NDIA's 55th Annual Fuze Conference
NAVY OVERVIEW

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Outline

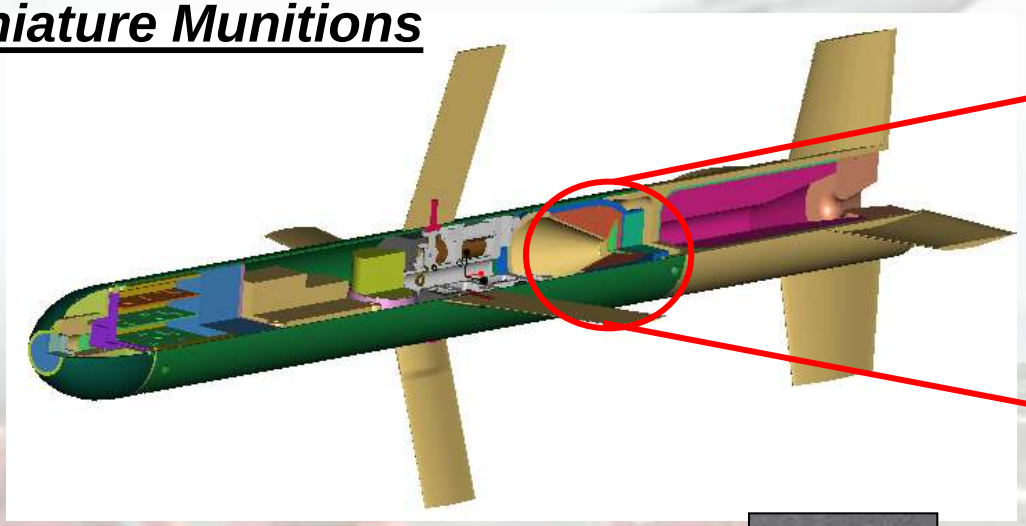
- Navy Fuze S&T Strategy
- Navy Fuzing Future Directions
- Navy Fuze Work Highlights
- Summary

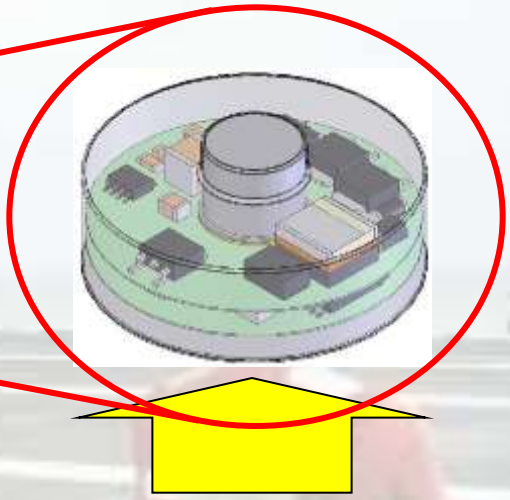
Navy S&T Strategy

- **Less of a formal Strategy, but more of a fuzing path into the future**
  - **Smaller - We really see that fuzing is heading in the direction of smaller is better.**
    - **Weapons are getting smaller and smaller sizes allow for redundancy to help reliability.**
  - **Reliability - Higher reliability is also a big player for Navy fuzing. Sub-munitions have very high reliability expectations and more traditional fuzing is also wanting higher reliability.**
  - **Lower Cost - With budgets falling, the pressure is on to make all weapons and weapons systems cost less.**

