NDIA
AT THE HEART OF THE MISSION



64TH ANNUAL FUZE CONFERENCE

Continued Fuze Advancements amid a Global Pandemic

May 11 – 12, 2021 | NDIA.org/Fuze21

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WHO WE ARE

The National Defense Industrial Association is the trusted leader in defense and national security associations. As a 501(c)(3) corporate and individual membership association, NDIA engages thoughtful and innovative leaders to exchange ideas, information, and capabilities that lead to the development of the best policies, practices, products, and technologies to ensure the safety and security of our nation. NDIA's membership embodies the full spectrum of corporate, government, academic, and individual stakeholders who form a vigorous, responsive, and collaborative community in support of defense and national security. For more than 100 years, NDIA and its predecessor organizations have been at the heart of the mission by dedicating their time, expertise, and energy to ensuring our warfighters have the best training, equipment, and support. For more information, visit **NDIA.org**

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LEADERSHIP

Thomas Harward
Committee Chair

Nassir Alaboud
Committee Vice Chair

Perry Salyers
Committee Secretary

MUNITIONS TECHNOLOGY
FUZE SECTION

WHO WE ARE

The Munitions Technology Division works to maintain the open exchange of technical information among government and industry programs and technical managers. In addition, the Division identifies changes and trends in policy, guidance, and organizational functions that affect the development, production, maintenance, and demilitarization of munitions.

The Fuze Section aims to promote an open exchange of technical information among government and industry personnel, and to identify and address changes in standards, guidance, policy, and organizational functions that impact the development, production, and performance of fuzes.

WELCOME TO THE 64TH ANNUAL FUZE CONFERENCE

On behalf of NDIA and the Fuze Conference Steering Committee, I would like to welcome you to NDIA's second virtual Fuze event: The 64th Annual Fuze Conference. This international conference brings together the work of top fuzing professionals from government, private industry, and academia, and provides an opportunity for the exchange of the latest research and development on fuzing—all with the common goal of improving safety, capability, and reliability for our warfighters. We have a thrilling keynote scheduled and will keep the conference's signature science and technology sessions. Through the ongoing passionate work of the presenters, sponsors, exhibitor, and attendees of this conference as well as across our worldwide defense industry, new challenges will be overcome, resulting in safer, more reliable fuzes being fielded to our warfighters.

Thomas Harward
Chair, Fuze Committee, Munitions Technology Division, NDIA
Engineering Fellow, Lead Technologist, and Chief Engineer, Raytheon Technologies

SCHEDULE AT A GLANCE

TUESDAY, MAY 11

General Session
10:00 am – 12:15 pm

Networking Break
12:15 – 12:35 pm

General Session
12:35 – 3:30 pm

WEDNESDAY, MAY 12

General Session
10:00 am – 12:20 pm

Networking Break
12:20 – 12:40 pm

General Session
12:40 – 3:40 pm



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- Low inductance
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EVENT INFORMATION

SURVEY AND PARTICIPANT LIST

You will receive via email a survey and list of participants (name and organization) after the conference. Please complete the survey to make our event even more successful in the future.

EVENT CONTACTS

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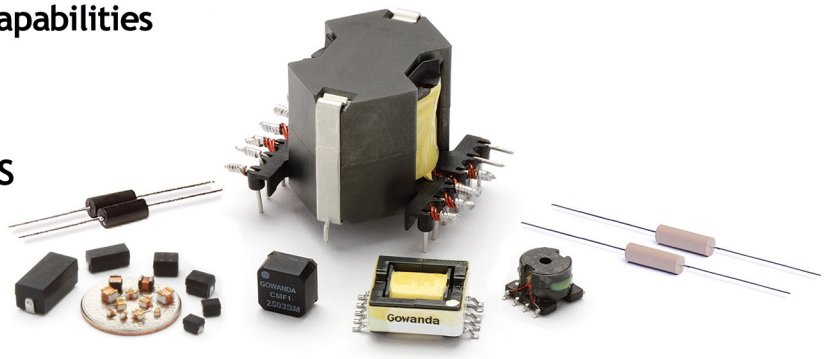
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AGENDA

TUESDAY, MAY 11

10:00 – 10:05 am
All times listed in EDT

OPENING AND ADMINISTRATIVE REMARKS

Thomas Harward
Engineering Fellow, Lead Technologist, and Chief Engineer, Raytheon Technologies

10:05 – 10:15 am

NDIA OPENING REMARKS

MG James Boozer, USA (Ret)
Executive Vice President, National Defense Industrial Association

10:15 – 10:45 am

KEYNOTE SPEAKER

Charles "Chuck" A. Kelly
Senior Munitions Analyst and Portfolio Manager, Office of the Secretary of Defense

10:50 – 11:15 am

U.S. ARMY AVIATION & MISSILE CENTER S&T STRATEGY

Mark Etheridge
Electronics Engineer, Fuzing & Ignition Systems, Aviation & Missile Center,
U.S. Army Combat Capabilities Development Command

11:20 – 11:45 am

U.S. NAVY S&T STRATEGY

John D. Hughes
Electronics Engineer, Weapons Division, Naval Air Warfare Center

11:50 am – 12:15 pm

U.S. AIR FORCE S&T STRATEGY

George Jolly
Technical Advisor, Air Force Research Laboratory

12:15 – 12:35 pm

NETWORKING BREAK

12:35 – 12:55 pm

DESIGN OF A TEST METHODOLOGY TO SIMULATE RAIN ENVIRONMENTS

Richard Johnson
Mechanical Engineer, Armaments Center, U.S. Army Combat Capabilities Development Command

1:00 – 1:20 pm

WIRELESS POWER TRANSMISSION AND COMMUNICATION FOR REMOTE FUZING

Thomas Hartmann
Research & Development Engineer, Sandia National Laboratories

Ian Sobering
Senior Member, Technical Staff, Sandia National Laboratories

1:25 – 1:45 pm

OPTICALLY CHARGING AND COMMUNICATING WITH AN ELECTRONIC ASSEMBLY

Mark Onuigbo
Senior Member, Technical Staff, Sandia National Laboratories

Thomas Hartmann
Research & Development Engineer, Sandia National Laboratories

1:50 – 2:10 pm

HIGH SHOCK MODELING OF FUZE COMPONENTS

Chris Cao
Mechanical Engineer, Naval Surface Warfare Center – Indian Head Division

2:15 – 2:35 pm

BINARY TRIAL AND STATISTICAL ANALYSIS METHODS FOR ELECTRO-EXPLOSIVE DEVICE CHARACTERIZATION

Ashley de Lotz
Senior Initiation Systems Engineer, Defence Ordnance Safety Group

Michael Hicks
Statistical & Mechanical Modelling & Simulation Specialist, Defence Ordnance Safety Group

2:40 – 3:00 pm

DETONATION TRANSFER RELIABILITY – AXIAL AND ANGULAR ALIGNMENT EVALUATIONS USING A NEYER STATISTICAL SENSITIVITY APPROACH

David Pray
Energetic Components Engineer, Excelitas Technologies

3:05 – 3:25 pm

EXPLODING FOIL INITIATOR DEVELOPMENT

David Pray
Energetic Components Engineer, Excelitas Technologies

3:25 – 3:30 pm

CLOSING REMARKS

Thomas Harward
Engineering Fellow, Lead Technologist, and Chief Engineer, Raytheon Technologies



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WEDNESDAY, MAY 12

10:00 – 10:05 am

OPENING AND ADMINISTRATIVE REMARKS

Thomas Harward
Engineering Fellow, Lead Technologist, and Chief Engineer, Raytheon Technologies

10:05 – 10:30 am

U.S. ARMY ARMAMENTS CENTER S&T STRATEGY

Robert Alston
Electronics Engineer, Fuze Division, Armaments Center, U.S. Army Combat Capabilities Development Command

10:35 – 11:00 am

SANDIA NATIONAL LABORATORIES CAPABILITIES AND MISSION

Shane Curtis
Senior Staff Member, Sandia National Laboratories

11:05 – 11:30 am

DOD JOINT FUZE TECHNOLOGY PROGRAM

Lawrence Fan
Fuze Program Manager, Explosive Ordnance Disposal Technology Division,
Naval Surface Warfare Center – Indian Head Division

11:35 – 11:55 am

SENSING FOR SMALL UNMANNED SYSTEMS

Caitlyn May
Sensing for Small Unmanned Systems, Naval Sea Systems Command,
Naval Surface Warfare Center – Indian Head Division

12:00 – 12:20 pm

NOVEL 2ND ENVIRONMENT SENSOR FOR NEXT-GENERATION WEAPONS

Matthew Grubbs
Design Engineer, L3Harris, Fuzing and Ordnance Systems, Inc.

12:20 – 12:40 pm

NETWORKING BREAK

12:40 – 1:00 pm

LOW VOLTAGE POLYMER MULTI-LAYER CAPACITOR DEVELOPMENT AND CHARACTERIZATION

Joshua Dye
Electrical Engineer, Sandia National Laboratories

1:05 – 1:25 pm

NEW FUZING SOLUTIONS FOR IMPROVED SAFETY AND OPERATIONAL CAPABILITIES

Max Perrin
Chief Technical Officer, JUNGHANS Defence

1:30 – 1:50 pm

CANNON CALIBER FUZE SETTER OVERVIEW

Tyler Wilson
Electronics Engineer, U.S. Army

1:55 – 2:15 pm

HIGH VOLTAGE FIRESET COMPONENT BEHAVIOR AT ELEVATED TEMPERATURES

Chris Cao
Mechanical Engineer, Naval Surface Warfare Center – Indian Head Division

2:20 – 2:40 pm

EFFECTS OF ORIENTATION & BOUNDARY CONDITION ON ENCAPSULATED ELECTRONICS

Caleb White
Research & Development Mechanical Engineer, Sandia National Laboratories

2:45 – 3:05 pm

CONFORMAL ANTENNA DESIGN FOR PROXIMITY FUZES

Dr. Simsek Demir
Chief Executive Officer, PRF Research and Development, Inc.

3:10 – 3:30 pm

SOFTWARE DEFINED RADIO FOR MEDIUM CALIBER APPLICATIONS

Viktor Bana
Electronics Engineer, Armaments Center, U.S. Army Combat Capabilities Development Command

3:30 – 3:40 pm

CLOSING REMARKS

Thomas Harward
Engineering Fellow, Lead Technologist, and Chief Engineer, Raytheon Technologies

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BIOGRAPHY



CHARLES "CHUCK" A. KELLY

Senior Munitions Analyst and Portfolio Manager
Office of the Secretary of Defense

Chuck Kelly is a weapon systems acquisition manager with over thirty-six years of experience in the Department of Defense (DoD) including military service and civil service in acquisition management. He is the Acting Director for Surface Warfare in Platform and Weapon Portfolio Management within the Office of Acquisition and Sustainment. In this position, he manages all capability portfolios within Land and Naval Warfare. He is the lead for the DoD Munitions Requirement process that produces the inventory requirements for all DoD munitions across the Military Services and the United States Special Operations Command. He also serves as the DoD Fuze Integrated Product Team Tri-Chair and an Executive Committee member of the Joint Ordnance Commanders Group.

Prior to service in the Office of the Secretary of Defense, in 2003, as a United States Marine Corps aviator, LtCol Kelly served as the Joint Staff's Force Application Land/ Special Operations Forces Section Branch Chief. LtCol Kelly held numerous leadership, staff and operational billets, as the: Operations Officer and Officer in Charge of the 4th Marine Aircraft Wing, Marine Aviation Support Detachment; Air Launched Strike Weapons Requirements Officer in the Office of the Chief of Naval Operations, Air Warfare Directorate; Squadron Training Officer and Flight Instructor at the Marine Corps' Fighter Attack Squadron (VMFAT 101); and deployed as a Forward Air Controller with the Marine Corps 3rd Battalion 2nd Marines in Operation Desert Shield/Desert Storm.

Mr. Kelly holds a Bachelor of Science degree with Iona College in New Rochelle, New York and is Defense Acquisition University certified Level III in Program Management. He was also certified as a Marine Corps instructor in the areas of Air Combat, Weapons and Tactics, and Night Tactics being a graduate of both the Navy Weapons Fighter School and the Marine Corps Weapons and Tactics Instructor Course.

Mr. Kelly's achievements include a Navy and Marine Corps Achievement Medal, two Navy and Marine Corps Commendation Medals, a Meritorious Service Medal, a Defense Meritorious Service Medal, an Office of the Secretary of Defense Award for Excellence and two Office of the Secretary of Defense Medals for Exceptional Civilian Service.

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Defense Electronic Systems (DES), a division of L3Harris, provides precision electronic components, subsystems, and systems for the DOD and international allies. DES specializes in the design and manufacture of fuze solutions, ignition safety devices, proximity sensors, inertial measurement and GPS navigation systems, aerospace status indicators, intelligence management systems, and radar-based threat detection technologies.

Headquartered near Cincinnati, Ohio, DES' primary manufacturing facility was specifically designed and constructed for the manufacture of fuzing and ordnance systems and precision electronic components. With additional locations in Anaheim, CA, Budd Lake, NJ, Orlando, FL, and San Diego, CA, DES has strategically positioned its resources, including program management, engineering, and quality assurance, at each site to ensure complete adherence to programmatic and technical requirements.

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Engage - At Excelitas, we engage with our customers in collaborative engineer-to-engineer relationships. Our photonic solutions teams are involved early in our customers' design cycles, helping them to accelerate time to market and secure unique technological differentiators and ensure barriers to entry for their competitors.

Enable - With our extensive integration expertise and diverse photonics technology portfolio, we enable a broad range of innovations and applications including clinical diagnostics, autonomous vehicles, surgical visualization, X-ray security screening, smart home systems, additive manufacturing, IOT products, scientific discovery, semiconductor equipment, medical device assembly, defense and aerospace applications.

Excel - Our customized, market-driven solutions for each of our OEM customers' unique system requirements — coupled with a focus on excellence in all aspects of product performance, quality, reliability, delivery and service — enable our customers to excel in their end-markets and applications.

EXHIBITOR

knowles
PRECISION DEVICE

Novacap, a Knowles Precision Devices Brand, features high temperature, high energy capacitors designed for reliable operation under single or multiple pulse firing applications. Energy density exceeds that of conventional Class 1 materials, providing excellent short duration pulse delivery at temperatures to 200°C. Integral bleed resistors are offered in a range of values.

Capacitors are 100% tested to application tailored, Novacap high reliability screening and evaluated at operational extremes consistent with munitions and oil field exploration/seismic detonation conditions. Other applications include power supply filtering, energy storage and coupling/decoupling. Custom size, voltages and capacitance ratings are available in single, series and series/parallel arrangements.

A division of Knowles Corporation, Knowles Precision Devices is a leading global innovator and manufacturer of high performance solutions. We focus on production of a wide variety of highly engineered Capacitors, EMI and Microwave to Millimeter Wave components for use in critical military, medical, industrial, electric vehicle, and 5G market segments. From 8,000 feet below the earth's surface to orbiting 254 miles above on the ISS, we take on the complex challenges that come with High Reliability, High Temperature, High Performance, High Energy and High Frequency solutions. Our Heritage Brands include Compex, Diablo TF, DLI, Johanson, Novacap, Syfer and Voltronics.

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ETi NDIA EMERGING TECHNOLOGIES INSTITUTE

A National Security Podcast with Dr. Mark Lewis

This brand-new podcast invites you to listen in on conversations with Dr. Mark Lewis, the Executive Director of NDIA's Emerging Technologies Institute, as he welcomes a diverse slate of national security leaders from government, industry, and academia to discuss the defense technologies of today and tomorrow. Each episode takes a deep dive as the experts share their personal views on future technology topics, providing listeners with unique perspectives on the latest in emerging technologies and how they relate to national security. Listen to Emerging Tech Horizons where you find all your favorite podcasts.

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APPROVED FOR PUBLIC RELEASE







U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND AVIATION & MISSILE CENTER

Overview Brief

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FEBRUARY 2021

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DEVCOM VISION AND MISSION



VISION

To be the scientific and technological foundation of the Future Force Modernization Enterprise through world-leading research, development, engineering and analysis.

MISSION

To provide the research, engineering, and analytical expertise to deliver capabilities that enable the Army to deter and, when necessary, decisively defeat any adversary now and in the future.

DEVCOM ORGANIZATION

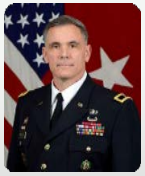
U.S. ARMY FUTURES COMMAND COMBAT CAPABILITIES DEVELOPMENT COMMAND



CG DEVCOM
MG John A. George



CSM DEVCOM
CSM Jon R. Stanley



DCG DEVCOM
BG James P. Bienlien



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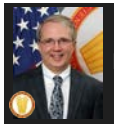
Mr. Keith Darrow (SES)



Software, Simulation, Systems Engineering and Integration Directorate

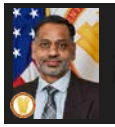
Dr. James Kirsch (SES)

Scientific & Technical Positions (STs)



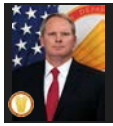
Airvehicle Aerodynamics and Preliminary Design

Dr. Mahendra Bhagwat



Optical Sciences

Dr. Henry Everitt



Radio Frequency Sensors

Dr. Brian Smith



Protective Technologies

Dr. Donna Joyce

OUR MISSION



Develop, integrate, demonstrate, and sustain aviation and missile systems capabilities to support modernization priorities and improve readiness.

PRIMARY MISSION AREAS

1. Develop and integrate next generation technologies to ensure aviation and missile dominance.



2. Provide world class functional engineering expertise to our PEOs, MDA, RCCTO, and other critical partners.



3. Provide world class sustainment engineering expertise to our AMCOM partners.



4. Recruit and develop the engineering talent to achieve the above.



BY THE NUMBERS

11,942 FY20 Strength

2,982 Civilian

10 Military

~8,940 Contractor

FY20 Funding
$4.3B

4% Aviation S&T

5% Missile S&T

65% Army

26% other



Core Competencies

Science and Technology:

- Materials and Structures
- Guidance, Navigation, Sensors/Seekers
- Propulsion, Explosives, Energetics, Warheads, Fuzing and Actuation
- Air Vehicles Technology
- Aviation Autonomy and Missiles Technology
- Air Defense Sensor Technology

Capabilities Engineering:

- Software Engineering
- Weapons Assurance
- Modeling and Simulation
- Configuration Management
- Prototype Design and Development
- Multidiscipline Acquisition and Project Engineering
- Systems Engineering, Integration, and Interoperability
- Airworthiness
- Aviation and Missile Product Performance

ARMY PRIORITIES

#1: People

People are the Army's greatest strength and its most important weapon system.



#2: Readiness

The Army must be ready to defeat any adversary, anywhere, whenever called upon, under any condition.

#3: Modernization

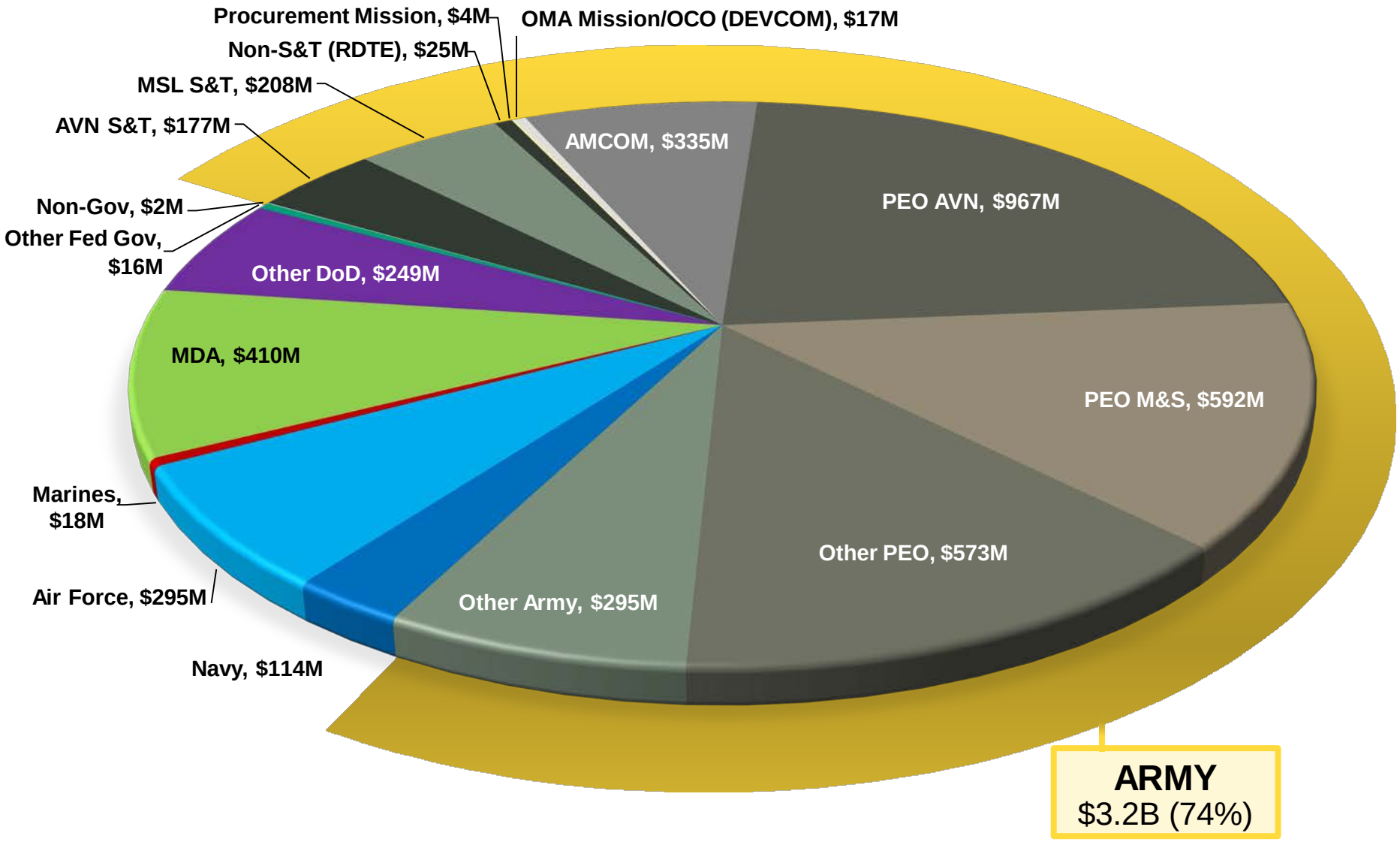
The Army must modernize to remain lethal and ready to fight tomorrow, against increasingly capable adversaries and near-peer competitors.



#4: Reform

The Army will improve the way we do business, including how we implement our top priorities, to make the Army more lethal, capable, and efficient.

FY20 TOTAL REVENUE ($4.3B)



ARMY
$3.2B (74%)

As of: 2 OCT 20

S&T PRIORITIES ALIGNED WITH THE ARMY MODERNIZATION STRATEGY


LONG RANGE PRECISION FIRES


NEXT GENERATION COMBAT VEHICLE


FUTURE VERTICAL LIFT


ARMY NETWORK


AIR & MISSILE DEFENSE


SOLDIER LETHALITY

Supporting Army and Joint Readiness now and in the Future MDO Environment

RESEARCH ISO FUTURE FORCE

Driving the discoveries and innovations which will be critical to realizing new capabilities for the Army of 2030 and beyond.

ANALYSIS

Conducting objective experimentation and systems analysis to support the equipping and sustaining of our Warfighters.

ENGINEERING

Providing lifecycle engineering expertise to support fleet development and readiness across warfighting battlefield operating systems.

AVIATION S&T ALIGNMENT TO ARMY MODERNIZATION PRIORITIES

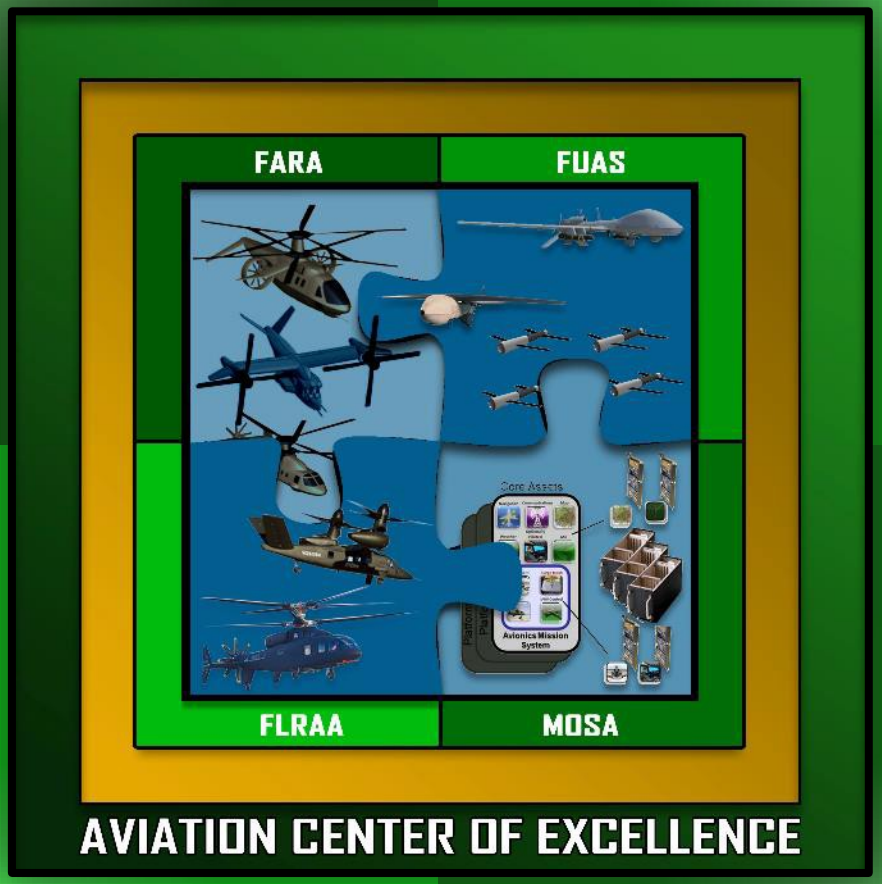
FVL Modernization Lines of Effort

Future Attack Reconnaissance Aircraft

Critical combat system needed to prevail in future wars by enabling Army Aviation to achieve a "leap-ahead" in lethality, survivability, and reach to find, fix, and finish our pacing threats.

Future Unmanned Aircraft Systems

Advanced teaming FVL with next generation UAS delivering lethal and non-lethal air launched effects enables cross-domain fires to penetrate and dis-integrate enemy A2AD systems and exploit expanded maneuver to overmatch peer adversaries.



Future Long Range Assault Aircraft

Essential to exploit the windows of opportunity created by FARA and advanced teaming with UAS/ALE with its increased speed and reach providing significantly more lethal and effective Air Assault and MEDEVAC capabilities on the future battlefield.

Modular Open Systems Approach

The government defined Modular Open System Approach will establish the digital backbone of FVL aircraft allowing for rapid and affordable integration of innovative avionics and mission equipment technologies into our platforms.

LETHALITY **REACH** **PROTECTION**

MISSILE S&T ALIGNMENT TO ARMY MODERNIZATION PRIORITIES

Army Modernization Priorities

Long Range Precision Fires

Technologies for the development, integration and delivery of long range fires at the operational and strategic echelons to restore overmatch, improve deterrence, and disrupt A2AD on a complex, contested and expanded battlefield.

Next Generation Combat Vehicle

Technologies for active protection systems and enhanced lethal effects that will increase our ability to survive and win in the complex and densely urbanized terrain of an intensely lethal and distributed battlefield where all domains are continually contested.

Air & Missile Defense

Technologies for the development of mobile air defense systems that reduce the cost curve of missile defense, restore overmatch, survive volley-fire attacks, and operate within sophisticated A2AD and contested domains.

Future Vertical Lift

Technologies for the development, integration, and delivery of aviation launched air-to-ground and air-to-air missile systems to restore overmatch within sophisticated A2AD and contested domains.



Engage First **Expand the Dome** **On the Move**

QUESTIONS?



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AFRL

Fuze Science and Technology Overview

George Jolly

Ordnance Division

AFRL Munitions Directorate

2021

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A World-Wide Enterprise of Researchers



	Employees	Civilian	Military
Total	6,254	5,072	1,182
S&Es	3,611	3,041	570

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AFRL/RW
The Munitions Directorate

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AFRL/RW Mission

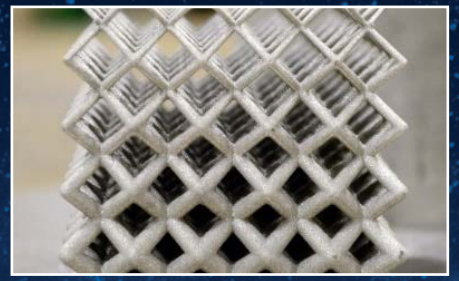
Lead the discovery, development, integration, and transition of **affordable** weapons technology, enabling the warfighter to **win across all domains**

Better Buying Power 3.0:
Achieving Dominant Capabilities through Technical Excellence and Innovation

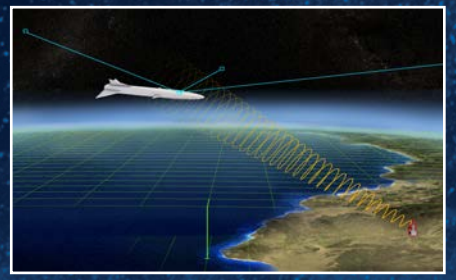
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Our Responsibility to the Warfighter

Develop Superior Weapons Technologies That Are Effective & Affordable



3D Printed Structural Reactive Materials



Alternative Navigation

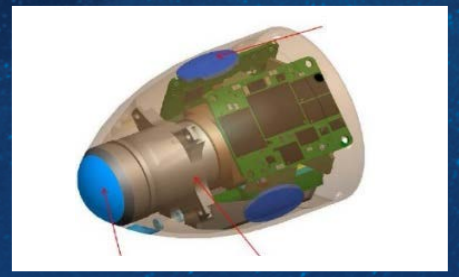


Autonomy / Networked

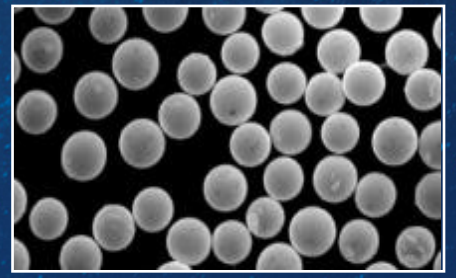


Selectable / Dialable Effects

Modeling & Simulation



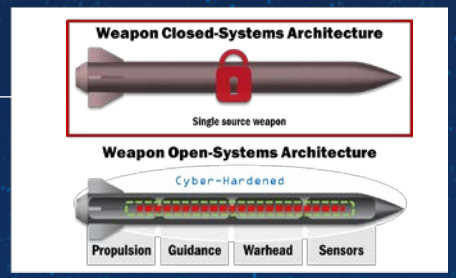
Advanced Seeker Technologies



Advanced Energetics



Stronger, Cost-Effective Metals



System Modularity

Maturing Tech to Give Our Warfighters an Asymmetric Advantage

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Key Collaborative Partnerships

OSD(AT&L)

Office of Land Warfare & Munitions

- Joint Munitions Program
- Joint Fuze Tech Program
- Joint Insensitive Munitions Tech Program
- Leveraging Dept. of Energy – NNSA
- Common services challenges

International

- The Technical Cooperation Program
- Program Agreements (PA's)
- International Cooperative Research and Development (ICR&D)
- Coalition Warfare Program (CWP)
- AFOSR Int'l Offices of Aerospace R&D

Industry

- Open and Special BAA
- DEFENSEWERX (Doolittle)
- SBIR/STTR/STMP
- NAC – National Armaments Consortium
- IRAD - Industry Research and Development
- CRADA – Cooperative Research And Development Agreement



Other Gov't Entities

- DARPA
- DoD Labs
- Other
- Communities of Interest (COI)
- Joint Capability Tech Demonstration
- Quick Reaction Support
- Emerging Capability & Prototyping
- POM & Seedling Initiatives
- Joint Service MOA's

Academia

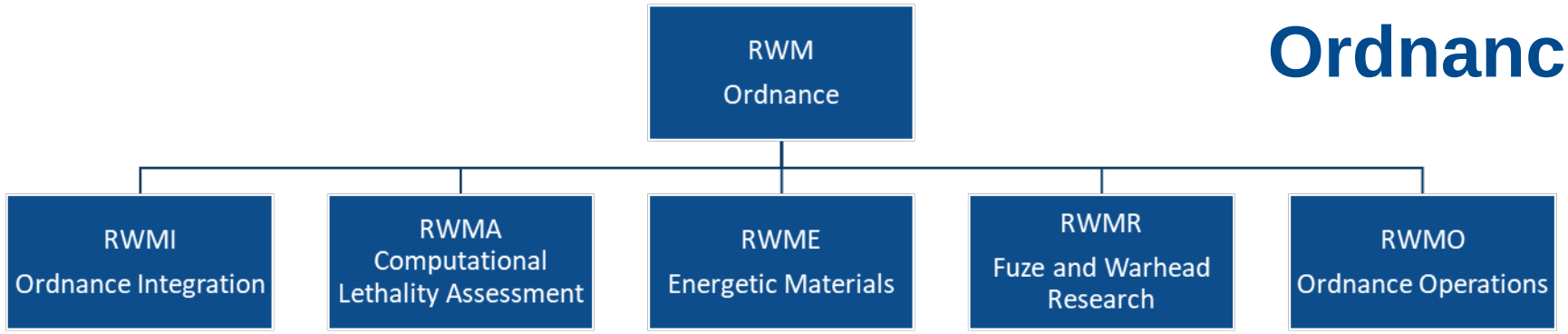
- AFOSR
- UARC- University Affiliated Research Center
- Centers Of Excellence
- Mathematics Modeling and Optimization Inst.
- Summer Faculty Fellowship Program
- SMART – Science, Mathematics & Research for Transformation
- AFRL Science and Technology Fellowship
- AFRL Scholars Program
- STEMM Academy

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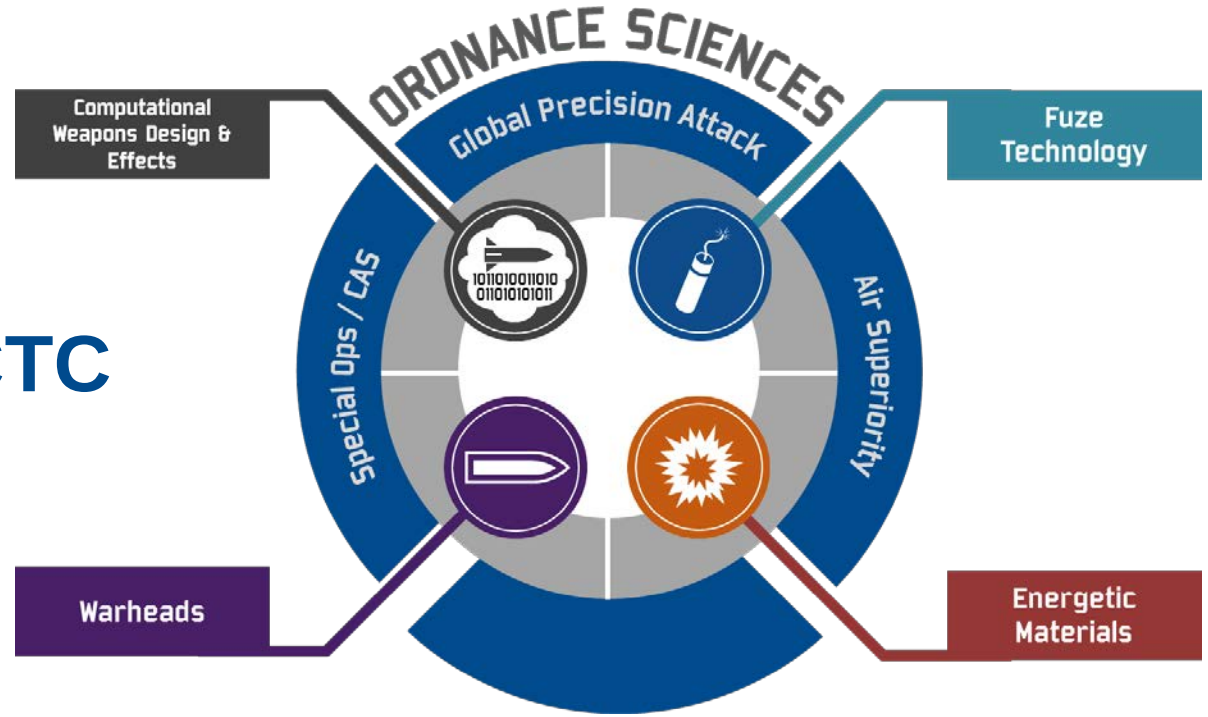
RWM Integrated Ordnance Fuzes

Distribution A: Approved for Public Release; distribution unlimited.

Ordnance Division (RWM)



Ordnance Sciences CTC

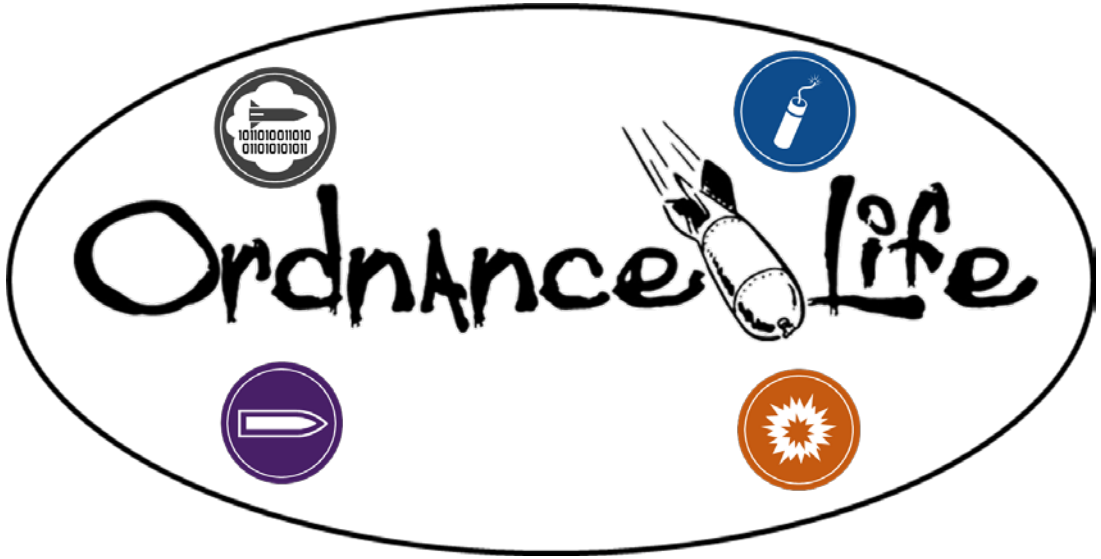


Delivering Ordnance Technologies for Optimal Kinetic Effects Against a Broad Spectrum of Targets

Distribution A: Approved for Public Release; distribution unlimited.

RWM Technology Area Priorities

- **Hypersonics**
- **Selectable Effects**
- **Hard Target Defeat**
- **Air-to-Air**
- **Distributed, Collaborative, Cumulative Effects**

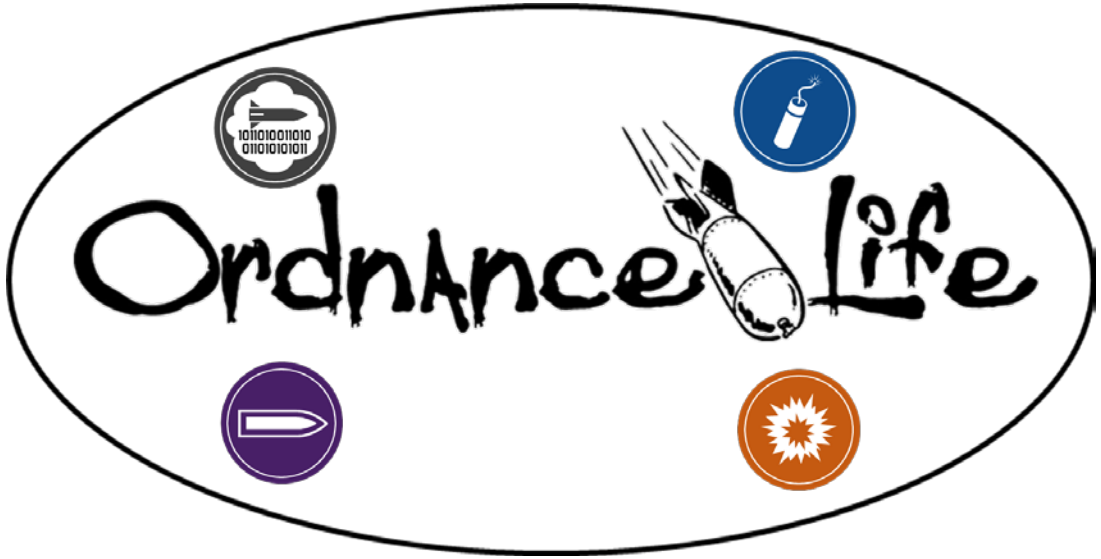


Integrated Research Teams

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RWM Technology Area Priorities

- Hypersonics
- ~~Selectable Effects~~
- Hard Target Defeat
- ~~Air-to-Air~~
- Distributed, Collaborative, Cumulative Effects
- Emerging Technology



Integrated Research Teams

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Fuze S&T Decomposition - Hypersonics

- **Initiation**
  - Initiation characterization of HE formulations
  - High temperature detonator and booster HE
  - Initiation and survivability of Pressed Explosives
- **Multipoint (Forward Modules)**
  - OSD funded JHTO program. SNL collaboration
  - Heavily leverages AFRL Distributed Embedded Fuze Sys (DEFS) Research
  - Focus is a single module that allows for both above and post perforation detonation.
  - Optimized location for survivability, lethality (asymmetric warhead shape), and reliability.
- **Sensors**
  - Proximity Sensor with High Temperature antenna
  - S&A Sensor
- **High Temperature Electronics**

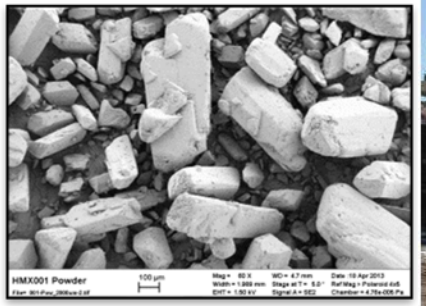




Figure 93: Sled2 Target Impact

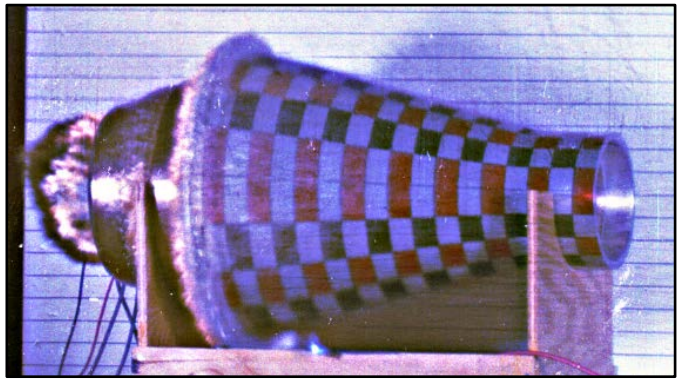
AFRL High Velocity Experimentation Facility



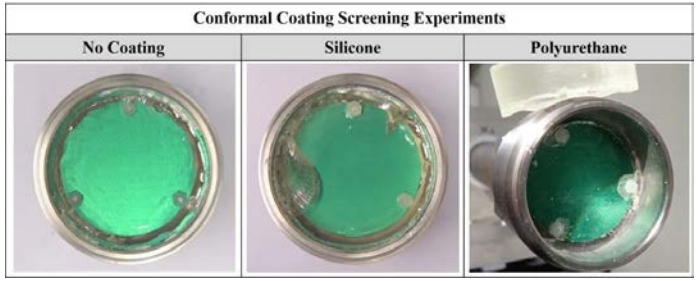


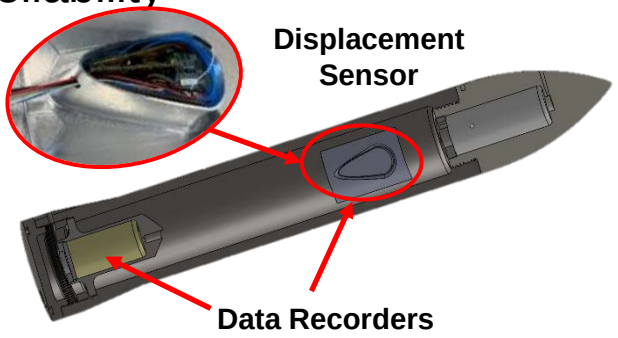
Distribution A: Approved for Public Release; distribution unlimited.

