Common Low-cost IM Explosive Program to Replace TNT

Joint U S Army & U S Marine Corps

October 2007

Department of the Army
Office of the Project Manager for Combat Ammunition Systems
Attn: Mr. Jim Rutkowski
Tel 973-724-2394 Fax 973-724-2048
james.rutkowski@us.army.mil
Picatinny Arsenal, New Jersey 07806-5000

DoD / Industry

Booz | Allen | Hamilton

BAE SYSTEMS

GENERAL DYNAMICS
Ordnance and Tactical Systems

Day & Zimmermann
We do what we say.®

Australian Government
Department of Defence
Defence Science and
Technology Organisation

MINISTRY OF DEFENCE

Common Low-cost IM Explosives

Artillery HE Projectiles

105mm HE (M1, M760) | 105mm HE-RA (M927, M913) | 155mm HE (M107) | 155mm HE (M795) | 155mm HE-RA (M549A1)

Baseline Explosive = TNT

TNT filled Projectiles FAIL all IM Tests

Mortar HE Cartridges

60mm HE (M720, M768, M888) | 81mm HE (M821, M889) | 120mm HE (M933, M934)

Baseline Explosive = Comp-B

Comp-B filled Cartridges FAIL IM Tests

- **ISSUE:**
  - ✓ TNT & Comp-B explosives have poor IM results
  - ✓ HE items require IM Waiver
    - IM explosives identified under prior efforts
      - Specific to individual program requirements
      - Lacked commonality
      - Some IM improvements – still need waiver
      - NTIB Cost Impacts

- **CORRECTIVE ACTION:**
  - ✓ Investigate new IM Explosives with intention to insert into production in near-term

Background

Objective: Common Low-cost IM Explosive Program

- ✓ **New IM Explosive for Artillery and Mortar applications that are:**
  - **Effective**
    - **Maintain Lethality with minimal or no degradation**
  - **Less Sensitive**
    - **If not fully compliant, must show improvement over Baseline explosive**
  - **Affordable**
    - **Artillery Cost Drivers = Steel Body Material & Explosive Fill**
    - **Mortar Cost Drivers = Steel Body Material, Fuze & Propelling Charges**
  - **Producible within the National Technology and Industrial Base (NTIB)**
    - **Infrastructure**
    - **Raw Ingredients**
    - **Explosive formulation**
    - **Projectile Load, Assemble & Pack (LAP)**
  - **Other Considerations**
    - **Intellectual Property Rights**
    - **Demilitarization**
    - **Environmental**

