ARDEC Fuze S&T and Acquisition

56th Annual Fuze Conference

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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Distribution A - The information contained in this briefing is Approved for Public Release.
Crash Landing approach
Exploding Fruit Technique
Bear “sit” in the woods method
Population 4,167
6,493 Acres
804 Buildings
64 Laboratories

Assigned/Direct Support Coordination

PEO Soldier
PM Soldier Weapons
PEO Integration
PM Lethality
PEO GCS
PM JLW155
DCMA
DCMA NE
CPAC
Navy
ACC

Distribution A
ARDEC Mission
Life Cycle Engineering & Support

Demilitarization

Research & Development

SUPPORT TOTAL LIFE CYCLE

Production

Field Support

Cryofracture

Plasma Arc Furnace

PAX 3

PAX 41

Common Smart Submunition

Advanced KE

Excalibur

Lightweight Handheld Mortar Ballistic Computer

Lake City Army Ammunition Plant

Lightweight Dismounted Mortar

M900 Armor Piercing Cartridge

M240B 7.62MM Machine Gun

Small/Cannon Caliber Ammunition

Dummy, Drilled, Inert

40mm Multi-Shot Launcher

Distribution A

Unclassified
Fuze S&T and Acquisition Efforts

OSD Joint Fuze Technology Program
- Target Classification Prox for Tailorable Whds
- Next Generation Proximity IPT
- Application of Probabilistic Technology
- Low voltage Command Arm for Distributed Fuzing
- High Density Supercaps
- Design of Detonator Outputs for Desired Effects
- Nano-Foil Heated Thin Film Thermal Battery
- MEMS Retard & Impact Sensor

RDECOM/ARDEC S&T Projects & Demonstrations
- Next Generation Prox Fuzing
- Distributed Multi-point Initiation
- Thin Film Power Sources
- MEMS Impact Switch Target Sensing
- Fuzing for Cluster Munition Replacement
- Direct Fire Prox Sensor - (Joint Non Lethal Dir)
- Accurate High Velocity Med Caliber Airburst Fuzing
- Autonomous Target Sensing for Shoulder Fired
- Airburst/PD and PD delay for Tank Ammo
- Command Arm MEMS S&A w/ Prox for 40mm

On-going 6.6 Fuze Technology Integration
- EMD/Production support for PM MAS, PM CAS, PM CCS, PD JP
Advanced Proximity Sensor Technologies

Next Generation Proximity Sensors
A Joint Fuze Technology Program
ARDEC led with technical participation by AFRL, NAWC-WD

Advanced next-generation low cost sensor technologies to provide
- Enhanced battlefield performance
- Small form fit precision burst point control

Research in the area of:
- FMCW, Spread Spectrum, Stepped Frequency RADAR Systems
- Novel Digital Signal Processing Range Extraction Techniques
- Improved performance RF front ends for miniature sensors

Target Classification Sensors for Fuzing Applications
A Joint Fuze Technology Program
Advanced Simulation toolsets for prediction of FMCW data for complex targeting scenes
- Mesh based object / scene creation
- Shooting-Bouncing-Ray Solver
- Generation of IF return data for use in algorithm development and performance estimation

Classification Technique Research
- Range profile, feature extraction
- Range vector envelope correlation techniques

Distribution A
Proximity Sensor Development and Production Support

**M789 / XM799 Prox Sensor**

- Development of autonomous airburst capability for the LW30 apache weapon system
  - Custom Power Source
  - Custom MMIC transceiver
  - Custom signal processor
  - Custom antenna designs
  - Integration, Design, Fabrication, and Test in-house

**Precision Acquisition Weapon System (PAWS)**

- Proximity sensor for a lethal UAS
  - Design and Fabrication
  - Evaluation and Qualification
  - Field Test Support
  - Completed in-house at ARDEC

**ORIOLE Medium Altitude Prox Sensor**

- Detection of tree canopy at 150m
  - Custom high power transceiver section
  - Custom antenna sub-system design
  - FPGA based software defined sensor
  - Directional Doppler Ratio Ranging Firmware developed in-house
  - All design, fabrication, and qualification completed in-house