Fuze S&T Decomposition – Hard Target Defeat



- **Initiation**
  - Reliable initiation of advanced formulations (Cast-cure and Pressed)
  - Initiation to detonation in cellular/lattice structured warhead
  - Effective initiation of combined DE/KE mechanisms
- **Multipoint (Forward Modules)**
  - Heavily leverages AFRL DEFS Research
  - Wireless technology to accommodate internal structures and increase reliability
  - Layer/Void detection



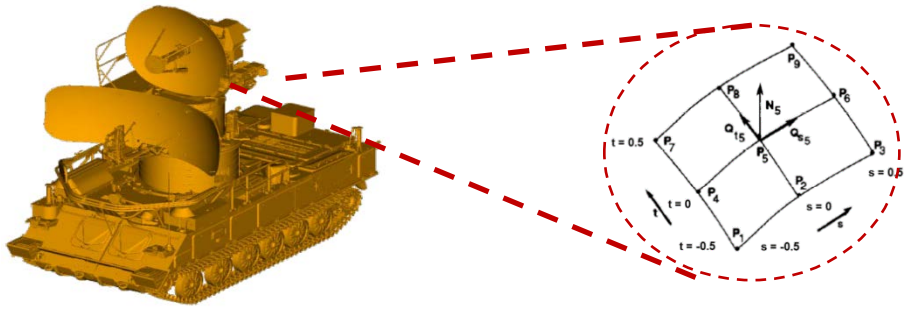


- **Sensors**
  - S&A Sensor
  - Terra sensing (non-inertial or tuned warhead)
  - Health Monitor Salvage

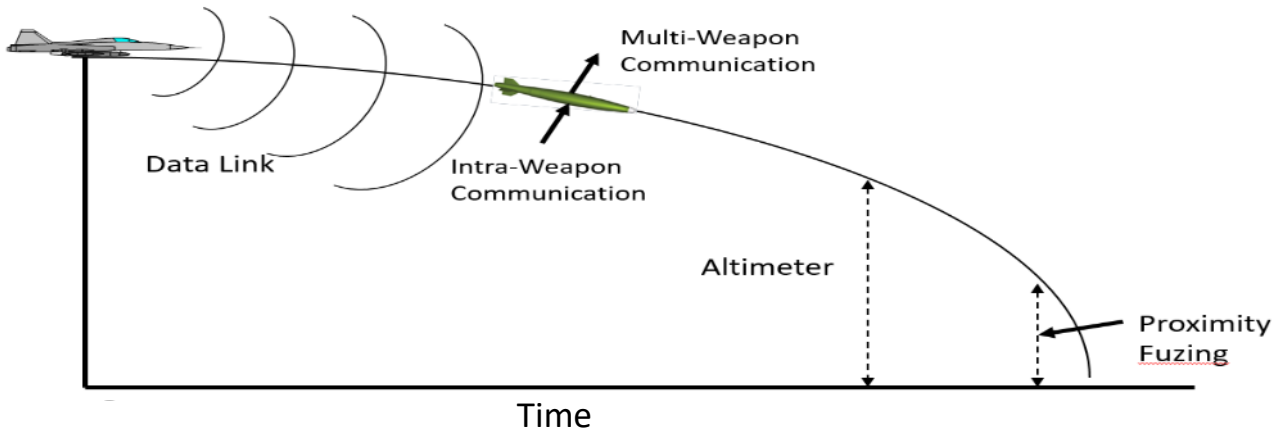
Distribution A: Approved for Public Release; distribution unlimited.

Fuze S&T Decomposition – Distributed, Collaborative, Cumulative Effects

- **Initiation**
  - Miniaturized Firesets
  - Focused Effects



- **RF Communication for Weapon Collaboration and Synchronization**
  - Data Link Radar Suite
  - Guidance Integrated Fuzing

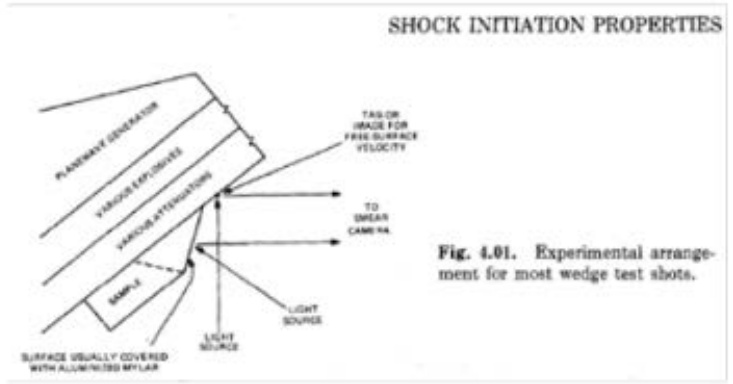


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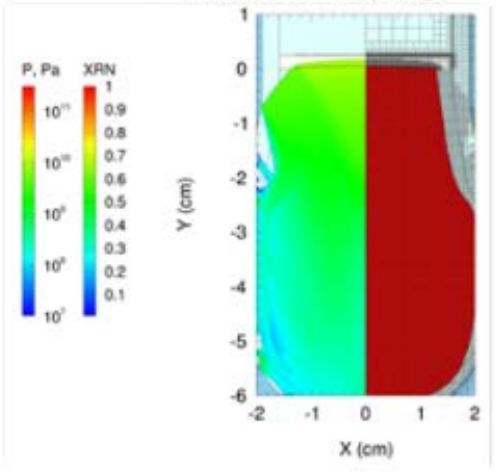
Fuze S&T Decomposition – Emerging and Pervasive Technology

- **Initiation**
  - Scalable and Transportable Explosive Experimental Capability for Economic Formulation Qualification

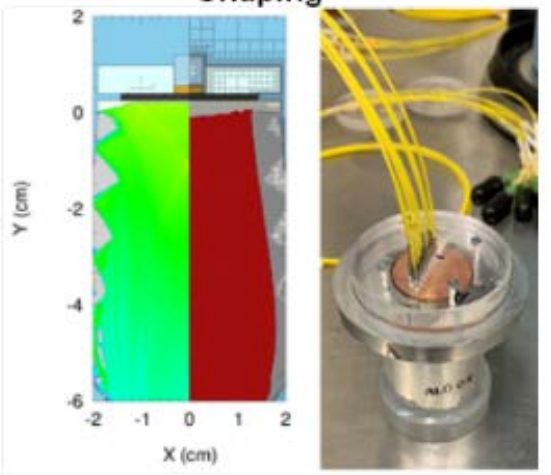
Traditional Explosive Plane Wave Lens



Initial Configuration without Shaping



Optimized Configuration with Shaping



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Questions?

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U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND

DESIGN OF A TEST METHODOLOGY TO SIMULATE RAIN ENVIRONMENTS

Richard Johnson

Mechanical Engineer

U.S. Army Futures Command, DEVCOM-Armaments Center, Picatinny Arsenal, NJ

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BACKGROUND INFORMATION

- **Advanced impact sensors are being integrated into fuze designs**
  - MEMS switches
  - Accelerometers
- **Rain impact testing is needed to prove out the switches ability to perform in harsh rain environments**
- **Unfortunately, rain impact testing is extremely costly and there is currently no facility capable of conducting these tests**

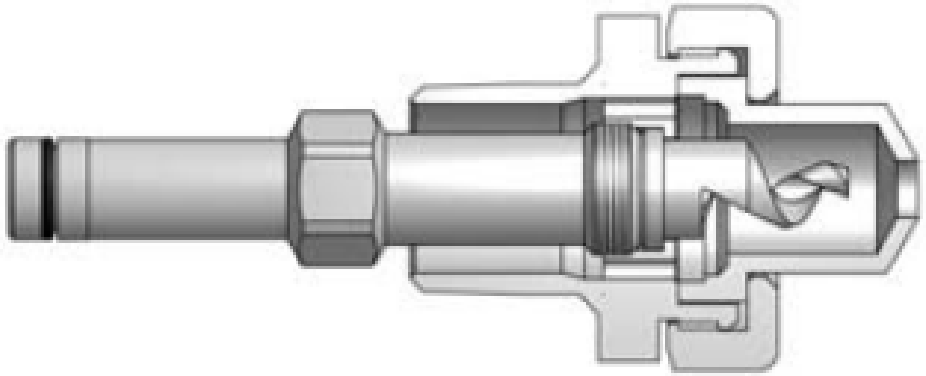
Due to high cost and low testing availability there grew a need to create a low cost solution to test sensor's performance in harsh rain environments

RAIN TEST FUNCTIONALITY

- **A BETE SpiralAir high flow air atomizing nozzle was used to emulate a rain field**

- **Droplet size is variable**
  - Altered by varying the pressure of the water and the pressure of air entering the nozzle
    - Droplet sizes vary up to 1 mm

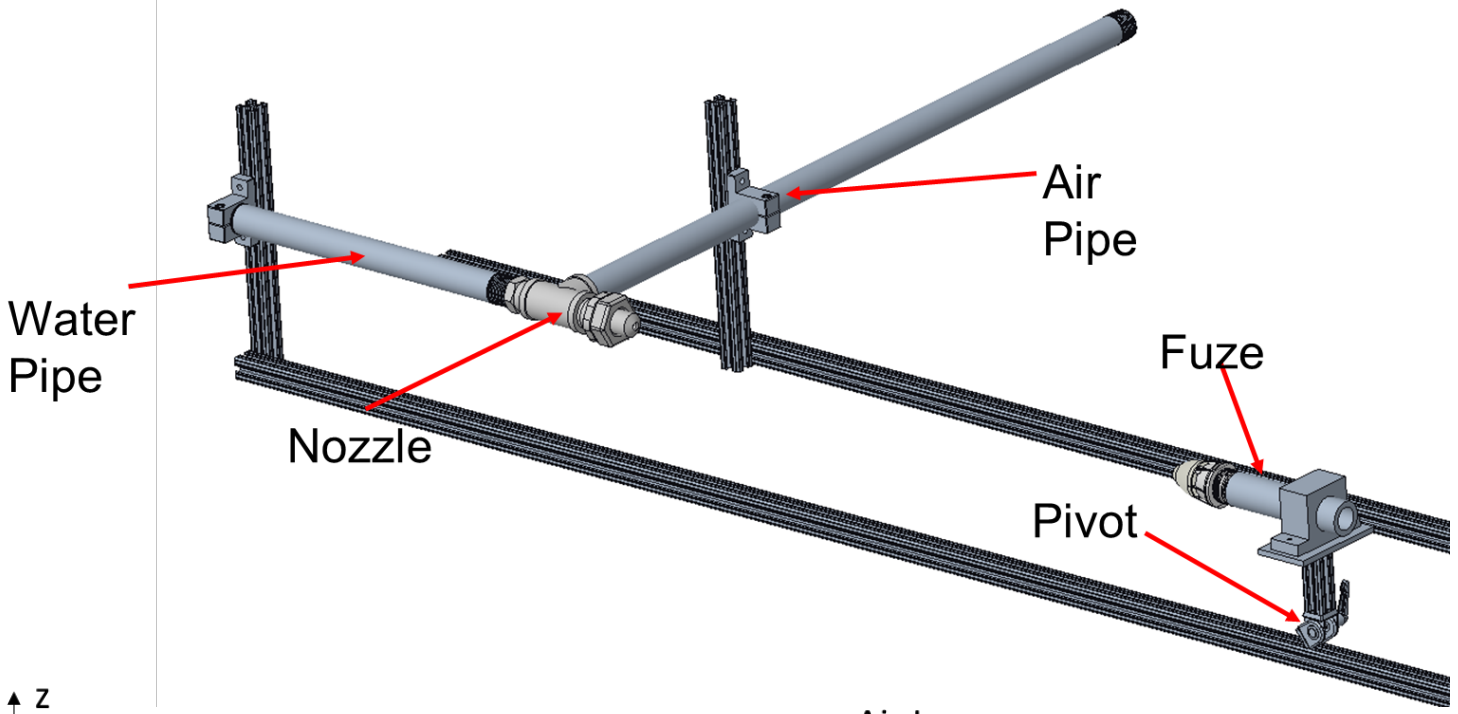
- **Rain field velocity is variable**
  - Altered by varying the flow rate of water and air entering the nozzle
    - Up to 20 m/s

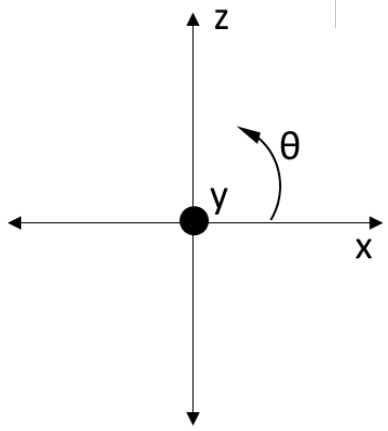


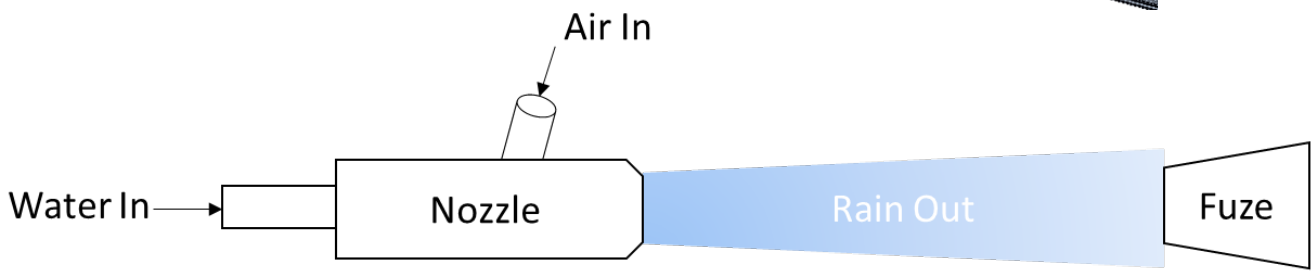


Flat Fan 60°

RAIN TEST FUNCTIONALITY







Fuze movement in x, z, and θ direction

RAIN TEST FUNCTIONALITY



RAIN TEST FUNCTIONALITY



CONCLUSIONS

- An instrumented fuze was tested to show closure of the impact sensor can be monitored during testing
- The velocity of the rain field was altered during testing along with droplet size
- The angle of the fuze relative to the rain field was also varied to understand the affect rain impact location on impact sensor sensitivity
- Total cost to build the test was under $10k

FUTURE WORK

- **More funding is needed to better characterize the rain field to verify that it is sufficient enough to emulate a harsh rain environment**
  - High speed cameras will be needed to record the test to elucidate velocity, liquid water content, and exact droplet size
- **Current nozzle is capable of producing a rain field up to 20 m/s**
  - Increased velocity is needed to better represent tactical environment
- **Droplet size of 0.5 mm does not properly represent the impact of larger (2-4mm) droplets**
  - A new nozzle may be needed to create larger droplet sizes



High Shock Modeling of Fuze Components

Presented to:

64th Annual NDIA Fuze Conference

Presented by:

Chris Cao

11 May 2021

Capt. Eric Correll, USN
Commanding Officer

Mr. Ashley G. Johnson, SES
Technical Director

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NAVSEA WARFARE CENTERS Indian Head

Overview

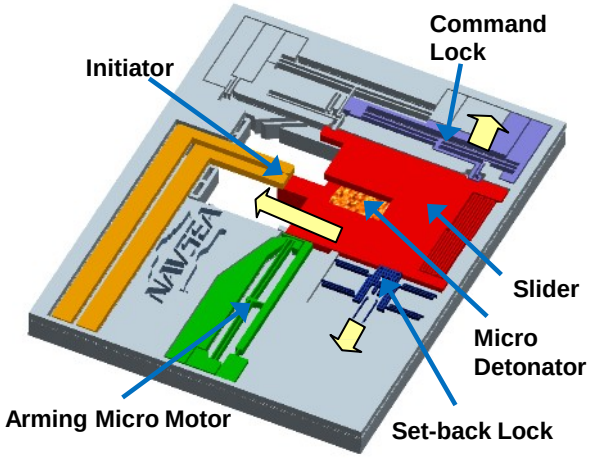
- Background
  - MEMS Safe and Arm
  - Purpose
  - DYSMAS
- Literature Search
- VHG Characterization
- Simulations
- Material Characterization Tests
  - Split Hopkinson Bar
  - 4-Point Bend Test
- Path Forward

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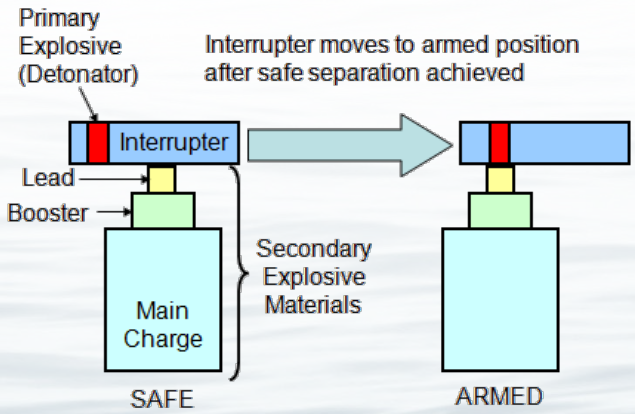
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MEMS Safe and Arm

- Micro-Electro Mechanical Systems (MEMS)
  - Low cost, out-of-line safety, small volume, low power alternative to ESADs
- Naval Surface Warfare Center Indian Head Division (NSWC IHD)
  - Two decades of silicon/silicon-on-insulator (SOI) MEMS design, fabrication, packaging and testing experience
  - Class 10,000 clean room with explosive capability
- Commercial processes
  - Non-explosive components only
- Safety locks
  - Integrated mechanical structures, command actuated locking architecture
- Arming
  - Environmentally derived command architectures



Interrupted
- "Out-of-line" systems
- Electro-mechanical
- Pure mechanical

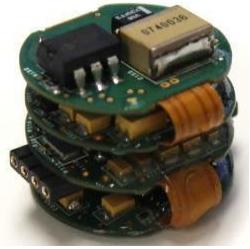


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NSWC IHD Core Capabilities

- Electrical design and test
  - Electronic Safe Arm Devices (ESADs) and MEMS SADs
  - Sensing technologies, imbedded systems, RF design



- Initiation systems design and test
  - Micro-energetics, micro-firesets
  - Characterization (e.g., Photonic Doppler Velocimetry)



- Mechanical design and test
  - Fuze packaging
  - Full scale launch and impact testing (reverse impact available and explosive certified)
    - Guns up to 21” diameter
    - Speeds >2000 ft/s
  - MEMS
  - High G shock testing and survivability



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High Shock Modeling

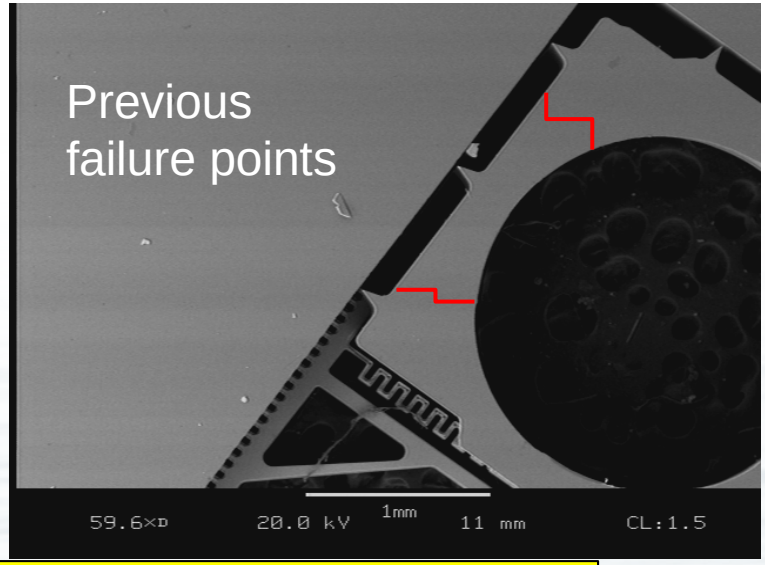
Objectives:

- Utilize modeling and simulation (M&S) to increase shock survivability of NSWC IHD MEMS fuze components
- Develop silicon material model for more accurate M&S at high strain rates using NSWC IHD MEMS S&A as testbed

Approach:

Gather silicon material models from literature/material characterization tests

Refine model and validate using experimental data from Very High G (VHG) testing



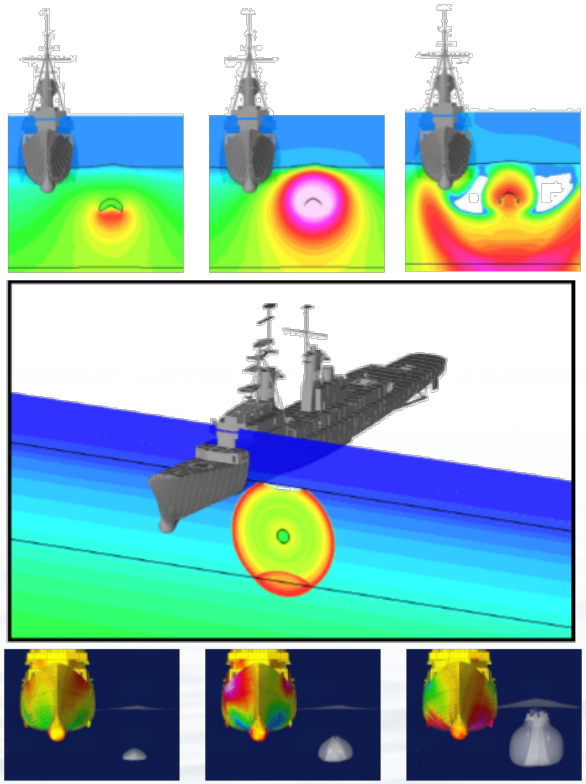
Current efforts funded through Joint Fuze Technology Program.

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DYSMAS

- Dynamic System Mechanic Advanced Simulation (DYSMAS)
  - ParaDyn-explicit 3D-finite element code for solid and structural mechanics that is good for highly dynamic environments
  - Similar to other commercial codes such as ABAQUS, LS-Dyna
- Government owned
- Extensively validated for underwater detonations against various surface and submerged structures
  - Can run structural loading and analysis or fluid dynamics separately
- Co-developed between the United States and Germany

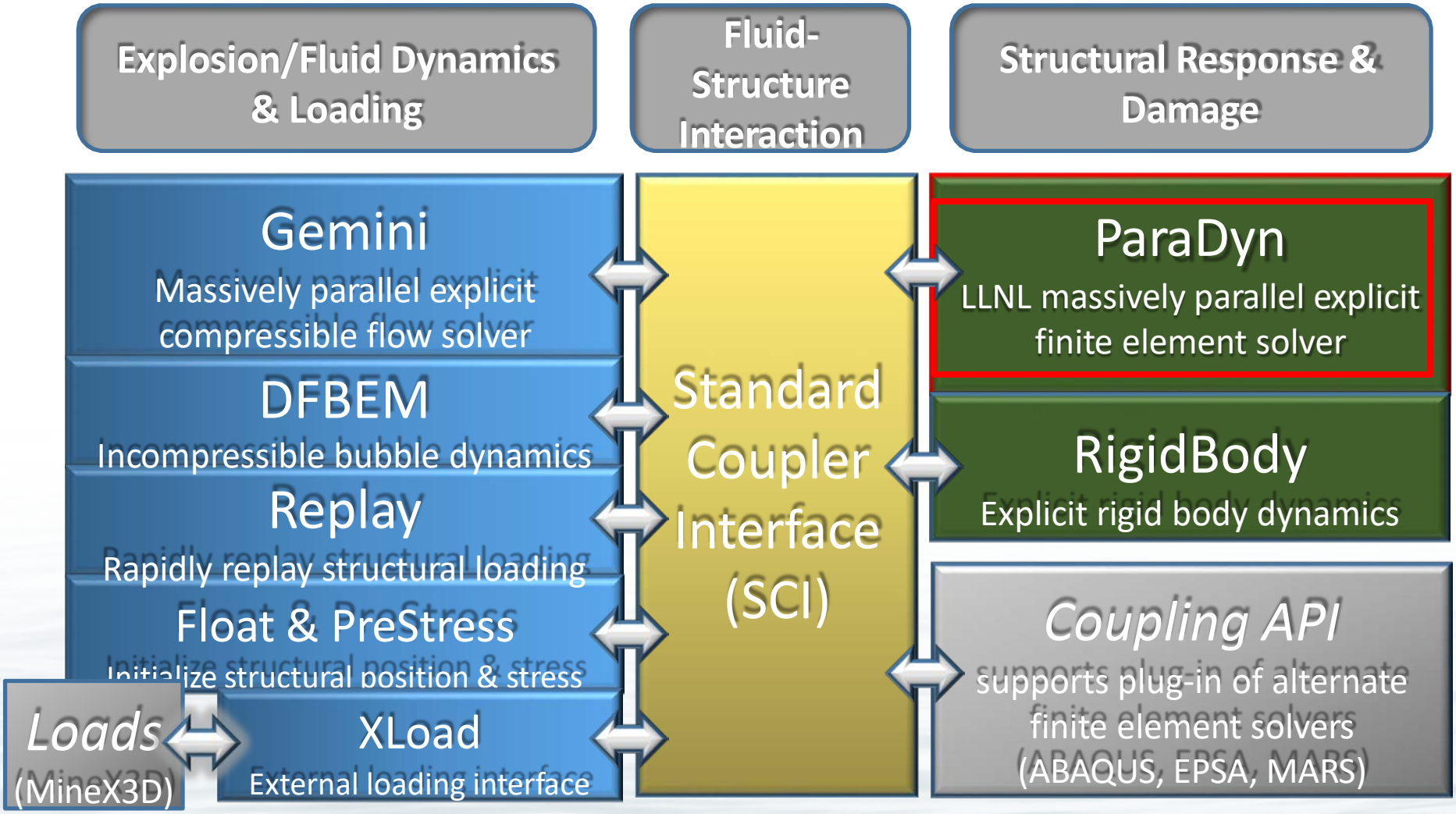


DYSMAS Version 7.7.00
Manual Dated: 18 Sep 2018

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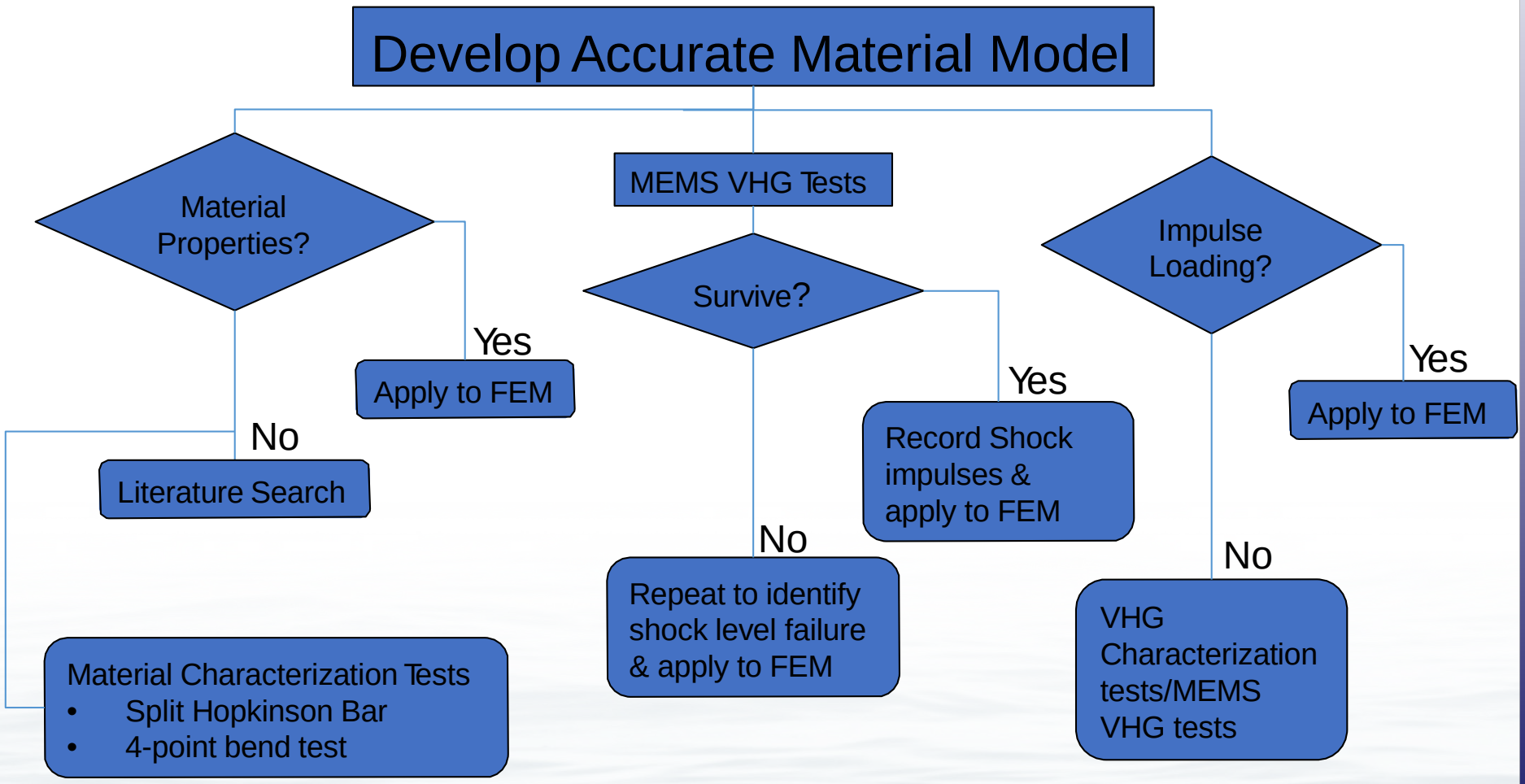
DYSMAS Architecture



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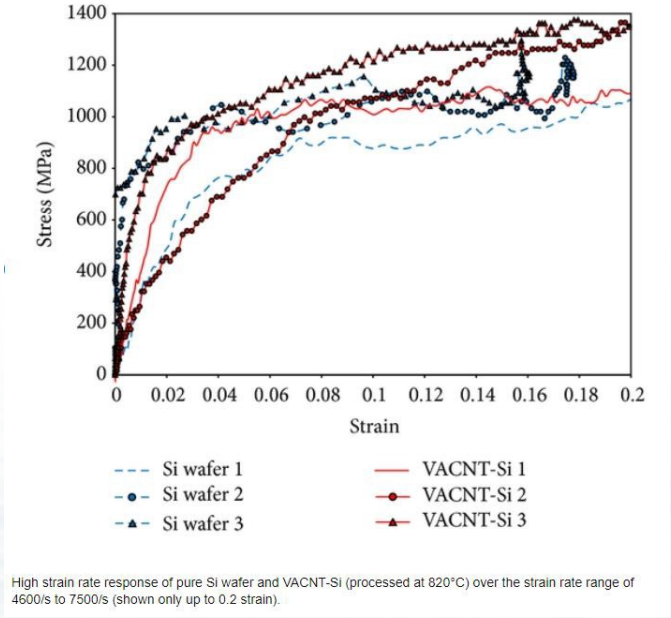
Process Flow



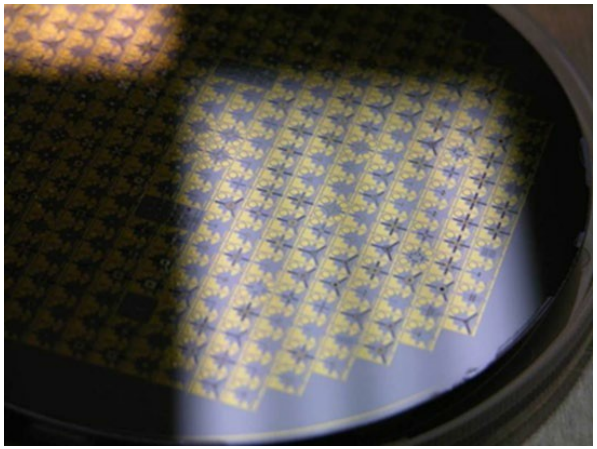
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Literature Search

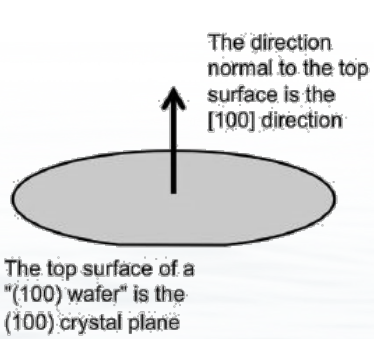
- Cubic symmetric anisotropic material
  - Single crystal wafers
  - Plane orientation
  - x & y-direction planes <110>

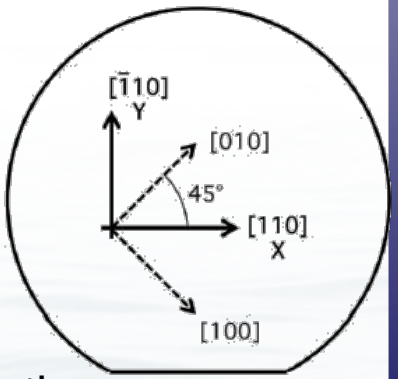


High strain rate response of pure Si wafer and VACNT-Si (processed at 820°C) over the strain rate range of 4600/s to 7500/s (shown only up to 0.2 strain).



Silicon Wafer





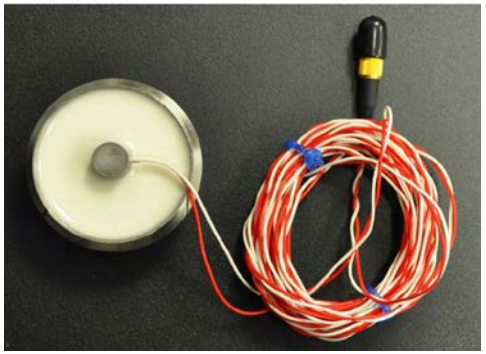
Orientation

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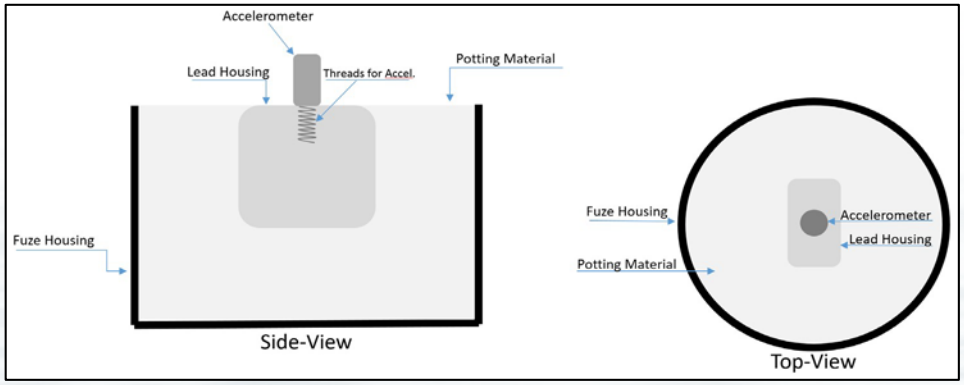
NAVSEA WARFARE CENTERS Indian Head

VHG Characterization

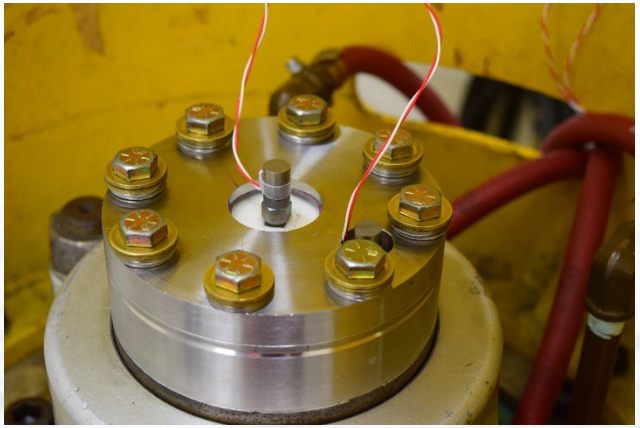
- Potted accelerometer to characterize high G loading
- Captured VHG loading(s) and applied to model



Potted Accelerometer



Cross-section view Top view



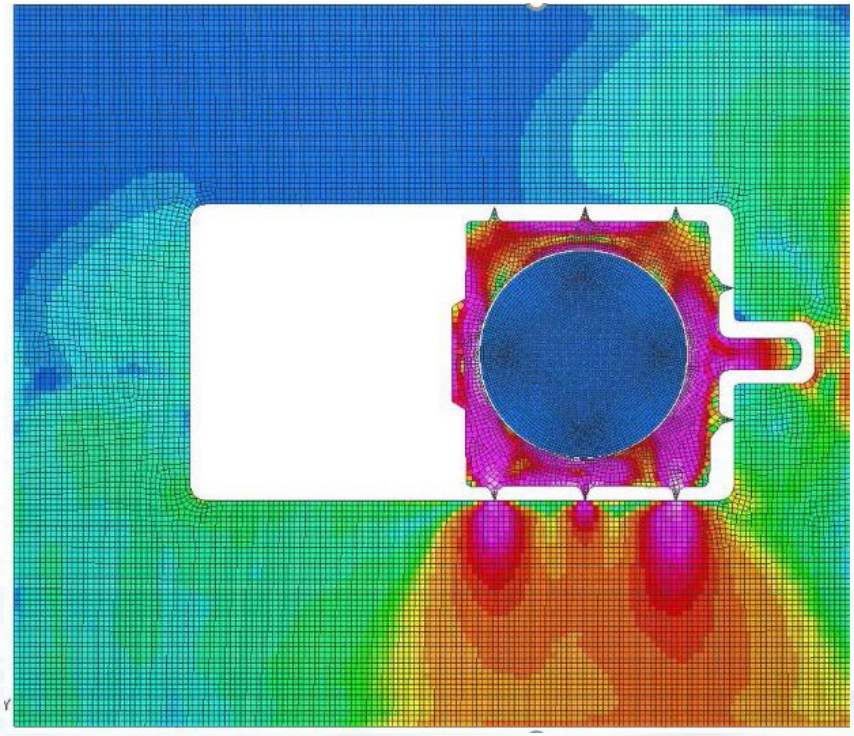
Test Setup

DISTRIBUTION A (#21-079): Approved for Public Release; Distribution Unlimited.

NAVSEA WARFARE CENTERS Indian Head

Initial Simulations

- High stress concentrations consistent with damage found
- Orthotropic elastic material model
  - No failure
  - No crack propagation

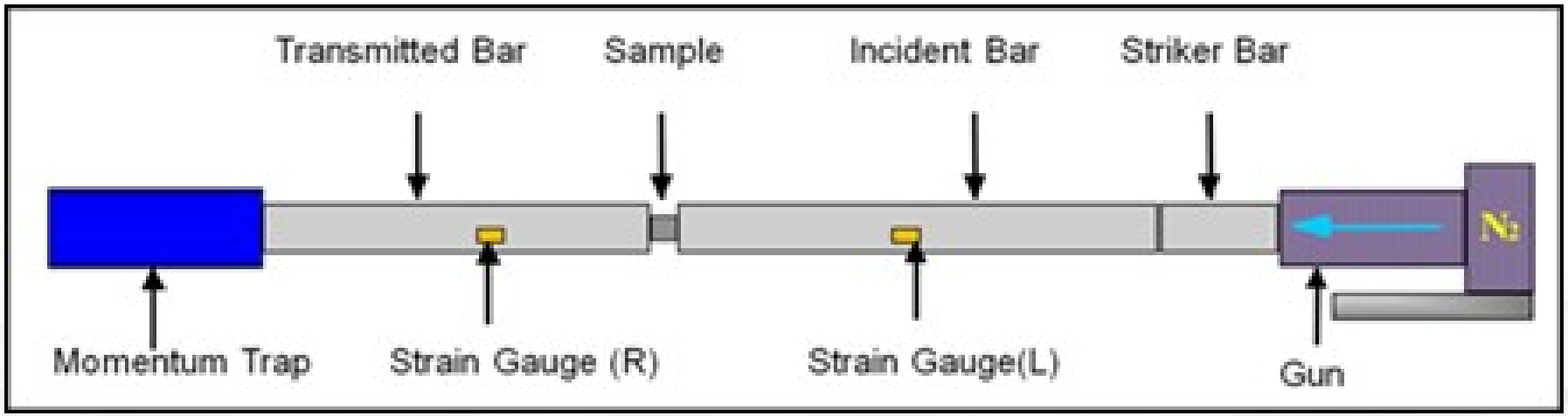


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Material Characterization Tests

Split Hopkinson Bar

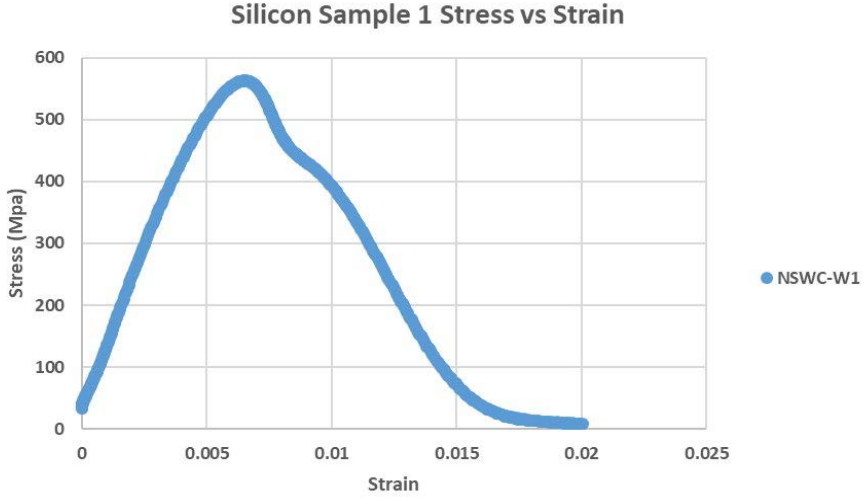
- Obtains high stress-strain rate



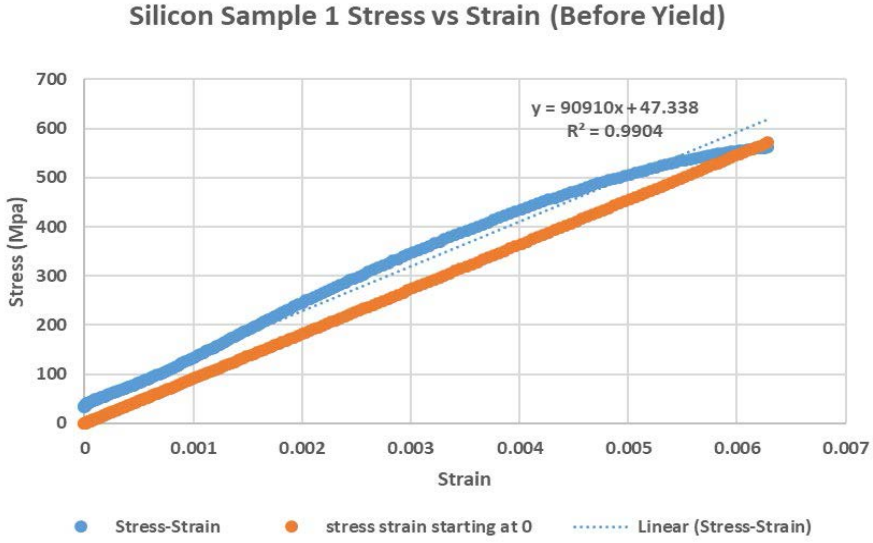
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Material Characterization Tests



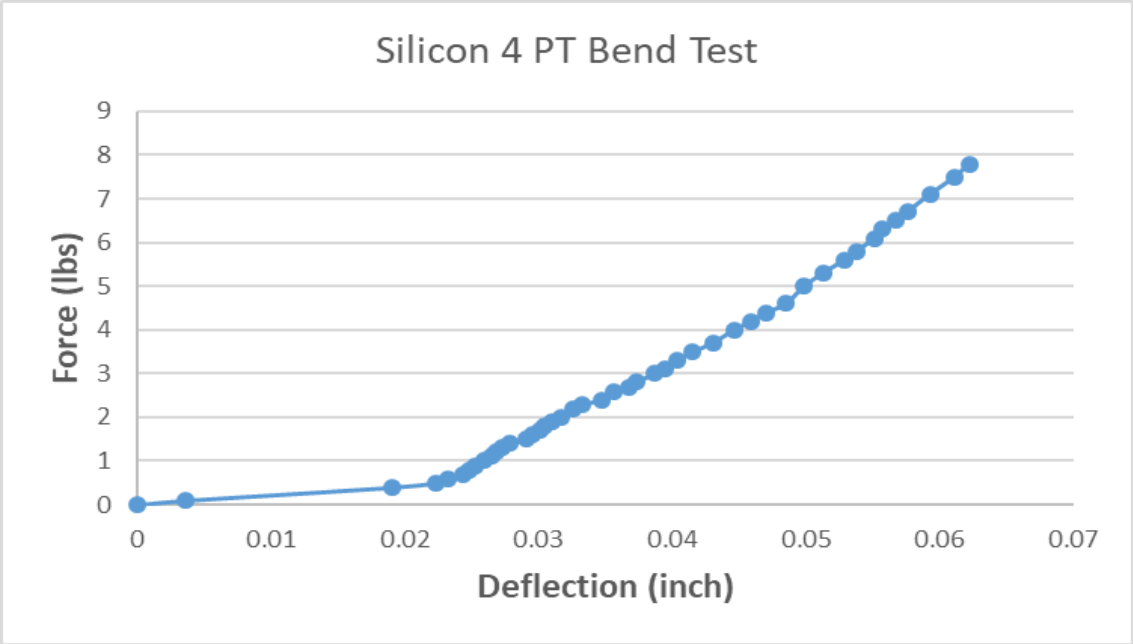
Split Hopkinson bar data

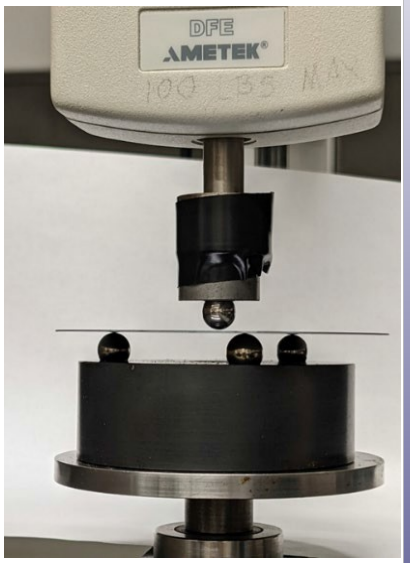


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NAVSEA WARFARE CENTERS Indian Head

Material Characterization Tests





4-Point Bend Test

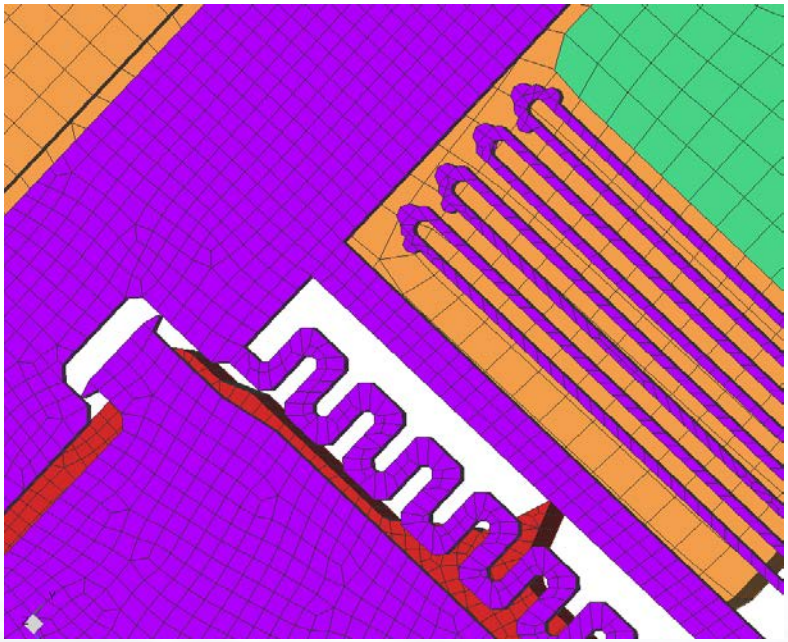
- Measures load and deflection

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NAVSEA WARFARE CENTERS Indian Head

Summary

- Material Properties
  - Literature search
  - Split Hopkinson bar
  - 4-point bend test
- M&S
  - ParaDyn within DYSMAS code
  - No failure as of yet
- Testing
  - VHG



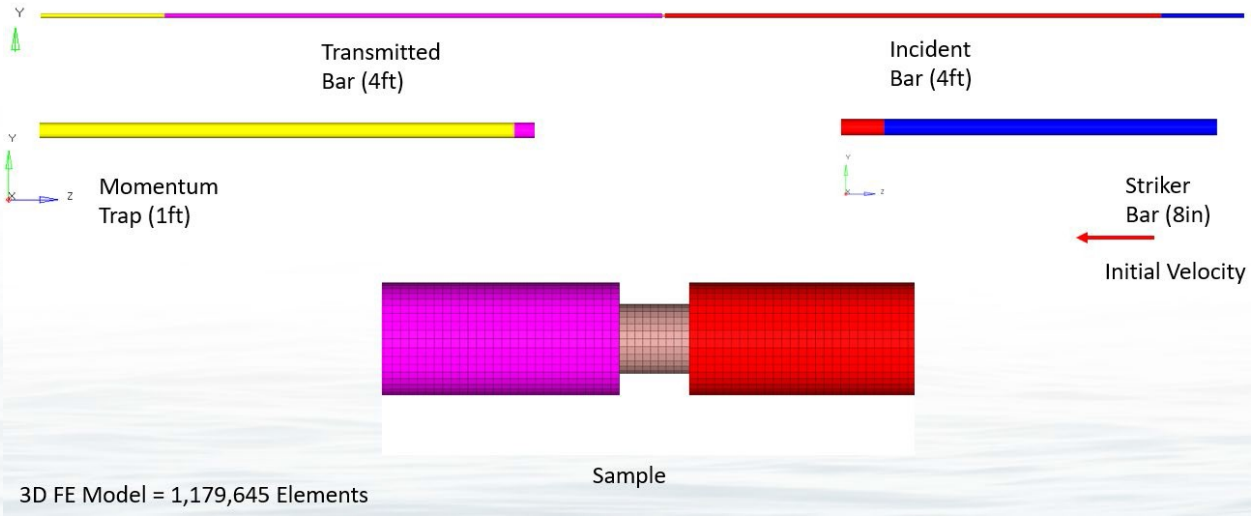
Increased # of elements to better capture effects

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Path Forward

- Fabricate test chips for high-g testing
- Model split Hopkinson bar test and compare to experimental
- Identify failure loading for MEMS S&A
- Capture failure loading and impart on model
  - Compare and refine/update FEM



FEM of Split Hopkinson Bar

DISTRIBUTION A (#21-079): Approved for Public Release; Distribution Unlimited.

