FUTURE FORCE CAPABILITIES

CONFERENCE & EXHIBITION

Armaments, Robotics, Munitions and EOD

September 19 - 22 | Austin, TX | NDIA.org/FutureForce22

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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**

NDIA | CAREER CENTER

Connecting Talent with Great Opportunities

This latest member benefit of the National Defense Industrial Association offers qualified defense and national security professionals and employers an intuitive platform to identify the next best opportunity or candidate. With single-sign-on, quick and advanced searches, job alerts, career resources, pre-screen questionnaires, success tracking, and more, the NDIA Career Center is the defense industry's premier resource for career growth and advancement.

Log in and complete your profile today at Jobs.NDIA.org

GET INVOLVED
Learn more about NDIA's Divisions and how to join one at **NDIA.org/Divisions**

ARMAMENTS DIVISION

WHO WE ARE

The Armaments Division provides a forum for industry, military, and government personnel to address issues in order to ensure a superior armament system capability today and in the future. The Division addresses armament operational needs and requirements, approaches and concepts, system integration, weapons, munitions, fire control, and logistic support. Attention is given to total systems, technology application, and state-of-the-art advancements in technology.

LEADERSHIP AND COMMITTEES

Brian Berger
Division Chair

Bruce Webb
Division Vice Chair

Steve Faintich
Small Arms Committee Chair

Alan Kull
UEA Committee Chair

Matt Phillips
GARM Committee Chair

COL Leo Bradley, USA (Ret)
EOD Committee Chair

MUNITIONS TECHNOLOGY DIVISION

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 Division is comprised of two sections, Fuze and Insensitive Munitions & Energetic Materials, and one advisory group, the Industrial Committee of Ammunition Producers.

LEADERSHIP AND COMMITTEES

Nick Perry
Division Chair

COL Moises (Mo) Gutierrez, USA (Ret)
Division Vice Chair

Don McLaughlin
Munitions Conference Chair

ROBOTICS DIVISION

WHO WE ARE

The Robotics Division focuses on security-related robotics technology, covering the development, acquisition, application, integration, and sustainment of unmanned ground systems to improve warfighters' capabilities and survivability. The Division sponsors the Ground Robotics Champion and Ground Robotics Technology Innovator Awards.

LEADERSHIP AND COMMITTEES

Matt Dooley
Division Chair

David Thomas
Division Vice Chair

EVENT INFORMATION

LOCATION

Conference Location
Austin Convention Center
500 E Cesar Chavez St
Austin, TX 78701

Live Demo Location
Reveille Peak Ranch
105 Co Rd 114
Burnet, TX 78611

WIFI

Network: Austin Convention Center

REAL-TIME Q&A

Slido is an audience engagement platform that allows users to crowd-source top questions to drive meaningful conversations and increase crowd participation. Participants can up-vote the questions they would most like to hear discussed. Simply tap the thumbs-up button to up-vote a question. Top questions are displayed for the moderator and speaker to answer. Ask your question in sessions by going to Slido! Event code: **NDIAFFC22**

MOBILE APP

Make the most of your time at the 2022 Future Force Capabilities Conference and Exhibition with the event app available on the App Store for Apple devices and Google Play for Android devices. by searching "2022 Future Force Capabilities."

Download this FREE app for complete access to: Agenda | Clickable Floorplan | Exhibitor Listing | Slido | Social Media | Speakers | Timely "Buzz" Event Updates. Build your personal itinerary, contact exhibitors by directly accessing their websites, and more! Whether logged into the event mobile app on your computer or mobile device, your Expo Plan and Itinerary will always be in sync!

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 CONTACT

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SPEAKER GIFTS

In lieu of speaker gifts, a donation is being made to the Fisher House Foundation.

HARASSMENT STATEMENT

NDIA is committed to providing a professional environment free from physical, psychological and verbal harassment. NDIA will not tolerate harassment of any kind, including but not limited to harassment based on ethnicity, religion, disability, physical appearance, gender, or sexual orientation. This policy applies to all participants and attendees at NDIA conferences, meetings and events. Harassment includes offensive gestures and verbal comments, deliberate intimidation, stalking, following, inappropriate photography and recording, sustained disruption of talks or other events, inappropriate physical contact, and unwelcome attention. Participants requested to cease harassing behavior are expected to comply immediately, and failure will serve as grounds for revoking access to the NDIA event.

EVENT CODE OF CONDUCT

NDIA's Event Code of Conduct applies to all National Defense Industrial Association (NDIA), National Training & Simulation Association (NTSA), and Women In Defense (WID) meeting-related events, whether in person at public or private facilities, online, or during virtual events. NDIA, NTSA, and WID are committed to providing a productive and welcoming environment for all participants. All participants are expected to abide by this code as well as NDIA's ethical principles and practices. Visit NDIA.org/CodeOfConduct to review the full policy.

ANTI TRUST STATEMENT

The NDIA has a policy of strict compliance with federal and state antitrust laws. The antitrust laws prohibit competitors from engaging in actions that could result in an unreasonable restraint of trade. Consequently, NDIA members must avoid discussing certain topics when they are together at formal association membership, board, committee, and other meetings and in informal contacts with other industry members: prices, fees, rates, profit margins, or other terms or conditions of sale (including allowances, credit terms, and warranties); allocation of markets or customers or division of territories; or refusals to deal with or boycotts of suppliers, customers or other third parties, or topics that may lead participants not to deal with a particular supplier, customer or third party.

AGENDA

MONDAY, SEPTEMBER 19

12:00 – 7:00 pm

REGISTRATION
4TH STREET LOBBY, AUSTIN CONVENTION CENTER

2:00 – 3:00 pm

ARMY FUTURES COMMAND CAPABILITY BRIEFING – MISSILES
ROOM 18B-C, LEVEL 4, AUSTIN CONVENTION CENTER

Hunter Blackwell
Deputy Capability Area Lead-Fires, U.S. Army DEVCOM Aviation & Missile Center

3:00 – 4:00 pm

ARMY FUTURES COMMAND CAPABILITY BRIEFING – NEXT GENERATION TECHNOLOGIES FOR ROBOTICS
ROOM 18B-C, LEVEL 4, AUSTIN CONVENTION CENTER

Dr. Brett Piekarski
Chief Scientist, Computational & Information Sciences Directorate, U.S. Army DEVCOM Army Research Laboratory

Dr. Elias Rigas
Mechanical Engineer, U.S. Army DEVCOM Army Research Laboratory

TUESDAY, SEPTEMBER 20

7:00 am – 6:30 pm

REGISTRATION
4TH STREET LOBBY, AUSTIN CONVENTION CENTER

7:00 – 8:00 am

NETWORKING BREAKFAST
4TH STREET LOBBY, AUSTIN CONVENTION CENTER

8:00 – 8:15 am

OPENING REMARKS
BALLROOM D, LEVEL 4, AUSTIN CONVENTION CENTER

The Hon. David L. Norquist
President & CEO, NDIA

8:15 – 9:15 am

KEYNOTE SPEAKER
BALLROOM D, LEVEL 4, AUSTIN CONVENTION CENTER

LTG Thomas Todd III, USA
Deputy Commanding General, Acquisition & Systems Management, Chief Innovation Officer, U.S. Army Futures Command

9:00 am – 6:30 pm

EXHIBIT HALL OPEN
EXHIBIT HALL 5, LEVEL 1, AUSTIN CONVENTION CENTER

9:15 – 9:45 am

NETWORKING BREAK
EXHIBIT HALL 5, LEVEL 1, AUSTIN CONVENTION CENTER

9:45 – 10:35 am

GUEST SPEAKER PANEL

BALLROOM D, LEVEL 4, AUSTIN CONVENTION CENTER

Chris Grassano
Deputy Program Executive Officer, Armaments & Ammunition
Moderator

Anthony Sebasto
Acting Director, U.S. Army Futures Command Armaments Center

Scott Adams
Program Manager, Ammunition, Marine Corps Systems Command

Nathan Hawley
Director, Munitions and Logistics Readiness Center, U.S. Army Joint Munitions Command

10:35 – 11:20 am

WHY NOT HYPERSONIC WEAPONS?

BALLROOM D, LEVEL 4, AUSTIN CONVENTION CENTER

Dr. Mark Lewis
Executive Director, Emerging Technologies Institute (ETI)

11:20 am – 12:30 pm

NETWORKING LUNCH

EXHIBIT HALL 5, LEVEL 1, AUSTIN CONVENTION CENTER

4:55 – 6:30 pm

NETWORKING RECEPTION

EXHIBIT HALL 5, LEVEL 1, AUSTIN CONVENTION CENTER

WEDNESDAY, SEPTEMBER 21

7:00 am – 4:55 pm

REGISTRATION

4TH STREET LOBBY, AUSTIN CONVENTION CENTER

7:00 – 8:05 am

NETWORKING BREAKFAST

4TH STREET LOBBY, AUSTIN CONVENTION CENTER

8:05 – 8:15 am

OPENING REMARKS

BALLROOM D, LEVEL 4, AUSTIN CONVENTION CENTER

The Hon. Micheal J. Bayer
Vice Chairman, NDIA Board of Directors

8:15 – 9:00 am

KEYNOTE SPEAKER

BALLROOM D, LEVEL 4, AUSTIN CONVENTION CENTER

Col Corey Beaverson, USAF
Prototyping & Experiments Directorate, Office of the Under Secretary of Defense for Research & Engineering (OUSD(R&E))

9:00 am – 3:00 pm

EXHIBIT HALL OPEN

EXHIBIT HALL 5, LEVEL 1, AUSTIN CONVENTION CENTER

9:00 – 9:30 am

NETWORKING BREAK

EXHIBIT HALL 5, LEVEL 1, AUSTIN CONVENTION CENTER

9:30 – 10:15 am

KEYNOTE SPEAKER

BALLROOM D, LEVEL 4, AUSTIN CONVENTION CENTER

H.E. Oleksii Reznikov
Minister of Defence, Ukraine
Virtual

Major General Volodymyr Havrylov
Deputy Minister of Defense, Ukraine

10:15 – 10:40 am

MODERN TRENDS & DEVELOPMENTS IN WEAPONS THREATS

BALLROOM D, LEVEL 4, AUSTIN CONVENTION CENTER

Dan Shea
General Director, Phoenix Defence

10:40 - 10:45 am

MAYOR'S WELCOME

BALLROOM D, LEVEL 4, AUSTIN CONVENTION CENTER

The Hon. Micheal J. Bayer
Vice Chairman, NDIA Board of Directors
Introducer

Steve Adler
Mayor of Austin, Texas

10:45 – 11:45 am

AWARDS PRESENTATION

BALLROOM D, LEVEL 4, AUSTIN CONVENTION CENTER

Glock, Inc.
The Ambrose Industry Award

Dr. Brett Bagwell
The Hathcock Award

Mark McFadden
The Chinn Award

Robert Wheeler
The Trifiletti Award

11:45 am – 1:00 pm

NETWORKING LUNCH

EXHIBIT HALL 5, LEVEL 1, AUSTIN CONVENTION CENTER

THURSDAY, SEPTEMBER 22

10:00 am

DEPARTURE FROM AUSTIN CONVENTION CENTER

11:30 am

ARRIVE AT REVEILLE PEAK RANCH

11:30 am – 12:30 pm

LUNCH PROVIDED BY LARUE TACTICAL

12:30 – 4:00 pm

ATTENDEE SECURITY BRIEF AND DEMO

2:00 pm

EARLY BUS DEPARTURE TO AUSTIN CONVENTION CENTER

4:00 pm

DEPARTURE TO AUSTIN CONVENTION CENTER

BREAKOUT SESSIONS

TUESDAY, SEPTEMBER 20

	Robotics Matt Dooley, Division Chair	Small Arms Steve Faintich, Committee Chair
	Level 4, Room 18A	Level 4, Ballroom D
12:30 – 12:50 pm		PM Soldier Lethality Session **COL Scott Madore, USA** Product Director, Soldier Lethality, U.S. Army *Moderator* **David Oatley** Product Director, Crew Served Weapons, U.S. Army **Barbara Muldowney** Deputy Product Manager, Individual Weapons, U.S. Army **LTC Joshua Headley, USA** Product Manager, Next Generation Weapons, U.S. Army
12:50 – 1:10 pm	Universal Common Controller Panel **COL Andy Boston, USA (Ret)** Consultant/Principal, Multi-Domain Consulting LLC *Moderator* **Colin Brodmerkel** Director, Business Development, Tomahawk Robotics **MAJ Cory Wallace, USA** Robot Combat Vehicle Lead, Next Generation Combat Vehicle Cross-Functional Team **Matt Dooley** Chair, NDIA Robotics Division	
1:10 – 1:30 pm		
1:30 – 1:50 pm		Joint Service Small Arms Synchronization Team **Gus Funcasta** Chief, Joint Service Small Arms Program Office, Armaments Center, U.S. Army DEVCOM, U.S. Army Futures Command *Moderator* **MAJ Marcus Farmer, USA** Maneuver Capabilities & Integration Directorate (MCDID), U.S. Army Futures Command **Christopher Woodburn** Deputy, Maneuver Branch, Marine Corps Capabilities Development Directorate **LCDR Werner Reschmeier, USN** Surface Warfare Weapons Branch, OPNAV N96C **Christopher Graham** Deputy Chief, Use of Force Office, Office of Specialized Capabilities, Headquarters U.S. Coast Guard **Eugene Rooker** Deputy Program Manager, SOF Lethality, USSOCOM
1:50 – 2:20 pm	24534 Rapid Development of Secure Robotic Platforms **Dr. Hal Aldridge** Chief Executive Officer, Secmation	
2:20 – 3:10 pm	**NETWORKING BREAK** EXHIBIT HALL 5, LEVEL 1, AUSTIN CONVENTION CENTER	

	GARM/Munitions Matthew Phillips, GARM Committee Chair Don McLaughlin, Munition Conference Planning Chair	UEA/GARM/EOD Alan Kull, UEA Committee Chair Matthew Phillips, GARM Committee Chair Leo Bradley, EOD Committee Chair
	Level 4, Room 18B-C	Level 4, Room 18D
12:30 – 12:50 pm	JPEO A&A Summary **Chris Grassano** Deputy Program Executive Officer, U.S. Army Joint Program Executive Office Armaments & Ammunition (JPEO A&A)	24726 Evolving Armament Systems to Support Multi-Domain Operations **Jonathan Ross** Director, Strategy & Market Intelligence, Marvin Engineering Co., Inc.
12:50 – 1:10 pm	JPEO A&A Assured Munitions **Gene Conner** Director of Integration (DOI), U.S. Army Joint Program Executive Office Armaments & Ammunition (JPEO A&A)	24706 Hypersonic Aerial Gunnery Ammunition **Dr. Ronald Barrett** Professor, University of Kansas
1:10 – 1:30 pm	Overview of PM MAS **LTC Paul Santamaria, USA** Product Manager, Medium Caliber Ammunition, U.S. Army Joint Program Executive Office Armaments & Ammunition (JPEO A&A)	24735 Non-Lethal Counter-Personnel Tactical Robotic Energetic Delivery Systems (TREDS) **John Chapman** Chief Executive Officer, Liberty Dynamic
1:30 – 1:50 pm		24826 Modernized GPS and Digital Anti-Jam Contributions to the Range and Lethality Challenge to MDO/JADO **Justin Wymore** Customer Requirements Manager, BAE Systems, Inc.
1:50 – 2:20 pm	Overview of PM CAS **COL Leon Rogers, USA** Project Manager, Combat Ammunition Systems (PM-CAS), U.S. Army Joint Program Executive Office Armaments & Ammunition (JPEO A&A) **Jason Foultz** Chief Engineer, Project Manager - Combat Ammunition Systems (PM-CAS), U.S. Army Joint Program Executive Office Armaments & Ammunition (JPEO A&A)	24496 Advanced Textiles Bring a New Level of Comfort & Performance to EOD Personal Cooling Systems **James McLaughlin** Strategic Business Development, Kennon Products, Inc.
2:20 – 3:10 pm	**NETWORKING BREAK** EXHIBIT HALL 5, LEVEL 1, AUSTIN CONVENTION CENTER	

	Robotics Matt Dooley, Division Chair Level 4, Room 18A	Small Arms Steve Faintich, Committee Chair Level 4, Ballroom D	GARM/Munitions Matthew Phillips, GARM Committee Chair Don McLaughlin, Munition Conference Planning Chair Level 4, Room 18B-C	UEA/GARM/EOD Alan Kull, UEA Committee Chair Matthew Phillips, GARM Committee Chair Leo Bradley, EOD Committee Chair Level 4, Room 18D
3:10 – 3:30 pm	24742 Person Tracking, Re-Identification, and Threat Detection by Autonomous Unmanned Systems Within Complex Urban Environments **Dr. Matt Brown** Principal Engineer, Kitware	Joint Service Small Arms Program (JSSAP) Office Session 24729 The Theory Behind DEVCOM Armaments Center's Gelatin Terminal Assessment Process **Kenneth Hohnecker** Mechanical Engineer, U.S. Army DEVCOM-AC	Overview of PM-CCS **LTC Isaac Cuthbertson, USA** Product Manager, Terrain Shaping Obstacles (TSO), Close Combat Systems (PM-CCS), U.S. Army Joint Program Executive Office Armaments & Ammunition (JPEO A&A)	24838 Lone Wolf: Weaponized Quadrupled Unmanned Ground Vehicle (Q-UGV) **Bhavanjot Singh** Advisor, Networked Lethality, AFC DEVCOM-AC
3:30 – 3:50 pm	24743 AFRL Autonomous Collaborative Enabling Technology **LtCol Lawrence Ware, USAF** Autonomous Collaborative Enabling Tech, Air Force Research Laboratory	JSSAP Overview **Gus Funcasta** Chief, Joint Service Small Arms Program Office, Armaments Center, U.S. Army DEVCOM, U.S. Army Futures Command Moderator		
3:50 – 4:10 pm	24829 Robotic System for Maneuvering Munitions with Military Vehicles **Dr. Adam Brant** Project Manager, RE2 LLC	Joint Service Small Arms Program FY22 Project Portfolio Update **Terence Rice** Armament Center, Joint Small Service Small Arms Program Office, U.S. Army DEVCOM 24700 Determining Representative Travel Distances for Small Arm Ammunition **Shawn Spickert-Fulton** Analyst/Engineer, Small Caliber Ammunition Technology Development	The Army Ammunition Plant Modernization Plan **COL Jason Bohannon, USA** Deputy Project Director, Joint Services, U.S. Army Joint Program Executive Office Armaments & Ammunition (JPEO A&A)	Overview of PM-CCS EOD Portfolio **Michael Burke** Product Manager, Demolitions and Counter Measures, Close Combat Systems (PM-CCS), U.S. Army Joint Program Executive Office Armaments & Ammunition (JPEO A&A)

SPONSOR DESCRIPTIONS

KGM TECHNOLOGIES

LIVE FIRE DEMONSTRATION SPONSOR

KGM Technologies is the largest designer and manufacturer of weapon suppressors in the country. We are protecting the hearing of shooters everywhere and significantly enhancing the capability of our war-fighters. Our patented technologies and advanced manufacturing methods have allowed KGM to set the new standard of suppression. Additional information can be found at www.kgm-tech.com.

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LIVE FIRE DEMONSTRATION SUPPORTING SPONSORS

NORTHROP GRUMMAN

REGISTRATION & LANYARD SPONSOR

For decades, Northrop Grumman has protected U.S. forces and our allies by designing, developing and delivering weapons of increasing complexity and capabilities for expanded missions and domains. We continue to build upon that legacy to pioneer weapons that consistently outmatch the range, speed, precision and firepower of fielded enemy weapon systems, with the parameters of current platforms in mind.

Northrop Grumman's weapon solutions define possible from tip-to-tail, integrating legacy capabilities with innovative technology for the toughest missions with increased survivability, speed to the field, and affordability at the forefront.

GENERAL DYNAMICS
Ordnance and Tactical Systems

TUESDAY RECEPTION SPONSOR

General Dynamics Ordnance and Tactical Systems is a global systems developer and manufacturer of munitions, weapons and tactical systems across the entire air, land, and sea battle spectrum. It is the purpose of GD-OTS to empower the United States Armed Forces and its Allies through readiness and innovation to protect what is most important, the warfighter. We are dedicated to our people, our products and our processes to ensure that every day we are Delivering the Best to the Best™

GEISSELE

REGISTRATION BAG SPONSOR

Geissele Automatics, founded by William Geissele in 2004, is an American firearms and firearms parts manufacturer located in North Wales, Pennsylvania.

The company first entered the civilian market by manufacturing trigger mechanisms for the AR15 rifle. While we haven't lost touch with our humble beginnings, we have evolved and now also manufacture firearms for sport shooting, hunting, and personal defense.

Geissele is also committed to servicing the Department of Defense, law enforcement agencies, and our allies around the world. Our first trigger, the Hi-Speed National Match, was originally designed for target shooting and the CMP and NRA Hi-Power Rifle competition, but was found to have U.S. Military applications and, in 2005, we received a request from the DoD to build a select-fire trigger like the Hi-Speed National Match trigger. Geissele then designed and built the Super Select-Fire trigger, which was adopted by entities in the U.S. Special Operations community and became their trigger of choice for M4 carbine-based weapons.

Using state of the art machine technology and the most modern materials, we engineer, develop, and produce solutions to meet the unique and complicated needs of the modern-day warfighter.

In short, We are Weaponmakers® committed to excellence in everything we do.

	Robotics Matt Dooley, Division Chair	Small Arms Steve Faintich, Committee Chair	GARM/Munitions Matthew Phillips, GARM Committee Chair Don McLaughlin, Munition Conference Planning Chair	UEA/GARM/EOD Alan Kull, UEA Committee Chair Matthew Phillips, GARM Committee Chair Leo Bradley, EOD Committee Chair
	Level 4, Room 18A	Level 4, Ballroom D	Level 4, Room 18B-C	Level 4, Room 18D
4:10 – 4:30 pm	24835 Emerging Armament Technologies for Unmanned Systems **Lucious Taylor IV** Chief Engineer, Naval Surface Warfare Center	NATO Panel **Mark McFadden** JSSARI Chairman, U.S Head of Delegation to NATO Dismounted Soldier Systems, Weapons & Sensors Subgroup *Moderator* **Adam Jacob** Chairman, NATO Dismounted Soldier Systems (DSS)/Weapons and Sensors SubGroup (WSSG) - Suppressor Team of Experts **Matthew Kretlow** U.S. Army Representative to NATO Dismounted Soldier Systems (DSS)/Weapons and Sensors SubGroup (WSSG) **Dr. David Dye** U.S. Navy Crane Representative to NATO Dismounted Soldier Systems (DSS)/Weapons and Sensors SubGroup (WSSG) **Aldo Sulga** Netherlands Representative to NATO Dismounted Soldier Systems (DSS)/Weapons and Sensors SubGroup (WSSG) **Dr. Mark Thoreson** U.S. Navy Representative to NATO Dismounted Soldier Systems (DSS)/Weapons and Sensors SubGroup (WSSG) **John Yoshida** Canadian Head of Delegation to NATO Dismounted Soldier Systems (DSS)/Weapons and Sensors SubGroup (WSSG)		Closing Remarks **Matthew Phillips** Chair, NDIA GARM Committee
4:30 – 4:50 pm	24723 Supervised Autonomous Function Executive: An Autonomy Enabler **Dean Barten** Senior Principal Engineer, MTSI		IBAT Presentation & Demo **Rob Roy** President, Decision Science Incorporated **LaDonna Schneller** IBAT Program Manager, Decision Science Incorporated	
4:50 – 4:55 pm	Closing Remarks **Matt Dooley** Chair, NDIA Robotics Division	Closing Remarks **Steve Faintich** Chair, NDIA Small Arms Committee	Closing Remarks **Don McLaughlin** President, T-Worx Technologies	

SPONSOR DESCRIPTIONS (CONTINUED)

GLOCK®
PERFECTION

TUESDAY LUNCH SPONSOR

As a global leader in firearms manufacturing, GLOCK provides quality firearms to military, law enforcement, and civilians worldwide. For 36 years in the United States, GLOCK products have become a favorite among many by offering a polymer-based pistol featuring the renowned Safe-Action System. Being a global leader in the industry, GLOCK's dedication to quality, innovation, and the pursuit of perfection continues to surpass the needs of loyal customers. For more information, visit us.glock.com.

Nammo
SECURING THE FUTURE

WEDNESDAY BREAKFAST SPONSOR

Nammo is a technology-driven aerospace and defense company specializing in high-performance solutions for customers. As a leading provider of ammunition and rocket motors for military and civilian customers around the globe, Nammo operates through four business units: Commercial Ammunition, Small and Medium Caliber Ammunition, Large Caliber Systems, and Aerospace Propulsion. The company's portfolio of products includes, but is not limited to: polymer-cased ammunition, true fire-from-enclosure shoulder-launched munitions (M72 FFE), scalable offensive hand grenades, large scale propellant production, and composite solutions.

Nammo is engaged in designing, developing and testing new technologies to enhance existing platforms and systems including long range precision fires; ammunition that's effective in all environments; hybrid rocket engines; and critical ejection seat pyrotechnic components. With decades of experience Nammo also manages complex projects to safely and securely complete demilitarization processes in an environmentally responsible manner.

With the United States division headquartered in Arizona and the corporate headquarters in Norway, Nammo has more than 2,700 employees; operates 28 manufacturing and production sites; and has a presence in 12 countries

WEDNESDAY, SEPTEMBER 21

	Robotics Matt Dooley, Division Chair Level 4, Room 18A	Small Arms Steve Faintich, Committee Chair Level 4, Ballroom D
1:00 – 1:20 pm	24751 Gesture Control for Small UAS and UAV Systems **Pete Moutsatson** Vice President, Business Development, Pison Technology	Suppressor Session **Adam Jacob** Chairman, NATO Dismounted Soldier Systems (DSS)/Weapons and Sensors SubGroup (WSSG) Suppressor Team of Experts *Moderator* Bang or Pop **Dr. Michelle Swearingen** U.S. Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory Effects of Sound on the Human Ear **Ruth Foutz** U.S. Army Public Health Center Human Eye Perception of Flash **Dr. David Dye** NSWC Crane Localization of Shooter Position Based on Weapon Signature **Dr. Paul Fedele** U.S. Army, DEVCOM ARL Outdoor Acoustics **Timothy Cler** Mechanical Engineer, U.S. Army DEVCOM ARL Tactical Advantage by Sound and Visual Suppression Military Operational Medicine Research of Blast Effects on firing M2A1 Small Caliber Weapon System: An Overview and Future Research **Fred Brozoski** U.S. Army Aeromedical Research Laboratory High-Temperature Evaluation of Suppressor Covers **Dan Baechle** U.S. Army DEVCOM ARL Flow Through and Reverse Flow Suppressors - Advanced Designs to Address Modern Suppression Challenges **Ernest Bray** X2 Dev Group Surefire's Advanced Suppressor Program- Blending Science, Technology, and Experience to bring Next Generation Signature Suppression to the Warfighter **Barry Dueck** Surefire **Ryan Steven Glasby** Oak Ridge National Laboratory
1:20 – 1:40 pm	24734 One Size Fits None: Integrating Unmanned Systems From the Bottom Up **Bryan Clark** Senior Fellow, Hudson Institute	
1:40 – 2:00 pm	24813 Free Space Optics (FSO) Lightwave Non-RF Data Communications for Robotic Systems in RF Denied Environments **Dr. Leo Volfson** President, Torrey Pines Logic, Inc.	
2:00 – 2:20 pm	24822 Lethal and Non-Lethal Launchers with Variable Trajectory Grenades for Robotic Systems **Howard Kent** Chief Executive Officer, Armor Development Group LLC	
2:20 – 2:50 pm	**NETWORKING BREAK** EXHIBIT HALL 5, LEVEL 1, AUSTIN CONVENTION CENTER	

	GARM/Munitions Matthew Phillips, GARM Committee Chair Don McLaughlin, President, T-Worx Technologies Level 4, Room 18B-C	UEA/GARM Alan Kull, UEA Committee Chair Matthew Phillips, GARM Committee Chair Level 4, Room 18D
1:00 – 1:20 pm	Wall Street Perspective **Pierre Chao** Proteus Capital Solutions	
1:20 – 1:40 pm	Ukraine Update **Maj. Gen. Borys Kremenetsky** Defense Attaché, U.S. Embassy of Ukraine **MG Volodymyr Havrylov (Ret)** Deputy Minister of Defense, Ukraine **Denys Kalachov** Founder, Association of Ukraine Defense Manufacturers	The Emerging Technologies Institute: NDIA's Own Think Tank **Dr. Mark Lewis** Executive Director, Emerging Technologies Institute (ETI)
1:40 – 2:00 pm		
2:00 – 2:20 pm		
2:20 – 2:50 pm	**NETWORKING BREAK** EXHIBIT HALL 5, LEVEL 1, AUSTIN CONVENTION CENTER	

	Robotics Matt Dooley, Division Chair Level 4, Room 18A	**Small Arms** Steve Faintich, Committee Chair Level 4, Ballroom D
2:50 – 3:10 pm	24712 Mission Planning for Multiple Autonomous CBRN Robotic Platforms **Kurt Bruck** Division Manager, Neya Systems	Small Arms Technology Development **Ross Towers** Lead for Soldier Lethality CFT (A), U.S. DEVCOM Armaments Center *Moderator* 24699 Small Arms Point Defense Systems (SAPDS) **Matthew Thompson** Engineer, NSWC Crane Suppressor Condemnation, Sustainment **Dr. Leslie Fleming** Engineer, Small Arms Signature Lab, Naval Surface Warfare Center 24824 Advancements in Armor Piercing Ammunition **Jay Bell** Business Development, UDC USA, Inc. **Matthew Young** Technical Director, UDC USA, Inc. 24800 Supersonic eXtreme Material Penetrator (XMP) and Subsonic Penetrator (SUB-P) **Thomas Campion** Sales Director, USA, DSG Technology 24741 Engaging Underwater Threats with Supercavitating Ammunition **Torgrim Joergensen** Senior Vice President, Business Development, DSG Technology 24727 An Alternate Method for Determining Penetration Limit Velocities Using Residual Velocity Data **Kenneth Hohnecker** Mechanical Engineer, U.S. Army DEVCOM-AC 24722 Full Performance Reduced Range Bullets R2: A Revolutionary Technology for Minimizing Collateral Damage **Kevin Sullivan** Nostromo, LLC 24769 Dynamic Motion of Carbon Fiber Over-Wrapped Rifle Barrels **Timothy Cler** Mechanical Engineer, Army Research Laboratory
3:10 – 3:30 pm	24714 Defensive Squad Equipment Transport (DSET). Autonomous Platform for Ground-Based Warfighter Protection, Supply, Navigation, and Evacuation **Dr. Brandon Conover** Chief Executive Officer, Practical Scientific Solutions, Inc.	
3:30 – 3:50 pm	24740 A Literature Review of Simulation Fidelity and Transfer of Training for Autonomous Vehicles **Professor Christopher Johnson** Assistant Professor, Embry-Riddle Aeronautical University	
3:50 – 4:10 pm	24508 Air Force Civil Engineer Robotic Applications **Steven Bailey** Research Engineer, Air Force Civil Engineer Center	
4:10 – 4:30 pm	Closing Remarks **Matt Dooley** Chair, NDIA Robotics Division	
4:30 – 4:50 pm		
4:50 – 4:55 pm		Closing Remarks **Steve Faintich** Chair, NDIA Small Arms Committee

	GARM/Munitions Matthew Phillips, GARM Committee Chair Don McLaughlin, President, T-Worx Technologies Level 4, Room 18B-C	**UEA/GARM** Alan Kull, UEA Committee Chair Matthew Phillips, GARM Committee Chair Level 4, Room 18D
2:50 – 3:10 pm	Legislative Update **Jay Brannam** Executive Director, Munitions Industrial Base Task Force	24554 Blast Amplifying Projectile Bodies for Medium and Large Caliber Projectiles **Robert Folaron** Chief Executive Officer, nP Technology LLC
3:10 – 3:30 pm		24721 XM813 Bushmaster Chain Gun & Linkless AHS Technology and its Integration Into the Stryker MCWS **Jesse Behrens** Senior Principal Systems Engineer, Northrop Grumman Corporation **Vince Virga** Project Engineer, Nobles Worldwide, Inc.
3:30 – 3:50 pm	Armaments, Robotics, and Munitions from a Threat Perspective **MAJ Marc Jason, USA** Threat Integration, Headquarters, Department of the Army, G-2	24707 Outgunning the A-10 With an Apache or Fara: New Flight-Safe Discarding Sabot Ammunition for Attack Rotorcraft **Dr. Ronald Barrett** Professor, University of Kansas
3:50 – 4:10 pm		24832 Assessing Potential Capability Enhancements of Hand Grenades Filled with CL-20 Compared to Current MK3A2 & M67 Hand Grenades **Jonathan Geymer** Technical Intern, ARA
4:10 – 4:30 pm	Utility of Drones in Modern Warfare **Stavros Daskos** President, ING Robotic Aviation, Inc.	24833 Highest Performing, Lowest CSWAP MEMS IMU for Precision Guided Munitions **Louis Ross** Chief Executive Officer, MEI Micro, Inc.
4:30 – 4:50 pm		24720 Introduction to the Dual Feed M230LF/XM914 Chain Gun **John Inman** Principal Systems Engineer, Northrop Grumman Corporation
4:50 – 4:55 pm	Closing Remarks **Don McLaughlin** President, T-Worx Technologies	Closing Remarks **Matthew Phillips** Chair, NDIA GARM Committee

LIVE FIRE DEMONSTRATING COMPANIES

Aero Precision

Explotrain LLC

FN America

HDT Global

HUXWRX Safety Co.

KGM Technologies

Nammo MAC

Radical Firearms/Radical Defense

SureFire, LLC

Trijicon, Inc

ABSTRACT SUMMARIES

EOD

24496

Advanced Textiles Bring a New Level of Comfort & Performance to EOD Personal Cooling Systems

James McLaughlin

Military operations have increased in hot climates where human performance is highly subject to time limitations. Kennon has demonstrated that a better cooling system, designed to the latest science and advanced textile technology, addresses these requirements with a unique design that flows cold carbon dioxide through a scientifically-tailored and channeled vest or bodysuit.

GARM

24554

Blast Amplifying Projectile Bodies for Medium and Large Caliber Projectiles

Robert Folaron

This presentation discusses a molded projectile body application which enhances explosive filler and fragmentation effects.

24707

Outgunning the A-10 with an Apache or FARA: New Flight-Safe Discarding Sabot Ammunition for Attack Rotorcraft

Dr. Ronald Barrett

This presentation summarizes the latest progress in Flight Safe Discarding Sabot (FSDS) ammunition for attack rotorcraft. This new class of aerial gunnery ammunition is shown to possess dramatically more KE on target, greater ranges, flatter trajectories, and tighter CEPs than conventional M50 and PGU-series 20mm ammunition and lower costs than the M789 30mm ammunition as well.

