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

ARDEC Fuze S&T and Acquisition

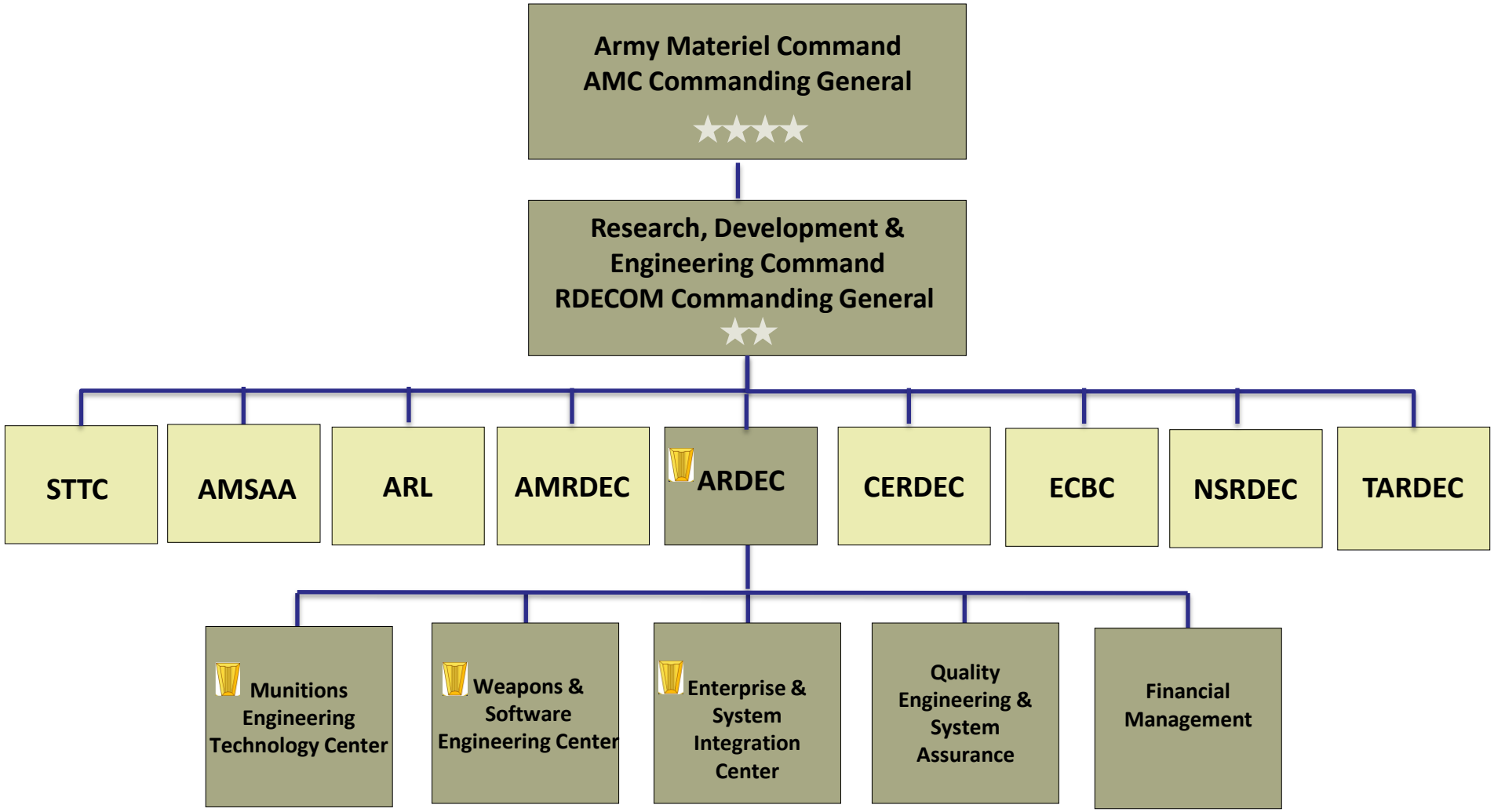
56th Annual Fuze Conference

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Philip T. Gorman, Jr.
Competency Manager
Fuze Division
973-724-7307
<philip.gorman@us.army.mil>

Distribution A - The information contained in this briefing is Approved for Public Release.