Navy Future Directions

Miniature Munitions

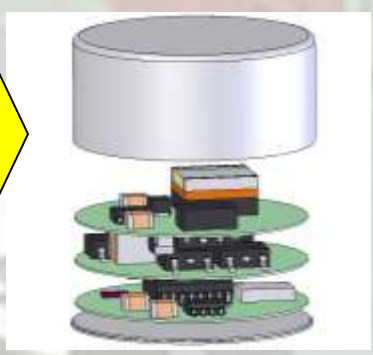




State-of-the-Art
In-Line & Out-of-Line
Safe-Arm Devices

Large and bulky
Electro- Mechanical
Safe-Arm Devices

Complex Electro- Mechanical
Safe-Arm Devices

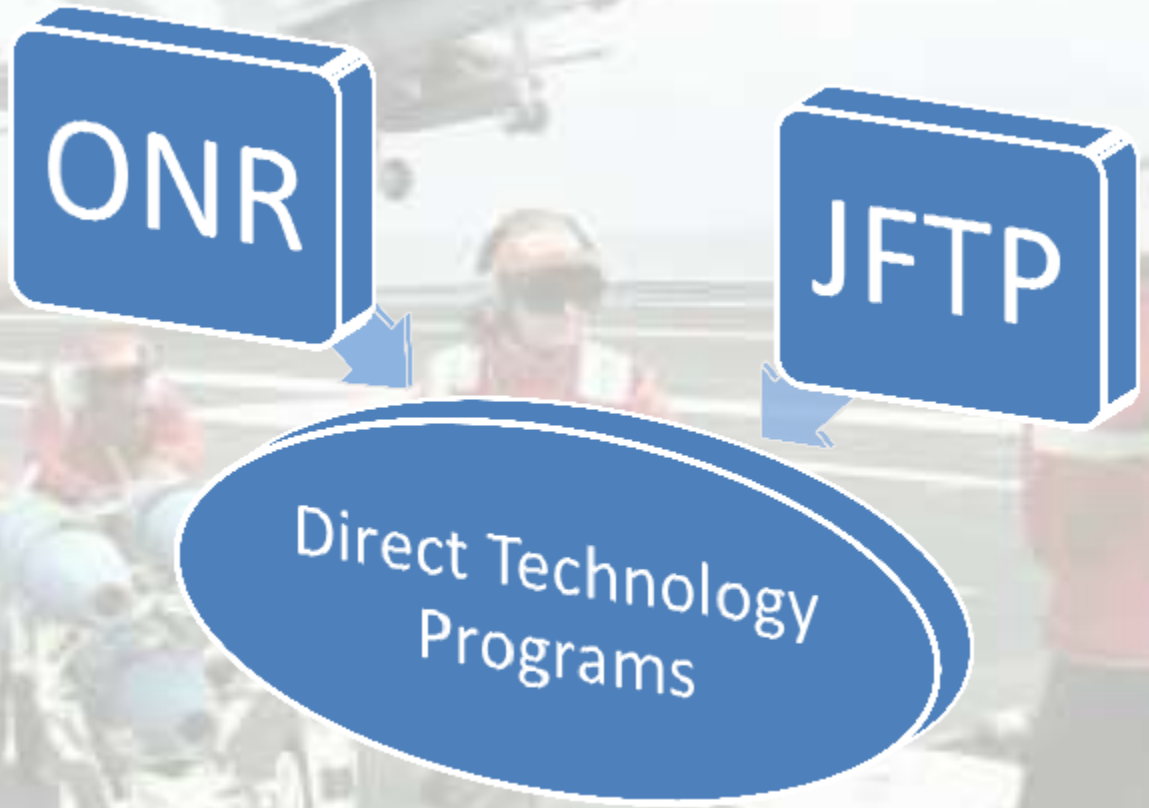


Advanced MEMS and
Electronic Technologies

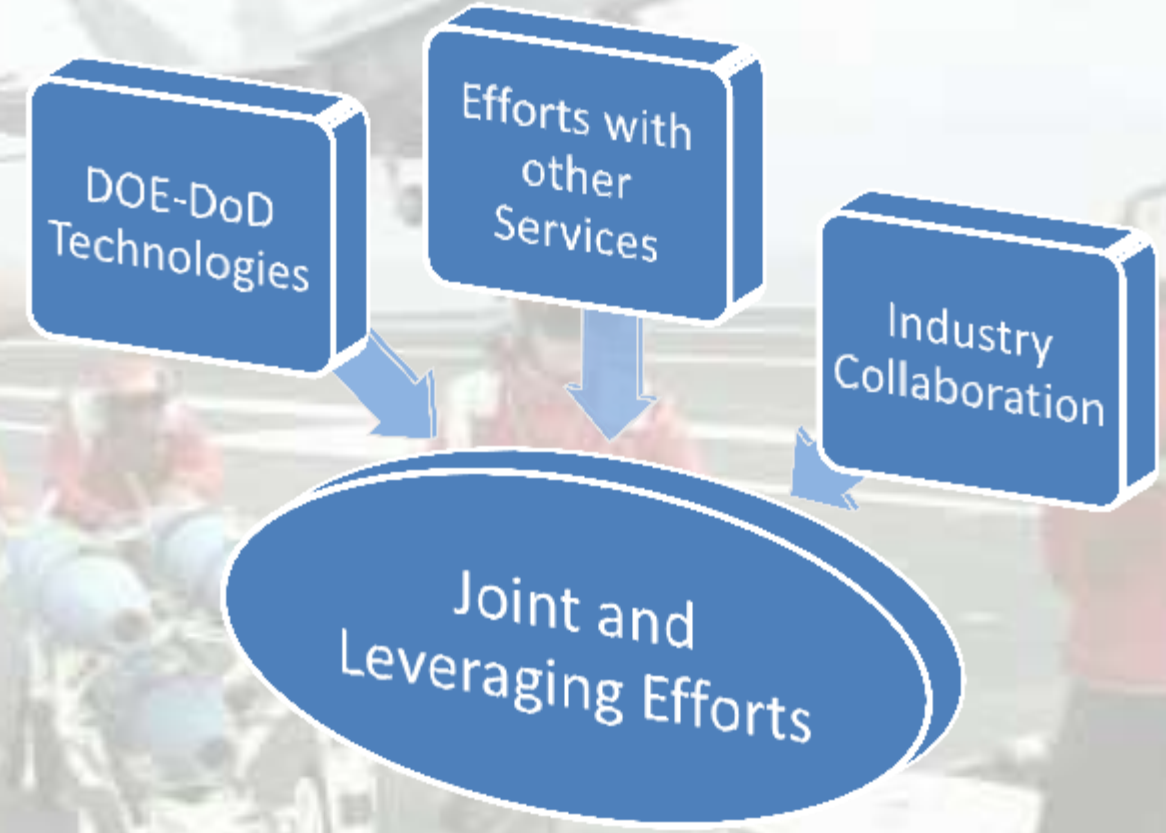
How Will We Get There?