24720

Introduction to the Dual Feed M230LF/XM914 Chain Gun

John Inman

An introduction to the Dual Feed M230LF/XM914 which will allow the operators to carry two different ammunition types. High-level details will be provided on the weapon design, integration requirements, and current development status.

24721
XM813 Bushmaster Chain Gun & Linkless AHS Technology & its Integration into the Stryker MCWS
Jesse Behrens

This presentation will discuss the development history of the XM813 as well as its design differences between other Mk44 Bushmaster Chain Guns. A high-level overview of the XM813 integration into the Stryker MCWS turret will be provided. In addition, an overview of Nobles Worldwide linkless ammunition handling technology will be presented.

24832
Assessing Potential Capability Enhancements of Hand Grenades Filled with CL-20 Compared to Current Mk3A2 & M67 Hand Grenades
Jonathan Geymer

Potential capability enhancement of grenade filled with CL-20 contrasted with conventional fill grenades.

24833
Highest Performing, Lowest CSWaP MEMs IMU for Precision Guided Munitions
Louis Ross

Description of the first chip-scale, multi-axis MEMs inertial sensor system platform for precision guided munitions.

ROBOTICS

24508
Air Force Civil Engineer Robotic Applications
Steven Bailey

This presentation will inform the audience about the Air Force Civil Engineer Center Airbase Technology Branch's mission; capability areas; and robotics research, development, test, and evaluation efforts which support Air Force explosive ordnance disposal and civil engineer airmen performing airfield damage repair.

24534
Rapid Development of Secure Robotic Platforms
Dr. Hal Aldridge

The operational applications of robotic systems and their software complexity are evolving rapidly necessitating a renewed emphasis on required cybersecurity standards to operate in contested environments. This presentation will discuss DevSecOps and cybersecurity challenges unique to robotic systems and the new technologies available to enable rapid development and cybersecurity certifications/Authority to Operate.

24712
Mission Planning for Multiple Autonomous CBRN Robotic Platforms
Kurt Bruck

Neya Systems has been developing a mission planning software suite to task and coordinate fleets of autonomous air and ground CBRN vehicles.

24714
Defensive Squad Equipment Transport (DSET): An Autonomous Platform for Ground-Based Warfighter Protection, Supply, Navigation & Evacuation
Dr. Brandon Conover

A robotic, autonomous platform prototype showcases capabilities in Warfighter protection under fire, personnel re-supply, navigational assistance, and emergency evacuation. A unique drivetrain has been coupled with computer vision and robotics resulting in a force multiplier for ground-based units.

24723
Supervised Autonomous Function Executive: An Autonomy Enabler
Dean Barten

Certification of autonomous vehicle behavior can be greatly enabled if an independent safety net is placed around the vehicle.

24734
One Size Fits None: Integrating Unmanned Systems from the Bottom Up
Bryan Clark

Realizing the benefits of unmanned systems requires an approach for integrating them into teams that establish their tactics, networks, and force compositions in mission time.

24740
A Literature Review of Simulation Fidelity & Transfer of Training for Autonomous Vehicles
Professor Christopher Johnson

There is ample research that details the effectiveness of simulation for training human operators for the cognitive demands of high-risk work environments. However, more research is needed to guide practitioners in using simulation to train and test artificial intelligence for autonomous agents such as robotic vehicles, so we conducted a literature review to consolidate what has been published to date on the topic, the details of which are provided herein along with suggestions for filling gaps in the literature.

24742
Person Tracking, Re-Identification & Threat Detection by Autonomous Unmanned Systems within Complex Urban Environments
Dr. Matt Brown

24743
AFRL Autonomous Collaborative Enabling Technology
LtCol Lawrence Ware, USAF

Autonomous Collaborative Enabling Technologies (ACET) Integrates technologies across AFRL to support Autonomous Collaborative Platform Mission concepts as well as Multi-Domain Collaboration.

24751

Gesture Control for Small UAS and UAV Systems

Pete Moutsatson

Gesture control of small unmanned systems is gaining favor over manual control to enable enhanced situational awareness for warfighters.

24813

Free Space Optics (FSO) Lightwave Non-RF Data Communications for Robotic Systems in RF Denied Environments

Dr. Leo Volfson

Radio frequency (RF) control systems currently used on unmanned systems, representing everything from Predator drones to EOD unmanned ground vehicles, are vulnerable to barrage and deception electronic warfare degradation.

FSO systems operate with impunity in radio-frequency (RF) denied, contested and congested environments, and when RF is undesired, i.e. covert operations, EMCON, or personnel or asset safety during fuel and ordinance transfer.

Such a system would support cooperative sensing functionality via FSO similar to how the F35 uses such sensing over Link 16. Our system could be used as a Non-RF 'Link 16' for Robotics in a denied environment.

24822

Lethal & Non-Lethal Launchers with Variable Trajectory Grenades for Robotic Systems

Howard Kent

Addressing Five To 400 Meters With Gas, Smoke, Non-Lethal, HE and AP Grenades

24829

Robotic System for Maneuvering Munitions with Military Vehicles

Dr. Adam Brant

RE2 LLCs' Robotic Ammunition Maneuvering System (RAMS) is a robotic manipulation system being developed as a solution for alleviating the heavy-lift burden for soldiers within Self-Propelled Howitzer Systems during fire missions

24835

Emerging Armament Technologies for Unmanned Systems

Lucious Taylor IV

Army Futures Command (AFC)/Combat Capabilities Development Command (DEVCOM)/Armament Center (AC) and Naval Surface Warfare Center, Crane are collaborating in the ongoing Joint Tactical Unmanned Armaments Working Group (JTUAWG). The working group is a network of Army and Navy Laboratories that collaborate to develop small/miniature weapons for smaller Unmanned Systems in the land, air, and sea domains. This multi-domain capability will ultimately save friendly lives by giving small combat units the ability to conduct armed reconnaissance, and optionally engage the enemy with scalable effects, and without exposing warfighters to enemy fire.

SMALL ARMS

24699

Small Arms Point Defense Systems (SAPDS)

Matthew Thompson

The Small Arms Point Defense System project is evaluating multiple enabling technologies for crew-served weapons to improve warfighter performance against small, maneuvering targets.

24700

Determining Representative Travel Distances for Small Arms Ammunition

Shawn Spickert-Fulton

This presentation will look at the effect of drag on max range estimates for training ammunition

24722

Full Performance Reduced Range Bullets R2: A Revolutionary Technology for Minimizing Collateral Damage

Kevin Sullivan

A new small caliber ammunition with reduced range, reduced ricochet using a eutectic core.

24727

An Alternate Method for Determining Penetration Limit Velocities Using Residual Velocity Data

Kenneth Hohnecker

This presentation will demonstrate an alternative method for determining penetration limit velocities of small arms projectiles from test data. The method uses the residual velocity of the projectile after penetrating the target in order to obtain a more accurate limit velocity prediction as compared to traditional binary regression models (i.e., methods that only record penetration or no penetration).

24729

The Theory Behind DEVCOM Armaments Center's Gelatin Terminal Assessment Process

Gavin McFarland

This presentation will provide the theory behind how DEVCOM AC dissects, analyzes, and assesses terminal data from gelatin block testing.

24741

Engaging Underwater Threats with Supercavitating Ammunition

Torgrim Joergensen

DSG's patented supercavitating ammunition is designed to initiate a cavitation bubble at its nose which reduces the skin friction drag on the supercavitating round, allowing the bullet to travel at high speed through the water. Additionally, the use of tungsten material allows this ammunition to offer exceptional armor piercing capability against multi-layer structures, structures of unique materials, and improved body armor materials.

24769
Dynamic Motion of Carbon Fiber Over-Wrapped Rifle Barrels
Timothy Cler

Testing barrel whip and dispersion correlations of Carbon Fiber over-wrapped barrels.

24800
Supersonic eXtreme Material Penetrator (XMP) and Subsonic Penetrator (SUB-P)
Thomas Campion

DSG's patented supersonic "eXtreme Material Penetrator (XMP)" ammunition is designed to defeat hard targets. These projectiles have a very high Ballistic Coefficient and are very accurate (Sub 1 MOA). The SUB-P version is the same projectile loaded for subsonic performance.

24824
Advancements in Armor Piercing Ammunition
Jay Bell

UDC has been working on advanced Armor Piercing Projectiles in 308 to 338 Calibers.

UEA

24706
Hypersonic Aerial Gunnery Ammunition
Dr. Ronald Barrett

This presentation summarizes the latest progress in hypersonic ammunition for fixed- and rotary-wing attack aircraft. This new class of aerial gunnery ammunition is designed to cut times of flight and CEP dramatically while maintaining extremely flat trajectories and high levels of KE on target while introducing no increase in recoil forces to the airframe.

24726
Evolving Armament Systems to Support Multi-Domain Operations
Jonathan Ross

Our focus is on the continued evolution of armament solutions to support multi-domain operations by providing operators with the flexibility to configure platforms to safely carry and release multiple stores types and increase stowed kills.

24735
Non-Lethal Counter-Personnel Tactical Robotic Energetic Delivery Systems (TREDS)
John Chapman

TREDS (Tactical Robotic Energetic Delivery System) is an energetic payload delivery system for integration on small tactical vehicles/platforms and small manned and unmanned systems (UxS). A multi-mission payload capability fosters discretion and pinpoint accuracy with optimized system size, weight, and power consumption.

24826
Modernized GPS and Digital Anti-Jam Contributions to the Range and Lethality Challenge to MDO/JADO
Justin Wymore Sr.

This presentation will discuss the role of precision geolocation in achieving weapons lethality at extended ranges and with autonomous loitering munitions; the trade space between the guidance, navigation, and control (GNC) components required to achieve that precision; define and distinguish absolute precision PNT; define the Radio Frequency (RF)-challenged conditions impacting the effectiveness of GPS-based PNT solutions; and present a model by which to understand, prioritize, and defeat those threats.

24838
Lone Wolf: Weaponized Quadruped Unmanned Ground Vehicle (Q-UGV)
Bhavanjot Singh

Weaponized Small Quadruped Unmanned Ground Vehicles (Q-UGVs) can help provide lethality and significant capability enhancement over difficult terrain and small spaces.

POSTER PRESENTERS

24494

Scorpion Mobile Mortar System

Michael Cherry
Director of Product Development

Scorpion Mobile Mortar system is a fully digital, INSANELY FAST mobile mortar system that revolutionizes how mortars are used on the battlefield. This 81mm/120mm interchangeable mortar system has a shoot and scoot capability that fires eight rounds on target (from park to drive away) in under two minutes.

24497

Zinc EPR Slug

Tyler Holland
5.56mm APO, DEVCOM-AC

Feasibility study to investigate potential materials that can be used to replace copper as the primary material for slugs in lead free ammunition. Performance impacts related to this change are analyzed.

24539

Eliminating Threading For Medium Caliber Projectile Assembly With Advanced Adhesives

Harry Arnon
CEO, Hernon Manufacturing, Inc.

Threads need structures to fit into better dedicated to fragments and energetics. Whenever you thread on a nut to a bolt or stud, you sacrifice the areas of the thread height and supporting structures behind the threads in your internal volume package.

24542

Countering The Root Cause Behind Barrel Erosion With Nano-Particulate Refractory Metals

David Tubb
CEO, TUBB Precision, Inc.

A Barrel Treatment That Does More Than Treat The Symptoms Of Barrel Erosion And Wear

24547

Advanced Condition Based Maintenance Retrofits For Ammunition Production.

Howard Kent
CEO, Armor Development Group LLC.

We're not talking predicting the future by analyzing the past: It's about affordable real time networked parametric monitoring.

24550

Dual Purpose Armor Penetrating And Personal Defense Handgun Ammunition

Cameron Hopkins
CEO, Super Vel Ammunition, Inc.

Defeating threats wearing soft body armor and highly effective without armor.

24553

Frangible Ammunition For Explosive Ordnance Disposal Missions:

Sueax Larreau
Director Of Ammunition, Maxim Defense Ammunition

Frangible ammunition for explosive ordnance disposal missions because sometimes you want more than one shot.

24570

The Fastest Way For Governments Around The World To Obtain US Military Standard Ammunition

Jerry Luger
International Sales, OLIN Winchester

An educational introduction to commercial sales from Icaap and second source manufacturers.

24573

Rapid Deploying Shoulder Support Speed Bar For Spade Grip Weapons:

Howard Kent
CEO, Armor Development Group LLC.

Rapid deploying shoulder support speed bar for spade grip weapons: the same functionality as the MK93 mount version, except for the rest of us.

24579

Variations in bolt face and extraction forces in small caliber weapon systems due to cartridge case material

Raymond Chaplin
Mechanical Engineer, CCDC-AC

A study on the impact on bolt face and extraction forces due to changes in cartridge case materials. Brass, Polymers, and high strength steel cases are compared.

24581

The More Bang For Your Research Buck: Piggyback Testing Review Board Proposal

Howard Kent
Consultant, Armament Mechanical LLC

Because why not test multiple non-conflicting items at once?

24634

Robotic TRAP T-360 Ultra-Light ROWS

John Warner
Strategic Account Manager, IEC INFRARED SYSTEMS / PRECISION REMOTES

The T-360 is a lightweight remotely operated weapon system used on robotic UGV, LTAV, APC, and MRZR to increase lethality and soldier fire suppression accuracy.

24687
Combat Optimized Ballistic Remote Armament (COBRA)
Alexander Smith
U.S. Army, CCDC AC

COBRA is a purpose built remote weapon station designed with size, weight, and power as key considerations.

24688
5.56mm Single Barrel Externally Powered Weapon for Remotely Operated Systems
Alexander Smith
U.S. Army, CCDC AC

US Army DEVCOM Armaments Center has been working with McNally Industries LLC to develop a lightweight single barrel externally powered 5.56mm weapon for arming small remotely operated ground and aerial platforms.

24702
PATCH: Encrypted, Off-Grid Texting, Geolocation & Activity Monitoring
Maeve Garigan
CEO, Roper

PATCH is a waterproof, body-worn device that is styled as a US flag patch. Packed with next generation AI-enabled sensor technology, PATCH provides leap-ahead capability in automated identification friend or foe (IFF), situational awareness and secure tactical communication, and is the result of three years of internal research and development, with multiple peer-reviewed technical papers published and patents filed.

24703
Infrared search and track (IRST) for long-range, wide-area detect and avoid (DAA) on small unmanned aircraft systems (sUAS)
Dr. Stephen Snarski
Director, Autonomous Systems, Modern Technology Solutions, Inc.

This paper describes ongoing research and development work demonstrating the potential for airborne long-range infrared target detection (infrared search and track, IRST) to meet critical requirements for small unmanned aircraft systems (sUAS) detect and avoid (DAA).

24705
Hexavalent Barrel Chrome Replacement
Zachary Torigian
Weapons Engineer, U.S. Army DEVCOM-AC

The purpose of this brief is to present the challenges, toxicity concerns, methodology and preliminary data from the US Army Hexavalent Barrel Chrome Replacement effort to the defense community. The presentation will illustrate the need for hexavalent chrome alternatives for small arms. The brief will contain technical content related to ongoing developments by both the USG and industry to develop alternate coatings, platings, and/or surface treatments to replace hexavalent chrome.

24708
Lightweight, Heat-Emissive Design for Extending Barrel Life
Kenneth Decker
Business Development/Operations, TacomHQ

Using geometric structuring to dissipate heat, lighten, accurize, and prolong the service life of small arms barrels.

24710
Compact Lightweight Freeform GRIN Optics for Small Arms Fire Control
LTC Robert Dionisio, USA (Ret)
DEVCOM-AC

The government is designing freeform gradient-index (GRIN) optics that will enable a reduction in the number of lens elements required to reproduce color-corrected imagery to benefit squad, crew-served, and sniper fire-control systems by reducing the size, weight, and complexity of the optics used in fire-control systems.

24711
Catalyst-Pathfinder Program - Soldier Inspired Innovation
LTC Robert Dionisio, USA (Ret)
DECVOM-AC

The Army is creating close working relationships between soldiers and universities in order to harness the creativity and technical skills of the nation's academic institutions to help the Army create better and faster solutions to real problems.

24718
HIMARS Guardian
Mike Sparks
Inventor

Force multiplication of MLRS ground mobile systems to deploy and thrive against enemy Surveillance Strike Complexes (SSCs). We interdict them; they don't evict us.

24719
Pressure Discriminating Cartridge Chamber
Brian Hoffman
Chief Engineer, NSWC Crane Weapons Systems Division

The pressure discriminating cartridge chamber allows for reliable passive system response to the inadvertent use of higher-pressure ball ammunition encountered during training activities or other firing events expecting the use of lower-pressure blank ammunition.

24724
Wheel Placement Reasoning in Rugged Off-road Terrain
Andrew Capodieci
Director of Robotics, Neya Systems, LLC

Neya is advancing the state of the art in off-road planning by developing wheel and track placement reasoning modules that enable Robotic Combat Vehicles (RCVs) to navigate rugged off-road terrain.

24728
Improving the Machinability of Refractory-Lined Gun Barrels
Dr. Jason Davis
Mechanical Engineer, NSWC Crane

Early results of a study focused on using a recently discovered mechanochemical effect to assist in the rifling of refractory-lined gun barrels.

24732

Rizse Autonomous Inspection Drone (RAID) for Fixed-Wing Aircraft

Colby Harvey
CEO, Rizse

The Rizse Autonomous Inspection Drone (RAID) is an air system that utilizes a 3D LiDAR and high-resolution camera to inspect fixed-wing aircraft in 20 percent of the current manual processes. The data is processed through an Artificial Intelligence system to locate and classify the damage type, enabling faster turn-around time for maintenance events.

24733

Artificial Intelligence Automated Malicious Location Detection Solution

Angela Henderson
Founder & CEO, RescueTrek Corp.

The SMARTExit Sign is an enhanced Artificial Intelligence Situational Awareness solution. It is a game-changer in tracking and accountability for safety and response during an Active Shooter scenario.

24737

NSWC-Crane Small Arms Flash Signature Kit

Dr. Leslie Flemming
Engineer, Naval Surface Warfare Center Crane

NSWC-Crane has and updated flash kit that takes advantage of additive manufacturing and commercially of the shelf components. The hardware and software package are available via a CRADA with NSWC-Crane.

24739

Supervised Autonomous Function Executive: An Autonomy Enabler

Dean Barten
Senior Principal Engineer, MTSI

Certification of autonomous vehicles would be enabled if a independent safety net was provided.

24744

Methods for Evaluating Blowback in Suppressed Weapon Systems

Jonathan VanBurskirk
R&D Engineer, NSWC Crane

A poster summarizing methods for measuring the increase in blowback provided by the addition of a suppressor on a weapon system

24745

Novel Small Arms Projectiles

Jonathan VanBurskirk
R&D Engineer, NSWC Crane

A poster covering various novel projectile technologies being explored in NSWC Crane's Small Arms Emerging Technologies Branch.

24746

Autonomous Refueling

Ben Bosma
Principal Engineer, Modern Technology Solutions, Inc.

A Method and Apparatus for Autonomous Air to Air and Air to Ground Refueling.

24748

Triton gen III Autonomous Underwater and Surface Vehicle (AUSV)

Jeffrey Williams
Vice President, Ocean Aero

Ocean Aero has pioneered a dual-modality and environmentally powered Autonomous Underwater and Surface Vehicle (AUSV). This unique capability offers customers a payload agnostic platform which can be deployed far from any designated operational area, navigate, and avoid detection along the route, perform its mission and return.

24762

Collins Aerospace Multi-function Modular Seeker Technology

Gary Willenbring
Senior Principal Systems Engineer, Collins Aerospace

Collins Aerospace is progressing the development of a modular seeker architecture composed of capability building blocks made possible through standard interfaces across the modules. This approach leverages technology across weapon platform applications creating value for the customer through reduced funding and technical risk. Customers implementing our technical solution allows new development programs to get to field testing faster with significantly lower risk.

24821

A Different Twist On 338 AP Penetration And Accuracy

Robert Folaron
CEO, nP Technology LLC

Leveraging Match Accuracy Developments To Improve Armor Penetrating Rounds

24825

High Accuracy 40mm Grenade Concept

Jay Bell
Business Development, Lake City Group

Applying rifle and cannon caliber projectile accurizing techniques to the 40mm grenade family.

BIOGRAPHIES

LTG THOMAS TODD III, USA

Deputy Commanding General, Acquisition and Systems Management, Chief Innovation Officer, U.S. Army Futures Command

LTG Thomas H. Todd III began his service as the Deputy Commanding General for Acquisition and Systems and the Chief Innovation Officer at U.S. Army Futures Command in July 2020.

In these executive roles, he is responsible for technology integration and capabilities development in the Army's research laboratories and centers. He previously served in numerous roles as Special Assistant for Acquisition and Systems Management to the Commanding General, U.S. Army Materiel Command, Program Executive Officer for Army Aviation, Deputy Commanding General of Research, Development and Engineering Command, Senior Commander of Natick Soldier Systems Center, and Modernization Advisor to the Director, Army Capabilities Integration Center. Todd led Army and Joint programs at all echelons, delivering advanced capabilities to soldiers, joint services, other government agencies, and over 60 foreign allied nations. He developed and delivered advanced capabilities CH-47F, H-60M, H-60V, AH-64E, Improved Turbine Engine, MQ-1C Gray Eagle ER, UH-72 Lakota, EMARSS-E, and the Black Hawk Aircrew Trainer. His joint assignments include: Defense Contract Management Agency Special Programs Multi-Service Team, Chief of Contracts, Joint Task Force Bravo, Honduras. Operationally, he served with A Co 3/501st Aviation Regiment in the Republic of Korea and 4th Squadron, 6th Cavalry Brigade, Fort Hood, TX. Todd is a 1989 graduate of The Citadel. He is an honor graduate of the Army's Initial Entry Rotary Wing training and a graduate of the Kiowa and Black Hawk Maintenance Test Pilot courses. He holds Masters of Science degrees in Contract Management and Strategic Studies from the Florida Institute of Technology and the U.S. Air War College, respectively. His awards and badges include the Legion of Merit (2 Oak Leaf Cluster), the Defense Meritorious Service Medal, the Meritorious Service Medal, the Joint Service Commendation Medal and other Army and joint commendations and awards. He is an Air Assault graduate and a Senior Army Aviator, rated in the UH-1 Iroquois, OH-58 A/C Kiowa, UH-60 A/L/M Black Hawk and CH-47 D/F Chinook.

DR. MARK LEWIS

Executive Director, Emerging Technologies Institute (ETI)

Dr. Mark J. Lewis is the Executive Director of NDIA's Emerging Technologies Institute (NDIA ETI), a non-partisan think tank focused on technologies that are critical to the future of national defense. ETI provides research and analysis to inform the development and integration of emerging technologies into the defense industrial base.

Prior to this position, Lewis was the Director of Defense Research & Engineering in the Department of Defense (DoD), overseeing technology modernization for all Services and DoD Agencies, as well as the acting Deputy Under Secretary of Defense for Research & Engineering. In that role, he was the Pentagon's senior-most scientist, managing a $17B budget that included DARPA, the Missile Defense Agency, the Defense Innovation Unit, the Space Development Agency, Federally Funded Research and Development Centers (FFRDC), and the Department's basic and applied research portfolio.

From 2012 to 2019, Lewis was the Director of the Science and Technology Policy Institute, an FFRDC that supported the Executive Office of the President and other Executive Branch agencies in the formulation of national science and technology policy. Lewis is a professor emeritus at the University of Maryland, where he served as the Willis Young, Jr., Professor and Chair of the Department of Aerospace Engineering until 2012. A faculty member at Maryland for 25 years, Lewis taught and conducted basic and applied research in the fields of hypersonic aerodynamics, advanced propulsion, and space vehicle design and optimization. Best known for his work in hypersonics, Lewis's research has spanned the aerospace flight spectrum from the analysis of conventional jet engines to entry into planetary atmospheres. From 2004 to 2008, Lewis was the Chief Scientist of the U.S. Air Force, the principal scientific adviser to the Chief of Staff and Secretary of the Air Force. As the longest-serving Chief Scientist in Air Force history, his primary areas of focus included hypersonics, space launch, energy, sustainment, advanced propulsion, basic research, and workforce development. From 2010 to 2011, he was President of the American Institute of Aeronautics and Astronautics.

Lewis attended the Massachusetts Institute of Technology, where he received his Bachelor of Science in Aeronautics and Astronautics, Bachelor of Science in Earth and Planetary Science (1984), and Master of Science (1985) and Doctor of Science (1988) in Aeronautics and Astronautics. He is the author of more than 320 publications and has been an adviser to more than 60 graduate students. In addition, he has served on various boards for NASA and DoD, including two terms on the Air Force Scientific Advisory Board. He is also a recipient of the USAF Exemplary, Meritorious, and Exceptional Civilian Service Awards, and of the Secretary of Defense Outstanding Public Service Award, among others.

COL COREY BEAVERSON, USAF

Director of Mission Prototypes, Office of the Under Secretary of Defense for Research and Engineering, Prototyping and Experiments Directorate)

Colonel Corey Beaverson currently serves as the Director of Mission Prototypes under the Office of the Under Secretary of Defense for Research and Engineering, Prototyping and Experiments Directorate, and leads the execution of Foreign Comparative Technology programs.

Beaverson served as commander, 47th Cyberspace Test Squadron, Joint Base San Antonio, TX. The squadron conducts test and evaluation of offensive and defensive cyber weapon systems and evaluates the resiliency and survivability of other weapon systems vital to executing the core functions of the Air Force in a cyber-contested environment.

He enlisted in the Air Force in 1992 as a signals intelligence analyst and was granted a Reserve Officer Training Corps Scholarship in 1995.

Following commissioning, Beaverson served as a measurement and signatures intelligence analyst supporting operations Allied Force, Northern Watch, Southern Watch, and Enduring Freedom. Later, he served in various flight test engineer capacities supporting E-3C, T-38A, C, KC- 135R, KC-10A, C-5M, C-17A, YAL-1, F-16C/D, F-35A, and electronic warfare tests.

As an engineer assigned to B-1B maintenance, he deployed in support of operation Enduring Freedom as Officer in Charge of an aircraft maintenance recovery team to return a B-1B to flying status following a Class-A mishap and damage sustained during combat operations. Later, he served as Operations Officer during the Airborne Laser first chemical carry, first light-in-flight, and system demonstration. Additionally, he was a member of the initial government cadre that transitioned F-35A operations from the contractor facility to Edwards AFB, CA; in this capacity he assisted with the delivery of the first three aircraft and conducted elevated-risk flight sciences and envelope expansion testing.

He served as the Operations Officer at the Benefield Anechoic Facility where he was responsible for antenna pattern measurements, electromagnetic interference compatibility tests, and classified electronic warfare tests. Additionally, Beaverson was responsible for the development, operations and maintenance of the Digital Integrated Air Defense System model, an F-16 systems integration laboratory, and F-35 manned flight simulators. He was then selected to serve as an Operating Location commander responsible for classified electronic warfare test capabilities.

While assigned to the Pentagon, he directed the planning, programming, budgeting, and security of Special Access Programs for a $3.8 billion dollar investment over the Future Years Defense Program. Additionally, Beaverson served as the Program Element Monitor for advanced weapon technologies and was the primary Air Force interface to Congress, the Office of the Secretary of Defense, Combatant Commanders and other services on the joint development of advanced weapons capabilities.

Serving as a Detachment commander at Hanscom AFB, MA, he guided test and evaluation involvement within command & control, intelligence, surveillance, reconnaissance, and nuclear command, control, and communications acquisition activities across three Program Executive Officer's portfolios valued at more than $31 billion dollars. Beaverson has more than 380 hours flying time in 28 different aircraft types.

H.E. OLEKSII REZNIKOV

Minister of Defence, Ukraine

H.E. Oleksii Reznikov is a Ukrainian lawer and has served as the Minister of Defence of Ukraine since November 2021.

From 1984 to 1986, Reznikov served in the Airborne Parachute Troops of the USSR Air Force. In 1991 he co-founded the brokerage company Galicia Securities. From 1999 – 2002 he served as the Deputy Chairman of the Center for the Development of Ukrainian Legislation in Kyiv.

In 2000 he established the law firm Pravis, that was later merged in 2006 with the law firm Magister and Partners, named the foremost law firm in Russia and the CIS. In 2011-2014, he served as Head of Litigation Practice at Egorov, Puginsky, Afanasiev and Partners. He served as an attorney and partner at Magisters.

In 2008-2014, he served in various capacities at the Kyiv City Council. On June 2014, he was elected Deputy Mayor – Secretary of Kyiv City Council VII. From 2015 to 2016, he was the Head of the Ukrainian National delegation to the Congress of Local and Regional Authorities of the Council of Europe, and Deputy Chairman of the Mayor of the Anti-Corruption Council.

He served as a Member of the Reformation Team for the Decentralization, Local Government and Regional Policy of the Ministry of Regional Development, Construction, and Communal Services of Ukraine; and as an advisor to Kyiv City's Mayor.

From April 2016 to September 2018 he served as Deputy Head of the Kyiv City State Administration, exercising power through the Kyiv City State Administration on the implementation of state policy in the areas of local self-government, domestic policy, international relations, tourism, advertising, protection of cultural heritage, education, culture, social protection, youth and sports. He was responsible for the implementation of reforms in the areas of decentralization, local government and other areas of life of the city of Kyiv.

In November 2018, he renewed his legal practice as a partner at the law firm, Asters. He specialized in alternative dispute resolution, including: expert opinions, negotiation, facilitation, conciliation, mediation, fact-finding, preliminary

independent assessment, pre-trial dispute resolution sessions and preparation of settlement agreements.

In 2005 and in 2019 he served as a member of the Supervisory Board of the State Savings Bank of Ukraine, or JSC Oschadbank.

In September 2019, he represented Ukraine in the working subgroup on political issues of the Trilateral Contact Group regarding a settlement to the war in Donbas. In March 19, 2020 he became a member of the National Security and Defence Council of Ukraine. On May 5, 2020 he was appointed as the first deputy of the Ukrainian delegation to the Trilateral Contact Group.

On March 4, 2020 he was appointed as Deputy Prime Minister, Ministry for Reintegration of the Temporarily Occupied Territories of Ukraine. And on November 4, 2021, Reznikov was appointed as Minister of Defence of Ukraine.

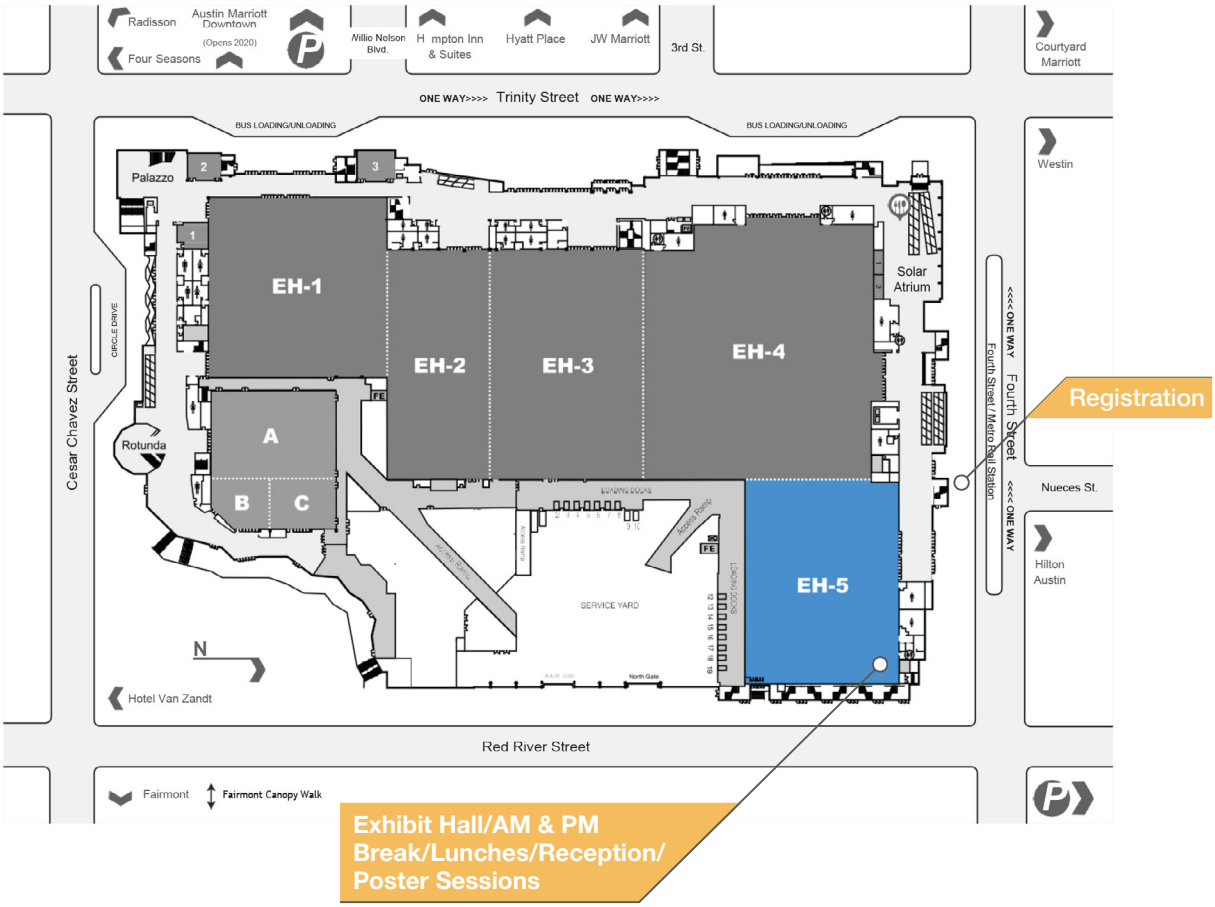
DAN SHEA

General Director, Phoenix Defence

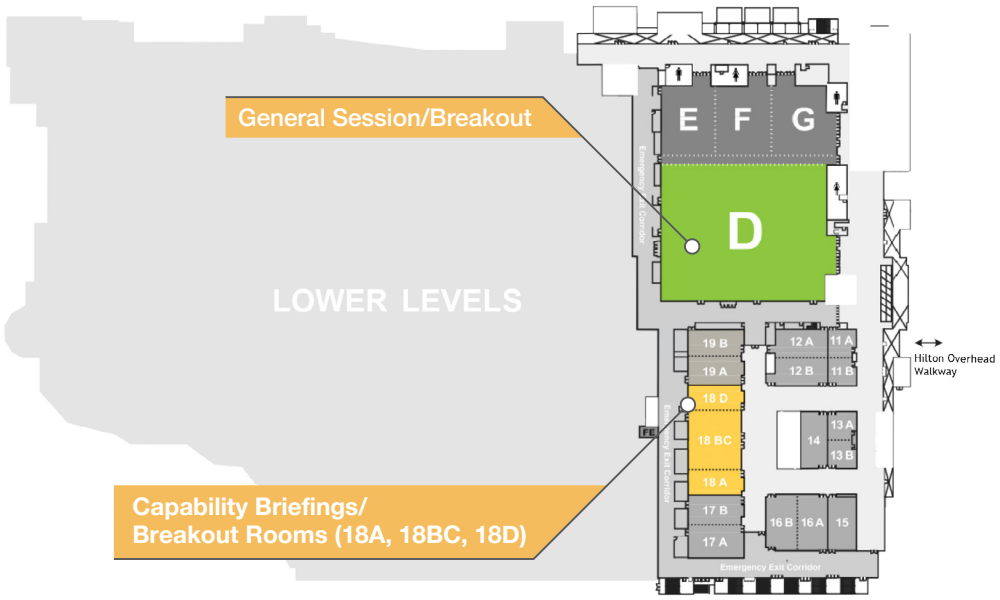
Dan Shea is a U.S. Army veteran who has been involved in military small arms and defense contracting for over 45 years. Shea is a certified government expert on small arms, and a Master Armorer certified as an armorer instructor on the following weapons systems: M16 series, AK47 series, M203, GP25, M249/MK46, M240, M60 series, M2HB, MK19, NSV, PKM, DShK, KPVT, RPG7, Carl Gustav M3 84mm, AGS-17/ BGA-30, M134 Minigun, most shoulder-fired or tripod-mounted weapons systems. Shea designed and implemented the 1997 and 1999 Silencer trials. He founded Long Mountain Outfitters, LLC, a small arms specialty sales and training company in Henderson, NV. He has served as the Editor-In-Chief and Technical Editor of Small Arms Review for the past 27 years and the newer, international Small Arms Defense Journal for 14 years.

