ARDEC Energetics

at

Joint Armaments Conference

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Distribution A: Approved for Public Release. Distribution is Unlimited.
• 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.
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.

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.

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 Technical Competency

- There are virtually no modern defense systems or munition types 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

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

GROUNDTACTICAL
- Smaller
- Lighter
- Affordability
- Longer Range
- Faster Time of Flight

AVIATION
- Longer Range
- Mission Flexibility
- Cold Temperature Operation
- Affordability
- Platform Survivability

FIRE SUPPORT
- Smaller
- Lighter
- Affordability
- Longer Range
- Accuracy

PROTECTION
- Counter UAS
- Counter Cruise Missile
- Affordability
- Longer Range
- Mission Flexibility
- Increase Defended Area

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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

Pyrotechnics

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

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

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UNCLASSIFIED
High Energy Propellant Formulation Complex
- MCA Funded - $20.2M (Complete)
- 45,000 ft²
  Propellant Pilot Plant / Characterization Laboratories / Magazine Storage / Engineering Offices

Pyrotechnic Research & Technology Complex
- MCA Funded - $14M (Complete)
- 27,000 ft²
  - Engineering Laboratories
  - Pilot manufacturing facility
  - Energetic storage

Explosives R&D Loading Facility
- MCA Funded - $9.4M (FY15 Completion)
- 28,000 ft²
  - Explosive Pressing, Melt Pour Cast Cure
  - Climate Controlling Machining & X-Ray
  - Energetic Storage, Engineering Offices

Extensive New Energetics Infrastructure
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

**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

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

**Partners:**
OSD-AT&L – Joint Insensitive Munitions Technology Program

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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

**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!**
**WHAT IS IT?** To develop and integrate technologies that enhance EOSH characteristics into the lifecycle 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

**Technical Approach**
- Removed Barium, Tungsten and Perchlorate with Boron Carbide and burn rate modifiers
- Removed Toxic Dyes and Sulfur based formulations with safer dyes and sugar based formulations. Leverage Yellow Smoke Hand Grenade & Simulator work.
- Removed hazardous HC Smoke with a benign Boron Carbide technology formulation.

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

**Lead Free Primers**
- TRL3

**Non Toxic Delay Mechanisms**
- TRL 5

**Non Toxic Colored Smoke**
- Smoke Grenade TRL"6/T Yellow HHS TRL 5

**Non Toxic White Smoke**
- TRL5

**Perchlorate Free Colored Signals**
- TRL"T/5 HHS TRL 5 40mm

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

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

**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

**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

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ARDEC Partners in the Energetics Area

Strong Partnerships with OGAs, Industry & Academia

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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.
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Final Thoughts

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

“Without Energetics, it’s just another parade”
Questions/Comments?

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