US ARMY RDECOM

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

ARDEC Fuze S&T and Acquisition

57th Annual Fuze Conference

ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
PICATINNY ARSENAL, NJ

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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US ARMY RDECOM

ARDEC Organization
Chain of Command

Army Materiel Command
AMC Commanding General
★ ★ ★ ★

Research, Development & Engineering Command
RDECOM Commanding General
★ ★

AMRDEC
Aviation & Missile Research, Development & Engineering Center

CERDEC
Communications- Electronics Research, Development & Engineering Center

ARL
Army Research Laboratory

ARDEC
Armament Research Development & Engineering Center

- **Munitions Engineering Technology Center**
- **Weapons & Software Engineering Center**
- **Enterprise & System Integration Center**

NSRDEC
Natick Soldier Research, Development & Engineering Center

ECBC
Edgewood Chemical Biological Center

TARDEC
Tank Automotive Research, Development & Engineering Center

Malcolm Baldrige National Quality Award 2007 Award Recipient

Team Picatinny

Assigned/Direct Support
Coordination

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

ASA, AL&T

AMC

NETCOM

DOIM

IMA

Garrison Commander

JM&L LCMC

RDECOM

TACOM LCMC

PEO Ammo/CG

PM MAS

PD JP

PM TAS

PM CAS

PM CCS

PD JS

ARDEC

US SOCOM

Other Tenants

PEO Soldier
|
PM Soldier Weapons

PEO Integration
|
PM Lethality

PEO GCS
|
PM JLW155

DCMA
|
DCMA NE

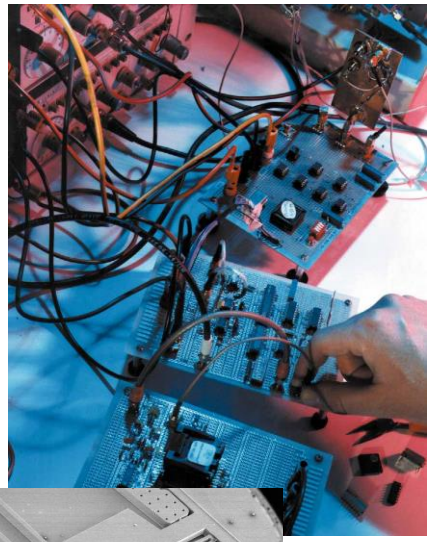
CPAC

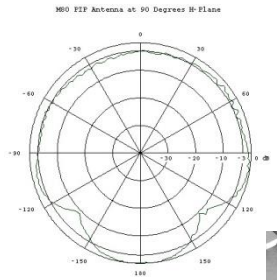
Navy

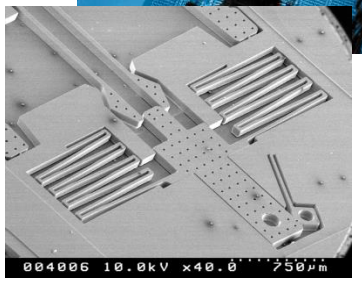
ACC

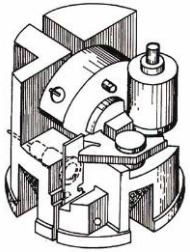
Fuze Division Expertise

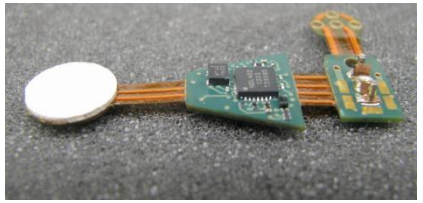
- Low Cost Electronic Fuzing
- Advanced Signal Processing Algorithms
- MMIC Radar Transceivers
- RF Components Design & Testing
- Analog and Digital Circuit Design
- Fuze Testers (RF and IF Simulators)
- ECM Evaluation
- Ultra miniature fuzes
- Antenna design
- MEMS S&As
- Design for High G Launch Loads
- CAD/CAM Design and Layout
- Rapid Prototype Fabrication
- Power sources
- Fuze setters