ARDEC Organization - Chain of Command



Team Picatinny

Assigned/Direct Support
Coordination

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

ASA, AL&T

AMC

NETCOM

IMA

JM&L LCMC

RDECOM

TACOM LCMC

DOIM

Garrison Commander

PEO Ammo/CG

PM CAS

PM CCS

PD JS

PD JP

PM MAS

ARDEC

US SOCOM

Other Tenants

PEO Soldier
|
PM Soldier Weapons

PEO Integration
|
PM Lethality

PEO GCS
|
PM JLW155

DCMA
|
DCMA NE

CPAC

Navy

ACC

US ARMY RDECOM

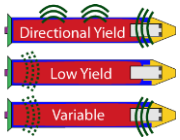
ARDEC Mission
Life Cycle Engineering & Support

ARDEC Video

Research & Development

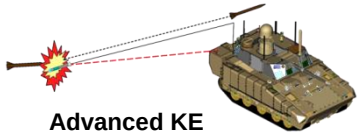
PAX 3

PAX 41



STAR

Common Smart Submunition

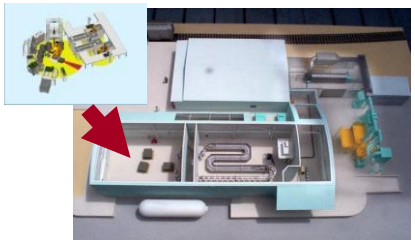


Advanced KE

Excalibur

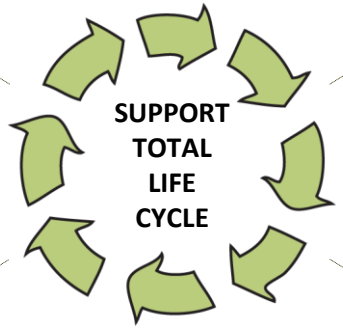
Plasma Arc Furnace

Lightweight Handheld Mortar Ballistic Computer



Cryofracture

Demilitarization

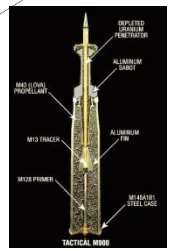


Production

Lake City Army Ammunition Plant

Lightweight Dismounted Mortar

Field Support



M900 Armor Piercing Cartridge

Small/Cannon Caliber Ammunition

Dummy, Drilled, Inert

M240B 7.62MM Machine Gun

40mm Multi-Shot Launcher

Malcolm Baldrige National Quality Award 2007 Award Recipient

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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

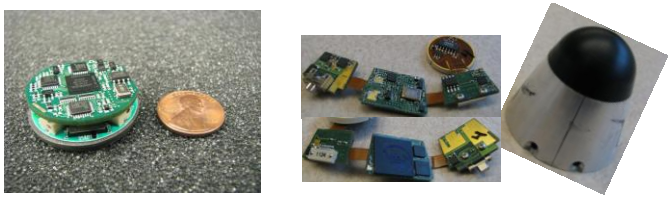
Advanced Proximity Sensor Technologies

Next Generation Proximity Sensors

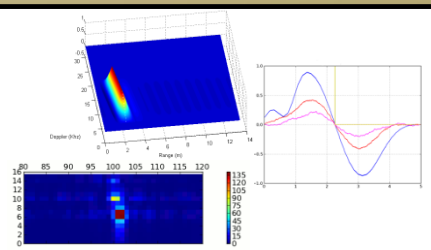
A Joint Fuze Technology Program
ARDEC led with technical participation by AFRL, NAWC-WD

