NDIA 49th Annual Fuze Conference
UNITED STATES NAVY OVERVIEW

Dr. John Robbins

Co-Lead of the Navy Energetics Enterprise

NAVAIR

NAVSEA
NAVAL SEA SYSTEMS COMMAND

OUTLINE

- Navy Energetics Enterprise - NEE
- Technology
  - Safe & Arm
  - TDD
  - Sensors & Fuze Components
- Concept Demonstrations & Rapid Response
- Development & Acquisition
- Production/In-Service Support
  - Quality Evaluation
  - Lot Acceptance Testing

Navy Energetics Enterprise

- **A coalition of NAVSEA and NAVAIR components**
  - NAVSEA Ordnance Product Area
  - NAVAIR Weapons and Energetics
- **Navy Energetics Leadership Board**
  - Led by SYSCOM Vice Commanders
  - Single voice (Virtual SYSCOM) for Energetics
  - Stewardship of the Navy's organic capability
  - Ensure energetics is strategically focused
  - Provide leadership in envisioning future Navy needs
- **Energetics IPT leads coalition efforts to achieve goals**

• Collaboration to provide best technical solutions for Warfighter needs

• Achieve long-term cost avoidance resulting from shared people and facilities

China Lake, Crane, Dahlgren, Indian Head

NEE Vision

One team, Navy Energetics Enterprise, with superior knowledge in energetics, dedicated to delivering effective, safe, cost-wise ordnance solutions to the Warfighters.

One Team providing
Superior Ordnance Solutions
to the Warfighter

Navy MEMS-Based F/S&A Technology Applications

Torpedo S&A

Exploder for **C**anisterized **C**ountermeasure **A**nti **T**orpedo (**CCAT**)

POC: Lawrence Fan, fanlc@ih.navy.mil

- **MEMS S&A optically interrupts firing energy**
- **MEMS sensors detect arming environments**

Low-Cost Submunition S&A

Shipboard Safe Submunition

POC:John Kunstmann, kunstmannjf@ih.navy.mil

- **MEMS S&A senses arming environments**
- **Micro Detonator aligned to booster**

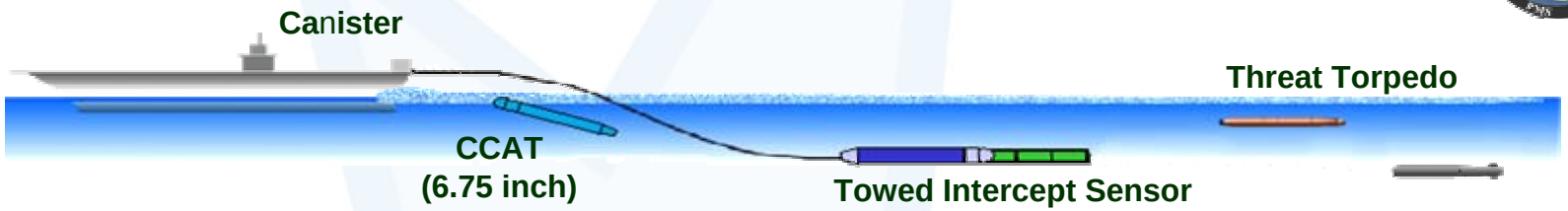
Advanced Missile Warhead S&A

MEMS Based Distributed S&A

POC:Walt Maurer, walt.maurer@navy.mil

- **Master control unit senses arming**
- **MEMS SA aligns explosive train to Micro Detonator**

Torpedo MEMS S&A



Small S&A with advanced sensors for CCAT and Multi-Mission Torpedo programs

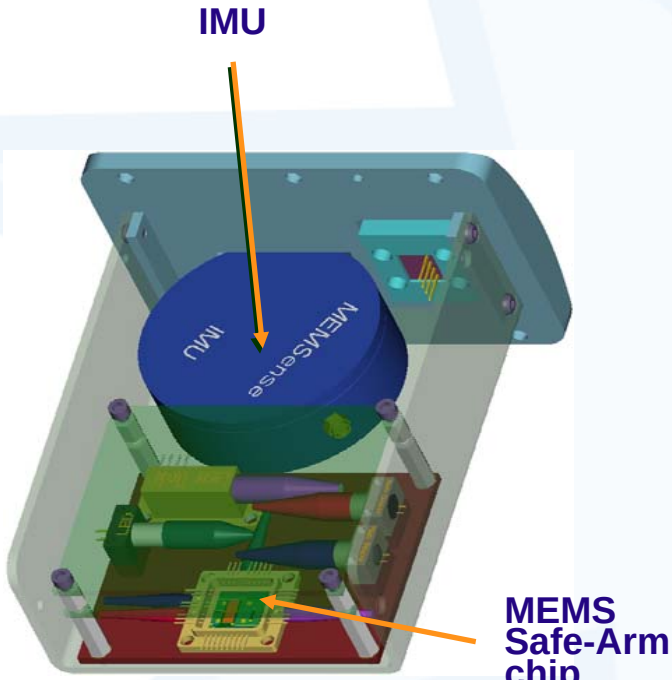
FY04-05 Highlights:

- Refined S&A Design, Demonstration in-water field tests
- Demonstrated MEMS S&A robustness
  - **H**ighly **A**ccelerated **L**ife **T**esting (**HALT**)
- Refined MEMS IMU-based Safe Separation System design
- Delivered integrated EFI design (MANTECH)
- Developed advanced micro-system packaging technology to CCAT S&A design

Miniaturized Fuze/S&A Technology for Next Generation of Navy Underwater Weapons

Torpedo MEMS S&A

- Design Overview:



- Hybrid Approach – MEMS Interrupters and In-Line/EFI
- Safety Sensors
  - MEMS G-sensor
  - Safe separation: IMU and flow sensor
- Optical isolation of firing energy using MEMS interrupters locked by MEMS locks
- Integrated Exploding Foil Initiator package