NAVSEA
WARFARE CENTERS
Indian Head

Questions?



PRELIMINARY DRAFT V2 June 7th

Detonation Transfer Reliability –
Axial and Angular Alignment Evaluations using a Neyer Statistical Sensitivity Approach

David Pray

May 11, 2021

EXCELITAS TECHNOLOGIES®

Distribution A

Transfer Reliability Background

System level detonation transfer reliability

- Ordnance to ordnance (Donor to Acceptor)
- Critical to system performance

RCC 319 –Range Commanders Council
Flight Terminations Systems Commonality Standard

- Section 4.35.3 – Detonation Flier Plate Ordnance Transfer Systems
  - .999 Reliability at 95% Confidence Level

Distribution A

Detonation Transfer Reliability

Transfer Reliability Background

RCC 319 (.999 Reliability at 95% Confidence Level)

- 2994 tests in flight representative configuration
  - Cost prohibitive
- Testing at 4X gap, axial, angular misalignment
  - May not be practical for some systems
  - No variable data
- Statistical sensitivity method that varies critical performance parameters: Gap, **Axial** and **Angular** alignment
  - Methods: Bruceton, Langlie, **Neyer**, etc.
  - Best Solution for variable data
- Testing must be conducted at qualification low temperatures (cold)

Distribution A

Neyer D Optimal

Neyer D Optimal -Sensitivity Test

- Threshold of individual unit cannot be determined
  - Detonation transferred or it did not (binary response)
  - Testing at different levels establishes the parameters of the population
  - Test levels optimized to maximize information of the population
  - Software algorithm determines “next test level”
- Reliability of system or subsystem can be predicted

Sentest™ (Neyersoftware.com)

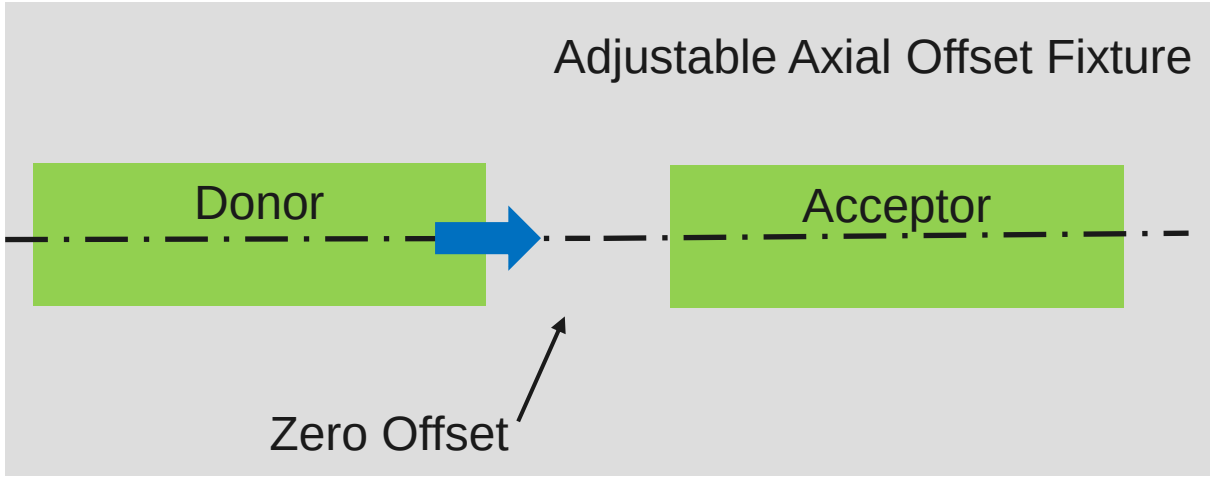
Distribution A

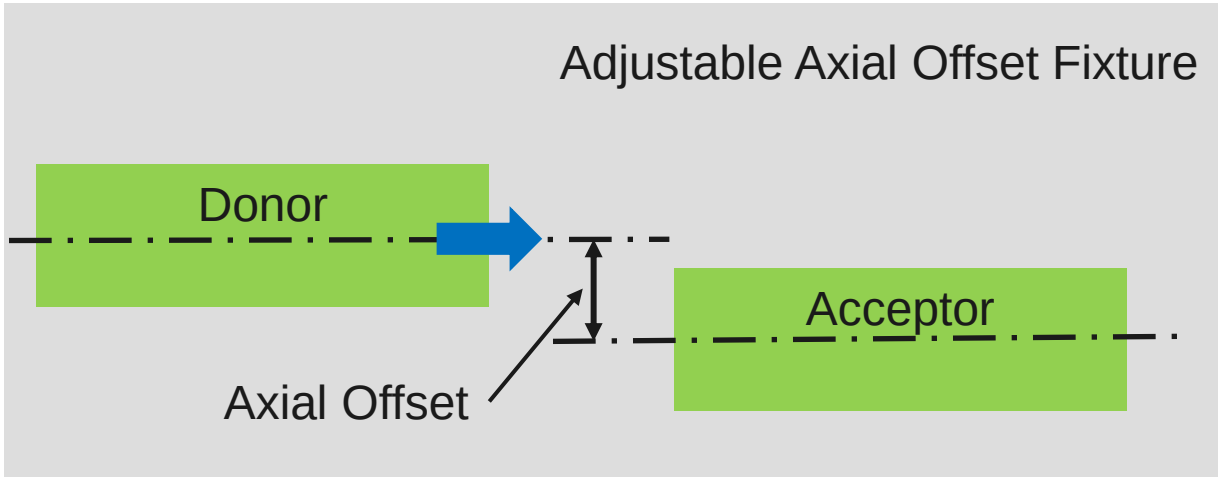
Detonation Transfer Reliability

Test Design – Axial Offset

Fixture Considerations

- Hold donor and acceptor
- Represent system level interface
- Large adjustment range
  - Beyond detonation transfer offset limit
    - Screening Tests Recommended
- High resolution required
- Fixture may be a single use
- Sentest™ software simulations
  - Evaluate potential outcomes





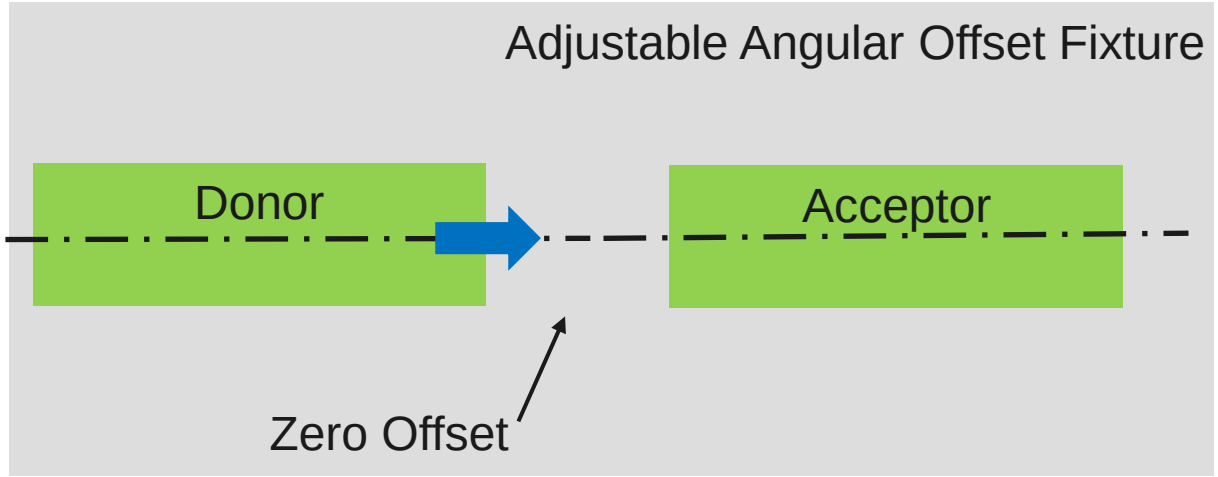
Distribution A

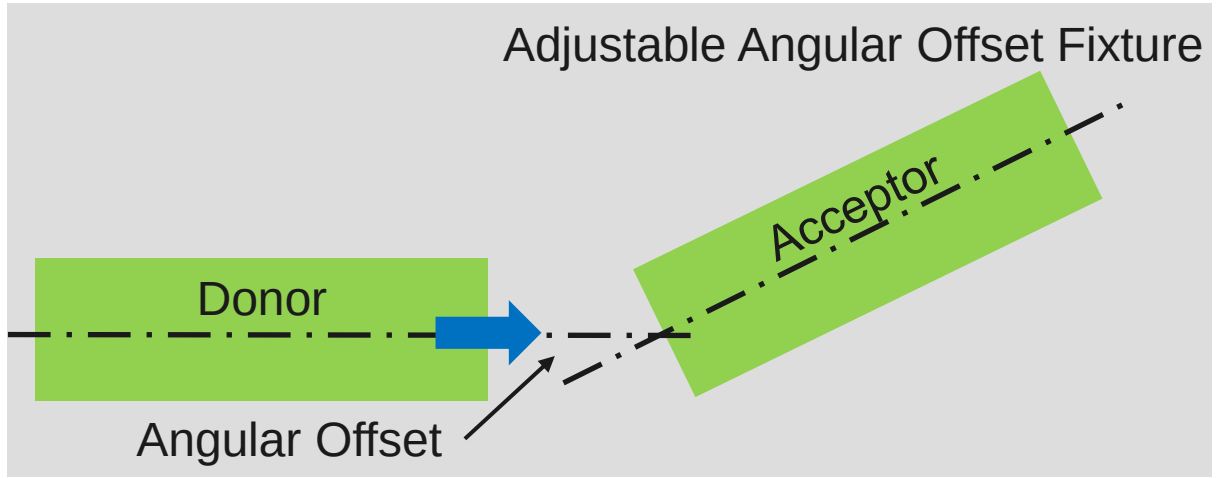
Detonation Transfer Reliability

Test Design – Angular Offset

Fixture Considerations

- Hold donor and acceptor
- Represent system level interface
- Large adjustment range
  - Beyond detonation transfer offset limit
    - Screening Tests Recommended
- High resolution required
- Fixture may be a single use
- Sentest™ software simulations
  - Evaluate potential outcomes





Distribution A

Detonation Transfer Reliability

Test Considerations

Test Temperature (cold – system defined)

- Thermal conditioning
  - Study to determine minimum soak time
  - Fixture material effects
- Test temperature -actual
  - Study to determine maximum time out of environmental chamber
  - Insulation required?

Donor material

- System representative
- From a single lot to minimize variables

Acceptor material

- System representative
- From a single lot to minimize variables

Distribution A

Detonation Transfer Reliability

Test Steps

Setup Software (Sentest)

- MuMin, MuMax, SigmaGuess (affects starting offset)
- Resolution, Upper and Lower Limits (fixture defined)

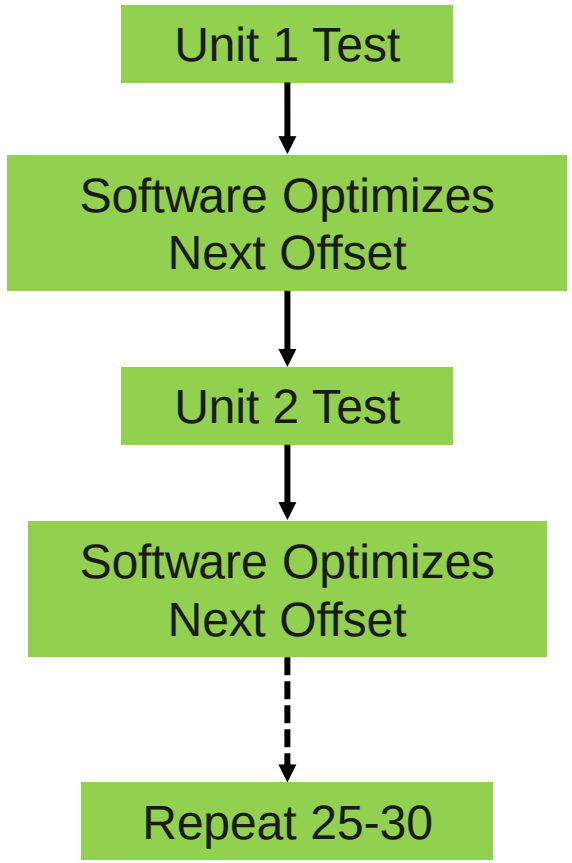
Setup & Test Unit 1

- Environmentally Condition
- Function
- Determine transfer success
- Enter Results of Test 1 into software
  - Neyer Software determines next offset to optimize data set

Setup & Test Unit 2

.
.
.

Repeat process 25 to 30 times (looking for stable data - Mu and Sigma)



Distribution A

Interpretation of Test Results

Tolerance stack analysis of system Interface

- Determine worst case offset

Neyer D Optimal Results for .999 reliability and 95% confidence interval (one sided)

- Offset determined

Goal

- Tolerance stack results ≤ Offset required for .999 reliability and 95% confidence interval

Actual achieved reliability can be determined by setting the necessary statistical calculations in the Neyer D Optimal software

Distribution A

Detonation Transfer Reliability

Interpretation of Test Results:

Axial Offset Example:

Tolerance stack (system interface between donor and acceptor)

- Worst case offset = .015”

Neyer D-Optimal Results (30-unit study)

- Mu= .082”
- Sigma= .0096”
- .999 Reliability at 95% Confidence Interval =.021”

.015”≤ .021” Therefore reliability goal is met

Distribution A

Detonation Transfer Reliability

Summary

RCC 319 .999 Reliability at 95% Confidence Level

- Statistical sensitivity method that varies critical performance parameters:

  Gap, Axial and Angular alignment

  - Success demonstrated by use of **Neyer-D Optimal**

- Fixture Design that permits adjustment of critical performance parameters is required

Distribution A

Detonation Transfer Reliability

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Distribution A

Detonation Transfer Reliability

About Excelitas Technologies

Excelitas Technologies is a global technology leader focused on delivering innovative, customized solutions to meet the lighting, detection and other high-performance technology needs of OEM customers.

From analytical instrumentation to clinical diagnostics, medical, industrial, safety and security, and aerospace and defense applications, Excelitas Technologies is committed to enabling our customers' success in their specialty end-markets. Excelitas Technologies has over 7,300 employees in North America, Europe and Asia, serving customers across the world.

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PRELIMINARY DRAFT V2 June 7th

Exploding Foil Initiator Development

David Pray

May 11, 2021

EXCELITAS TECHNOLOGIES®

Distribution A

Exploding Foil Initiator Development

Blue Chip® Initiator

Blue Chip® Detonator family

- 7 Different Variations
- High voltage chip slapper detonator (low energy)
- Qualified to MIL-DTL-23659 Appendix A
- TO-5 Header
- Exploding metal foil bridge
- Polyimide flying plate
- HNS-IV energetic



Distribution A

Exploding Foil Initiator Development

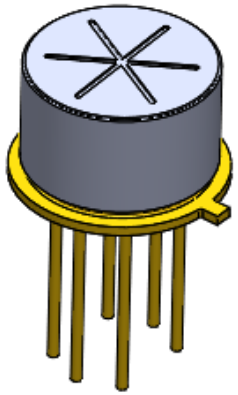
Blue Chip® Initiator

Slapper Detonator - Exploding Foil Initiator (EFI) based design

- Low-cost MIL-STD-1901 compliant design
- Leverages Blue Chip® Detonator design and technology
- Offers safety features of an EFI device
  - High Voltage
  - Insensitive HNS-IV explosive (used with EFI)
  - Not a Pyrotechnic Load in contact with hot bridge wire
- $BKNO_3$ pyrotechnic load



Functioned



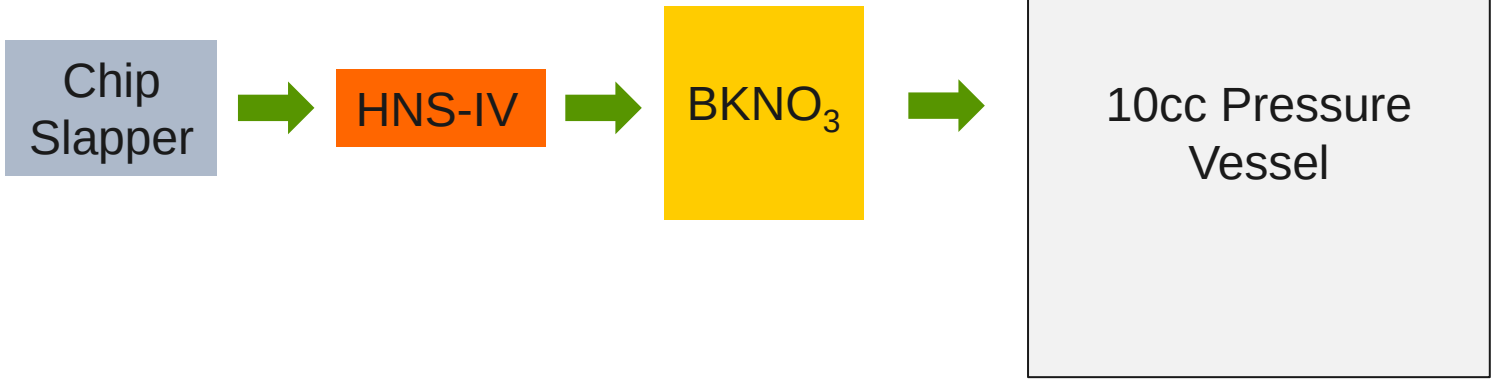
Distribution A

Exploding Foil Initiator Development

Blue Chip® Initiator

Fundamentals

- High voltage chip slapper header (low energy)
- HNS-IV (detonation)
- $BKNO_3$ (deflagration)
- Hot gas/particles
- Pressure in 10cc vessel



Distribution A

Exploding Foil Initiator Development

Blue Chip® Initiator

Development

- $BKNO_3$ Density and Load Shape
  - Manufacturability
  - 10cc Performance
  - Temperature Test Range -40°C to 71°C
    - Potential for expanded Range



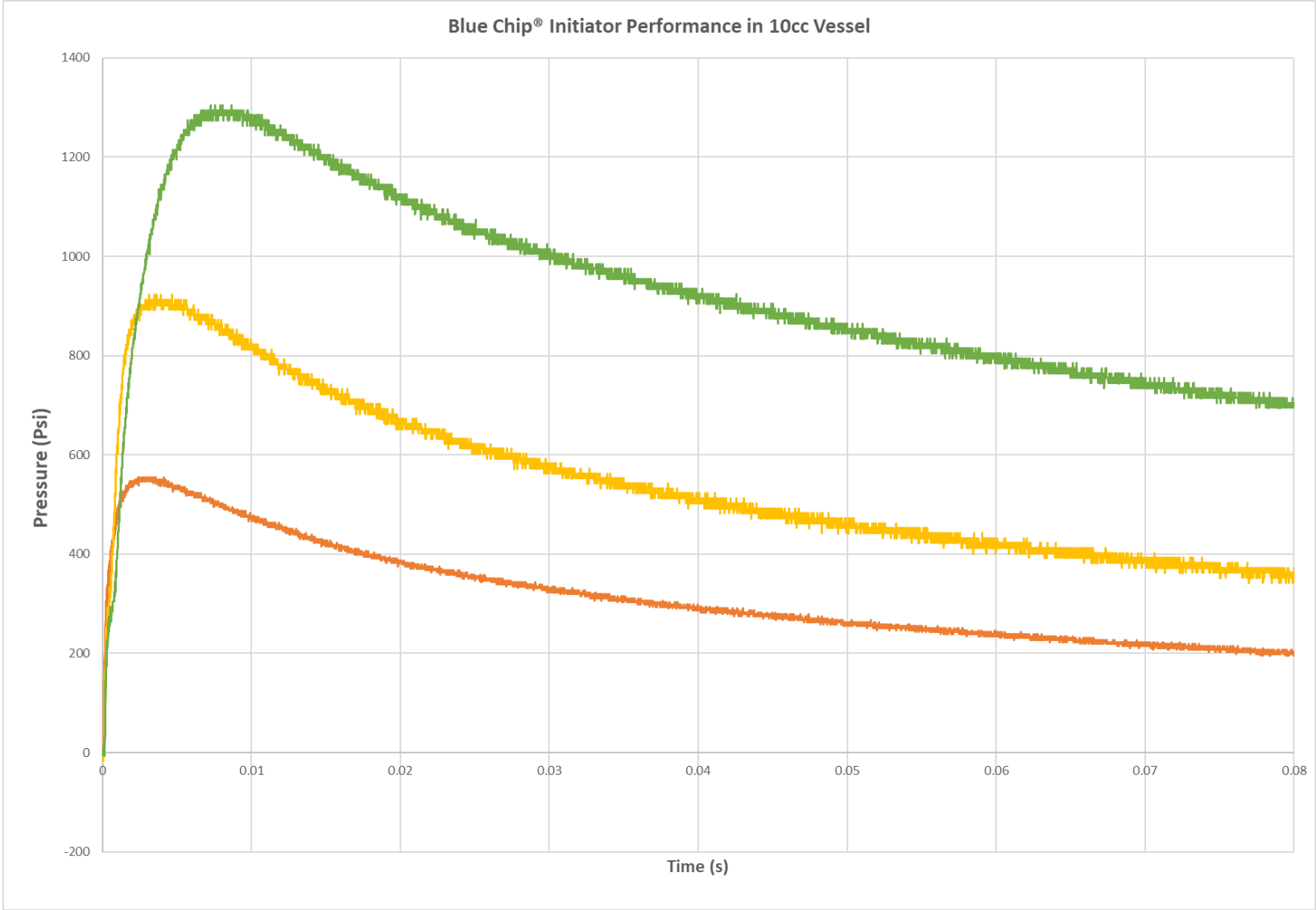
Distribution A

Exploding Foil Initiator Development

Blue Chip® Initiator

Output Performance

- 10cc Pressure Vessel data
  - Pressure range
    - 400 to 1300 Psi
  - Time to Peak Pressure
    - 2 to 10 Millisecond
  - Time to First Pressure
    - .1 to .5 Millisecond



EXCELITAS TECHNOLOGIES

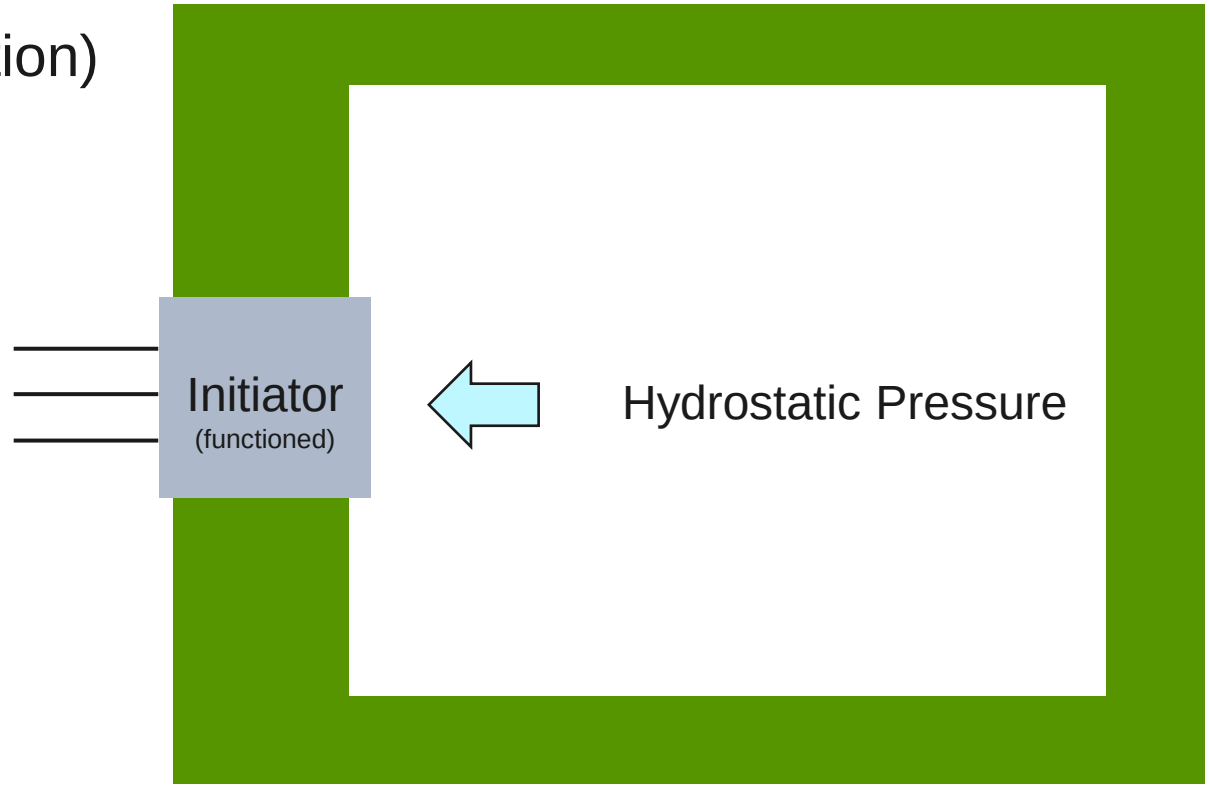
Distribution A

Exploding Foil Initiator Development

Blue Chip® Initiator

Performance

- Hydrostatic Testing (post function)
  - Pressure
    - 5,500 Psi minimum
  - Hold Time
    - 10 seconds minimum



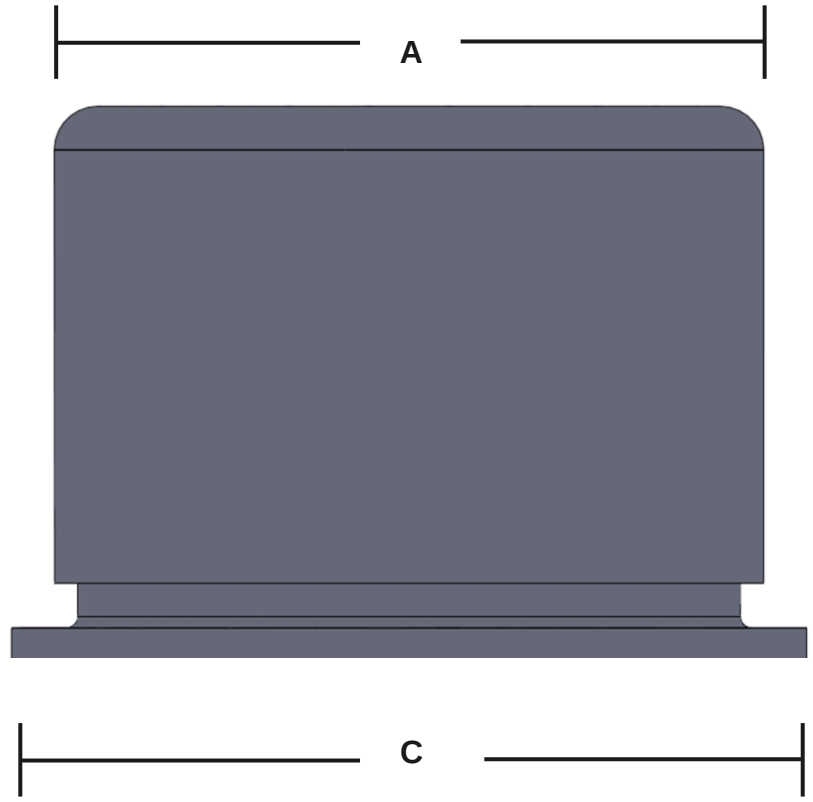
Distribution A

Exploding Foil Initiator Development

Blue Chip® Initiator

Dimensions:

A TYP.	B TYP.	C TYP.
(Ø 0.320” max)	(0.215 - .440”)	(Ø 0.360”)
Note: lead pins not shown		



Distribution A

Exploding Foil Initiator Development

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Distribution A

Exploding Foil Initiator Development

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U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – ARMAMENTS CENTER

ARMY Fuze S&T Overview at the 64th NDIA Fuze Conference

Robert Alston Ph.D.

Fuze and Precision Armaments Directorate, Fuze Division

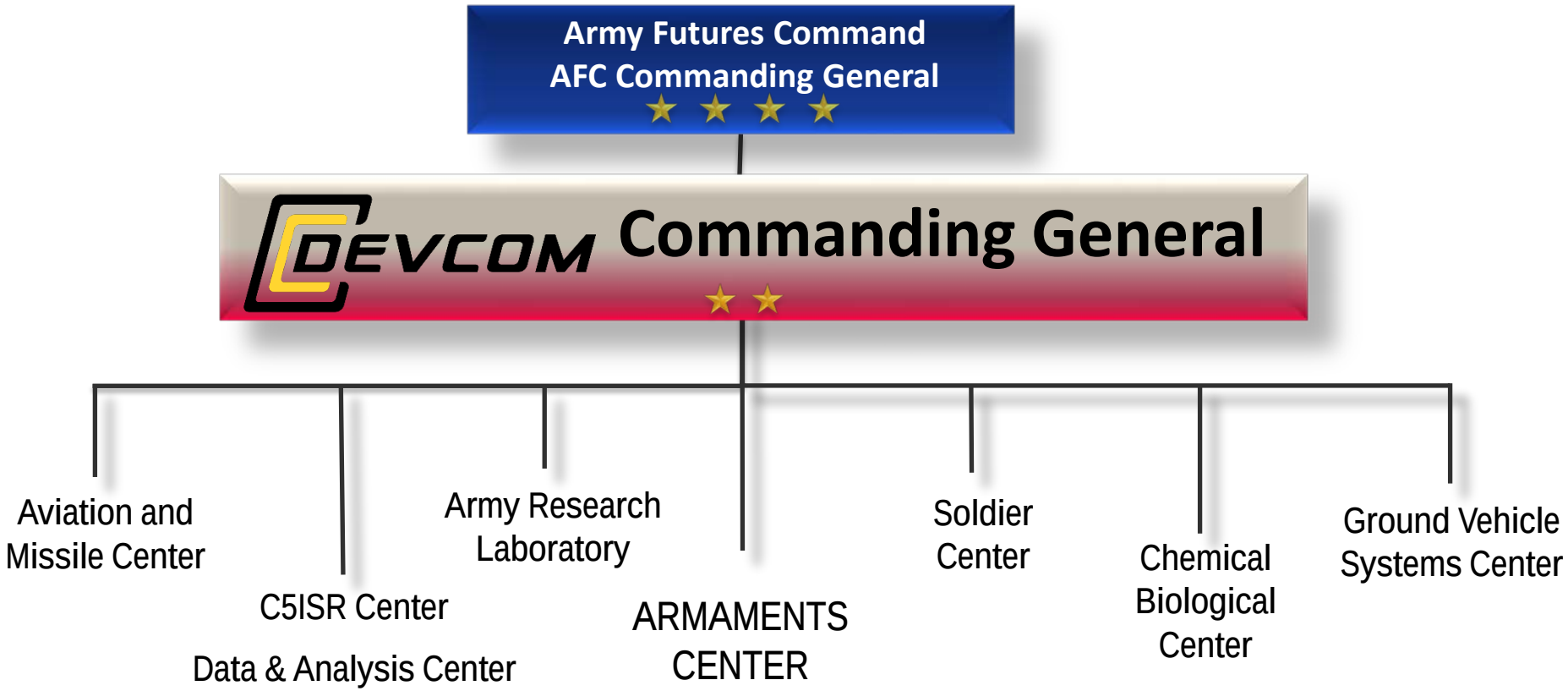
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AGENDA

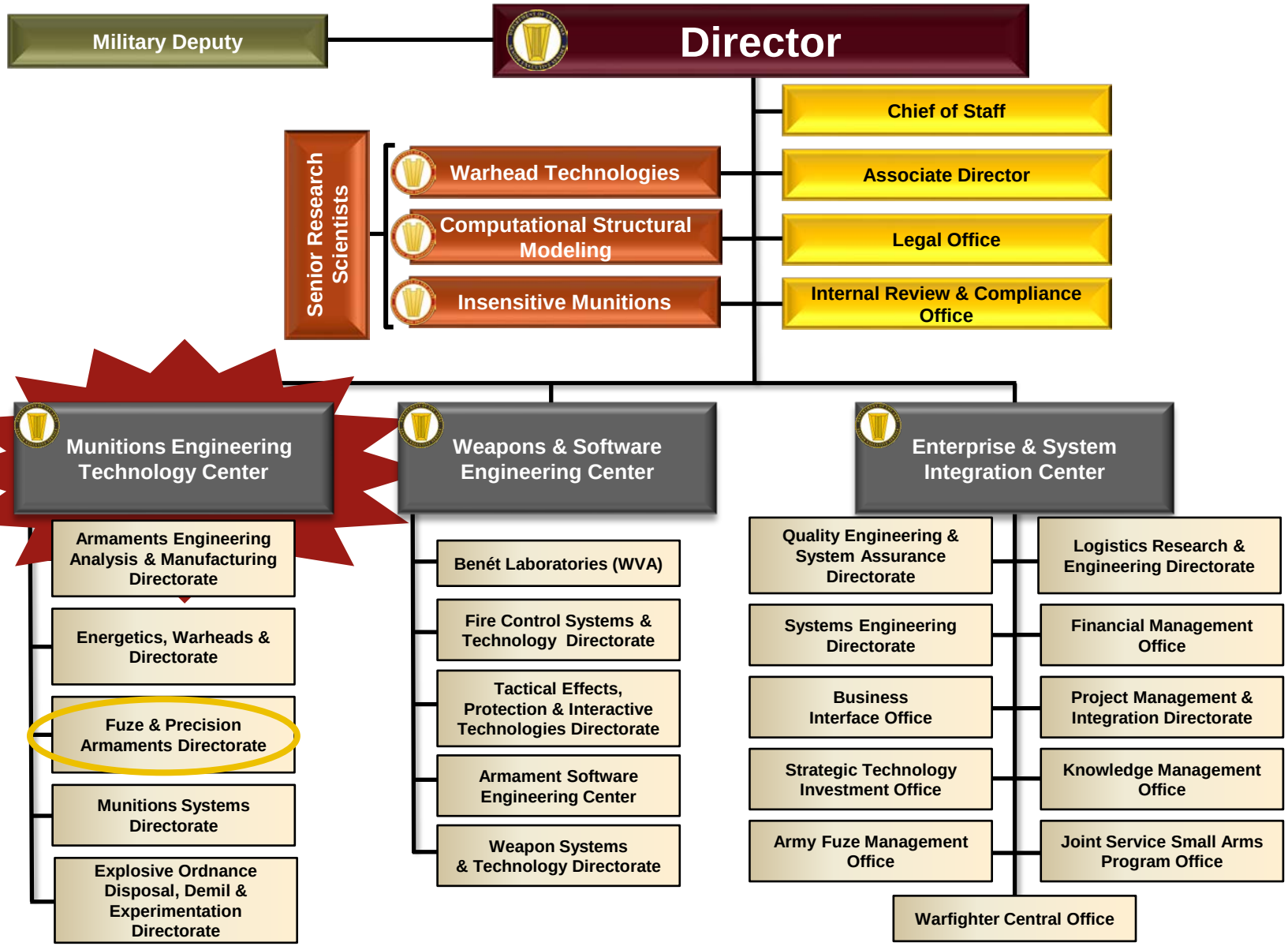
- Organization
- Facilities
- Fuze S&T Overview
  - –Current Investment Areas
  - –Ongoing Projects
  - –Thrust Areas
- Collaboration Opportunities
- 64th Annual Fuze Conference Presentations

ARMY FUTURES COMMAND ORGANIZATION



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ARMAMENTS CENTER ORGANIZATION



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PICATINNY'S OTHER TENANTS

DEVCOM ARMAMENTS CENTER

Combat Capabilities Development Command – Armaments Center DEVCOM-AC

PEO Ammunition

CG/JPEO Armaments & Ammunition

Joint Munition & Lethality LCMC

PEO Soldier
PM Soldier Weapons

PEO Ground Combat Systems
PM Ground Combat Vehicle

DCMA - Springfield

Garrison Commander

PM CCS
PM CAS
PM MAS
PM TAS
PM JS
PM JB

Office of the Executive Director for Conventional Ammunition O/EDCA

Civilian Human Resources Agency

Naval Surface Warfare Center

Marine Corps G Co 2-25

Army Contracting Center – CCNJ

Recruiting Northern NJ HQ (Company)

7245th Installation Medical Support Unit

DoD Joint Specialty Site for Guns and Ammunition

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ARMAMENTS CENTER CAPABILITIES



RESEARCH



DEVELOPMENT



PRODUCTION



FIELD SUPPORT



DEMILITARIZATION

Advanced Weapons:

- Line-of-sight (LOS), beyond line-of-sight (BLOS) and non line-of-sight (NLOS) fire
- Scalable effects; non-lethal; directed energy; autonomous weapons.