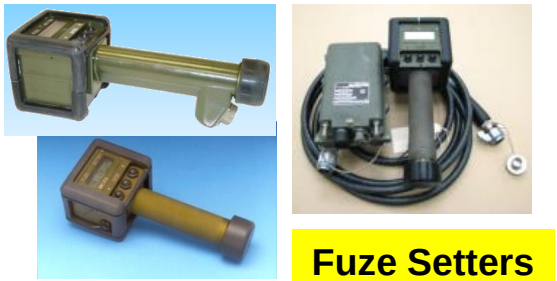


Commodity Areas

Artillery Fuzes

Mortar Fuzes

Medium Caliber Fuzes



Fuze Setters

Safe and Arm Devices

Hand Grenades

Rockets & Missiles

Tank Ammo

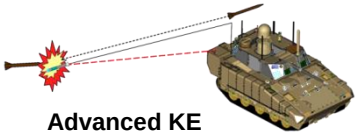
ARDEC Mission
Life Cycle Engineering & Support

ARDEC Video

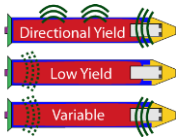
PAX 3

PAX 41

Common Smart Submunition



Advanced KE



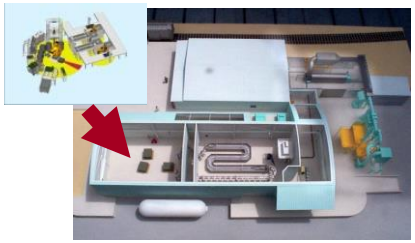
STAR

Excalibur

Plasma Arc Furnace

Research & Development

Lightweight Handheld Mortar Ballistic Computer



Cryofracture

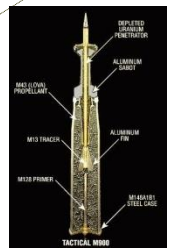
Demilitarization

SUPPORT TOTAL LIFE CYCLE

Production

Lake City Army Ammunition Plant

Lightweight Dismounted Mortar



M900 Armor Piercing Cartridge

Field Support

Small/Cannon Caliber Ammunition

Dummy, Drilled, Inert

M240B 7.62MM Machine Gun

40mm Multi-Shot Launcher

2007 Malcolm Baldrige National Quality Award Recipient

ARDEC Fuze S&T

S&T Thrust Areas

Army Challenge: Create Operational Overmatch (enhanced lethality & accuracy)

Reduced logistical burden

Tailorable Effects

Enhanced Lethality

Scalable Effects

High Reliability

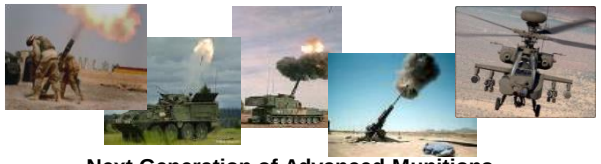
Advanced Fuze Setting


PIAFS

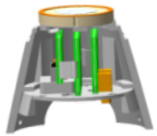

EPIAFS

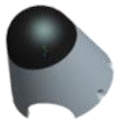

iPIK

Innovative Packaging Schemes
EM Modeling & Simulation
Complex data processing

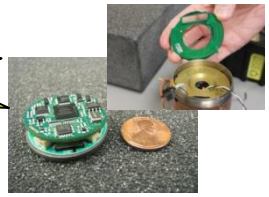

Next Generation of Advanced Munitions

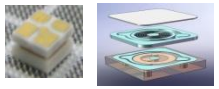
Launch & Target Sensing





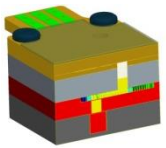

Fuze Decision Logic


Next Generation Prox Sensors


MEMS Acceleration / Impact Switch

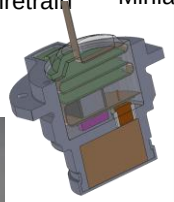

Target Media Sensing

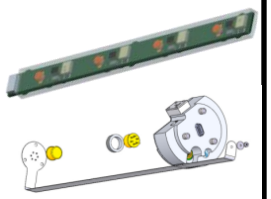
Advanced Warhead Initiation Schemes


Microscale Firetrain

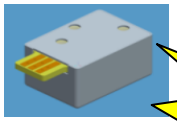

Miniature Firesets


Electronic Safe & Arm Devices

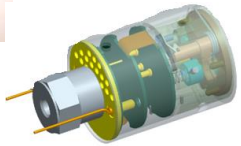



Low Cost Multipoint Initation

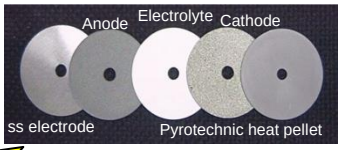
Advanced Safe & Arming


MEMS S&A

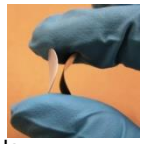

Rotor S&A


Electromechanical S&A

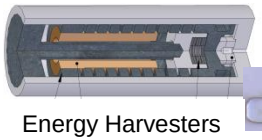
Novel Power & Energy




Thermals




Liquid Reserves


Energy Harvesters

Fuze S&T and Acquisition Efforts

Emerging & MaturingTechnologies

(6.2 OSD Joint Fuze Technology Program)