Primary Objective is to provide a Common IM Fill

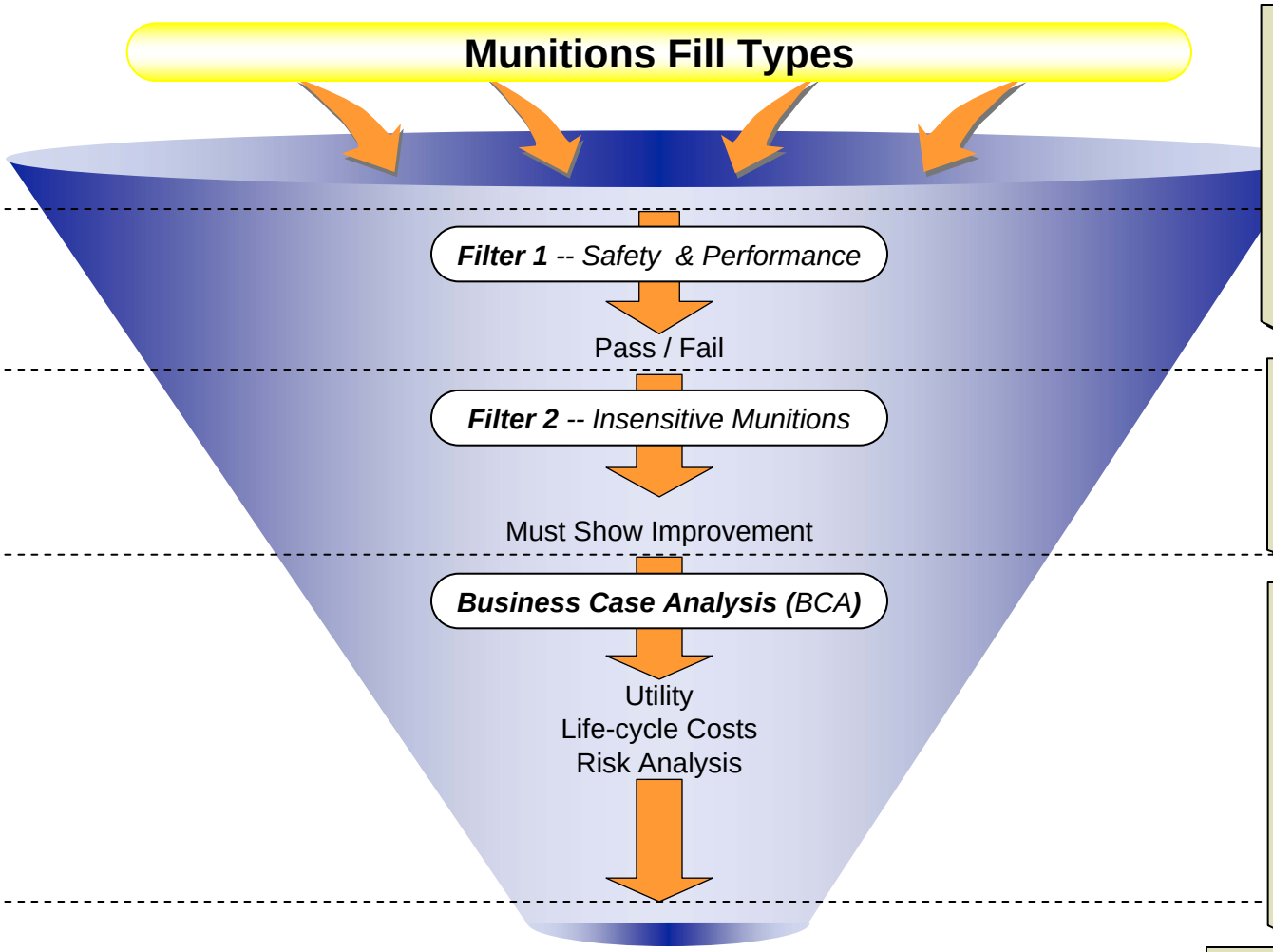
-- or --

one common TNT replacement (Artillery)...

...and one common Comp-B replacement (Mortars)

PM-CAS Common Low-cost IM Explosives Program

➢ "Funnel" framework to progressively screen candidates



Filter 1 Criteria

- Cheetah Calculations
- Standard Safety Tests
- Electrostatic
- Friction Impact Sensitivity
- Vacuum Thermal Stability
- Differential scanning
- Critical Diameter

Filter 2 Criteria

- Tier 1 IM Tests (BI, FI, SCO)
- Tier 2 IM Tests (SD)
- Tier 3 IM Tests (FCO, SCJI)

BCA Criteria

- IM Tests, Lethality, Logistics, Safety, Platform
- Performance of the alternatives against weighted factors
- Risk analysis
- Comparable cost analysis
- Sensitivity Analysis

Arena Test & Qualification

IM Test Results
155mm Artillery Baseline

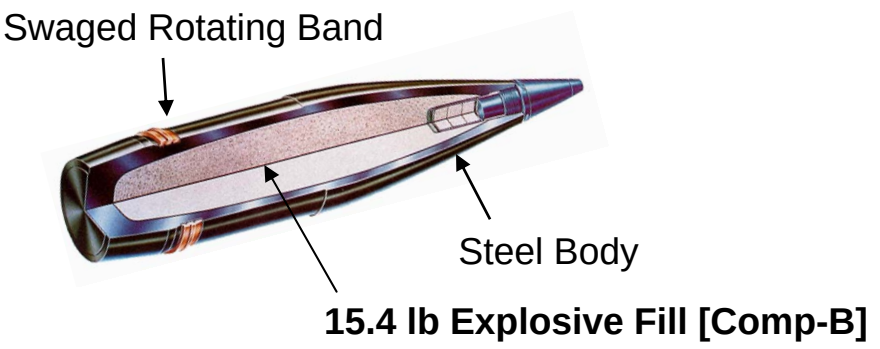
Reactions:

VI	V	IV	III	II	I
No Sustained Reaction	Burn	Deflagration	Explosion	Partial Detonation	Detonation

IM Test:	FCO	SCO	BI	FI	SD	SCJI
Passing Criteria	V	V	V	V	III	III
155mm M107 (TNT)	III	III	III	III	(I)*	(I)*
155mm M107 (Comp-B)	III	III	III	I	(I)*	(I)*
155mm M795 (TNT)	III	III	IV	IV	I	(I)*

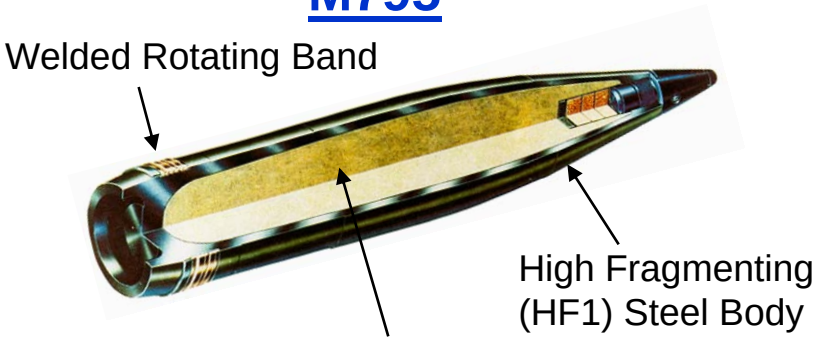
* Assessment (not tested)