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



Miniature Software Defined Sensors



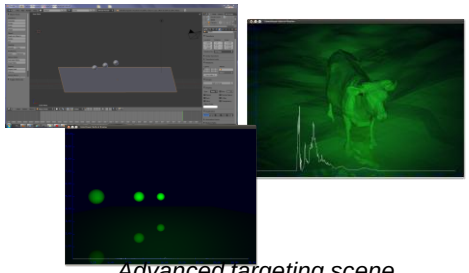
Novel Signal Processing Techniques

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

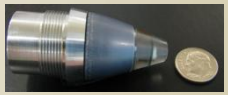
Classification Technique Research
- Range profile, feature extraction
- Range vector envelope correlation techniques



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

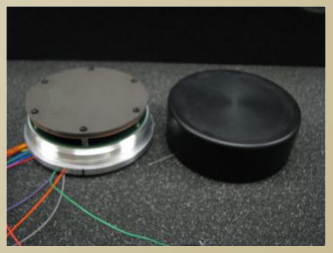
- Custom Power Source
- Custom MMIC transceiver
- Custom signal processor
- Custom antenna designs
- Integration, Design, Fabrication, and Test in-house

Precision 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

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

MEMS S&A

S&A Lid

Initiator Board Assembly

Seal

Cover Input Assembly

MEMS Assembly

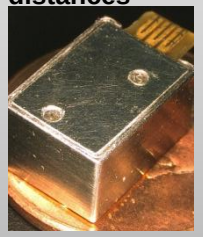
Base Output Assembly

Seal

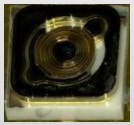
Metal Can

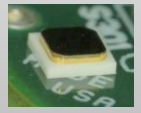
Benefits

- 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



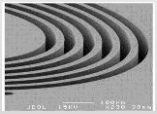


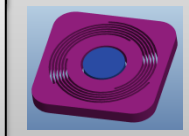
Impact Switches

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

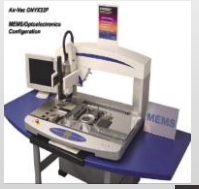
Spin Switches

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

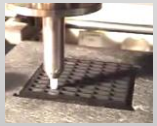




Robotic Micro-Assembly



- 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:

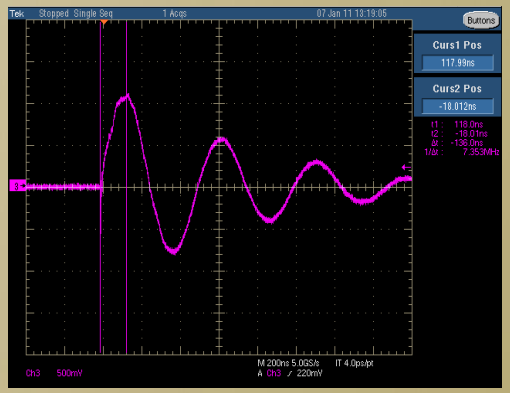
- Energy discharge from capacitor – $Q = \frac{1}{2}CV^2$
- **Time to first peak (t = 75ns-150ns)**
- Voltage on capacitor (1-2kV)
- **Current Discharge from switch (minimum I = 1.5kA)**

Cost Reduction

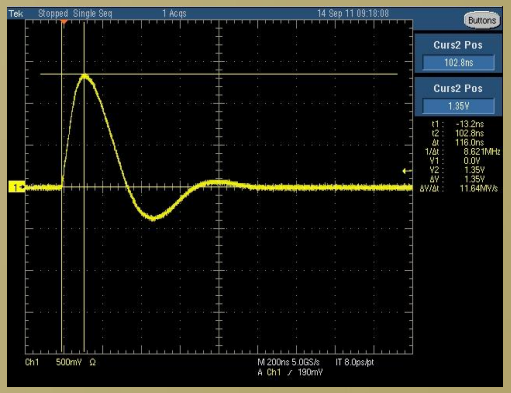
Use of High Voltage components identified will yield a **SIGNIFICANT** reduction in component cost of ESADs