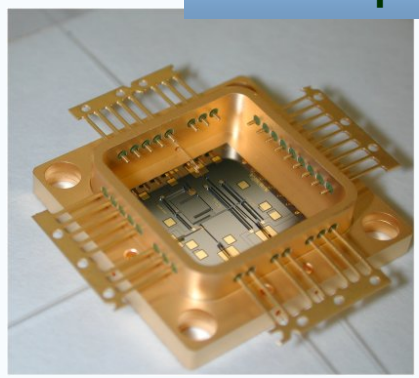
Fuze S&T Development and Reliability

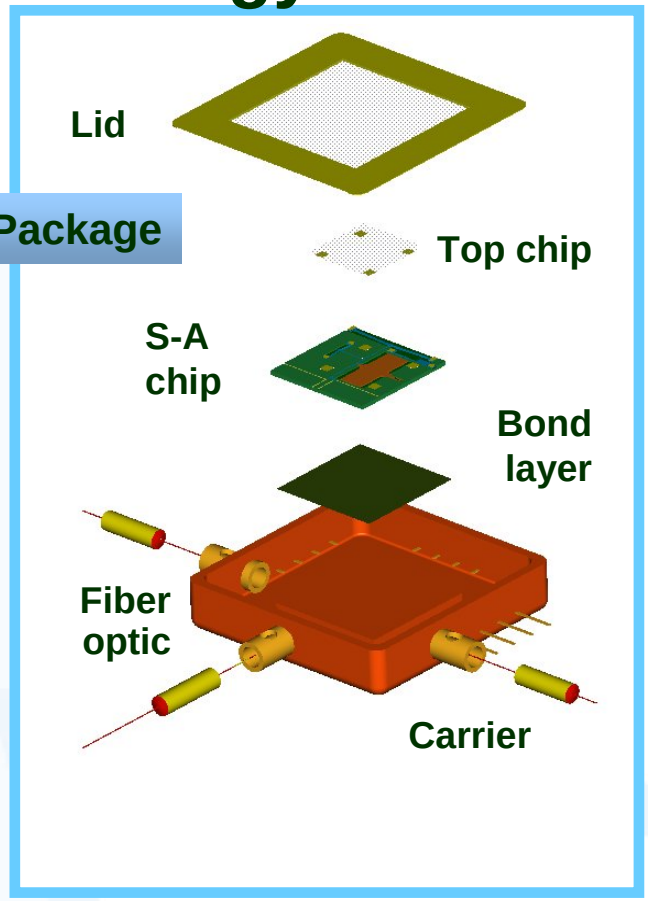
- Micro-Systems Packaging Technology

Objective:

•Develop robust, reliable and manufacturable MEMS packaging processes for Miniature S&A applications

S&A Chip Package





Briefed in Session IV-B

Conducting demonstration and validation of S&A chip packaging through testing including HALT, HAST and MIL-SPEC-331

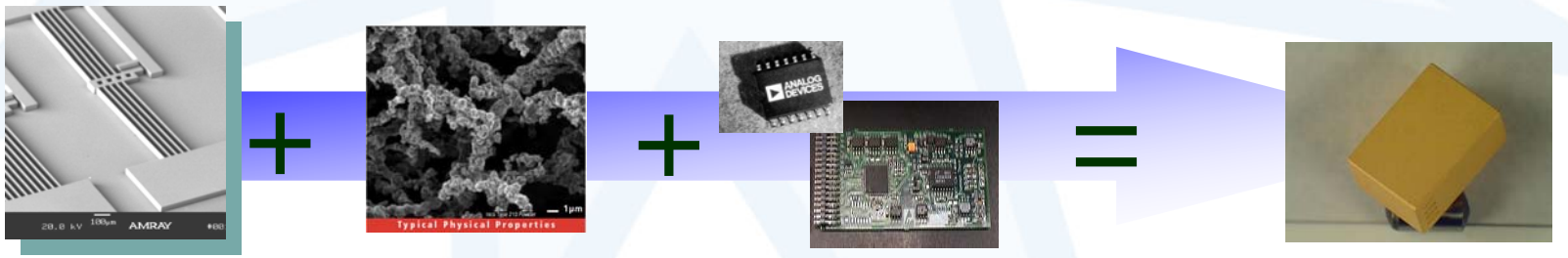
Low Cost Submunition MEMS S&A
- Shipboard Safe Submunition Program

• 6.2 ONR S&T program to develop very high reliability & low cost submunition S&A architecture

• Submunition must meet SECDEF **>** 99% reliability policy & Navy (WSESRB) inadvertent expulsion requirement - no function when inadvertently expulsed on deck of ship, **<** one in million chance of arming

• Navy slow cook-off testing with cargo (grenade submunition) round resulted in arming of 1 out every 5 Fuzes

• Design solution must be cost effective to be realized in fielded munition system



MEMS S&A Chip | Micro-Detonics | Sensors and Electronics | Micro Fuze Module

Safety & Reliability Through Technology

Low Cost Submunition MEMS S&A
- In-Situ Micro Detonator Technology

Objective:

- Develop MEMS based enabling technology with integrated energetic materials for Low Cost (Small) MEMS S&A
  - Goal: Develop detonator that is less than 300μm thick, end item will contain approximately two orders of magnitude less (primary) energetic material than conventional (macro) detonator

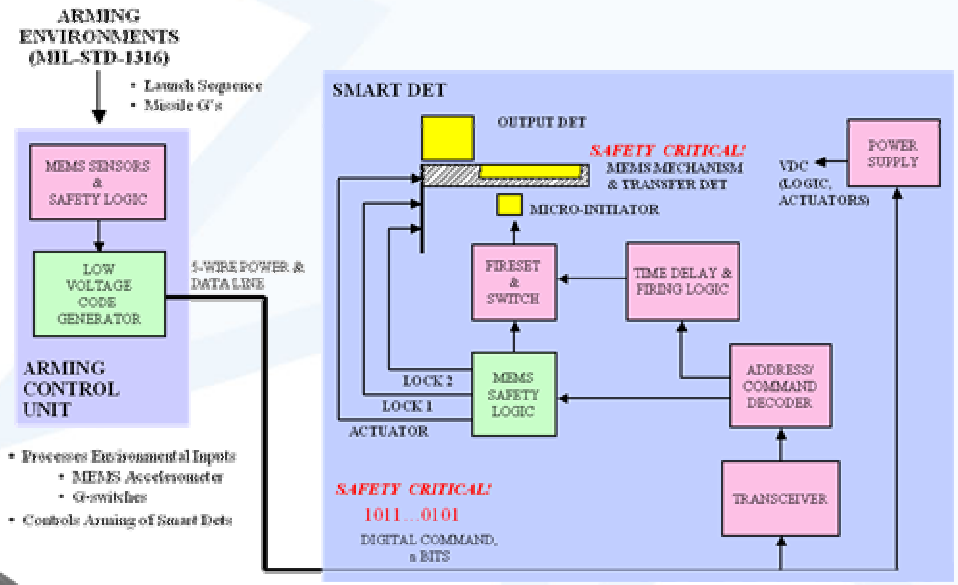
Approach:

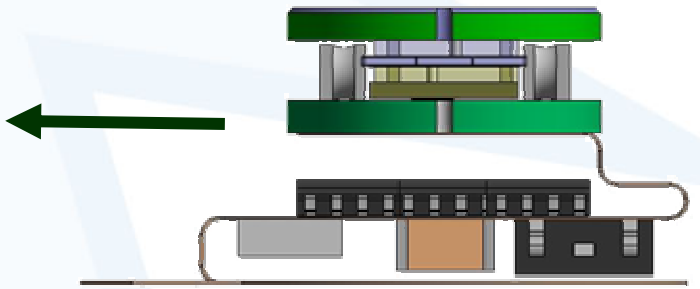
- An *in situ* formed explosive compatible with batch MEMS processing requiring no assembly
- Physically out of line system utilizing inorganic salts as donor explosive
- No explosive waste or contact with MEMS processing equipment
- Low initiation energy and power requirements
- Novel energetic material approach,
  - Copper Azide utilized initially due to facile synthesis