CONVENTION CENTER MAP

FLOOR 1 EXHIBIT HALLS, BALLROOMS AND MEETING ROOMS



FLOOR 4 GRAND BALLROOM, MEETING ROOMS



EXHIBITORS BY COMPANY

As of 9/9/2022

908 Devices 405
ACTinBlack US, LLC 413
ADS, Inc. 423
Aero Precision 513
AimLock 205
Aimpoint Inc. 422
Altaeros 315
Applied Research Associates (ARA) 310
Barrett 414
Bren-Tronics, Inc. 211
CEIA USA 411
Defense Systems Information Analysis Center (DSIAC) 323
DTC 311
Environics USA 212
Explotrain LLC 324
Noble Supply & Logistics 204
Fjord Defence 210
General Dynamics - OTS 505
Ghost Robotics 305
HDT Global 214
HUXWRX Safety Co. 415
KGM Technologies 304
L3Harris 521
LMT Defense 517
Long Capture 316
Mistral Inc 510
National Armaments Consortium 523
National Defense Industrial Association (NDIA) 515
NOVO DR Inc. 213
Otis Technology 314
QinetiQ, Inc. 410
Radical Firearms/Radical Defense 320
Small Arms Defense Journal 514
SmartRayVision 522
SureFire, LLC 511
Teledyne FLIR 504
The University of Kansas 412
Trijicon, Inc 217
UDC USA 407

EXHIBIT HALL FLOORPLAN

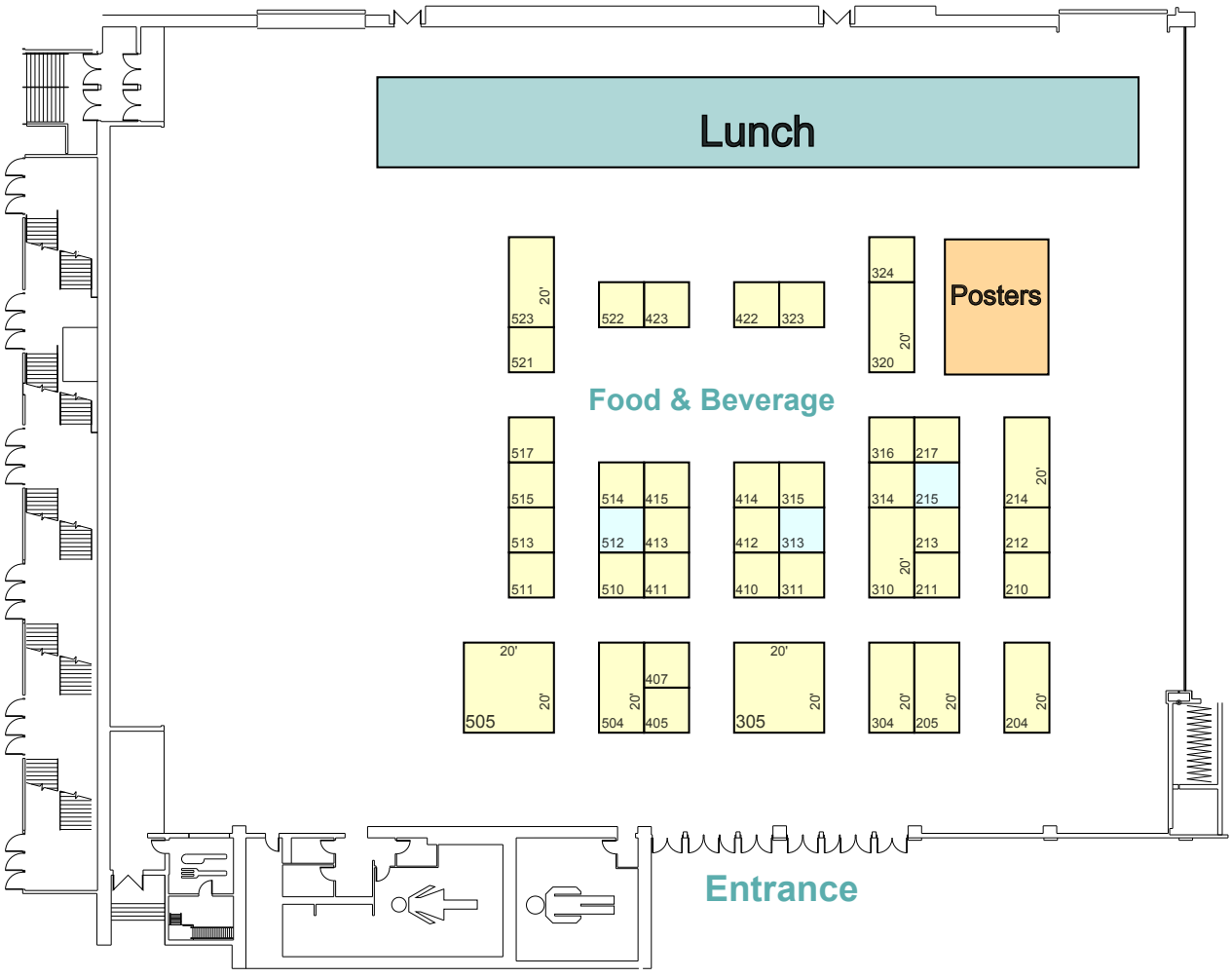


EXHIBIT HALL HOURS

TUESDAY, SEPTEMBER 20
9:00 am – 6:30 pm

WEDNESDAY, SEPTEMBER 21
9:00 am – 3:00 pm

EXHIBITOR DESCRIPTIONS

908 DEVICES 405

908 Devices is democratizing laboratory mass spectrometry with simple handheld and desktop devices. These devices are used at the point-of-need to interrogate unknown and invisible materials and provide quick, actionable answers to address some of the most critical problems in life sciences research, bioprocessing, pharma / biopharma, forensics and adjacent markets.

ACTINBLACK US, LLC 413

ACTinBlack (ACT) is a leading developer and manufacturer specializing in Advanced. Night Vision Optics. In addition to producing high-quality Night Vision Equipment, ACT is a recognized researcher in the field of Night Vision Technologies.

ADS, INC. 423

ADS, Inc. provides equipment, procurement, logistics, and supply chain solutions. We offer access to the largest product and service selection, the broadest array of procurement and contract options, and world-class expertise and support to assist you—every step of the way.

AERO PRECISION 513

Aero Precision is a leading manufacturer in the firearms industry. With roots in Aerospace, our quality and attention to detail are unmatched. When building something that flies, there is no margin for error. Aero always delivers extremely high-quality, American-manufactured rifles and components that your soldiers can count on.

AIMLOCK 205

Specializing in the development of organic autonomous precision strike weapon systems, AimLock enhances speed, accuracy, and reduced cognitive load for deployment of lethal fires from unmanned systems. AimLock's CORE engine offers decision accelerating autonomy in target detection, classification, identification, sensor fusion, and target prioritization, and shortened sensor-to-shooter times.

AIMPOINT INC. 422

Aimpoint red dot sights are trusted by hunters, sport shooters, military, and law enforcement officers around the world. Over 2 million sights have been supplied to the United States military since 1997. Today, Aimpoint is recognized globally as the most rugged, reliable, and efficient electronic sighting system in the world. When your life depends on your equipment, don't settle for anything less.

ALTAEROS 315

Altaeros' autonomous ST-Flex aerostats outperform tethered drones and traditional aerostats without requiring a ground crew for day-to-day operations. Our tactical aerostats are designed to lift heavy payloads (ISR, Radar, Communications & more) for long durations while providing significant OPEX savings.

APPLIED RESEARCH ASSOCIATES (ARA) 310

ARA is an international research and engineering company globally recognized for applying technically-excellent, in-depth and diversified research, engineering, and technical support services to provide answers to complex and challenging problems in the physical sciences. We have a broad range of technical expertise in defense technologies, civil engineering, computer software and simulation, systems analysis, environmental technologies, and blast testing and measurement.

BARRETT 414

Barrett Firearms Manufacturing, Inc. (Barrett) is the world leader in large-caliber and long-range rifle design and manufacturing. Our products are used by civilian sport shooters, law enforcement agencies, the United States military, and over 70 State Department approved countries. The Barrett Quality Management System has received the prestigious ISO 9001:2015 certification for the design and manufacture of firearms, ammunition, and accessories, and to provide training for those systems.

BREN-TRONICS, INC. 211

Supporting the Warfighter and EOD teams for 48+ years, all made in the US. Lithium-Ion batteries for every major military robot platform, small to large ground robots, air and sea. Chargers that get power from solar, vehicles, and other batteries in any climate between -40C / 80C. High power 24V Li-Ion batteries to start/power military vehicles (6T) + high energy power for mobile/fixed silent watch applications (>3 kWh). Winner: Conformal Wearable Battery (CWB) that also uses our ABC charger.

CEIA USA 411

CEIA Ground Search Metal Detectors provide overall superior performance in the areas of detection distance, soil compensation capability, and immunity to external interference. CEIA USA provides nationwide sales, service, and customer support to customers in North America. Dynamic solutions are the foundation of CEIA USA's commitment to customer satisfaction. For more information about CEIA USA, visit www.ceia-usa.com

DEFENSE SYSTEMS INFORMATION ANALYSIS CENTER (DSIAC) 323

The Defense Systems Information Analysis Center (DSIAC) is a component of the U.S. Department of Defense's (DoD's) Information Analysis Center. As an information and knowledge resource for DoD, DSIAC leverages expertise and knowledge from other Government agencies, research laboratories, industry, and academia to help solve the toughest scientific and technical problems of the Defense Systems community.

DTC 311

DTC Communications is the world leader in mission critical communications at the tactical edge. DTC's Software Defined Mesh Radios provide the Warfighter, the Special Forces Operator, and Uncrewed Systems with the greatest performance and reliability. Recently, DTC's IVAS Radio surpassed Industry standards culminating in an $11.2m award. Spectronic, a DTC Company, is well known in the SOFIC community for world-class Covert Surveillance solutions. We look forward to seeing you at Booth 306.

ENVIRONICS USA 212

Environics has over 30 years of experience in improving CBRN safety around the world with its in-house technologies, and portable and fixed monitoring solutions. Different organizations in over 50 countries, from civil defense and homeland security to the military, have already selected Environics as their partner in CBRN threat detection.

EXPLOTRAIN LLC 324

Explotrain provides patented training and simulation technologies for battlefield effects, C-IED, EOD, live fire, field maneuvers, MOUT, indirect fire, drone-based attacks, and role player augmentation. Technologies include a new UXO and chemical weapon simulation system, MILES compatible propane/OXY and pneumatic powered blast simulator for OPFOR and battlefield FX, long range remote control via dedicated transceiver or tablet-based, and wireless monitoring of high-fidelity EOD/IED training.

NOBLE SUPPLY & LOGISTICS 204

Noble Supply & Logistics is a global supply chain, logistics, mission support, and technology solutions provider for the U.S. military, federal, state, and local governments. The company distributes 13,000 brands of Aerospace, C5ISR, CBRNe, Expeditionary, MRO, and Tactical equipment. Noble streamlines procurement, reducing the cost of readiness while responding to today's challenges rapidly.

FJORD DEFENCE 210

Fjord Defence specializes in a system approach around weapon mounts and customized integration within ground, vehicle and boat applications. We develop weapon accessories with decades of experience, military background, and a user focused organization. We always bring the elements of user friendliness, high precision, low weight, and modularity into our products to deliver something more than «just another piece of equipment". We want to be a recognized as added value to a weapon system.

GENERAL DYNAMICS – OTS 505

General Dynamics Ordnance and Tactical Systems is a global systems developer and manufacturer of munitions, weapons and tactical systems across the entire air, land, and sea battle spectrum. It is the purpose of GD-OTS to empower the United States Armed Forces and its Allies through readiness and innovation to protect what is most important, the warfighter. We are dedicated to our people, our products and our processes to ensure that every day we are Delivering the Best to the Best™

GHOST ROBOTICS 305

Ghost Robotics™ is revolutionizing legged robotics and the market for autonomous unmanned ground vehicles (Q-UGVs) used in unstructured terrain and harsh environments. Our Q-UGVs are rugged and unstoppable. Beyond all terrain operation, a core design principle for our legged robots is size-scalability, and reduced mechanical complexity with total software (SDK) control when compared to other legged and traditional wheeled and tracked UGVs on the market.

HDT GLOBAL 214

A provider of highly-engineered mobile military and emergency response solutions, HDT Global is widely recognized for its industry-leading production of state-of-the-art, fully integrated deployable solutions. With advanced systems currently being used by the U.S. and allied military units stationed worldwide, HDT's products include shelter systems, water filtration, environmental control systems, generators, heaters, air filtration devices, and robotics.

HUXWRX SAFETY CO. 415

HUXWRX Safety Co. is the result of years of research, development, and commitment towards the advancement of suppressor systems. The proprietary technology we've designed mitigates sound and flash signature while reducing exposure to toxic fumes without sacrificing weapon functionality. The simplicity and effectiveness of these systems is why armed forces and law enforcement agencies worldwide recognize the benefits of our technology and are adopting HUXWRX as their suppressor standard.

KGM TECHNOLOGIES 304

KGM Technologies is the largest designer and manufacturer of weapon suppressors in the country. We are protecting the hearing of shooters everywhere and significantly enhancing the capability of our war-fighters. Our patented technologies and advanced manufacturing methods have allowed KGM to set the new standard of suppression. Additional information can be found at www.kgm-tech.com

L3HARRIS 521

The large robot supplier for the UK Ministry of Defence and the U.S. Air Force, L3Harris' highly intuitive and ruggedized robotic systems are deployed worldwide to tackle challenging missions so humans don't have to. Offering best-in-class manipulation, unparalleled precision and human-like dexterity, the T7 and T4 push the envelope of robotic capability. By sharing an intuitive haptic controller, our robots streamline operation, reduce training time, and minimize through-life cost.

LMT DEFENSE 517

Est. in 1980, Lewis Machine & Tool Company (LMT®) manufactures M4 type carbines, 7.62 x 51 rifles, and M203 40mm launchers. LMT is 100% US made and an ISO 9001:2015 registered US Govt. GSA contractor. Models include the MWS classified by the UK MOD as the L129A1 DMR and the 5.56 x 45 monolithic rifle with ambidextrous features, classified as the MARS-L, Modular Ambidextrous Rifle System, Light. Our products are currently in service with the US Govt., SOCOM, and 40 countries around the world.

LONG CAPTURE 316

Long Capture promotes the advancement of commercial companies and their technology through government funding programs such as the Small Business Innovative Research (SBIR), Small Business Technology Transfer (STTR), and other strategic opportunities. By leveraging its network of government officials, industry partners, and universities, Long Capture drives growth for clients in the DoD space.

MISTRAL INC 510

Mistral Inc. serves as a "bridge" between the User requirements and innovative, relevant and ready solutions for the challenges faced while out in the field. Continuous analysis of capability gaps and existing technologies enables Mistral to stay ahead of the problems faced by Users today, tomorrow and into the future.

NATIONAL ARMAMENTS CONSORTIUM 523

The National Armaments Consortium (NAC) serves as the industry partner for the Aviation and Missile Technology Consortium (AMTC), the Department of Defense Ordnance Technology Consortium's (DOTC), and the Naval Energetic Systems and Technologies Consortium (NEST). Our robust, transparent, and unique collaboration approach, once considered a novel and unrealistic concept, has evolved into a well-established process through which our DoD stakeholders acquire the innovative Armament technologies needed to maintain U.S. technological superiority.

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION (NDIA) 515

NDIA engages thoughtful and innovative leaders to promote the best policies, practices, products and technology for warfighters and others who ensure the safety and security of our nation. NDIA offers 25 chapters, 27 divisions for corporate involvement, award winning publications, and numerous conferences and trade shows annually. Corporate and individual memberships are available. U.S. government and military are welcome to join free of charge.

NOVO DR INC. 213

NOVO DR Inc. offers the highest image quality in the portable digital radiography industry. The ruggedness and reliability of our systems combined with amazing X-Ray Images make them the best in the market. Our intuitive and easy to use products have been designed and engineered by our incredibly professional and highly experienced team! For more information please visit website: www.novo-dr.com

OTIS TECHNOLOGY 314

Otis Technology is known for manufacturing the most advanced firearms maintenance systems. The superior Breech-to-Muzzle® design combined with unmatched quality has positioned Otis as the gun care system of choice with the US Military, Hunters, Shooters and Law Enforcement professionals worldwide. Made in the USA, Otis Technology is AMERICA'S GUN CARE.

QINETIQ, INC. 410

QinetiQ, Inc. provides cutting-edge technology and revolutionary products to the defense, security and military markets. Our product offerings include tactical land vehicle and aircraft protection, sensors to protect soldiers, unmanned robots in a variety of sizes and with varying capabilities and power and control systems. Customers rely on our products to enhance security, aid in personal safety, streamline operations, increase situational awareness and improve efficiencies.

RADICAL FIREARMS/ RADICAL DEFENSE 320

Radical Defense is dedicated to delivering cutting-edge capabilities into the hands of soldiers and Law Enforcement. They provide innovative solutions to battle major issues with modern weapons. The most common issues that we have tackled head on are: Heat, thermal signatures, end user serviceability, longevity and reliability. Radical Defense is a true manufacturer with modern CNC and Additive manufacturing. They are capable of true RND, engineering, manufacturing and full production.

SMALL ARMS DEFENSE JOURNAL 514

Distributed at defense trade shows worldwide, Small Arms Defense Journal is a bimonthly publication focused on small arms, accessories, soldier gear, new products, industry news, and defense trade show reviews. Small Arms Review is a 10 issue publication. Our aim is to provide a forum for all aspects of Class 3 interests and the military small arms industry. Semper Fi highlights the charitable works and fellowship of the Marine Corps League and covers league and chapter events across the U.S.A.

SMARTRAYVISION 522

SmartRayVision Portable EOD X-Ray is designed, developed and manufactured by SharpLogixx LLC. Made in the USA in Green Bay Wisconsin, the SmartRayVision system is the #1 selling EOD kit in the country. SharpLogixx LLC is a leading technology company focused on advanced research and development of X-Ray equipment and specialized software.

SUREFIRE, LLC 511

Located in Fountain Valley, California, SureFire LLC is the leading manufacturer of high-performance flashlights, weapon-mounted lights and other tactical equipment for those who go in harm's way, or anyone who demands the ultimate in quality, innovation and performance. SureFire illumination tools are used by more SWAT teams and elite special operations groups than any other brand. SureFire is an ISO 9001:2015-certified company.

TELEDYNE FLIR 504

Teledyne FLIR's UIS Division comprises the largest global provider of tactical unmanned ground vehicles as well as leading nano and Class-1 unmanned aircraft systems. We design and build the most trusted, rugged, easiest-to-operate drones and robots – from 1.2 ounces to 500 pounds – used to safeguard life and property around the world. Whatever the mission, our advanced platforms are out there every day supporting US and international military, law enforcement, and industrial users.

THE UNIVERSITY OF KANSAS 412

The University of Kansas Aerospace Engineering Department supports advanced weapon system RDT&E via its Aircraft Design Lab. Its investigators claim a number of DoD "firsts," including guided and hypersonic aerial gunnery, Micro Aerial Vehicles (MAVs), and Hovering Missiles. KUAE works with Government labs and corporations to conceive and prove unique weapon systems and licenses critical patents and trade secrets. The Lab has worked for years with all branches of the DoD, DARPA and NASA.

TRIJICON, INC 217

Backed by a limited-lifetime warranty, Trijicon's aiming systems are proven on the range and in the field. As a result, Trijicon has earned the trust of those who are most in need of aiming accuracy and dependability. Our customers include the United States Navy, Marine Corps, Army, Air Force, and United States Special Operations Forces; United States Government, as well as state and local Law Enforcement.

UDC USA 407

UDC produces small & medium caliber ammunition of several types, support munitions and demolition products. UDC is headquartered in Tampa, Florida with offices & facilities in the Kansas City, Missouri, metro area. For 2022 we are introducing a new line of Armor Piercing rounds. UDC specializes in munitions manufacturing, prototyping and testing, full rate production, modernization of legacy weapon systems, and training and equipping of foreign military or indigenous defense forces.

NDIA LEADING THE WAY IN ENGAGEMENT, NETWORKING, AND NATIONAL DEFENSE

PLAN AHEAD FOR SUCCESS | 2022 – 23 FEATURED MEETINGS, CONFERENCES, AND EVENTS

FUTURE FORCE CAPABILITIES CONFERENCE & EXHIBITION

September 19 – 22, 2022 | Austin, TX

Autonomous Systems | GARM | Live Fire | Multi-Domain | Small Arms | EOD

25TH ANNUAL SYSTEMS & MISSION ENGINEERING CONFERENCE

November 1 – 3, 2022 | Orlando, FL

Program Management | Security Models | Test & Evaluation | Manufacturing

UNDERSEA WARFARE FALL CONFERENCE*

September 26 – 28, 2022 | Groton, CT

Aviation USW | C4I | Mine Warfare | Undersea Sensors & Vehicles | Warfighter Performance

AIRCRAFT SURVIVABILITY SYMPOSIUM

November 1 – 3, 2022 | Monterey, CA

Combat Survivability | Concealment and Deception | Countermeasures | Urban Warfare | Vulnerability Reduction

WOMEN IN DEFENSE NATIONAL CONFERENCE

September 27, 2022 | Arlington, VA

Pivots and Prospects: Success in the New Normal

33RD ANNUAL NDIA SO/LIC SYMPOSIUM

November 17 – 18, 2022 | Washington, DC

Special Operations Forces | Strategic Competition

PRECISION STRIKE TECHNOLOGY SYMPOSIUM (PSTS-22)* SECRET – NOFORN

October 18 – 20, 2022 | Laurel, MD

Precision Capability | Air & Missile Defense | Technology Advancements

I/ITSEC 2022

November 28 – December 2, 2022 | Orlando, FL

Simulation | Training | Virtual Reality

2022 INSENSITIVE MUNITIONS & ENERGETIC MATERIALS (IMEM) TECHNOLOGY SYMPOSIUM

October 18 – 20, 2022 | Indianapolis, IN

Energetic Materials | Insensitive Munitions | Munitions Technology

2023 TACTICAL WHEELED VEHICLES CONFERENCE

February 27 – March 1, 2023 | Columbus, OH

Autonomous Vehicles | Electric Drive | Modernization & Sustainment | Acquisition

2022 JOINT AIA/NDIA INDUSTRIAL SECURITY COMMITTEE CONFERENCE

OCTOBER 24 – 26 | Tucson, AZ

Security Clearance Reforms | Insider Threat Guidance | Cybersecurity Policy

2023 PACIFIC OPERATIONAL SCIENCE & TECHNOLOGY (POST) CONFERENCE

March 6 – 9, 2023 | Honolulu, HI**

Regional Security | Science & Engineering Technology | Technology Engagement

*All Classified | **Partially Classified

VISIT NDIA.ORG FOR MORE INFORMATION ON ALL OF OUR MEETINGS, CONFERENCES, AND EVENTS

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

Fire Support Science & Technology Portfolio

R. Hunter Blackwell

DB-IV / Deputy Fire Support Capability Area Lead

DEVCOM AvMC

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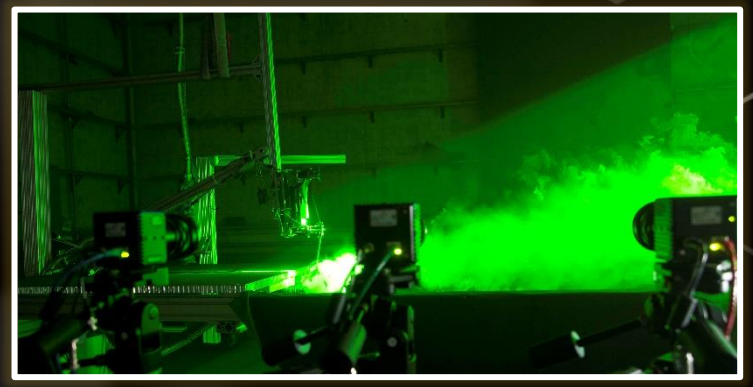
OUR MISSION



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

OUR LEADERSHIP TEAM

Director (A)
Dr. James Kirsch
(SES)

Chief of Staff
Mr. Steve Fisher

MILDEP
COL Steve Ansley

Systems Readiness Directorate
Mr. Keith Darrow
(SES)

Software, Simulation, Systems Engineering and Integration Directorate (A)
Ms. Miranda Oden

Technology Development Directorate
Ms. Christi Dolbeer
(SES)

Scientific & Technical Positions (STs)

Radio Frequency Sensors
Dr. Brian Smith

Protective Technologies
Dr. Donna Joyce

Airvehicle Aerodynamics & Preliminary Design
Dr. Mahendra Bhagwat

Rotorcraft Flight Dynamics and Control
Dr. Jeffery Lusardi

BY THE NUMBERS

12,367 FY22 Strength

2,983 Civilian

19 Military

~9,358 Contractor

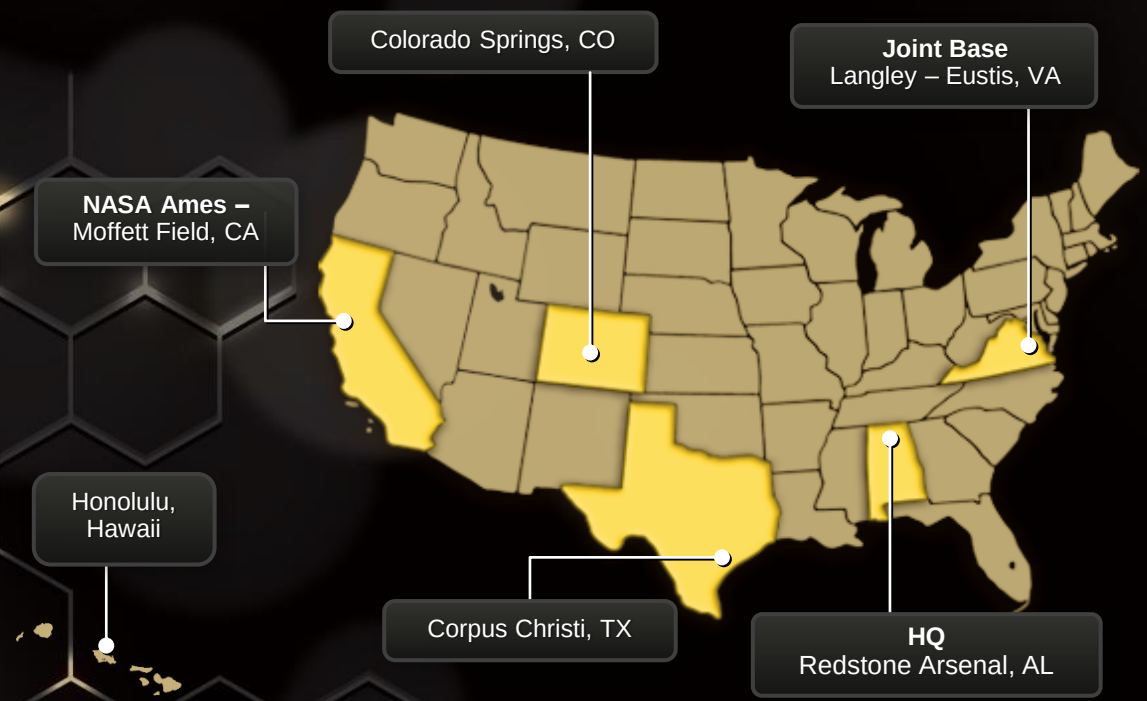
FY21 Funding
$4.4B

6% Aviation S&T

5% Missile S&T

68% Army

21% Other



CORE COMPETENCIES

SCIENCE AND TECHNOLOGY:

- Missile Seekers, Guidance, Navigation and Control
- Missile Materials and Structures
- Missile Propulsion, Warhead Integration, and Fuzing
- Air Vehicles
- Aviation Mission Systems and Architecture
- Air Defense Radar and Fire Control

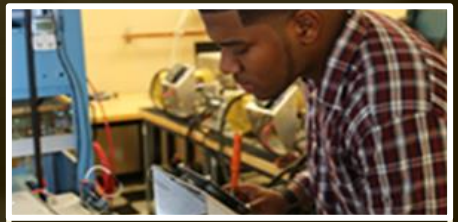
LIFE CYCLE ENGINEERING:

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

AvMC TECHNOLOGY
EXPERTISE • ENGINEERING • TALENT

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 areas 1-3.

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

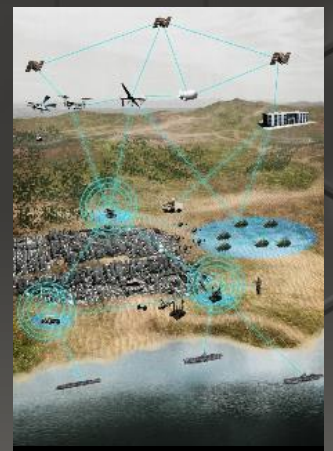
The Army must modernize to remain lethal and ready to fight tomorrow, against increasingly capable adversaries and near-peer competitors.

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 IN SUPPORT OF FUTURE FORCE

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

ANALYSIS

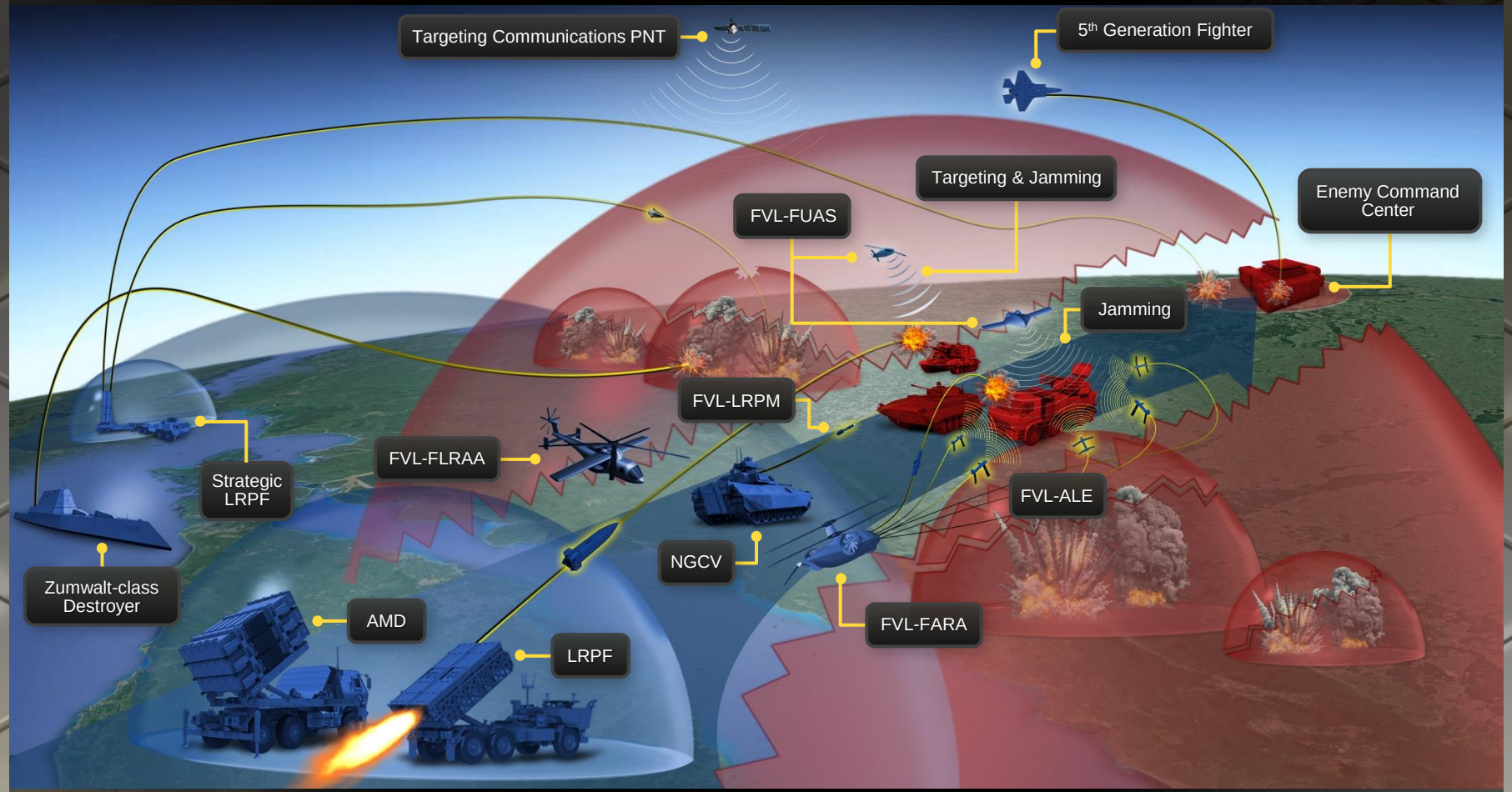
Conducting objective experimentation and systems analysis to support the equipping and sustaining of our Warfighters.