Ammunition:

- Small, medium, large caliber
- Propellants; explosives; pyrotechnics; warheads; advanced munitions
- Fuzes
- Logistics; packaging; environmental technologies and explosive ordnance disposal

Fire Control:

- Battlefield digitization; embedded system software; aero ballistics and telemetry

"Center of Lethality" for Armament Systems and Munitions for Joint Services

ARMAMENTS CENTER FUZE DIVISION MUNITION PRODUCTS









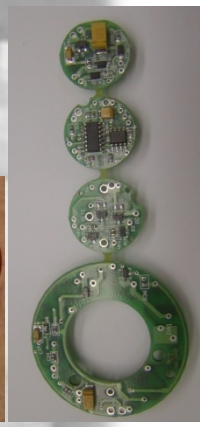












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ARMAMENTS CENTER FACILITIES

Armament Software Engineering Center



Ballistic Gun Range Complex



Energetics Synthesis, Formulation and Scale-up Complex



High Performance Propellants Complex



Davidson Warhead Facility



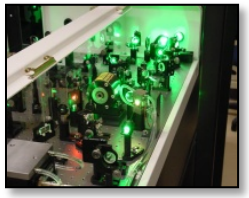


Automated Test Sets Facility



Fuze Development Center





Directed Energy Facility

Electromagnetic Effects Complex



Remote Armaments Facility



Soft Catch Gun Facility



Our Organic Facilities Enable Integrated Armament System Solutions

Demilitarization Facility

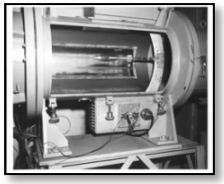




Drop Tower Facility



Non-Destructive Evaluation Facility



Wind Tunnel Facility



Precision Armaments Complex



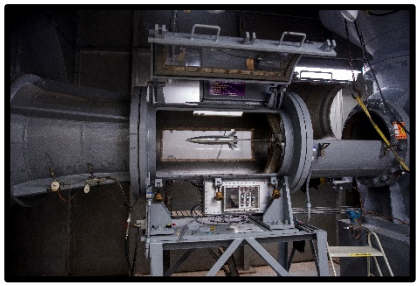
DoD Joint Packaging, Handling, Storage, and Transportation Complex

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FUZE AND PRECISION ARMAMENTS FACILITIES

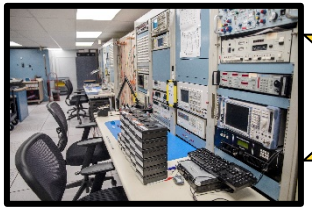

Precision Armaments Lab


Encapsulation Lab


Wind Tunnel Facility

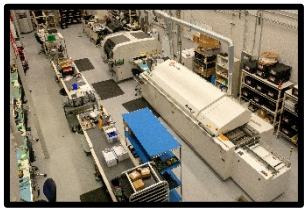

Environmental Lab


Hardware In the Loop Lab


Telemetry Ground Station & Electronics Lab

Our Organic Facilities Enable Integrated Armament System Solutions

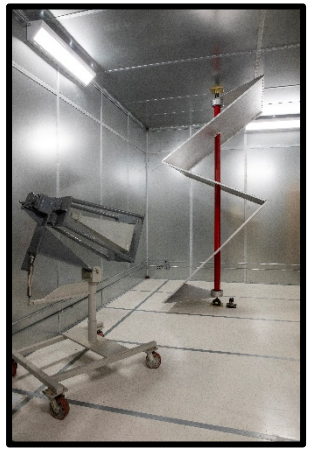

Electronics, Electro-Mechanical & Prototype Facility


Fuze Development Center


RF Anechoic Chamber

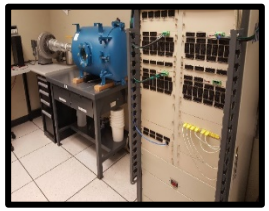

Integration Lab


Electromagnetic Sensor Test Facility


Electromagnetic Environmental Effects Lab

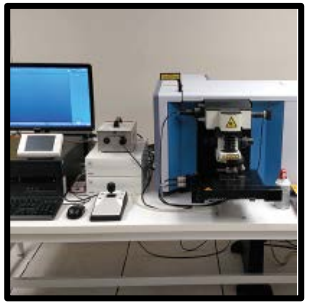

Soft Catch Gun Facility


Sensor Calibration Lab


Battery Test Lab


Fuze Division Lab


Soldering Inspection Facility


Raman Spectroscopy Lab

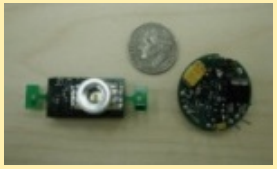
FUZE S&T INVESTMENT AREAS

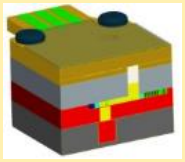
Advanced Fuze Setting
- Next Gen Large Caliber Setter (NGLCS)
- High speed wireless setting

NGLCS

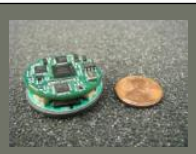


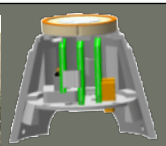
Advanced Warhead Initiation Schemes
- High count multi-point initiation
- Scalable and selectable initiation for Collaborative Munitions
- Micro-Scale Firetrain (MSF)

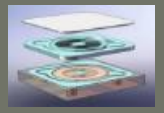





Launch and Target Sensing
- Next Gen prox, tracking prox, dynamic triggering, optical prox, active imaging
- G-Switch, Target Media Sensing





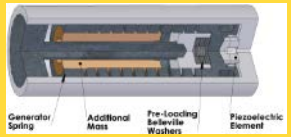


Fuze Decision Logic

Novel Power & Energy
- Thermals, liquid reserve, harvesters

Thermals



Liquid Reserves

Advanced Safe and Arming
- MEMS S&A, Low Cost ESAD




CURRENT FUZE PROJECTS

Emerging & MaturingTechnologies

6.2 OSD Joint Fuze Technology Program JFTP (JEMTP)

- EPIC-ABAQUS Subroutines
- Low Cost Tracking Proximity Sensor
- Fracture & Damage Mechanisms of LIGA MEMS
- TPV Power Generation for HVP
- Time Integrating Miniature Setback Switch
- SHF Command Link for CUAS Munitions
- AI/ML for HOB applications in Contested Environments

6.3 OSD Joint Fuze Technology Program JFTP (JEMTP)

- Determination Optimal Potting Hi-G Electronics & Fuzes
- COTS Accelerometer As Impact Sensor
- Glass Ampoule Analysis Capability Transition
- SiC High Voltage Switch Maturation

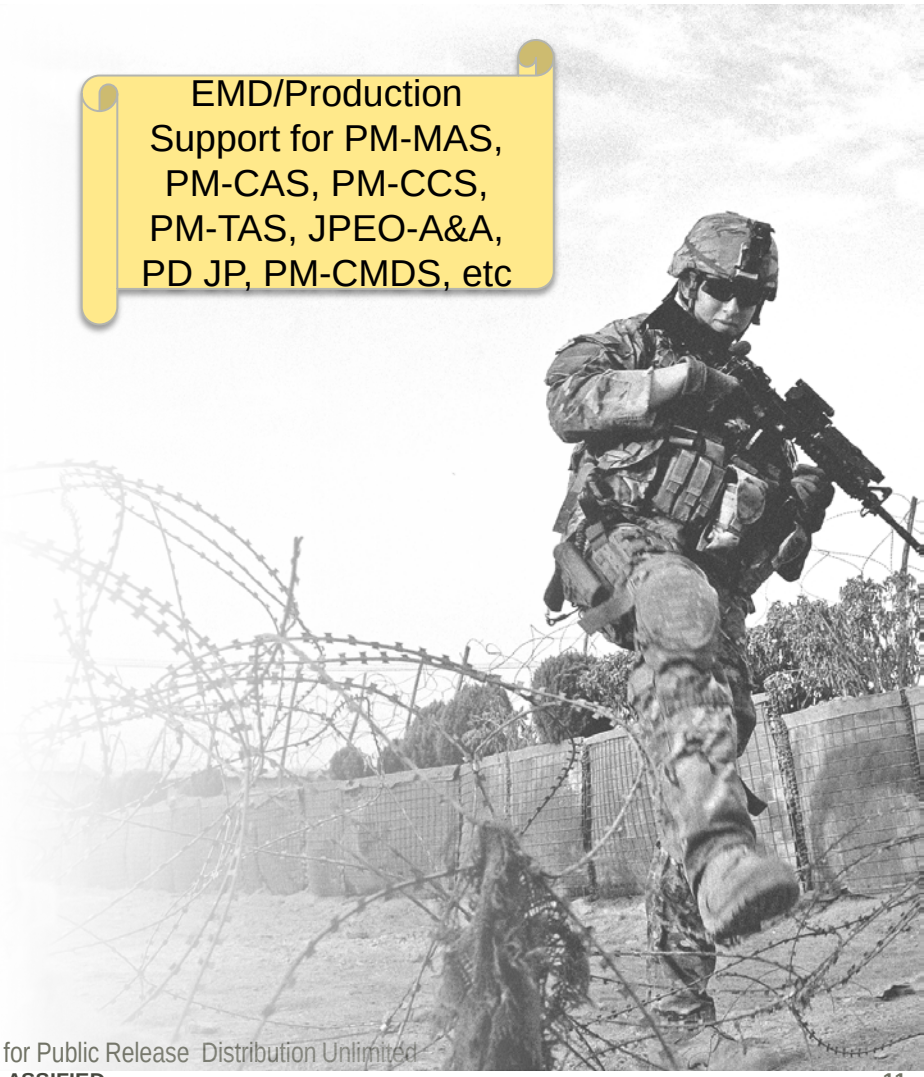
DEVCOM S&T Projects & Demonstrations

- Fuze & Power Tech Enablers: Tracking Proximity Sensors, Advanced Initiation, Wireless Setting, Novel Power
- XM1155 Development
- XM1182, XM1204, and XM1206 Hardware Development
- MOFA2/iMOFM Development

6.7 JPEO A&A Fuze Technology Integration (FTI) Program

- M550 S&A Spin Lock Improvements
- Hand Grenade Improvements (M213)
- M739A1 Impact Delay Improvements
- M783 Product Improvements
- M734A1 Microcontroller Replacement
- MEMS Impact Switch Producibility & Implementation
- Proximity Sensor MMIC Transceiver Translation
- Proximity Fuze Alternate Transceivers
- Long Range Artillery Fuze Compatibility
- Alternate Suppliers for Critical Fuzing Components

EMD/Production Support for PM-MAS, PM-CAS, PM-CCS, PM-TAS, JPEO-A&A, PD JP, PM-CMDS, etc



Distribution Statement A: Approved for Public Release Distribution Unlimited

FUZE S&T THRUST AREAS

- Novel Power for Long Range Applications
- MEMs Sensing and MEMs S&A
- Advanced Initiation Schemes – High count multi-point initiation
- Fuze Proximity - Low Cost Tracking Proximity Sensors, Dynamic Triggering, Optical Proximity and Active Imaging
- Secure Wireless Data Transmission for Fuze Setting
- Collaborative Fuzing Architectures
- Moving toward highly integrated electronic fuzing – (ESAD, Prox, Setting)

COLLABORATION OPPORTUNITIES

- **Industry to DEVCOM-AC engagements**
  - Technology Transfer Office (Contact us for more information)
  - Cooperative Research and Development Agreements (CRADAs)
  - Test Service Agreements (TSAs)
- **NAC/DOTC**
- **Joint Enhanced Munition Technology Program (JFTP)**
- **DOD Fuze IPT**
- **SBIR**
- **Broad Agency Announcement (BAA)**

ARMAMENTS CENTER BRIEFINGS AT 64TH NDIA FUZE CONFERENCE

Presenter/Author	Titles	Time
Richard Johnson	Design of a Test Methodology to Simulate Rain Environments	Tue 12:35p
Tyler Wilson	Cannon Caliber Fuze Setter Overview	Wed 1:30PM
Viktor Bana	Software Defined Radio for Medium Caliber Applications	Wed 3:10PM

Thanks for your time and attention

20-G-017: Polymer Multi-Layer Capattery

Sandia National Laboratories

ADVANCED FUZING TECHNOLOGY

Low Voltage PML Capacitor Development and Characterization

Presented By:

Joshua Dye

(505) 844-8627, josdye@sandia.gov

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Distribution A

SAND2021-5438 C

Introduction

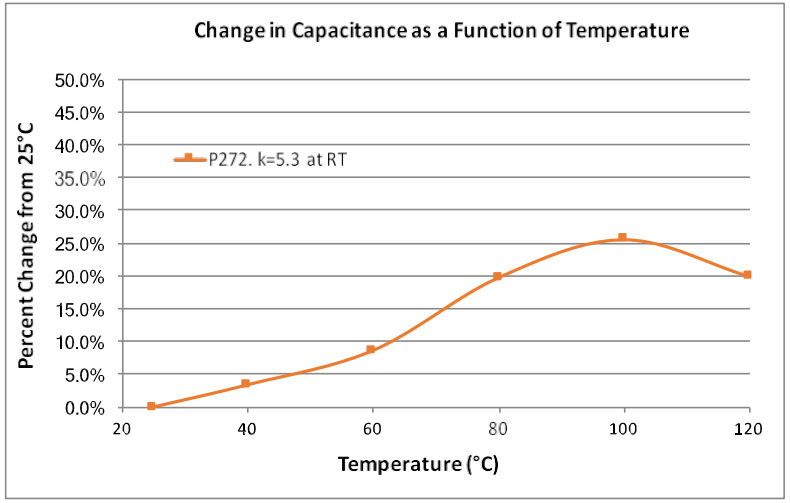
Polymer Multi-Layer (PML) capacitors display advantageous characteristics worth pursuing

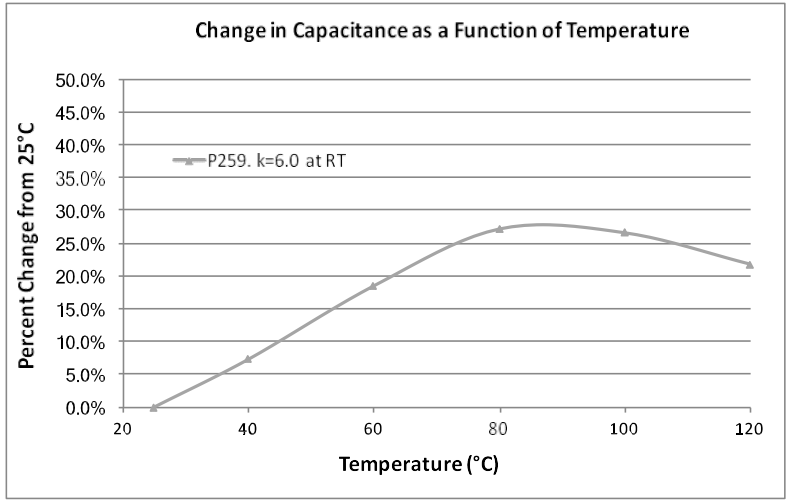
- High energy density
- Lightweight
- Robust
  - Self-healing
- Stable
  - Temperature
  - Voltage

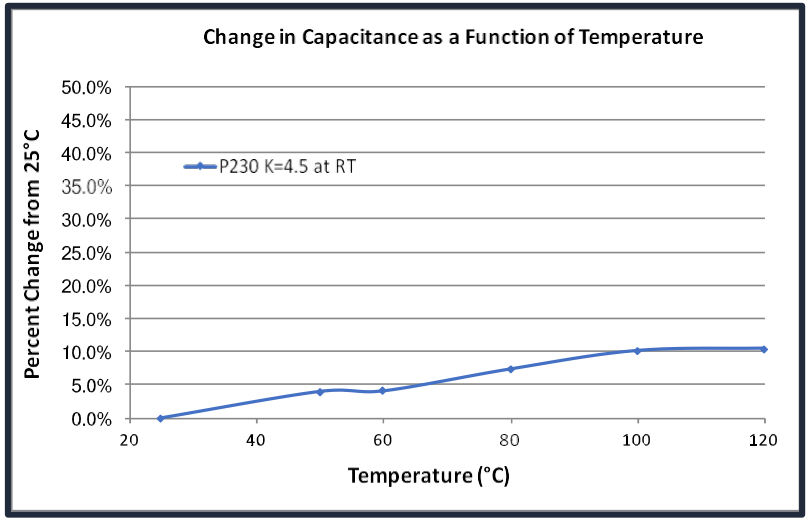


COTS PML capacitors (licensed by PolyCharge America Inc.) not optimized for energy density

- Can be improved through material selection and processing







Multiple polymer formulations evaluated for dielectric characteristics

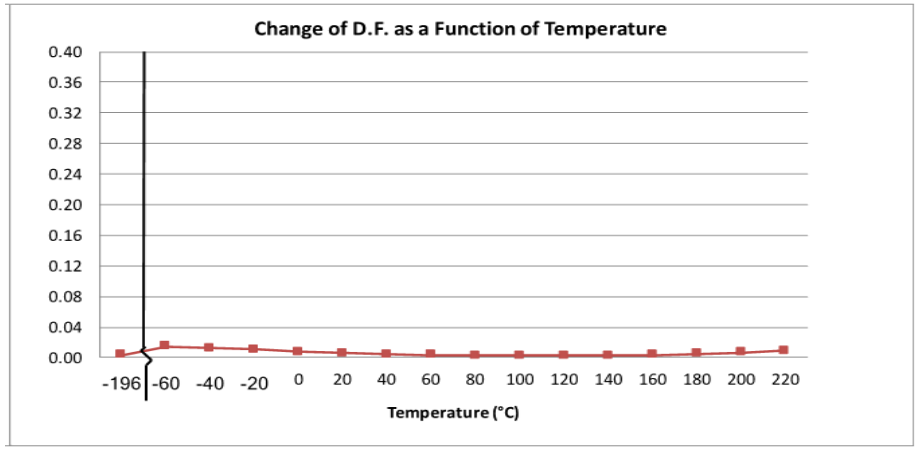
Distribution A

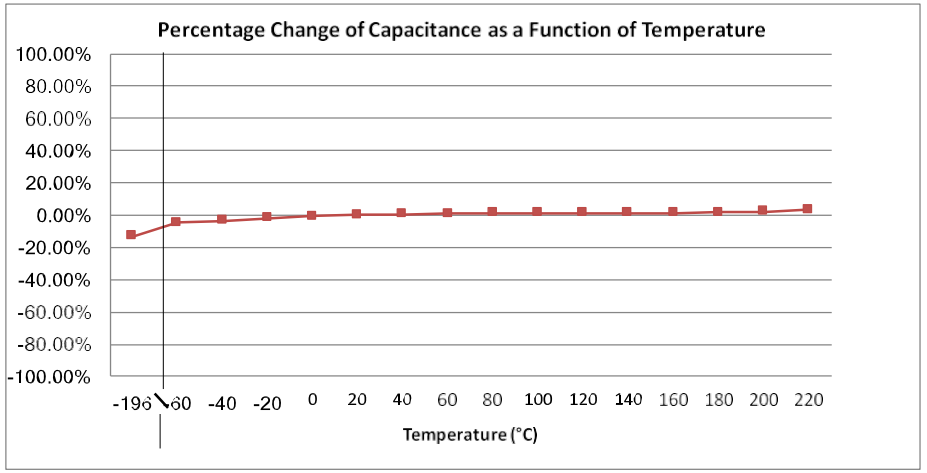
Material Fabrication Challenges

Attempted fabrication of P230 material. Ultimate Failure due to moisture sensitivity

	Sample 1	Sample 2	Sample 3	Sample 4
Initial Leakage (μA)	1117	691	1292	1004
Leakage after vacuum drying (μA)	19	15	87	80
Leakage after 3 hours (μA)	45	44	40	31
Leakage after 24 hours (μA)	1174	924	1241	1800

Returned to standard polymer formulation, using very thin layers





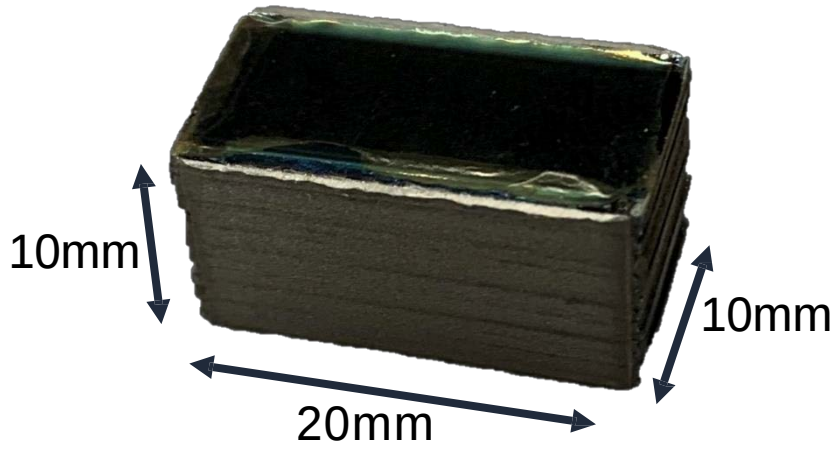
Lower dielectric constant (k=3.2), but extremely stable across temperature and easier to fabricate

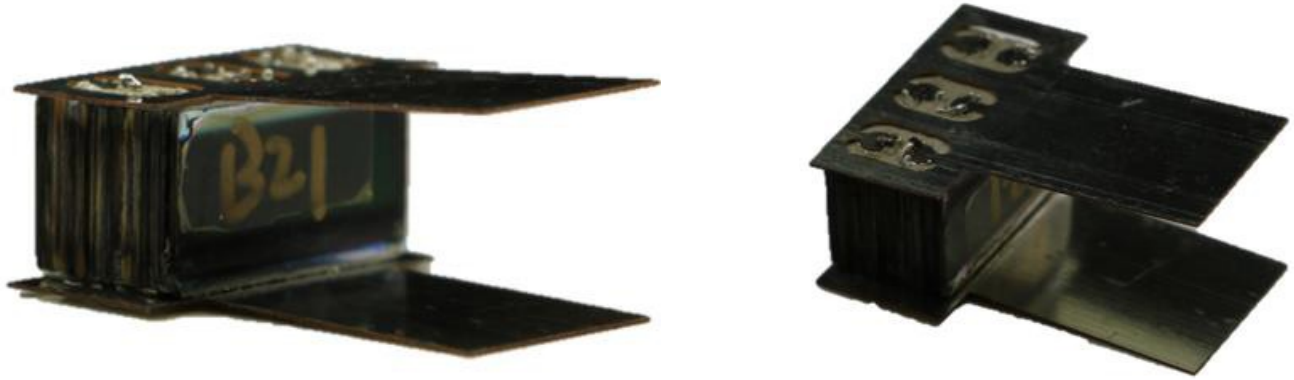
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Prototype Hardware

Prototype PML Capacitor completed and tested

- Frequency characterization
- Temperature characterization
- Leakage current vs voltage
- Voltage characterization
- Comparison to alternative technologies
  - Ceramics (X7R[1] and X5R[2])
  - Tantalum[3]
  - Hybrid/Wet Tantalum[4]

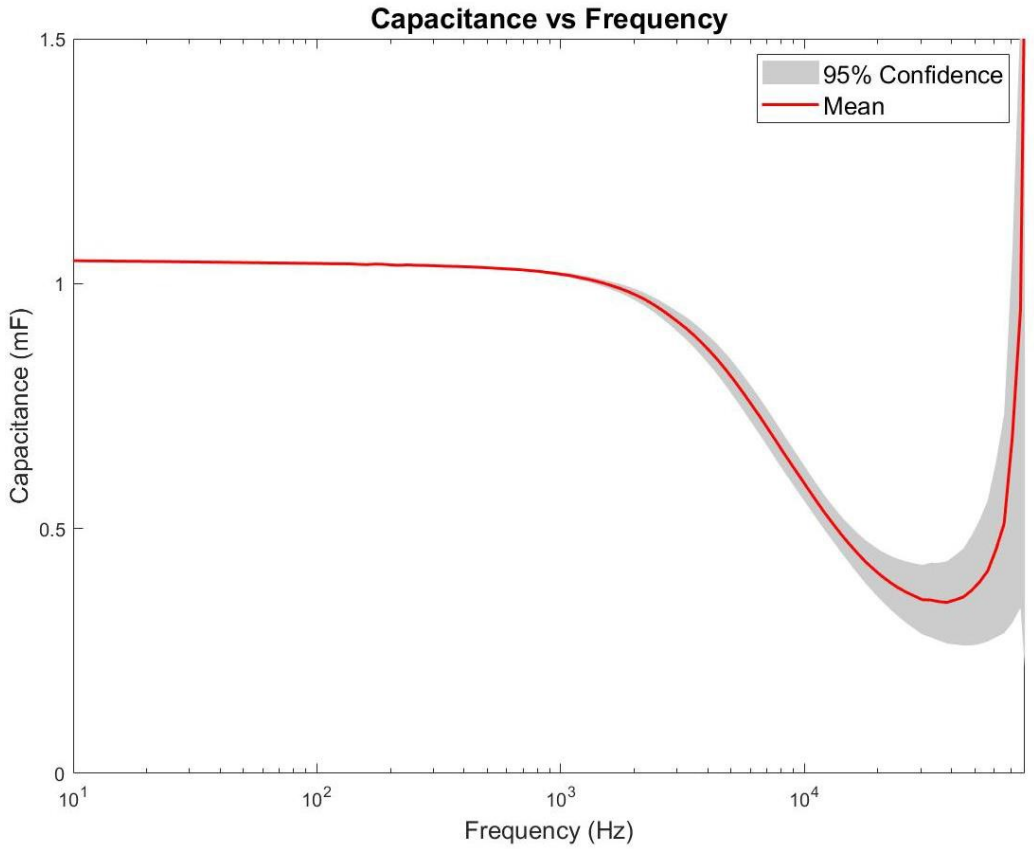




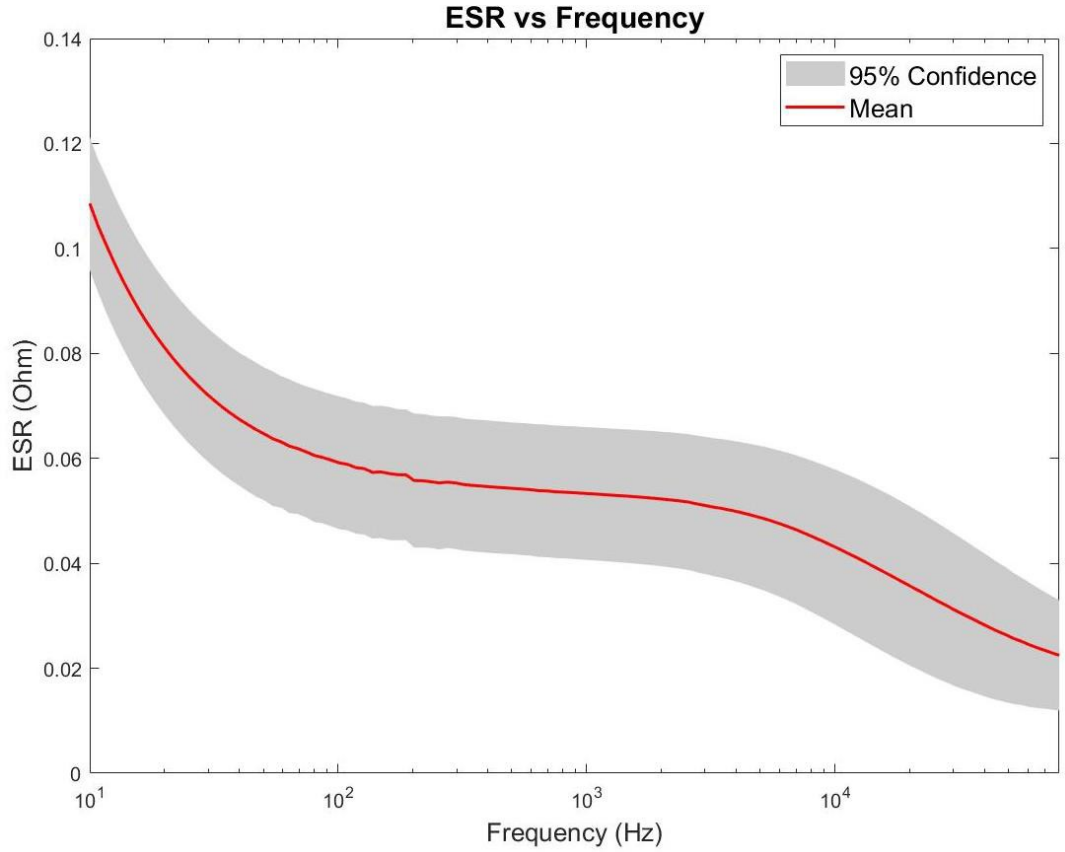
15 Capacitors Received and Tested

Comparisons made to the following part numbers
(1) P/N: GCJ21BR71C475KA01, (2) P/N: GRM31CR61C476ME44
(3) P/N: TAJE337M016RNJ, (4) P/N: HC2B025102

Frequency Characterization

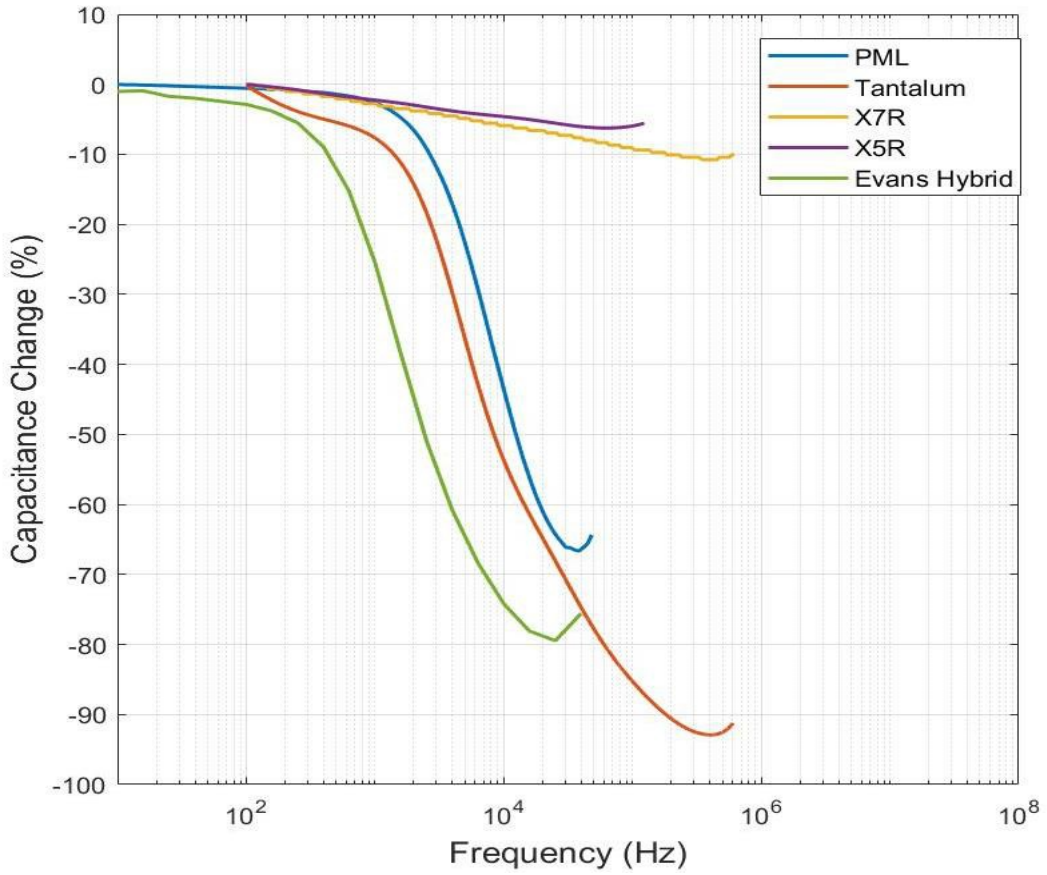


Capacitance roll-off after 1kHz

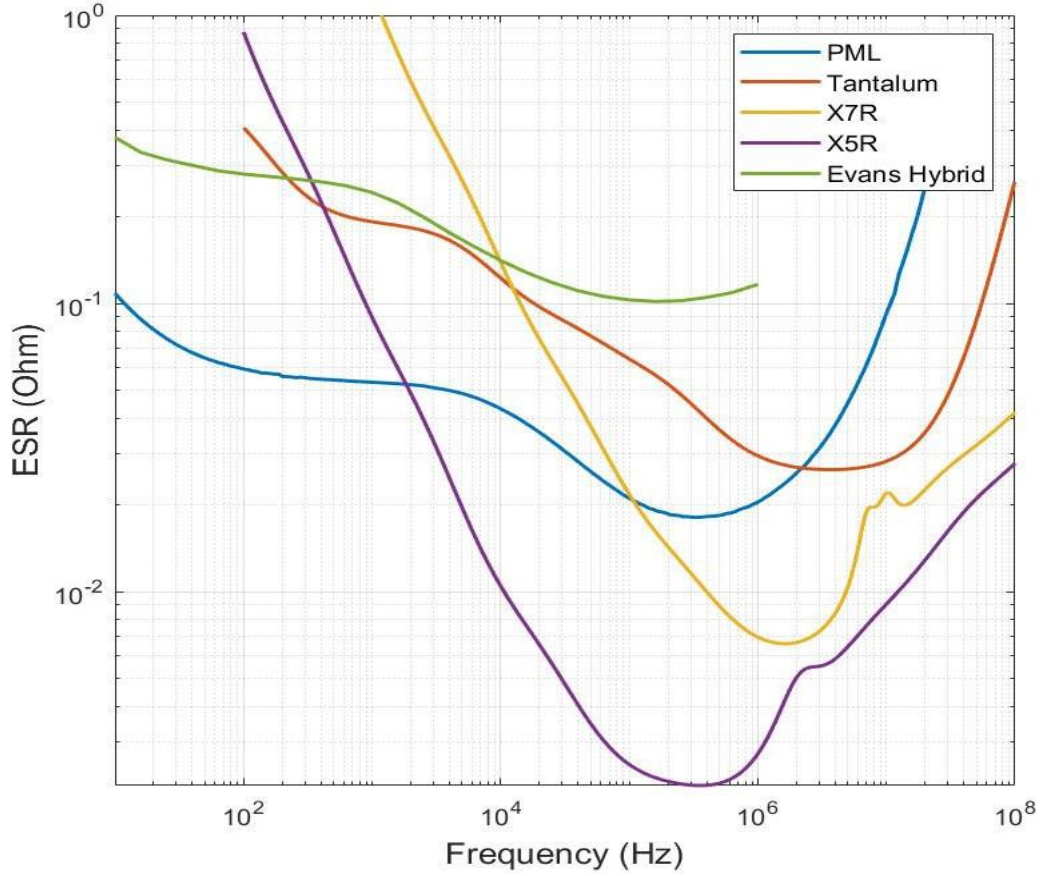


Low ESR

Frequency Comparison

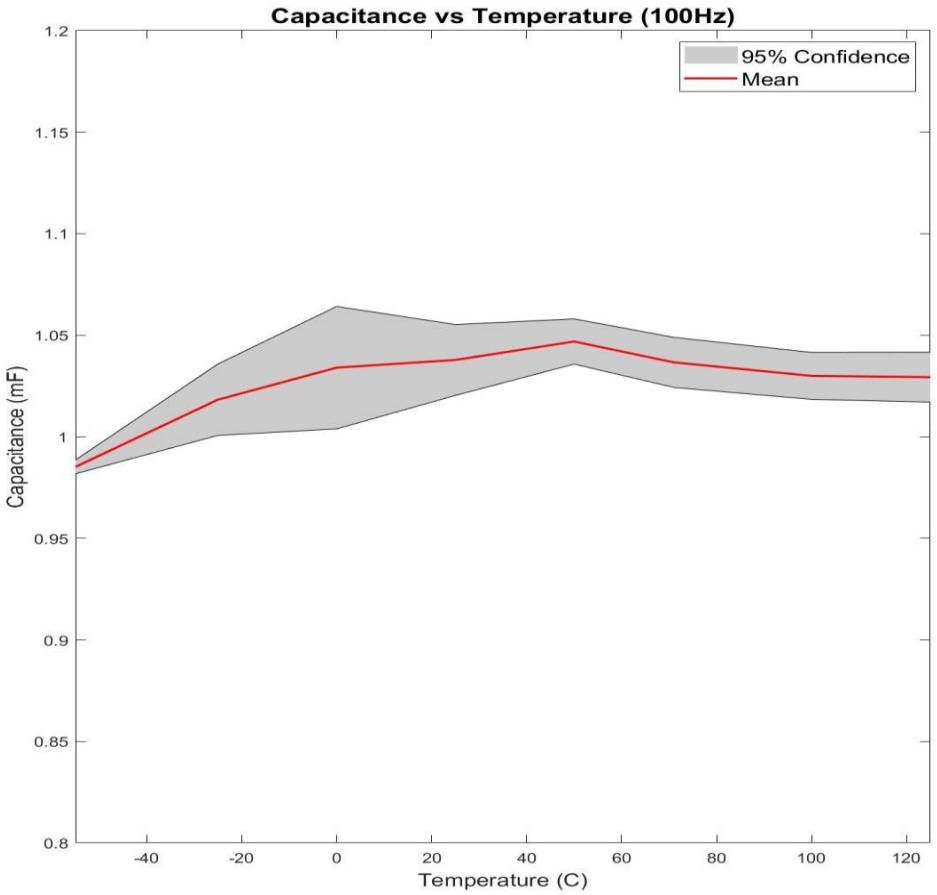


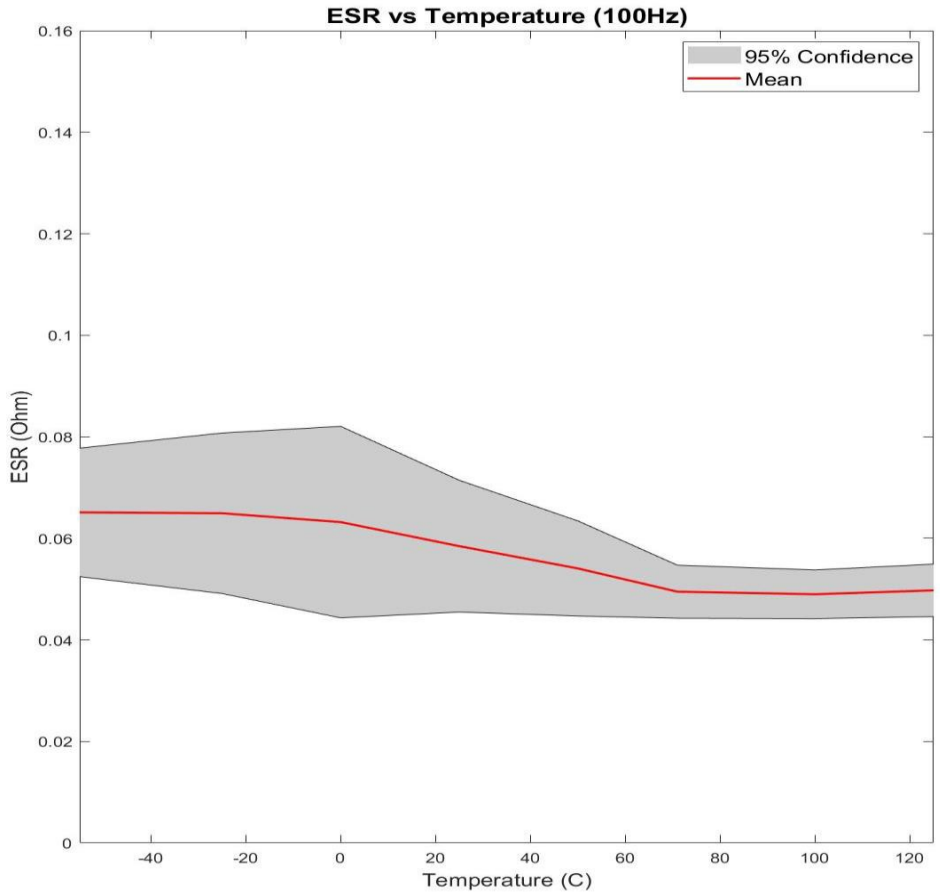
Similar roll-off to tantalum
Ceramics stable



ESR comparable, best at low frequency

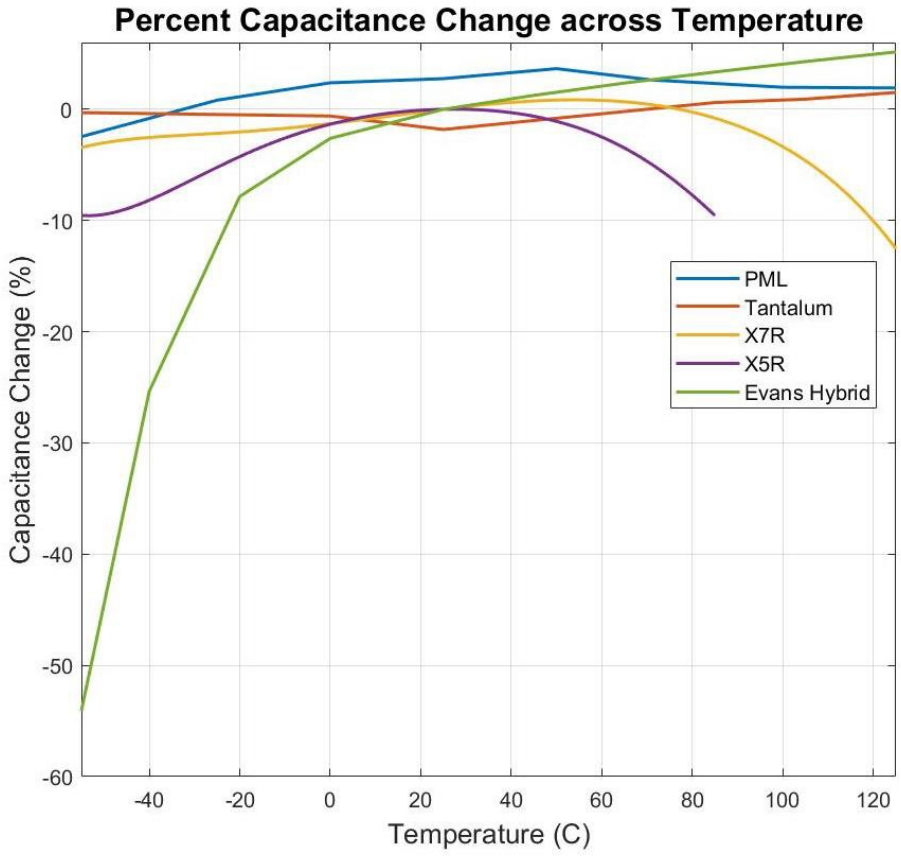
Temperature Characterization



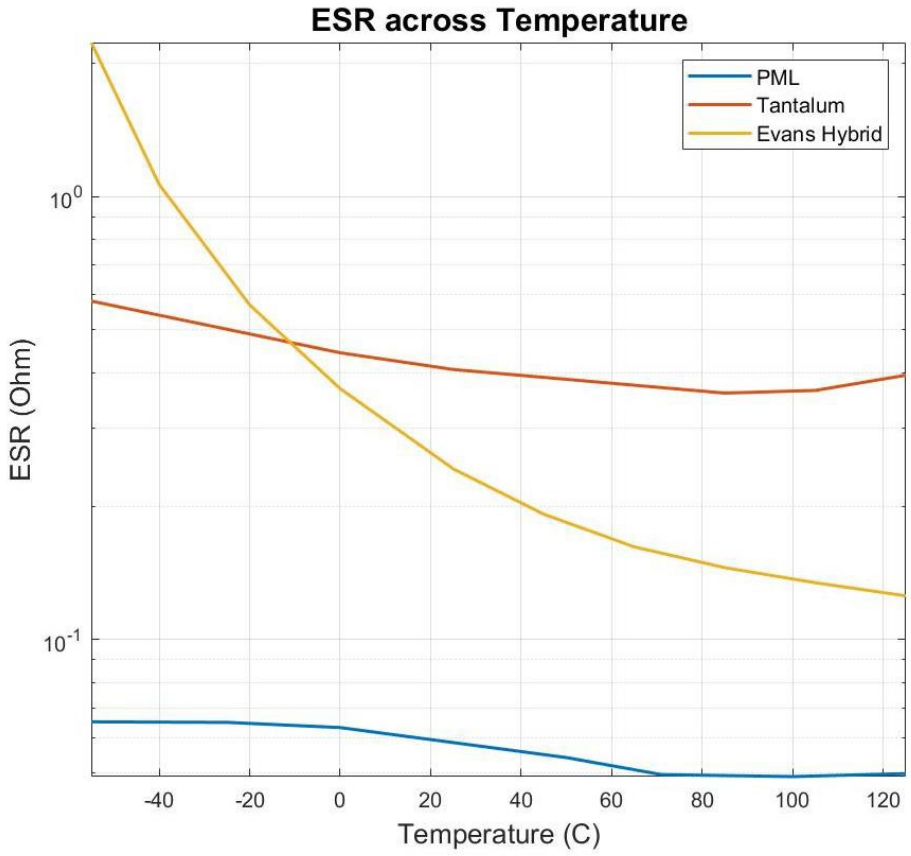


Very stable across temperature

Temperature Comparison



PML and tantalum are top performers

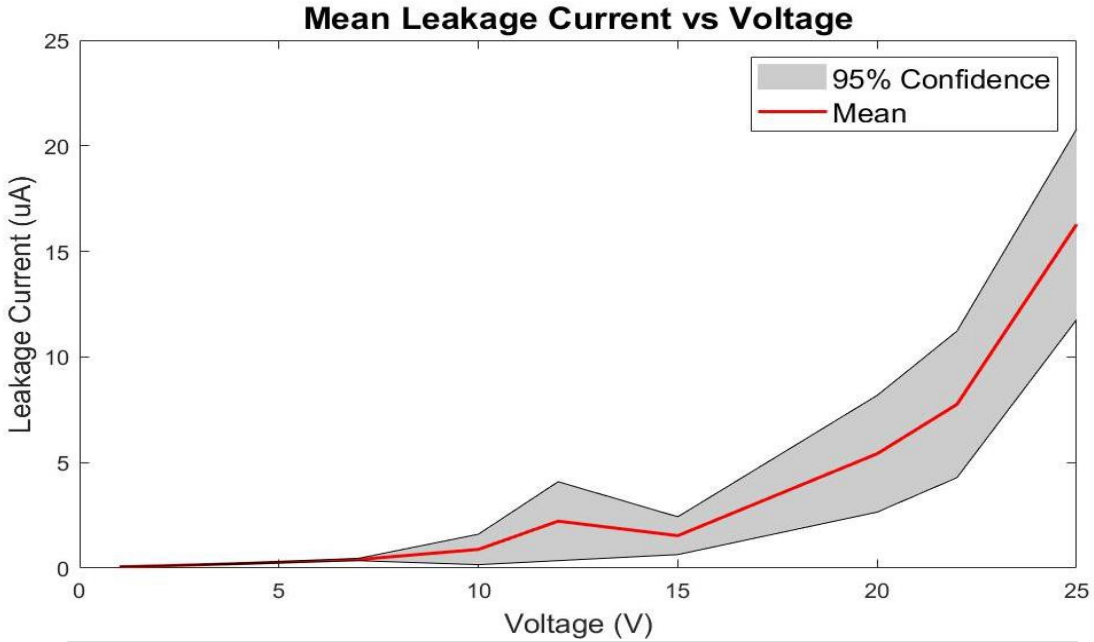


PML ESR ~10X better ESR than tantalum. No data on ceramics.