Briefed in Session IV-B

MEMS-Based Distributed S&A

- **Description**
  - **Arming control unit senses arming environments per MIL-STD-1316, then generates unique arming commands to selected “smart” detonators**
  - **Each detonator contains MEMS mechanical locks to prevent inadvertent arming**
- **Accomplishments**
  - **Demonstrated sequential firing of multiple smart detonators**
  - **Proven basic out-of-line safety and in-line transfer of small charges**

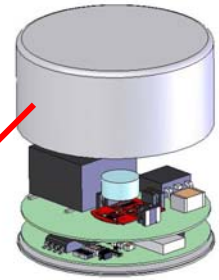




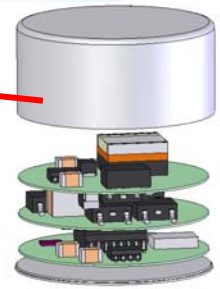
Miniature Munitions

✓ Combination of microfabrication/MEMS and microelectronics technologies can provide significantly smaller Safe-Arm devices

Miniature SA Housing (preliminary)



Mechanical Out-of-Line SA Concept

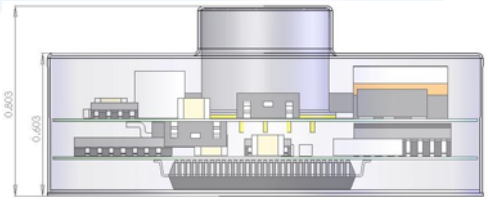


Electrical In-Line SA Concept
(~ 1000 Vdc)

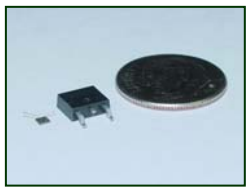
Briefed in Session IV-B

✓ Schematics & Packaging developed for two basic types of Miniature SAs:
- miniature Mechanical Safe-Arm Device (MSAD)
- miniature Electronic Safe-Arm Device (ESAD)

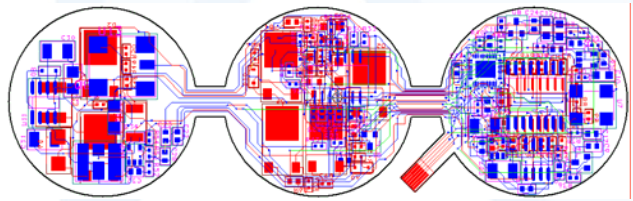
✓ Either concept can be further miniaturized by:
- Replacing COTS packages with custom packages and die
- high-density flexible circuits



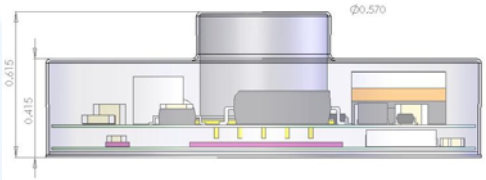
Miniature ESAD, COTS Version



FET Die (left) & COTS Package



Flex Circuit for Miniature SA

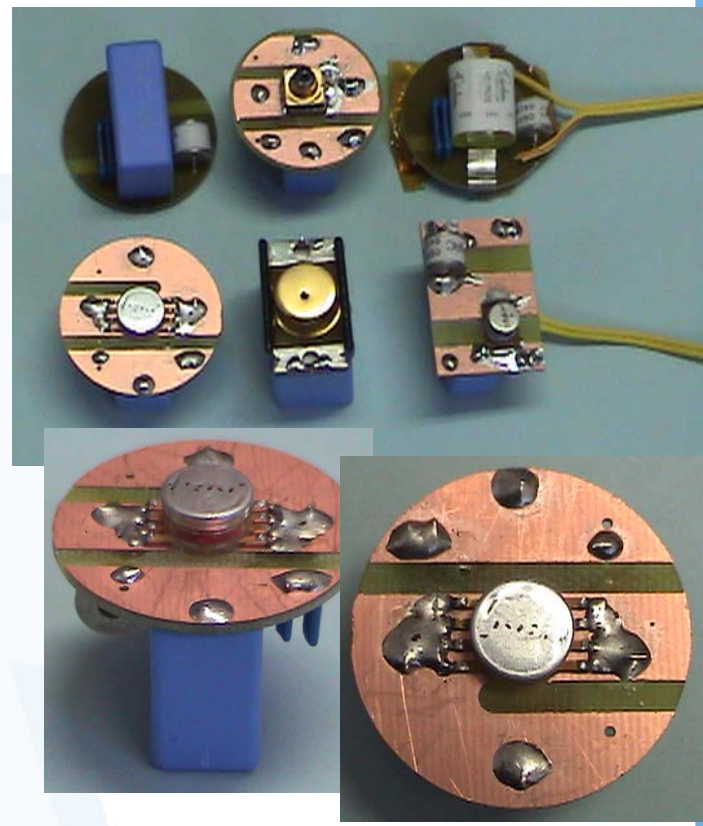


Miniature ESAD, Die Version

HIGH PERFORMANCE EXPLODING FOIL INITIATOR
Explosive Ordnance Disposal (EOD) Applications

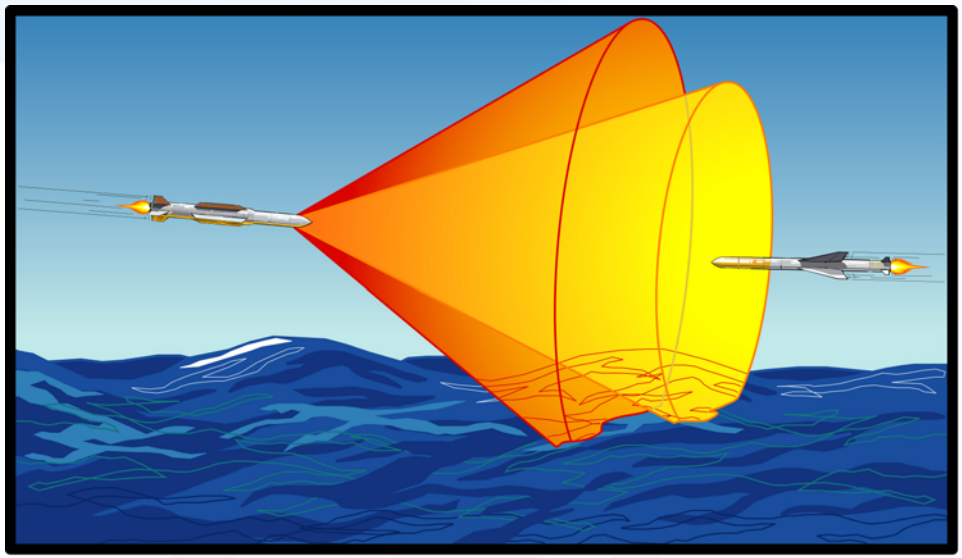
- Low Cost Fire Modules
  - Leveraged Effort
    - Low Cost/Disposable ~$5 in 100's
    - HV Capacitor, Bleed down resistors
    - HV Switches (two tested)

- Controller for EFI Electrical Initiation
  - Sample Field Test Unit



Target Detection Devices

Short Pulse Laser TDD



Attributes

- Operation in Dense Aerosol Environments
- Single High Peak Power Sub-nanosecond Laser Transmitter
  - Large Target to Aerosol Backscatter Ratio
  - High Speed Optical Switch
- Single High Bandwidth / High Gain Receiver
  - Increased Signal to Noise Ratio
- High Speed controller and Processor
- Variable Neutral Density Filter