M107



15.4 lb Explosive Fill [Comp-B]

M795



23.8 lb Explosive Fill [TNT]

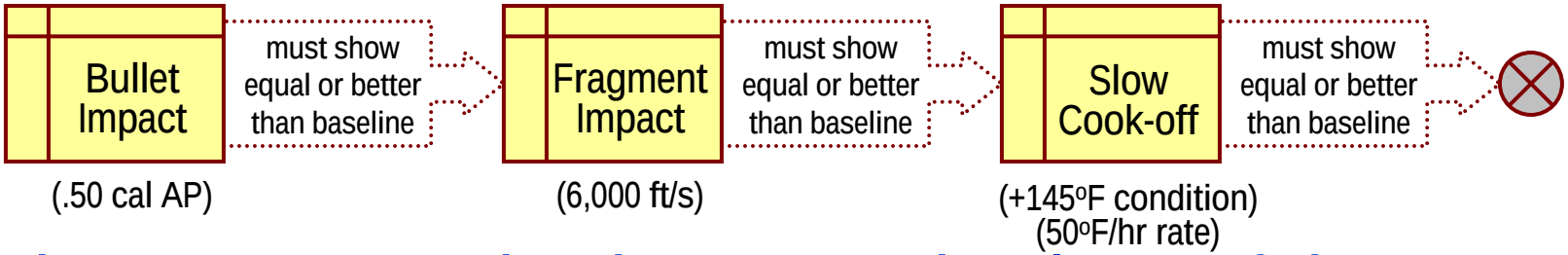
Test Configuration

- **Established IM Test Configuration for TNT-Replacement**
  - ✓ **155mm established as test vehicle**
    - **M795 Projectile with HF1 Steel**
    - **Vented Nose Plug/Meltable Fuze Plug**
    - **Supplementary Charge of Pressed-TNT/PBXN-9**
  - ✓ **Palletization**
    - **8 Projectiles per Pallet, Wood (2 x 4)**
    - **No S.D. Barriers**

Test Protocol

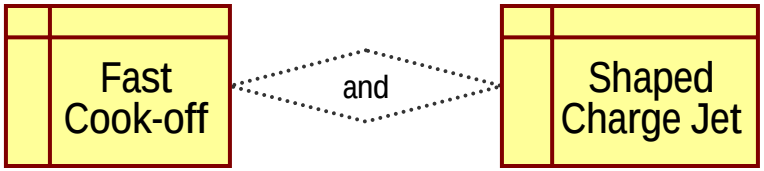
➢ Established IM Test Protocol for Artillery (155mm M795)

✓ Tier 1 Tests



✓ Tier 2 Tests -- must show improvement in at least 1 of Tier 1 Tests

✓ Tier 3 Tests – Candidates based on Tier 1 & 2 Test Results



Protocol Considerations:

- Cost of Test
- Ease of Setup
- Threats for Comparison to Baseline
- Reaction Level for proceeding

Phase 1 Summary (Tier 1 & 2)

✓ Performed IM Tests

- **23 Explosive candidates considered**

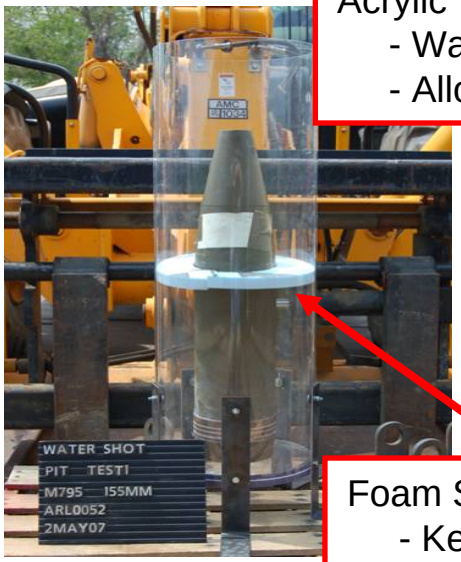
CANDIDATES:	Melt-pour	Cast-cure	Press-fill
Inert Binder	2	5	1
Energetic Binder	15	-	-

- **9 candidates tested (melt-pour, cast-cure, pressed)**
- **Top 3 Candidates**
  - **All three are Melt-pour and each passed SD test without Barriers**
    - » **Insufficient difference to select the go forward candidate**
  - **Perform Tier 3 prior to entering Qualification Testing and address**
    1) **Producibility**
    2) **High Risk Areas**
    3) **Lethality Assessment**