- Target Classification Prox for Tailorable Whds
- Nano-Foil Heated Thin Film Thermal Battery

(Current 6.3 OSD Joint Fuze Technology Program)

- PGK IMX-101 Compatibility
- Next Generation Proximity Sensor for Prox Fuzing
- MEMS Retard & Impact Sensor

(RDECOM/ARDEC S&T Projects & Demonstrations)

- Future Initiation, Target Detection, Fuze Setting, Power
- Next Generation Prox Fuzing (*includes OSD sponsored DEF*)
- Distributed Multi-point Initiation
- Thin Film Power Sources
- MEMS Impact Switch Target Sensing
- Fuzing for Cluster Munition Replacement
- 120mm Guided Mortar
- Low Volume and Low Power Prox
- Direct Fire Prox Sensor - (Joint Non Lethal Dir)
- Autonomous Target Sensing for Shoulder Fired
- Airburst/PD and PD delay for Tank Ammo
- Command Arm MEMS S&A w/ Prox for 40mm
- Enhanced Multi-Purpose Grenade
- Low cost air dropped precision guided munition
- MEMS Safe & Arm Reliability & Manufacturing

On-going 6.6 Fuze Technology Integration

EMD/Production support for PM MAS, PM CAS, PM CCS, PD JP

2007 Award Recipient

Advanced Proximity Sensor Technologies

Next Generation Proximity Sensors

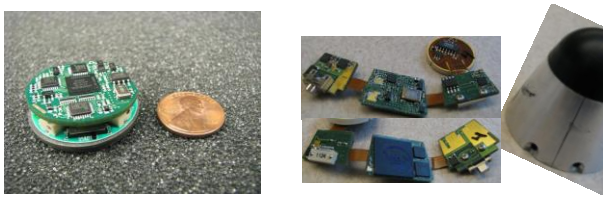
A Joint Fuze Technology Program
ARDEC led with technical participation by AFRL, NAWC-W

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

Target Classification Sensors for Fuzing Applications

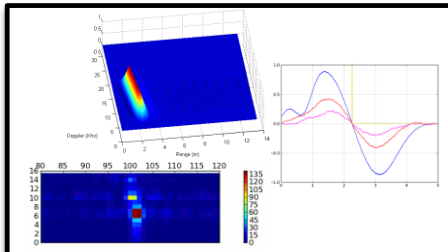
A Joint Fuze Technology Program

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

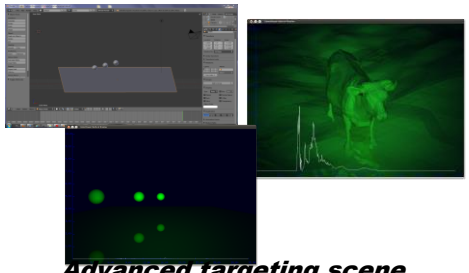
- Mesh based object / scene creation
- Shooting-Bouncing-Ray Solver
- Generation of IF return data for use in algorithm development and performance estimation

Classification Technique Research

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



Novel Signal Processing Techniques



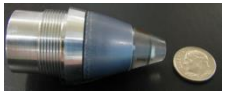
Advanced targeting scene modeling

Malcolm Baldrige National Quality Award 2007 Award Recipient

US ARMY RDECOM

Proximity Sensor Development and Production Support

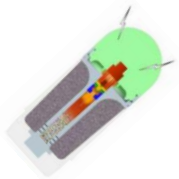
M789 / XM799 Prox Sensor



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

XM1112 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

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

Small Arms Grenade Munition (SAGM)