Goal

- Provide High Lethality Against Sea Skimming Supersonic Targets
- Extend the Operation Capability to Include All Aspect Encounter, Adverse Weather, Increased Target Sets, Low Altitude Severe Clutter Operation

Target Detection Devices

TDD Signal Processor In A Chip Set

Attributes

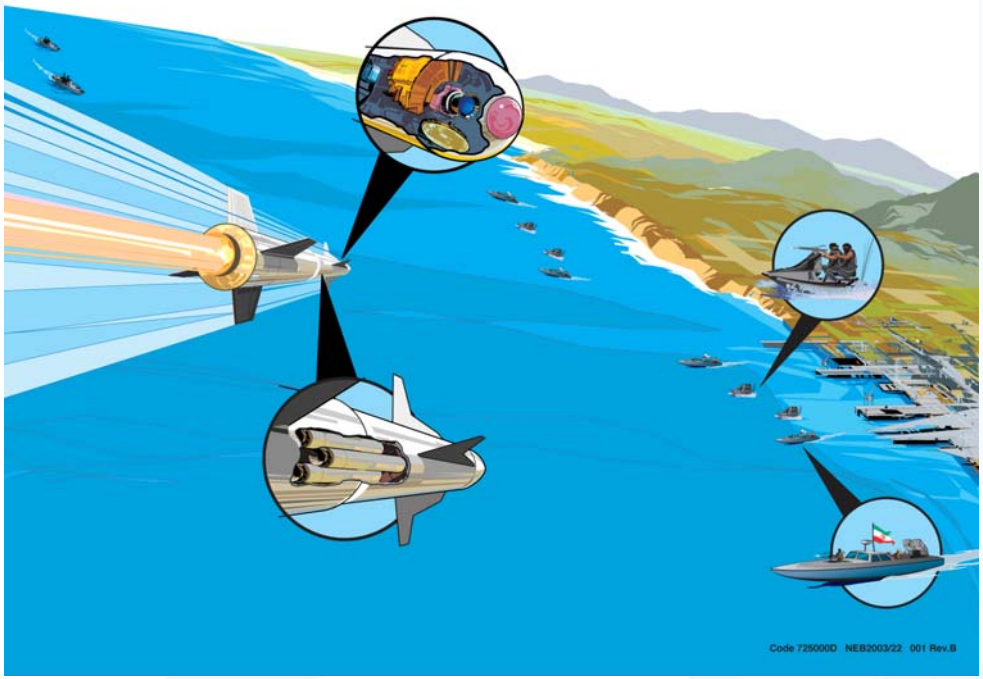
- Variable-gain amplifier IC
  - Throughput bandwidth > 2.5 GHz
  - Gain-control bandwidth > 200 MHz
  - Voltage-gain dynamic range = 60 dB
- Range counter IC
  - 17-bit binary counter
  - Max count frequency = 23 GHz
  - Provides 0.25” range resolution at 2850’ max range if clocked at 23 GHz
- Filter bank IC
  - Combination of low-pass and band-pass filters spanning 0-1.5 GHz
  - Provides frequency discriminates

Goal

- China Lake – Mayo – DARPA effort to develop state-of-the-art TDD capability using IBM’s SiGe 8HP process (0.13-micron feature size, f_T > 250 GHz)
- Reduce processor volume and power consumption for tactical compatibility
- Improve processing speed, reliability, and provide previously unattainable TDD performance capabilities at reduced cost

Target Detection Devices

Synchronous Strike (S2)



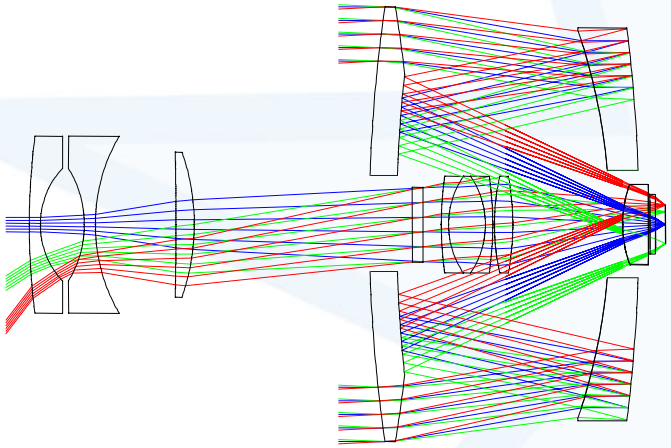
Attributes

- Technology for:
  - Powered or Freefall Munitions
- Low Collateral Damage
- Increased Load-out
- High Mission Flexibility
- Sensors for Pattern & Endgame Shaping
- Kill Amplification
- Weapon Reconfiguration
- GPS Timing for Synchronization
- Data Link for Cooperative Engagements

Goal

- Provide High Lethality Against Surface, Subsurface and Asymmetric Targets in Littoral and Urban Environment.
- High Combined Kill Yield from Small Munitions

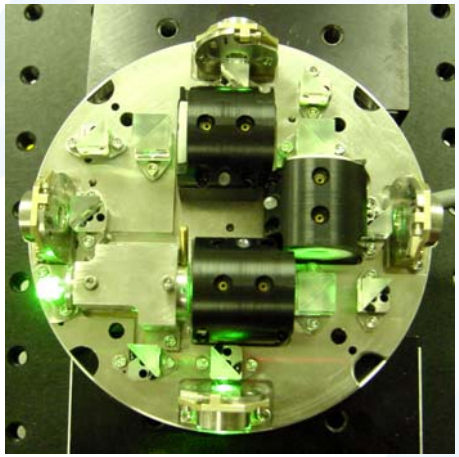
IR/EO/Optical Passive/Active Sensors

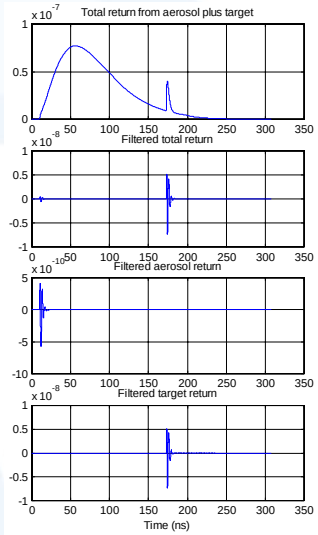


Sensor Design

Optical Design

- **Systems Analysis**
- **Modeling & Simulatio**
- **UXO Discrimination**
- **SLook Through Aeros**