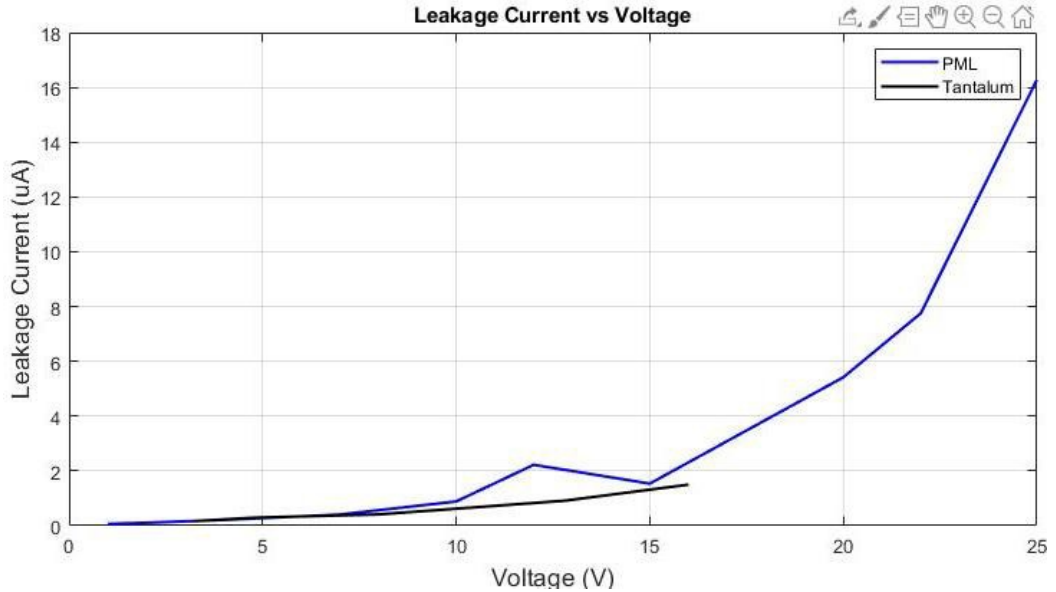
Leakage Current

Limited Leakage Current Data

- **X5R: 15.1µA at 16V**
- **X7R: 17µA at 25V**
- **Hycap: 7.5µA (unknown voltage)**
- **Tantalum: 1.7µA at 16V (plot below)**



PML Leakage Current

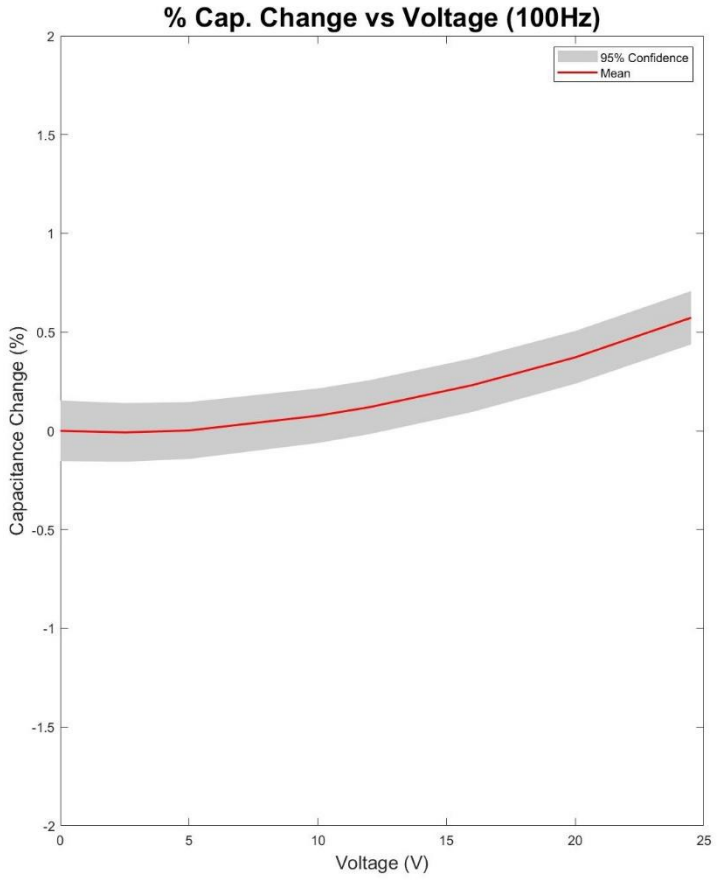


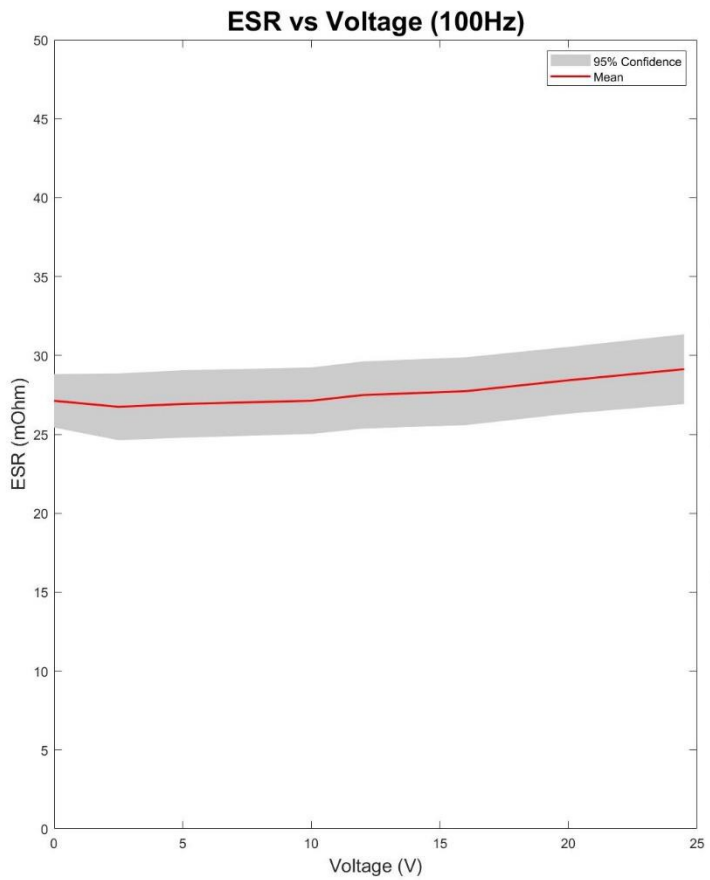
Comparison to Tantalum

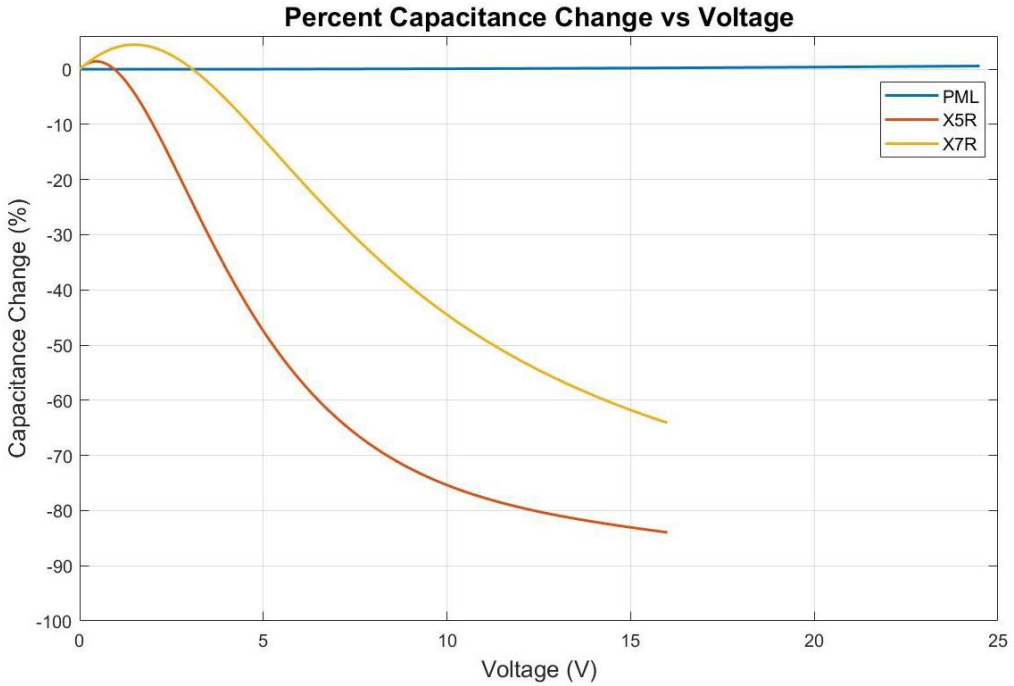
Comparable leakage current to alternatives

Distribution A

Voltage Characterization







Extremely stable across voltage
Known capacitance loss with ceramics

Comparison Chart

Volumetric Capacitance (VC): Capacitance (mF) / Volume (cm^3)

Capacitor	VC at 0V	VC at 12V	VC at 125C at 12V	VC at -55C at 12V
PML Prototype	.52	.52	.52	.52
X7R Ceramic	1.5	.54	.52	.48
X5R Ceramic	5.74	1.18	1.07 (@ 85C)	1.07
Tantalum	2.56	2.56	2.64	2.54
Evans Hybrid	1.54	1.54	1.68	.72
COTS PML	.28	.28	.28	.28

Inherent stability makes comparisons more favorable for PML
ESR, reliability, and robustness (not captured in chart) add to PML desirability

Conclusions

- Initial development and demonstration of prototype PML capacitor complete!
- Great electrical and mechanical characteristics inherent in the material
- Continuing to develop improved designs for increased energy density and usability
  - Prototype 2: 1mF, 10mm x 10mm x 10mm (half the size!)
  - Prototype 3: Same material as 2 in 5mm x 5mm x 5mm footprint
- Mechanical testing to come



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Exceptional Service in the National Interest

Sandia National Laboratories

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NEW FUZING SOLUTIONS FOR IMPROVED SAFETY AND OPERATIONAL CAPABILITIES

JUNGHANS Defence

64th Fuze Conference- May 12, 2021

JUNGHANS Defence
Max Perrin, Chief Technical Officer

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A Diehl and Thales company

Distribution A

Content

- Safety Requirements - Trends
- Operational Capabilities / Terminal Effect - Trends
- Challenges and Solutions For New Safety Requirements
- Challenges and Solutions For New Operational Capabilities

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JUNGHANS Defence – The Fuze Company



Complete Range of Fuzing Systems

- **Fuzes for all types of munitions**
- **Safety & Arming Devices and Fuzing Modules for Missiles and Complex Weapons**

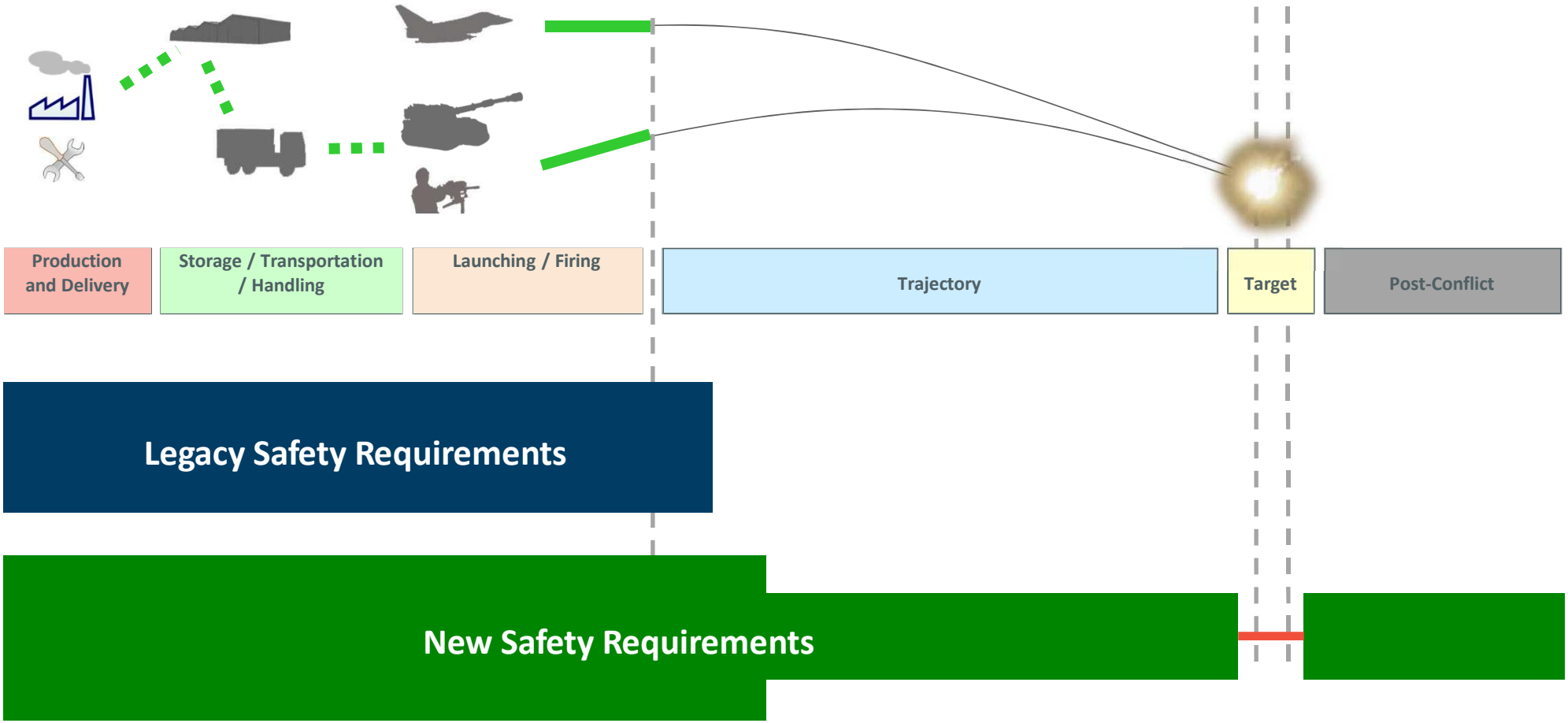
Key competences in Fuzing technologies, Micro-technologies and Ammunition electronics

Two Centers of Competences located in Germany and France

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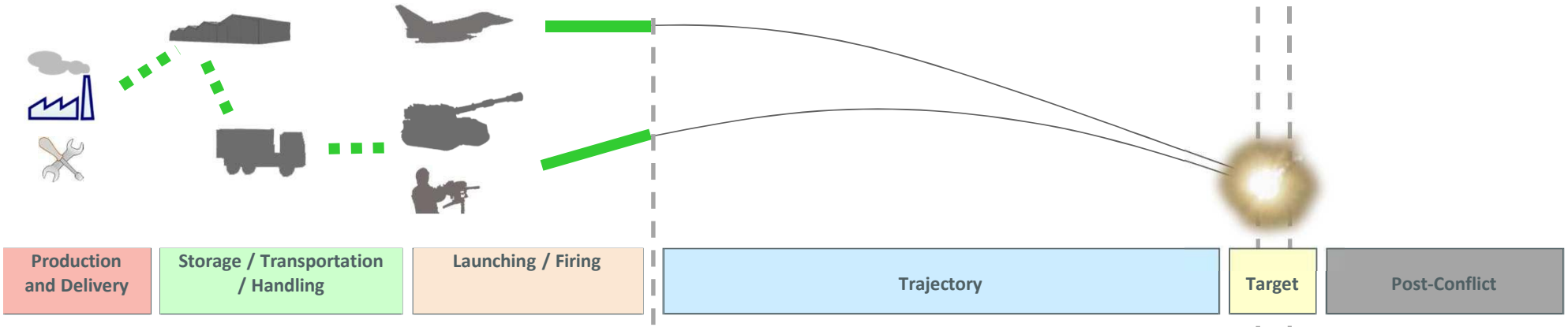
Safety Requirements - Trends



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Safety Requirements - Trends



New Safety Requirements

- Extended safe separation distance
- STANAG 4187 Compliance – all munition fuzes
- STANAG 4368 Compliance (Rocket Motor)
- IM features
- New Weapons Systems (automatic loading / ramming, extended range, new propulsion…)
- Enhanced overflight inhibition/safety
- New Guided Munitions requirements (mission abort, arming control)
- Post-conflict "Safety" (UXO, hazardous duds, Return to safe status, …)

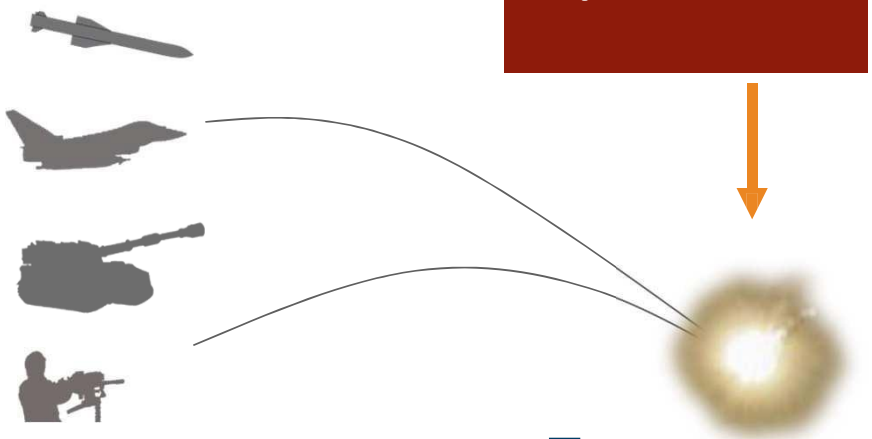
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Operational Capabilities / Terminal Effect - Trends

Target Detection

Terminal Effect Optimization



- Multi-function
- Scalable effects

Operating Modes

Point Detonating (Impact)



- Graze Impact
- Soft ground operation

Time

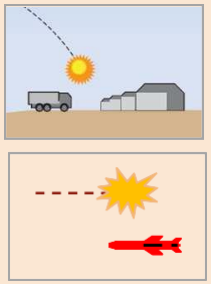


- Time accuracy
- Direct fire / programmable airburst
- Easy integration of Fuze Setter

HoB

Proximity

Air -defence

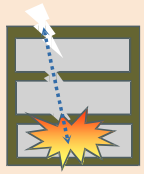


- HoB accuracy / type of surface
- HoB selection
- Implementation on new munitions

"Tricky targets":

- UAV
- Sea-skimmer missiles
- Fast Inshore Attack Craft

Impact Delay



- Hard Target Fuzing
- for A-G weapon, Tank ammo, rocket and missile

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Distribution A

JUNGHANS Defence



SOLUTIONS FOR NEW SAFETY REQUIREMENTS

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STANAG 4187 Compliance – Dual Safety Features

- Now required for all new munitions
- Still challenging to the fuze designer

Flight environment detection

in particular for non-spin or low-spin munitions

⇨ **Relative wind measurement**

- Wind-wheel (for mechanical fuzes)
- Wind generator (for electronic fuzes)
- Pressure / airflow sensors

⇨ **Other flight characteristics measurement**

- Low spin sensing (mechanical or electronic)
- Accelerometers / Signal processing
- Magnetic sensors

Space requirements for medium caliber fuzes

⇨ **Small size / Miniaturization of S&A Devices and Firing trains**



DM111S PD Fuze for Mortar Ammunition



Dual Safe Fuze for Air-to-Ground Rocket (THALES 68mm)

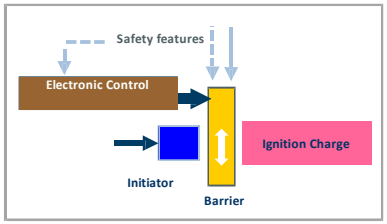
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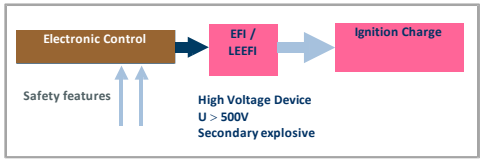
STANAG 4368 Compliance – Motor Ignition Systems

- Ignition Safety Devices now required for all new generation rocket and missile motor ignition
  - Comparable to safety requirements for warhead S&A units
  - Capability to revert back to "non-armed" status

Interrupted train solutions (pyrotechnic) ⇨ **Electromechanical ISD**

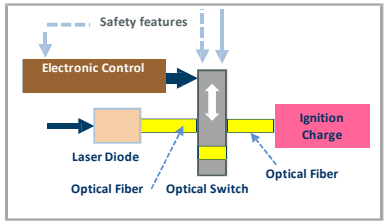


In-line solutions EFI/LEEFI-based ⇨ **Fully electronic ISD**



- Use of EFI (Exploding Foil Initiator) or LEEFI (Low Energy EFI)
- Possibility of multi-pulse ignition (dual stage motor)
- Adaptation to various form factors

Laser ignition Optical interrupted train ⇨ **Electromechanical ISD (optical switch)**







LEEFI-Based ISD with TBI
(JUNGHANS Defence – PYROALLIANCE)

With TBI (Through Bulkhead Initiator)
or
Direct ignition of propellant





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Distribution A

New weapons systems – Fuze Design and Safety Requirements

- New generation of weapon systems generate more severe firing environments
- This has an impact on fuze design, in particular regarding safety features

Automatic loading systems for howitzer (flick-ramming)	**High shock prior to firing**	**Robust design of SAD and battery activation system**
Automatic loading systems for mortar	**No man-in-the-loop -> Removable Safety pin issue**	**2nd safety feature – fully autonomous (flight detection)**
Extended range artillery (artillery fuzes)	**High muzzle velocity Long flight time: body heating issue**	**Reinforced fuze design / specific materials**
Long carriage flight time (aircraft bombs)	**Severe vibrations environment**	**Fully electronic design (Electronic SAD based on EFI/LEEFI)**



PD fuze with reinforced nose cone

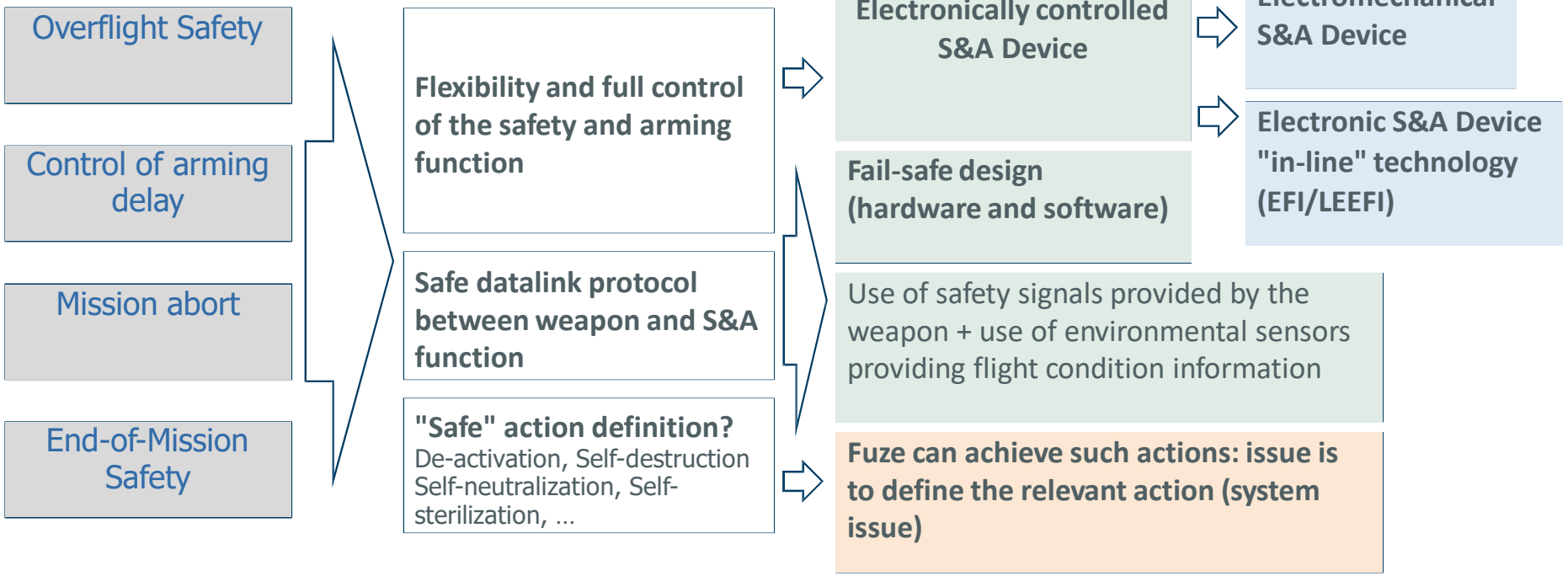
FBM21
Aircraft Bomb Fuze

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Distribution A

New Guided/Smart Munitions - New Safety Requirements

- New generation of munitions, as guided and "smart" munitions, provide new functionalities for new operational capabilities
  - These new functionalities lead to new requirements regarding safety management (+ possible impact on reliability)





Miniaturized Electromechanical S&A Device



LEEFI-based S&A Device and fireset module



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Distribution A

JUNGHANS
Defence



SOLUTIONS FOR NEW OPERATIONAL CAPABILITIES

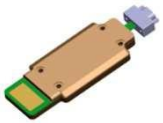
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Distribution A

Optimizing Burst Position at Target – Proximity fuzing

- Objective: provide optimum terminal effect at target, with fully autonomous fuze

Implementation of proximity function in new munitions	Incorporate Proximity Module in available space, with environmental issues	Proximity Module with flexible design and adaptable form-factor
Air-defence, Naval and littoral warfare Attack of "tricky targets"	Ability to detect a variety of targets, in difficult environment	New State-of-the-Art FMCW sensor with digital signal processing
Achieve proximity function for Land Combat / Urban Warfare weapons	Ability to detect a variety of targets, not very well characterized, in a very tricky environment	Still very challenging! ? Alternative option: programmable airburst



Proximity Sensor Modules

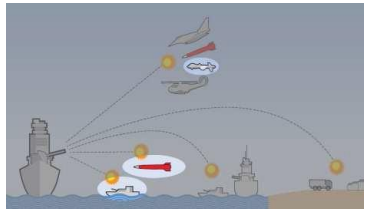






Implementation on Air-to-Ground Guided Weapon





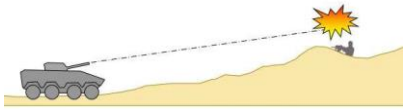
FREMEN New Generation Naval Fuze

© JUNGHANS Microtec GmbH and JUNGHANS T2M SAS

Distribution A

Optimizing Burst Position At Target – Airburst Fuzing (Programmable Time)

- Objective: provide optimum terminal effect at target by airburst operation, controlled with programmed time
  - Achieving "proximity" operation when proximity is difficult or not possible
  - e.g. land combat / urban warfare



Limitation of integration issues	**Program the fuze without requiring substantial change of the weapon system for fuze setting integration**	**Achieve fuze setting at muzzle exit or in-flight**
Time accuracy / Correction of deviations	**Ability to** • **measure relevant flight parameter deviations (e.g V_0)** • **Correct the set time**	**Automous solutions: on-board correction with "cooperative" system or fully autonomous** **System controlled solutions: Measurement V_0 + corrected order sent by the system**

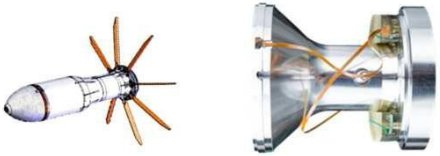


Airburst Fuze for 40mm Infantry Grenade
Fuze setting by magnetic induction at muzzle exit





Dynamit Nobel Defence RGW90 LRMP
Shoulder-launched infantry weapon system



Airburst fuze with velocity correction
for RGW 90 LRMP munition

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Distribution A

Multi-function Fuze Issue

- Objective: to improve operational flexibility with fuzes able to achieve all operational missions, whatever the requested and relevant operating mode
  - Optimized value for money, from an overall mission perspective
  - Obvious benefits but possible trade-offs and challenges for the fuze designer

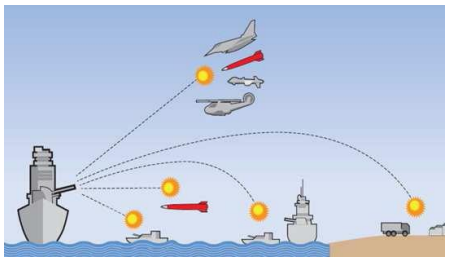
"One-fits-all" but not with discounted performances	**Ability to achieve the required function with the same performances than a single dedicated fuze**	**Now possible with the implementation of state-of-the-art electronics, sensors and signal processing**
Keep interoperability and independence to the weapon	**No substantial change to the weapon system.** **Possibility to use on different weapon systems**	• **Autonomous fuze, capable of automatic mode selection** • **Fuze setting devices not "intrusive" with the system (e.g. in-flight prog.)**

DM173 Tank ammunition fuze Airburst, PD and PD-Delay (hard target) for Rheinmetall 120mm DM11 round



FREMEN Naval Fuze (cal. 76mm, 100mm, 127mm) Autonomous Fuze for Air-defence / Littoral warfare (direct fire) as well as Fire Support (indirect fire)





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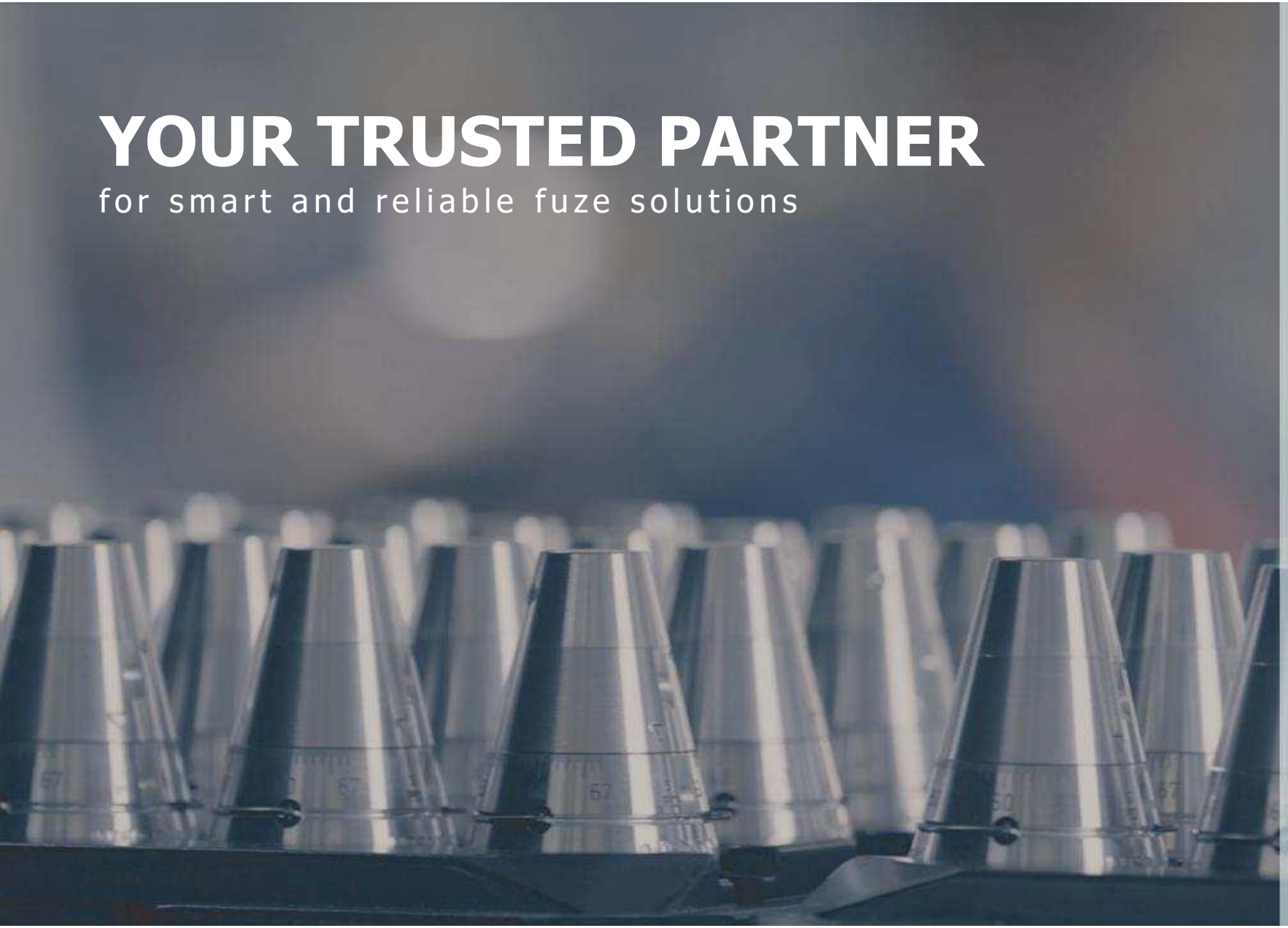
Conclusion

- Fuzes and fuzing systems are fundamental contributors to safety and operational capabilities of munitions and missiles
  - Modern fuzes have to deal with new requirements in terms of operational effectiveness and safety features
- New technologies in micro-mechanical systems, electronics and sensors lead to significant improvements in new generation fuzes, providing solutions to meet these new requirements
- As a dedicated Fuze Company JUNGHANS Defence is able to
  - leverage and share such solutions for the benefit of various fuze applications
  - take up technological challenges to provide the war-fighter with state-of-the-art and efficient fuzes



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YOUR TRUSTED PARTNER

for smart and reliable fuze solutions

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Distribution A







U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – ARMAMENTS CENTER

Cannon Caliber Fuze Setter Overview

64th Annual NDIA Fuze Conference

Tyler Wilson & Tom Emanski

DEVCOM-Armaments Center, Fuze Division

DISTRIBUTION STATEMENT A:
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BACKGROUND

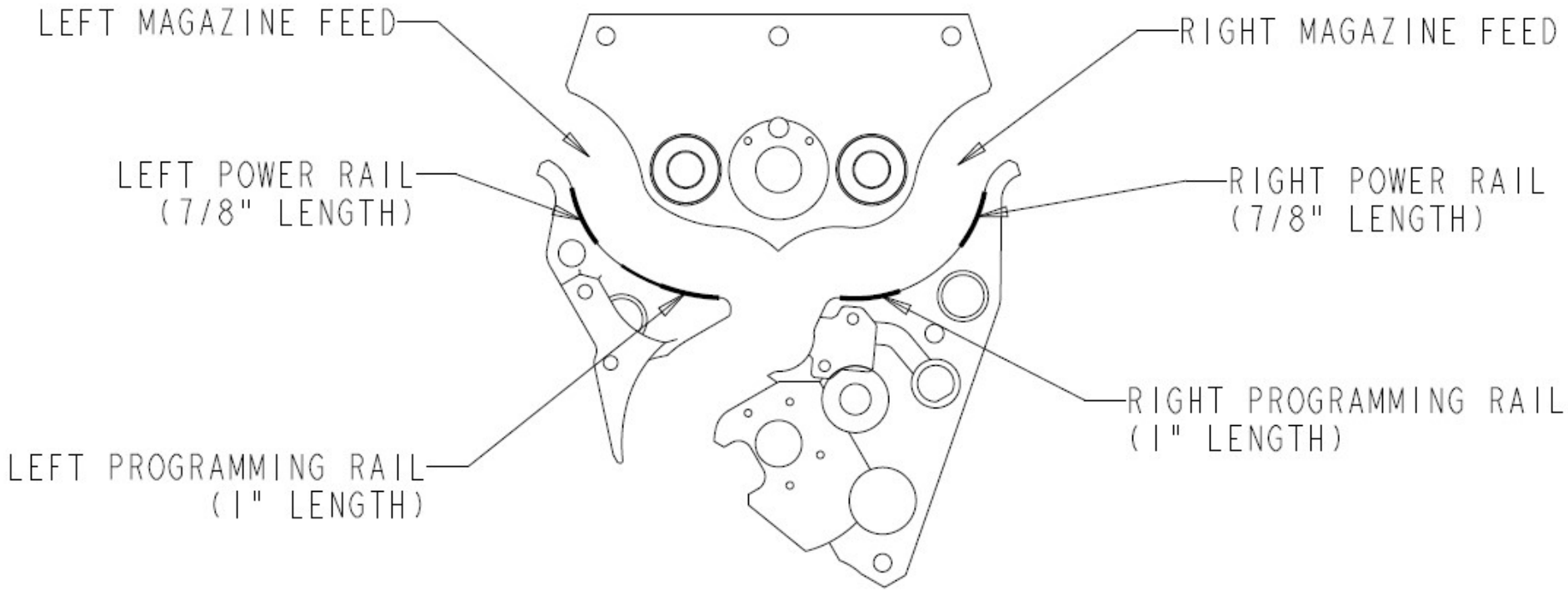
- **Cannon Caliber Fuze Setter Background**
  - 2QFY17, PM-MAS tasked DEVCOM-Armaments Center Fuze Division to design and integrate a contact fuze setter for the XM813 Weapon System in support of the XM1182 High Explosive Air Burst (HEAB-T) program

- **XM813 Overview**
  - 30x173mm Ammunition
  - 200 Shots per Minute (SPM), Dual Feed, First Round Select, Chain Gun

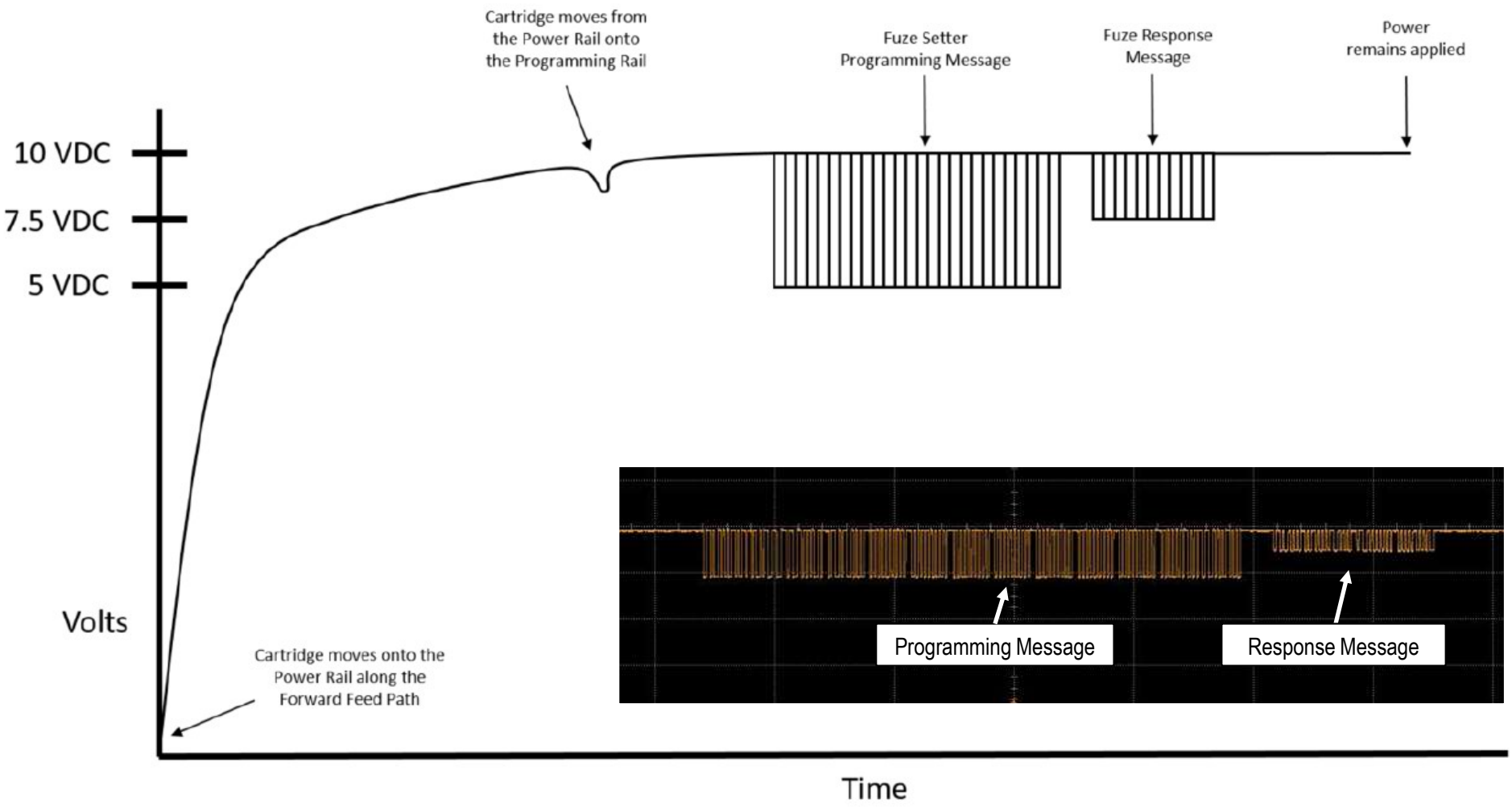
- **Fuze Division performed analysis on XM813 Weapon System**
  - Studied munition cycle timing
    - Determined programming message must be completed in under 20ms
  - Determined best location for programming contacts in the feed system
  - Implemented an additional set of power contacts in the feed system
    - Pre-powering munitions, reduces programming time
  - Developed a programming message protocol with munition talkback
  - Authored ICD's specific to communication protocol and ammo/weapon interfaces

XM813 WEAPON MODIFICATIONS

- **Forward Feed Path Modifications**
  - Utilize one power contact, one programming contact per side
  - Fire Control determines feed select & when to send power/program



PROGRAMMING MESSAGE TIMELINE



CANNON CALIBER FUZE SETTER ICD

- **Armaments Center authored and control four ICD's:**
  - ICD 13074734 - Cannon Caliber Fuze Setter - REV B
    - Base document outlining power, data, and protocol requirements for setter/munition communication
  - ICD 13076761 - Cannon Caliber Fuze Setter - 30x173mm - REV B
    - Addendum document outlining physical interfaces between the setter/munition including 30x173mm contact bands and XM813 contact locations
  - ICD 13076762 - Cannon Caliber Fuze Setter - 50x228mm - REV XB
    - Addendum document outlining physical interfaces between the setter/munition including 50x228mm contact bands and XM913 contact locations
  - ICD 13076762 - Cannon Caliber Fuze Setter - 30x113mm - REV -
    - Addendum document outlining physical interfaces between the setter/munition including 30x113mm contact bands and M230/XM914 contact locations

SOFTWARE / PROTOCOL

- **Programming Message to Fuze**
  - Currently 13 Byte Message
    - Can be expanded to 32 bytes for future - would need to study re-assess contact timing
  - Allows for different methods of air burst timing calculation
  - Up to 7 fuze modes
  - CRC virtually assures no miscommunicated data

- **Response (ACK/NACK) Message from Fuze**
  - Allows the fuze to positively or negatively acknowledge the receipt of a programming message
  - Allows for the communication of (up to 255) error codes
    - For Example: Bad CRC, Value – Out of Range, etc.

