US ARMY RDECOM

U.S. ARMY ARMAMENT RESEARCH, DEVELOPMENT, & ENGINEERING CENTER (ARDEC)

ARDEC Energetics

at

Joint Armaments Conference

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Presented By:
Jim Wejsa
ARDEC
Phone: 973-724-5441
Email: james.l.wejsa.civ@mail.mil

Bottom Line Up Front

- Army (and ARDEC) energetics efforts are focused on meeting a wide range of Warfighter needs.
- The full spectrum of energetics (explosives, propellants & pyrotechnics) are needed to make ammunition effective.
- Maximizing ammunition performance requires system tradeoffs so energetics should cannot stand alone.
- Successfully transitioning energetics into products.
- Numerous promising energetics technology areas being pursued.
- Close ties with ammunition project managers is critical for transition.
- Full lifecycle involvement with ammunition is integral to the U.S. Energetics Ammunition National Technology & Industrial Base (NTIB).
  - Extensive energetic prototyping and analytical facilities support transition of process technologies to ammunition producers.
- Effectively leveraging worldwide investments.

DoD Energetics

Why we need

The Department of Defense (DoD) invests in and sustains within the Defense Laboratory Enterprise a substantial In-House Energetics Core Technical Competency (CTC) for significant reasons, among them:

- Lack of a commercial market for high-performance Energetics;
- Responsiveness to demands for defense unique lethality solutions;
- Inherently governmental responsibilities for certification, liability, risk reduction and warfighting application;
- Limited defense industry incentive to absorb the costs required to sustain and advance energetics science, technology & engineering (ST&E);
- Long term concerns about the energetics workforce and the ability of industry and academia to sustain current and future skills needs;
- Demand for unique, irreplaceable skills and facilities in areas that lack defense industry alternatives.

What we have

Service Laboratories maintain the most cutting edge and relevant domestic ST&E facilities and personnel for Energetics.

- Nearly every energetics system in use by DoD today originated within the Defense Laboratory Enterprise.
- The DoD is often the only customer for specific energetic materials that are critical for DoD applications and therefore an In-House Laboratory CTC must be maintained.

What is the advantage

The specific advantages of robust In-House Energetics competency include:

- Organic Energetic advancements that allow for more effective warfighting;
- Responsiveness to warfighter demands in operationally critical areas ;
- Ability to sustain defense unique capabilities to fill defense industrial gaps
- Ability to sustain the investments required to pursue far-term high-risk, high-pay-off research that leads to technology breakthroughs **;**
- Joint service collaboration accelerating advanced Energetics R&D;
- Development of alternatives to industry proprietary solutions;
- Sustained oversight over the security and protection of critical technology from inception and innovation stages to advanced development.

Energetics is a DoD Critical Technicial Competency

There are virtually no modern defense systems or munitiontypes that does not rely on energetic materials.	There exists no commercial market for nearly all military Energetics.	Relatively few industrial and academic performers exist in the Energetics area largely because it is nearly exclusively a DoD need.	The DoD laboratories developed all of the currently-fielded tactical and strategic propulsion –that are produced by DoD contractors presently	Advances in energetic materials are tied to achieving specific objectives –and will almost surely result from In-House competency.	Defense Laboratory Enterprise has a unique role to drive and integrate the Energetics community.

ARDEC Energetics Application Areas

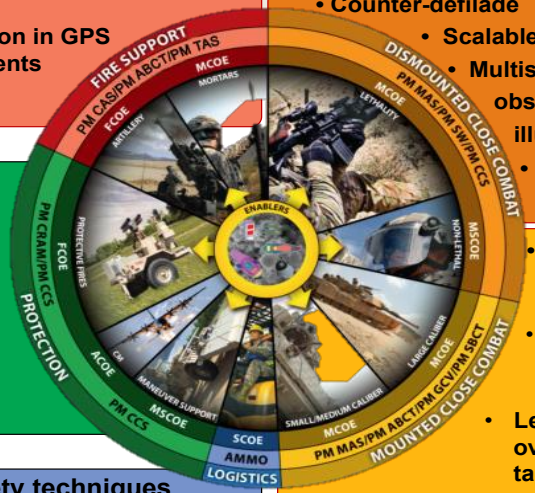
- Extended range
- Increased precision in GPS denied environments
- Tailorable effects