ENGINEERING

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

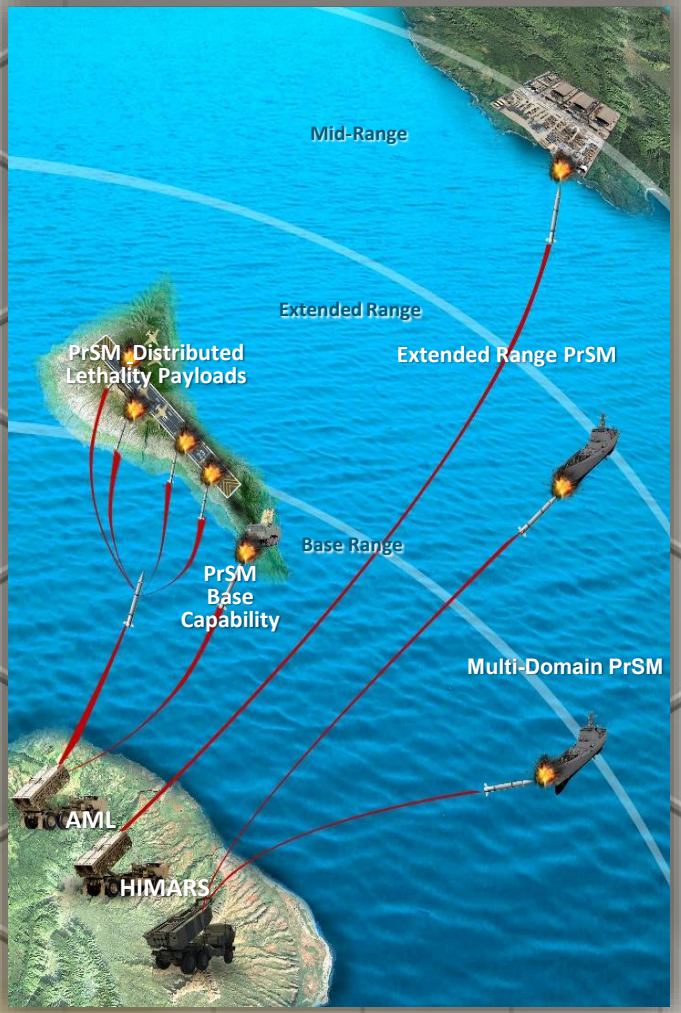
S&T STRATEGY

BREAK THE ENEMY'S BUBBLE | **PROTECT OUR FORCE** | **ON THE MOVE**



ELIMINATE A2/AD AT ALL ECHELONS | **REACH, RANGE, AND SPEED** | **AGILE MANEUVER TO CONTACT**

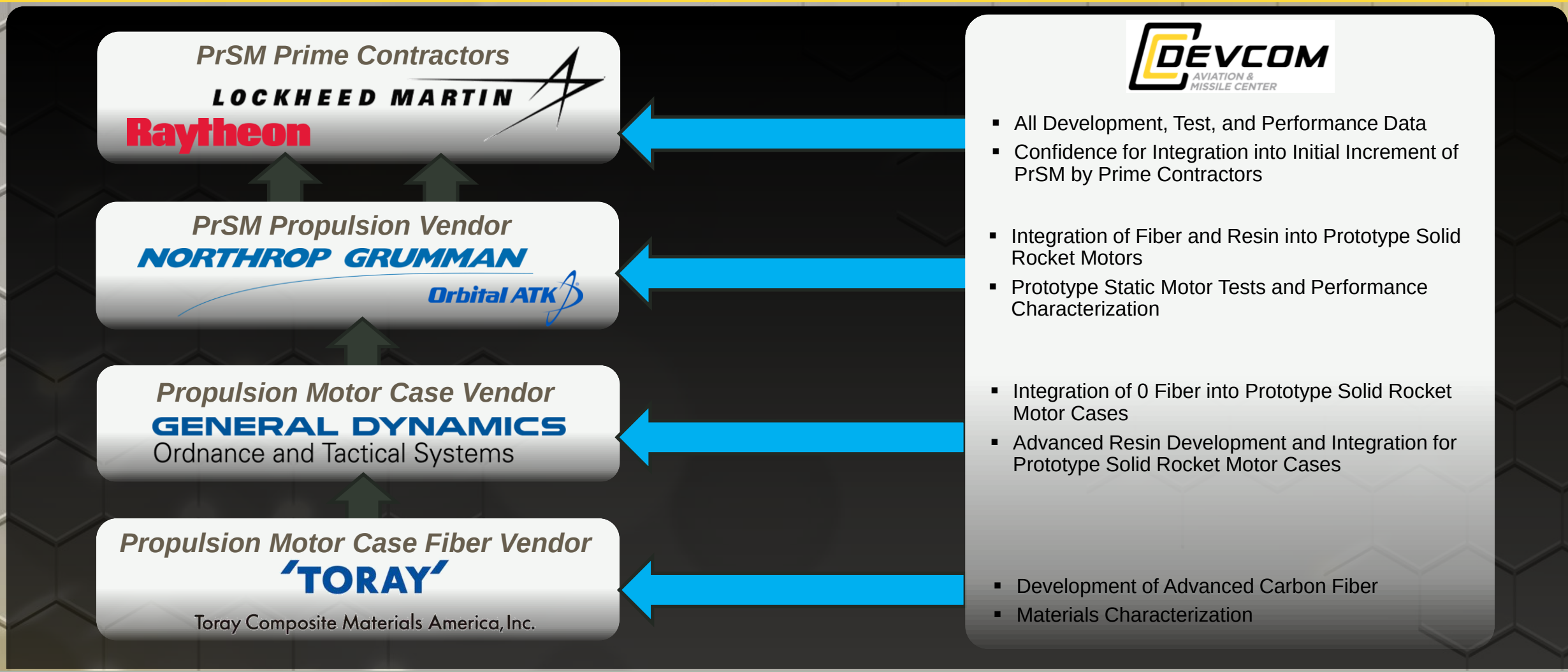
LONG RANGE PRECISION FIRES S&T FOCUS



- **PRSM BASE CAPABILITY:** Successful S&T incorporated as component updates to reduce dependence on GPS for precision navigation; extend range beyond initial range capability
- **MULTI-DOMAIN PRSM:** Multi-mode Seeker Technology that enable *PrSM to Engage Moving High Priority Multi-Domain Land and Maritime Targets*
- **PRSM MODULAR PAYLOADS:** Kinetic and Non-Kinetic Modular Payload Technologies to provide ***PrSM Distributed Lethality*** Against the Full Spectrum of Moving, Dispersed and Poorly Located Targets
- **EXTENDED RANGE PROPULSION AND LONG-RANGE MANEUVERABLE FIRES S&T:** Solid Rocket and Alternate Propulsion Cycle Technologies
- **AUTONOMOUS MULTI-DOMAIN LAUNCHER (AML):** Unmanned, highly mobile, USAF transportable, HIMARS chassis based, unmanned LRPF launcher. Autonomy Technology to *Thicken the Force and Increase Fire Power and Magazine Depth*
- **ENABLING TECHNOLOGIES:** S&T Research in Navigation, Guidance & Controls, Sensors, Materials as well as Modeling & Simulation

Capabilities that Enable the Joint Force to Prevail with Overmatch through A2AD Lethality, Range, Speed, Firepower and Accuracy

LC-TERM PROPULSION & STRUCTURES TECHNOLOGY TRANSITION PATH



Transition of Advanced Propulsion Technology to PrSM Prime Contractor and Vendor Base for Increased Range

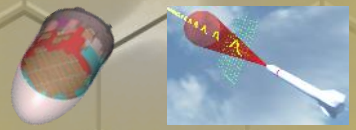
AMD S&T ENABLING TECHNOLOGIES

Maneuver Air Defense

Development of technologies that support low cost, small form factor air defense interceptors for the maneuver force.

Sensors/Seekers

RF and IR Tech | Algorithms



Seeker technology and algorithms to support the broad air defense mission set.

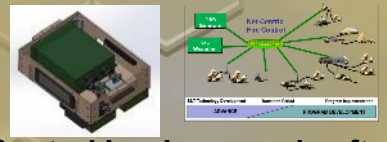
Advanced Propulsion

Advanced Divert and Attitude Control Systems | Air-breathing/High Speed Propulsion Tech

Propulsion technologies to increase interceptor range, velocity, and maneuverability.

Fire Control

Hardware | Techniques

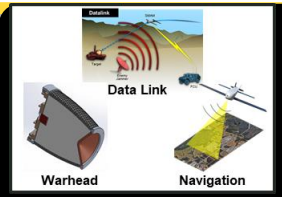


Fire Control hardware and software to optimize the integration of current systems, enable “shoot on the move,” and facilitate engagements of advanced threats.

Resiliency

Technologies to enable air defense performance in all environments.

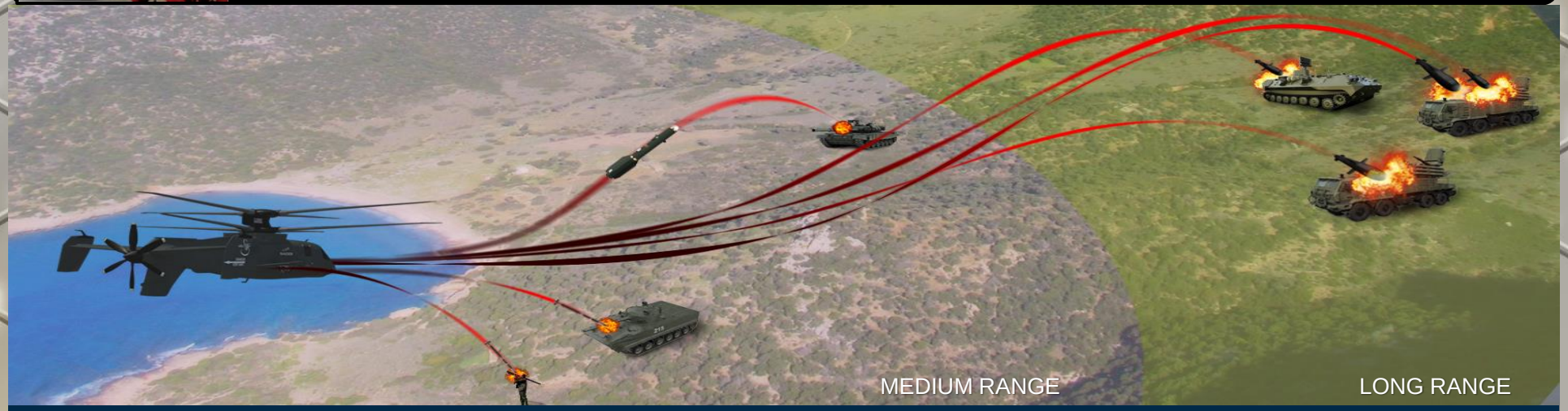
CLOSE COMBAT AVIATION S&T FOCUS



SINGLE MULTI-MISSION ATTACK MISSILE TECHNOLOGIES provides enabling technologies for maneuverable guided missiles to support Multi-Domain /expeditionary on-the-move capability in contested environments

MULTIPLE SIMULTANEOUS ENGAGEMENT TECHNOLOGIES enables multi-missile, simultaneous target engagements, with minimized operator workload, as a result of autonomous target acquisition and missile coordinated time of arrival.

HIGH SPEED MANEUVERABLE MISSILE TECHNOLOGIES increases aviation lethality and platform survivability by increasing missile standoff range, speed, maneuverability, and multi-threat lethal effects.



Disruptive, leap-ahead technologies to increase range, lethality, improve mission flexibility, and support Joint Force Operations in highly contested environments.

Questions?

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JOINT PROGRAM EXECUTIVE OFFICE
ARMAMENTS & AMMUNITION

Presented to:

Future Forces Conference
Guest Speaker Panel

Presented by:

Mr. Chris Grassano
Deputy Joint Program Executive Officer
Armaments & Ammunition

20 September 2022

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JPEO Armaments & Ammunition Video

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Joint Program Executive Office
Armaments & Ammunition

JPEO A&A
BG John Reim

DJPEO A&A
Mr. Chris Grassano SES

APEO International
Mr. Thomas Coradeschi

Dir Talent Management
Mr. Keith Gooding

Mission:
Develop, procure and field lethal armaments and ammunition providing Joint Warfighters and Allied Partners overmatch capabilities.

US Army
US Navy

COL Leon Rogers

Project Manager
Combat Ammunition Systems
Indirect Fire Munitions and Mortar Weapon Systems
- Long Range Precision Fires
- Cannon Delivered Area Effects Munitions
- Mortar Weapon Systems

COL Russell Hoff

Project Manager
Close Combat Systems
Terrain Shaping Obstacles, Close Combat Munitions, Protection and Support Systems
- Interim Top Attack Munition
- Individual Shoulder Launched Munition
- Countermeasure Flares/Decoys

COL Paul Alessio

Project Manager
Maneuver Ammunition Systems
Direct Fire Munitions
- Small, Medium and Large Caliber
- Special Ammo & Weapon Systems

Mr. Matthew Zimmerman

Project Director
Joint Services
- Ammunition Industrial Base
- SMCA Integration
- Demilitarization
- Technology and Prototyping

Mr. Ben Harris

Chief of Staff
- Human Resources
- Security / Foreign Disclosure
- Acquisition Processes
- Audit Readiness
- Business Management
- Information Technology

Mr. Chris Hatch

Acting Program Manager
Towed Artillery Systems
Joint Artillery & Survey
- M777A2 Lightweight 155mm Howitzer
- M119A3 105mm Howitzer
- Survey Systems
- Next Generation Howitzer

CAPT Brian Schorn USN

Project Director
Joint Bombs
- Air Force and Navy Bombs
- Navy Deck Gun Ammo
- Energetics / Cartridge Actuated Device / Propellant Actuated Device

Mr. Eugene Conner

Director for Integration
- Science and Technology
- Systems Integration
- Architectures and Standards
- Ammunition Logistics R&D

Single Manager for Conventional Ammunition

DISTRIBUTION

JPEO Armaments & Ammunition Vision, Mission & Priorities

- **Vision:** Innovative and empowered Teams rapidly fielding dominating capabilities.
- **Mission:** Develop, procure and field lethal armaments and ammunition providing Joint Warfighters and Allied Partners overmatch capabilities.
- **Priorities:**
  - Develop Agile People, Teams and Acquisition Leaders
  - Develop and Field Overmatch Capabilities to Warfighters
  - Innovate and Operate Effectively and Efficiently
  - Modernize and Maintain Viable Strategic Capabilities to Ensure Current and Future Readiness
  - Strengthen Alliances and Establish New Partners

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Armaments and Ammunition Where We Are

- Challenging Environment
  - Tight Labor Market (Great Resignation – 2x Attrition Rate)
  - Dynamic and Difficult Supply Chains
  - Inflation
  - Minimum Sustaining Production Rates (Priority on Modernization)
- Compounding Challenges
  - Step Function Demand Increase
    - ✓ Ukraine
    - ✓ Rebuild Inventories – Total Munitions Requirements Re-look
    - ✓ FMS Customers and SDAF Replenishment
    - ✓ Potential Critical Munitions Fund
  - Expanding Capacity and Establishing New Sources
    - ✓ Attracting, Training and Retaining Labor
    - ✓ Long Lead Time for Capital Equipment
    - ✓ Maintaining Excess Capacity; Multiple Sources Long Term

Dynamic and Challenging Environment

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Armaments and Ammunition
Where We Are Going

- Modernization of Munitions
  - Longer Range (Propellants, Charges & Ballistics)
  - Precision (M-Code & Alt-Nav)
  - Lethality (Armor, Area Effects, Air-burst, Seekers)
  - Multi-use & Multi-target (AMP & IAM)
- Modernization of the Industrial Base
  - Automation and Robotics
  - Safety (Isolate and Reduce Mass Energetics)
  - Capacity Expansion and Dual Sources
  - Resilient & Sustainable Operations
  - Leverage Title III for Commercial Facilities
- Assured Munitions
  - Supply Chain Risk Management (Early & Continuous)
    - ✓ New Sources
    - ✓ Secure Sources
    - ✓ Stockpiles & Life-time Buys
    - ✓ Design Out
- Digital Engineering
  - 3D TDPs
  - Digital Thread & Digital Manufacturing
  - Physics-based Models
  - Virtual Testing

Ukraine Experience is Shaping the Future

JPEO A&A is Modernizing Munitions and Industrial Base

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Delivering Overmatch Capabilities to Warfighters
Supporting Army Modernization Priorities

1 Long Range Precision Fires

Supported by 12 Projects, Includes:

- Enhanced Lethality
- Cannon Munitions
- 155mm HE Rocket Assist
- Extended Range
- Cannon Delivered Area Effects Munitions

2 Next Generation Combat Vehicle

Supported by 7 Projects, Includes:

- 30mm Family of Ammunition
- 50mm Multi-Mode Family of Ammunition
- 120mm Extended Line of Sight (ELOS)
- 105mm Mobile Protected Firepower

3 Future Vertical Lift

Supported by 2 Project:

- Aviation Expendable Countermeasures
- PGU28 Anti-Personnel Family of Ammunition

PGU-28

Countermeasure Flares

5 Air and Missile Defense

Supported by 2 Project:

- 30mm Multi-Mode Proximity Air Burst (MMPA)

30MM MMPA

6 Soldier Lethality

Supported by 9 Projects, Includes:

- 6.8mm Family of Ammunition
- 7.62mm Advanced Armor Piercing (ADVAP)
- Precision Sniper Rifle Ammunition

7 Assured PNT

Supported by 1 Project:

- Assured Precision Weapons and Munitions

Status

- Program of Record
- Concept Dev
- Requirements Dev
- MidTier Acquisition

The JPEO Directly Supports Six of Eight CFTs

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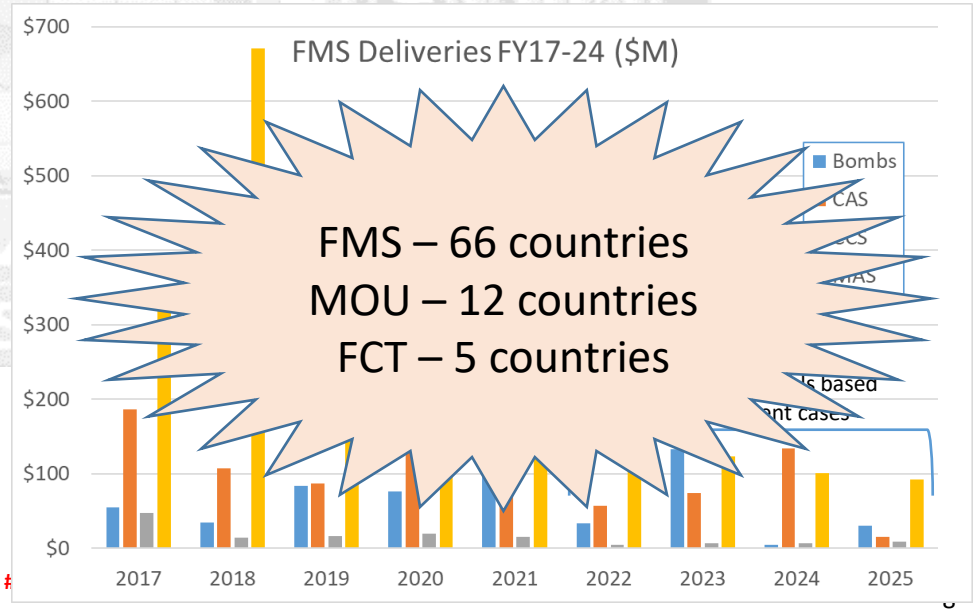
Efforts to Strengthen Alliances and Establish New Partners

- DoD Strategy is to encourage and enable partner nation security goals consistent with our national security objectives
- Key elements:
  - Cooperative R&D/Production
  - Foreign Military Sales
  - Direct Commercial Sales
  - Foreign Comparative Test
  - Interoperability / Interchangeability
  - Strategic Sourcing



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Summary

- JPEO A&A is Fully Engaged Supporting our National Military Strategy
- Modernization is Maintaining Momentum
- Shaping the Industrial Base to Meet Emerging and Future Requirements
- Moving towards more products made in America
- Strengthening Alliances and Establishing New Partners

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

2022 NDIA Future Force Capabilities Conference

Mr. Anthony J Sebasto, SES

(A) Director

DEVCOM – Armaments Center

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ARMAMENTS CENTER

RESEARCH

DEVELOPMENT

PRODUCTION

FIELD SUPPORT

DEMILITARIZATION

Munitions Engineering and Technology Center:

Energetics; Propellants; explosives; pyrotechnics; warheads; scalable effects; fuzing; guidance & controls; seekers; insensitive munitions; environmental technologies and explosive ordnance disposal; aero ballistics and telemetry; materials & structures

Weapons and Software Engineering Center:

Small, medium and large caliber weapons design, experimentation, evaluation, manufacturing, and integration; ballistics; automation & stabilization; digitization; embedded system software; directed energy; targeting, technical and tactical fire control; materials & structures; homeland defense and e-business systems

Enterprise and Systems Integration Center:

System engineering & analysis; quality engineering; logistics engineering; project management; business development; S&T planning; financial, data & knowledge management

Providing Holistic Armament System Solutions for Fieldable Lethality Overmatch

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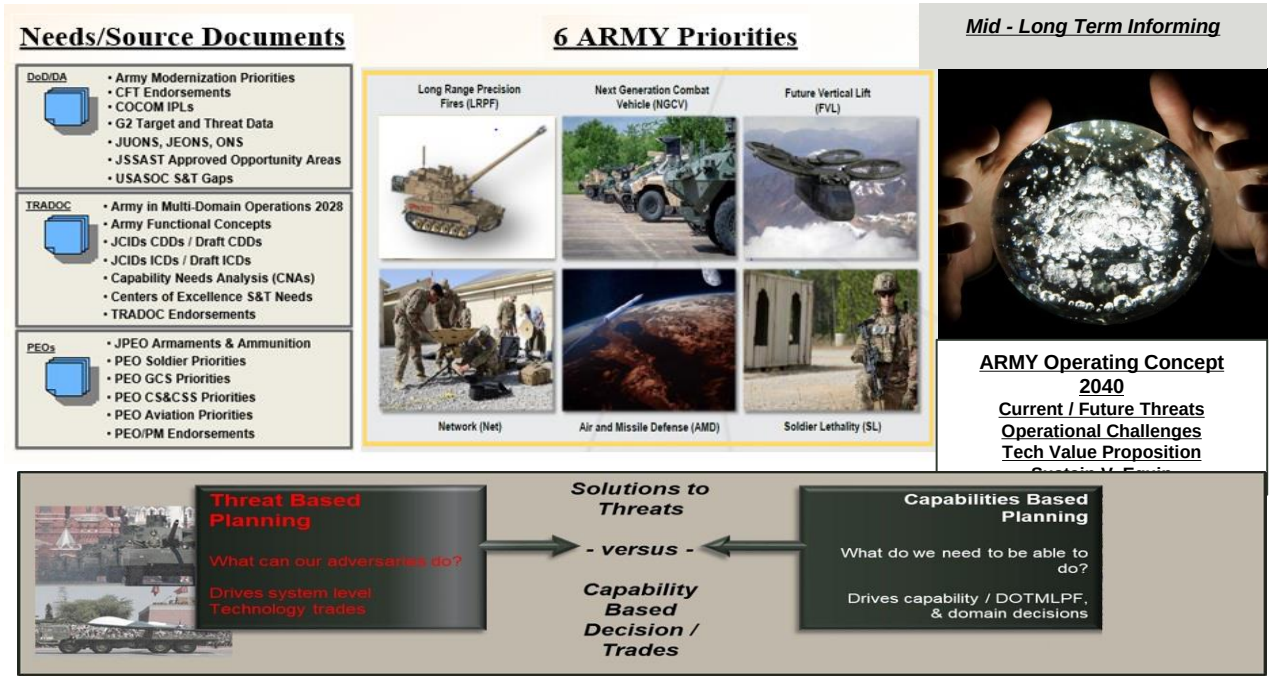
ARMAMENTS CENTER TECH BASE PLANNING

✓Needs/gaps/priorities are analyzed across DoD Lethality stakeholders, Threat/Tech Trends, Future WF Concepts

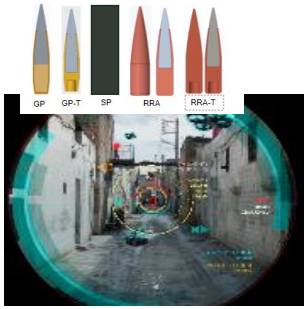


Armaments Tech Base Planning across:

Threat, PM/Joint Stakeholders, Users/Combat Dev, SPAR, Technology Trends, Partner R&D

SMALL CAL ARMAMENTS

Recent Accomplishments:



- **6.8mm Next Generation Squad Weapon**
  - 3QFY19 – Successful transition of 6.8mm AR and Carbine Technology
- **6.8mm Family of Ammo**
  - 4QFY22 – Successful transition of 6.8mm FoA
- **Fire-Control Technologies**
  - Successful transition of Squad Combat Optics Performance Enhancement (SCOPE) tech to enable FY24 Av. Fire Control Tech Transition

6.8mm NGSW Weapon & Ammunition Tech Demo

Future Technology Thrusts:

Enhanced Weapon Concepts & Lightweighting Tech
Enhanced Precision & Complex Target Defeat
Enhanced Concealed / Protected Target Defeat
Signature / Suppressor Technologies
Fires from Enclosure
Enabling / Augmenting Robotics
Intelligent / Collaborative Fire Control
Common Fire Control
Expanded Data Link Capabilities
Advanced Ballistic Algorithms

MEDIUM CAL ARMAMENTS - GROUND

Recent Accomplishments:

- **50mm XM913 Weapon**
  - 3QFY21 – Successful transition of 50mm stabilized weapon & ammunition handling system
- **50mm Ammunition**
  - 3QFY21 – Successful transition of 50mm Area engagement and SP defeat ammunition
- **Scenario Based Intelligent Fire Control**
  - Successful demonstration of cross-caliber/platform MOSA F-C enabling significant increase in target engagement response, accuracy & effects

XM913 Weapon , Ammo & Fire Control Tech demo

Future Technology Thrusts:

Smart / Enhanced Targeting Munitions
Multi-function / Cross-domain Munitions
Advanced Fuzing & Datalinks
Extended Range & Area Effects
Interceptor Munitions
Modular, Common, Multi-Use Components
Platform Agnostic Remote Weapons Tech
Robotic and Autonomous Armaments
Collaborative / Cooperative Fires
Non-Volume Suppressive Effects
Intelligent & Common Fire Control (FC)
Expanded Data Link Capabilities

MEDIUM CAL ARMAMENTS - AIR

Recent Accomplishments:

- **20mm XM915 Weapon**
  - Successful demonstration of airworthy 20mm weapon system w/ >125k rounds fired to date
- **Fire-Control**
  - Successful demonstration of FACE/MOSA compliant architecture for enhanced targeting
- **Expendable Aviation Countermeasures**
  - Successful verification of expendable performance against sophisticated threat systems

XM915 Weapon & Fire Control Tech enhancements

Future Technology Thrusts:

Smart / Enhanced Targeting Munitions
Multi-function, tunable & cross-domain Munitions
Advanced Fuzing & Datalinks
Extended Range Precision & Area Effects
Interceptor Munitions
Modular, Common, Multi-Use Components
Lightweight / Stabilized Weapon Mounts
Autonomous / Unmanned Armaments
Collaborative / Cooperative Fires
Non-Volume Suppressive Effects
Intelligent & Common Fire Control (FC)
Expanded Data Link Capabilities

LARGE CALIBER INDIRECT FIRES

Recent Accomplishments:

- **Extended Range Cannon Artillery (ERCA) Weapon**
  - 4QFY21 – Successful XM1299 SPH demo & transition o ERCA Extend Range Weapon System
- **ERCA Ammo-Handling**
  - 2QFY21 – Successful demonstration of High Rate-of-Fire Artillery Autoloader >>2x current RoF
- **ERCA Suite of 155mm Munitions**
  - 4QFY19 – Successful XM1113 / XM1210 HE RAP transition
  - 1QFY22 – Successful demonstration of novel 155mm range extension technology >> 2x Future

ERCA Weapon & Munition Tech enhancements M109 FoV

Future Technology Thrusts:

Smart/ Collaborative Munitions & Fires
Multi-function & Scalable Munitions
Non-Kinetic / Multi-Domain Effects
Counter Measure Hardened Munitions
Advanced Fuzing
Extended Range & Precision Effects
Interceptor Munitions
Robotic and Optionally Manned Artillery
Intelligent & Common, Fire Control (FC)
Expanded Data & Targeting Link Capabilities
Advanced FC & Ballistic Algorithms
Assured PNT for GPS Degraded Env
Advanced Target Seeking and Maneuver

LARGE CALIBER DIRECT FIRE

Recent Accomplishments:

- **LCAS Weapons Turret**
  - 4QFY21 – Successful demonstration & industry transition of a platform agnostic LW 120mm automated weapon system
- **Extended Line of Sight (ELOS) Munitions**
  - 1QFY22 – Successful Guide-to-Hit demonstration of 120mm Extended Line of Site engagement >>3km
- **Scenario Based Intelligent Fire-Control**
  - Successful demonstration of cross-caliber/platform MOSA Fire-Control enabling significant increase in target engagement response, accuracy & effects

AMP Tech enhancements to fielded MBT

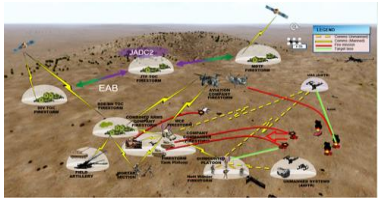
Future Technology Thrusts:

Smart / Enhanced Targeting Munitions
Advanced Accuracy and Pentration Tech
Multi-function & Scalable Munitions
Extended Range Targeting & Precision Effects
Counter Measure Hardened Munitions
Advanced Fuzing

Robotic and Autonomous Armaments
Intelligent & Common Fire Control (FC)
Expanded Data Link Capabilities
Advanced FC & Ballistic Algorithms

ENABLING ARMAMENTS TECH

Recent Accomplishments:



- **Ballistic Low Altitude Drone Engagement (BLADE)**
  - 2QFY22 – Successful demonstration and defeat of small Unmanned Aerial System (UAS) threats
- **FIRES Synchronization To Optimize Responses in MDO (FIRESTORM)**
  - 1QFY22 – Successful demonstration of Sensor-to-Shooter Networked Lethality across echelons in support of integrated and Joint Fires

Blade Tech enhancements to fielded RWS

Future Technology Thrusts:

Cross mission/domain tech
Highly Directional / Scalable Explosives & Warheads
Application of Advanced Materials
Enhanced Propulsion & Energetic Science
Advanced / Additive / Subtractive Manufacturing
Ballistically Hardened structural materials
Multi-function Fuzing and Power
Advanced Decision Aids & Networked Lethality
Verified and Validated M&S tools
Reduced Life Cycle Environmental Impact
Contested Logistics Automation and Reduction

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FUTURE OF ARMAMENTS STRATEGY

- **DEVCOM Armaments Center has initiated a Future of Armaments (FoA) Workshop series to:**
  - Identify Necessary Armaments Capabilities and Attributes to support the Army Operating Concept of 2040
  - Inform, shape, and align Armaments Investments through Threat-Based Analytics and Broad-Stakeholder Input
  - Broaden strategic partnerships & cooperative investments
- **Industry perspective to be provided by the National Armaments Consortium (NAC)**
- **Strategy completion targeted FEB 2023**

Leading the Continued Modernization of Armaments through both Evolutionary and Revolutionary Strategic Investments

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PARTNERING THROUGH TECHNOLOGY TRANSFER

- Our most common tools:
  - CRADAs
  - Educational Partnerships
  - Service Agreements
  - Consortia
  - Patent Licensing
  - IR&D
  - SBIR/STTR
  - International Agreements

- **Science & Technology**
  POC: Michael George, michael.c.george1.civ@army.mil
- **Cooperative R&D Agreements (CRADAs)/Patent Licenses/Testing Services/Engineering Services**
  POC: Andrew Lenz, andrew.j.lenz6@army.mil
- **IR&D Technical Interchange**
  POC: Don Geiss, donald.a.geiss.civ@army.mil
- **Small Business Innovation Research**
  POC: Ben Call, benjamin.d.call.civ@army.mil
- **International Cooperation**
  POC: Scott Cawood, scott.a.cawood.civ@army.mil
- **Department of Defense Ordnance Technology Consortium (DOTC)**
  POC: Glen Berg, glen.w.berg.civ@army.mil

Visit our Technology Transfer Website
https://ac.ccdc.army.mil/collaborate/

CCDC Armaments Center Transfers Technology to the Industry Base to Speed Transition to the Warfighter

QUESTIONS / DISCUSSION

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Marine Corps Systems Command
Program Manager, Ammunition

Mr. Scott Adams
20 September 2022

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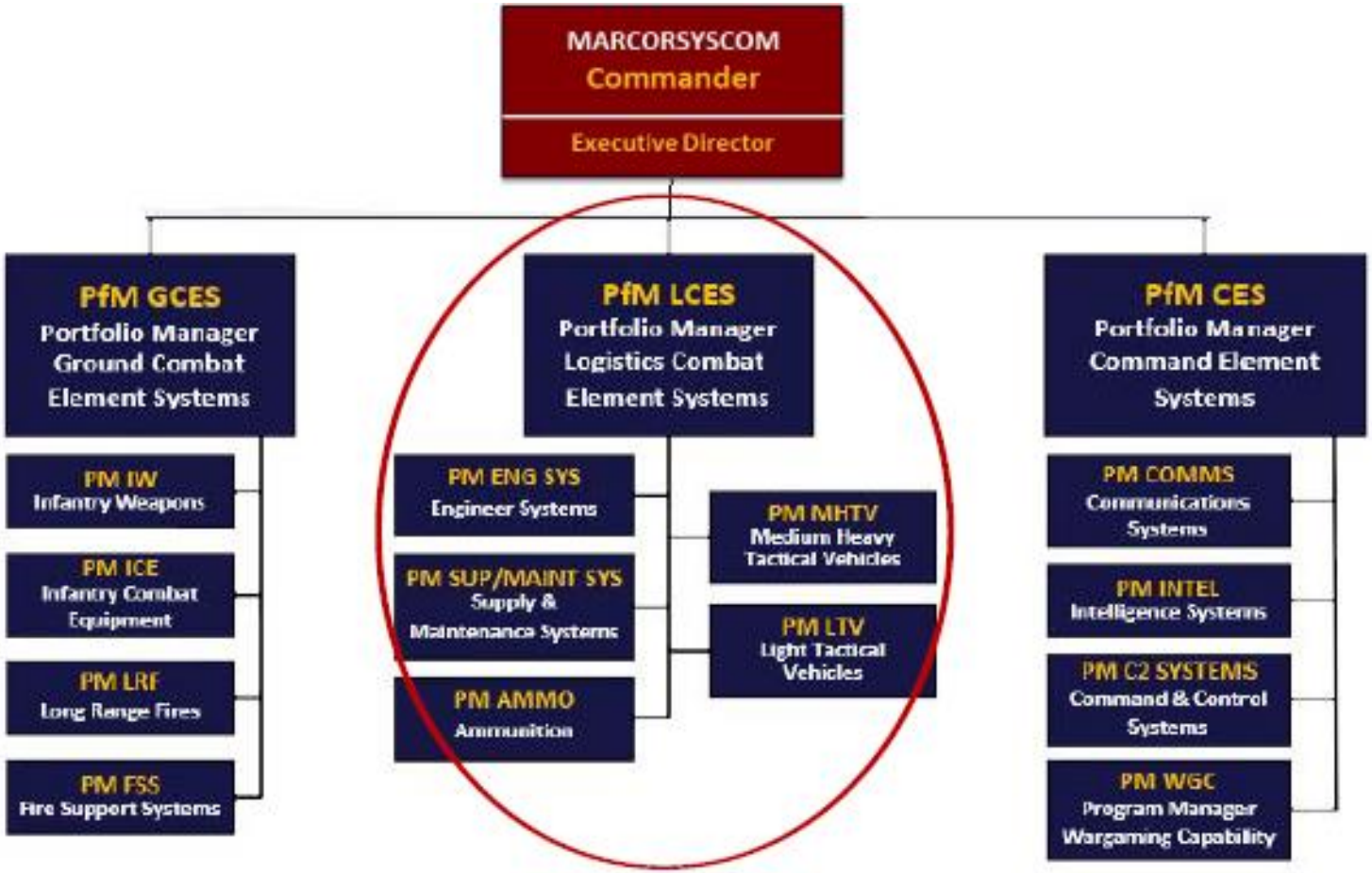
MARCORSYSCOM Organization



PM Ammo

Program Manager
Mr. Scott Adams

Deputy Program Manager
LtCol Brian Wisneski

JPEO / JMC LNOs

Contracts Support Team

Technical Support Team

- **Product Manager Maneuver Ammo and Missiles**
- **Product Manager Close Combat and Combat Ammunition**
- **Environmental & Explosives Safety Branch**
- **Inventory Management Branch**
- **Plans & Analysis Branch**
- **Ammunition Operations & Systems Team**

CIV: 42
MIL: 31
***OGE: 4**
CTR: 17

- 38th Commandant of the Marine Corps' Planning Guidance
  - Force Design is his #1 priority
  - Divest of legacy defense programs and force structure that support legacy capabilities
  - Modernization effort to remain an expeditionary crisis response force
  - Ability to partner, persist and operate forward despite adversary employment of long-range precision fires
  - Decisions informed by wargaming, experimentation, and analysis

- Expeditionary Advanced Base Operations
  - Allows naval expeditionary forces to operate from a series of austere, temporary locations ashore or inshore within a contested or potentially contested maritime area in order to conduct sea denial, support sea control, or enable fleet sustainment.