- Smaller and more reliable and robust electronics and power conditioning technologies.
  - Improved reliability across all fuze applications.
- Improved detonator/initiator designs and components.
  - Improved IM and variable output weapons characteristics.
- Improved MEMS Technologies and producible MEMS designs.
  - Smaller and more robust fuzing application.
  - New families of contact sensors and fuzing devices
- Leverage spiral development of existing fuzes.
  - Improved reliability and capability.
  - Stop-gap to help support fuzing industry.
  - Demonstration beds for new technologies.
- Service life extension programs for existing fuze inventories.

Navy Tech Money Sources

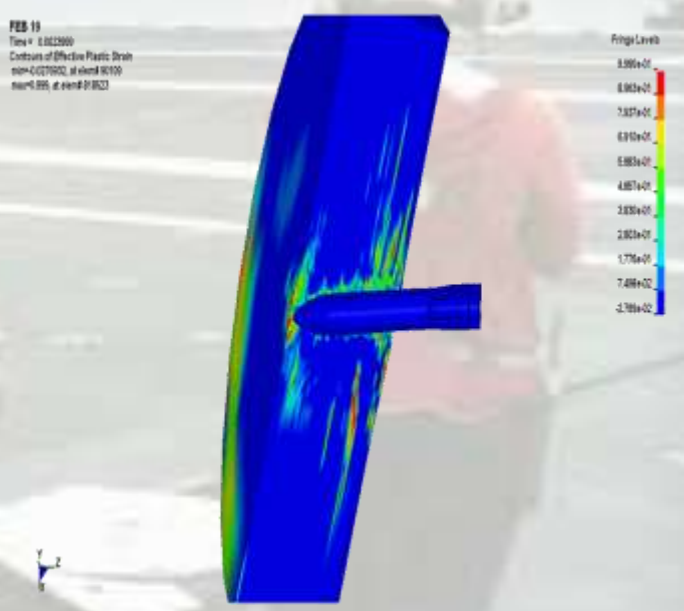


Navy Tech Money Sources



Dynamic Impact Simulation of Deceleration Pulse for Void Sensing Fuzes

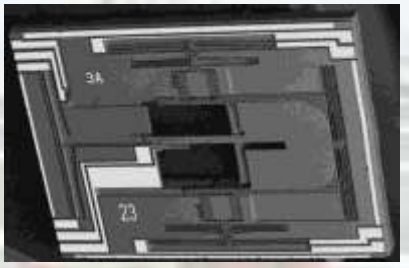
- Evaluation of latest LS-DYNA Impact Simulation Software
- Creating LS-DYNA input templates for hard target penetration application
- Impact deceleration, stress & strain calculated for penetrator Fuzes
- Results compared to NAVAIR cannon and sled test data

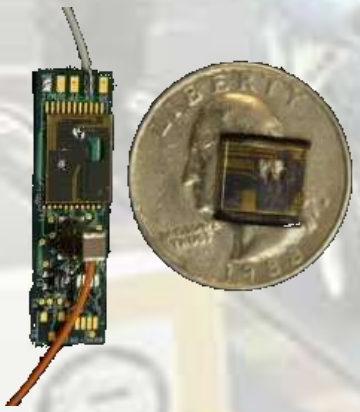


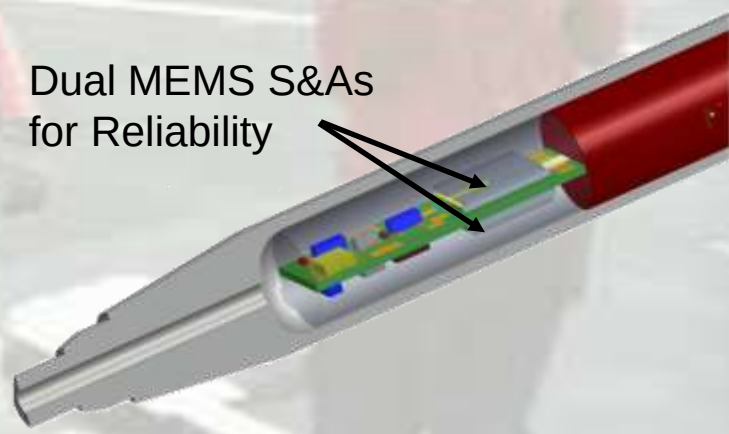
Open Session IVB Briefing provided by Dr. Paul Glance

