



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

ARDEC Fuze S&T and Acquisition

56th Annual Fuze Conference



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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Crash Landing approach





Exploding Fruit Technique



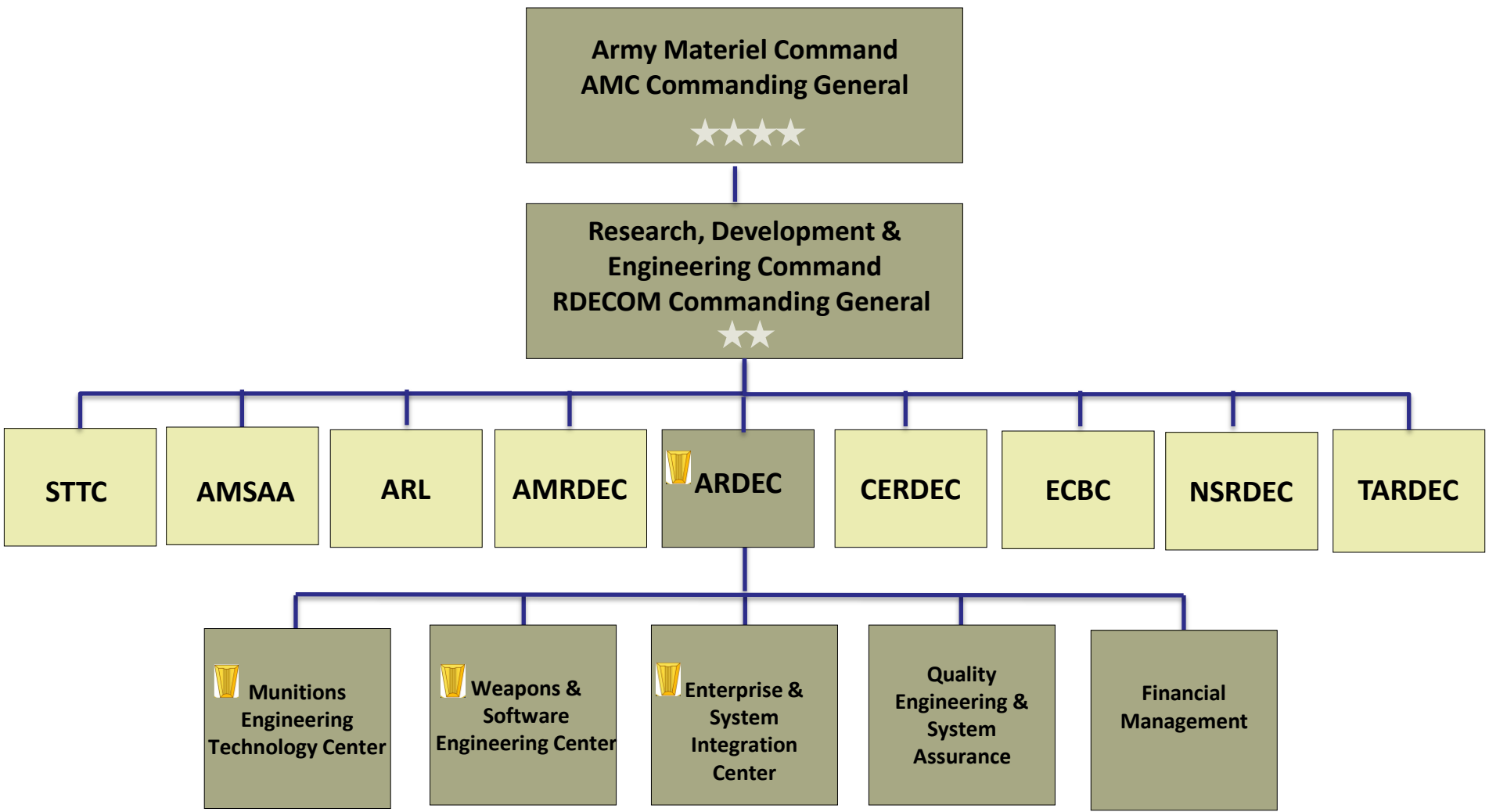


Bear "sit" in the woods method





ARDEC Organization - Chain of Command

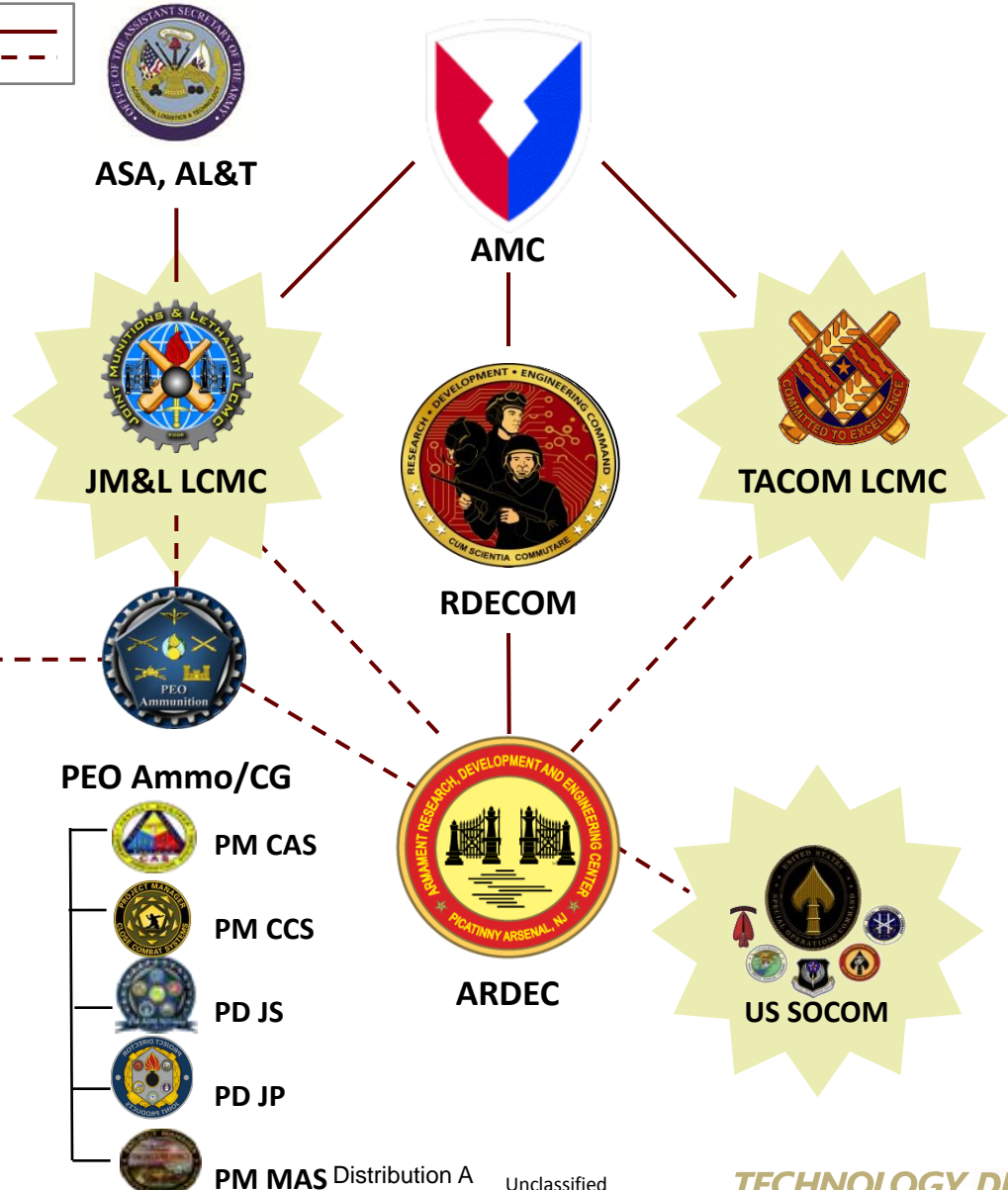
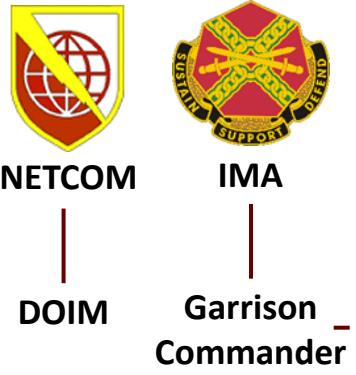