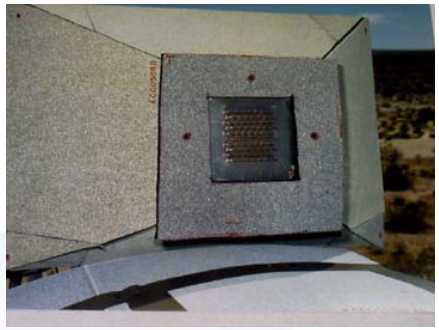




RF/Antennas Sensors

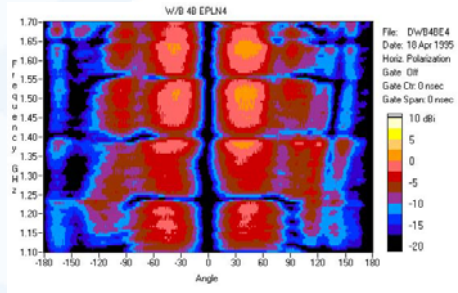
Float Coat

RCS & Antenna Measurements
Outdoor Antenna Range
100MHz to 60 GHz

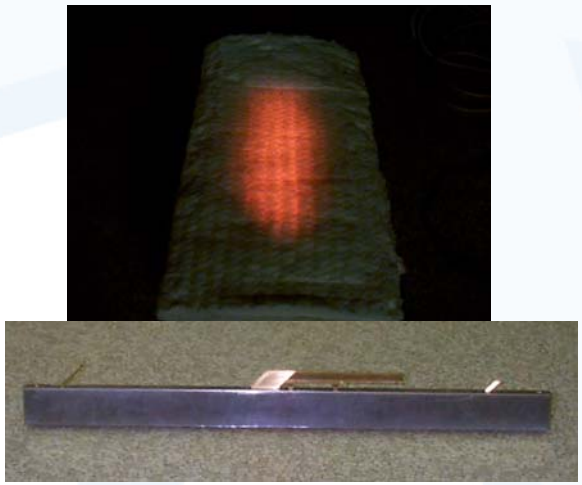


Electronic Scanned Arrays

•GPS/GPS Jamming



Electromagnetic Computer Predictions



High Temperature Antennas

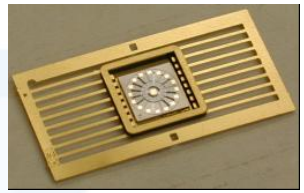
RF Tags & Data Links

NAVY Energetics

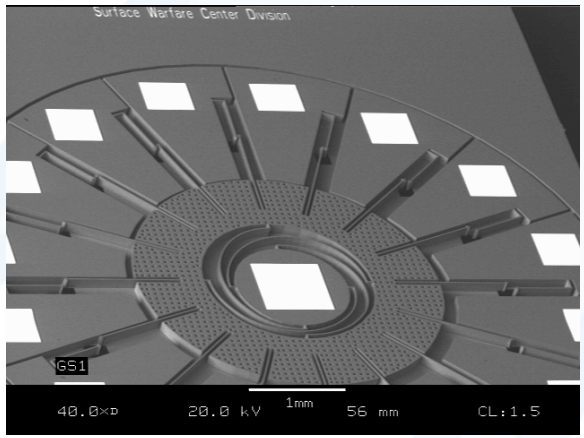
MEMS Fuze / Target Detection Technology

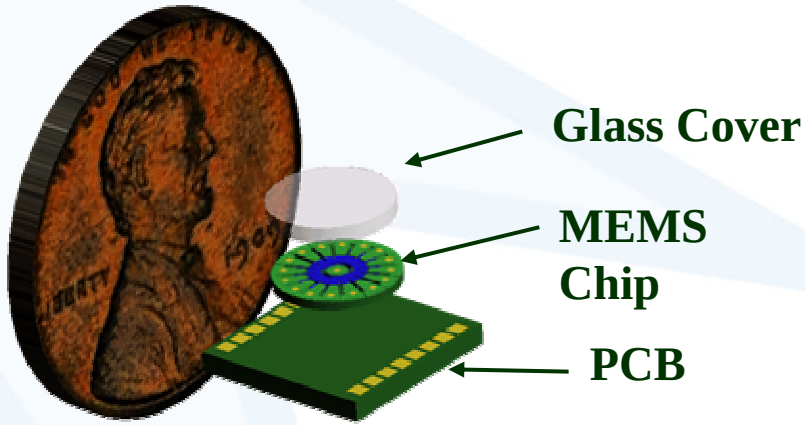
- MEMS Multi Directional G (Impact) sensor

- No power required, simple spring mass system
- DRIE SOI MEMS
- Current designs eliminate chip carrier & wire bonding
- Currently developing wafer level package design
- Demonstrated high-G (30KG) survivability
- Currently developing 5mm x 5mm package
- Private party interest in leasing for commercial shock sensing applications



Carrier Level Package





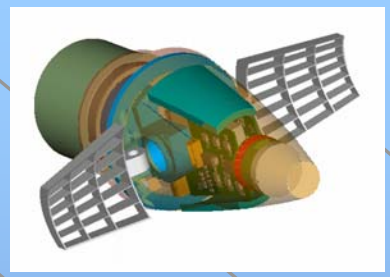
Chip Level Package

Over 1000 MEMS g-sensors successfully fabricated to date

Technology Demo: Guidance integrated Fuze (GIF)
OSD sponsored Tech Demo for Projectile fuze

Increases Effectiveness – Kills targets quicker

- **Increases Stowed kills per platform**
- **Reduces Collateral Damage**
- **Reduces Logistics Burden**
- **Allows closer support of friendly troops**