Common Low-cost IM Explosives TNT Replacement Program
Lethality Assessment

➢ Comparison to TNT

- ✓ **Water Pit Tests**
  - **M795 projectiles loaded with IM formulations**
- ✓ **Cylinder Expansion Tests**
  - **4” copper cylinders**



Acrylic Tube
- Watertight seals
- Allows expansion to 2x CD

Foam Spacer
- Keeps projectile upright
- Centering device

All 3 formulations have fragmentation and Gurney Energy equivalent or better than TNT

Achievements

- ✓ **Demonstrated IM Compliance**
  - **Production Equipment**
  - **Product Ingredients**
  - **Production scale**

Passed SD
Passed SCJI

IM Test:	FCO	SCO	BI	FI	SD	SCJI
Passing Criteria	V	V	V	V	III	III
M795 Baseline (TNT)	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
						50mm RPG
IMX-101	PASS	PASS	PASS	PASS	PASS	PASS PASS
IMX-102	(PASS)	PASS	PASS	PASS	PASS	PASS PASS
IMX-103	PASS	PASS	FAIL	PASS	PASS	FAIL FAIL

Qualification Program
Schedule for TNT-Replacement

- **Phase 1 – Screening / Downselect**
  - ✓ Passed SD without Barriers
- **Phase 2 – Selection / Qualification**
  - ✓ Passed RPG SCJI
  - ✓ Equal or better lethality
  - ✓ Producible
- **Phase 3 – Transition / Qualification**
  - ✓ EMQB Certification and Gun Qualification

TNT-Replacement

Phase 1 "Screening"

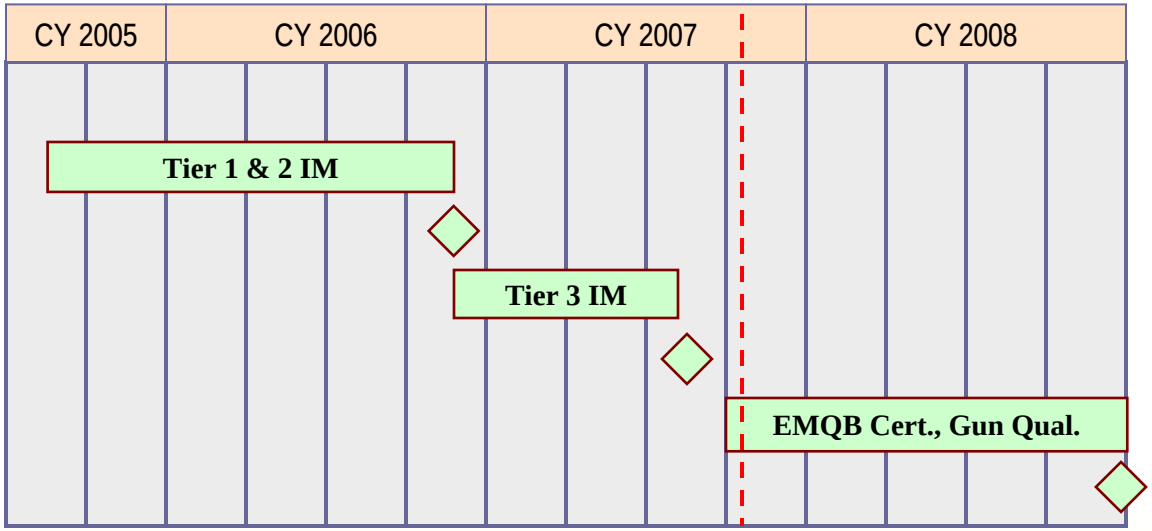
- **Identify & Test Candidates**
- **Downselection**

Qualification Phase 2

- **Selection (**Primary/Secondary**)**

Qualification Phase 3 (IMX-101)

- **ECP into TDP**



Summary

- Demonstrated IM Compliance
  - ✓ Results far exceeded expectations
  - ✓ Suitable Affordable & Sustainable solution

- **Further details on this effort will be presented in the following presentations:**
- **Characterization**
  - ✓ **The Characterization of IM Explosive Candidates for TNT Replacement – Brian Roos, US Army Research Lab**
- **Producibility**
  - ✓ **Manufacture of Explosive Ingredients and Compositions for the IM M795 Artillery Ammunition – Andrew Wilson, BAE Holston OSI**
- **IM Testing**
  - ✓ **The Application of New IM Explosive Candidates in the M795 Projectile – Sanjeev Singh, US Army ARDEC**
- **Projectile Filling**
  - ✓ **IM HE Loading of 155 mm Projectiles – Paul Betts, US Army ARDEC**

This technology saves lives, facilities & assets