CURRENT FUZE SUPPORT OVERVIEW

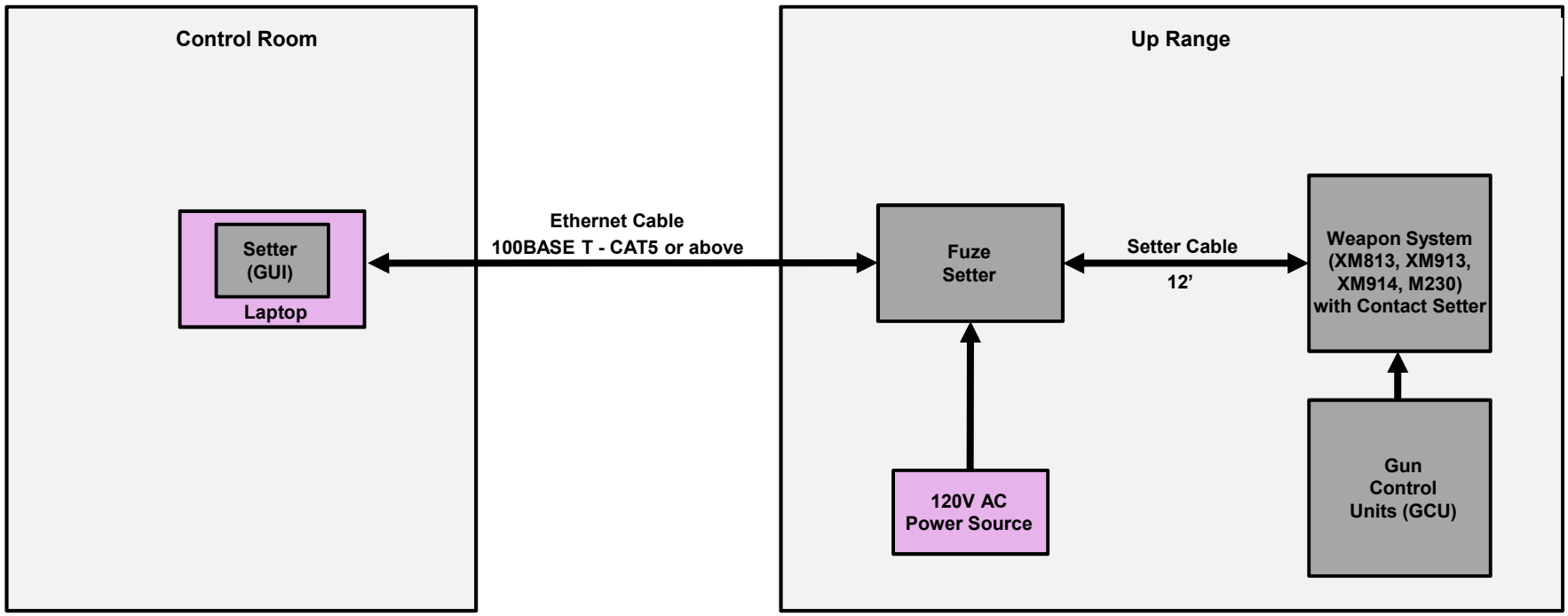
- **Supporting the following RDT&E Air Burst ammunition efforts:**
  - XM1182 HEAB-T (30x173mm)
  - XM1204 HEAB-T (50x228mm)
  - XM1206 HEDP-AB** (30x113mm)
  - M-SHORAD (30x113mm)

- **Supporting the following Fuze Setter development efforts:**
  - M230 (30x113mm, 625 spm, Apache Helicopter)
  - XM813 (30x173mm, 200 spm, Stryker)
  - XM913 (50x228mm, 200 spm, NGCV/OMFV*)
  - XM914 (30x113mm, 200 spm, M-LIDS, LRV, M-SHORAD)

* Leading candidate for NGCV/OMFV main armament

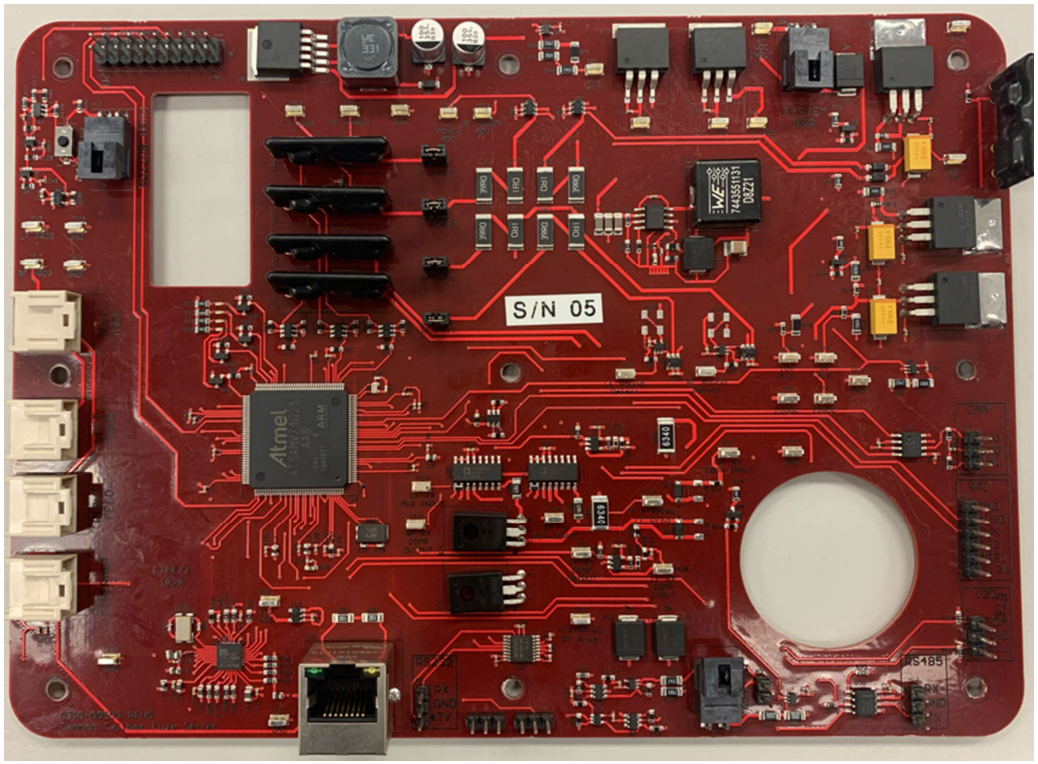
** Selectable Point Detonate/Proximity munition (On/Off Programming)

CANNON CALIBER FUZE SETTER DESIGN



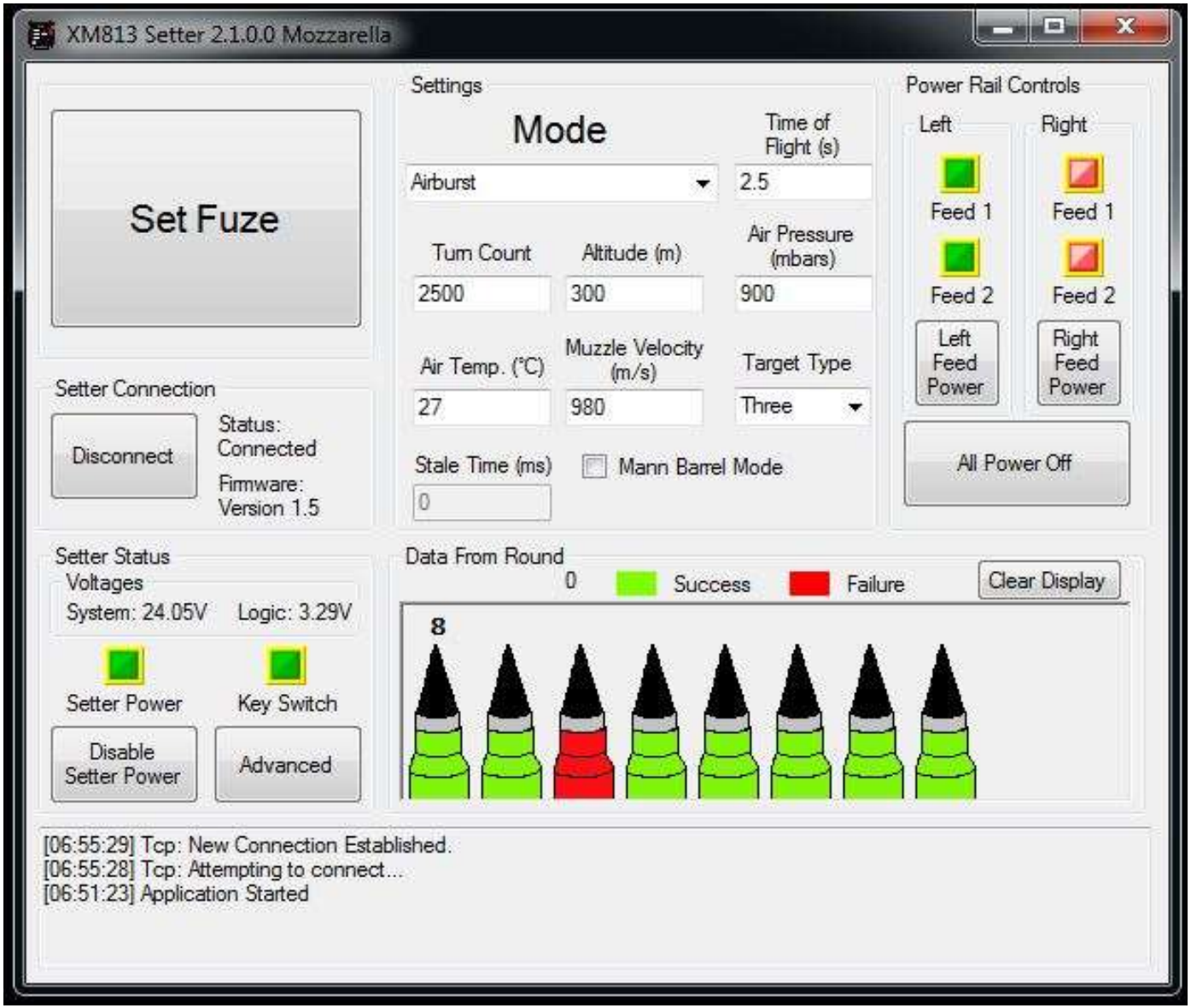
FUZE SETTER DEVELOPMENT STATUS

- **Fuze Setters**
  - USG owned design
    - Hardware & Software developed in house
  - 25 units procured
    - Split across all on-going ammunition and weapon development programs
    - Divided amongst contractors, test ranges, and USG





FUZE SETTER GUI



SETTER VERIFICATION DEVICE (SVD)



30x173mm



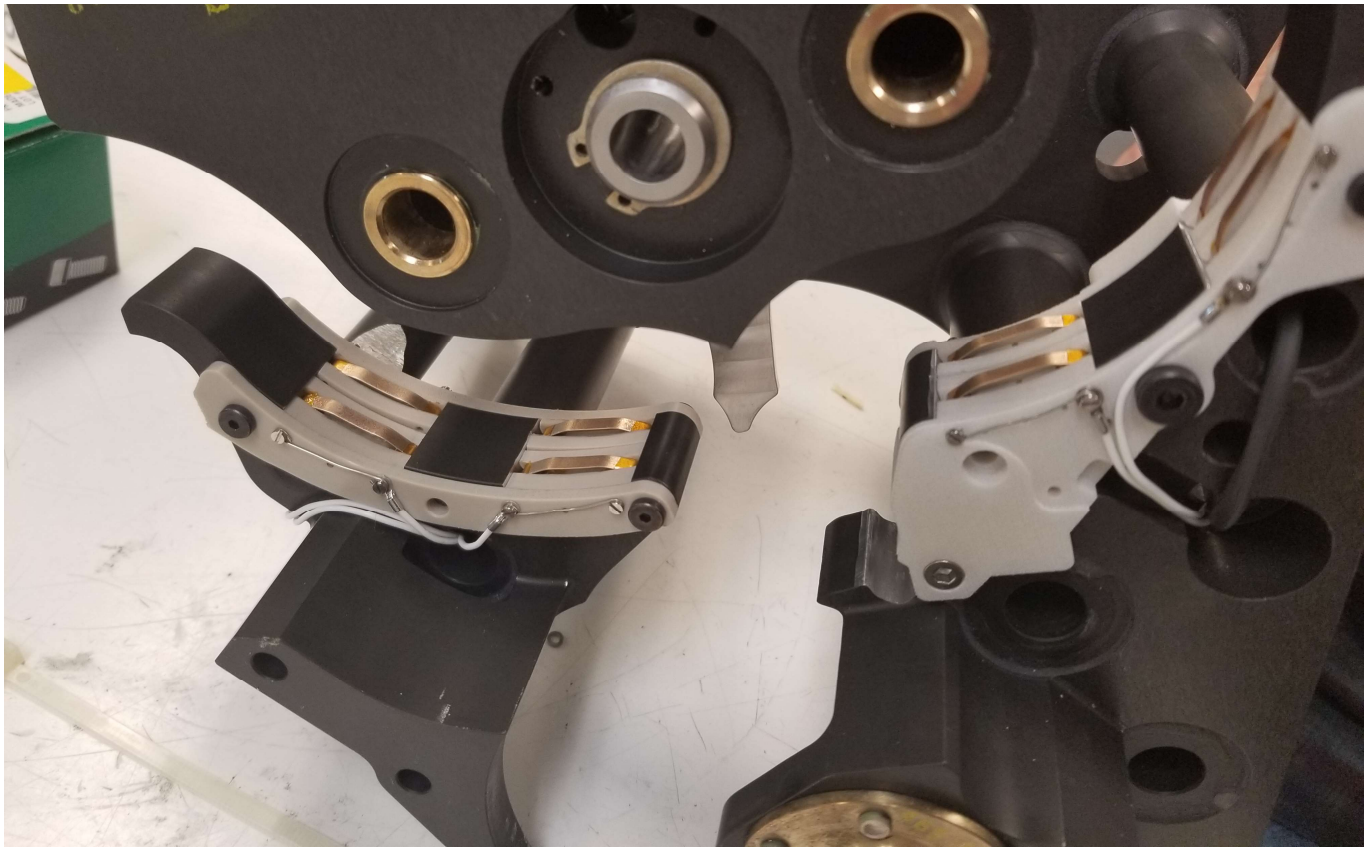
50x228mm



30x113mm

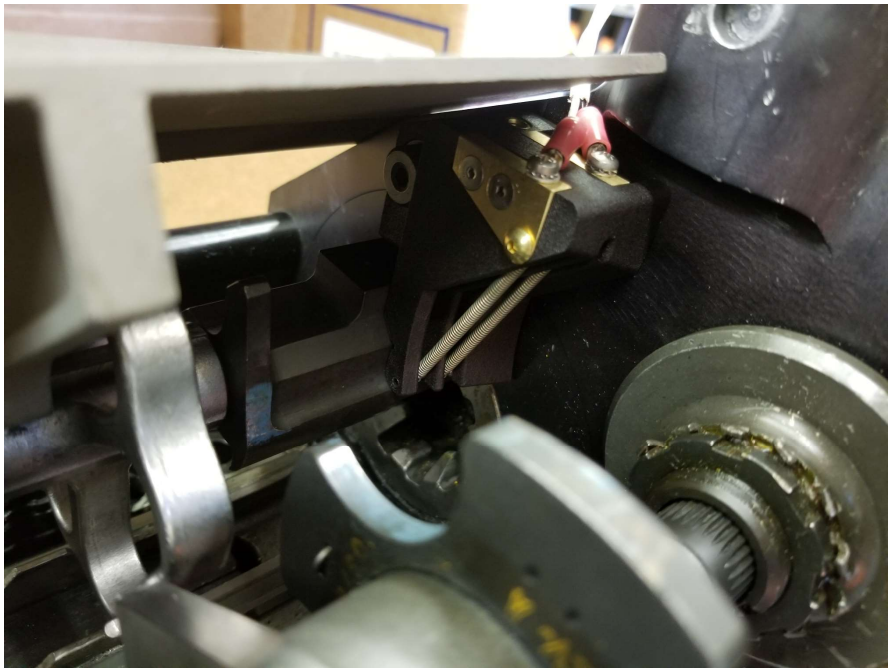
XM813 CONTACT FUZE SETTER STATUS

USG Contact Setter Design

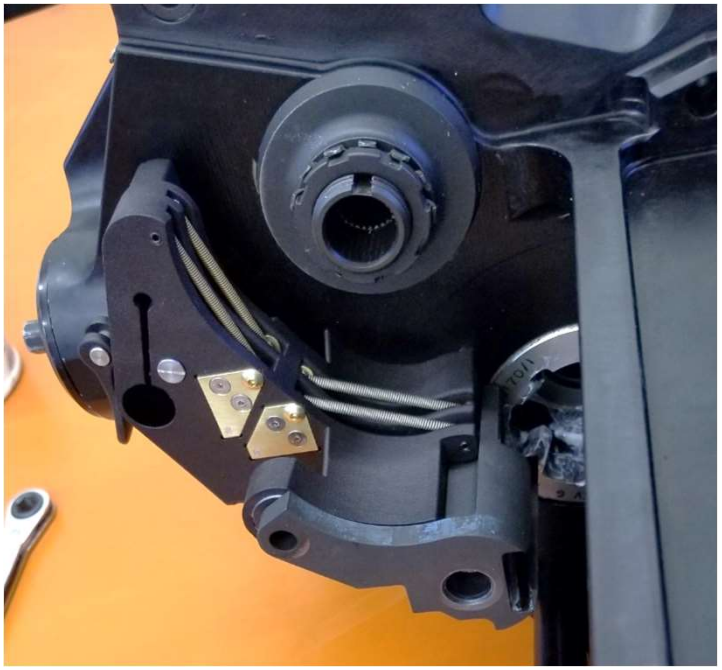


- TRL6 Live Fire Demo at APG
- Utilized by defense contractors for XM1182 HEAB-T development
- Transitioned to defense contractor for MRL design improvements

M230 & XM914 CONTACT FUZE SETTER



M230 Fuze Setter



XM914 Fuze Setter

M230 - 12 ROUND BURST



XM914 - 3 ROUND BURST



SUMMARY

- **Cannon Caliber Fuze Setter successfully demonstrated across multiple weapon systems**
- **ICDs in place to outline power, data, and protocol requirements and setter / munition interface to support multiple calibers of air burst ammunition**
- **Fuze Setter Hardware GFE'd to multiple contractors, test ranges, and USG entities to support all on-going ammunition and weapon development programs**



High Voltage Fireset Component Behavior at Elevated Temperatures

Presented to:

64th Annual NDIA Fuze Conference

Presented by:

Chris Cao

May 12, 2021

Capt. Eric Correll, USN
Commanding Officer

Mr. Ashley G. Johnson, SES
Technical Director

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NAVSEA WARFARE CENTERS
Indian Head

Overview

- Background
- High Voltage Firesets
  - Applications
  - Components
- Technical Survey
- Testing Methodology
  - MIL-STD 331D
  - Things to consider
- Path Forward

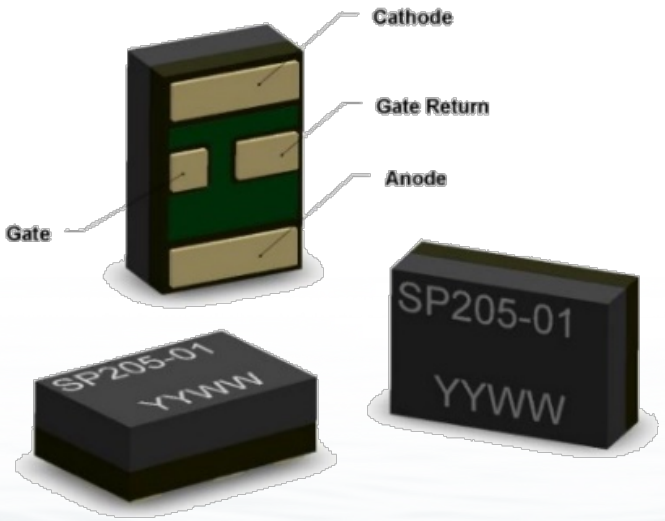
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Background

- **Technology Goal:** Determine the margin of survivability of existing and mature high voltage fireset technologies at elevated temperatures.

Approach: Survey/consult, obtain/build and test mature fireset designs at temperatures greater than MIL-STD 331D (failure).

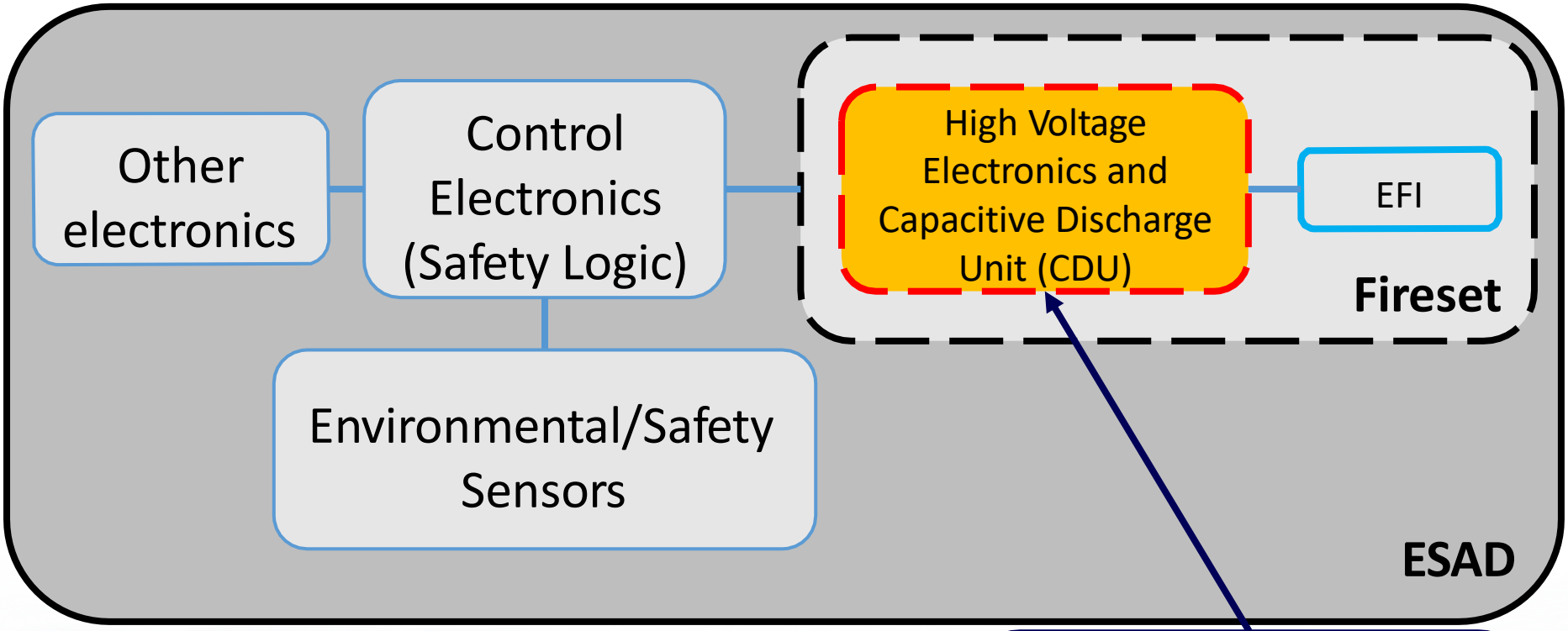


Current efforts funded through Joint Fuze Technology Program.

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High Voltage Firesets



- Found in ESADs (non-interrupted or in-line)
- High voltage (>500V)
- Used in Ordnance systems

Primary Focus:

~~Key Components~~

- HV Capacitor
- HV Switch
- HV Converter (Transformer)

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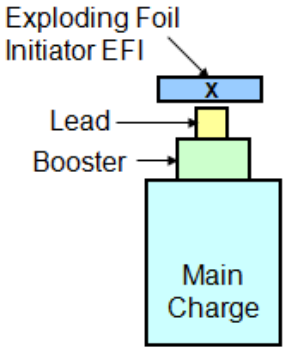
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Typical Applications

- Precision guided munitions
- Air-to-Air Missile (AAM)
- Air-to-Ground Missile (AGM)
- Surface-to-Air Missile (SAM)
- Surface-to-Surface Missile (SSM)
- Light and Heavy Weight Torpedoes

Non-Interrupted

- "In-line" systems
- Electronic Safe Arm Device (ESAD)
- High voltage system



Electronic based system, no moving parts required



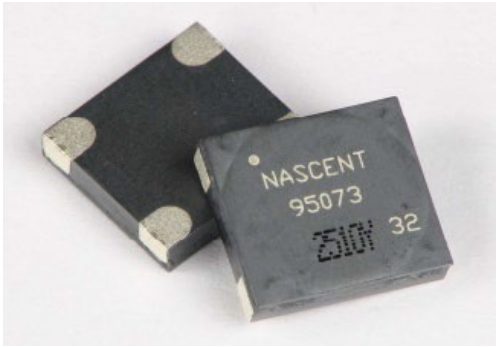
Example of AAM

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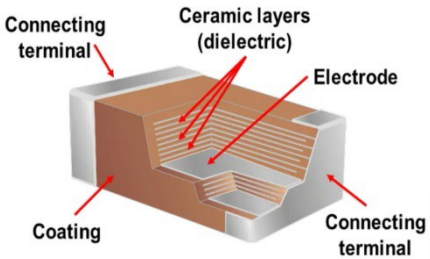
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HV Fireset Major Components

- Flyback Transformer
  - HV generation
    - Wire wound
    - Multilayer/Monolithic Ceramic
- High Voltage Storage Capacitor
  - Responsible for energy storage until ready to fire
    - Multi-layer Ceramic (MLCC)
    - Polymer Multi-Layer (PML)
- High Voltage Switch
  - Triggering mechanism that completes circuit upon fire command



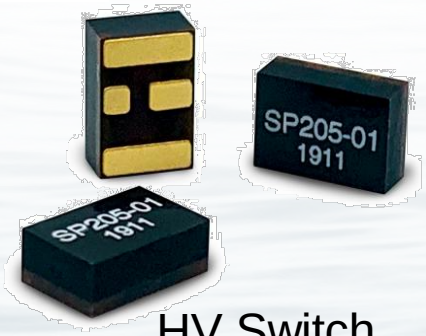
Flyback Transformer



MLCC



PML



HV Switch

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Other Key Subsystems

- Static Switches
  - Upper/lower
  - Prevents fireset from charging
- Dynamic Switch
  - Provides pulse signal for transformer
- High Voltage Feedback
  - Maintains high voltage threshold

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Technical Survey

- Surveyed/Received HV firesets from across the DoD/DoE agencies
  - Navy
  - Army
  - Air Force
- Key Components Analyzed/Compared
- MIL-STD 331 Requirements
- Temperature regimes
  - Note: Fuzes traditionally located along central may be less affected; however, it is important to understand the margin to which these HV firesets can survive

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MIL-STD 331D

- Appendix C
  - Requires a bare, unpackaged fuze and its components to be able to survive temperature extremes up to 160°F or 71°C for 28 days.

- Intend to test to failure

No Standard or Requirement above 160°F or 71°C

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Testing Methodology

- Variables to consider, included here but not limited to:
  - Potential cable failures at higher temperatures
  - Soak duration in order to thoroughly evaluate HV fireset performance
  - Isolation of non-key infrastructure
    - Conformal coat/potting
  - Potential redesign for instrumentation
  - Discrete vs. Non-discrete temperature testing
  - Avoid “re-inventing the wheel”

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Path Forward

- Continue to develop testing methodology for FY21
  - Temperatures and duration
  - Locations for evaluation (leakage current, etc.)
  - Perform INERT tests in thermal chamber(s)



Thermal Chamber

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Questions?

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Sandia National Laboratories

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THE AIR FORCE RESEARCH LABORATORY
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ADVANCED FUZING TECHNOLOGY

Effects of Orientation & Boundary Condition on Encapsulated Electronics

Presented By:

Caleb White, Shane Curtis

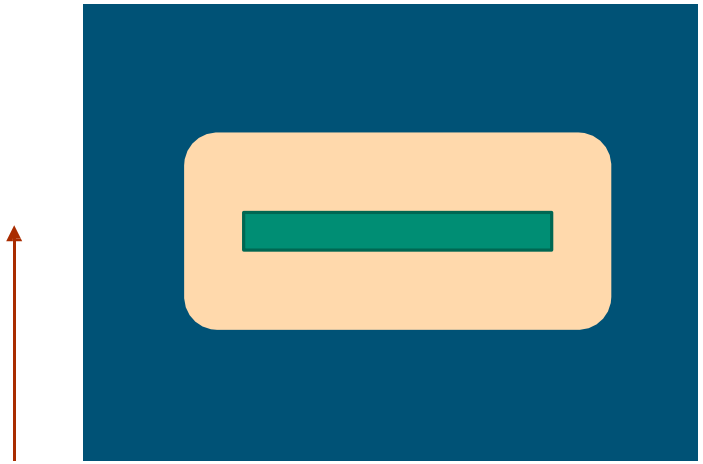
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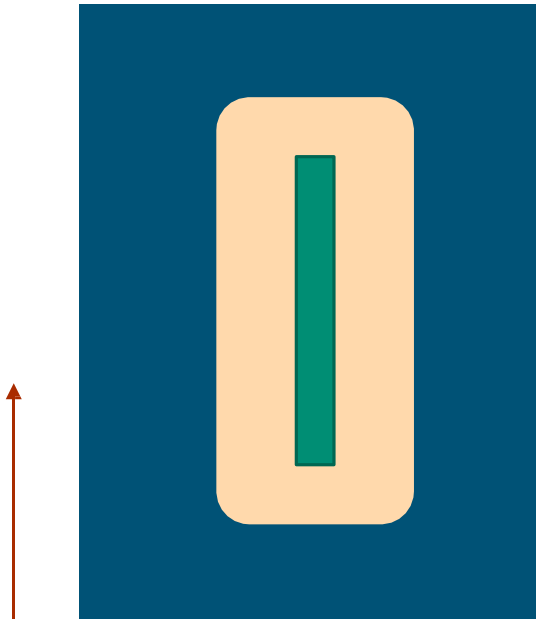
Distribution A/ Unclassified

SAND2021-5442 C

Introduction



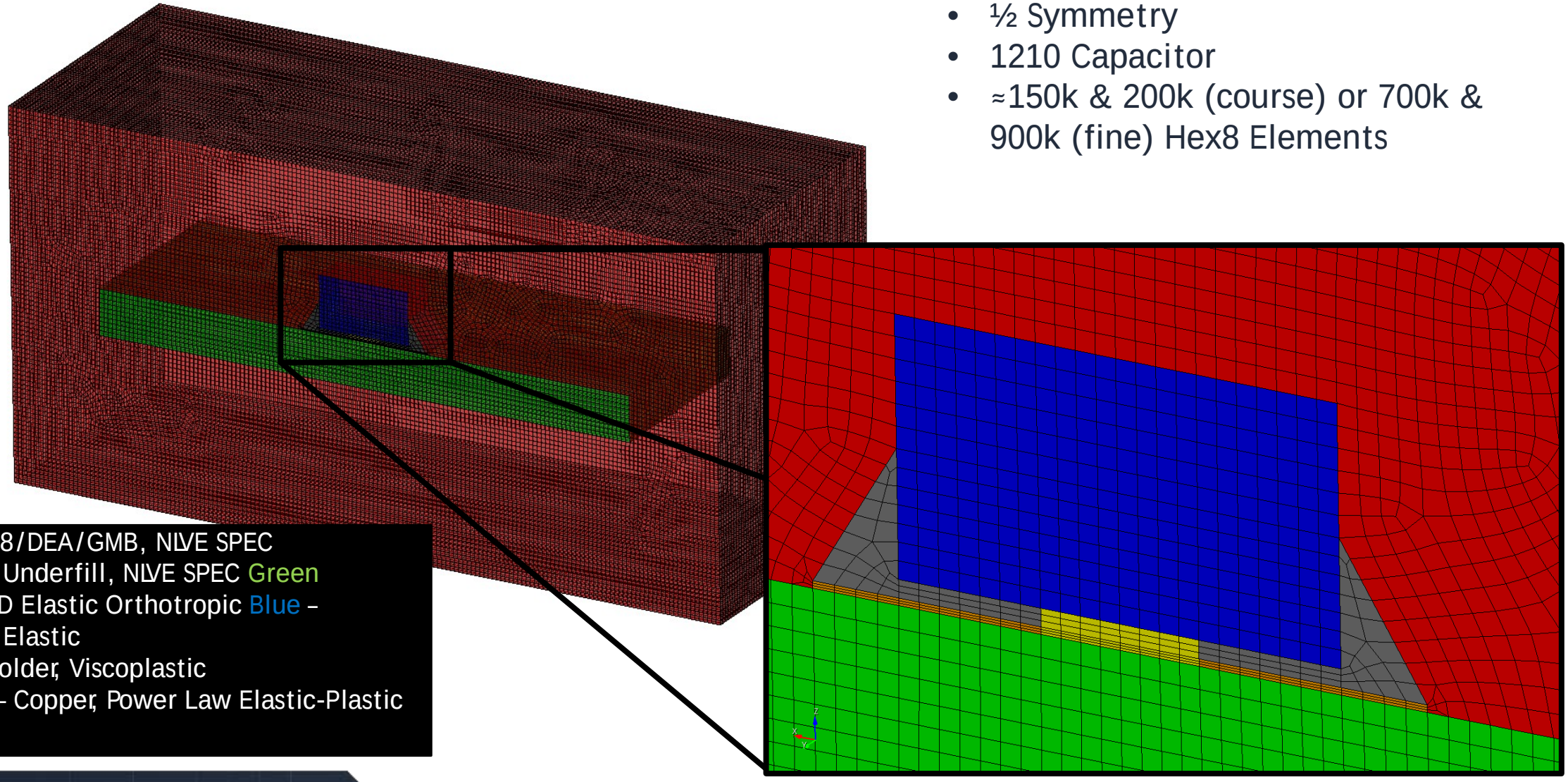
Horizontal / Perpendicular



Vertical / Parallel

Generic Mesh

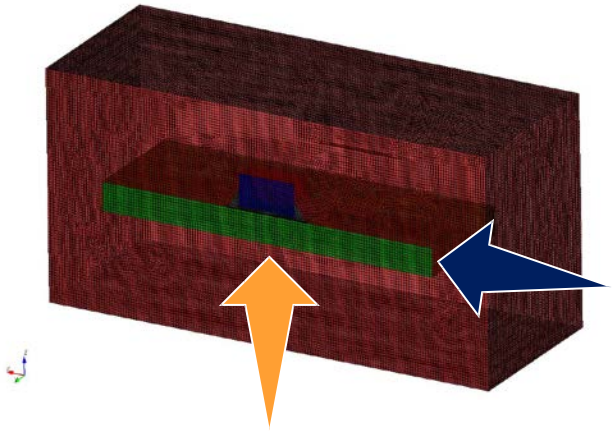
- ½ Symmetry
- 1210 Capacitor
- ≈150k & 200k (course) or 700k & 900k (fine) Hex8 Elements

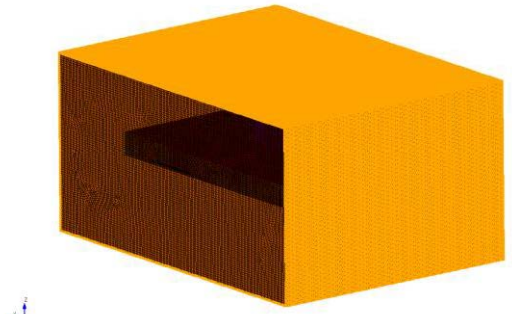


Red – 828/DEA/GMB, NLVE SPEC
Yellow – Underfill, NLVE SPEC Green – FR4, 3D Elastic Orthotropic Blue – Ferrite, Elastic
Grey – Solder, Viscoplastic
Orange – Copper, Power Law Elastic-Plastic

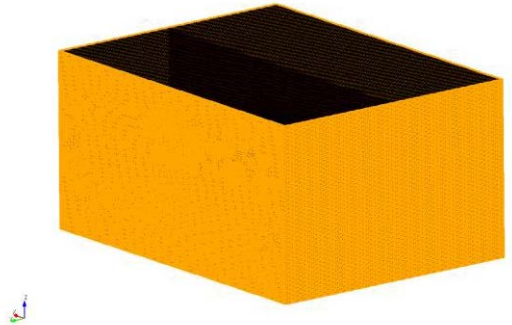
FEA Procedure & Parameters

1. Instantiate parametric study with Dakota
2. Create generic mesh geometry using Cubit
3. Implicitly cure (Sierra/SM Adagio) from 70ºC → 25ºC
4. Explicitly accelerate (Sierra/SM Presto) fixed exterior with representative haversine pulse*
5. Post-process with Python & Paraview

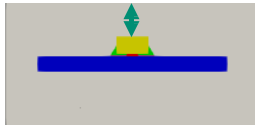




Side Relief

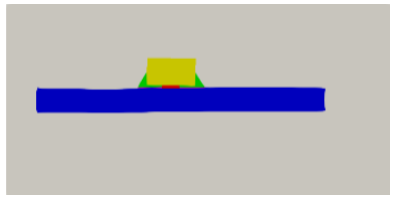
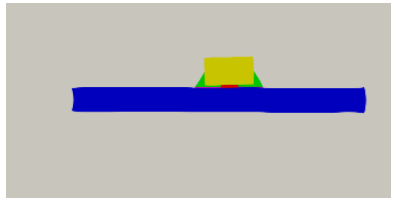
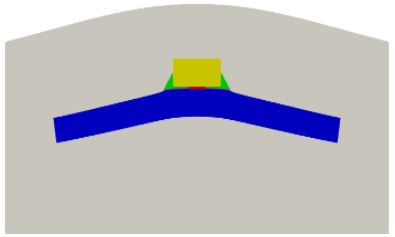
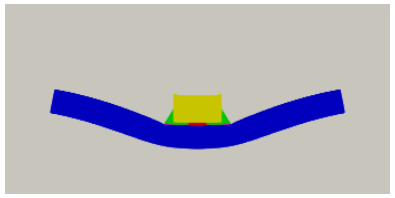
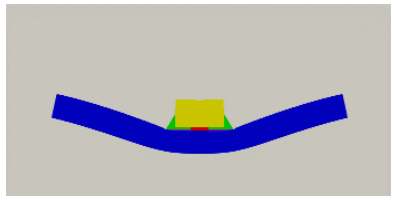
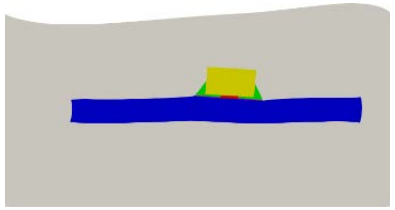


Top Relief

Parameter	Value
Boundary Condition	No Relief Side Relief Top Relief Bottom Relief Top/Bottom Relief
Loading Direction	Normal-to-PCB Parallel-to-PCB
PCB Length	.75”x.5”x.062” .50”x.5”x.062”
Boundary Proximity 	.041” .075” .108” .141”
Mesh Size	Course: .010” Fine: .006”
Pulse Width (µs)	1.95, 2.93, 3.91, 5.87, 7.81, 11.72, 15.6, 23.4, 31.3, 46.95, 62.5, 93.75, 125, 250, 500

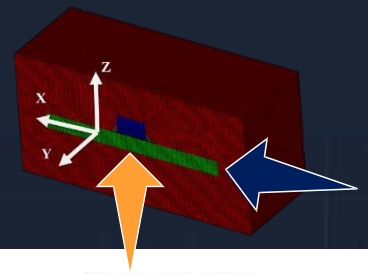
*Simulation extended for 1 ms after pulse to allow assembly to freely resonate.

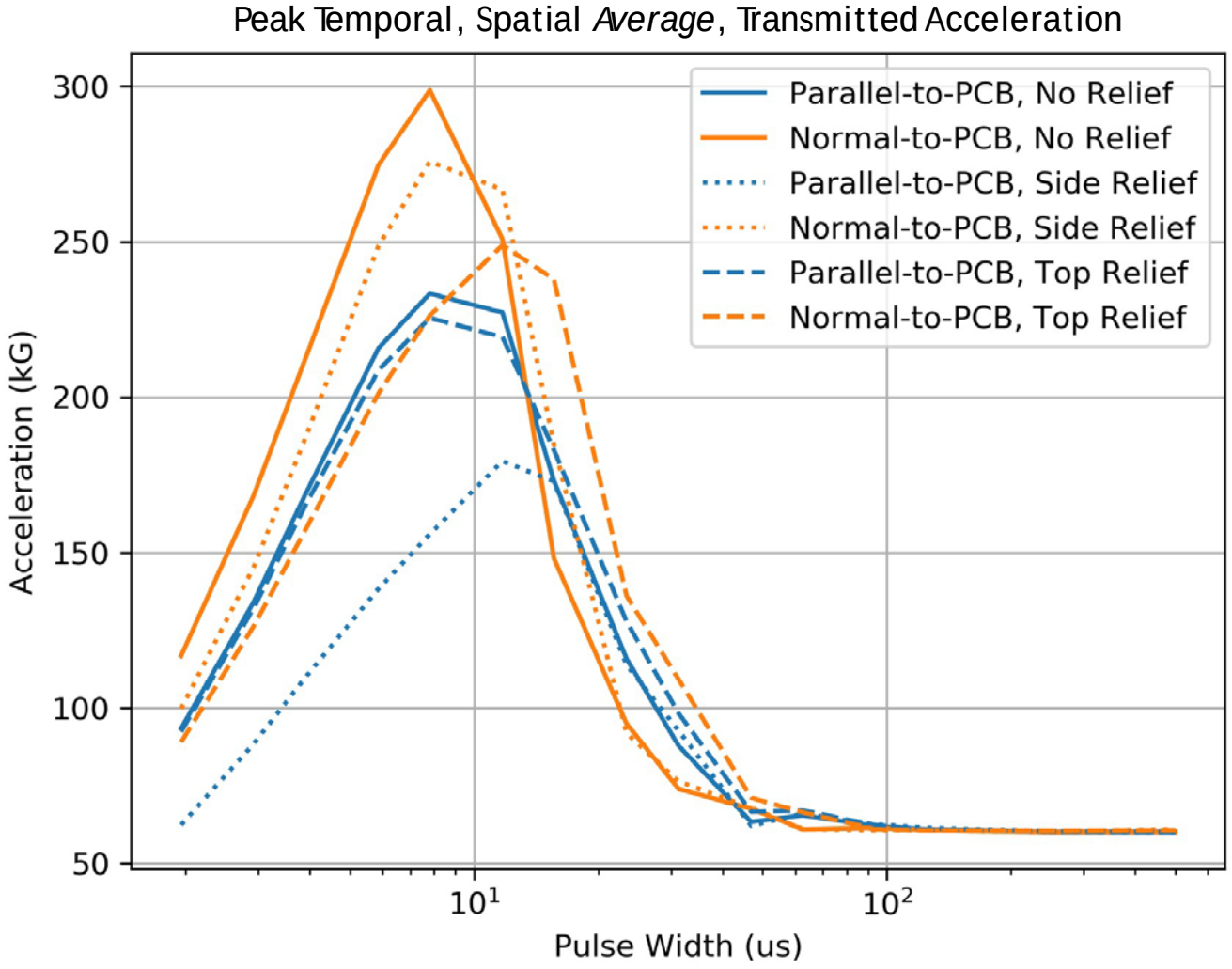
Fundamental Mode Shapes

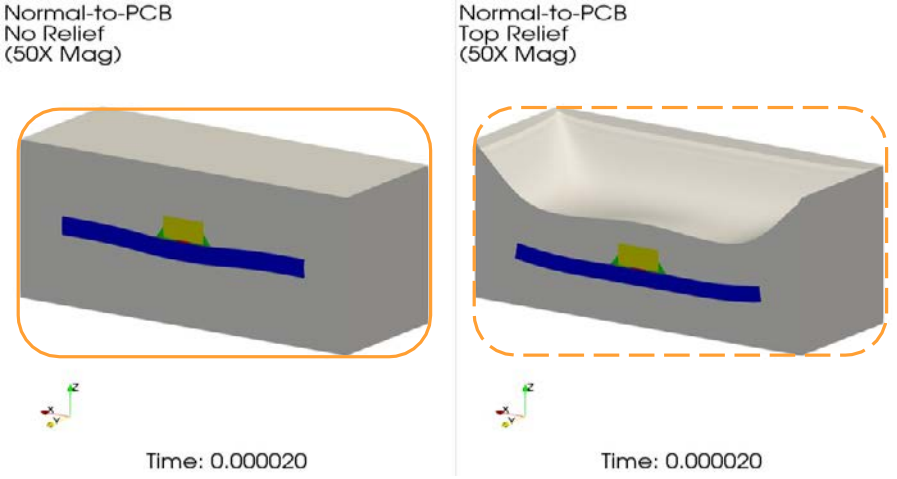
	No Relief	Side Relief	Top Relief
Mode 1	 67 kHz	 61 kHz	 54 kHz
Mode 2	 82 kHz	 77 kHz	 57 kHz

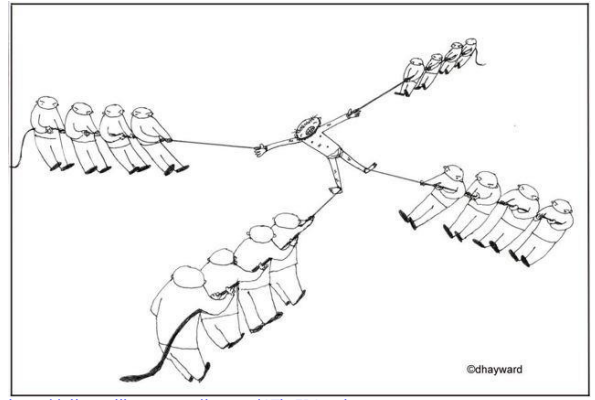
During mechanical insult, the shape of the PCB deflection is determined by the loading direction, *regardless of boundary condition* (i.e., different loading directions excite different modes).

Capacitor Acceleration Transmissibility





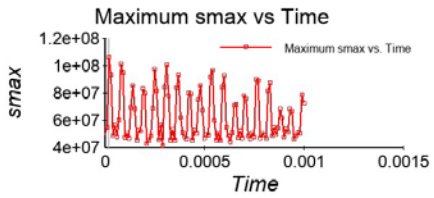


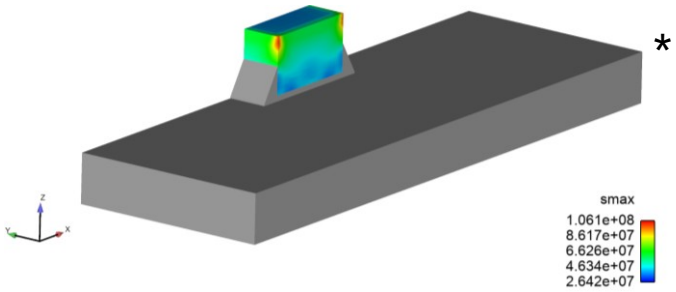


http://clipart-library.com/images/ATbr5BAyc.jpg

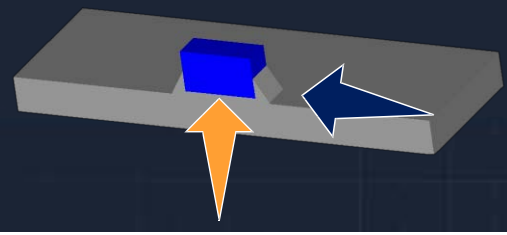
Relief mechanisms drastically affect deflection behavior.