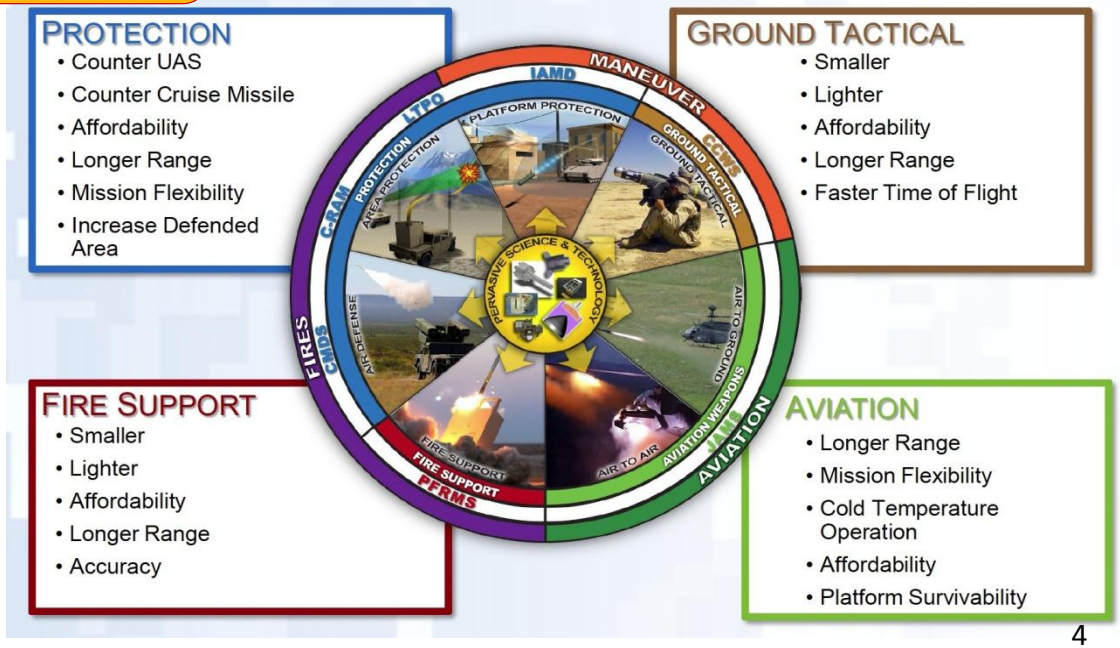
- Explosive detection neutralization
- Breach of entry points

- Explosives safety techniques

- Counter-defilade
- Scalable Effects
- Multispectral obscurants and illumination
- Imperceptible trace

- Extended (2km+) ranges
- Precision airburst munitions
- Lethal overmatch and tactical standoff
- Breach of entry points





ARDEC Energetics Competencies & Lifecycle Involvement

ARDEC

Basic Research/ Applied Research → Technology Development → Demo & Prototyping → Transition to Production → Propellant Surveillance → Demilitarization Technologies

Gun Propellants

- Formulation
- Mixing
- Extrusion
- Coating & Drying
- Characterization
- Pilot Manufacturing
- Surveillance

Explosive Materials

- Synthesis
- Characterization
- Qualification Testing
- Machining
- Pilot Manufacturing
- Nitration/Crystallization

Propellants

- Formulation
- Mixing
- Casting
- Controlled Cooling
- Drying
- Pressing

Pyrotechnics

- Synthesis
- Formulation
- Characterization
- Pilot Manufacturing
- Munitions Integration
- Qualification Testing

ARDEC Full Energetics Lifecycle Involvement Supports Sustainment of the Ammunition National Technology & Industrial Base

New State of the Art World Class Facilities

High Energy Propellant Formulation Complex

- MCA Funded - $20.2M (Complete)
- 45,000 ft^2

  Propellant Pilot Plant /
  Characterization Laboratories /
  Magazine Storage / Engineering Offices