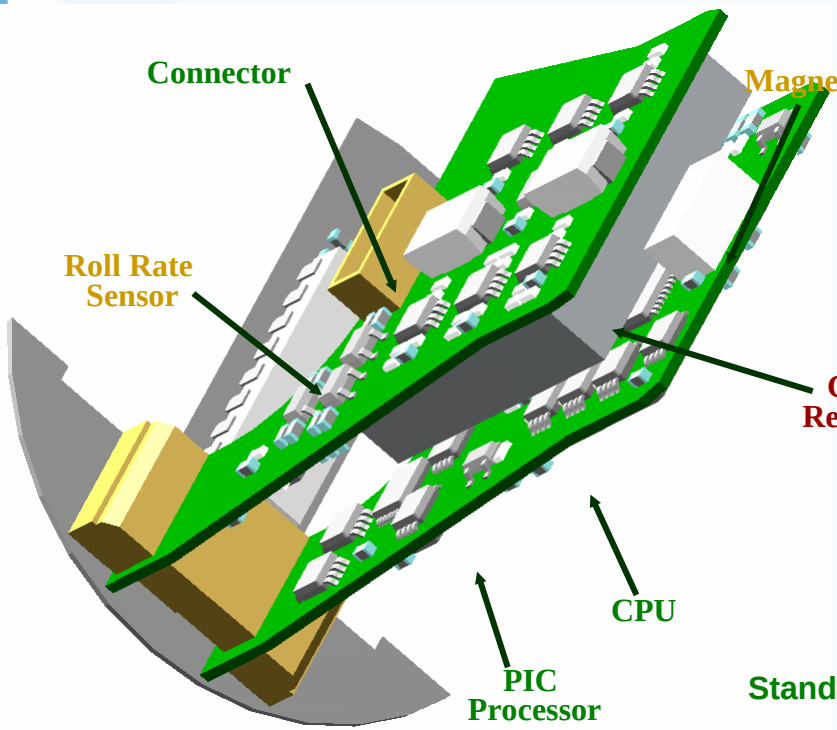


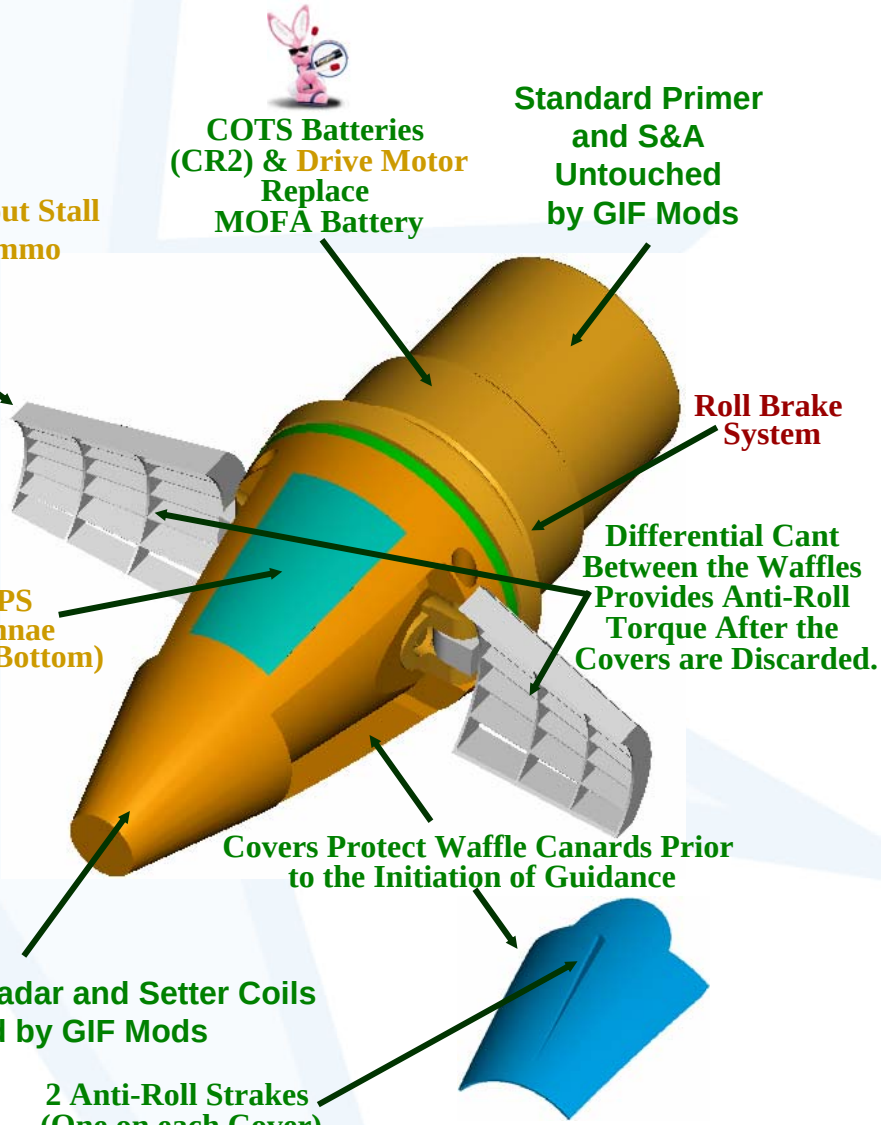
CEP vs. Range

(Major Improvements to Artillery Effectiveness)

Technology Demo: Guidance integrated Fuze (GIF)

Technical Status

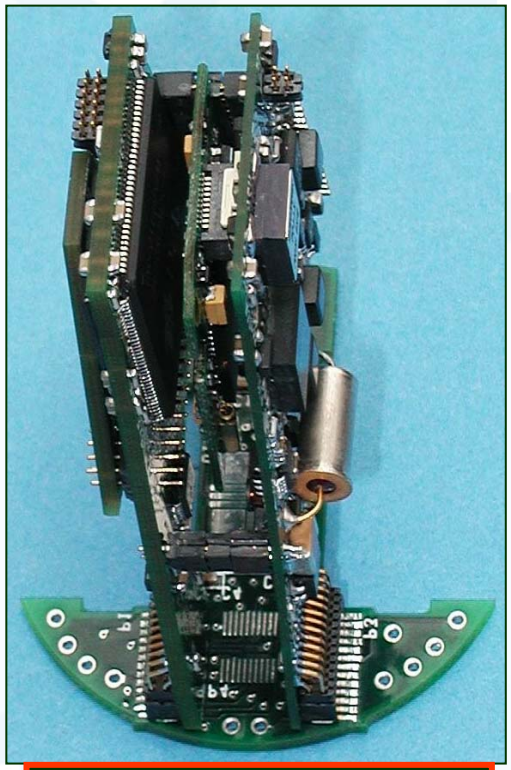




Technology Demo: Guidance integrated Fuze (GIF)