- Stand-In Force
  - Small, lethal, low signature, and mobile
  - Designed to operate across the competition continuum within a contested area as the leading edge of a maritime defense-in-depth
  - Positioned forward, shoulder-to-shoulder with allies and partners

- Navy Marine Expeditionary Ship Interdiction System (NMESIS)
  - Two Naval Strike Missiles (NSM) containers on a remotely-operated unmanned Joint Light Tactical Vehicle (JLTV)

- Organic Precision Fires-Mounted (M)
  - Loitering munition; provides the Marine Corps with ISR and precision indirect fire strike capability

- Infantry Modernization
  - Improved lethality while maintaining/improving the mobility of the individual Marine, the Marine Rifle Squad, and the MAGTF
  - M27 Infantry Automatic Rifle
  - Next Generation Squad Weapon
  - Shoulder-Launched Weapon Systems
    - 66 mm Lightweight Assault Weapon-Fire From Enclosure (LAW-FFE)
    - 84mm AT-4 Confined Space (AT-4 CS)
    - 84mm Carl Gustaf recoilless rifle

PM Ammo Initiatives

- Polymer-cased ammunition
- Signature on Target ammunition for 7.62mm /.50 Cal /.338 Norma
- Increased lethality for 40mm weapon systems
- Trace capability for 40mm high velocity one-way luminescence (OWL)
- Improved Anti-Personnel Obstacle Breaching System (APOBS)
- Lightweight ammunition packaging
- Polymer recycling
- 3D Printable munitions and energetics

Questions?

Mr. Scott Adams
scott.adams1@usmc.mil
(703) 414-9531

U.S. ARMY JOINT MUNITIONS COMMAND

FUTURE FORCE CAPABILITIES & EXHIBITION

MR. NATHAN HAWLEY
JMC, MUNITIONS AND LOGISTICS READINESS CENTER DIRECTOR

COL LANDIS MADDOX ▪ COMMANDER
CSM PETRA CASAREZ ▪ COMMAND SERGEANT MAJOR

Version Number 2
As of 14 September 2022

Controlled by: AMJM-CIG
Distribution Statement A
Approved for public release
POC: Ms. Michelle Timmerman

READY – RELIABLE – LETHAL!

MISSION AND PRIORITIES

PRIORITIES

SA Priorities
- People
- Readiness
- Modernization

CSA Priorities
- People
- Readiness
- Modernization

AMC Priorities
- People
- Readiness
- Modernization

JMC Priorities
- People
- Readiness
- Modernization

AMC

MISSION

Army Materiel Command Delivers Logistics, Sustainment and Materiel Readiness From the Installation to the Forward Tactical Edge to Ensure Globally Dominant Land Force Capabilities.

VISION

Army Materiel Command is Operationalized and Postured to Sustain a MDO Capable and Ready Force

JMC

MISSION

Provide the Joint Force with Ready, Reliable, Lethal Munitions at the Speed of War Sustaining Global Readiness.

VISION

Provide Lethality that Wins!

People – Readiness – Modernization

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OUR PORTFOLIO

PRODUCE

DISTRIBUTE

STORE

DEMIL

GLOBAL SUSTAINMENT

U.S.ARMY

Enables

JOINT MUNITIONS COMMAND

READY - RELIABLE – LETHAL!

Supports

JOINT SERVICE SUPPORT

17 Organic Industrial Base Facilities
15 Ammunition Sites
2 Chemical Sites

$64B Munitions Inventory

$6.2B in Total Foreign Military Sales (FMS); 86 Countries

12,000+ Employees Enabling Joint Warfighter Readiness, While Relentlessly Modernizing.

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JMC ORGANIC INDUSTRIAL BASE

PRODUCE
Iowa Army Ammunition Plant
LTC Jason Crist
- Med. & Large Cal. Load, Assemble & Pack
- Missile Warheads
- C4 Extrusion

PRODUCE
Quad City Cartridge Case Facility
- Deep Drawn Cartridge Cases

HQ, Joint Munitions Command
COL Landis Maddox
CSM Petra Casarez
- Produce
- Distribute
- Store
- Demil

PRODUCE • DISTRIBUTE • STORE • DEMIL
Crane Army Ammunition Activity
COL Santee Vasquez
- Ammo Supply Depot Ops
- 5"/54 & 76mm
- Illum, Pyro, Flares

DISTRIBUTE • STORE • DEMIL
Letterkenny Munitions Center
LTC Timothy Ballas
- Ammo Supply Depot Ops
- Tactical Missiles
- **CITE** for Missile Maintenance

PRODUCE
Scranton Army Ammunition Plant
Mr. Richard Hansen
- Projectile Metal Parts

HQ, Chemical Materials Activity
Mr. Kelso Horne
- Oversight of BGCA and PCD

DISTRIBUTE • STORE • DEMIL
Tooele Army Depot
COL Eric Dennis
- Ammo Supply Depot Ops
- **CITE** for Ammunition Peculiar Equipment

DISTRIBUTE • STORE • DEMIL
Hawthorne Army Depot
Mr. Larry Cruz
- Ammo Supply Depot Ops

MOTCO

DISTRIBUTE • STORE • DEMIL
Blue Grass Army Depot
COL Brett Ayvazian
- Ammo Supply Depot Ops
- Chemical Defense Equipment

STORE • DEMIL
Blue Grass Chemical Activity
LTC Tyler McKee
- Chemical Weapons
- Stockpile Storage

STORE • DEMIL
Pueblo Chemical Depot
COL Jason Lacroix
- Chemical Weapons

MOTSU

PRODUCE
Radford Army Ammunition Plant
LTC Russell Jones
- Propellants

PRODUCE
Lake City Army Ammunition Plant
LTC Christopher Denton
- Small Caliber
- Perform Reliability Testing for Small Cal

PRODUCE • DISTRIBUTE • STORE • DEMIL
Holston Army Ammunition Plant
LTC Joel Calo
- Explosives

PRODUCE • DISTRIBUTE • STORE • DEMIL
McAlester Army Ammunition Plant
COL Michael Hammond
- Ammo Supply Depot Ops
- Navy/Air Force Bombs
- Intelligent Munitions

PRODUCE • DISTRIBUTE • STORE • DEMIL
Pine Bluff Arsenal
COL Tod Marchand
- Ammo Supply Depot Ops
- Smoke/Obscurants & Phosphorus
- **CITE** for Chemical and Biological Defense Equipment
- **CITE** for Smoke Ammunition
- **CITE** for Textile Manufacturing

Milan Army Ammunition Plant
Mr. Thomas Nowell
- Load, Assemble & Pack (Inactive)

DISTRIBUTE • STORE • DEMIL
Anniston Munitions Center
LTC Daniel Cross
- Ammo Supply Depot Ops
- Missile Supply Depot

PRODUCE
DISTRBUTE
STORE
DEMIL
SPECIALTY SITES
OUTLOAD SITES

Team JMC - Providing Munitions Readiness to the Warfighter

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JMC OIB MODERNIZATION: 15-YEAR APPROACH

GUIDANCE

Congress
- Title 10
- U.S. Codes

OSD
- DODD/DODI
- FMR
- DOD Strategy

SECARMY/CSA
- Regulations
- Policy
- AOIB Strategy
- Priorities

ASA(ALT)/CDR AMC
- Army Regulations
- Army Policy
- AMC Regulations
- AMC Policy

AMC Lines of Effort

- LOE 1: Facilities
- LOE 2: Tooling and Processes
- LOE 3: Workforce
- LOE 4: Network/ Cyber
- LOE 5: Energy / Environment

AMC Goals & Outcomes

- Meet current Army readiness demands
- Posture for supporting enduring and signature modernization systems
- Surge for Large Scale Combat Operations (LSCO)
- Reduce single points of failure and reliance on foreign sources
- Identify and mitigate supply chain risks
- Sunset legacy systems and excess capacity
- Retrain / realign workforce to support 21st Century technology

Phase I: FY24 – FY28
Building the Foundation for 21st Century Capabilities

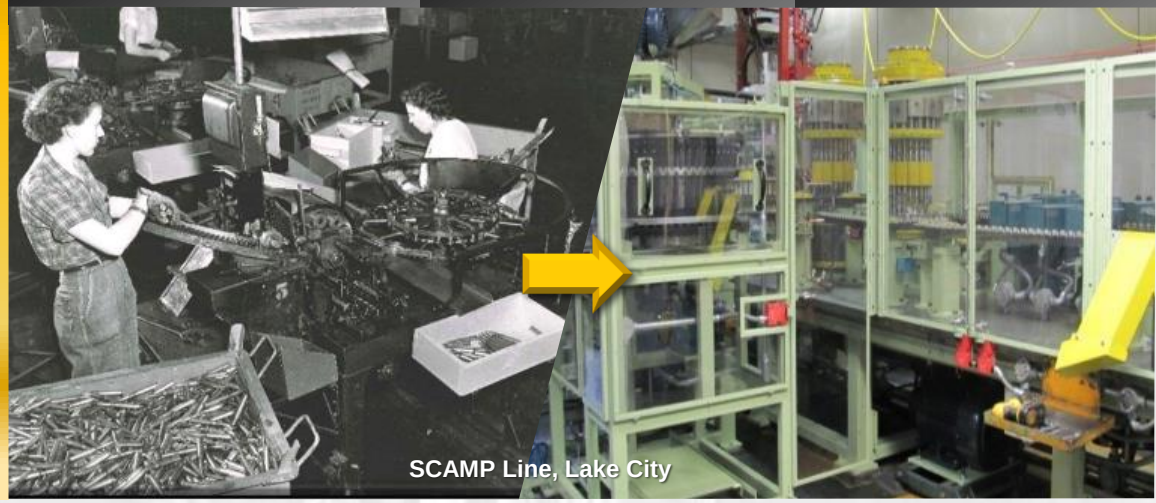
- New Next Gen Squad Weapon Ammo Facility (LAKE CITY)
- Modernize Long Range Artillery Munitions (IOWA)
- Establish Precision Strike Missile Depot Maintenance (LETTERKENNY)

Phase II: FY29 – FY33
Continuing to Build Capabilities and Attacking Vulnerabilities

- Advanced Pyrotechnic Production (CRANE)
- Modernize Solventless Propellant (RADFORD)
- Replace Water Distribution System (HOLSTON)

Phase III: FY34 – FY38
Maintaining and Sustaining our Investments

- Right-sized Smoke & Illum production (PINE BLUFF)
- Modernize Tank Ammo (IOWA)
- New Water Treatment Plant (MCALESTER)



SCAMP Line, Lake City

A Strategic Sustainable Path to Modernization

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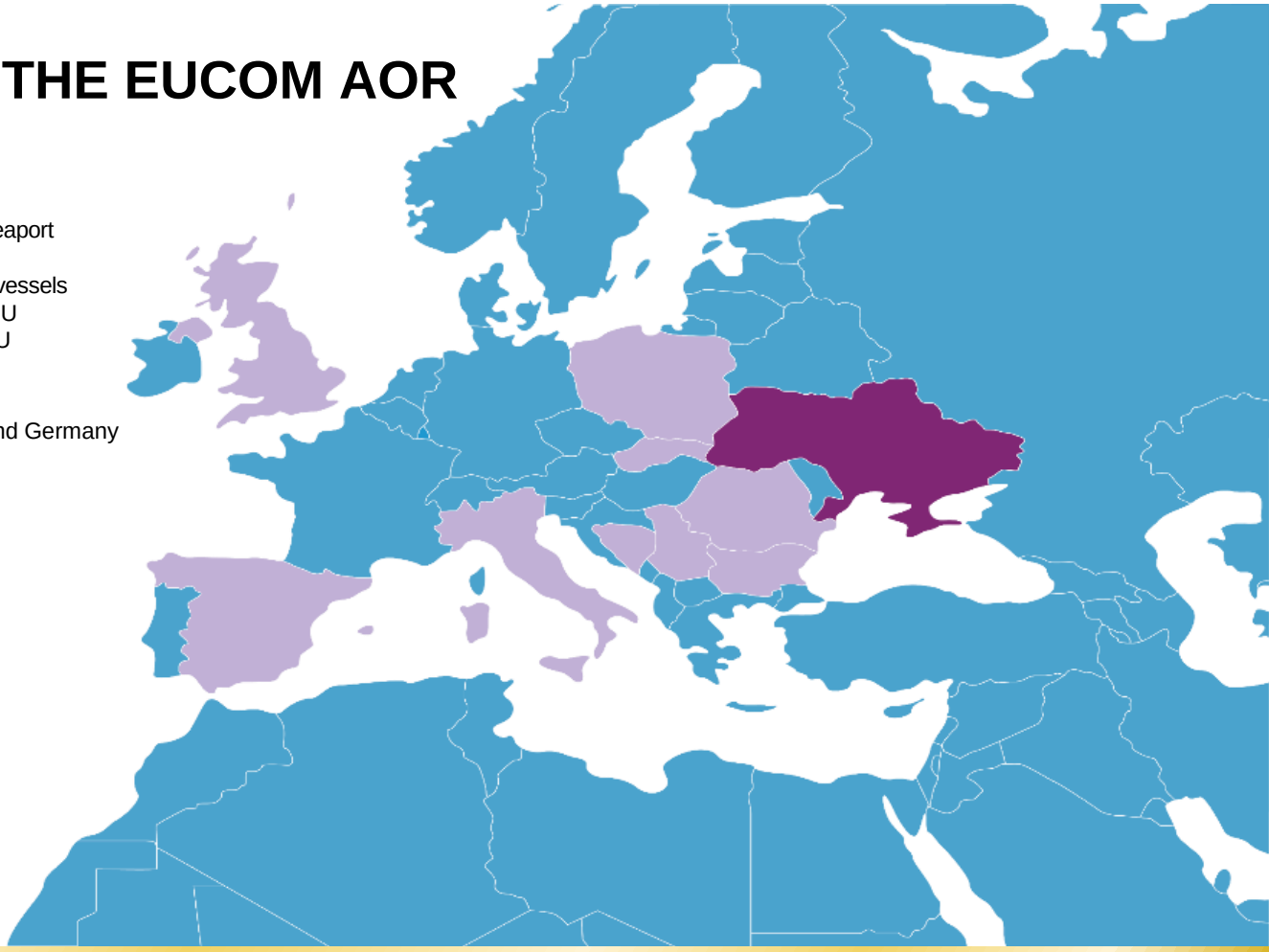
MUNITIONS TO THE EUCOM AOR



JMC Industrial Base Support:

- 2141 trucks from 8 locations to 5 airfields and 1 seaport
  - 1543 trucks to APOEs, 598 trucks to SPOEs
- 1733 TEUs shipped to MOTSU for 5 un-forecasted vessels
  - 598 TEUs of ammo moved by truck to MOTSU
  - 1135 TEUs of ammo moved by rail to MOTSU

Air

- 2022 – 327 flights of ammo to Ukraine, Poland and Germany
- 2021 – 80 fights of ammo total

Vessels

- Mar – (AS29) 413 containers.
- Apr – (AS32) 451 containers
- Jun – (AS33/AF58) 318 containers
- Jul – (AS34) 294 containers
- Aug – (AS35) 257 containers

Presidential Drawdowns #1-19
  - 70M+ Rounds valued at over $1.3B

Ukraine Security Assistance Initiative
  - 1.1M Rounds valued at $373.3M

Foreign Military Sales
  - 2.7M Rounds valued at $185.6M

READY – RELIABLE – LETHAL!

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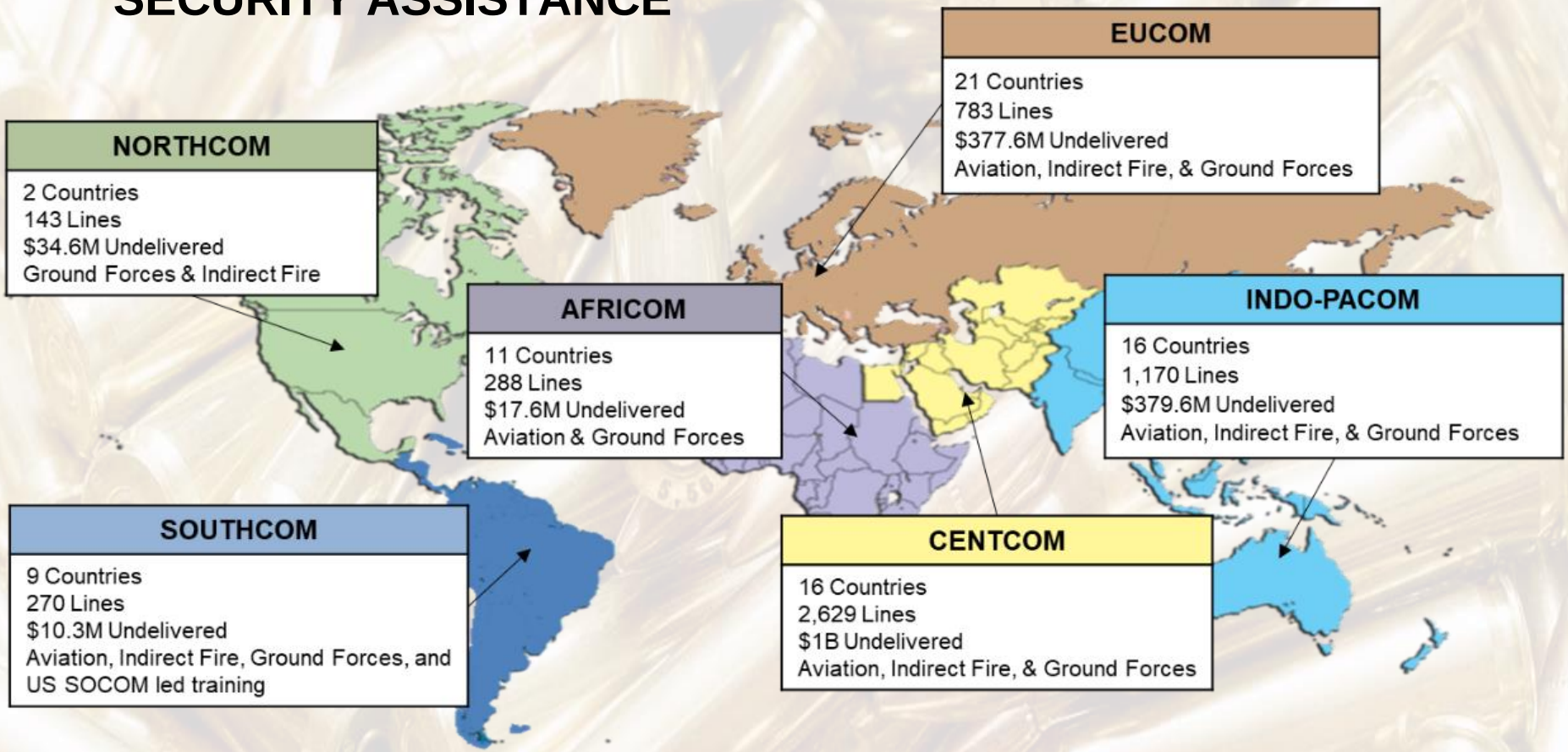
SECURITY ASSISTANCE



Building Capacity and Capability for Partners and Allies.

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TAKE AWAYS

- **We remain nested with the Army's and AMC priorities of People, Readiness, and Modernization.**
- **JMC synchronizes, integrates, and operationalizes the capabilities of our Organic Industrial Base (OIB), providing munitions readiness to the Joint Force to meet current, future, and contingency requirements in Large Scale Combat Operations.**
- **We are focused on transforming the Ammunition OIB and mitigating risk in the munitions supply chain.**
- **Collaboration with our unmatched network of alliances and partnerships is vital in providing strategic readiness to our Warfighters.**

Ready – Reliable – Lethal!

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QUESTIONS

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SUPERVISED AUTONOMOUS FUNCTION EXECUTIVE SAFE™

An Autonomy Enabler

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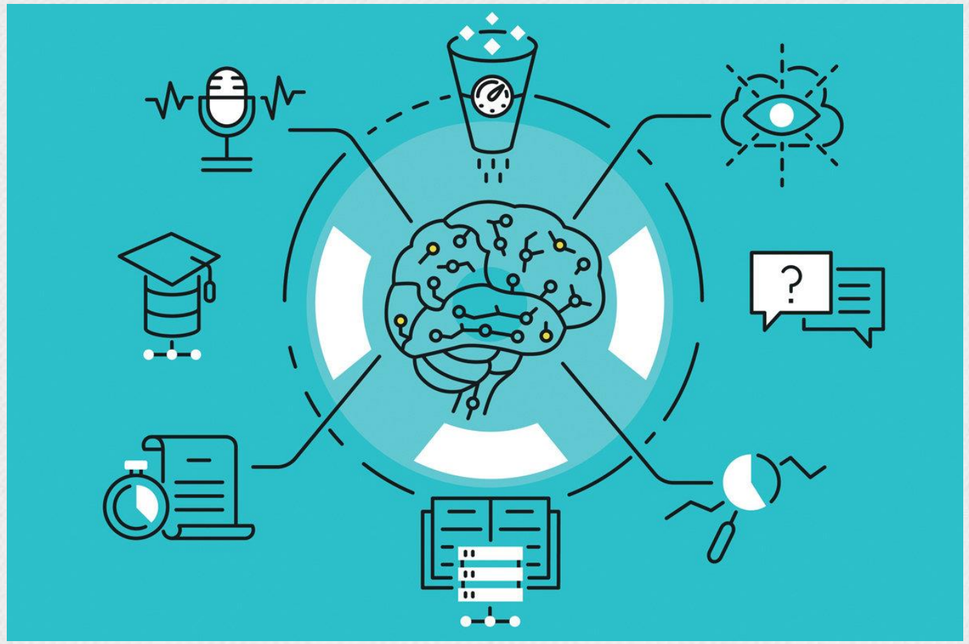
MTSI
MODERN TECHNOLOGY SOLUTIONS, INC.®
Innovative Technical Solutions for the 21st Century

The Problem

How do we certify?

Artificial Intelligence



Machine Learning

DoD Artificial Intelligence Principals:
Responsible, Equitable, Traceable, Reliable, **Governable**

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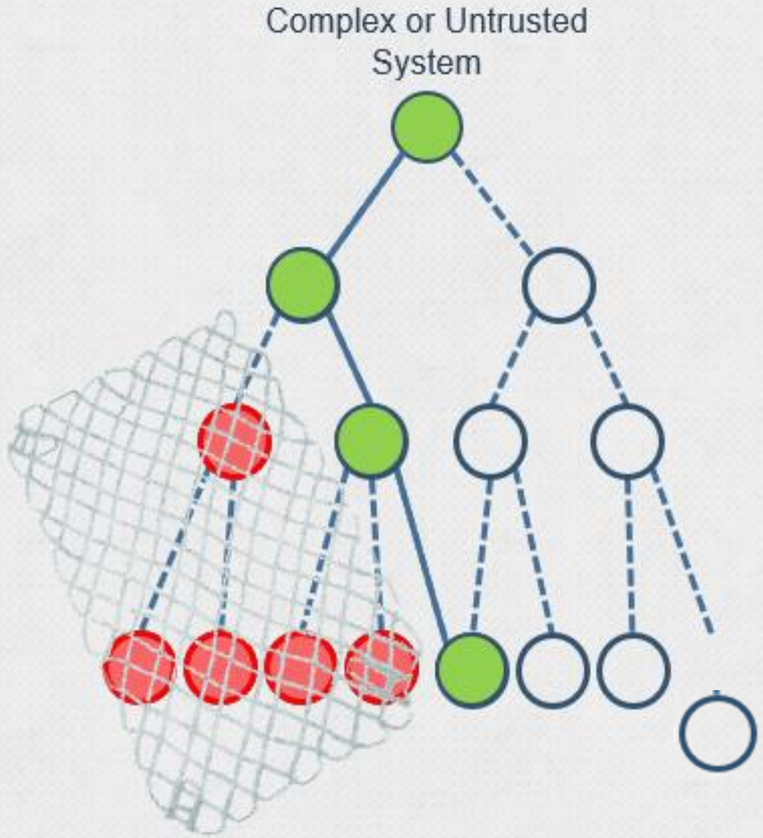
THE SOLUTION : SAFE™

Supervised Autonomous Function Executive (*SAFE*™)

Simple and deterministic Multi-Monitor Runtime Assurance software that restricts vehicle from violating user selected criteria

A safety net around untrusted systems.



MODERN TECHNOLOGY SOLUTIONS, INC.®

An Employee Owned Company

EVAA/SAFE UPDATE

- MTSI was imbedded with NASA team during development of Expandable Variable Autonomous Architecture (EVAA)
- EVAA has flown on several aircraft since 2010 and the basic Ground Collision Avoidance algorithms are fielded on F-16/35
- MTSI has a Software Usage Agreement with NASA
- MTSI has HWIL/SWIL conducting independent evaluation and is improving/maturing the software

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HISTORICAL BACKGROUND

MODERN TECHNOLOGY SOLUTIONS, INC.®

An Employee Owned Company

Performance Based Certification

F-16 Auto GCAS & ACAS

AvSP

1st Industry Standard

UTM & SASO

2018 Collier

Resilient Autonomy

Reference Implementation Development

Autonomy Safety Standards

NASA

Industry

DoD

MTSI Flight Demo CY22

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How EVAA/SAFE™ Works

EVAA

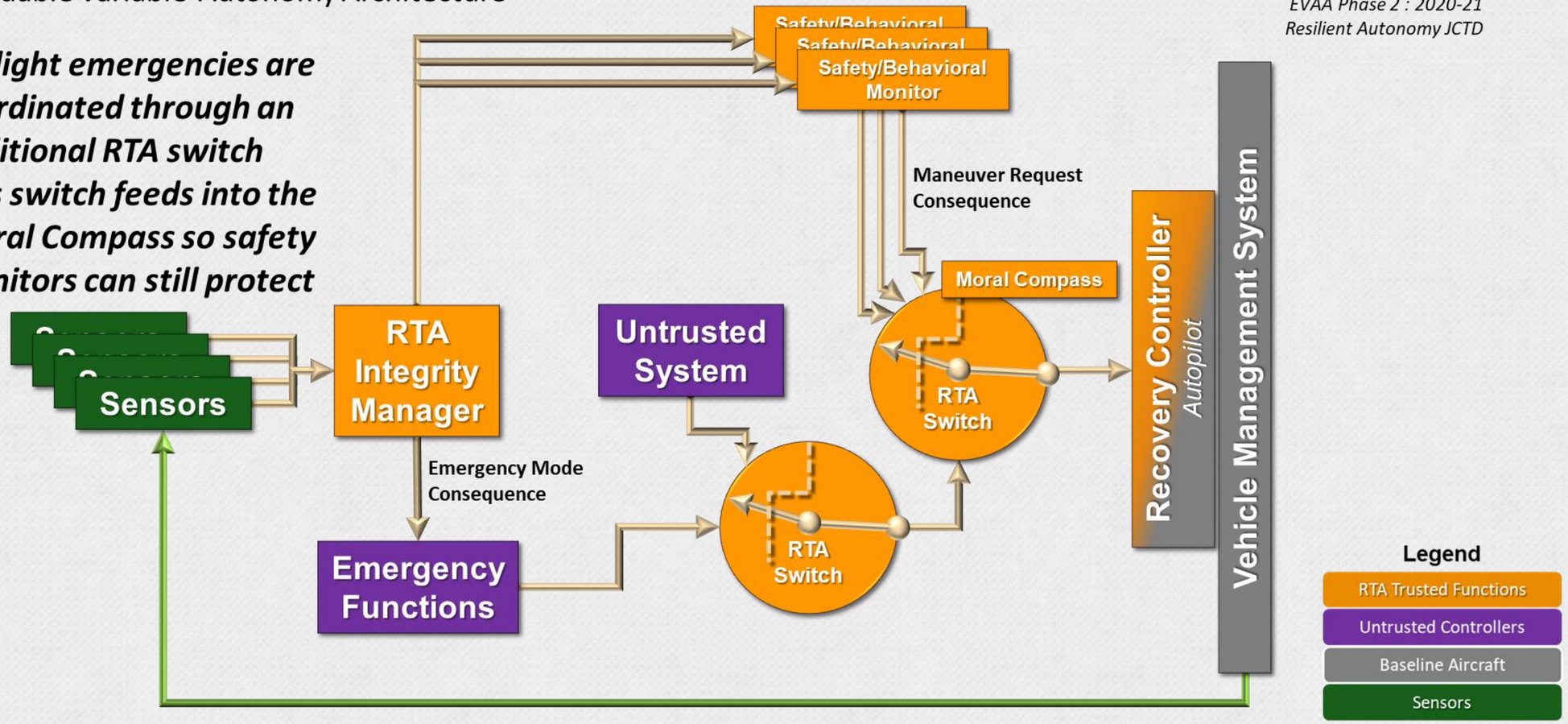
Phase 2 : Current Work

Expandable Variable-Autonomy Architecture

- ***In-flight emergencies are coordinated through an additional RTA switch***
- ***This switch feeds into the Moral Compass so safety monitors can still protect***

RTA Network

EVAA Phase 2 : 2020-21
Resilient Autonomy JCTD



RTA: RunTime Assurance

SAFE™ ARCHITECTURE

- **Microservices**
  - Easily scalable by adding more hardware
  - Publish / Subscribe means adding new services is easy and painless.
- **Robust**
  - Multiple Processes
    - If a component crashes, then all other components still work as intended.
  - Self-Healing by using heartbeats & hardware watchdogs.
- **Built using modern C++ best practices.**
  - Static Analyzers help detect bugs before they become an issue.
  - RAII handles memory management instead of the developer.
    - Eliminates an entire class of bugs.
- **Built with formal requirements**

SUMMARY

- SAFE™: Government owned software
- Demonstrated capabilities:
  - Ground Collision Avoidance
  - Air Collision Avoidance
  - Weather Avoidance
  - Forced Landing
- Architecture adaptable to ground systems
- MTSI flight demo planned for CY22
- Artificial Intelligence certification enabler
- Per NASA Software Usage Agreement, continued development/integration requires government sponsor

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

NDIA - JOINT SERVICE SMALL ARMS SYNCHRONIZATION TEAM (JSSAST)

Gus Funcasta

Chief, Joint Service Small Arms Program Office

U.S. Army DEVCOM Armament Center | Picatinny Arsenal, NJ 07806

JSSAP email: usarmy.pica.futures-cmd.mbx.jssap@army.mil

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JSSAST BACKGROUND

- In 1978, by the direction of US Congress, the Office of the Under Secretary of Defense directed the establishment of the Joint Service Small Arms Program (JSSAP) Office and the JSSAP Management Committee (JSSAP MC) with the Army as the Executive Agent.

- A Management Committee (JSSAP MC) was chartered and originally consisted of representatives from the US Army, US Navy, US Marines and US Air Force

- The JSSAP MC Charter was updated and endorsed by Mr. Claude M. Bolton Jr., Assistant Secretary of the Army for Acquisition, Logistics, and Technology on 31 Aug 2004 to include USSOCOM and US Coast Guard and re-titled the JSSAP MC to the Joint Service Small Arms Synchronization Team (JSSAST).

JSSAST MISSION

- The overarching mission of the JOINT SERVICE SMALL ARMS SYNCHRONIZATION TEAM (JSSAST) is to:

  – coordinate and harmonize new Service materiel requirements with potential joint applications,

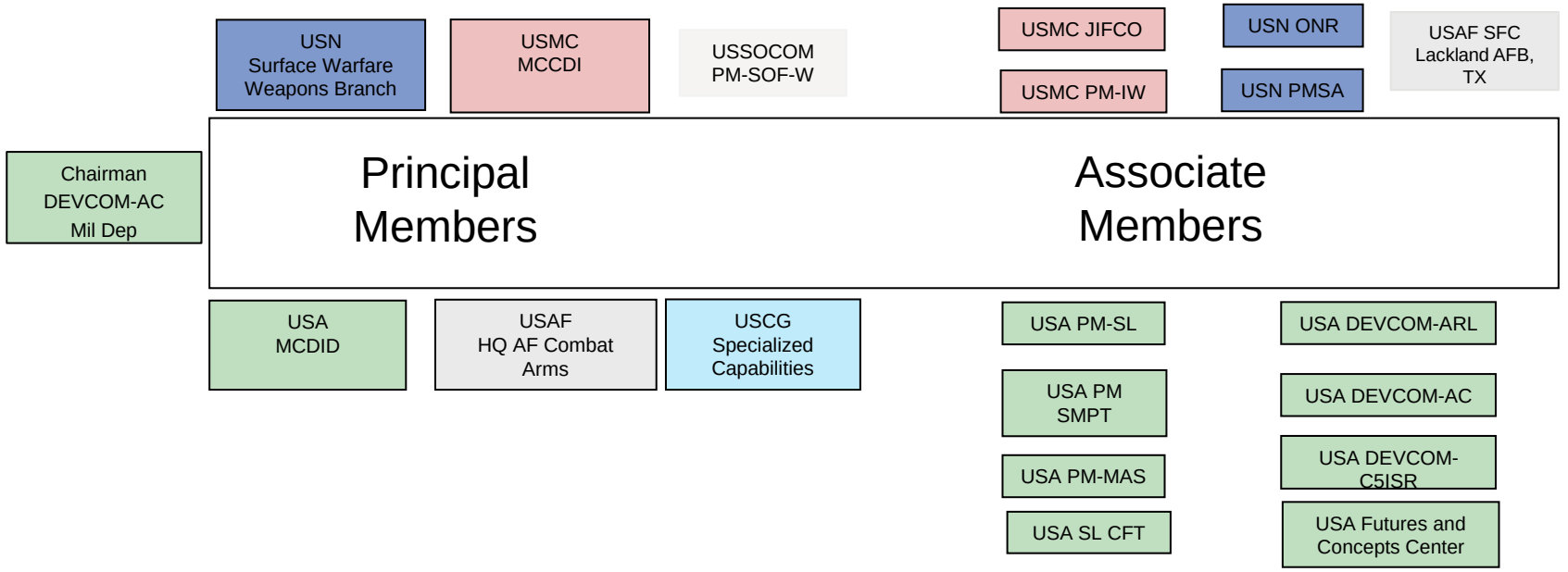
  – approve annual updates of Joint Service Small Arms Capability Gaps, approve the JSSAP S&T project portfolio on an annual basis,

  – and to maintain an awareness of the Services' efforts to improve small arms capabilities in order to reduce duplication of ongoing and planned technology, acquisition, and sustainment activities.