Pyrotechnic Research & Technology Complex

- MCA Funded - $14M (Complete)
- 27,000 ft^2
  - Engineering Laboratories
  - Pilot manufacturing facility
  - Energetic storage

Explosives R&D Loading Facility

- MCA Funded - $9.4M (FY15 Completion)
- 28,000 ft^2
  - Explosive Pressing, Melt Pour Cast Cure
  - Climate Controlling Machining& X-Ray
  - Energetic Storage, Engineering Offices

Extensive New Energetics Infrastructure

ARDEC Energetics Areas of Emphasis

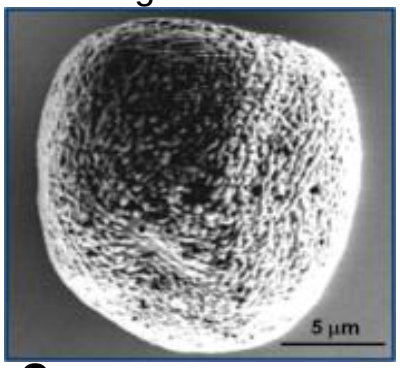
- ARDEC's energetics technology roadmaps have been developed in collaboration with our project managers to align with their thirty year product roadmaps. Areas of emphasis include:
  1) insensitive munitions technology for increased survivability,
  2) new materials for increased energetics performance,
  3) application of "green technology" to reduce/eliminate environmental hazards,
  4) additive energetics manufacturing for novel designs and manufacturing flexibility and
  5) improved manufacturing technologies to increase yield and reduce product cost.

Nano-Explosive Composites

WHAT IS IT?

Submicron explosive particles organized into dermal safe clusters that maintain current infrastructure and drastically increase weapon lethality, safety and performance against hard targets.

Individually coating each particle decreases sensitivity



WHAT DOES IT OFFER?

Superior performance 30-50% in munitions from 20mm through 250mm by use of less sensitive existing ingredients resulting in explosives so powerful they require new materials for warhead bodies.

68% increase in Safety

Smaller/Safer Industrial footprint

Partners:

OSD-AT&L – Joint Insensitive Munitions Technology Program

TECHNICAL APPROACH:

- **COTS** equipment to produce the least sensitive explosive particles ever (200-800 nano-meters) enabling use of formerly dangerous highly explosive, once thought to be too powerful.
- The resultant material is also 3-4 times stronger for penetration into hard targets

Legacy Warhead

Nano-Explosives

Leveraging multiple funding sources and interested parties, we are making progress toward pilot production and should have live warhead tests in FY14

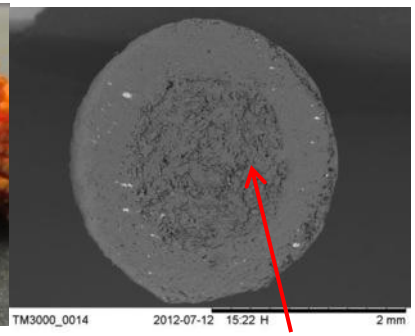
Co-Extruded Gun Propellant Technology

What Is It?

Two propellant formulations exhibiting differing burning rates are co-extruded so that the combustion of faster burning propellant layer is delayed by exposing only the slower burning formulation initially during the ballistic cycle.