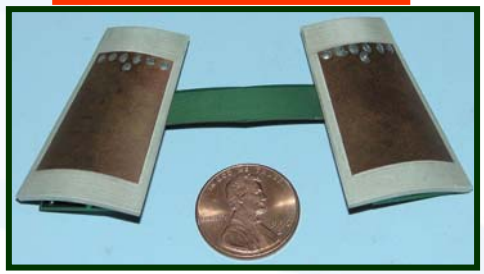
Technical Status

Roll Bearing Test Fuze with Tactical Strakes



Guidance and Electronics Unit

GPS Antennae System

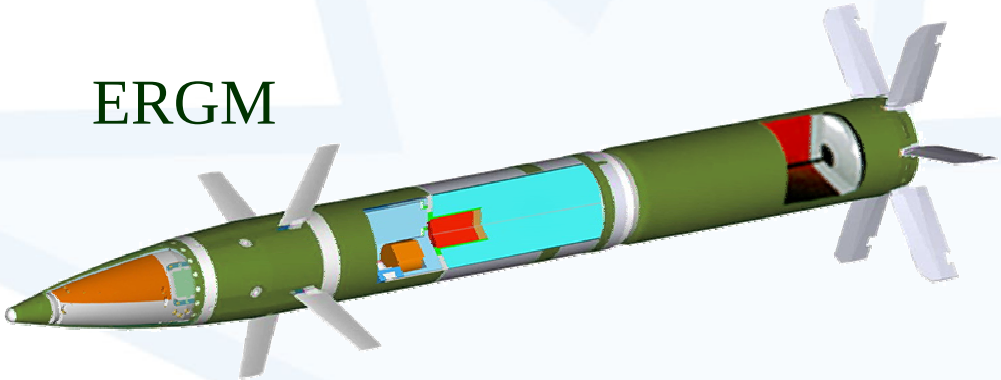


HOB/DCI Module

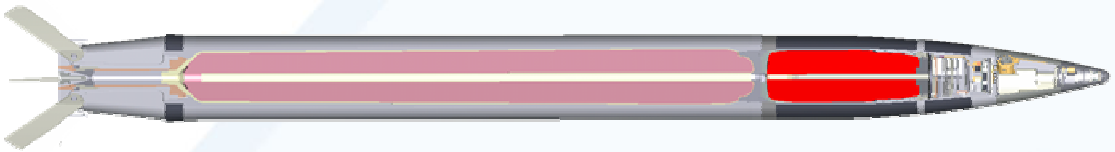
Roll Brake and Bearing Assembly

Product Improvements & Developments:
Extended Range Projectiles

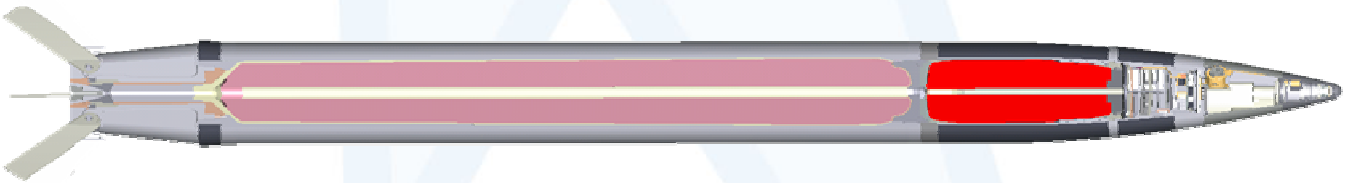
ERGM



BTERM



LRLAP



- Teams: Dahlgren, Indian Head, China Lake, Carderock, Crane & many industry partners

Anti-Swimmer Grenade (ASG)

Briefed in Session IV-B

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Program Objective

Demonstrate a depth-activated underwater device with advanced safe arm technology, selectable depth and a lethal radius of 30 feet at depths from 10 to 100 feet.

Technical Approach

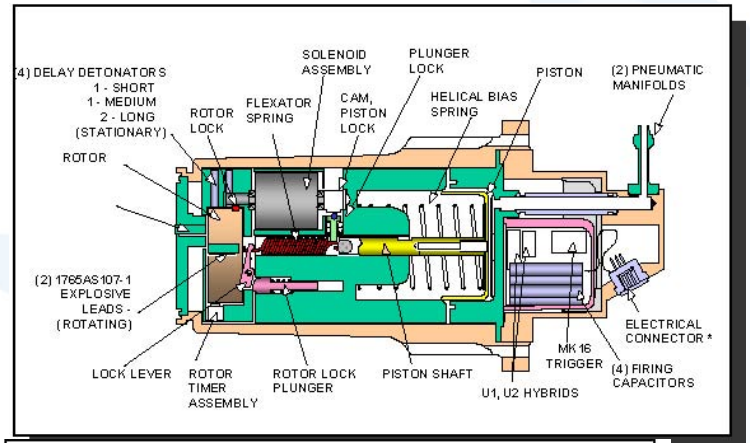
- **Operational Requirements for Underwater Port Security**
  - **Signed 31 January 2004**
- **MIL-STD-1911 compliant**
- **All electronic in-line explosive train**
  - **State-of-art guided missile fuzing technology**
- **Depth selection in ten foot increments to 100 feet**
- **Extensive use of COTS components**

Technology Reaching the Warfighter: SRAW MPV

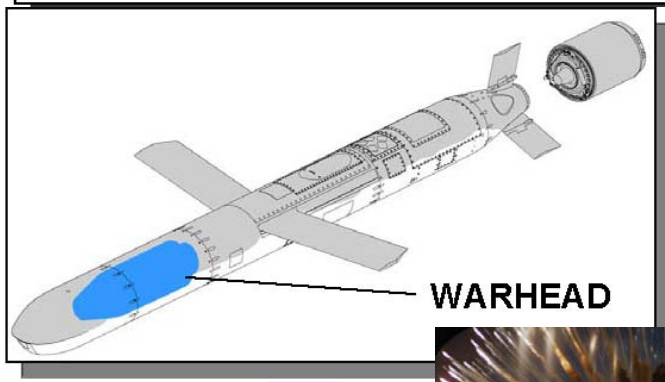
- **SRAW MPV** is a one-man portable, soft-launch from enclosure, fire-and-forget, disposable weapon. Flight module and Launcher is common with SRAW-Predator
- **MK 431 MOD 0 Fuze** was qualified, field tested and approved for use within 9 months. Zig-zag mechanism was key enhancement.

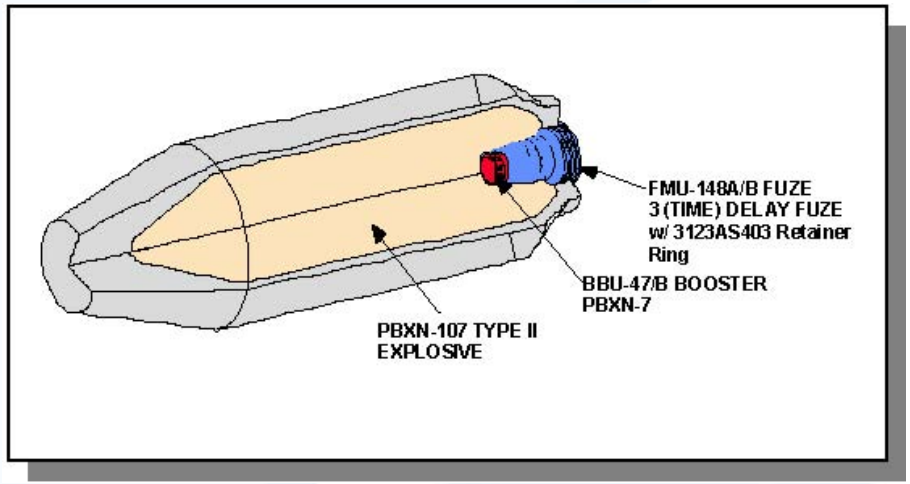
- **Status:** Fielded in February to support OIF.
- **Team:** Dahlgren, China Lake, & industry partners

Tomahawk FMU-148A/B



- **Production support**
  - **4,106 fuzes delivered**
- **Surveillance testing**





NAVY Energetics

FMU-139 Bomb Fuze Programs

- KDI Under contract for 78K FMU-139 C/B Fuzes
- ATK Under Contract for up to 50K FMU-139 C/B Fuzes
- ATK and KDI providing FMU-139 B/Bs for FMS