Development of a miniaturized defilade detection prox sensor system

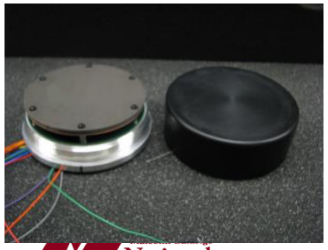
- Developed using government owned technology
- Defilade detection to support PM MAS's Increased Range Anti-Personnel (IRAP) program
- Integration with custom battery and MEMS based fuze

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

National Quality Award 2007 Award Recipient

2007 Malcolm Baldrige National Quality Award Recipient

The Armament Research, Development & Engineering Center

Innovative Armaments Solutions for Today and Tomorrow

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

- **Small Size**
  - **Increased payload potential**
  - **Improved warhead potential**
  - **Volume to add advanced sensors**
- **Reduced tolerances on no-arm/arm distances**
- **Command arm function and optional Self-Destruct**
- **Gun Hardened**
  - **2,000 to 100,000g Setback**
  - **2,800 to 60,000 RPM Spin**
- **Enabling technology for adv. Prox,W/H, UAS, etc.**
- **Broad application across munitions**
- **Disruptive to technology base (clockworks)**
- **TRL 6 (low-velocity 40mm), now in Mfg. Facilitization**

Lid

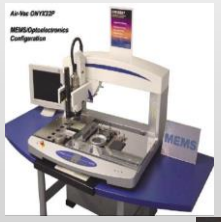
Initiator Board

Cover

Mechanism

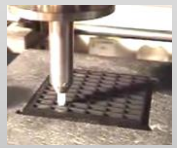
Output Base

Metal Can



Robotic Micro-Assembly

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



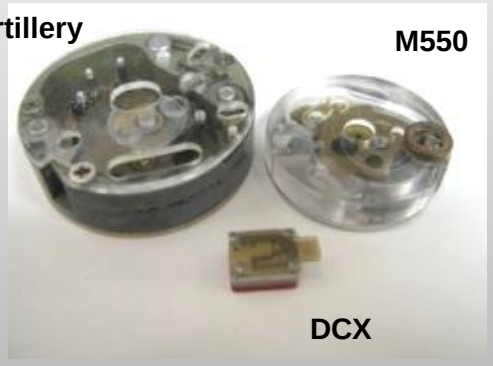
ONYX500 Platform inspecting and kitting parts

MEMS S&A Packaged, showing size reduction

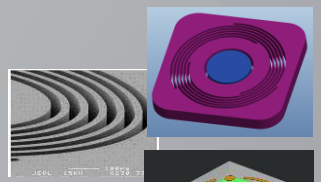
DCX

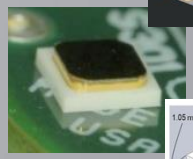
Artillery

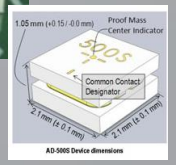
M550



DCX







MEMS G-Switches

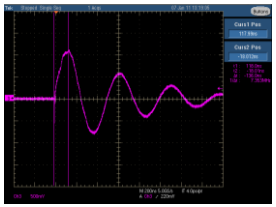
46,000 impact switches produced
- **2 x 2 mm footprint**
- **Multi-axis sensitivity**
- **250-, 500-, and 1000-G available**
- **Spin switch configuration available**

Multi-Threshold Impact Characterization Switch
- **4 x 4 mm footprint**
- **Distinguish hard/soft target impact**

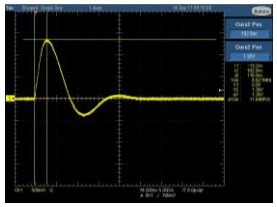
Integrating G-Switch
- **Setback acceleration sensor**

Electronic Safe and Arm Technologies

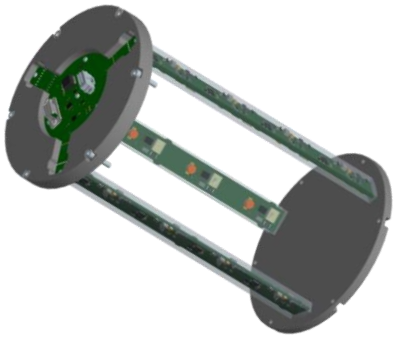
- *Low Cost Components*
  - Low cost ceramic capacitors
  - Alternative High Voltage switch technologies
  - Custom flyback transformers
  - Non-magnetic transformers