MEMS Fuzing for High Reliability Systems

- Development of G-hardened miniature Fuze component technology mine defeat penetrator application
  - Silicon on Insulator (SOI) MEMS S&A
  - Micro detonator
  - MEMS initiator
  - Low-cost miniature fire-set



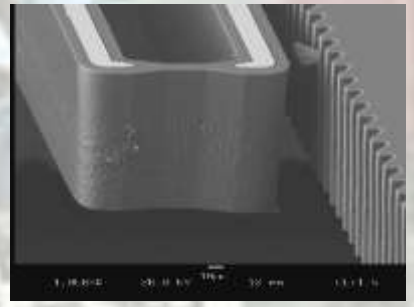




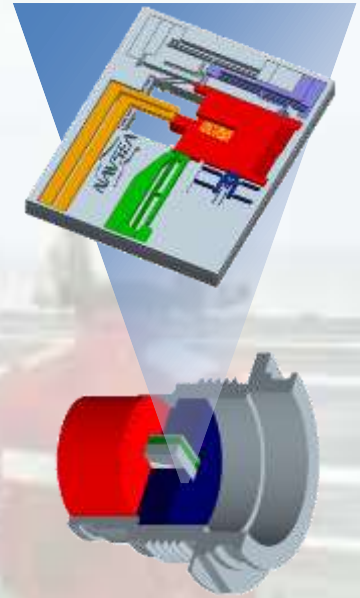
A Versatile Explosive Train Integrated into a MEMS S&A Device

- Development of integrated initiation and explosive train component technology for MEMS based S&A application
- Developed for small volume applications turning tight corners
- Employs Cl-20 based explosives RSI-007 & EDF-11 ink

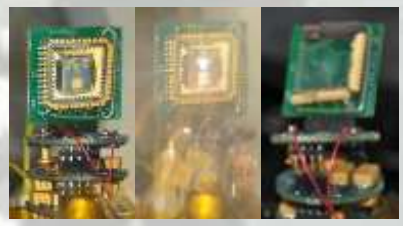
Vaporization of an IHDIV MEMS initiator



Navy MEMS Fuze For Marine Corp Flight Control Mortar



- S&A for 81 mm Precision Urban Mortar Attack (**PUMA**) – Future Naval Capability (FNC)
  - Joint Navy / Army S&T system development
  - Supports Marine Corps Conventional Weapons (CW) Science & Technology Objectives
  - System demonstration in FY14
- MEMS based S&A



MEMS Retard & Impact Sensors

- ***Objective: Obtain DoD retard and impact sensors with precision, reliability, producibility and cost effectiveness by exploiting existing MEMS microfabrication and packaging technologies***
- ***Traditional coilspring-mass technology:***
  - *Wide performance variability per mechanical spring tolerances*
  - *Difficult to precisely sense low G's with "macro world" springs*

- ***MEMS technology appears well-suited for making improved low-G sensors per DoD exploratory work to date:***
  - *NAWCWD: precision-electroplated G-sensors*
  - *NSWCIH: silicon G-sensors and packaging*
  - *ARDEC: metal G-sensors and packaging*

Illustration and Photograph Courtesy of NAWCWD

- ***FY11 Focus: low-G impact sensors (<100G) & very low-G retard sensors (<5G)***

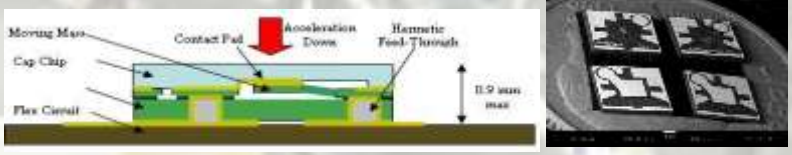


Illustration and Photograph Courtesy of NSWCI

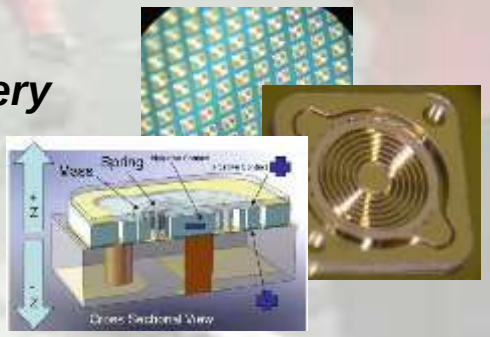
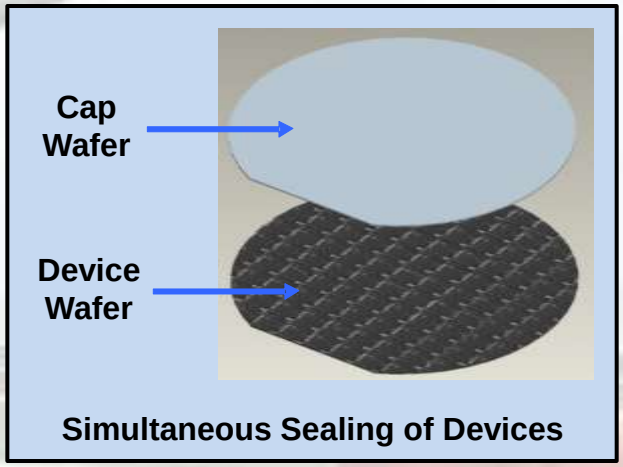