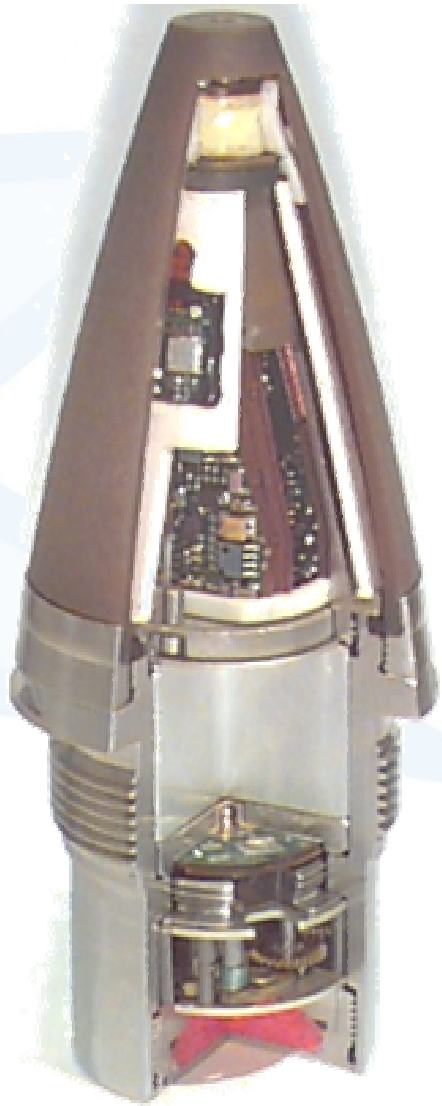
- Contract with KDI to develop, qualify and provide 100 FMU-139 C/B PIP Fuzes
  - High Reliability
  - RS-422 Communication Capability
  - In Line technology
  - Improved Penetration

JSOW FSU-26/B MAFIS Fuze

- MAFIS Fuze being modified to support JSOW BLK II, Broach and BLU-111 Configured Weapons
  - Move Connector to Fuze
  - Add Removable booster
  - Internal changes for cost reduction and enhanced survivability

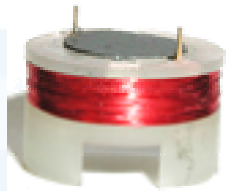
Technology Reaching the Fleet:
Multi-Function Fuze (MFF)

- 7000 MFFs in inventory
  - Gives Fleet best all-around 5” capability against all threats
  - Passed OPEVAL
  - Milestone III next month
- Ships are ready (fire control & gun mount upgrades in place)
- Team: Dahlgren, Crane, Carderock, Indian Head, China Lake, Louisville, & Port Hueneme & industry partners

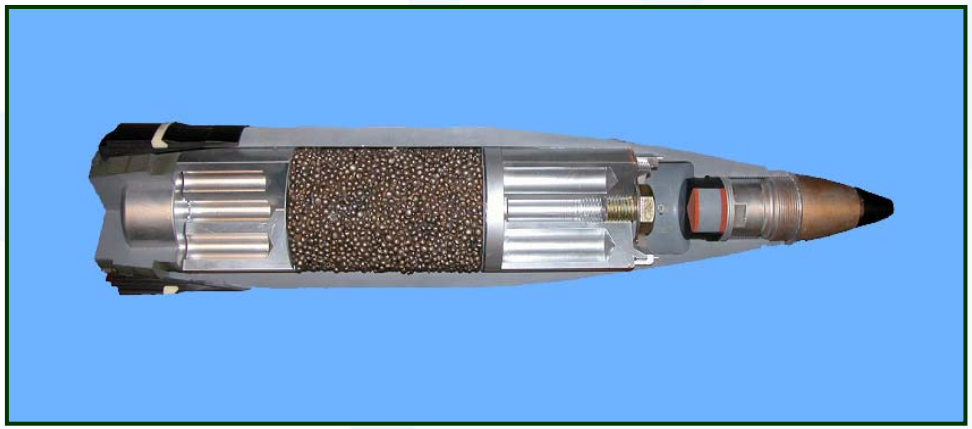


PIPs & Developments: MK 437 MOFN (PIP)

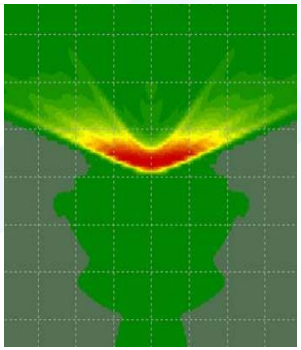
- **Navalization effort**
  - Modify inductive set software & hardware for gun setter compatibility
  - Increase timing accuracy to .01 seconds
  - Harden for Navy electro-magnetic radiation environment
- **Progress**
  - Phase I, prototypes - completed
    - Designed, built 50, tested
  - Phase II qualification - underway
    - Completion of testing end of FY05
  - Phase III Fleet integration
    - Completion by FY07
  - Production
    - Expect ~5000 fuzes per year starting in FY07
- **Team:**
  - Dahlgren, Crane, Indian Head, China Lake, Carderock, Port Hueneme, Louisville, & KDI



Technology Reaching the Fleet: Mk 432 ET Fuze on 5-Inch Shotgun (BB) & HIFRAG Rounds

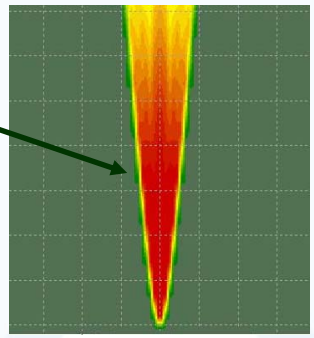


Existing HIFRAG



Twice the Lethal Area

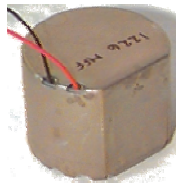
Shotgun Projectile



Status: On Deployed Ships. New production coming.

Team: Dahlgren, Crane, China Lake, Louisville, & Port Hueneme & industry partners

PIPs & Developments:
Projectile Fuze Power Supply PIP



- **Objective**
  - Develop battery to replace MFF's lead acid battery
- **Approach**
  - Investigate three existing battery designs
- Tested 80 from both ATK and Thales and limited samples from Diehl/EP

- **Conclusion**
  - Do not buy Mod-MOFA-2
    - Poor performance, although capacity problems were solved
  - Buy Thales
  - Wait and see if Diehl/Eagle-Picher 5x2 battery can perform as well as Thales
    - D/EP possible 2nd source with improved reliability against accidental activation during storage and handling
- **Team**: Dahlgren, Carderock, Crane, ARL, Thales, ATK, Diehl/Eagle-Picher

Production/In-Service Support

Quality Evaluation

- HARPOON, SLAM-ER , AMRAAM, TOMAHAWK, SIDEWINDER, ESSM, STANDARD, RAM, MAVERICK, HARM, CHAPPARAL, Navy Ammunition Gun Fuzes
- Evaluates stock pile for degradation due to aging, environment and handling
- Evaluate and recertify fuzes for use in special testing
- Evaluate materials prior to FMS sales

Production/In-Service Support

Lot Acceptance Efforts

- HARPOON, SLAM-ER,M1134A4 FUZE TOMAHAWK, STANDARD
- Provides independent Laboratory assessment of manufactured fuzes
- Maintains data in government to provide starting point for Quality Evaluation analysis
- Provides hands on experience to keep government as a smart buyer for fuzes.

Summary

The Path Forward …

The Navy's Fuze Team, under the umbrella of the Navy Energetics Enterprise, have combined resources to provide the Warfighters of today and tomorrow a full-spectrum Fuzing capability …from basic technology to in-service engineering and fleet support

- Navy Laboratories working together
  - Combined Expertise
  - Cost-Wise Efficiency
- Unequaled combination of capabilities and facilities to provide cradle-to-grave support of the Navy's Weapons
- Actively teaming with Industry & Academia