JOINT SERVICE SMALL ARMS SYNCHRONIZATION TEAM (JSSAST)

The JSSAST Team is composed of:

- Principles representing each of the Services and SOCOM Combat Developers
- Associates representing each of the services PMs, S&T/R&D Labs, Soldier Lethality-CFT and the Joint Intermediate Force Capabilities Office (formerly Joint Non-Lethal Weapons Office)



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JOINT SERVICE SMALL ARMS PROGRAM OFFICE FRAMEWORK

Joint Service Small Arms Synchronization Team (JSSAST)

PRINCIPALS:

CHAIRMAN:	LTC Kevin Shilley (P) (DEVCOM-AC MILDEP)
ARMY:	Mr. John Yancey (USA MCDID-SRD)
MARINES:	Mr. Christopher Woodburn (MCCDC)
AIR FORCE:	Mr. Craig LaMudge (HQ AFSFC)
NAVY:	CAPT John "Dave" Stoner (LCDR Nicolas) (OPNAV N96C)
COAST GUARD:	CAPT Eric Casper (Chris Graham (HQ USCG)
SOCOM:	LTC John Lancaster (Gene Rooker) USSOCOM PM-SOF-L

ASSOCIATES:

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USA PM MAS:	COL Paul Alessio (PEO Ammunition)
USA DEVCOM-ARL:	Dr. James Newill (CCDC-ARL)
USA SL-CFT:	Ms. Artesha Bishop/MAJ Hendrix/MAJ Ottmar
USA C5ISR:	Mr. Dean Kissinger (NVESD)
USA DEVCOM AC	Mr. Michael George (DoT)
USN ONR:	Mr. Daniel Simons (Firepower)
USN PMSA:	Mr. Peter Gill (PMS-340)
USMC PM-IW:	LtCol Timothy Hough (MARCORSYSCOM)
USMC JIFCO:	Mr. Rob DeCoito (JIFCO)
SOCOM:	TBD
F&C Center:	Mr. Daryl Robinson

Joint

AC-JSSAP Office

- Joint Service Small Arms Requirements Integration Working Group
- JSSAP Science & Technology Advisory Council
- JSSAME-Joint Service Small Arms Metrics and Evaluation Working Group
- DoD Ordnance Technology Consortium (DOTC)

USMC Small Arms Modernization Brief

Mr. Chris Woodburn

Deputy, Maneuver Branch

Marine Corps Capabilities Development Directorate

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Summary

- CMC and DoD emphasis on the infantry
- Informed by operational lessons, technological maturity, industrial capabilities
- Guided by concepts and initiatives such as the CMC Planning Guidance, Close Combat Lethality Task Force, and Marine Expeditionary Rifle Squad
- Pending Force Design decisions in support of prioritized modernization for close combat personnel
- Aligned with the Joint strategy for weapons modernization to improve accuracy, lethality and mobility
- Prioritizes selective modernization and sustainment of critical legacy capabilities in the short term (now – FY26)
- Mid-term goals will capitalize on technological advances to deliver modern replacements for critical weapon systems (FY26-32)

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Weapons Strategy

- **Maintain current capabilities**
  - Implement improvements (accuracy, lethality, ergonomics and weight reduction) when technology and funding allow to keep small arms relevant
- **Improvements will be implemented on a much smaller scale, primarily to the infantry**
  - Expand to other combat arms when relevant and feasible
- **Future capabilities will be pursued via Joint efforts whenever possible**
- **End-State: Improved lethality while maintaining/improving the mobility of the individual Marine, the Marine Rifle Squad, and the MAGTF**

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Rifle Squad Lethality Improvements

Near Term

- **M27**
  - Procured and fielded 1 per Marine in rifle platoon
- **Squad Common Optic**
  - Trijicon VCOG, 1-8x, First Focal Plane, Mil-reticle
  - 1 per Marine in Rifle platoon
- **Rifle Squad Suppressor**
  - 1 per close combat Marine
  - Meets near term operational need while ongoing technology advancements are assessed

Mid Term

- **Next Generation Squad Weapon w/ Squad-Fire Control**
  - The Marine Corps is working with the Army on requirements and materiel solution development in pursuit of the next generation of squad weapons.

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Small Arms Capabilities

- **M27 – M4 (GCE Modernization Plan)**
  - The Marine Corps is currently modernizing the Ground Combat Element (GCE) in order to increase the lethality of the individual warfighter. Within the infantry platoons all M4s have been replaced with M27s and all M16A4s are being replaced by M4s within the GCE.

- **Advanced Sniper Rifle (ASR)**
  - 1:1 replacement of M40A6 and Mk13 Mod 7
  - The Marine Corps has an operational need for an improved capability to suppress and engage adversaries out to 1500 meters.

- **Machine Gun Modernization**
  - Seeking to increase lethality without impacting mobility of our machine gun sections within the rifle companies.
  - Participating in US Army Platoon Arms Ammunition Configuration (PAAC) Study to inform future machine gun capability requirements and solutions.

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Targeting Enablers

- **Squad Binocular Night Vision Goggle (SBNVG)**
  - White phosphorous, dual tube, image intensified binocular goggle with overlay thermal fusion provided through an Enhanced Clip-On Thermal Imager (ECOTI).
  - 12 of 21 infantry battalions fielded thus far.
  - The Marine Corps continues to assess the US Army's ENVG-B and IVAS solutions for maturity, suitability and affordability to meet our operational requirements.

- **Squad Range Finder**
  - Weapon-mounted device provides small unit leaders with an accurate range-to-target to enable an increased first round probability of hit.
  - Fielding to one per squad.
- **Squad Thermal System**
  - Lightweight thermal imager enables man-sized target detection out to the maximum effective range of squad weapon systems and can be employed in either a handheld or in-line clip-on weapon sight mode.
  - Fielding to squad and fire team leaders.

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Optics

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QUESTIONS?

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

NDIA - Joint Service Small Arms Program (JSSAP) Office

Gus Funcasta

Chief, Joint Service Small Arms Program Office

U.S. Army DEVCOM Armament Center | Picatinny Arsenal, NJ 07806

JSSAP email: usarmy.pica.futures-cmd.mbx.jssap@army.mil

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JOINT SERVICE SMALL ARMS PROGRAM OFFICE

An OSD Joint-Centric activity harmonizing requirements & providing Small Arms Technology for all the Armed Services

JSSAP Background/History

- 1978: Under Secretary of Defense established JSSAP office and the Joint Service Management Committee (JSMC) with the Army as the Executive Agent.
- JSMC was composed of 4 principal voting members: USA, USN USMC, USAF
- Harmonize multi-service requirements
- Consolidate and coordinate development, reduce costs, and improve the efficiency of the material acquisition process.
- 1991: JSSAP transitions PM and lifecycle support, focusing exclusively on S&T
- 2004: Charter updated adding 2 more principal members: USCG, SOCOM

Mission Statement

- ✓ **Intensive management of the DoD Small Arms Tech Base**
- ✓ **Coordinate and Harmonization of Requirements**
- ✓ **Transitions Technology to Program Managers for Engineering and Manufacturing Development**
- ✓ **Long Range Plans and Strategies**
- ✓ **Influence of International Small Arms Activities**

… and fulfill Executive Agent responsibilities per Deputy Under Secretary of Defense (Research and Engineering) Memorandum, 10 May 1978

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JSSAP AREAS OF RESPONSIBILITY (AOR)

JSSAST –Joint Services Small Arms Synchronization Team
- Approves Annual Updates of Joint Service Small Arms Capability Gaps
- Approves JSSAP S&T project portfolio on annual basis
- Promotes, coordinates, and manages the exchange of small arms technology, acquisition, and sustainment information across the Joint Services, Program/Product Managers, Labs, R&D Centers, and Industry

JSSARI – Joint Services Small Arms Requirements Integration
- Develop, review, report, and submit Joint, harmonized Small Arms Systems capability documents
- Harmonize service requirements, including concurrence, disposition, support, and staffing of Small Arms Systems Capability Based Developments.
- Routinely review Service threat statements and assessments.

JSTAC – Joint S&T Advisory Council
- Manage timely exchange of Science & Technology information
- Manage Technology Development Strategy (TDS)
- Maintain awareness of the small arms science & technology Joint portfolio
- Maintain awareness of domestic and foreign technology - identify areas of possible exploitation
- Recommend prioritized plans, programs and strategies to the Steering Committee

JSSAME – Joint Service Small Arms Metrics & Evaluation Working Group
- Ensure that test and evaluation of small arms weapon systems is operationally relevant, and done in a consistent, repeatable, and standardized manner.
- Review, coordinate, and monitor test and evaluation activities within the JSSAP project proposals and the JSSAP portfolio.

INTERNATIONAL
- NATO Army Armaments Group (NAAG) / Dismounted Soldier Systems (DSS)
  - Weapons and Sensors Subgroup (WS SG) - Serve a US Head of Delegation
  - Suppressor Team of Experts Lead
  - Several DEA/IEA/PA with various foreign nations
  - NATO CUAS WG participation

SL-CFT Soldier Lethality Cross Functional Team
- Lethality LOE - How do we increase lethality to achieve and maintain overmatch against a peer/ near peer adversary?
- CCDC Armaments Center Lethality Lead

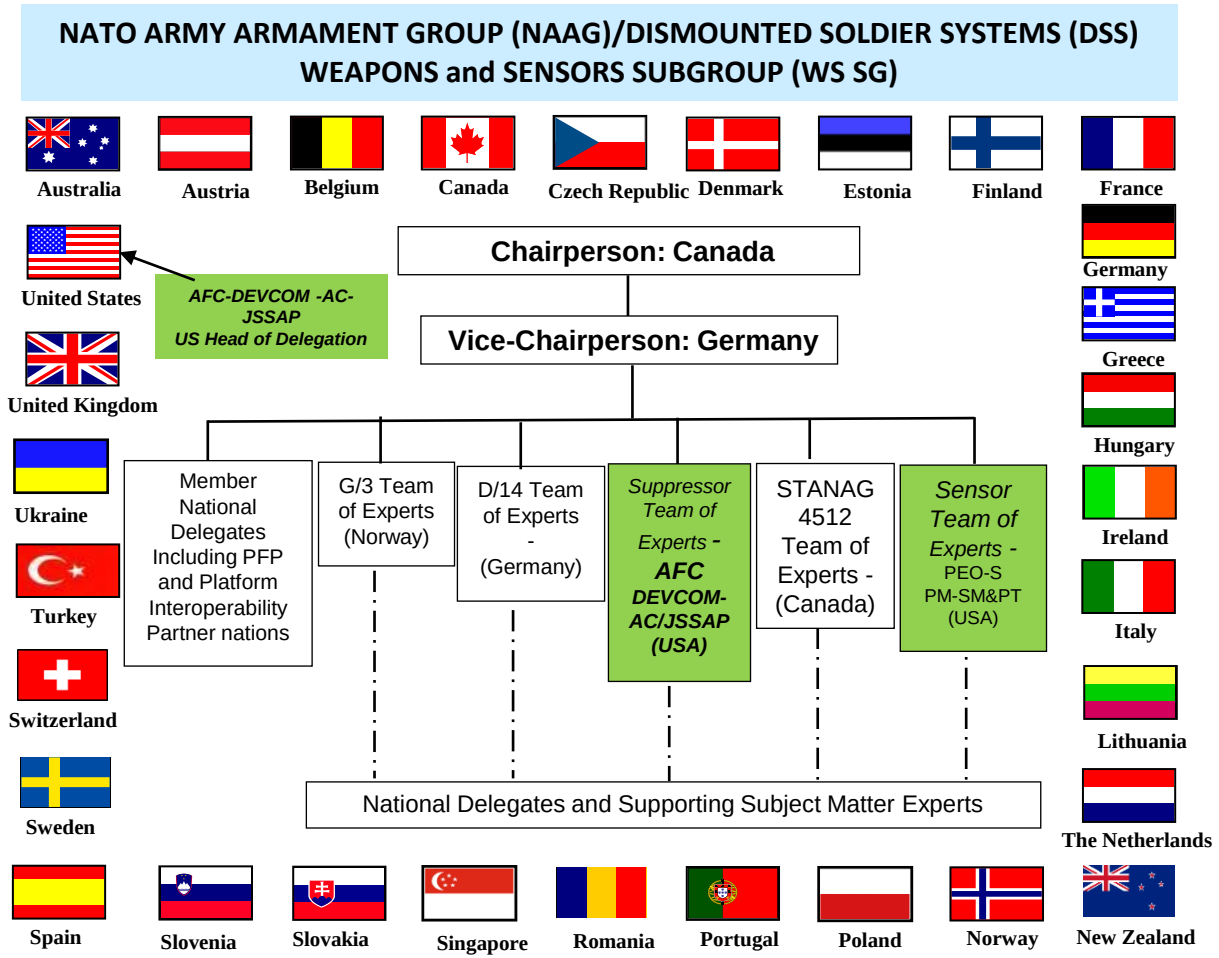
OSD-SBIR - Office of Secretary of Defense / Small Business Innovation Research
- Allows small, high-tech U.S. businesses and academia the opportunity to provide innovative research and development solutions in response to critical Army needs.
- To be the Army's premier source of innovative technology solutions, providing direct access to America's high-tech small business research and development community, enabling our Soldiers deployed around the world.

Industrial / OGA Base
- DOTC/NAC - Defense Ordnance Technology Consortium / National Armaments Consortium
- DARPA
- DOE-National Labs
- DOD-Research Labs

JS3 -Joint Service Signature Suppression IPT
- Develop harmonized understanding of signature suppression across the Joint Services
  - Test methods and standards
  - Requirements
  - S&T efforts

JSSAP Barrel Technology Development Strategy
- Fundamental understanding, capabilities, and tools are lacking
- Future small arms systems will require advanced barrel technologies in order to meet Warfighter needs
- Legacy weapon system barrels would benefit from various improvements
- Recent barrel technology development has not transitioned

INTERNATIONAL SMALL ARMS ACTIVITIES



Project Arrangement (PA):

- Defence Research and Development of Canada
- Focus on enabling technologies for future small arms systems.

Data Exchange Agreement (DEA):

- Defence Research and Development of Canada
- Small Caliber Weapons and Ammunition Data Exchange

Information Exchange Agreements (IEAs):

- Defence Science and Technology Laboratory (DSTL) of UK
- Infantry Weapons and Munitions Information Exchange Agreement

Future Force Capabilities Conference

19 September 2022

COL Scott J. Madore
Project Manager Soldier Lethality
scott.j.madore.mil@army.mil

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PM SOLDIER LETHALITY

Mission

Develop and Deliver Innovative and Relevant Small Arms Lethality to our Warfighters

Vision

Be the premier provider of integrated small arms weapon systems for our Warfighters, and our Allies and Partners

Priorities

1. Take Care of Our ***People***
2. ***Deliver Lethality*** at the Speed of Relevance
3. Foster a culture of ***Innovation*** for our processes and products

Principles

- Alignment
- Collaboration & Teamwork
- Transparency & Communication
- Empowerment

Every Soldier Armed – Every Formation Ready

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Project Manager Soldier Lethality Reorganization

- PEO Soldier Reorg Phase III (Summer 2022)
  - Product Manager Small Arms Fire Control (SAFC) established
  - Product Manager Small Arms Fire Control aligned with PM Soldier Lethality

- Efficiencies/Highlights and Planning Tasks
  - Realigns under PM SL C2:
    - Family of Weapon Sights
    - Other weapons enabler programs
    - Next Generation Squad Weapon - Fire Control
  - PdM SAFC HQs located at Fort Belvoir, VA
  - Next Generation Squad Weapon – Fire Control team remains at Picatinny Arsenal, NJ
  - Realigning programs to optimize unity of effort

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Project Manager Soldier Lethality

Enlisted Advisor
MSG Daniel Saucedo

PM Soldier Lethality
COL Scott Madore
Deputy
Mr. Angelo Scarlato

Picatinny Arsenal, New Jersey

Director, Business Mgt.
Ms. Lora Sgroi

Director, Sys Engineering
Mr. Douglas Cohen

Director of Logistics/PSM
Mr. Michael Friedman

Director, Acquisition Operations
Mr. Mark Keck

Product Manager Individual Weapons
LTC M. Rue
Deputy
Ms. Barbara Muldowney

APMs
CPT E. Forsgren
(Incoming)

Product Director Crew Served Weapons
Mr. David Oatley
Deputy
Mr. Peter Errante

APMs
MAJ N. LaSorba
MAJ D. Stephens

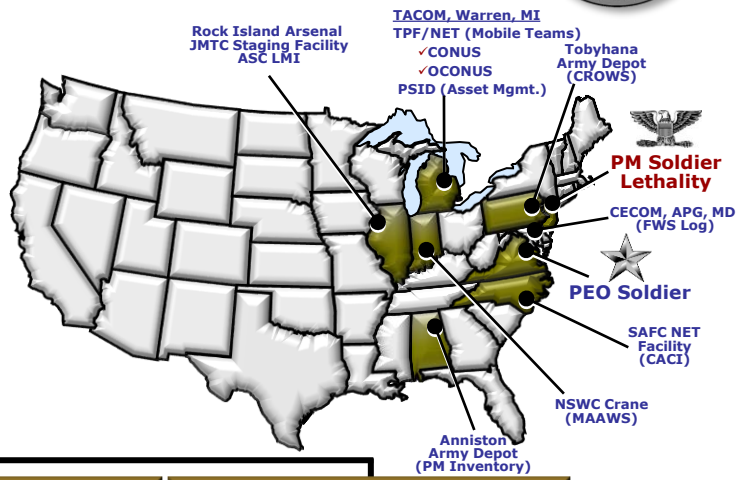
Product Manager Next Generation Weapons
LTC J. Headley
Deputy
Mr. Arthur Fiorellini

APMs
MAJ J. Williamson
CPT T. Morgan

Product Manager Small Arms Fire Control
LTC T. Ruud
Deputy

APMs
MAJ H. Van Matre
MAJ A. Jordan
MAJ A. Kipetz
CPT M. Boissy

Army and Other Services and Agencies



Kuwait

Iraq

PM SL Fielding Team

FWS / STORM

Contractor NET Teams

TACOM Materiel Fielding and Training Team

Weapons Total Package Fielding

Weapons New Equipment Training

CROWS

As of: 22Aug22

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PM Soldier Lethality Portfolio

Operations & Support

M150
Rifle Combat Optic (RCO)

M68
Close Combat Optic (CCO)

M145
Machine Gun Optic

M24
Mini Binocular

M22
Binocular

M25
Binocular

M4 w/ M203
Grenade launcher

M11
Pistol

M7
Bayonet

M9
Bayonet

M9
Pistol

M4/M4A1
Carbine

APC9K
Sub Compact Weapon

AN/PAS-13(V)1
Light Weapon Thermal Sight (LWTS)

M14
Enhanced Battle Rifle (EBR)

M16A2/M16A4
Rifle

M26
Modular Accessory Shotgun System (MASS)

AN/PAS-13(V)2
Medium Weapon Thermal Sight (MWTS)

M2010
Enhanced Sniper Rifle (ESR)

M107
Long Range Sniper Rifle

AN/PAS-13(V)3
Heavy Weapon Thermal Sight (HWTS)

M240B
Medium Machine Gun

M500/M590
Shotgun

M249
Squad Automatic Weapon (SAW)

M110
Semi-Automatic Sniper System (SASS)

M240H
Medium Machine Gun

M192
Lightweight Tripod

M2
Machine Gun

MK19
Grenade Machine Gun

Production & Deployment

M320
40mm Grenade Launcher

Grenadier Sighting System

M17/M18
Modular Handgun System

XM250
NGSW-AR

M155
MMO (M2A1)

M156
MMO (M240)

M152
MMO (Mk19)

Mounted Machine Gun Optic (MMO)

XM5
NGSW-R

Small Tactical Optical Rifle Mounted (STORM)

Family of Weapon Sights-Sniper (FWS-S)

Family of Weapon Sights-Individual (FWS-I)

Family of Weapon Sights-Crew Served (FWS-CS)

Direct View Optic (for USAF)

M3A1
Carl Gustaf (MAAWS)

Small Tactical Optical Rifle Mounted II (STORM II)

M3
Carl Gustaf (MAAWS)

Non-Standard Weapons

XM157
NGSW-FC

NGSW 6.8mm
Family of Ammunition

MK22
Precision Sniper Rifle (PSR)

M110A1
Squad Designated Marksman Rifle (SDMR)

M240L
Medium Machine Gun

M25A1
Stabilized Binocular

Gunner Integrated Protection and Restraint System (GIPRS)

M2A1
Machine Gun

M205
Lightweight Tripod

M153
Common Remotely Operated Weapon Station (CROWS)

CROWS Low Profile

CROWS-J

Future

(Notional Images)

Next Gen Medium / Heavy Machine Gun

Precision Grenadier System

Thermal Imaging

Smart Rail

Wind Sensing

Advanced Barrel Technology

4th Gen Fire Control

Provide premier Soldier weapons systems enabling battlefield dominance

11Sep22

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PM SL Technology Focus Areas

- Engaging Targets in Defilade and UAS
- Communication Capability across weapon enablers
- Toxic fumes improvement concepts
- Suppressor technology
- Future Medium Machine Gun technologies
- Remote Weapon System capabilities

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PdM SAFC

DISTRIBUTION A. Approved for public release: distribution unlimited.

PdM SAFC Portfolio

Operations & Support

AN/PAS-13(V)3
Heavy Weapon Thermal Sight (HWTS)

AN/PAS-13(V)2
Medium Weapon Thermal Sight (MWTS)

AN/PAS-13(V)1
Light Weapon Thermal Sight (LWTS)

Production & Deployment

AN/PSQ-23B
Small Tactical Optical Rifle Mounted (STORM)

XM157
NGSW Fire Control

AN/PSQ-23A
Small Tactical Optical Rifle Mounted (STORM) micro-Laser Range Finder (mLRF)

Small Tactical Optical Rifle Mounted II (STORM II)

Family of Weapon Sights-Sniper (FWS-S)

AN/PAS-37
Family of Weapon Sights-Crew Served (FWS-CS)

AN/PAS-35
Family of Weapon Sights-Individual (FWS-I)

Future

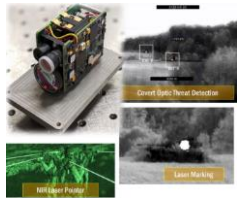
(images notional)

Power Data Rail

XM157
Thermal Imaging

Wind Sensing

GEN 4 Fire Control Aim Augmentation



Laser Range Finder Improvements

1Sep22

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PdM NGW

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PdM Next Generation Squad Weapons

Accomplishments:

- ✓ Received Rapid Fielding Authority under the Middle Tier of Acquisition pathway
- ✓ 6 Jan 2022, awarded Vortex Optics a 10-year Other Transaction Agreement (P-OTA) for production of NGSW Fire Control.
- ✓ 19 April 2022, awarded a 10 year contract to Sig Sauer for the production of the NGSW Rifle, Automatic Rifle, and ammunition.

Interest:

- Integrated Thermal Technology
- Interface and integration solutions

Upcoming Opportunities:

- Innovative Designs & Engineering Assessment (IDEA) program has an active announcement on sam.gov to assess innovative technologies, responses due 30 September 2022.

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PdM IW

DISTRIBUTION A. Approved for public release: distribution unlimited.

PdM Individual Weapons

- **FY22 Accomplishments:**
  - ✓ Fielded the first MK22 Precision Sniper Rifles
  - ✓ Completed deliveries of the M110A1 Squad Designated Marksman Rifle (SDMR); optimized over 1,500 systems, increasing weapon reliability
  - ✓ Completed Army deliveries of the Modular Handgun System

- **Upcoming Opportunities:**
  - *Precision Grenadier Capability:* The Army is pursuing a requirement to mitigate the squad level counter defilade gap
  - *Soldier Enhancement Program:* Identify and procure off-the-shelf items that have the potential to substantially improve weapons and support equipment

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Product Director Crew Served Weapons

David Oatley
PdD Crew Served Weapons
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Peter Errante
Deputy PdD Crew Served Weapons
peter.p.errante.civ@army.mil

Product Director
Crew Served Weapons Portfolio

Medium and Heavy Machineguns

MAAWS Recoilless Rifle

Accessories / Optics

Non-Standard Weapons

Medium Caliber Weapons

Remote Weapons Stations (RWS)

Technical Expertise

- Development of weapons
- Lethality
- Fire Control
- Software development
- Integration with RWS and vehicles
- Independent analysis

Efficient Management

- Consolidate requirements for multiple customers
- Single procuring agent vs. multiple
- Economies of scale
- Life Cycle Weapon Management

CSW Services

- Program / IPT Management
- Platform Integration
- Logistics Management
- Configuration Management
- Testing / Qualification / Type Class
- Vendor validation

PdD CSW provides weapon system SOLUTIONS to meet customer needs

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FY22 Accomplishments/FY23 Plans

FY22 Accomplishments:

- **CROWS-Javelin** – Fielded CROWS-J to the first Army unit
- **C-UAS** – Demonstrated use of CROWS as C-UAS platform
- **RCV** – Demonstrated wireless CROWS-Tech Refresh on Robotic Combat Vehicle (RCV) Soldier Operational Experiment 2 (SOE 2)
- **M3A1 MAAWS** – Achieved TC Standard for new M3A1 w/ digital fire control
- **Non-Standard Weapons** – Awarded $21.8M for NSW program
- **CSW Vendor Demo Days** – Held 2nd Annual event
- Procurements of M249, M240, Mk19, and accessories for Army, DoD, and FMS customers

FY23 Plans and Opportunities:

- TC & FMR for HE441E High Explosive Air Burst Munition
- Industry solicitation for .50 caliber weapon systems for a multi-year, competitive contract
- XM152 and XM155 FUE (May 2023) and FMR (Dec 2022)
- CSW Vendor Demonstration Days

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CROWS-J / Tech Refresh

- **CROWS-J fielding to 2-4ID SBCT at Fort Carson, CO**
  - First SBCT to receive new Tech Refresh CROWS system architecture
  - Significant lethality upgrade
  - Integrates Javelin missile as secondary effector

- **CROWS-J / Tech Refresh adds additional capabilities:**
  - High Definition (HD) Video
  - Improved Thermal Sensor
  - Situational Awareness Strip
  - Common Interface Bracket
  - Smoke Grenade Launchers

- **CROWS-J fielding to additional SBCTs**

- **Tech Refresh hardware backwards compatible w/ legacy CROWS**

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CROWS C-UAS Capability: CROWS-B (Ballistic Low Altitude Drone Engagement)

- Developed by DEVCOM-Armaments Center to **enhance organic armament systems** to counter Group 1-2 UAS
- **Enhances organic armament systems** to counter sUAS threats in addition to conventional targets (Multi-Domain capability)
- **Addresses the entire kill chain** from target acquisition, tracking, fire control to semi-autonomously defeat sUAS (Human-on-the-loop)
- **Low cost per kill; high stowed kills**; maintaining conventional mission capability
- Closed loop **networked, integration** of detection and tracking sensors (fire control radars, EO/IR, etc.) with armament systems

C-UAS B-Kit Applique
Precision Fires Radar/ Optical Tracking, Precision Targeting Unit Architecture and Counter Swarming Algorithms

CROWS with M2 0.50 cal

Air & Ground Targets

Bullet correction happens autonomously with user on-the-loop

CROWS w/ conventional target and CUAS capability for Group 1-2 UAS; low cost per kill Brigade and below

Leverages existing infrastructure and platforms to defeat threat

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PdD CSW's Vendor Demonstration Days

- 2nd Annual Vendor Demonstration Days held at Close Quarters Tactical, GA, 3-5 May 2022

- Concept:
  - PdD CSW provides range for industry
  - Attendees receive instant feedback
  - Soldier participation on site
  - Informs Government about state of technology

- FY22 Summary
  - Focused on Next Gen Medium MG and Remote Weapons
  - 26 vendors
  - Live Fire and Static demonstrations / exhibits
  - Day and night firing
  - More than 150 attendees

- FY23 event planning underway

Coming soon - check SAM.gov for FY23!!

MAAWS TC and HE441E

Recent Accomplishments:

- Achieved Type Classification (TC-S) Standard for new M3A1 Weapon system w/integrated digital fire control
- Fielded 1000+ new M3A1 and 300+ M3 weapon systems to date

Near Term Future Accomplishments:

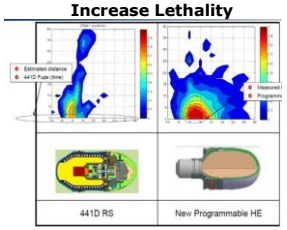
- Type Classification and Full Materiel Release for new programmable air burst HE 441E munition
- Complete fielding of new M3A1 weapon system w/FC planned FY24

NEW M3A1 w/FCS13-RE Digital Fire Control

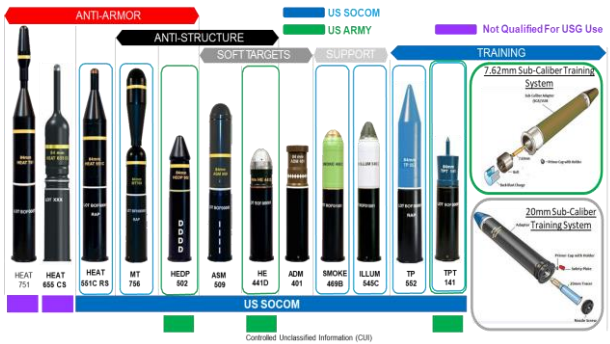
Legacy M3 w/Mechanical PFCD Fire Control

HE441E Programmable Airburst Anti-Personnel

Increase Lethality



MAAWS Family Of Ammunition



Non-Standard Weapons Program

- NSW program maintains contracts and agreements to provide non-Army standard weapons
- Customers include US Army, FMS, and Other Government Agencies:
  - US Army
  - SOCOM
  - DHS ICE
  - DHS CBP
  - USCG
- $21.8M awarded to 16 companies (FY22)
  - Weapons/Acessories/Spare Parts
  - In support of 21 FMS cases

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Industrial Base Assessment Tool (IBAT)

Presentation

September 2022

Decision Sciences Incorporated

Agenda

- IBAT Background
  - IBAT Resume
  - How IBAT is Organized
  - ConOps Graphic
  - How IBAT Works
  - Set Up Examples
- Demonstration
- Minimum Sustaining Rate
- Discussion

IBAT Resume

- **IBAT Construct**
  - Designed, developed, maintained by DSI
  - Focused on munitions
  - Includes facilities, suppliers, components, and end-items
  - Identifies ***Risks, Bottlenecks, and Production Capabilities*** of the industrial base
  - Near real-time – Not a Report – Not a PowerPoint

- **IBAT System Forensics**
  - ***Hundreds of facilities and thousands of components/end-items*** in IBAT
  - ***Hundreds of Users*** from DOD organizations
  - ***18 Years*** of continuous operation
  - Thousands of use cases
    - \+ 1,700 Reports Generated
    - \+ 500 Disaster Mapping Calculations
    - \+ 48,000 Supplier and Item Lookups
    - \+ 4,500 Simulations

    Briefed to Multiple Four-Star Officers, JOCG Principals, OSD, HASC / SASC

  - *DOD Relies on IBAT!*
  - *JMC Marque System*

OSD - IBAT is the Gold Standard for How to Perform Industrial Base Analysis

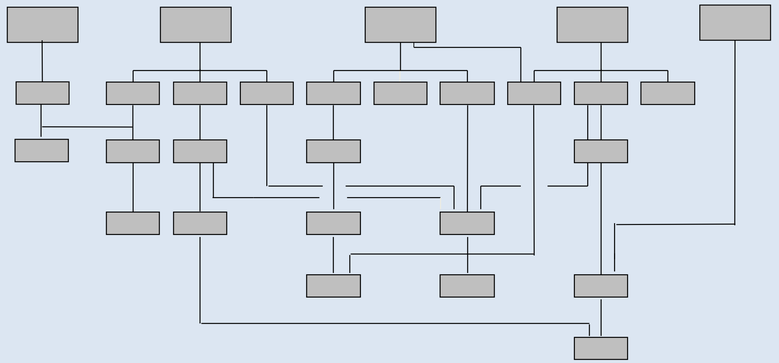
What is IBAT?

How IBAT is Organized – Technical and Programmatic

Munitions Supply Chain

OEMs

Tier 1
Tier 2
Tier 3
Tier 4
Tier 5



Extended Supply Chain

Inventory **Contracting** **Manufacturing** **Budget** **Financial** **Source Attributes**

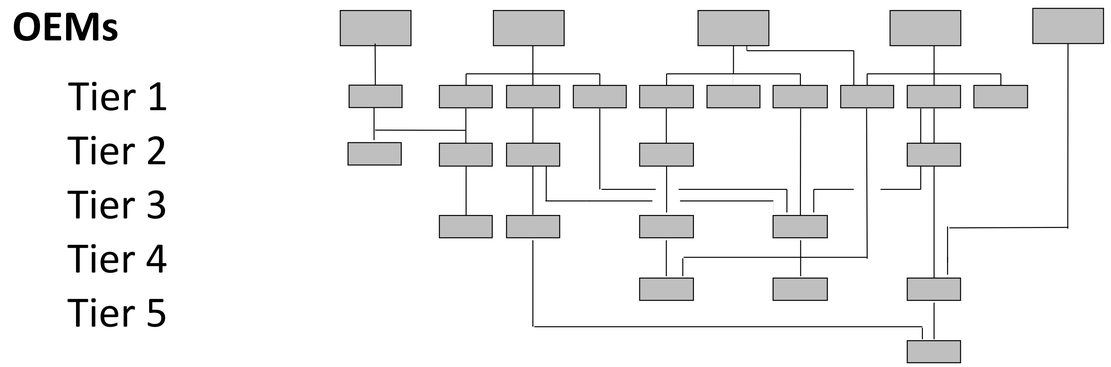
What is IBAT?