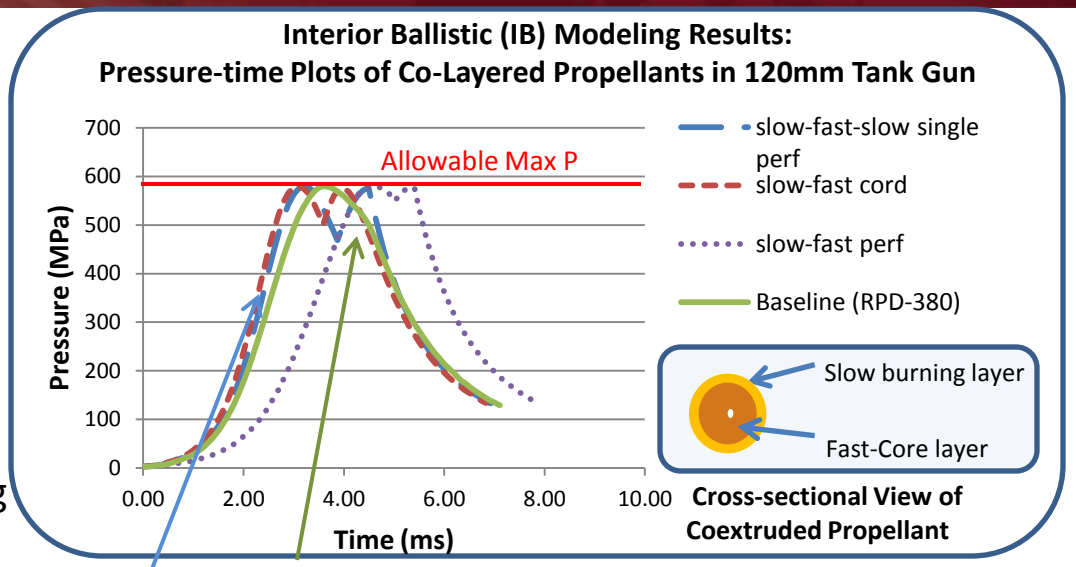
What Does It Offer?

- Improved **interior ballistic efficiency** resulting in:
  - **Increased Range**
  - Increased Payload and Lethality



Images of Co-Extruded Propellants: Sticks in 30mm Configuration (Left); Cross-Sectional View (Right)

Two layers are intimately adhered at the interface



Single Peak (Baseline) ➔ Area under the curve is less

Double Peaks (Co-Extruded) ➔ Area under the curves are greater

Area under the curve translates to muzzle velocity, increased range and lethality

Technical Approach:

- Extrude two streams of propellants simultaneously
- Optimize the propellant geometry to the technology using IB modeling tool
- Design the die and scale-up the co-extrusion process using the rheological data and flow model
- Verify through gun firing test

Partners: GD-OTS-Canada

Achieve Higher Muzzle Energy = Higher Energy on Target!

Pyrotechnic Environmental Program

WHAT IS IT? To develop and integrate technologies that enhance EOSH characteristics into the lifecyle aspects of current and future pyrotechnic tactical munitions.

ASA(ALT) S&T Challenge Area:

Force Protection, Maneuver, Operational Over Match, Life Cycle Cost

PEO Strategic Initiative:

Small Unit Direct Engagement, Armored/ Mechanized Direct Engagement, NLOS/BLOS Indirect Engagement, Air Support, Improved Manufacturing Processes, Demil Efficiencies

WHAT DOES IT OFFER? *Payoff:*

- Sustained War fighter capability.
- Safer pyrotechnic energetic solutions.

Partners: Navy, PEO Ammo, ECBC, RDECOM EQT, USAMCOE, ESTCP. SERDP Industry, Academia

Distribution A: Approved for Public Release

TECHNICAL APPROACH?.

Non Toxic Delay Mechanisms
TRL 5

Removed Barium, Tungsten and Perchlorate with Boron Carbide and burn rate modifiers

Non Toxic Colored Smoke
Smoke GrenadeTRL"6/T
Yellow HHS TRL 5

Removed Toxic Dyes and Sulfur based formulations with safer dyes and sugar based formulations. Leverage Yellow Smoke Hand Grenade & Simulator work.

Non Toxic White Smoke
TRL5

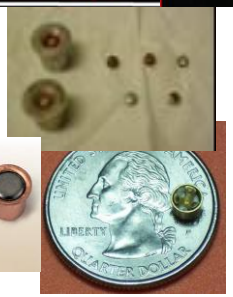
Removed hazardous HC Smoke with a benign Boron Carbide technology formulation.

Perchlorate Free ColoredSignals

TRL"T/5 HHS
TRL 5 40mm

M126A1: Perchlorate Free Oxidizer.
M195: High Nitrogen Oxidizer.
40mm: Leverage HHS and Tunable Pyro Work.

Lead Free Primers
TRL3



Primary candidate formulation is free of lead, barium and antimony.

Alternate mix in Nano Al based.

