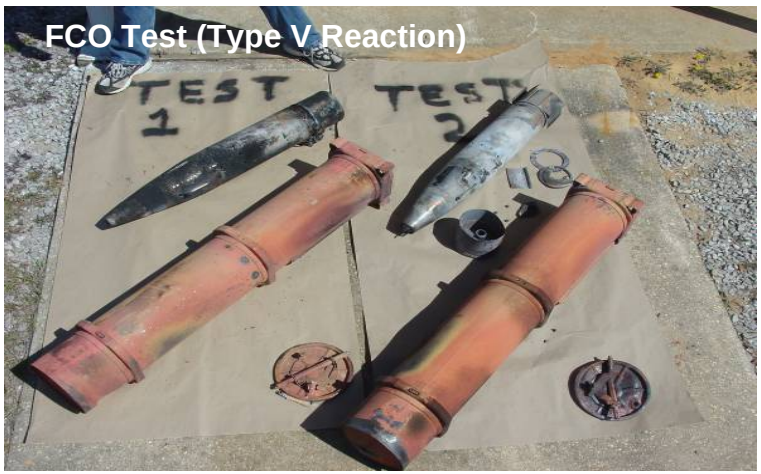
Fast Cook-Off Test


SCO Test (Type III)

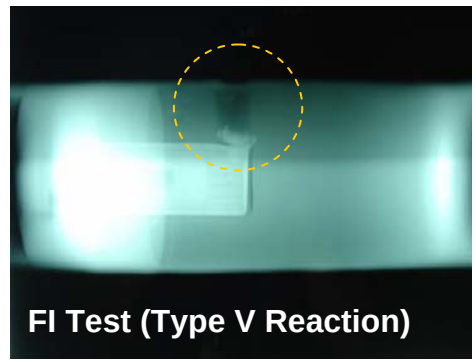

Bullet Impact Test (Type V Reaction)


FI Test (Type V Reaction)



FCO Test (Type V Reaction)

SD Test (Type III)


FI Test (Type V Reaction)

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# Acknowledgements


- Raytheon Missile Systems
  - ↗ Larry Wasielewski
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  - ↗ Pär Eriksson