How IBAT is Organized - Informational

- Ammunition Families
  - Artillery Caliber
  - Bombs
  - CAD/PAD
  - Demolitions
  - Dispenser
  - Explosives
  - Fuzes
  - Grenades
  - Inactive
  - Loaded Components
  - Medium Caliber
  - Mortars
  - Navy Gun
  - Non-Lethal Munitions
  - Other
  - Propellants
  - Pyrotechnics
  - Rare Earth Element
  - Rockets, Warheads
  - Shoulder Launched Munitions
  - Small Caliber
  - Special Projects
  - Tank
  - Terrain Shaping

IBAT System

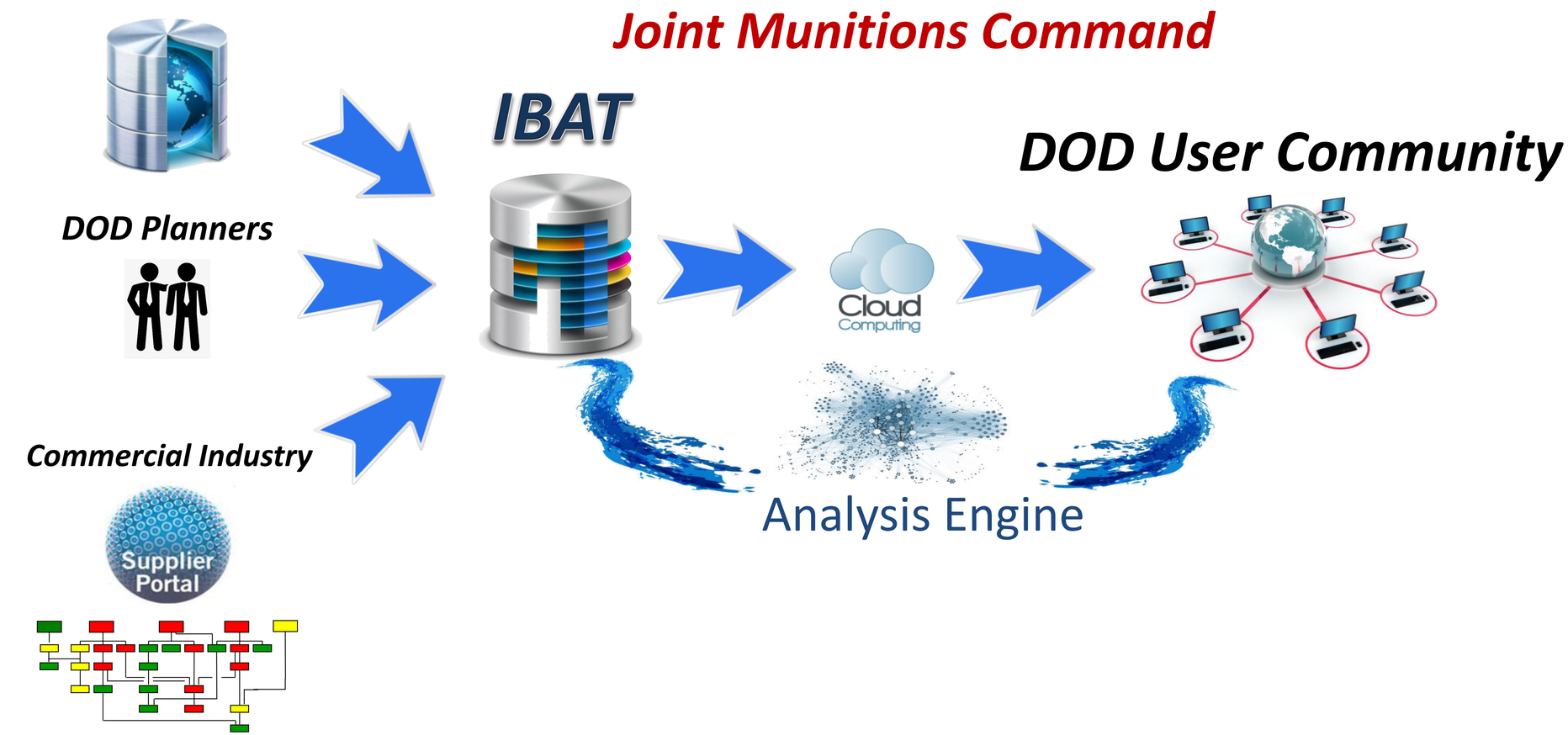
- 24 Ammunition Families
  - Each Family Contains of Many End-Items
  - Each End-Item Consists of a Critical Bill-of-Material (Components)
  - Each Component has an Associated Supplier(s)



- Each Component/Supplier Combination Encompasses:
  - Attribute Information (SPF, Foreign Sources, Service, etc.)
  - Operating Modes (Information, Manufacturing, Contacting, Inventory, Demand)

IBAT Background

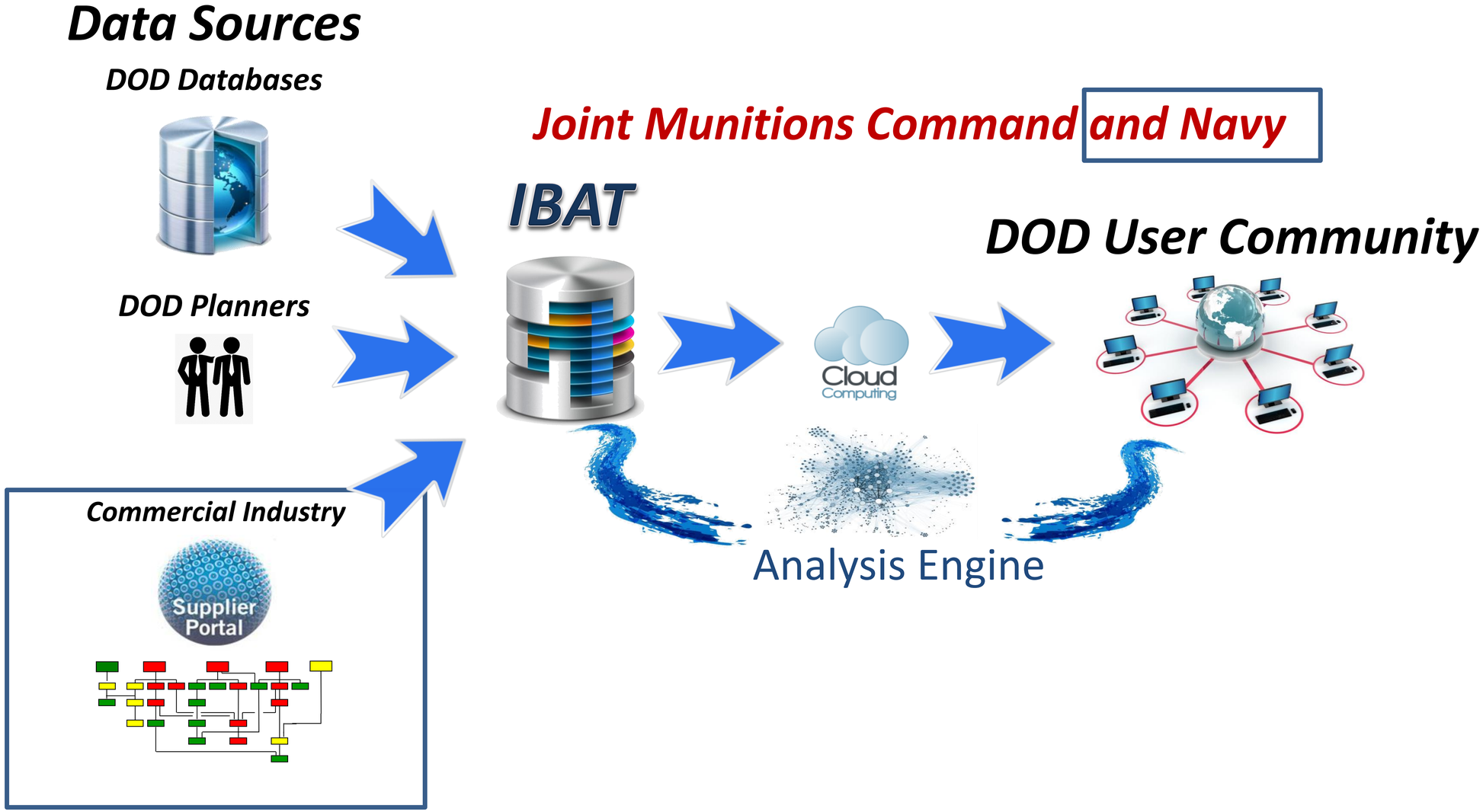
Concept of Operations Graphic



Supports *Readiness, Resiliency and Affordability*

IBAT Background

Concept of Operations Graphic



Supports *Readiness, Resiliency and Affordability*

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IBAT

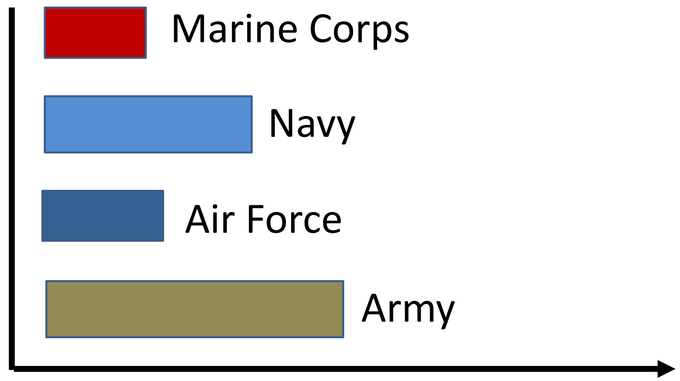
How IBAT Works - Analytical

Budget Analysis

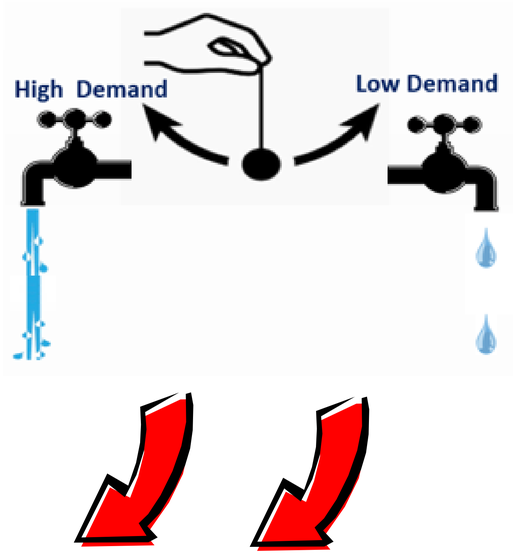
War Planning

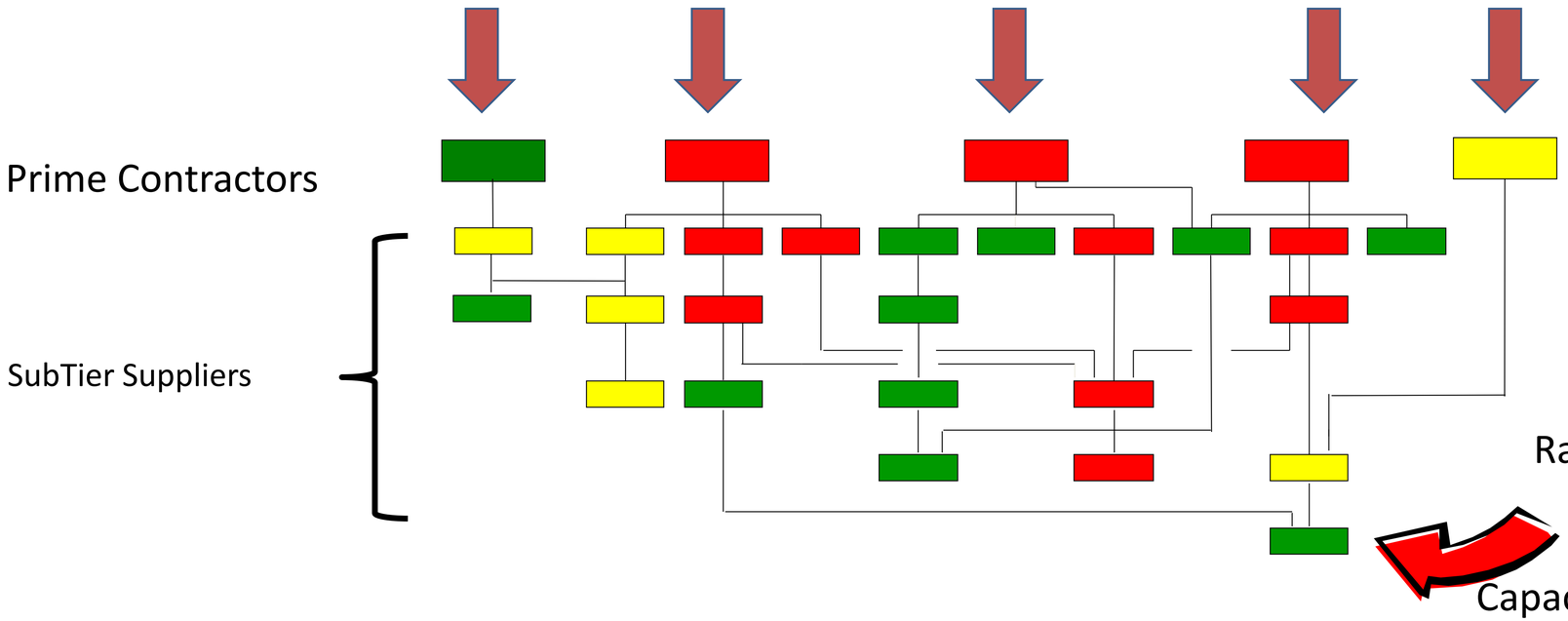
Disaster Planning

Demand for Munitions
Four Services



Demand Flow





Constraint Based Simulation

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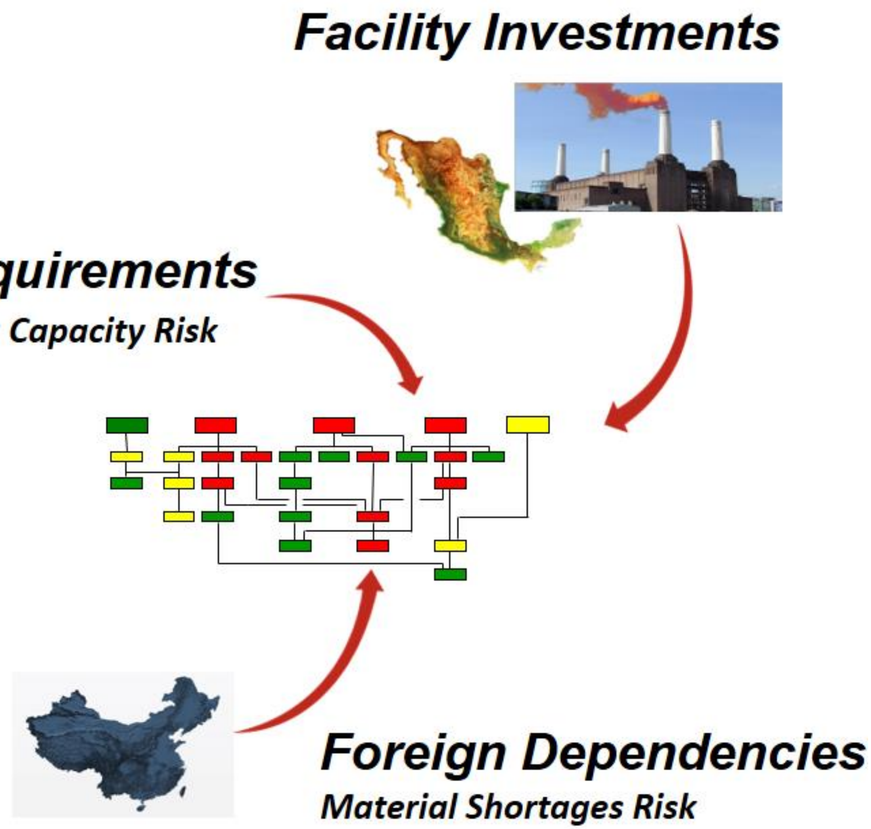
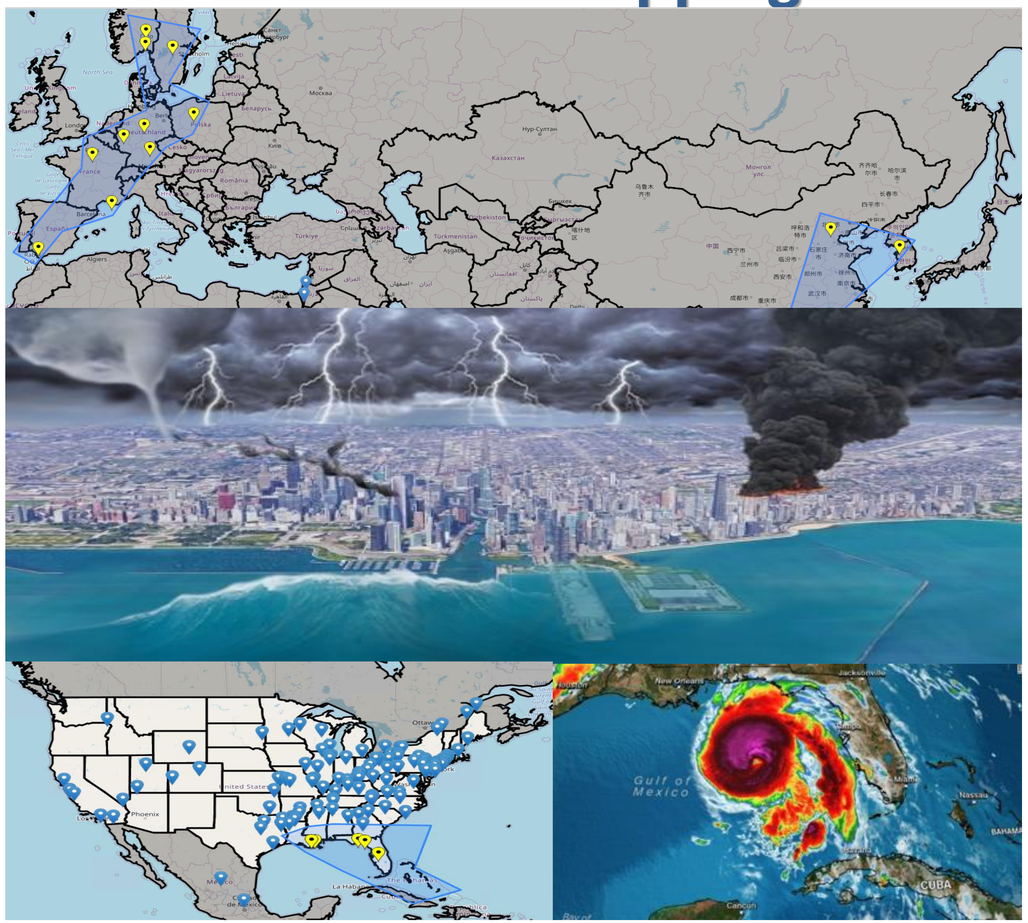
Demonstration
IBAT Demo Examples

Example 1
War Planning & Operational Use



Example 2
Disaster Mapping



Features:

- *Advanced Filtering*
- *Supplier Attributes*
- *Item Attributes*
- *Deep Supply Chain Networks*
- *Industrial Base Demand*
- *Manufacturing*
- *Contracting*
- *Inventory*
- *Simulation*
- *Minimum Sustaining Rate*
- *Disaster Mapping*
- *Revenue Analyzer*

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IBAT Demonstration

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Baseline (Healthy Base)

Family	Month 1	2	3	4	5	6	7	8	9	10	11	12
BASE	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%
Ammo Family 1	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ammo Family 2	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ammo Family 3	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ammo Family 4	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ammo Family 5	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ammo Family 6	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ammo Family 7	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ammo Family 8	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ammo Family 9	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ammo Family 10	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%	96%

No China

Family	Month 1	2	3	4	5	6	7	8	9	10	11	12
BASE	98%	92%	85%	85%	83%	81%	80%	79%	78%	77%	77%	76%
Ammo Family 1	100%	97%	95%	95%	94%	94%	94%	94%	93%	93%	93%	93%
Ammo Family 2	100%	91%	61%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ammo Family 3	50%	48%	40%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Ammo Family 4	100%	97%	89%	92%	90%	88%	86%	85%	84%	83%	83%	82%
Ammo Family 5	100%	92%	81%	83%	79%	76%	74%	73%	71%	69%	67%	66%
Ammo Family 6	100%	97%	87%	87%	83%	80%	78%	77%	76%	75%	74%	73%
Ammo Family 7	100%	100%	99%	98%	97%	97%	96%	96%	96%	96%	96%	95%
Ammo Family 8	100%	92%	73%	68%	61%	56%	53%	51%	49%	47%	46%	45%
Ammo Family 9	100%	100%	94%	83%	77%	72%	69%	67%	65%	63%	62%	61%
Ammo Family 10	95%	77%	57%	53%	46%	41%	37%	34%	32%	30%	29%	27%

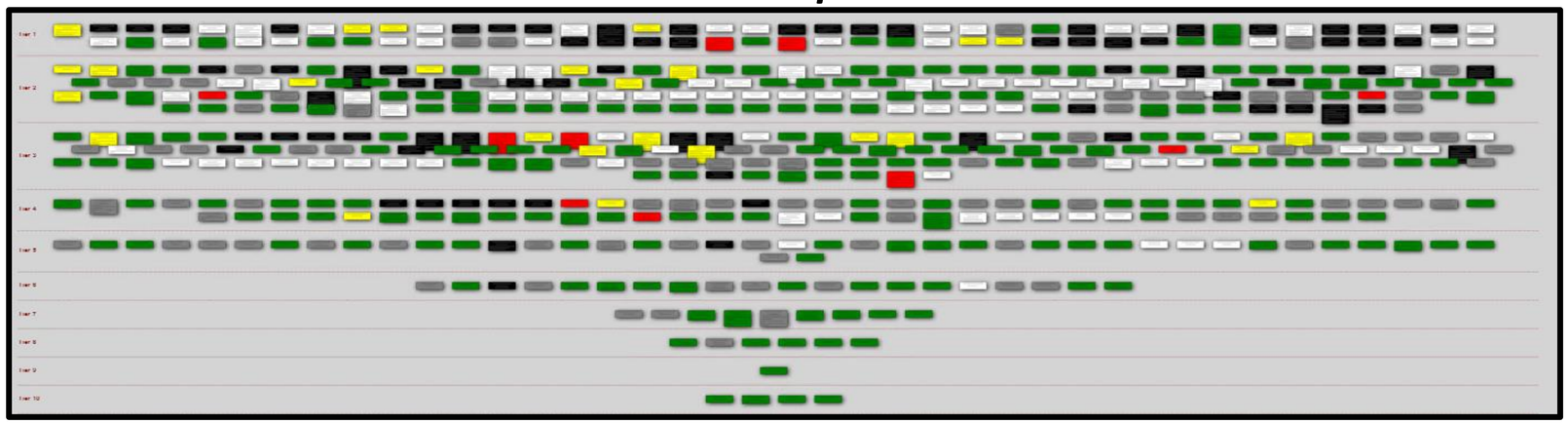
No China – Add Mexico

Family	Month 1	2	3	4	5	6	7	8	9	10	11	12
BASE	98%	93%	86%	86%	91%	91%	90%	90%	90%	90%	90%	89%
Ammo Family 1	100%	98%	96%	96%	97%	97%	97%	97%	96%	96%	96%	96%
Ammo Family 2	100%	91%	61%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Ammo Family 3	50%	48%	40%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Ammo Family 4	100%	97%	89%	92%	100%	100%	100%	100%	100%	100%	100%	100%
Ammo Family 5	100%	92%	81%	83%	82%	81%	80%	79%	79%	78%	78%	78%
Ammo Family 6	100%	97%	87%	87%	100%	100%	100%	100%	100%	100%	100%	100%
Ammo Family 7	100%	100%	99%	98%	97%	97%	96%	96%	96%	96%	96%	95%
Ammo Family 8	100%	92%	73%	68%	78%	76%	75%	74%	73%	72%	72%	71%
Ammo Family 9	100%	100%	94%	83%	77%	72%	69%	67%	65%	63%	62%	61%
Ammo Family 10	95%	77%	57%	53%	76%	76%	75%	75%	74%	74%	74%	73%

No China – Add Mexico – Surge

Family	Month 1	2	3	4	5	6	7	8	9	10	11	12
BASE	70%	64%	62%	67%	77%	78%	79%	80%	80%	80%	81%	81%
Ammo Family 1	94%	93%	93%	94%	96%	96%	96%	96%	96%	96%	96%	96%
Ammo Family 2	29%	14%	10%	93%	99%	100%	100%	100%	100%	100%	100%	100%
Ammo Family 3	19%	10%	7%	21%	35%	45%	50%	50%	50%	50%	50%	50%
Ammo Family 4	71%	62%	59%	72%	98%	100%	100%	100%	100%	100%	100%	100%
Ammo Family 5	30%	15%	10%	30%	46%	48%	52%	56%	58%	60%	60%	60%
Ammo Family 6	55%	39%	26%	36%	64%	69%	70%	72%	73%	74%	74%	75%
Ammo Family 7	88%	88%	88%	88%	88%	88%	88%	89%	90%	91%	91%	91%
Ammo Family 8	48%	40%	38%	38%	67%	67%	67%	67%	66%	66%	65%	65%
Ammo Family 9	66%	60%	57%	55%	54%	53%	53%	53%	52%	52%	52%	52%
Ammo Family 10	25%	15%	11%	11%	29%	34%	36%	37%	38%	39%	39%	40%

Network – China Impact



Analysis Takeaways:

1. Domestic Production of Antimony Sulfide would be Helpful

2. Many other Foreign Rare Earth Materials are Chokepoints

3. Acquisition / Logistical Strategies can Reduce Risk

Unclassified. Distribution Unlimited.

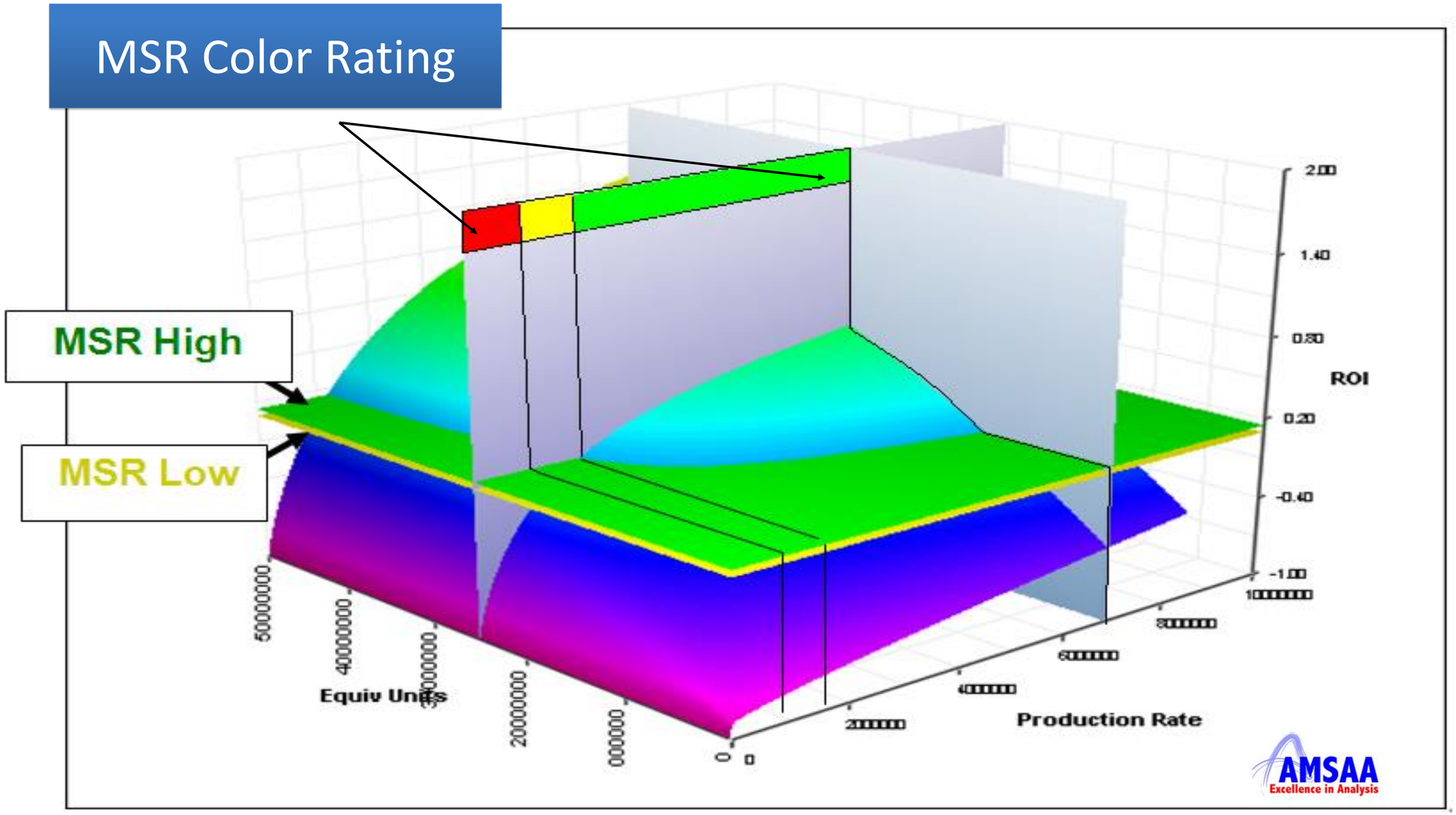
Minimum Sustaining Rate (MSR)

Unclassified. Distribution Unlimited.

Minimum Sustaining Rate

Financial Viability Rating

Supplier A – Component X



Only DOD Vetted MSR Methodology

(Vetted by United States Army Materiel Systems Analysis Activity)

Summary – Future Direction

- **Commercial Portal Being Integrated into the IBAT**
- **Greater Industry / DOD Collaboration**
- **Navy to Join IBAT Effort**
- **IBAT Can be Scaled to Other Commodity Areas (Aircraft, Armor, Missiles, Ships, etc.)**

Thanks !

Decision Sciences Incorporated

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JOINT PROGRAM EXECUTIVE OFFICE ARMAMENTS & AMMUNITION

National Defense Industries Association

Future Force Capabilities Conference

Assured Munitions

Eugene Conner
Director of Integration, JPEO A&A
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20 September 2022

DISTRIBUTION STATEMENT A: Approved for public release; distribution unlimited. PAO Log # 001-23, 01 Oct 2022.

Assured Munitions
Overview

- **Munitions supply chain**
  - Must be able to deliver the required quantity and quality of munitions under all circumstances
  - Threats to supply chain must be managed
  - End items, components and precursors
- **Threats to the supply chain**
  - Foreign influence
  - Geopolitics
  - Cyber security
  - Criminal activity
  - Financial health
  - Environmental regulation
  - Catastrophic events (e.g hurricane or earth quake)
- **Congressional interest**
- **Executive Orders 14017 and 14005**

A robust and resilient supply chain is key to producing and sustaining dominant warfighting capability

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Assured Munitions

Current State

- **JPEO A&A Strategy**
  - Secure our domestic munitions supply chains, Commercial and Organic, to ensure continued availability of end items and constituent components in peace and war
- **Continuous assessment of the supply chain across the portfolio**
  - Initial focus on energetic materials
  - Risks to the supply chain have been prioritized
  - Mitigation plans have been established and are being executed
- **Coordination with OUSD Critical Energetics Material Working Group**
- **Leveraging Defense Production Act Title III where appropriate**

JPEO A&A is managing risk within the domestic organic and commercial supply chains

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Assured Munitions

Looking forward

- **JPEO A&A will continue to:**
  - Assess and manage risk within the supply chain
  - Onshore sources of supply where warranted
- **Push supply chain risk assessment earlier in the life cycle**
- **Dialogue with Industry will be key to managing risk**
  - PMs and Industry must collaborate on SCRM
  - Different perspectives but the same interest
  - Collectively appreciate the risk that exists within supply chains and work to mitigate
- **Supply Chain Risk Management (SCRM) in contracts**
  - Solicitations will request a description of company's approach to SCRM
  - SCRM may be a factor in source selection
  - Supply chain identification

Supply Chain Risk Management must be collaborative

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Assured Munitions

Summary

- Supply Chain Risk Management is critical to ensuring we can produce the necessary munitions in support of the war fighter
- There is tremendous support to address supply chain risk
- JPEO A&A is continuously assessing, prioritizing and mitigating risk within the munitions supply chains
- Industry will see increased emphasis on obtaining insight into supply chains
- Supply Chain Risk Management must be collaborative

DISTRIBUTION STATEMENT A: Approved for public release; distribution unlimited. PAO Log # 001-23, 01 Oct 2022.

Future Force Capabilities

19-22 SEP 2022

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Medium Caliber (PdM MC), PM MAS
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DISTRIBUTION A: PAO# 682-22; Dated: 14 SEP 2022
Approved for Public Release; distribution is unlimited.