Additive Energetics

WHAT IS IT?

2D and 3D printing technologies for Energetics Additive Manufacturing applications that Integrate energetics (explosives, propellants and/or pyrotechnics) with electronics and other material components into new and novel munition designs

WHAT DOES IT OFFER?

- Additive energetics allows for a revolutionary new approach to weapon design and use
- Enables rapid development and prototyping of solutions for current and emerging threats
- Leveraging of commercial additive manufacturing techniques
- May significantly reduce distribution logistics

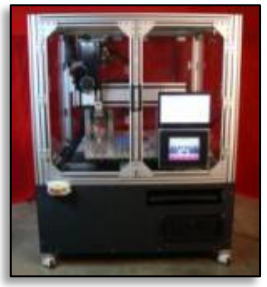
Potential Applications:

- Fuzing, Detonators, Initiators
- Explosive Fills
- Micro-Electro Mechanical Systems
- Gun Propulsion Systems
- Pyrotechnic System Components

Micro-Electro Mechanical Systems (MEMS)

TECHNICAL APPROACH:

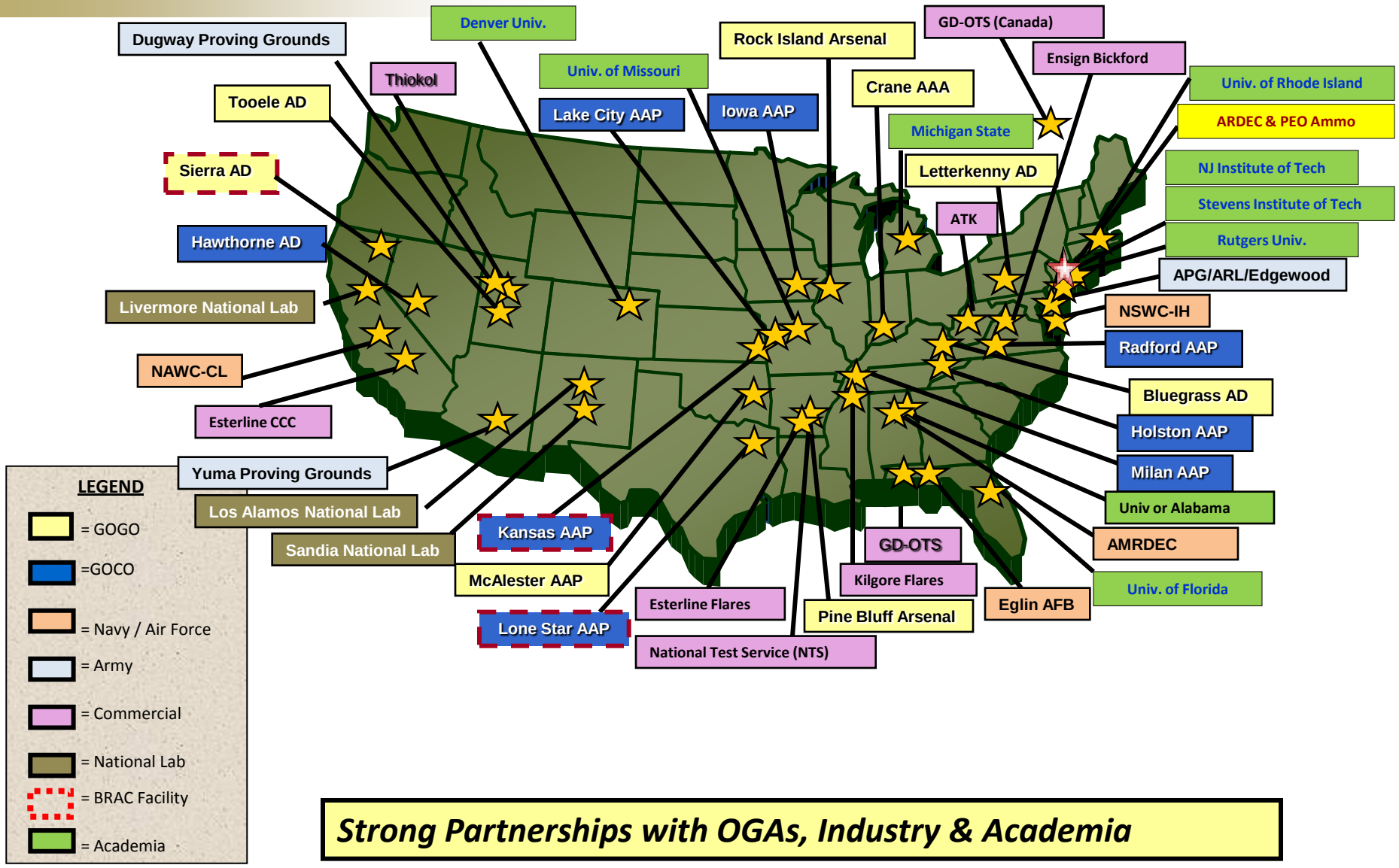
- Develop new prototype additive energetics technologies for munitions applications
- Utilizes COTS additive manufacturing technology along with the integration of advanced energetic materials