Illustration and Photographs Courtesy of ARDEC

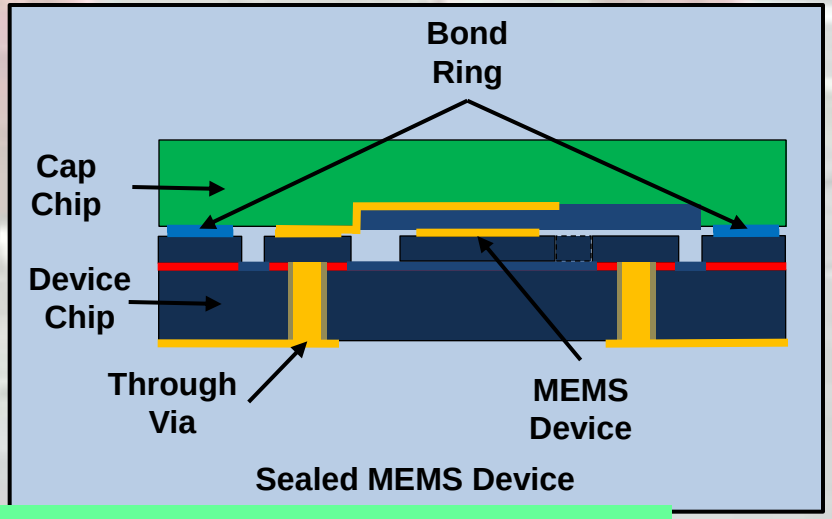
Closed Session VB Briefing provided by Mr. Walt Maurer

Wafer Level Packaging for High Aspect Ratio MEMS

- Develop wafer level packaging techniques that are applicable to high-aspect ratio MEMS devices
  - Wafer bonding
  - Through vias
- Improved reliability and safety of MEMS components in the fuze, including sensors and / or the MEMS S&A chip
- Increased throughput (2 orders of magnitude) and yield of the MEMS manufacturing process
- Lower cost components (submunition applications)



Simultaneous Sealing of Devices

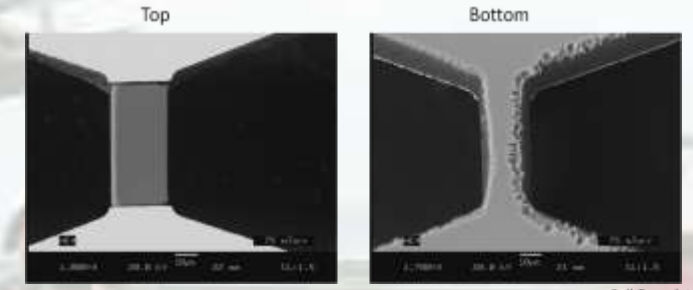


Sealed MEMS Device

Open Session VA Briefing provided by Mr. Kevin Cochran

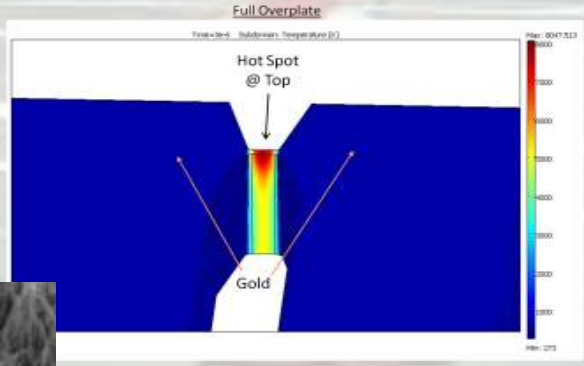
Enhanced Performance of MEMS Electric Initiators

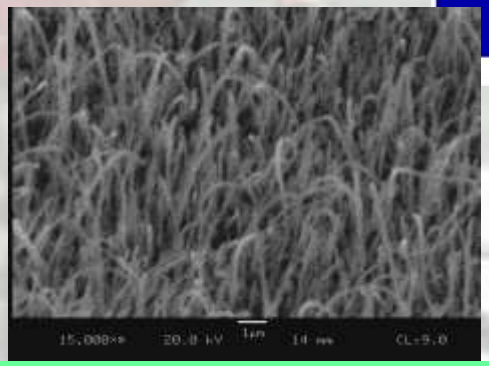
- Increase the output of an initiator that can be easily integrated into a MEMS fuze to maximize micro-detonator output
  - Replaces low performance energetic
  - Prompt initiation (< 2µs)
  - Low power (< 1mJ)
  - Highly uniform fabrication
- Understand differences between reactive material bridge as compared to simple metal/silicon
- Provides compact, safe and low energy S&A for distributed multipoint initiation systems.