**Precision Air Dropped Guided Munition (PADGM)**

- Development of a miniaturized prox sensor system
  - Short range Height of Burst sensor
  - Single board solution with integral Antenna and flexible interconnect
  - Integration, Design, Fabrication, and Test in-house

**XM1158 Airburst Non-Lethal Munition (ANLM)**

- Direct Fire proximity sensor technology
  - Custom signal processor, MMIC transceiver, and power source
  - Initial demonstrations and tactical electronics design completed in-house
  - Currently in Developmental Test

**M782 Multi-Option Fuze for Artillery (MOFA)**

- Integrated Sensor and Fuze electronics
  - Custom signal processor, MMIC transceiver, and power source
  - Initial demonstrations and designs completed in-house
  - Production Item

**M734A1 Multi-Option Fuze for Mortars (MOFM)**

- Integrated Sensor and Fuze electronics
  - Custom signal processor, MMIC transceiver, and power source
  - Initial demonstrations and designs completed in-house
  - Production Item

Distribution A
Micro-Electro-Mechanical Systems (MEMS) Safe and Arm (S&A) and G-Switch Devices

**Benefits**

- Small Size
  - increased payload potential
  - improved warhead potential
  - incorporation of advanced sensors potential
- High Precision
- Reduced tolerances on no-arm/arm distances
- Self-Destruct
- High Reliability
- Gun Hardened
  - 2,000 to 100,000g Setback
  - 2,800 to 60,000 RPM Spin
- Unlimited Applications

**MEMS S&A**

- S&A Lid
- Initiator Board Assembly
- Seal
- Cover Input Assembly
- MEMS Assembly
- Base Output Assembly
- Seal
- Metal Can

**MEMS G-Switches**

**Impact Switches**
- 2x2 mm footprint
- Multi-Axis Switch
- 250, 500, 1000 g Available

**Spin Switches**
- 1.5 x 1.5 mm footprint
- Single-Axis Sensing
  - Scalable Design
  - 25g to 500g in Development

**Robotic Micro-Assembly**

- Machine vision inspection
- Kitted parts
- Two-micron placement accuracy

ONYX500 Platform inspecting and kitting parts

Distribution A
Objective

- The high voltage (HV) components on the ESAD account for about ½ the cost of the entire S&A
- High cost prohibits ESADs to be manufactured in large volumes.
- Reducing the cost of the ESAD will place these safer and more reliable fuzes in the hands of the Warfighter by integrating them into lower cost munitions.

Environmental Testing

Airgun: 18,000g’s ✔
Operating Temperature: +63°C, -46°C ✔

Simulation of Candidate Components

Low Energy Exploding Foil Initiator (LEEFI) detonation testing modeled a passing criteria for ringdowns (current discharge waveforms). This reduced the time and cost of evaluating each new candidate component by quantifying what it takes to initiate a specific LEEFI. Passing criteria took into consideration:

- Energy discharge from capacitor
- Time to first peak (t = 75ns-150ns)
- Voltage on capacitor (1-2kV)
- Current Discharge from switch (minimum I = 1.5kA)

Cost Reduction

Use of High Voltage components identified will yield a SIGNIFICANT reduction in component cost of ESADs

Results

Successful completion of environmental testing has enabled low cost components to be considered for integration into future Single and Multipoint ESAD applications.
Problem Statement:
Advanced fuzes and guided munitions require complex data input for varied mission requirements.

Lean Methods Applied:
Integrated Product Teams (IPT)
Benchmarking
Concurrent Engineering
Kaizen - Continuous Improvement
Process Mapping
Work Instructions
Quality Audits

Portable Inductive Artillery Fuze Setter (PIAFS):
PM-CAS sponsored the development of a device to field that would set STANAG 4369 inductively set fuzes, specifically the M762 and M782 (Multi-Option Fuze for Artillery, MOFA). ARDEC fabricated approximately 40 initial units in house.