CURRENT CHALLENGES:

- Energetic and related materials suitable for additive manufacturing techniques
- Address geometric and functional challenges in munitions design and fabrication
- Qualification and certification of new energetic components

ARDEC Partners in the Energetics Area



Strong Partnerships with OGAs, Industry & Academia

Distribution A: Approved for Public Release

Examples of Recent Successes & Transitions

- **Explosive: M738 60mm Mortar PAX-21 Generation 1 IM Explosive proven during Operation Enduring Freedom**
  - In 2009, MRAP was attacked with a large IED and was engulfed in flames, no reaction in M738 60mm mortars. **All of the crew survived!!**
- **Explosive: PMA201 (Navy), EBSN (Air Force), PDJP (Army), & OSD-AT&L**
  - All agree Army energetic fill (Al-IMX-101) to be best solution for evaluation in 500# bomb (BLU-111)
- **Explosive: IMX-104 developed as a replacement for Comp B, which provides significant IM improvements**
  - Mortars (60mm, 81mm, 120mm) LRIP Expected FY13 for the 81mm
- **Explosive: IMX-101 developed as a replacement to TNT**
  - Provides significant insensitive munition improvements
  - Transitioned to PM CAS for M795 (tactical) and M1122 (training) 155MM– Currently in LRIP
- **Propellant: Successfully demonstration of recovery in range for the 120mm Accelerated Precision Mortar Initiative**
  - Transitioned to the USMC EFSS round
- **Pyrotechnics: Successfully Demonstrated Prototype (TRL 6 Achieved)**
  - Hand Held Signal Infrared Illuminating Composition in a Full up XM210 Hand Held Signal.
  - High Nitrogen Red Hand Held Signal Composition in a Full up M158 Red Star Cluster Hand Held Signal.
  - Perchlorate Free Oxidizer (M115A2 Artillery Simulator;M116A1 Hand Grenade Simulator;M117/M118/M119 Booby Trap Simulators;M195 Green Star Cluster HHS;M274 2.75” Rocket Training Round) in full up munitions.

Summary

- Army (and ARDEC) energetics efforts are focused on meeting a wide range of Warfighter needs.
- The full spectrum of energetics (explosives, propellants & pyrotechnics) are needed to make ammunition effective.
- Maximizing ammunition performance requires system tradeoffs so energetics should cannot stand alone.
- Successfully transitioning energetics into products.
- Numerous promising energetics technology areas being pursued.
- Close ties with ammunition project managers is critical for transition.
- Full lifecycle involvement with ammunition is integral to the U.S. Energetics Ammunition National Technology & Industrial Base (NTIB).
  - Extensive energetic prototyping and analytical facilities support transition of process technologies to ammunition producers.
- Effectively leveraging worldwide investments.

Final Thoughts

Energetics is a Key Enabler and Driver for the Army's Modernization Strategy

Questions/Comments?

Questions/Comments?

For additional info:

Contact Mr. James L. Wejsa

Comm: (973)-724-5441

FAX: 973-724-3972

Cell: 973-879-1776

E-mail: james.l.wejsa.civ@mail.mil