DRIE of Si Bridge

Model Hot Spots



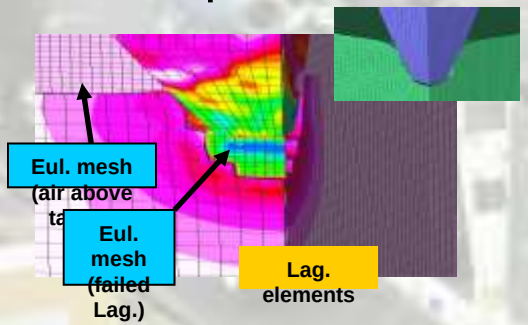


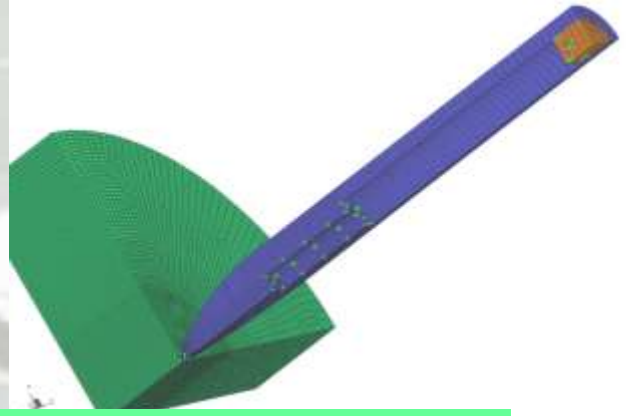
RM Nanowires

Open Session VA Briefing provided by Mr. Daniel Pines

Improving Fuze Environment Prediction During Hard Target Penetration Using A Coupled-Code Erosion Technique

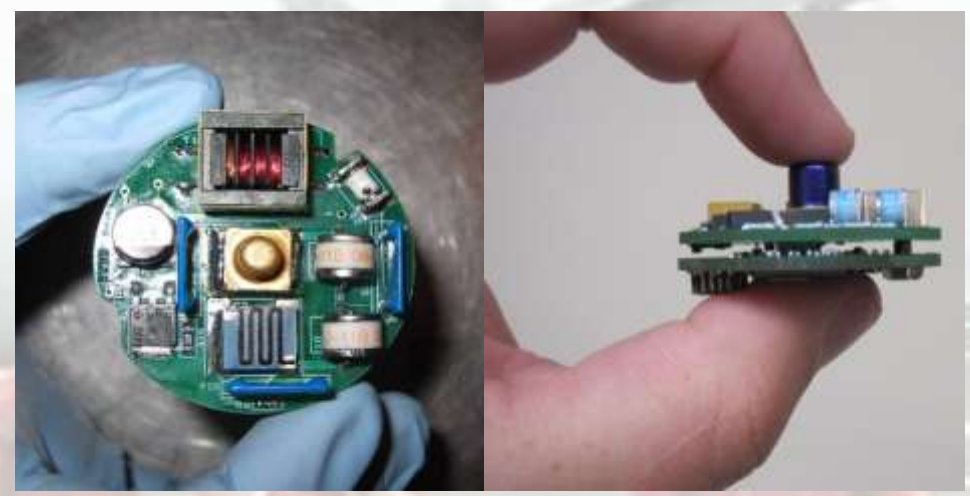
- Development of Element Deletion – Material Donation (EDMD) Erosion technique to improve prediction of forces experienced by fuzing components during hard target penetration
  - Replace artificial void with real target material
  - Reduce “numeric” noisy in fuze region
  - Prevent tensile failure of elements next to failed element
  - Avoid small time steps that stop the calculation
  - Overall improvement of HT Fuzing M & S

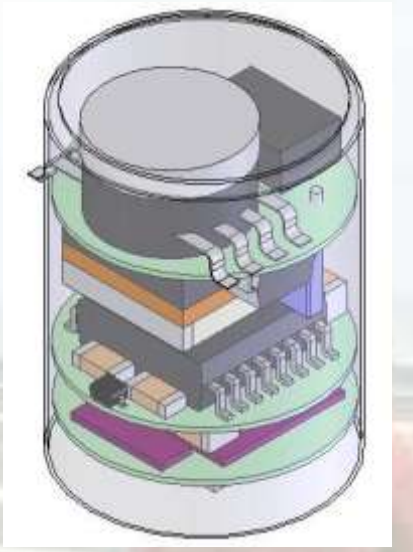




Closed Session IVB Briefing provided by Mr. Sean Tidwell

Low-Cost Miniature Electronic Safe-Arm Device (ESAD)