High Cost Components Current Discharge



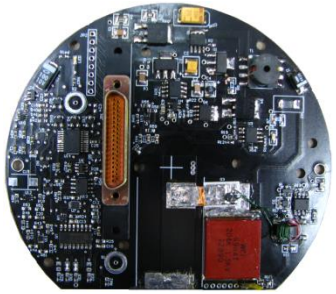
Low Cost Components Current Discharge



Networked Sequential Fireset (NSF) for Artillery

- *Multi-point Initiation*
  - High speed sequential initiation for scalable/tailorable warhead effects
  - Advanced initiation techniques for sustainment of detonation velocity in highly insensitive energetic materials
  - Highly simultaneous multi-point solutions for initiation of IM fills

- *Advanced ESAD Solutions*
  - Kinetic Energy Active Protection System (KE APS)
  - Lethal UAV
  - Precision Air Dropped Guided Mortar (PADGM)



KE APS Countermeasure ESAD

Inductive Setter Development Success Stories

Problem Statement:
Advanced fuzes and guided munitions require complex data input for varied mission requirements.

Team:
PM-CAS
PM-Excalibur
PM-Mortars
PM-TAS
TRADOC-Field Artillery School, Ft. Sill
ARDEC: Setter design and software development; initial production
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

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. PM-TAS is beginning to use the iPIK for its platforms. ARDEC fabricated approximately 400 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

2007 Army's Top 10 Greatest Inventions Winner

US ARMY RDECOM

Novel Power Sources for Advanced Munitions

Medium Caliber Power Sources

Medium Caliber applications present unique and challenging power requirements

- Fast Rise Time
- Energy Density
- High-G Survivability
- Long Shelf Life
- Operational Temperatures
- Form Factor

Current investments addressing technical challenges for the development of a small form factor liquid reserve battery to meet operational and performance requirements.

Target applications

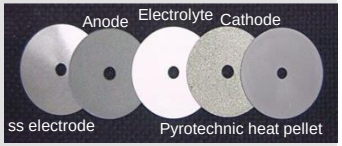
- M789 LW30mm Proximity Sensor for Apache
- XM1158 Airburst Non-Lethal Munition
- Small Arms Grenade Munition

Thin Film Thermal Battery Electrode Fabrication

Traditional pressed pellet fabrication methods press powders into pellets.

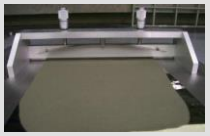
Large presses with high force produce flat discs

- 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

Malcolm Baldrige National Quality Award 2007 Award Recipient

ARDEC continues to seek industry and academia partnerships to explore next generation power sources to meet the increasing power demands for munitions and fuzing applications

Video

- ARDEC Fuze Division Papers
  - Legacy Fuze Arming Time Study M549A1 and M550, Ms. Melissa Rhode
  - Proximity Sensor for LW30mm Munitions, Mr. Patrick Deluca
  - Multi-g-Threshold Metal MEMS Sensor for Target Discrimination, Mr. Mike Pica
  - Impact Sensitivity of off-Axis MEMS Impact Switch in High Spin Environment, Mr. Mike Pica
- Other ARDEC Papers
  - Advances in Energetic Direct Write Technologies for Fuze Applications, Mr. Jeffrey Kraft
  - Modeling and Simulation of Circuit Board with COTS Resistors under High G load, Dr. Jennifer Cordes
  - Effects of Glass Transition on structural integrity of gun launched electronics, Dr. Aisha Haynes
  - Initiation Train Analysis via Penalty Testing, Mr. Erik Wrobel
  - Printing Fuze Components, Dr. Brian Fuchs

- Other Papers that ARDEC Fuze Division has an active role in:
  - Small Arms Grenade Munition Proximity Sensor, EDC Corp, Mr. Steve Stephey
  - Reliability of MEMS explosive Train Interfaces, NSWC IHEODTD, Mr. Daniel Pines
  - Distributed Embedded Fuzing System, USAF AFRL, 2d Lt Michael Seacord
  - RF Range Simulator, EDC, Mr. John Gautz
  - Accelerated Distributed Target Simulation for Adv Fuze Processor Development, Univ of Florida, Mr. Charles Overman
  - 40mm MEMSAD Fuze, ATK, Mr. John Krafcik
  - Stinger Missile Target Detecting Device, EDC, Mr. Don Atkins

- QUESTIONS?