Team Picatinny

Assigned/Direct Support Coordination

- Population 4,167
- 6,493 Acres
- 804 Buildings
- 64 Laboratories



Other Tenants

- TEAM SOLDIER
- PEO Soldier
- PM Soldier Weapons
- PEO Integration
- PM Lethality
- Program Executive Office Ground Combat Systems
- PEO GCS
- PM JLW155
- DCMA
- DCMA NE
- CPAC
- NAVSEA WARFARE CENTERS DAHLGREN
- Navy
- ARMATI COORDINATOR
- ACC





ARDEC Mission Life Cycle Engineering & Support



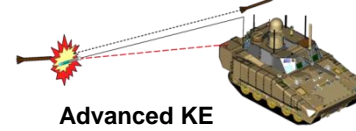
PAX 3



PAX 41



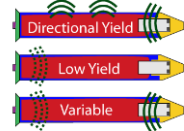
Common Smart Submunition



Advanced KE



Excalibur

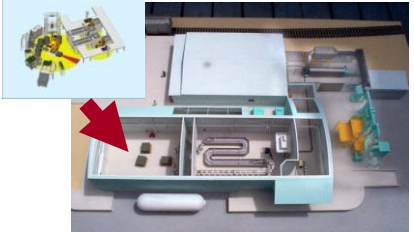


STAR

Research & Development



Plasma Arc Furnace



Cryofracture

Demilitarization

Production



Lightweight Handheld Mortar Ballistic Computer



Lake City Army Ammunition Plant



Lightweight Dismounted Mortar

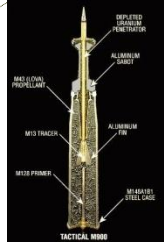
Field Support



Small/Cannon Caliber Ammunition



Dummy, Drilled, Inert



M900 Armor Piercing Cartridge



M240B 7.62MM Machine Gun



40mm Multi-Shot Launcher





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

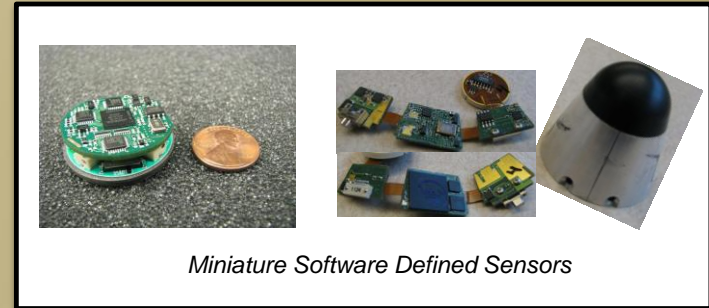
A Joint Fuze Technology Program

Advanced Simulation toolsets for prediction of FMCW data for complex targeting scenes

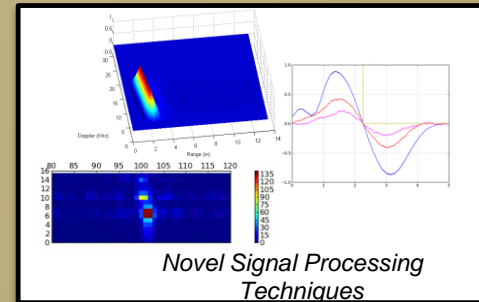
- Mesh based object / scene creation
- Shooting-Bouncing-Ray Solver
- Generation of IF return data for use in algorithm development and performance estimation