Improved Platform Integration Kit (iPIK):
The Urgent Material Release of the Accelerated Precision Mortar Initiative (APMI) needed the EPIAFS system but required the GPS receiver integrated with the PIK functionality. The iPIK was designed to fit this need. ARDEC fabricated approximately 200 units in house.

Platforms:
Portable Excalibur Fire Control System (PEFCS)
M777A2 Towed Howitzer
M109A6 Paladin Self-Propelled Howitzer
Accelerated Precision Mortar Initiative (APMI) Urgent Material Release
Digitized M119A2 Towed Howitzer
NOVEL POWER SOURCES FOR ADVANCED MUNITIONS

Supercapacitor

Advance the development of novel supercapacitors utilizing processable Inherently Conductive Polymer (ICP) materials to provide highly ordered lamellae, light weight, flexible sheet-like structure, and high energy storage.

Benefits
• Quick charging time
• Function-over operating temperature and extend shelf-life at storage temperature
• Enable scalable & modular design configuration
• Enhance flexibility, cost effectiveness through large scale manufacturing & processing, and capability.

Target applications
• Artillery (Excalibur, Precision Guided Kit - PGK)
• Mortar (Accelerated Precision Mortar Initiative – APMI)
• and possible Navy Guidance Integrated Fuze - GIF

Thin Film Thermal Battery Electrode Fabrication

Traditional pressed pellet fabrication methods press powders into pellets.

Large presses with high force produce flat discs
• Components are fragile
• Geometry limitations – excess material
• Batch process

Transition to thin film manufacturing process
• Reduced limitations on electrode thickness, aspect ratio, and shape
• "Roll to Roll" manufacturing process – low cost
• Electrodes stamped out from continuous sheet
• More robust – flexible, less waste in manufacturing

Target applications
• Pushing long runtime applications for artillery (150s)
• Ideal for those applications that require excess material for pellet manufacture/handling
  - Short runtime applications (EAPS)
  - High Voltage
• Continuous production and scalability should reduce cost
FUZE DESIGN FOR 120MM ADVANCED MULTI-PURPOSE PROJECTILE (AMP)

Electronic Programmable Fuze for 120mm AMP Projectile

ARDEC FUZE engineers designed this electromechanical programmable fuze which incorporate a microcontroller and other digital logic circuitry. ARDEC Fuze engineer also designed and built a Setter Box to simulate M1 fire control for test purpose. The two use the 120mm Ammo data link power the fuze and transmit setting data.

Sequence of Fuze Programming Operation
- Setter Box charges the fuze power capacitors
- Setter Box programs the fuze for either Air Burst or Impact Delay mode
- Setter Box programs the fuze function time for Air Burst or Impact Delay
- The Fuze transmits a data received confirmation message back to Setter Box
- Setter Box displays "Pass" or "Error", based on talkback message received

On launch, setback releases one S&A safety. Base pressure closes a switch to enable later functioning of a piston actuator to complete arming. After setback, the fuze waits 20 msec, then fires the Piston Actuator to arm the fuze.

For the Air Burst mode the fuze counts down the programmed msec delay then fires the Detonator to function the warhead.

For the impact mode, after sensing the target, the fuze counts down the programmed microsecond penetration delay, then fires the detonator to function the warhead.

The fuze also have the backup power generation for the target impact in the case the fuze lost the contact data link from Setter Box.

Distribution A
## US Army ARDEC Fuze Technology
### Future Goals

<table>
<thead>
<tr>
<th>Technology</th>
<th>FY13</th>
<th>FY14</th>
<th>FY15</th>
<th>FY16</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEMS S&amp;A</td>
<td>$ 10 per S&amp;A, ability to integrate electronics on a chip</td>
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<tr>
<td>MEMS Sensor</td>
<td>Significantly reduced cost, high production volumes, achieves commodity status, MEMS target discrimination sensor</td>
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<td>ESAD</td>
<td>Multi-point 3D distributed system, improved simultaneity and selectable control</td>
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<tr>
<td>Proximity Sensor</td>
<td>Develop target classification capability in low power digital and exportable system</td>
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<td>Fuze Setting</td>
<td>Over the air setting capabilities before and during flight Improve energy transfer speed and efficiency</td>
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