Resultant Capacitor Stress

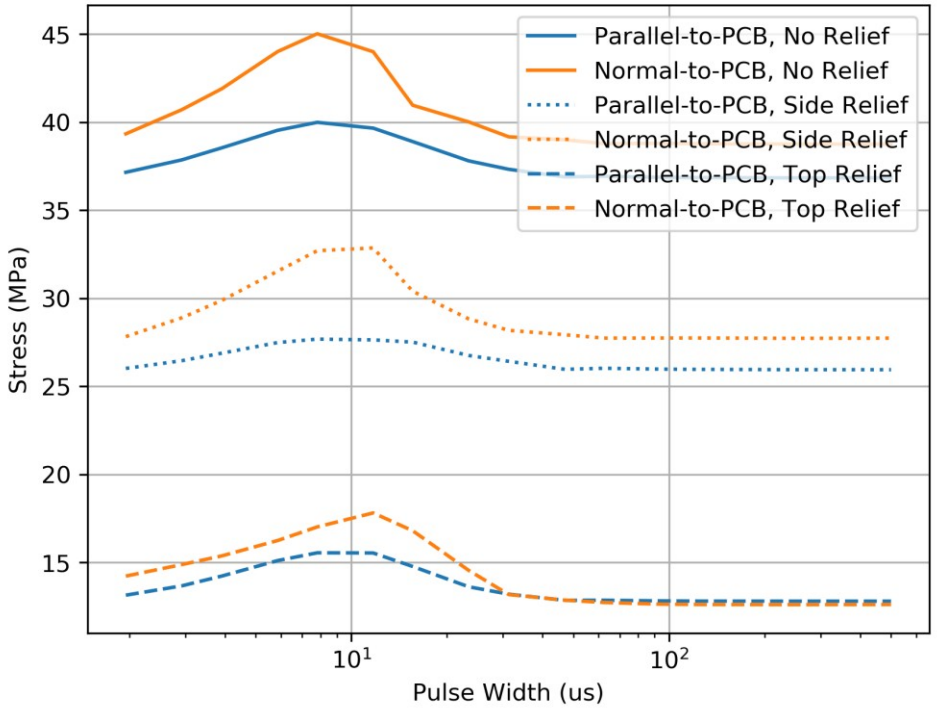




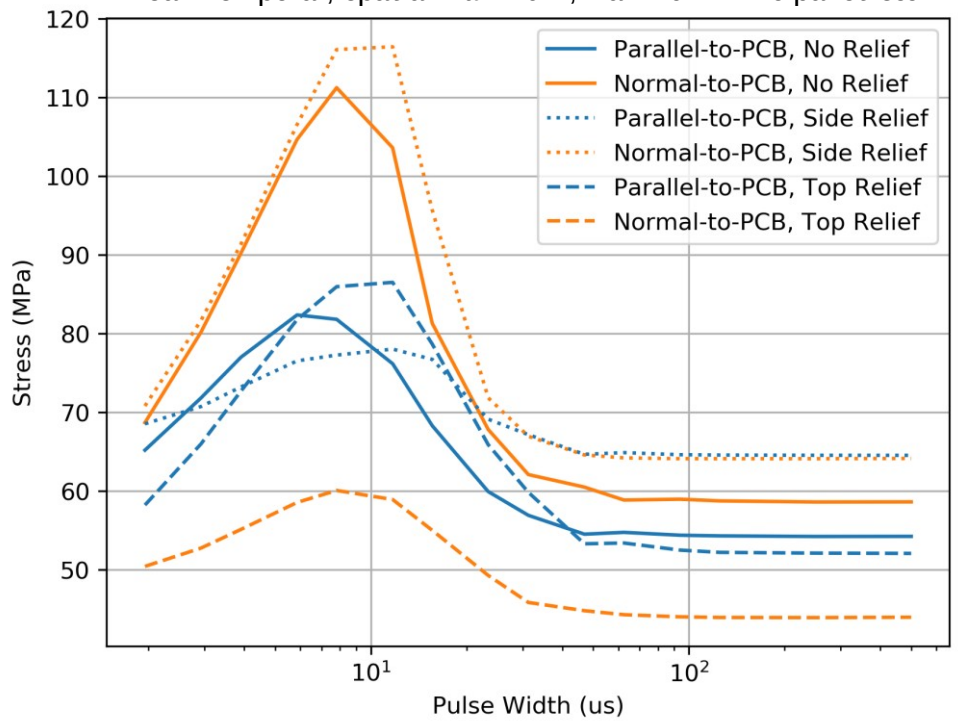
*



Peak Temporal, Spatial *Average*, Maximum Principal Stress



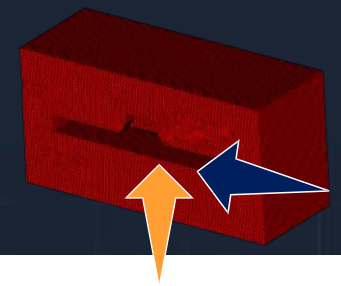
Peak Temporal, Spatial *Maximum*, Maximum Principal Stress

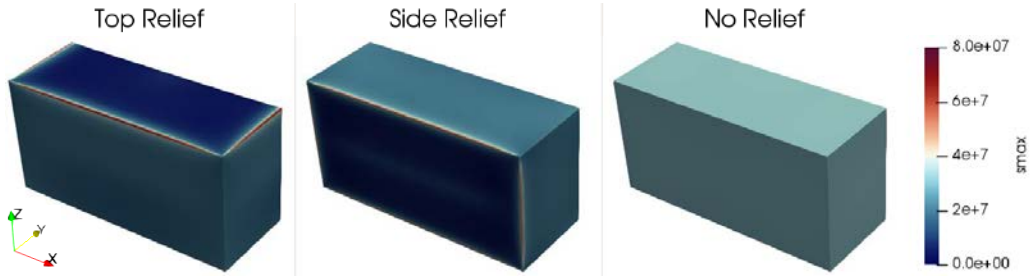


Tensile load on capacitor exacerbates dynamic stress.

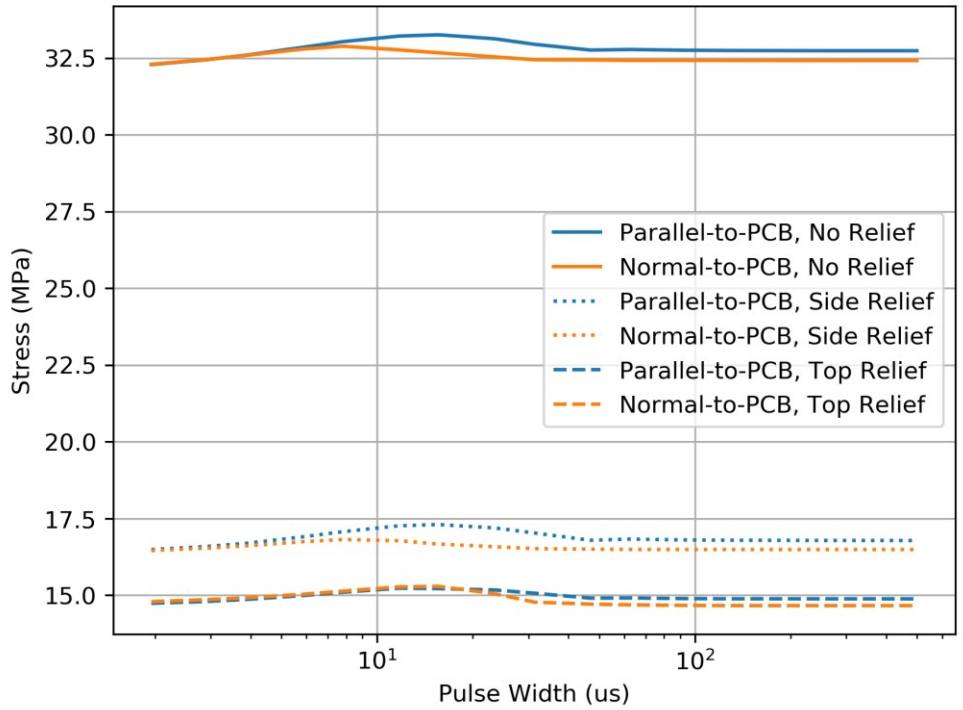
*No Relief, Normal-to-PCB, Pulse Width: 7.81 µs

Resultant Potting Stress

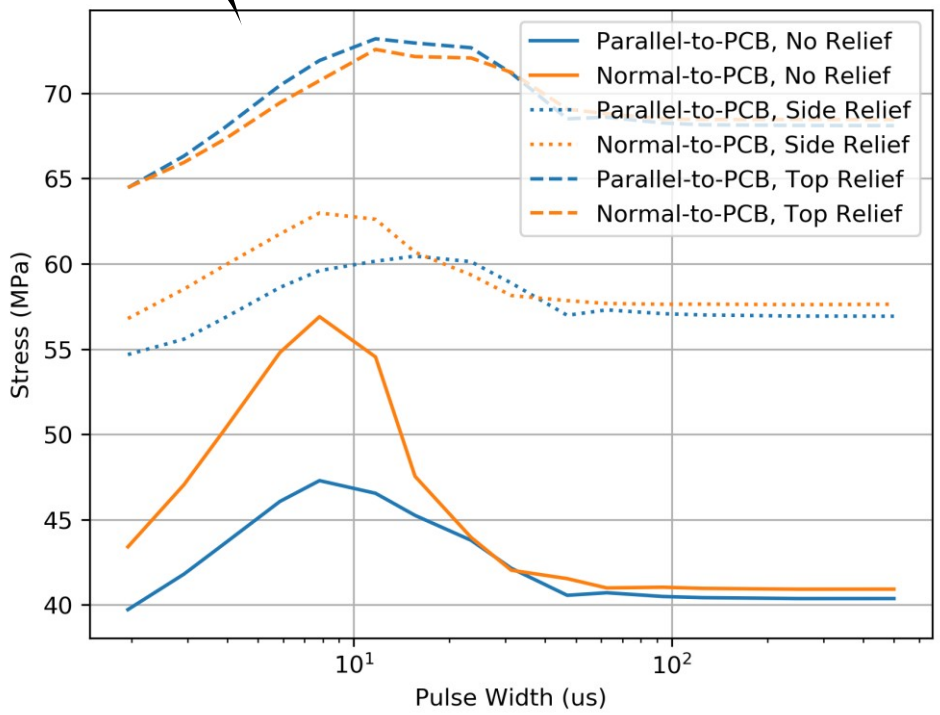




Peak Temporal, Spatial *Average*, Maximum Principal Stress

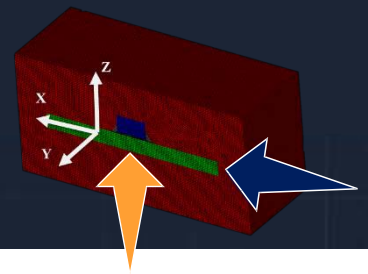


Peak Temporal, Spatial *Maximum*, Maximum Principal Stress

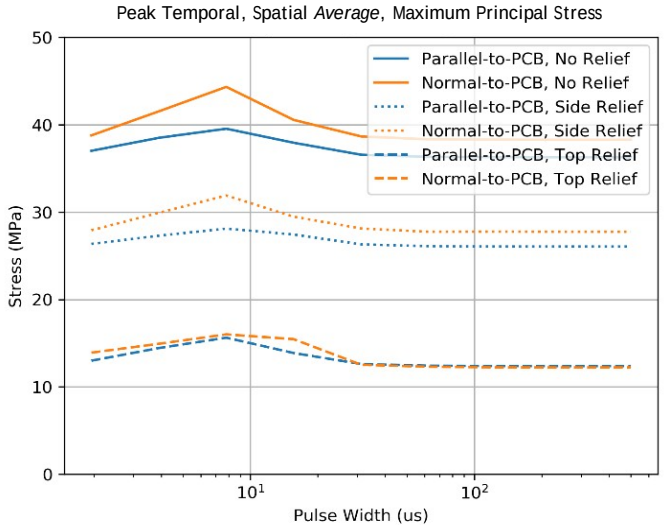


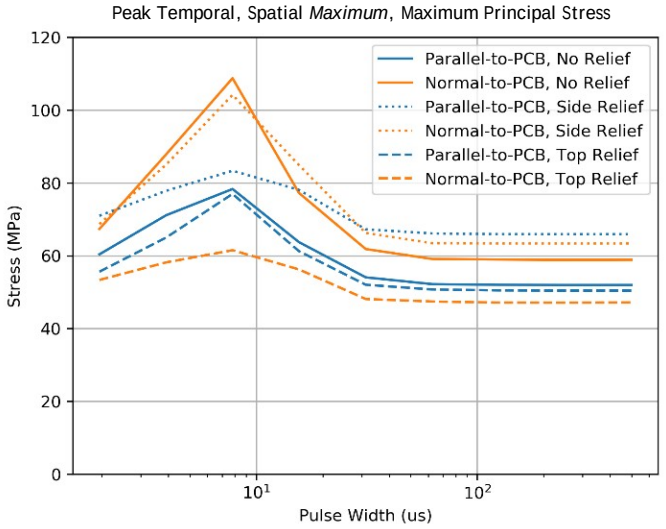
Delamination likely to occur along housing interface.

PCB Length Comparison: Capacitor Stress

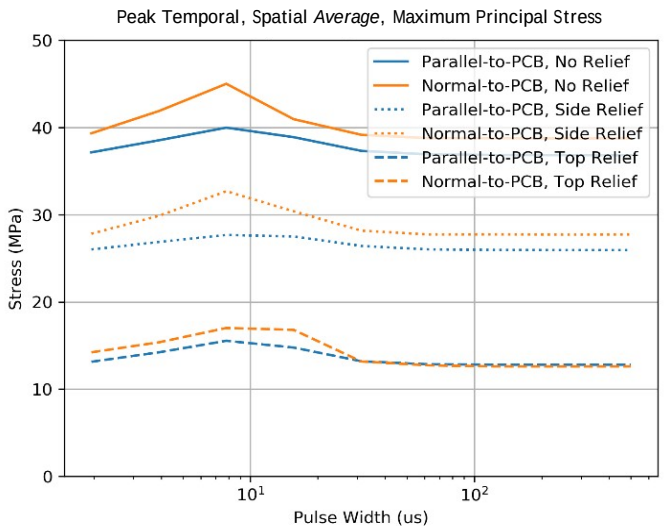


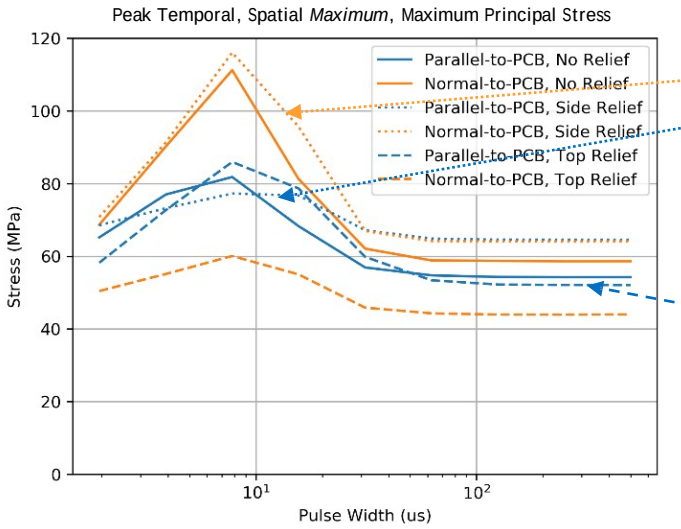
.5”L PCB



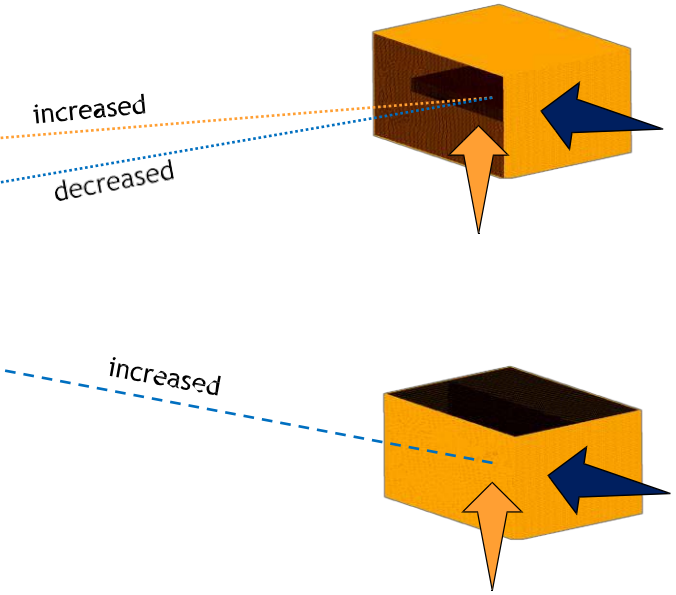


.75”L PCB



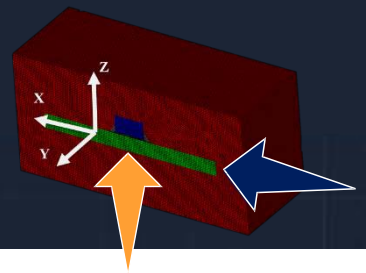


- Negligible effect on spatial averaged stress
- Stress increased for Normal-to-PCB/Side Relief and Parallel-to-PCB/Top Relief
- Stress decreased for Parallel-to-PCB/Side Relief

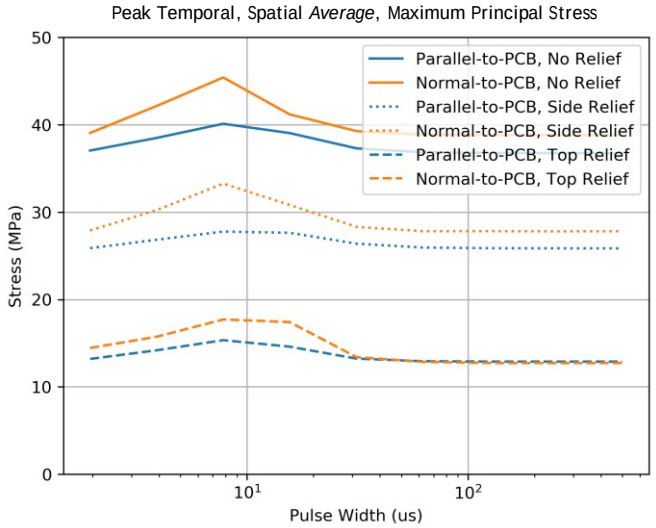


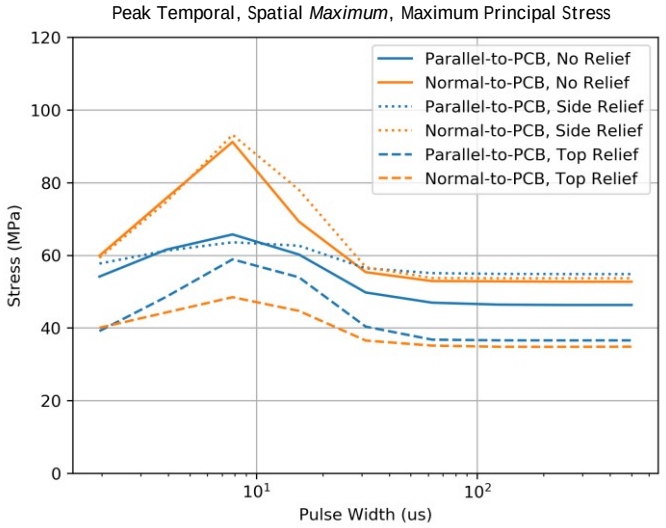
Increasing PCB length reduces bending stiffness and resonant frequency.

Mesh Comparison: Capacitor Stress

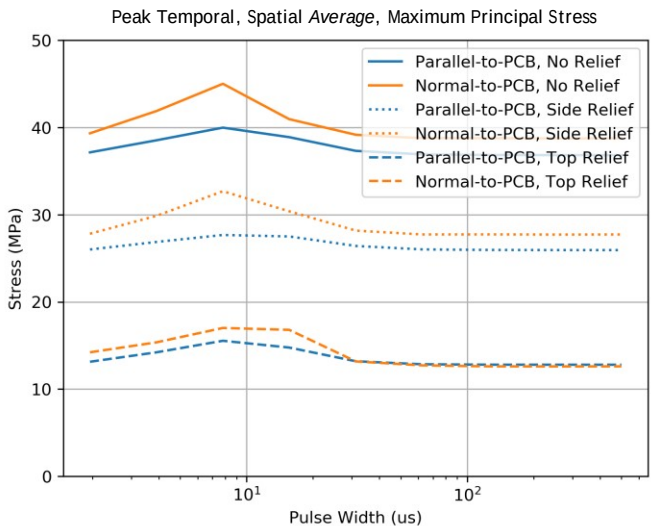


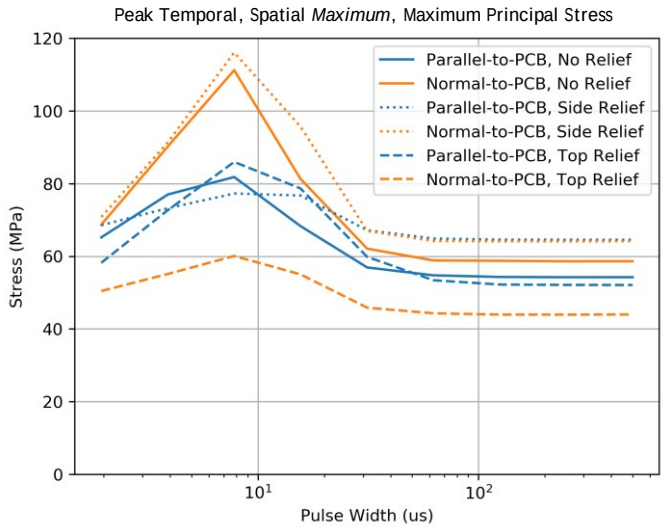
Course: .010”



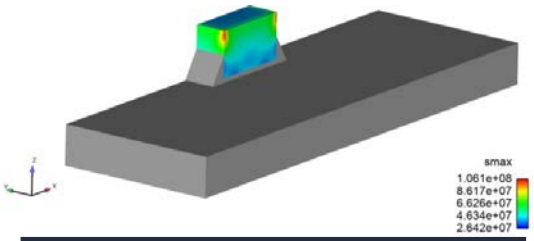


Fine: .006”

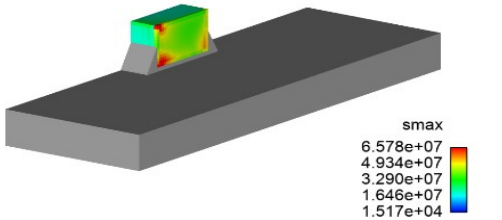




- Spatial averages stresses have converged
- Mesh contains stress risers which fail to converge



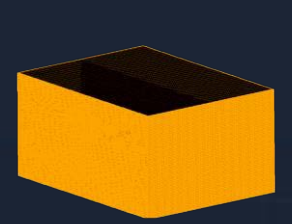
Normal-to-PCB/No Relief

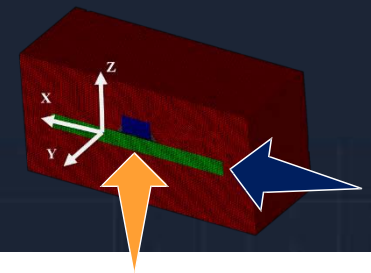


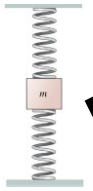
Parallel-to-PCB/Side Relief

Geometry is mesh-dependent due to existence of stress concentrators.

Bottom/Top Comparison: Capacitor Stress

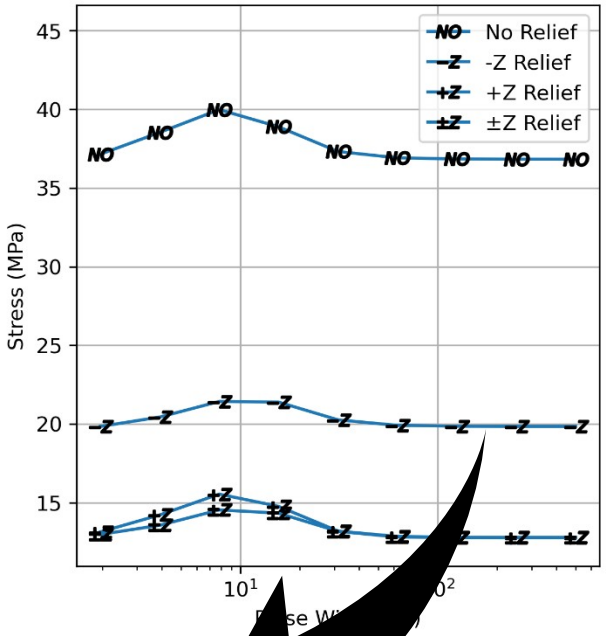




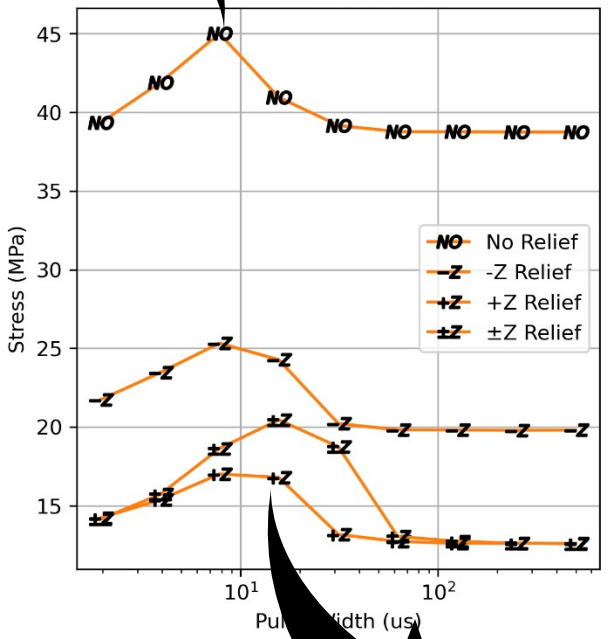


Peak Temporal, Spatial *Average*, Maximum Principal Stress

Parallel-to-PCB



Normal-to-PCB

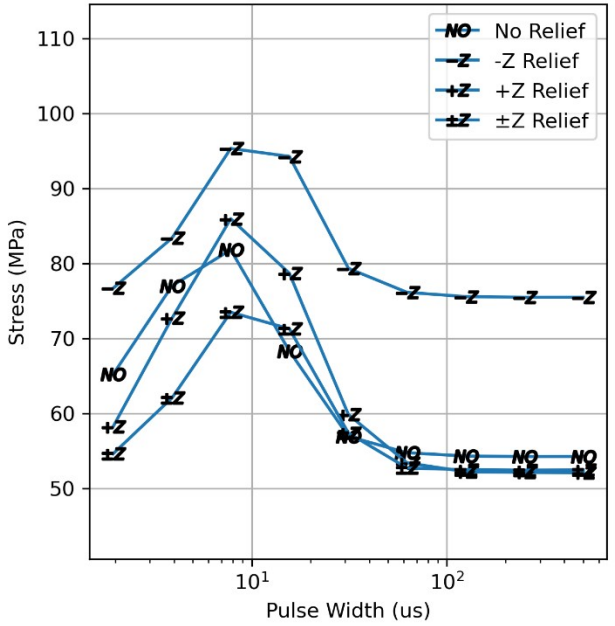




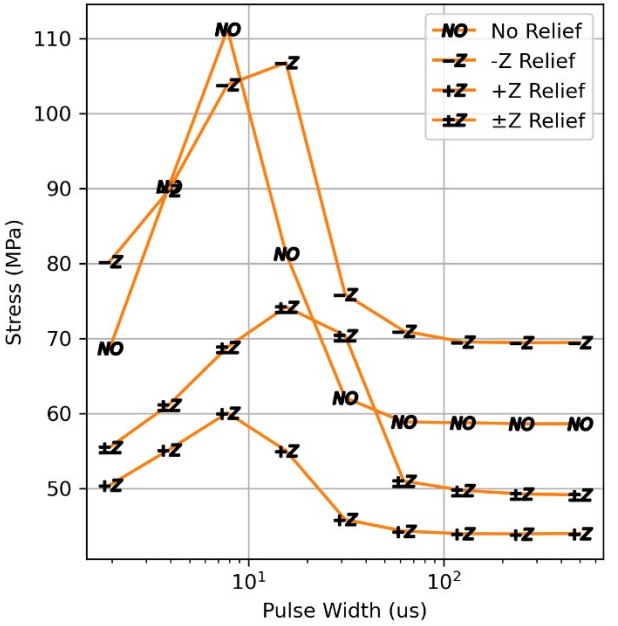


Peak Temporal, Spatial *Maximum*, Maximum Principal Stress

Parallel-to-PCB

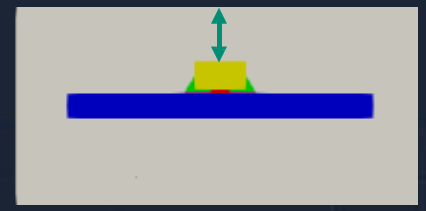


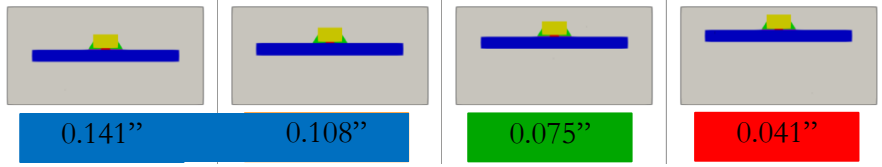
Normal-to-PCB

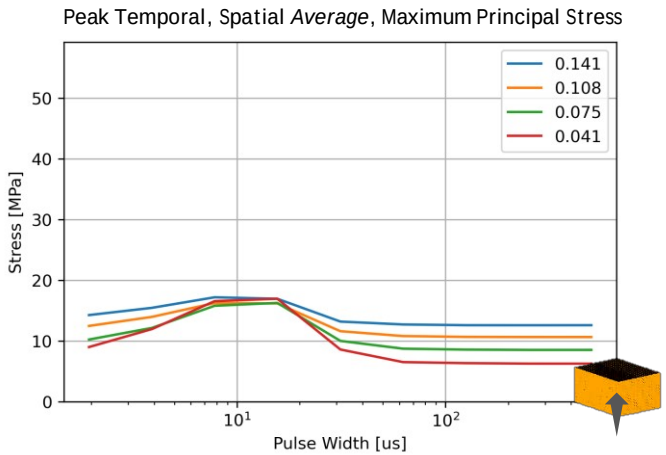


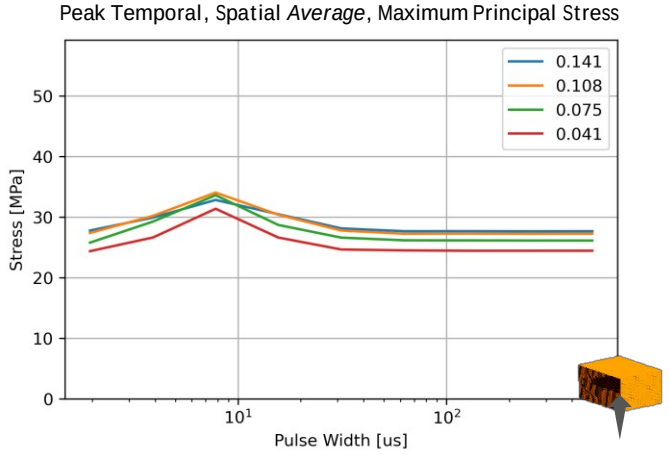
Tensile loads can resist PCB deflection; reliefs can exacerbate stress.

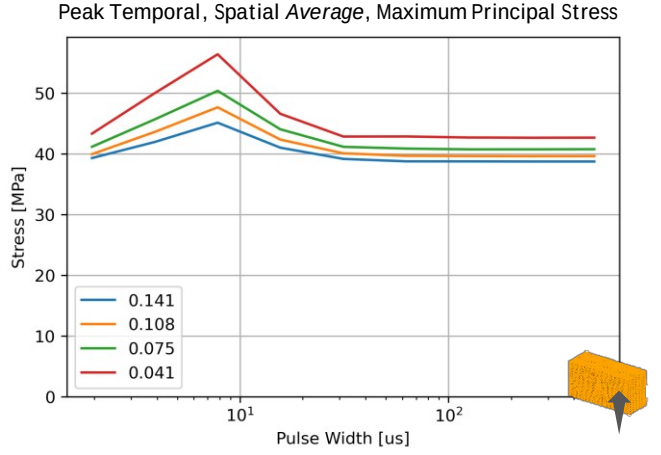
Boundary Proximity: Average Capacitor Stress

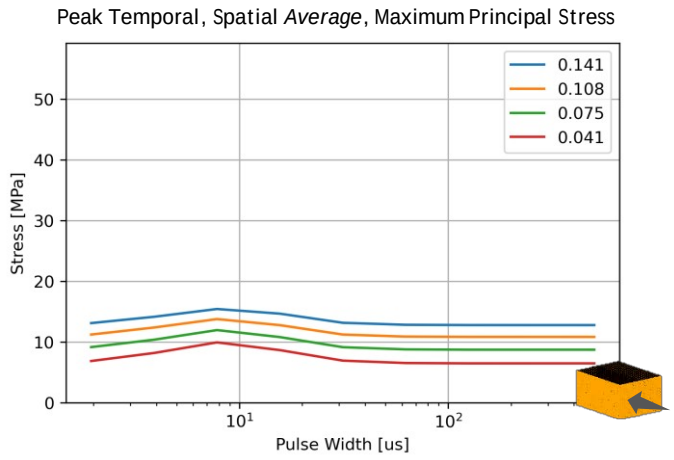


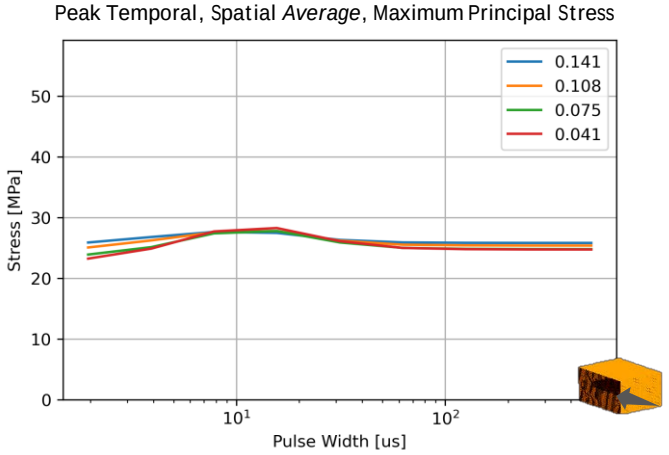


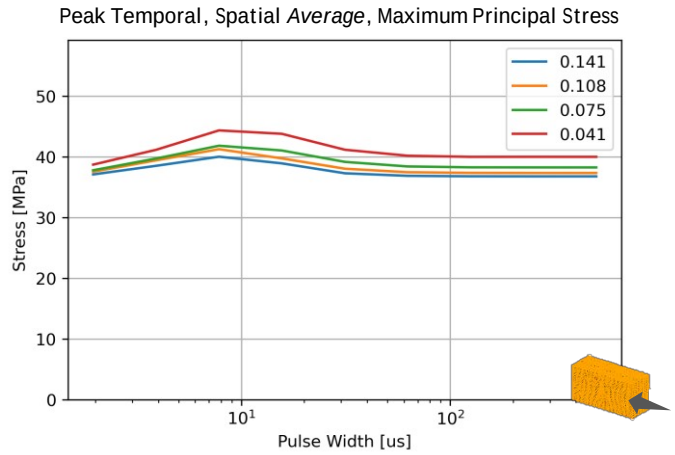






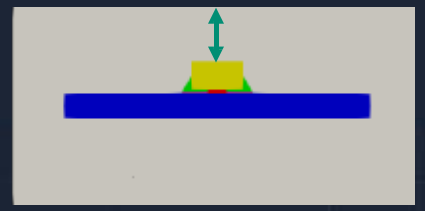


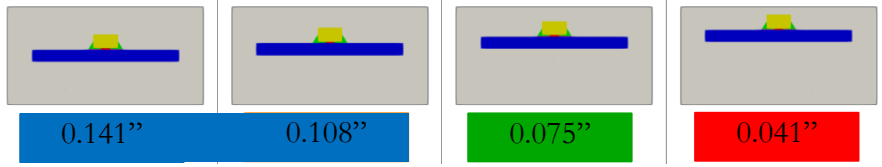


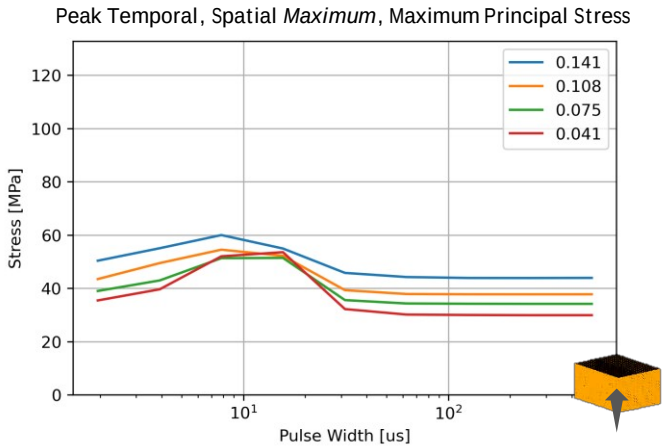


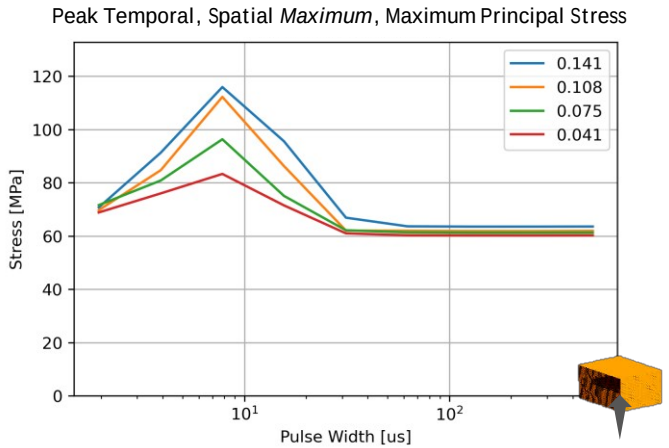
Proximity negligibly affects stress for Side Relief boundary condition.

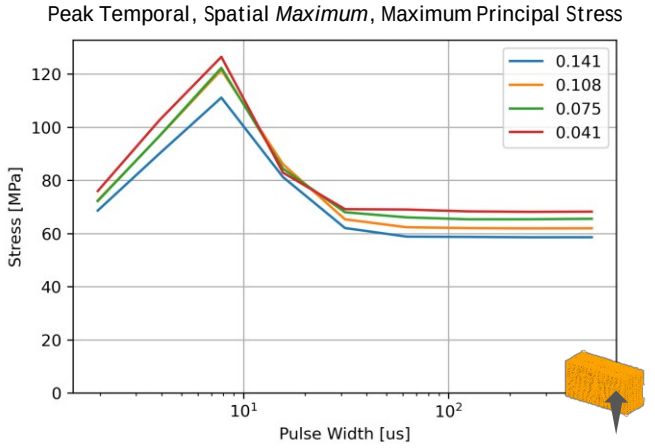
Boundary Proximity: Maximum Capacitor Stress

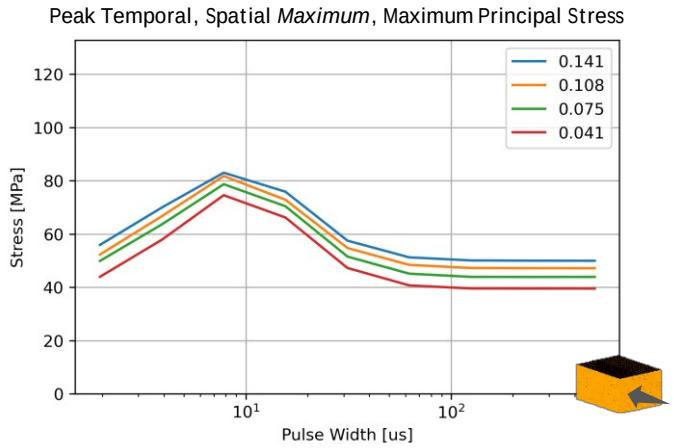


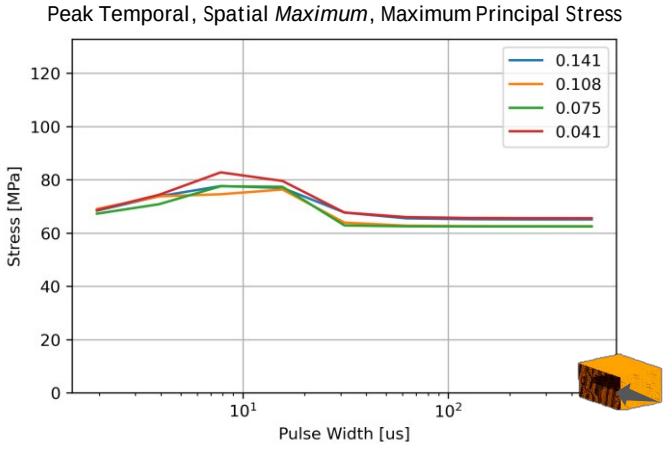


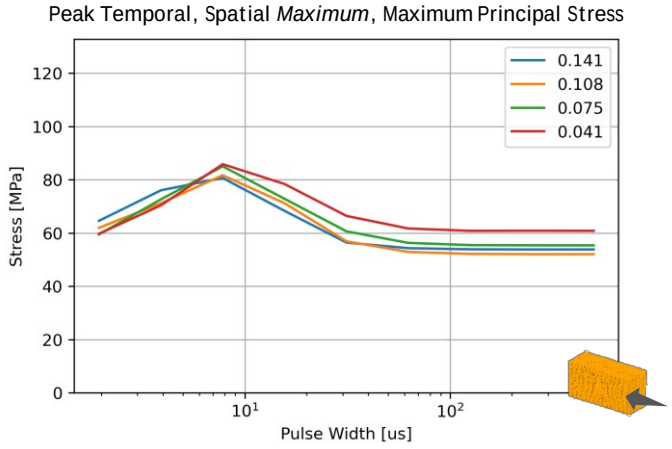






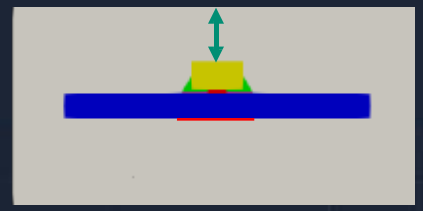


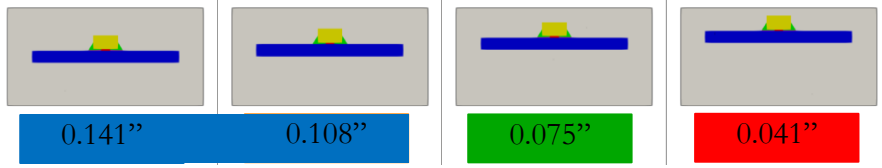


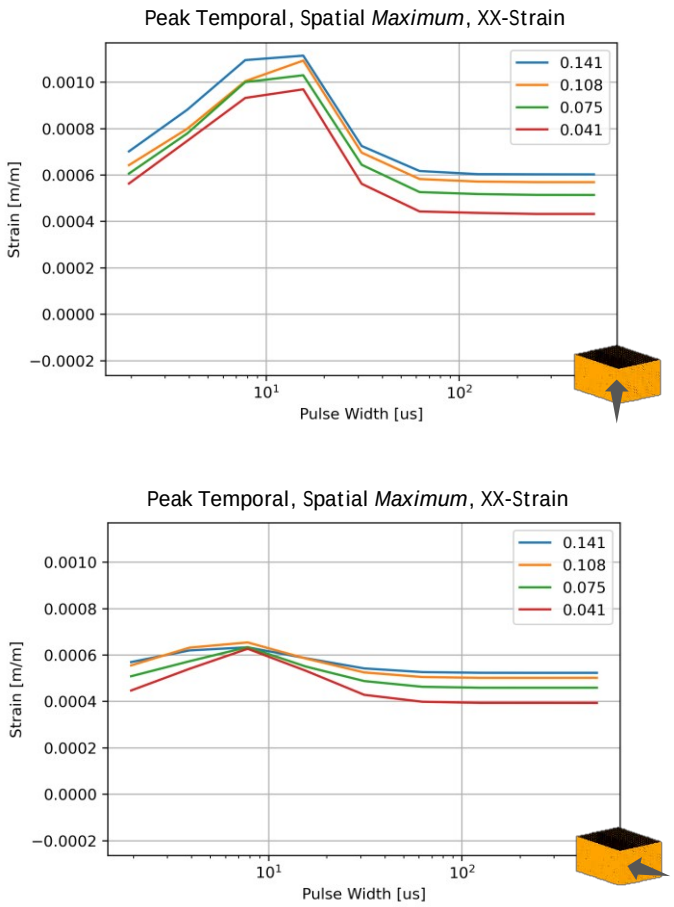


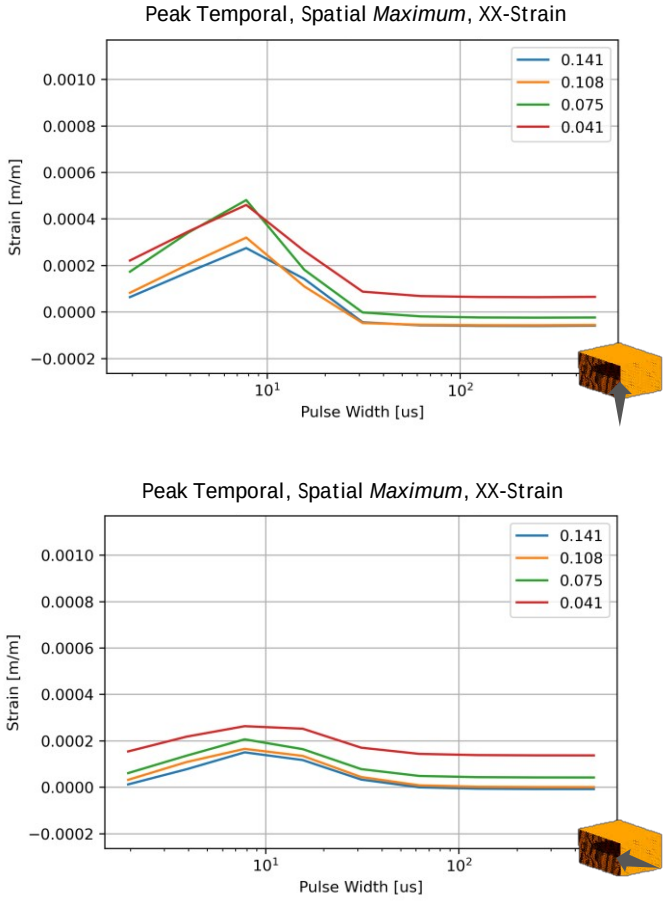
Relation of proximity to stress inverts in absence of reliefs.