2.0 in^{3*}
(Demonstrated)

1.1 in^3

0.44 in^3
(Near Future)

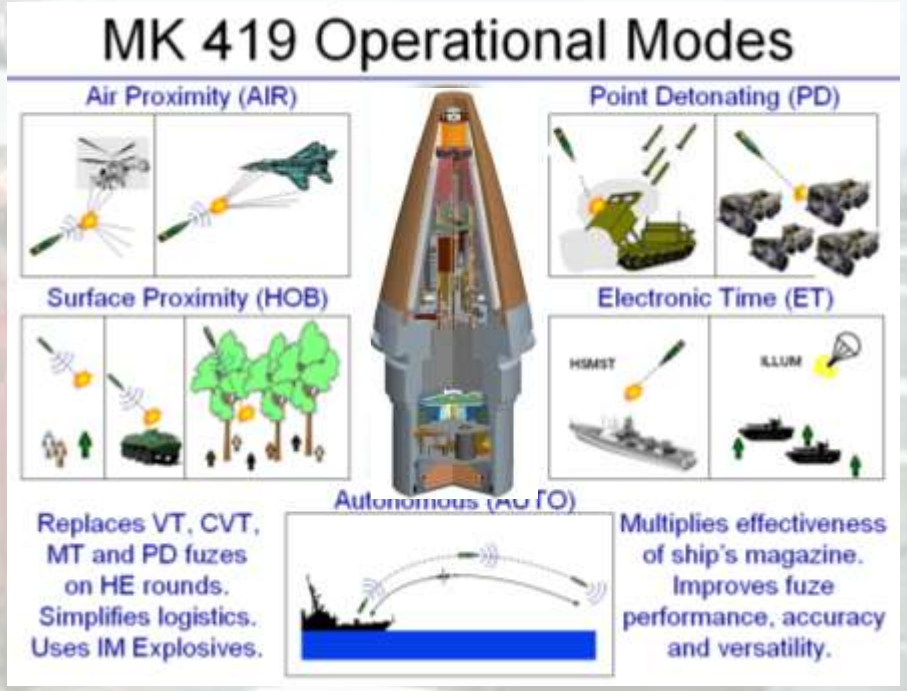
- All COTS components
- Production Low Energy Exploding Foil Initiator (LEEFI)
- Fuze safety board recommended 3-interrupter architecture
- Very low cost high-voltage switch
- Parts cost for this architecture ~ $260 (1000 unit pricing)

***has now had 4 successful flight tests where the ESAD functioned flawlessly**

Open Session VA Briefing provided by Mr. Michael Haddon

MK419 Mod 1 Multi-Function Fuze Product Improvement Program

- **The MK 419 Mod 1 Multi-Function Fuze fits 76 mm and 5 inch AURs.**
- **The PIP goal was to reduce cost.**
- **Major cost drivers:**
  - **Cheaper electronic components.**
  - **Smaller footprint of electronic devices.**
  - **Configuration modification for efficient manufacturing.**
  - **Sophisticated assembly techniques to reduce cycle time.**



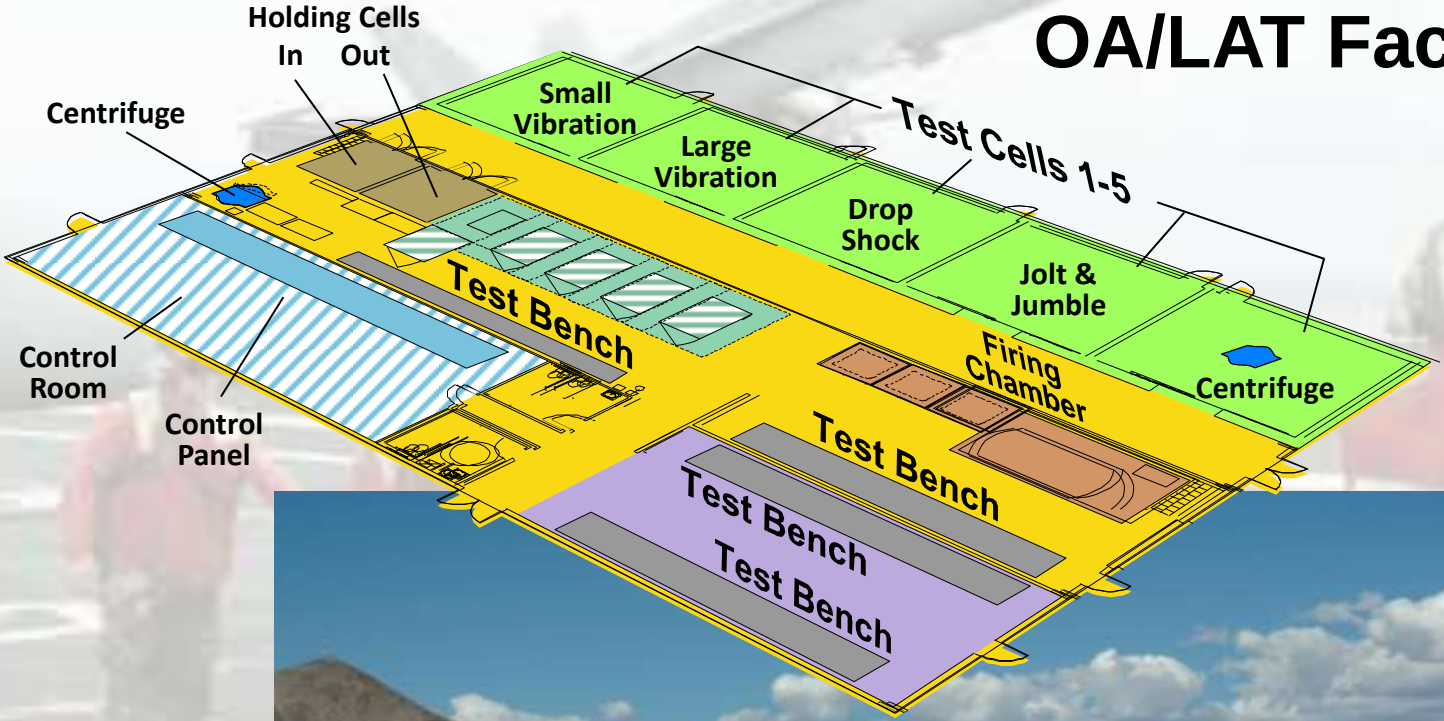
Open Session IVA Briefing provided by Mr. Richard Chapman