Classification Technique Research

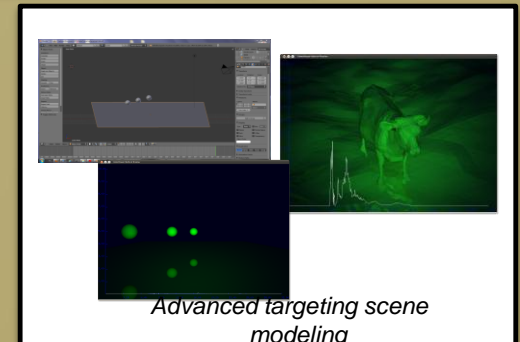
- Range profile, feature extraction
- Range vector envelope correlation techniques



Miniature Software Defined Sensors



Novel Signal Processing Techniques



Advanced targeting scene modeling



Proximity Sensor Development and Production Support

M789 / XM799 Prox Sensor

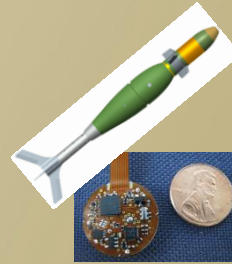


Development of autonomous airburst capability for the LW30 apache weapon system

- Custom Power Source
- Custom MMIC transceiver
- Custom signal processor
- Custom antenna designs
- Integration, Design, Fabrication, and Test in-house



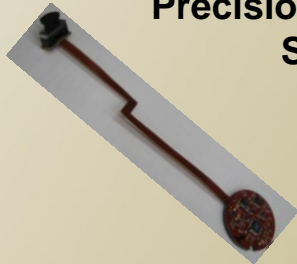
Precision Air Dropped Guided Munition (PADGM)



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

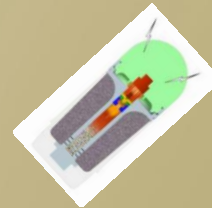
Precision Acquisition Weapon System (PAWS)



Proximity sensor for a lethal UAS

- Design and Fabrication
- Evaluation and Qualification
- Field Test Support
- Completed in-house at ARDEC

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

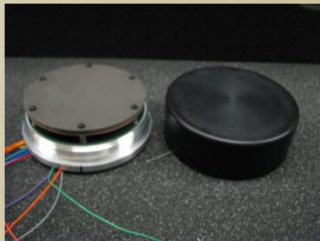
M782 Multi-Option Fuze for Artillery (MOFA)



Integrated Sensor and Fuze electronics

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

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

M734A1 Multi-Option Fuze for Mortars (MOFM)



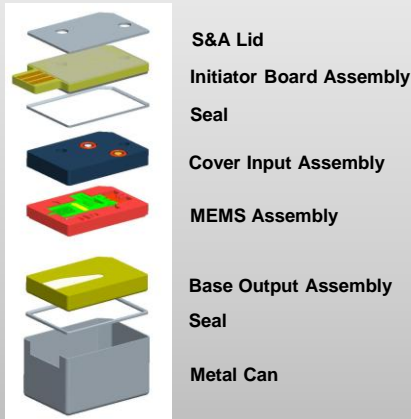
Integrated Sensor and Fuze electronics

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



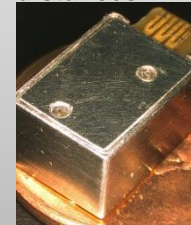
Micro-Electro-Mechanical Systems (MEMS) Safe and Arm (S&A) and G-Switch Devices

MEMS S&A



Benefits

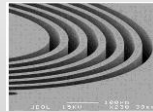
- Small Size
 - increased payload potential
 - improved warhead potential
 - incorporation of advanced sensors potential
- High Precision
- Reduced tolerances on no-arm/arm distances
- Self-Destruct
- High Reliability
- Gun Hardened
 - 2,000 to 100,000g Setback
 - 2,800 to 60,000 RPM Spin
- Unlimited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