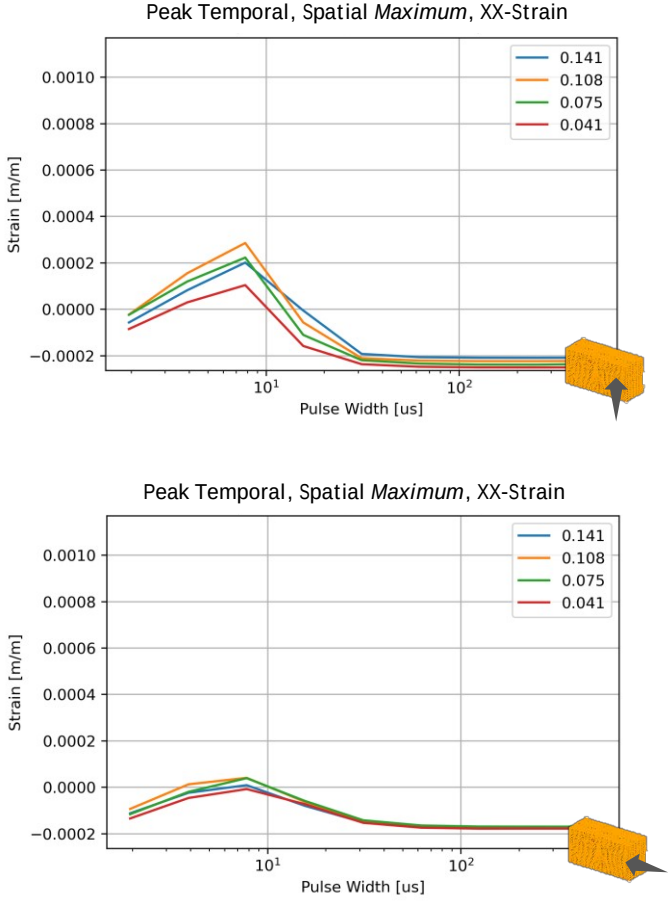
Boundary Proximity: Maximum PCB XX-Strain





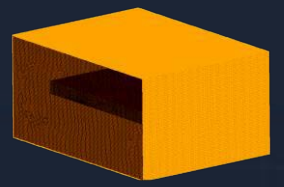


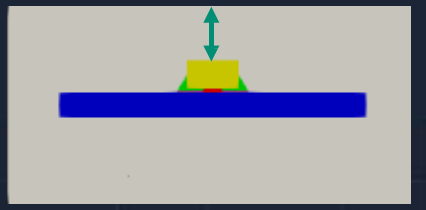




PCB flexure behavior is complicated/dependent on variety of parameters.

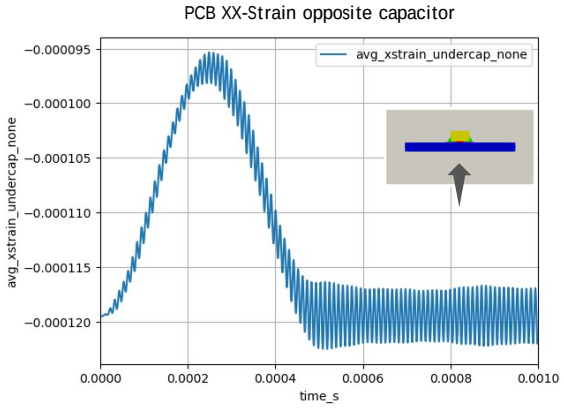
Boundary Proximity: Nuances



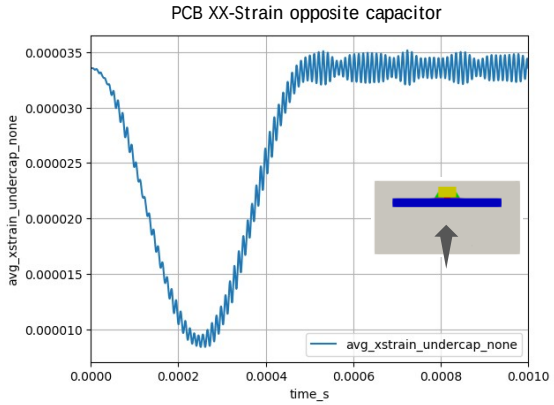


Normal-to-PCB / Side Relief

.141”

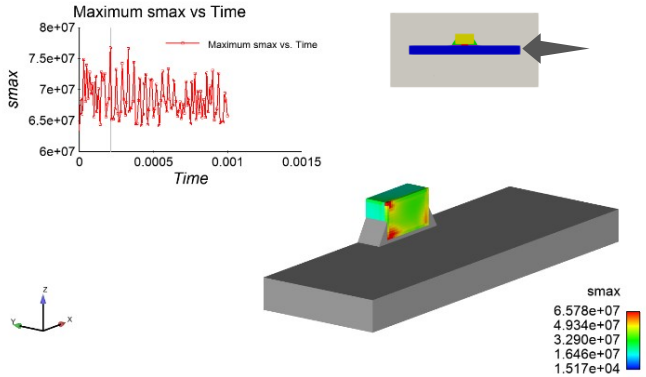


.041”

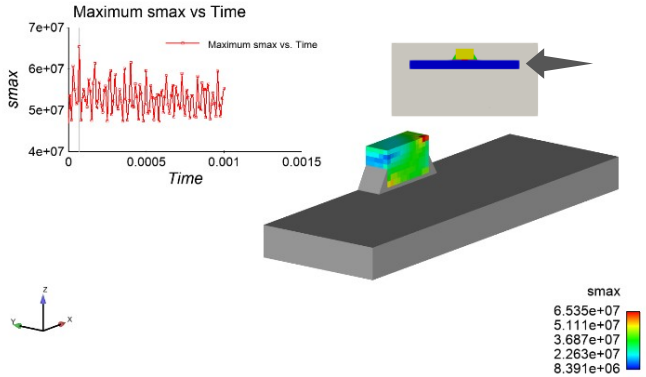


Parallel-to-PCB / Side Relief

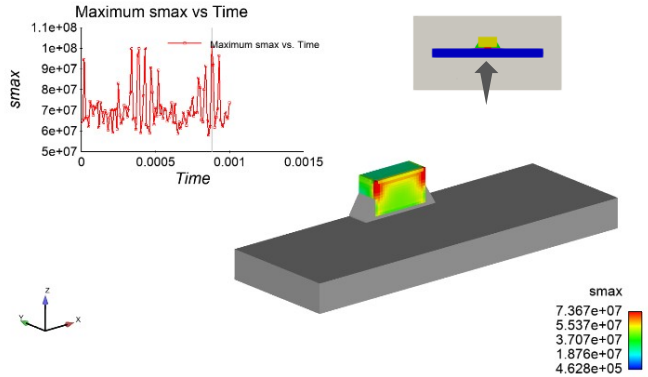
.141”

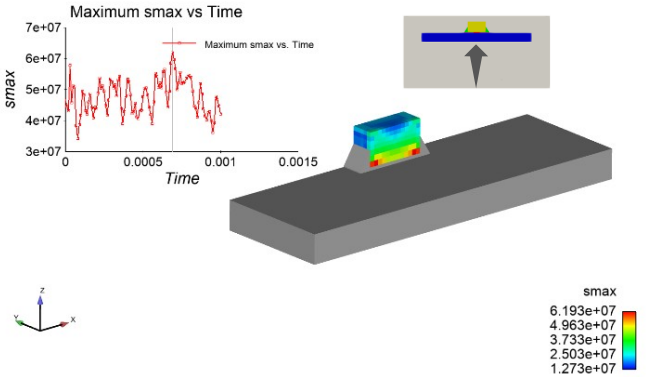


.041”



Normal-to-PCB / Side Relief





Inconsistent, complex damage mechanisms confound intuition.

Conclusions

- Strategic inclusion of relief mechanisms are critical for electronic survivability.
- The PCB *orientation* dictates fundamental displacement mode, the *relaxation condition* of the boundary in the direction of the displacement mode affects the resultant component stress state.
- Analyses of systems are vital, as complex, non-linear damage mechanisms can defy engineering intuition.
- Length of PCB has little effect in this study, longer PCBs could induce greater PCB deflection in other applications.
- Boundary proximity is directly related to the stress state in the absence of reliefs, but inversely related otherwise.
- Best performer[1]: Top Relief boundary condition & Normal-to-PCB loading direction.
- 2nd performer[2]: Side Relief boundary condition & Parallel-to-PCB loading direction.



[1]Does not account for components on opposite side of PCB.
[2]Possibly best case for real applications.



Exceptional Service in the National Interest

Sandia National Laboratories

PRF Research & Development Inc.

Conformal Antenna Design for Proximity Fuzes

Prof.Dr. Şimşek Demir,
Dr. Aydin Vural, Yiğit Haykır

64th Annual Fuze Conference
May 11-12, 2021

Distribution A

OUTLINE

- Company Profile
- Product Portfolio
- Design of the Conformal Antenna
- Future Works
- Working through COVID-19

Distribution A

COMPANY PROFILE

- Founded 2013, PRF R&D provides State-of-the-Art customised solutions for RF requirements and fuzing applications.

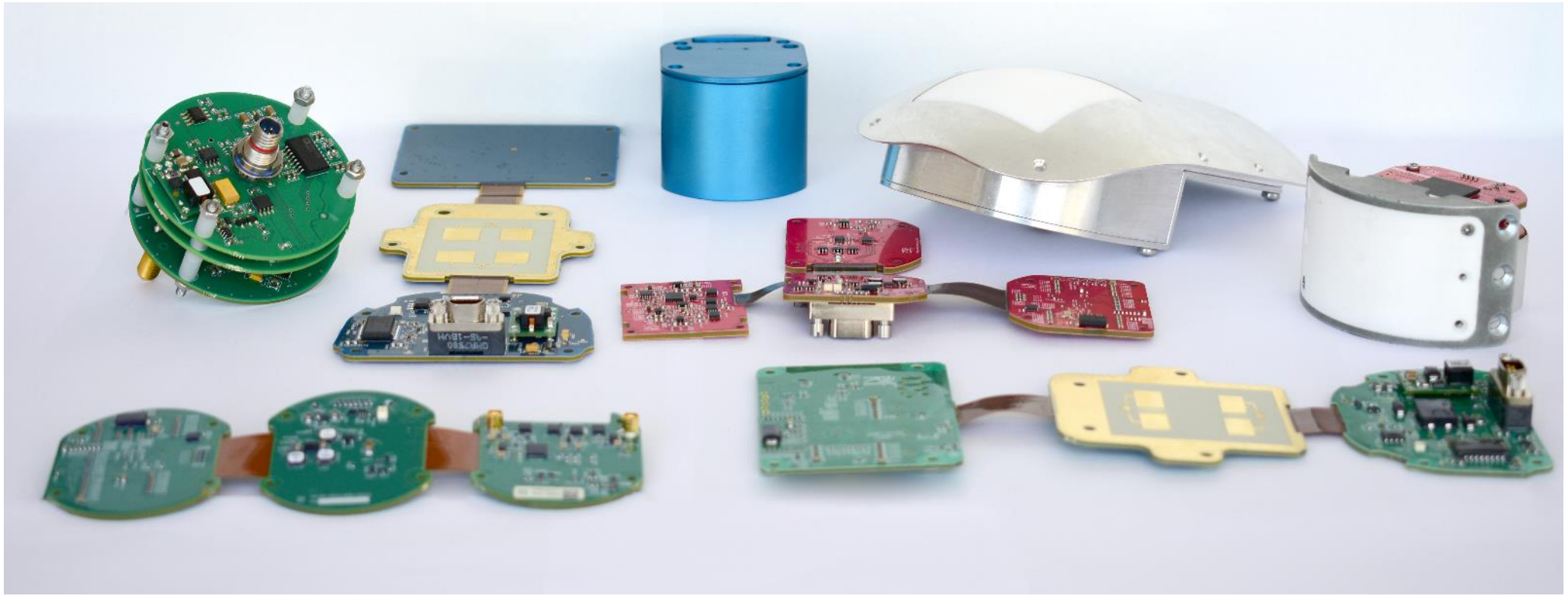
- Conveniently located in Middle East Technical University Techno-Park (Ankara/Turkey), innovative solutions are developed by utilizing benefits of research and development heritage with 24 engineers.

- Solutions provided are in a wide frequency range, from HF to millimetres waves.

Distribution A

PRODUCT PORTFOLIO

- Both CW and LFMCW Proximity Sensors for munitions which are operable up-to a few Mach velocities with a sensitivity of 1 metre are in service in TAF.



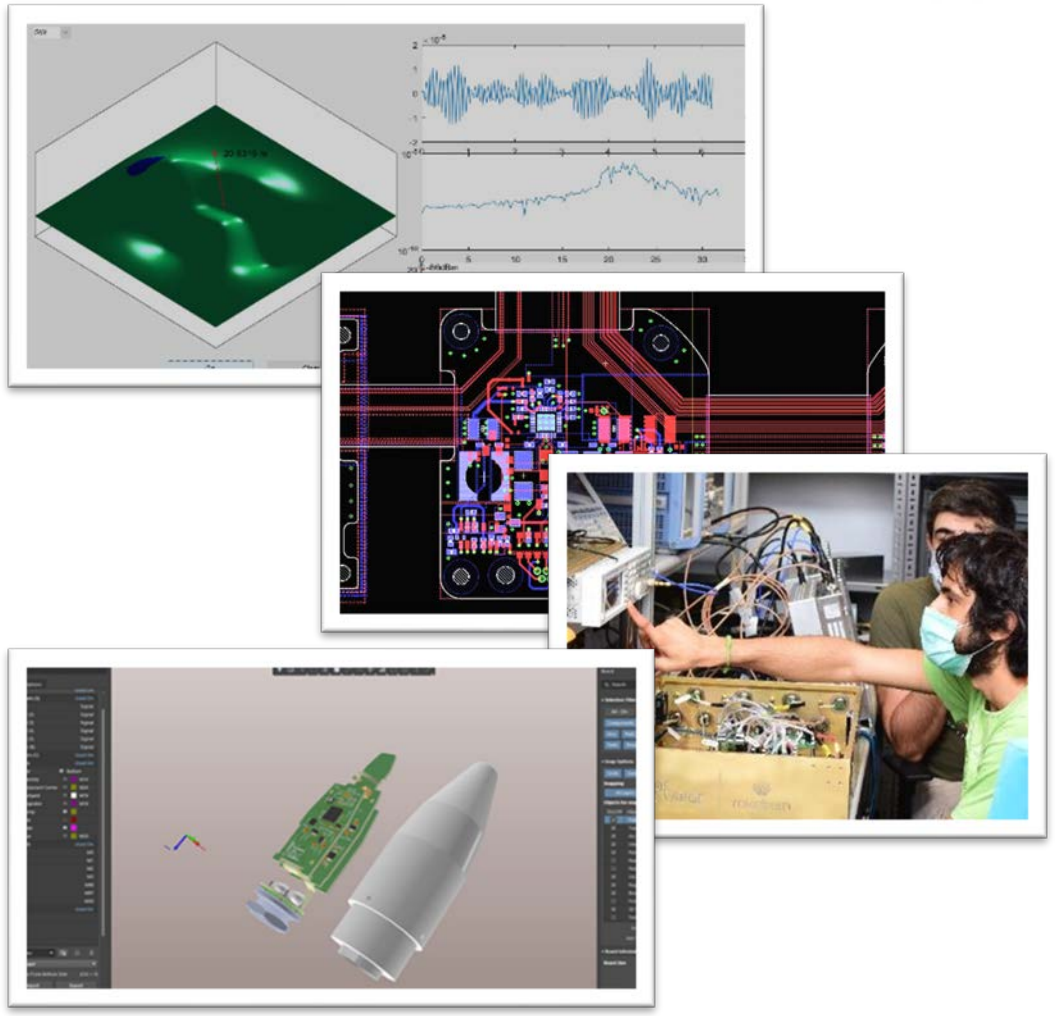
Distribution A

PRODUCT PORTFOLIO

Specialised in proximity sensors,

- RF ground reflection simulations,
- SIL/HIL test and simulation systems,
- Frequency Diversity Arrays,
- Solid State Power Combiners,
- Customised Antennas,
- RF Combiners and Waveguides,

are the products in our portfolio.



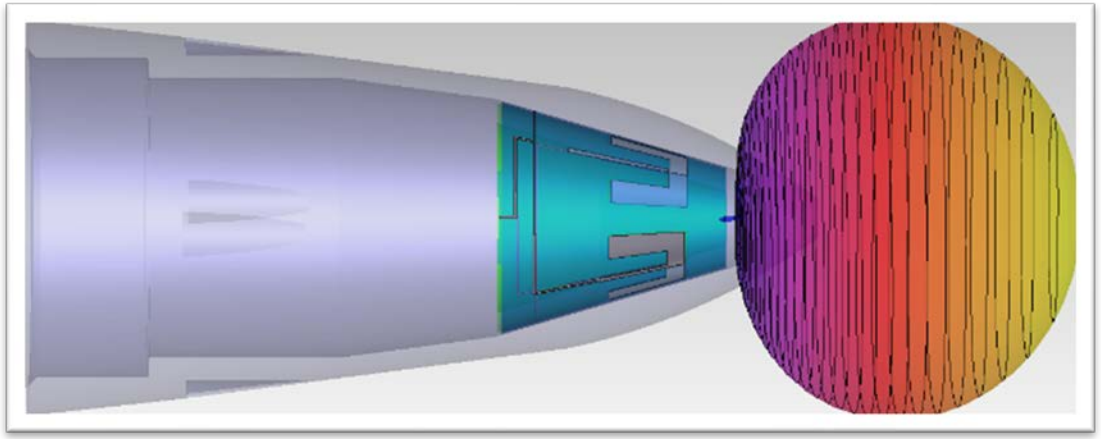
Distribution A

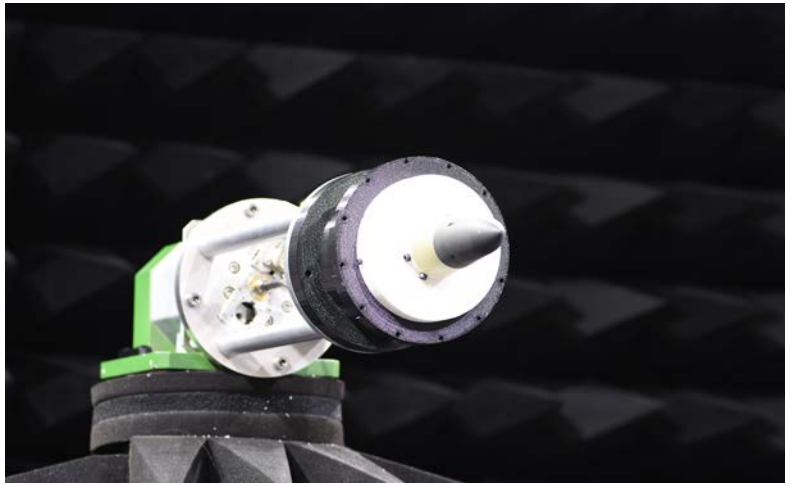
APPLICATION

122mm fuze head

Small space for antenna and the electronics

A conformal antenna pair in C-band





Distribution A

DESIGN GOALS AT A GLIMPSE

- Electrically small, yet directive antenna
- Integration with electronics
- Scalable design for similar geometries

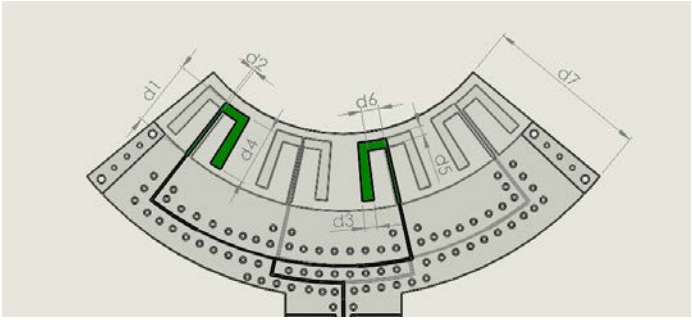
- Flexible PCB

Distribution A

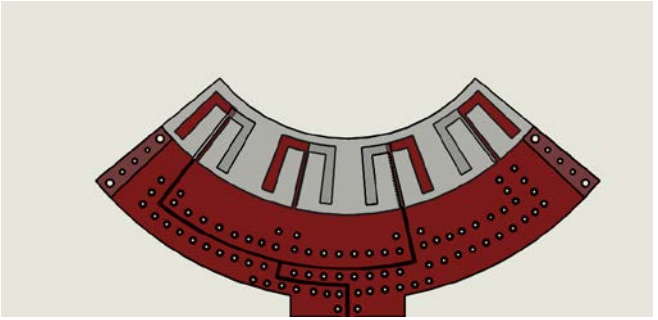
CONFORMAL ANTENNA

- Printed folded dipole pairs and truncated reflector plane.
- Wide band characteristics with a directed radiation

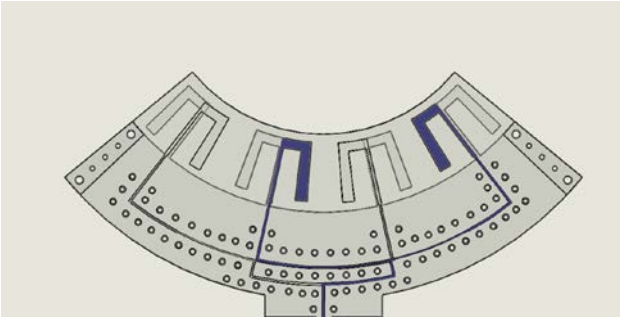




TX Dipoles arms



Ground and Dipole arms on Layer-2

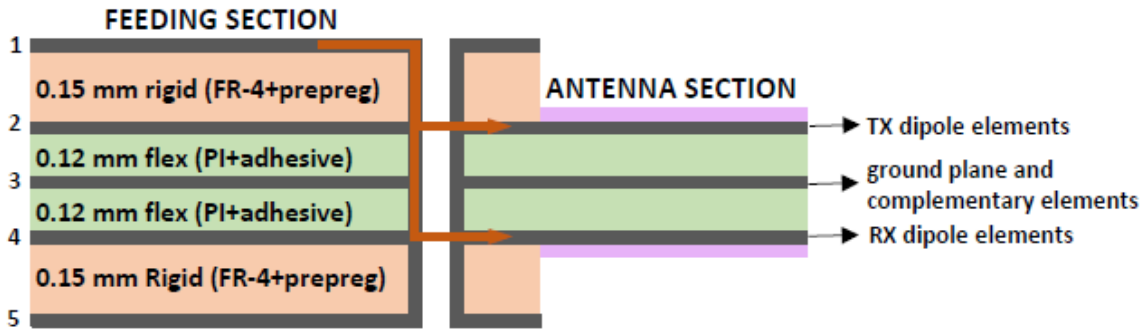


RX Dipole arms on Layer-3

Distribution A

CONFORMAL ANTENNA

- A hybrid board laminated together
  - 5-layer rigid section
  - 3-layer flexible section



PCB Stack-Up



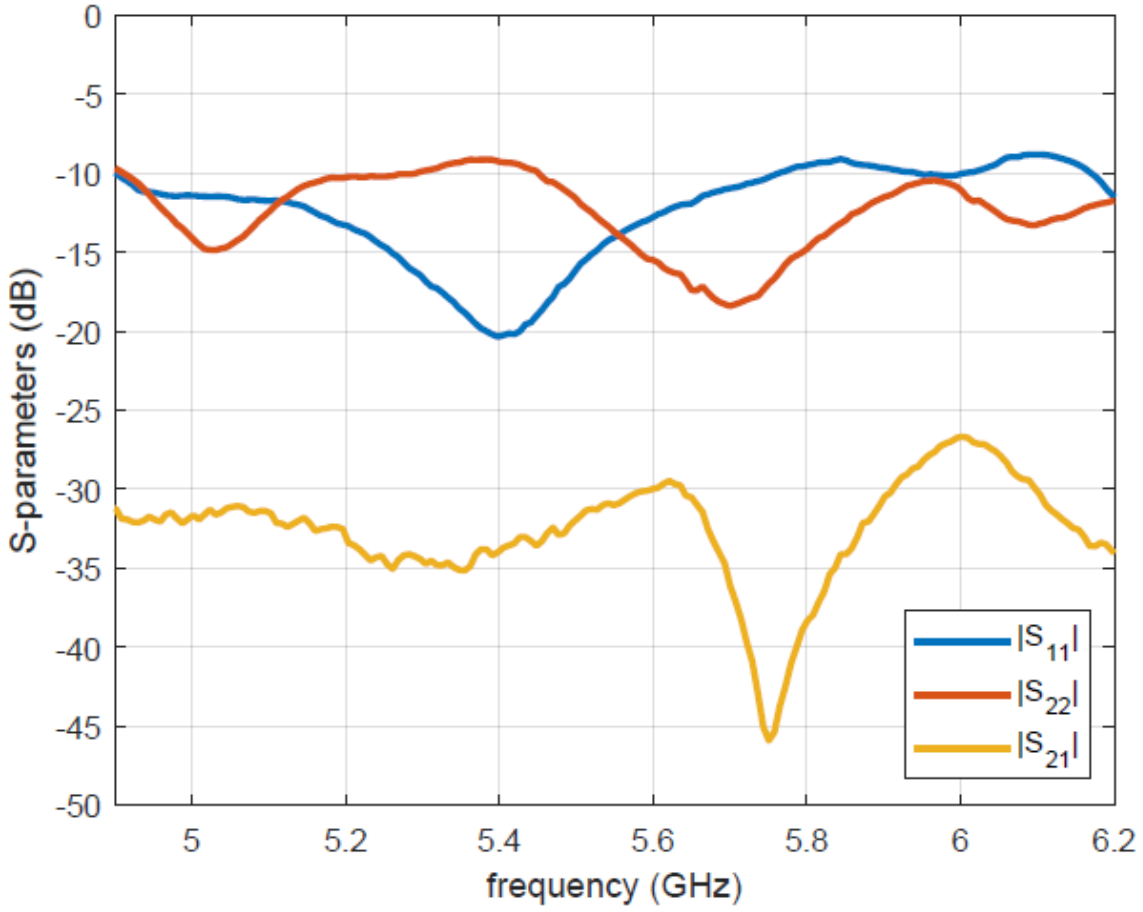
Coplanar Antenna

Distribution A

MEASUREMENT RESULTS

Wideband match

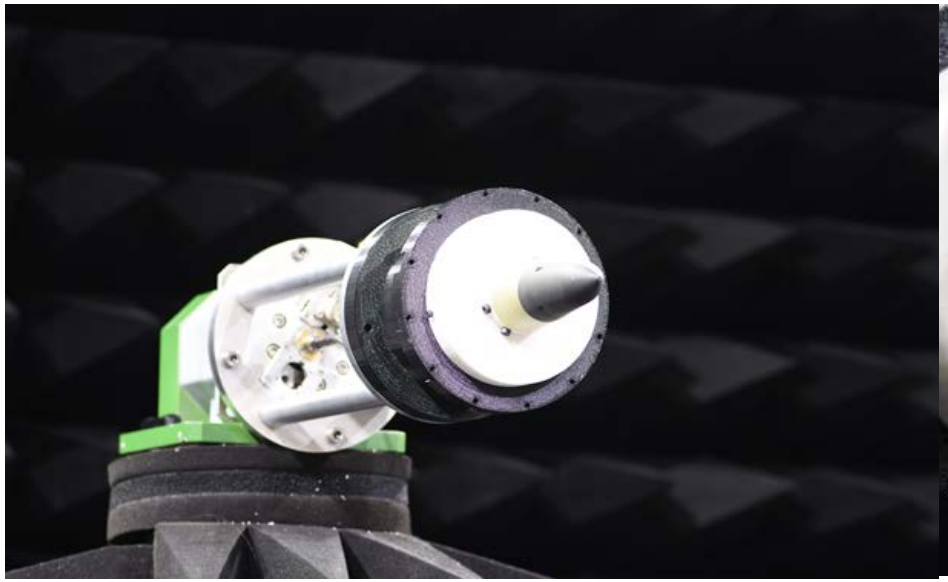
Better than 30dB isolation



Distribution A

PATTERN MEASUREMENT

Far Field and Spherical Near Field Measurements



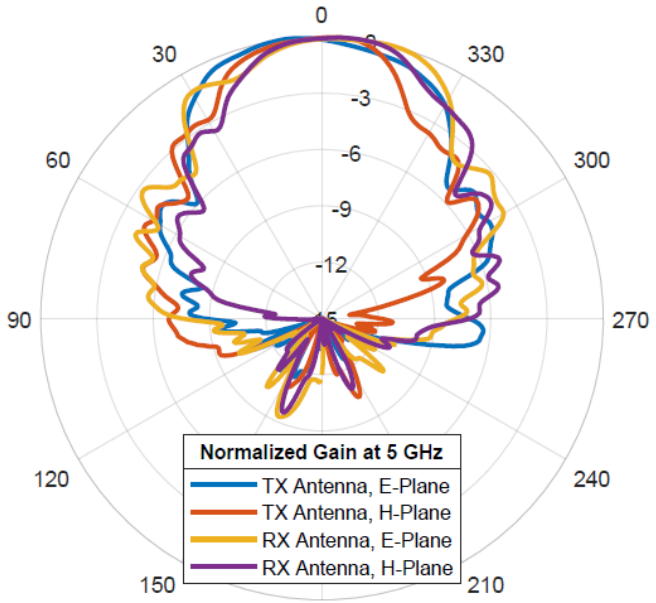


Anechoic Chamber Tests

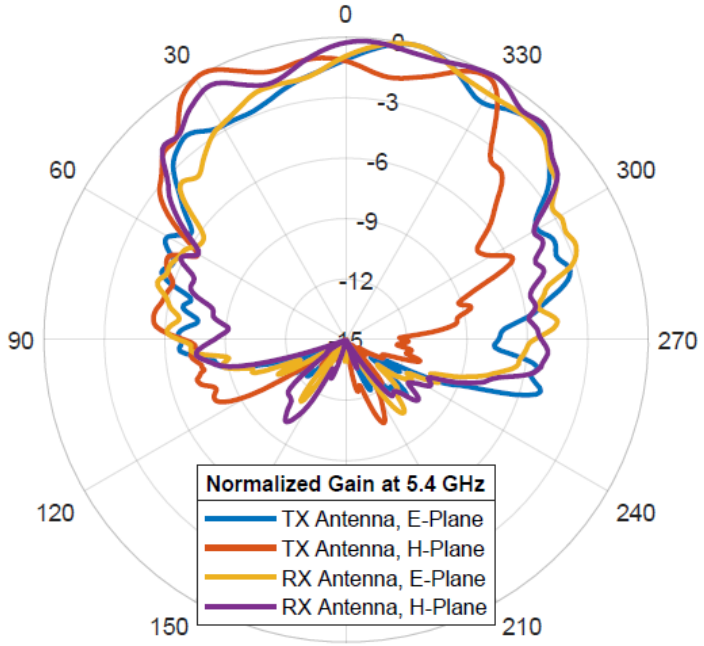
Distribution A

MEASUREMENT RESULTS

- It yields wide band characteristics with a directed radiation towards the tip of the cone.
- The mutual coupling has been achieved less than 30dB.



Radiation Pattern @ 5GHz

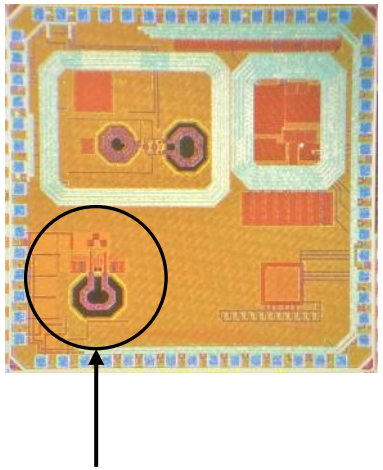


Radiation Pattern @ 5.4GHz

Distribution A

FUTURE WORKS

- To develop and produce customised RFIC including most possible components to get more space in the fuze,
- MEMS S&A device combined with EFI.



VCO Section

(Developed by PRF R&D)

Distribution A

WORKING WITH COVID-19

- Transportation
  - Car polling and avoding public transport
  - Fuel Compensation
- Clean air ventilation at any weather condition
- Remote Working
  - Remote Desktop access
  - Deploying personal computers and some test equipment to home
  - Meeting with Zoom

Distribution A

THANK YOU !



"**P**rofessional, **P**owerful, **P**recise **RF**"

Distribution A







U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – ARMAMENTS CENTER

Software Defined Radio For Medium Caliber Munitions

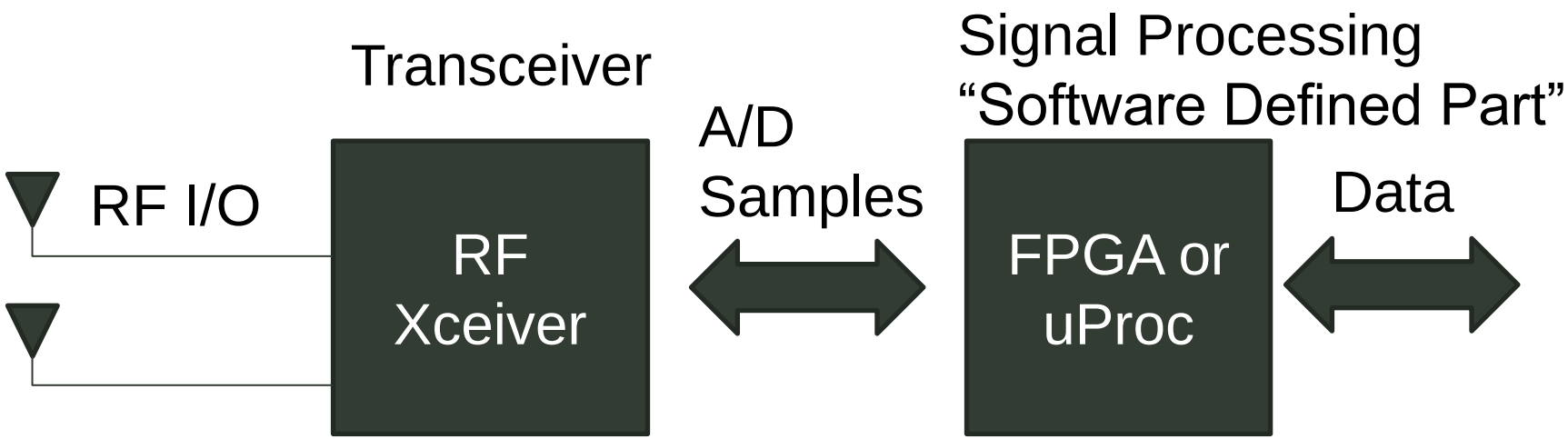
64th Annual NDIA Fuze Conference

Viktor Bana & Lam Vo

DEVCOM-Armaments Center, Fuze Division

WHAT IS A SDR

"Software-defined radio (SDR) is **a radio communication system where components that have been traditionally implemented in hardware (e.g. mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) are** instead implemented by means of software on a personal computer or embedded system"



WHY A SOFTWARE DEFINE RADIO

- **Software Defined Radio**
  - Arbitrary Waveform
  - Arbitrary Bandwidths
  - Arbitrary Data Packets



- **Allows for Host Nation operation**
  - Programmable Waveforms
  - Adjustable Frequencies
  - Adjustable Bandwidths



- **Demonstrate Prototype with EVM hardware**
  - Goal to eventually fit in 30 mm or 40 mm sized munition

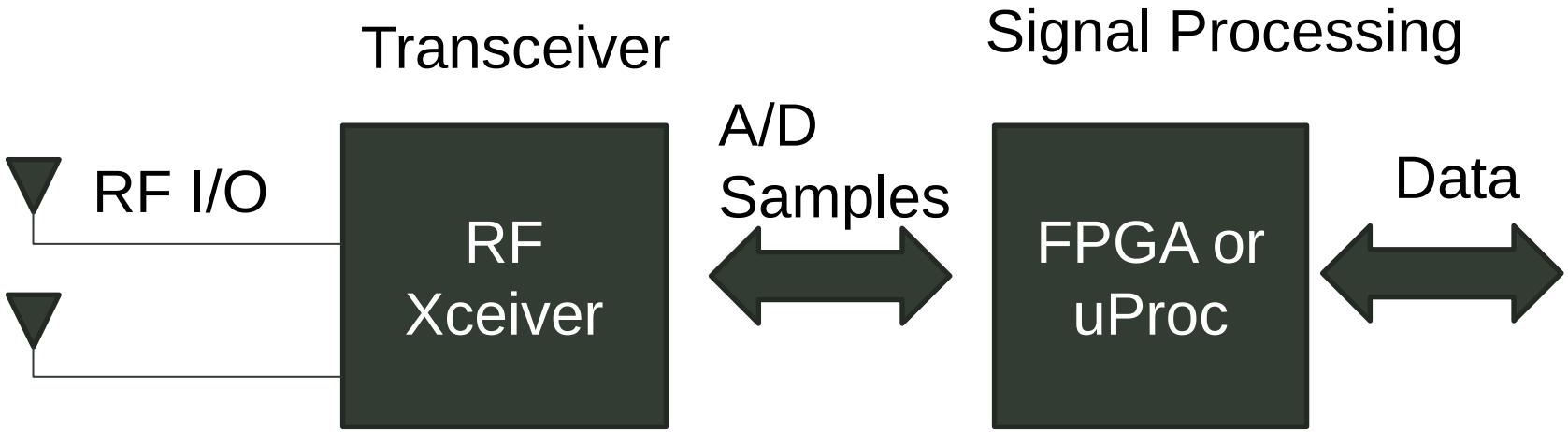


ISSUES IN DEVELOPING RF DATA LINK

- **Performance Requirements**
  - Information Requirements
  - Data Latency < xx milliseconds
- **Munition Radio Pairing in Real Environment**
  - Operate with Arbitrary Channel Assignment
- **Spectrum Supportable Regulatory Approval to Operate**
  - Frequency Assignments : Manual (SPXXI) Authority to use a specific frequency under specified operating conditions, location (like a “LICENSE” to operate something).
  - Host Nation Approval: Manual (HNC Process & HNSWD) Authority to operate equipment/emitter on a specific frequency within a Host nations sovereign borders (PERMIT & LICENSE in another country).

USES OF SDR

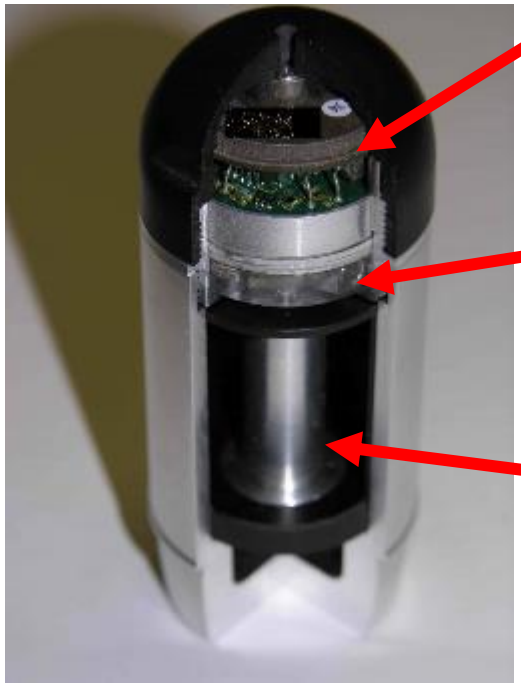
- **In Munitions**
  - Experimental system development before FCC approval
  - Allow for custom telemetry beyond COTS chips
  - Receive Communication from Base Station
- **Ground Station**
  - Experimental system development before stage FCC approval
  - Allow for custom telemetry beyond COTS chips
  - Direct access to Data for post processing



Traditional Round vs. SDR System

Off board Sensor allows for
Advanced Detection Algorithms

Conventional



Electronics

Warhead

S&A

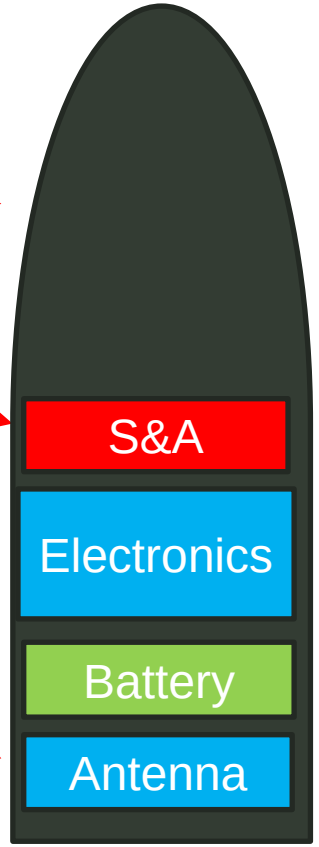
S&A

Warhead

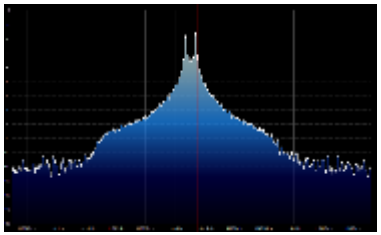
SDR
Electronics

Antenna

Base Station



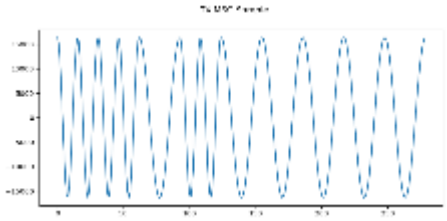
LABORATORY DEMONSTRATION OVERVIEW



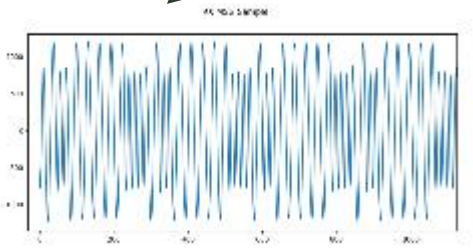
Channel

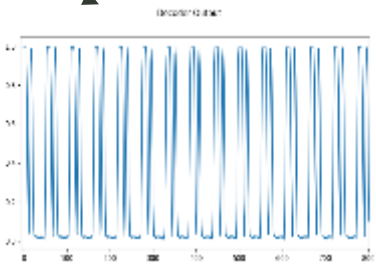
SDR





Transmit





Demodulate

Data



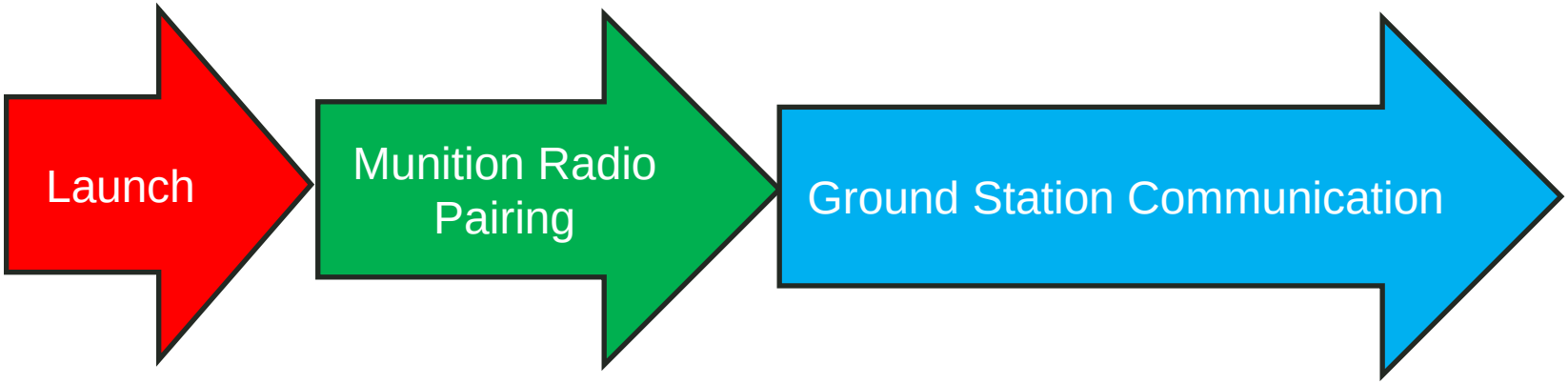
Ground Station

SDR VERSUS COTS SUMMARY
5 = BEST, 1 = WORST

Description	(ASIC COTS CHIP)	Software Defined Radio
Channel Scan Time	1	5
Power Consumption	5	1
Wakeup Time	5	3
Component Size	5	1
Power	5	1
Host Nations Support	1	5
DoD Waveforms	1	5

FUTURE WORK
JFTP SHF COMMUNICATION LINK

- ***Use SDR to Investigate Communication Waveforms***
- ***Demonstrate with Hardware in the Loop***
- **Develop Munition Pairing Algorithm**



0<Time<4ms 4 ms<Time < xx ms xx ms<Time <yy ms

OTHER RESOURCES

- **GNU Radio**
  - GNU Radio is a free open-source software development toolkit that provides signal processing blocks to investigate software radios.
- **Mathworks**
  - Complete End to End development of Radio Link into Embedded Hardware
  - Simulink, Communication Tool Box, Hardware Description Language Coder
- **Analog Devices**
  - Free Book “Software-Defined Radio for Engineers, 2018 | Education | Analog Devices”

SUMMARY

- **ASIC Chips are smaller and lower power than SDR**
- **SDR allows for more flexibility for DoD applications**
- **SDR's are becoming more prevalent. Free software tools are available for evaluation.**
- **SDR allows for development and demonstration of DoD systems without having to build custom ASIC's**