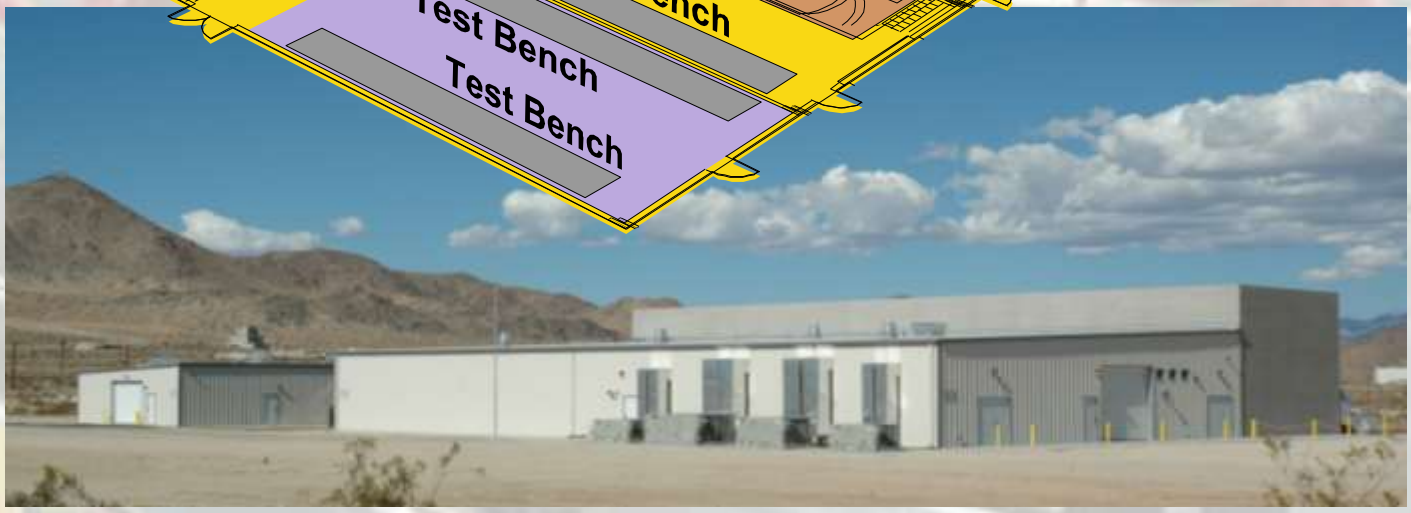
Near-Term Trends for Navy Fuzing

- Potential cost effective approaches for fuzes.
  - Leverage spiral development of existing fuzes.
  - Refurbish existing inventories.
  - Modify existing inventories to meet new requirements.
  - Demonstration beds for new technologies.
- Service life extension programs for existing fuze inventories.
  - Increase Ordnance Assessment (OA) Activities
  - Establish Ordnance Health Assessment program
- New State-of-the- Art Fuze Assessment Test Facilities
  - Modern multi-fuze test sets and data acquisition

New Navy Fuze Capabilities

OA/LAT Facility





Summary

Smaller, More Robust, Higher Reliability and Lower Cost fuze designs are future thrusts for future Navy Fuzing