MEMS G-Switches

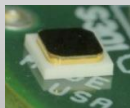
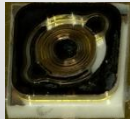
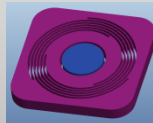
Impact Switches

- 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



LOW COST ELECTRONIC SAFE AND ARM DEVICE

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:

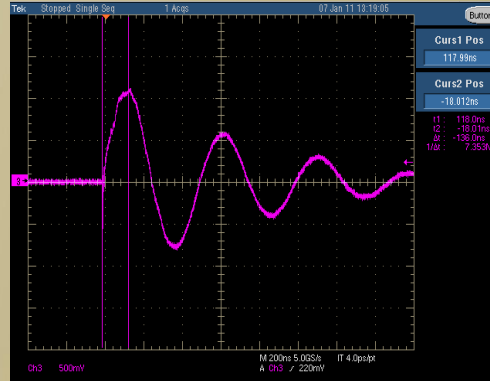
- Energy discharge from capacitor – $Q = \frac{1}{2} CV^2$
- **Time to first peak (t = 75ns-150ns)**
- Voltage on capacitor (1-2kV)
- **Current Discharge from switch (minimum I = 1.5kA)**

Cost Reduction

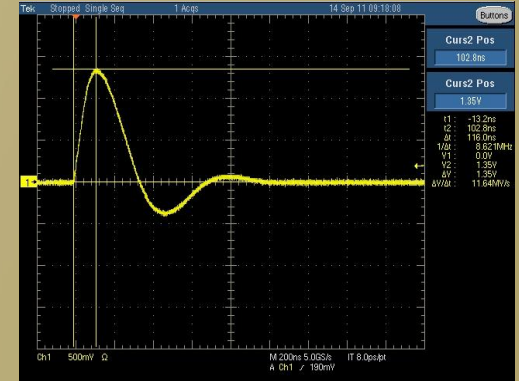
Use of High Voltage components identified will yield a **SIGNIFICANT** reduction in component cost of ESADs

Results

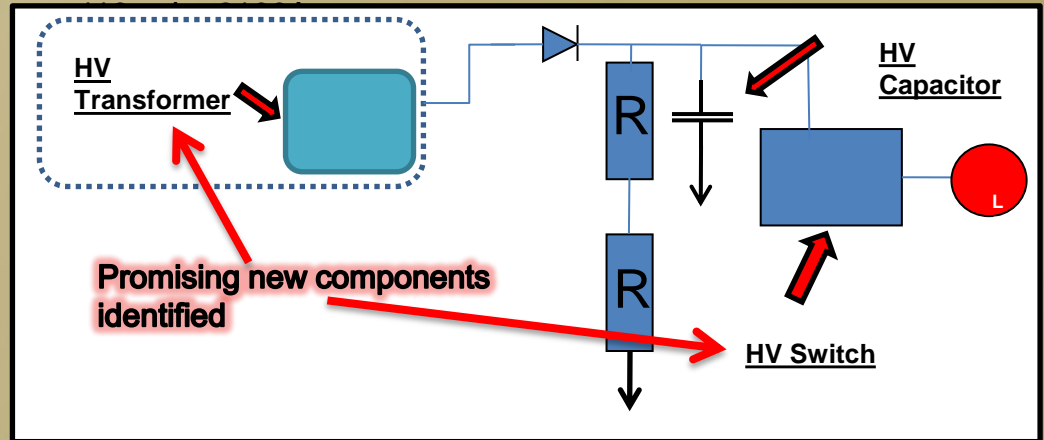
Successful completion of environmental testing has enabled low cost components to be considered for integration into future Single and Multipoint ESAD applications.