Results

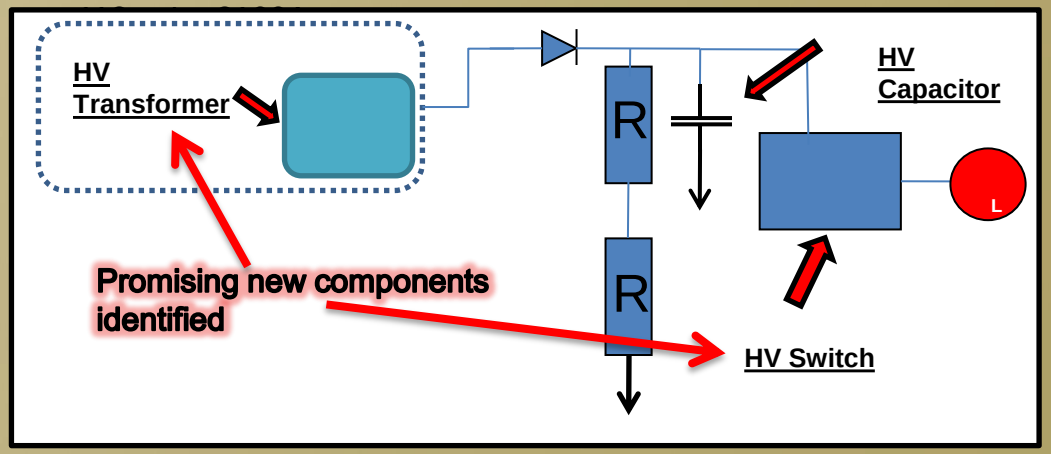
Successful completion of environmental testing has enabled low cost components to be considered for integration into future Single and Multipoint ESAD applications.



High Cost Components Current Discharge



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



Inductive Setter Development Success Stories

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.

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.

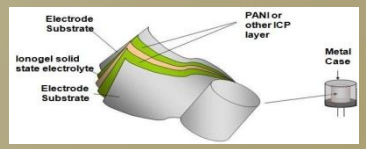
Platforms:
- Portable Excalibur Fire Control System (PEFCS)
- M777A2 Towed Howitzer
- M109A6 Paladin Self-Propelled Howitzer
- Accelerated Precision Mortar Initiative (APMI) Urgent Material Release
- Digitized M119A2 Towed Howitzer

Distribution A

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.

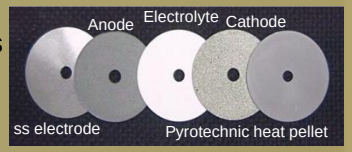


Benefits
- Quick charging time
- Function-over operating temperature and extend shelf-life at storage temperature
- Enable scalable & modular design configuration
- Enhance flexibility, cost effectiveness through large scale manufacturing & processing, and capability.

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

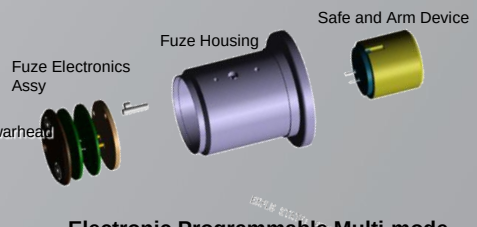
Setter Box

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.

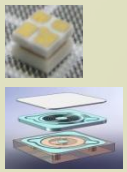
Sequence of Fuze Programming Operation

- 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.



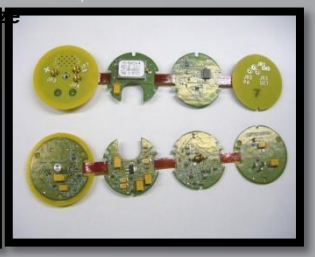
MEMS Acceleration /Impact Switch



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

Electronic Programmable Multi-mode Fuze



US Army ARDEC Fuze Technology Future Goals

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		