High Cost Components Current Discharge



Low Cost Components Current Discharge
 t = 116ns I = 2700A





Inductive Setter Development Success Stories



EPIAFS
SETTER
EXCALIBUR

Team:
 PM-CAS
 PM-Excalibur
 PM-Mortars
 TRADOC-Field Artillery School, Ft. Sill
 ARDEC Picatinny/Adelphi: Setter design and software development; initial production
 Naval Surface Warfare Center, Indian Head: Software Development
 Army Research Labs: Machining and fabrication services
 Raytheon Missile Systems: Supported the development of the inductive interface between EPIAFS and Excalibur
 L3: Produced PIAFS
 ATK: Produced PIAFS and EPIAFS
 Sechan Electronics: Produced EPIAFS

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

2007 Army's Top 10 Greatest Inventions Winner

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.



PIAFS



EPIAFS



iPIK

Enhanced Portable Inductive Artillery Fuze Setter (EPIAFS):

The EPIAFS was a product improvement to the PIAFS system that added the capability to communicate with and be controlled by a host fire control system and to set programmable guided munitions. ARDEC fabricated approximately 200 initial units in house to support development, qualification and initial fielding.

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

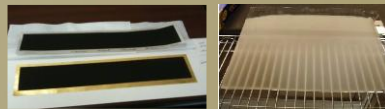
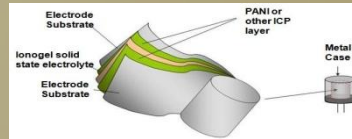
Advance the development of novel supercapacitors utilizing processable Inherently Conductive Polymer (ICP) materials to provide highly ordered lamellae, light weight, flexible sheet-like structure, and high energy storage.

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

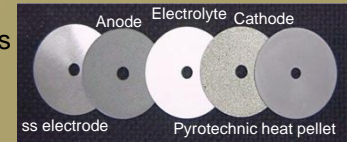


Thin Film Thermal Battery Electrode Fabrication

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



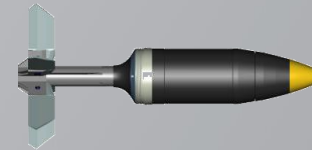


FUZE DESIGN FOR 120MM ADVANCED MULTI-PURPOSE PROJECTILE (AMP)

Electronic Programmable Fuze for 120mm AMP Projectile



Setter Box



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" base on talkback message received

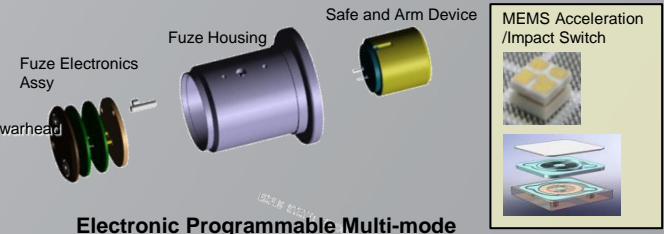
On launch, setback releases one S&A safety. Base pressure closes a switch to enable later functioning of a piston actuator to complete arming.

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.



Electronic Programmable Multi-mode








Spotting round Testing

Three Spotting round fuzes (two Airburst mode and one Point detonation mode) performed flawlessly tests on Aug-2011. The next step is to demonstrate the fuze with a live warhead.



AMP Video



| Technology | FY13 | FY14 | FY15 | FY16 | FY17 | FY18 |
|------------------|--|------|------|---|------|------|
| MEMS S&A |  | | | \$ 10 per S&A, ability to integrate electronics on a chip | | |
| MEMS Sensor |  | | | Significantly reduced cost, high production volumes, achieves commodity status, MEMS target discrimination sensor | | |
| ESAD |  | | | Multi-point 3D distributed system, improved simultaneity and selectable control | | |
| Proximity Sensor |  | | | Develop target classification capability in low power digital and exportable system | | |
| Fuze Setting |  | | | Over the air setting capabilities before and during flight Improve energy transfer speed and efficiency | | |