PM MAS
Mission, Vision and Priorities

Mission:
PM MAS develops, equips and sustains integrated lethal direct fire ammunition effects to enable joint and Allied warfighters overmatch in the battlefield

Vision:
Innovative and dedicated hard-working professionals ensuring our warfighters prevail in battle and return home safely

Objectives:
1. **Develop and deliver reliable and timely ammunition to the warfighter**
2. **Inform and influence future capability requirements**
3. **Create opportunities to grow a multi-talented acquisition workforce/team**
4. **Shape and optimize the industrial base (organic and commercial)**

DISTRIBUTION A: Cleared for Public Release
Distribution Unlimited

PM MAS Organization

PROJECT MANAGER
COL Paul Alessio

DEPUTY
PROJECT MANAGER
Mr. Robert Kowalski

APM's

SMALL CALIBER
MAJ ANDREW HOLZHEIMER

MEDIUM CALIBER
MAJ JACOB LAGUE

LARGE CALIBER
CPT JER-MICHAEL NICHOLS

MEDIUM CALIBER
CPT DANIEL OESTERHELD

PRODUCT MANAGER
SMALL CALIBER
Mr. M. David Ahmad

PRODUCT MANAGER
MEDIUM CALIBER
LTC Paul Santamaria

PRODUCT MANAGER
LARGE CALIBER
LTC Brent Odom

PRODUCT DIRECTOR
SPECIAL AMMO &
WEAPON SYSTEMS (SAWS)
LTC Joseph Miozzi

BUSINESS MANAGER
Ms. Laura Emanski

CHIEF ENGINEER
SYSTEMS ENG. & TECH.
INTEGRATION (SETI)
Mr. Doug Wong

DEPUTY
PRODUCT MANAGER
Mr. Robert Muth

DEPUTY
PRODUCT MANAGER
Mr. Kevin Vo

DEPUTY
PRODUCT MANAGER
Mr. Reinaldo Martinez

DEPUTY
PRODUCT DIRECTOR
Ms. Stacy Poto

DISTRIBUTION A: Cleared for Public Release
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Family of Products

PM MAS develops, equips and sustains integrated lethal direct fire ammunition effects to enable joint and Allied warfighters overmatch in the battlefield

557 PM-MAS Products Under Mgmt.

Small Caliber

85 Products

Development

PRODUCTION

Medium Caliber

50 Products

Development

PRODUCTION

Large Caliber

22 Products

Development

PRODUCTION

Special Ammunition & Weapon Systems

400 Products Managed

PRODUCTION

Non NATO Munitions, Soviet Calibers

NOT TO SCALE

Distribution Unlimited

PM MAS Support to Army Modernization Priorities

2

Next Generation Combat Vehicle

- 30mm Family of Ammunition
- 50mm Family of Ammunition
- 105mm Mobile Protected Firepower (MPF)
- 120mm Extended Line of Sight (ELOS)

3

Future Vertical Lift

- FMR of PGU-28 Anti-Personnel Family of Ammunition

5

Air and Missile Defense

- 30mm Multi Mode Proximity Air Burst (MMPA)

6

Soldier Lethality

- 6.8mm Family of Ammunition
- 7.62mm Advanced Armor Piercing (ADVAP)
- Precision Family of Ammunition

Common Ammunition Themes

- Greater Lethality -

(Air Bursting, Larger Caliber)

- Greater Range -

Defeat Old & New Targets

(New: UAS, Defilade Targets)

STATUS
PROGRAM OF RECORD
CONCEPT DEV.
REQUIREMENTS DEV.
MID TIER ACQUISITION

PICTURES NOT TO SCALE

DISTRIBUTION A: Cleared for Public Release
Distribution Unlimited

Challenges and Industry Participation

- **Project Manager:**
  - Material Cost Price Increases
    - Affordable raw material and processing / forming
  - Understanding of and communication of Minimum Sustaining Rates

- **Small Caliber: Supply chain challenges driven by global supply shortages and increased prices on raw materials**
  - Commercial ammunition market demand constraining supply chain (e.g. key ammunition components)
  - Shortages of energetic material constituents due to supply shortages from OCONUS sources
  - Increased commodity costs stressing supply chain profitability and viability

- **Medium Caliber:**
  - Cost reduction in proximity fuzes
  - Increased throughput – liquid reserve batteries or other power options
  - Circuit board miniaturizing for proximity and airburst fuzes
  - Total Armament Systems Integration: weapon, ammunition, and fire control

- **Large Caliber:**
  - 105mm tactical ammunition for MPF
  - Continuing to push the envelope of 120mm KE capability
  - Cost increases and materiel lead times

- **Special Ammunition and Weapon Systems (SAWS):**
  - Affordable OCONUS produced Non-Standard Small/Medium/Large/Tank Caliber ammunition and Non-Standard Mortar Weapons Systems

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PdM Small Caliber Focus Areas

- **Implement Next Generation Squad Weapon 6.8mm Ammunition for System Fielding**
  - Produce projectiles for initial vendor production
  - Establish organic ammunition manufacturing capability at Lake City Army Ammunition Plant (LCAAP)
- **Develop and Field Improvements to Legacy Capabilities**
  - Lightweight Case
  - One-Way Luminescence
  - Reduced Range Ammunition

OWL Trace Concept

- **Maintain Production of Combat, Training Standard and Unique Ammunition**
  - Plan, Program, Budget and Execute Small Caliber Portfolio
  - Supports readiness for Army, Other Services and Allied Partners

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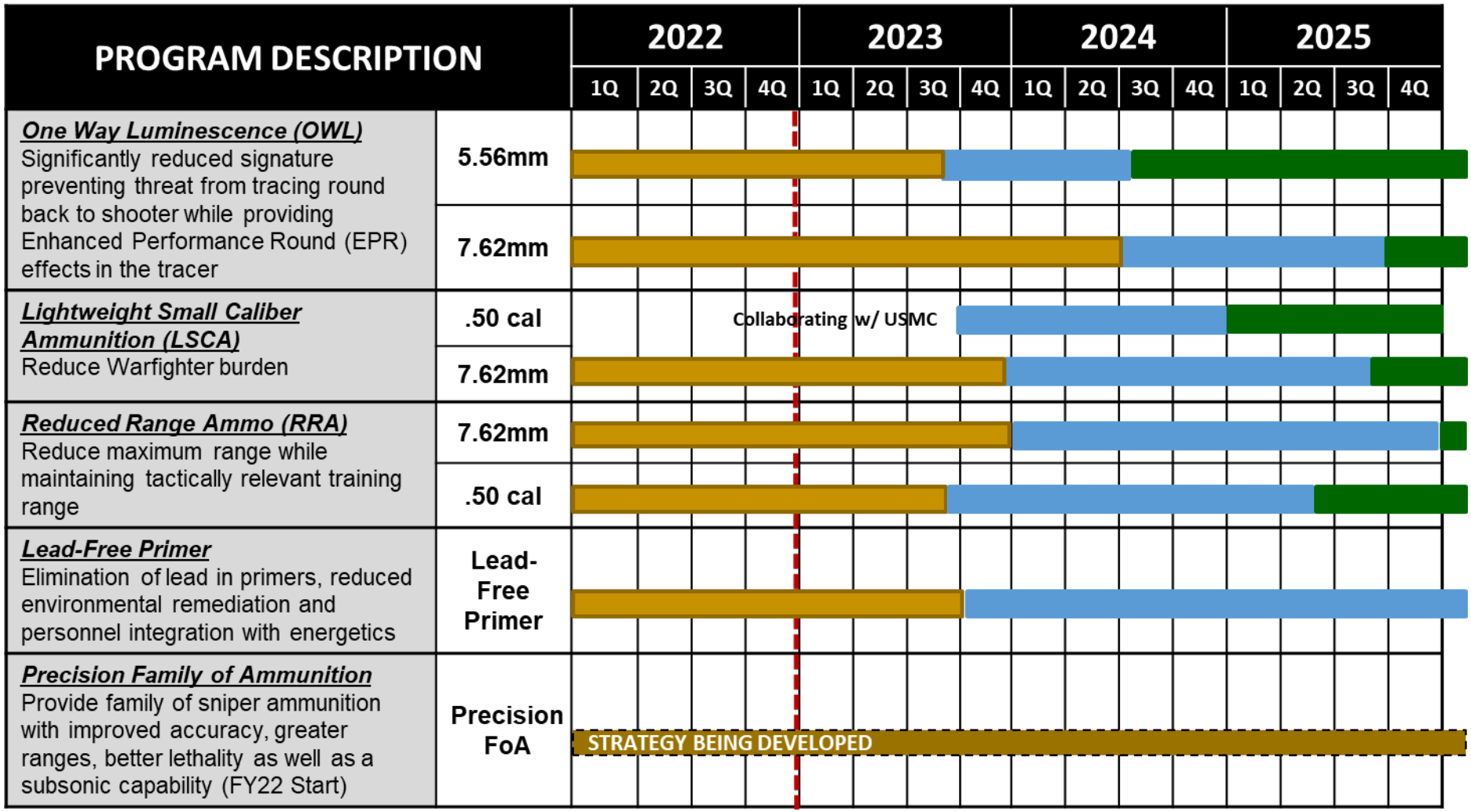
Small Caliber Developmental Program Overview



Development | Low Rate Production | Full Rate Production

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PdM Medium Caliber Focus Areas

- **Develop and Field Medium Caliber Capabilities per Cross Functional Teams (CFTs)**
  - 30mm Multi-Function Munition (Stryker and OMFV)
  - 30mm APFSDS-T (Stryker and OMFV)
  - 30mm Multi-Mode Proximity Airburst (M-SHORAD)
  - 30mm for C-UAS (M-SHORAD and other Air Defense Platforms)
  - 20mm for Future Vertical Lift (FARA)

- **Develop and Field Airburst/Counter-defilade Ammunition**
  - 40mm XM1176 HEDP-AB (Mk 19 Grenade Launcher)
  - 40mm XM1166 HEAB (M320 Grenade Launcher)

- **Support Aviation Platform Munitions**

Notional Photos

- **Maintain Training Readiness**
  - Procurement of Legacy 40mm TP
  - 40mm DNT Back on Track

XM1176
HEDP-AB

Being fielded to Stryker ICVVA1-30mm

NOT TO SCALE

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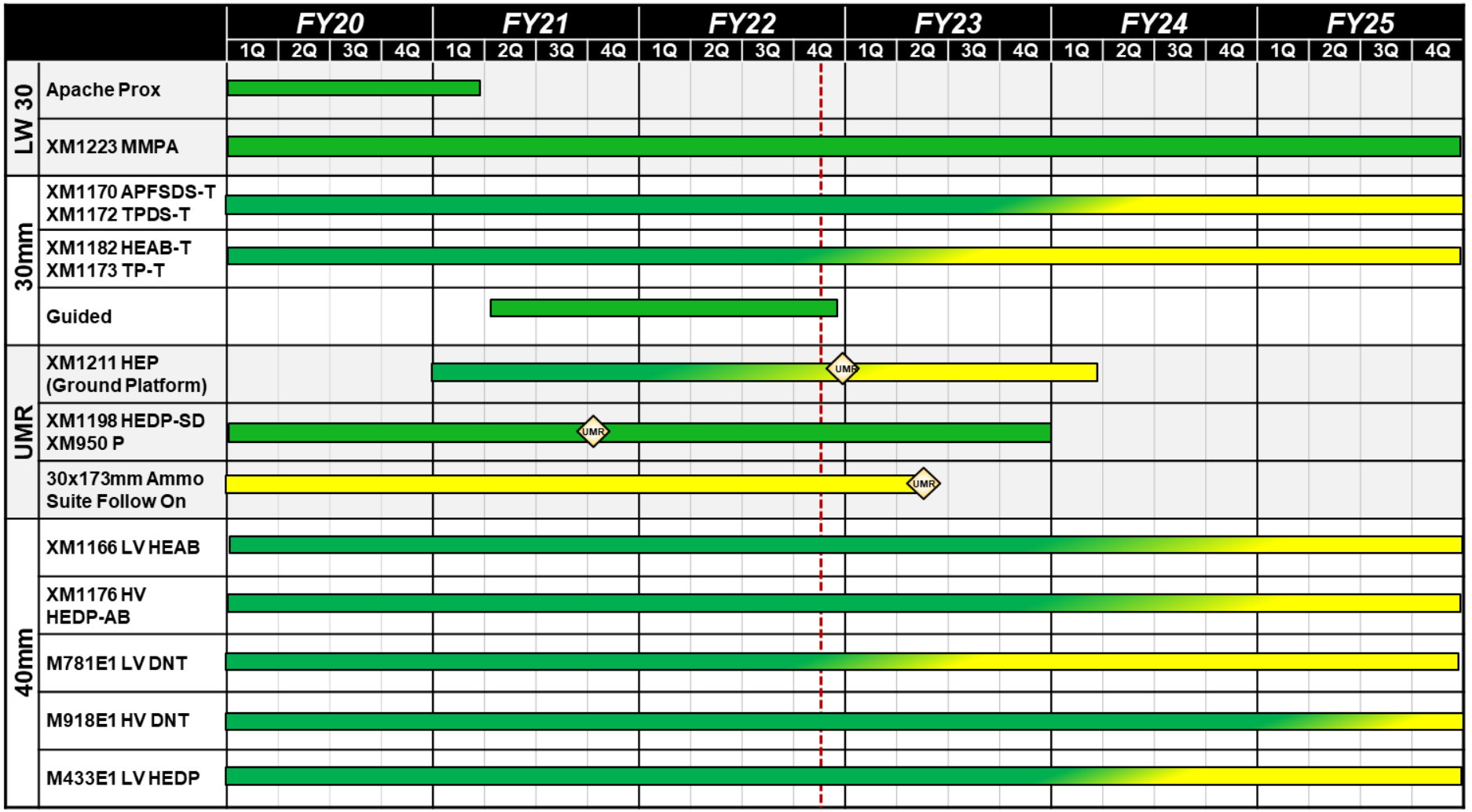
Medium Caliber Development Program Overview



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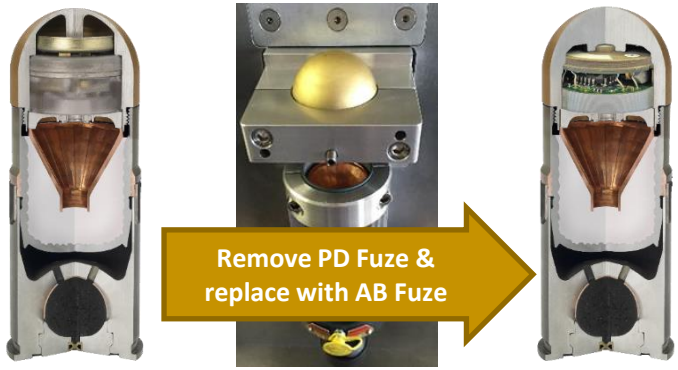
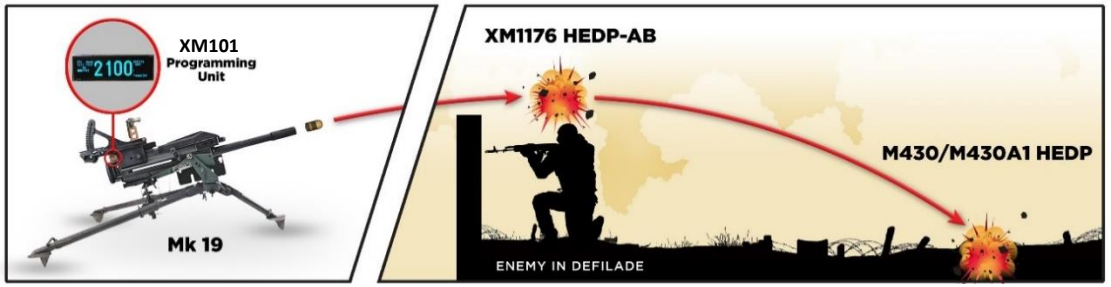
40mm Airburst Capabilities

40mm High Velocity XM1176 HEDP-AB

40mm HV XM1176 HEDP-AB will provide Mk19 Mod 3 Grenade Machine Gun (GMG) an airburst capable cartridge with ability of achieving required lethal effects against enemy targets in the open and in defilade while maintaining the capability to defeat unarmored and lightly armored vehicles

M430A1 HEDP | **XM1176 HEDP-AB**





Prime Contractor: Rheinmetall Day & Zimmermann Munitions (RDZM)

Legacy M430A1 Ballistic Trajectory Inhibits Engagement of Personnel Threats in Defilade

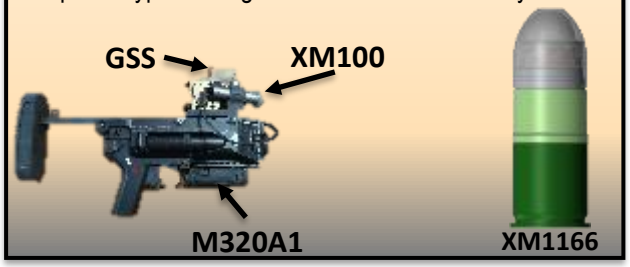
40mm Low Velocity XM1166 HEAB

40mm LV XM1166 HEDP-AB will provide M320 Grenadier a programmable airburst capable cartridge with the ability of achieving required lethal effects against enemy targets in the open and in defilade

Programmable Airburst

Advantages

- Increased Lethality in open and counter-defilade
- User Adjustability (Burst Point and Function Modes)
- Expands types of targets that can be defeated by 40mm



Legacy M433 HEDP Ballistic Trajectory Inhibits Engagement of Personnel Threats in Defilade

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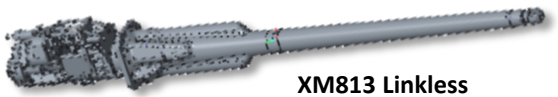
Distribution Unlimited

30x173mm Family of Ammunition

Provide desired required lethal effects, with greater accuracy at extended ranges, against light-to-medium armored vehicles, enemy personnel in the open, defilade position and within urban structures

- **XM1182 High Explosive Airburst with Trace (HEAB-T)**
  - Multi-Mode for effectiveness across multiple engagement scenarios
    - Airburst (AB): defeat personnel targets in the open and in defilade
    - Point Detonate (PD): defeat unarmored vehicles
    - Point Detonate Delay (PDD): penetrate urban structures or trucks before detonating
    - Self Destruct (SD): reduces UXO hazards
  - Advanced Warhead - increased fragmentation for larger lethal footprint and ability to penetrate urban structures
  - Contact Set Programming – increased communication enabling full firing rate, two-way communications for increased reliability, and common USG defined programming



XM813 Linkless Autocannon

- **XM1170 Armor Piercing Fin Stabilized Discarding Sabot with Trace (APFSDS-T)**
  - DU penetrator replaces Tungsten-Nickel-Cobalt for improved penetration
    - Compliant with environmental guidance prohibiting use of cobalt
  - Increased effectiveness at extended range
  - Domestic steel cartridge case

Being fielded to Stryker ICVVA1-30mm

NOT TO SCALE

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30X113mm for Ground Platforms

FORCE PROTECTION

Light Materiel

Personnel

Counter-Defilade

Capability for Current & Future Light / Medium Weight Ground Platforms

XM914 WEAPON SYSTEM

- 30X113mm Ammunition
- Single Feed
- Percussion Primed
- Link Fed

AIR DEFENSE

UAS & Swarms

30X113mm AMMUNITION

XM950 P
(Practice)

XM1198 HEDP-SD
(High Explosive Dual Purpose Self Destruct)

XM1211 HEP
(High Explosive Proximity)

XM1223MMPA
(Multi-Mode Proximity Airburst)

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Challenges w/ Distributed Armament System Development

- Independently Integrated Medium Caliber Weapons
  - Multiple PMs integrating medium caliber weapons onto platforms
  - Increased risk for integration of ammunition, weapon, and fire contr

- Multiple Configuration Issues
  - Unstable Medium Caliber Weapon System TDPs
  - Lack of TDP control leads to numerous weapon variants

- Contractor Overseeing Change Control
  - Platform OEM make weapon modifications without USG armament expertise
  - Ammunition qualification delays and issues due to uncontrolled weapon variants

- Disjointed Armament System Development Resources
  - Weapon, ammo, and fire control experts divided by org. boundaries
  - Future ammunition capabilities require armament system integration at beginning of program development

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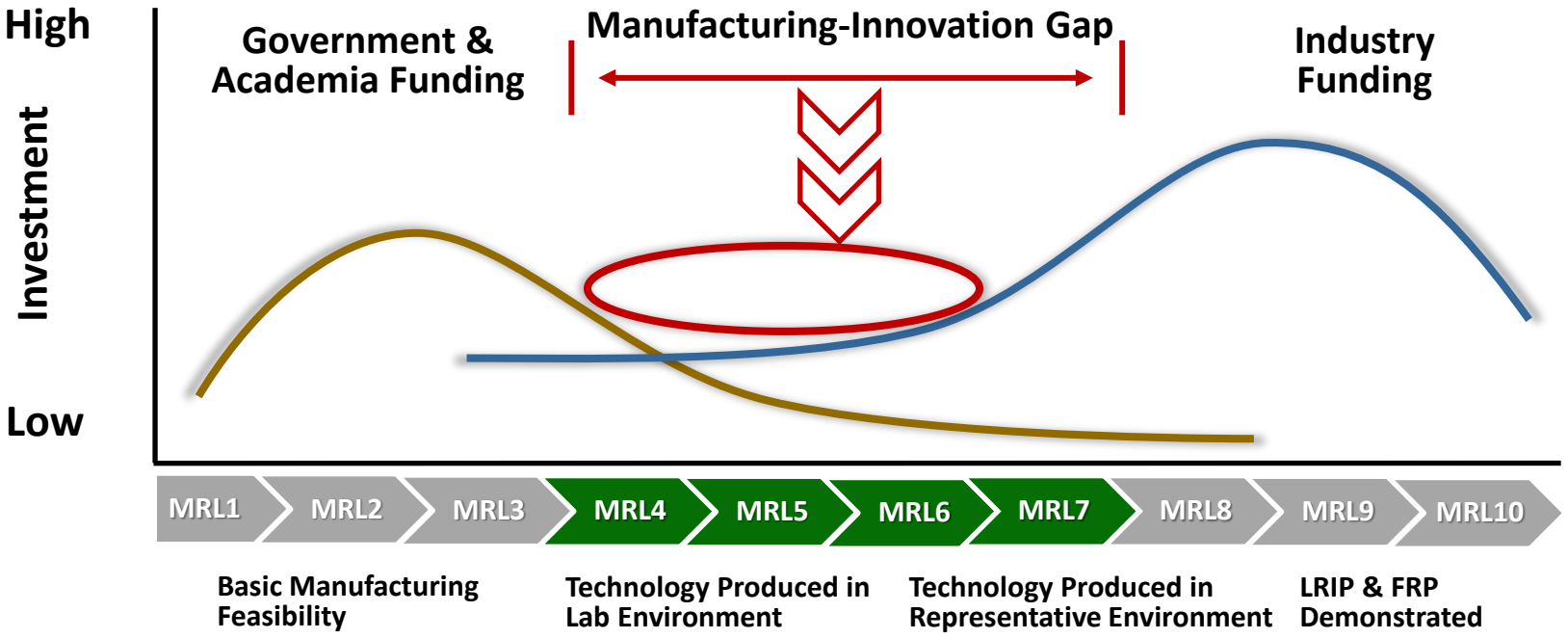
Producibility



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PdM Large Caliber Focus Areas

- **M829A4 Production Year 6-9**
  - 3QFY24 Award
  - Competition likely (limited to U.S. and Canada, Firmed Fixed Price)
  - Aerojet sustainment contract

- **120mm M1147 Advanced Multi-Purpose LRIP 1 First Article Acceptance Test (FAAT)**
  - LRIP resuming in 3QFY23

- **50mm Family of Ammunition (FoA) development**
  - Capability Development Document (CDD) writing underway
  - Conducting Design Engineering Tests (DET')s for each variant (AP, AB, TP)

NOT TO SCALE

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PdD SAWS Mission

Mission:

Procure and deliver safe, reliable, and lethal Non-Standard Ammunition and armaments to fully equip the U.S. allies' and Joint Forces' warfighter to support the U.S National Security Strategy (NSS) and U.S. Agencies for the purpose of training and familiarization

Vision:

Enable our coalition partners to fight the fight and Create a stable situation around the world

Over 400 Munitions and Weapon types managed
Over $1.8 Billion Contracted
Over 1 Billion Rounds Delivered

Non-Standard Ammunition: Ammunition that is not Type Classified (TC), Materiel Released (MR), Safety Certified or in US Inventory

NOT TO SCALE

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PdD SAWS Short List of Products

- **Small Caliber**
  - AK-74: 5.45x39 (Blank, Ball, Tracer)
  - Makarov: 9x18mm
  - AK-47: 7.62x39mm (Blank, Ball, Tracer, Armor Piercing (AP))
  - Sniper & PKM: 7.62x54mm (Blank, Ball, Tracer, AP)
  - DsHK: 12.7x108mm (Blank, Ball, Tracer, AP)
- **Medium Caliber**
  - 14.5mm (Ball, Tracer, AP, Armor Piercing Incendiary (API))
  - 23mm (High Explosive (HE), High Explosive Incendiary (HEI), API, Armor Piercing Incendiary-Trace (API-T)
  - 30mm (HE, HEI, API, API-T)
- **Large Caliber**
  - 120mm IM HE-T
  - 120mm KE-W
  - 125mm (HEAT, APFSDS-T, Practice)
  - 90mm (HESH-T, APFSDS-T, Practice)
  - 100mm Hollow Charge
- **Recoilless Rifle Ammunition**
  - 40mm HE Frag ((Rocket Propelled Grenade) (RPG)) 40x70.5 to 106mm High Explosive Anti-Tank (HEAT) Thermobaric (RPG)
  - 73mm ((Tripod stand mounted Rocket Propelled Grenade) (SPG-9))
- **Under Barrel Grenade (VOG-25)**
  - 40mm HE FRAG
  - 40mm HE Bounding
  - 40mm Ground Smoke & Illum
- **Mortar Weapons and Spare Parts**
  - 60mm: M57, M6-211Long Range
  - 82mm: M37, M41, M69
  - 120mm: NEMO, M43, M75
- **Mortar Ammunition**
  - 60mm HE, Illum, Smoke
  - 82mm HE, Illum, Smoke
  - 120mm HE, Illum, Smoke
  - 120mm Breach Loaded, HE Practice, HE, Illum, Smoke
- **Artillery**
  - 122mm HE Part & Full
  - 122mm Smoke & Illum
  - 130mm HE Part & Full
  - 152mm HE Part & Full
- **Other**
  - Anti Tank Guided Missile (ATGM) and launchers
  - 57mm, 80mm, 107mm, 122mm Rockets
  - Fire Suppression: PP3, PP9
  - YAK B WPN Cycle: PPL
  - Counter Measure: PPI-26
  - Links, Belts, Linking Machines

Over 400+ items available and additional as needed by customer

DISTRIBUTION A: Cleared for Public Release
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Questions?

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Joint Program Executive Office Armaments & Ammunition

NDIA Future Force Capabilities Conference

September 2022

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Chief Engineer: PM-CAS

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DISTRIBUTION A. Approved for public release, distribution unlimited (09/09/2022) PAO Log #: 662-22

Cannon Ammunition Future Force

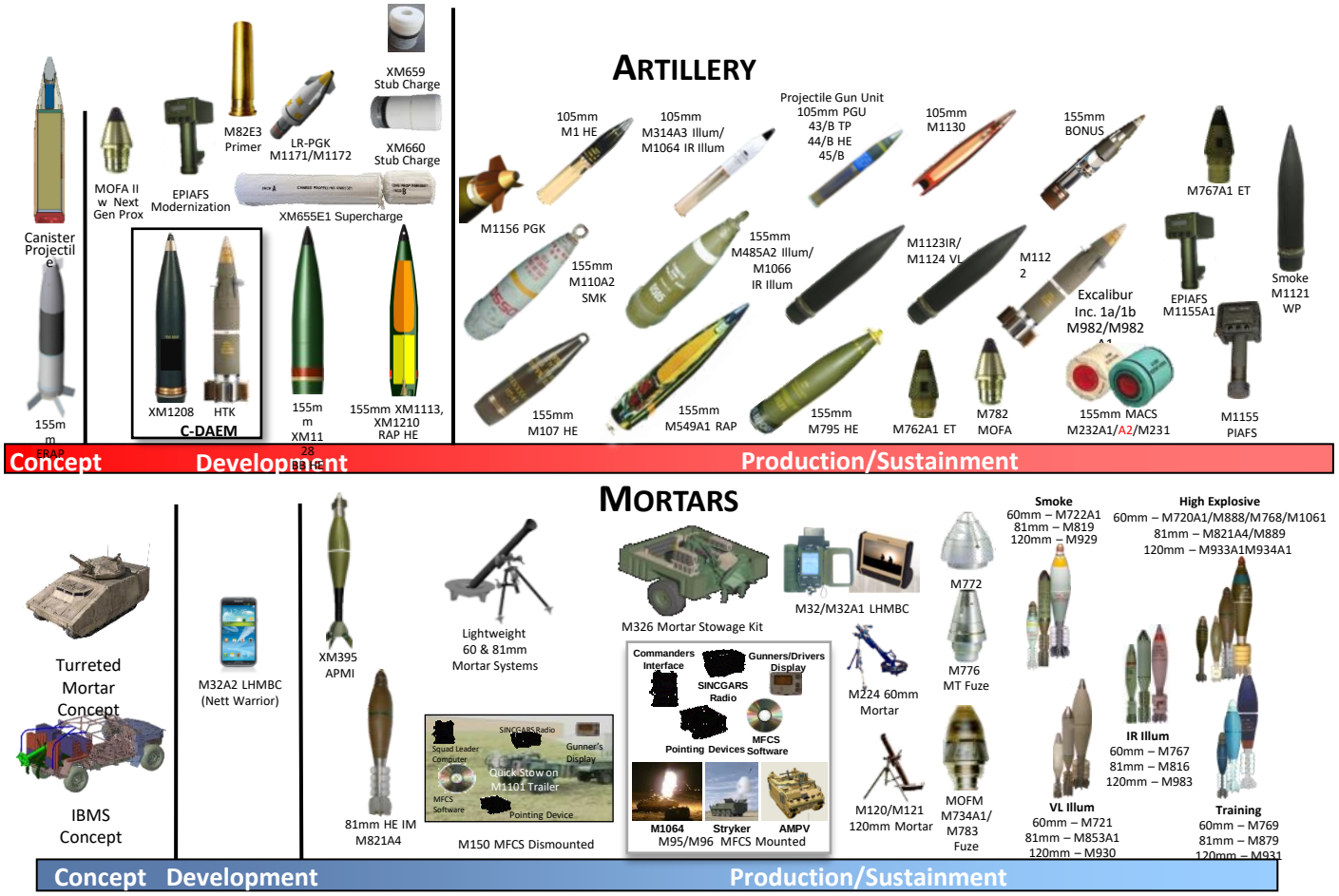
- Modernization activities are continuing, but **increasing production in critical munitions** to **rebuild inventories** and **provide continued support to Ukraine** has become the emerging priority

- Ukraine is challenging assumptions we have long held on **total munition requirements** and **how the industrial base should be scaled**

- How can we more rapidly mobilize throughout the Defense Industrial Base, mitigate supply chain risk, and better posture/scale for future needs?

Distribution A. Approved for public release, distribution unlimited (09/09/2022) PAO Log #: 662-22

PM CAS Family of Products



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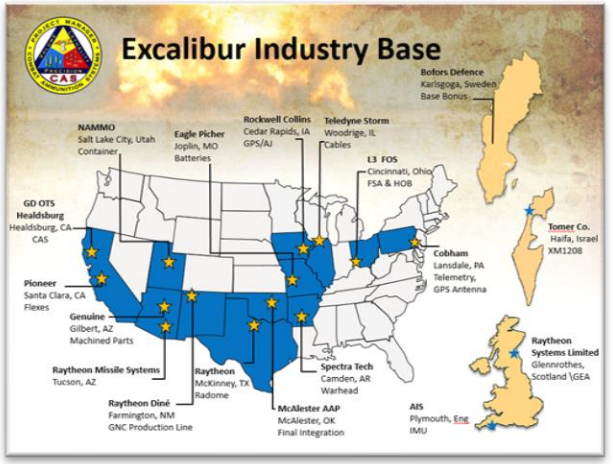
PM CAS Supply Maps



Indirect Fires Situation

Cannon Artillery Gaps

Capacity

- Range
- Lethality
- SEAD

Traditional Paradigm	Emerging Paradigm	Enabled Through…
Suppress	Open up Windows of Opportunity	Mass
Neutralize	Close the Kill Chain	Momentum
Destroy	Create Multiple Dilemmas	Precision

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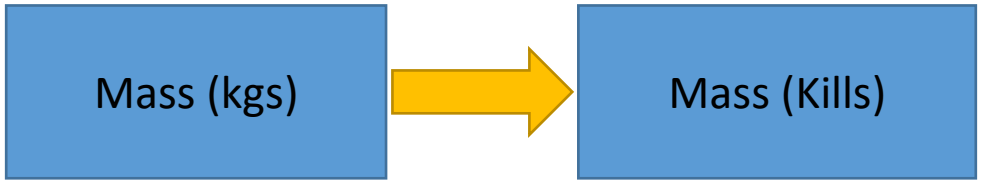
Fundamental Measures of Artillery Fires

- Traditional Mass in Fires meant large quantities, for long durations, to sustain suppressive, neutralizing and destructive fires
  - 100s of rounds per tube per day
  - High intensity peaks
  - Requires ENORMOUS inventories of munitions on hand, extremely high production capability…or both
- Requires near parody in the quantity of shooters and the effects of conventional fires
  - Reality is we have less shooters
  - DPICM no longer an option for massed area fires
- As ranges are extended – propellant pressures and temperature increase, tubes wear out quicker, and thermal limits on gun tubes are reached more quickly
- Sustaining fires makes the platform a target on the modern battlefield



Unit Production Cost

Time to Defeat
Rounds to Defeat
Cost/Kill
Life Cycle Cost

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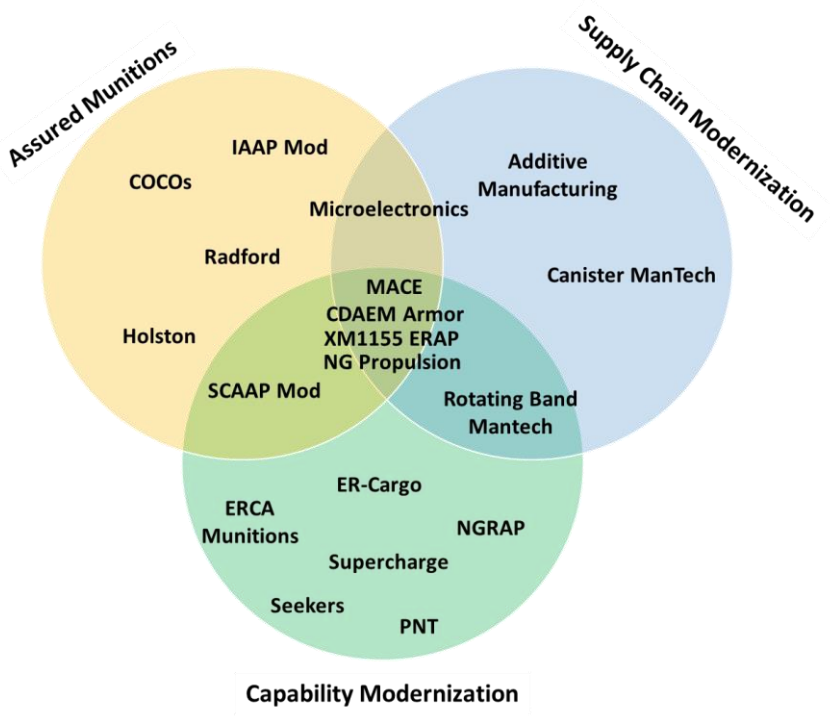
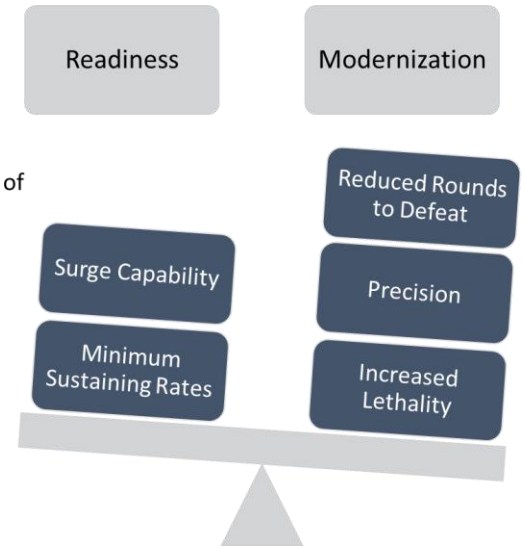
Balancing Readiness and Modernization





Readiness: Increase Mass of Projectile

Supply Chain: Increase rate at which Mass can be increased or decreased

Capability: Decrease Mass required

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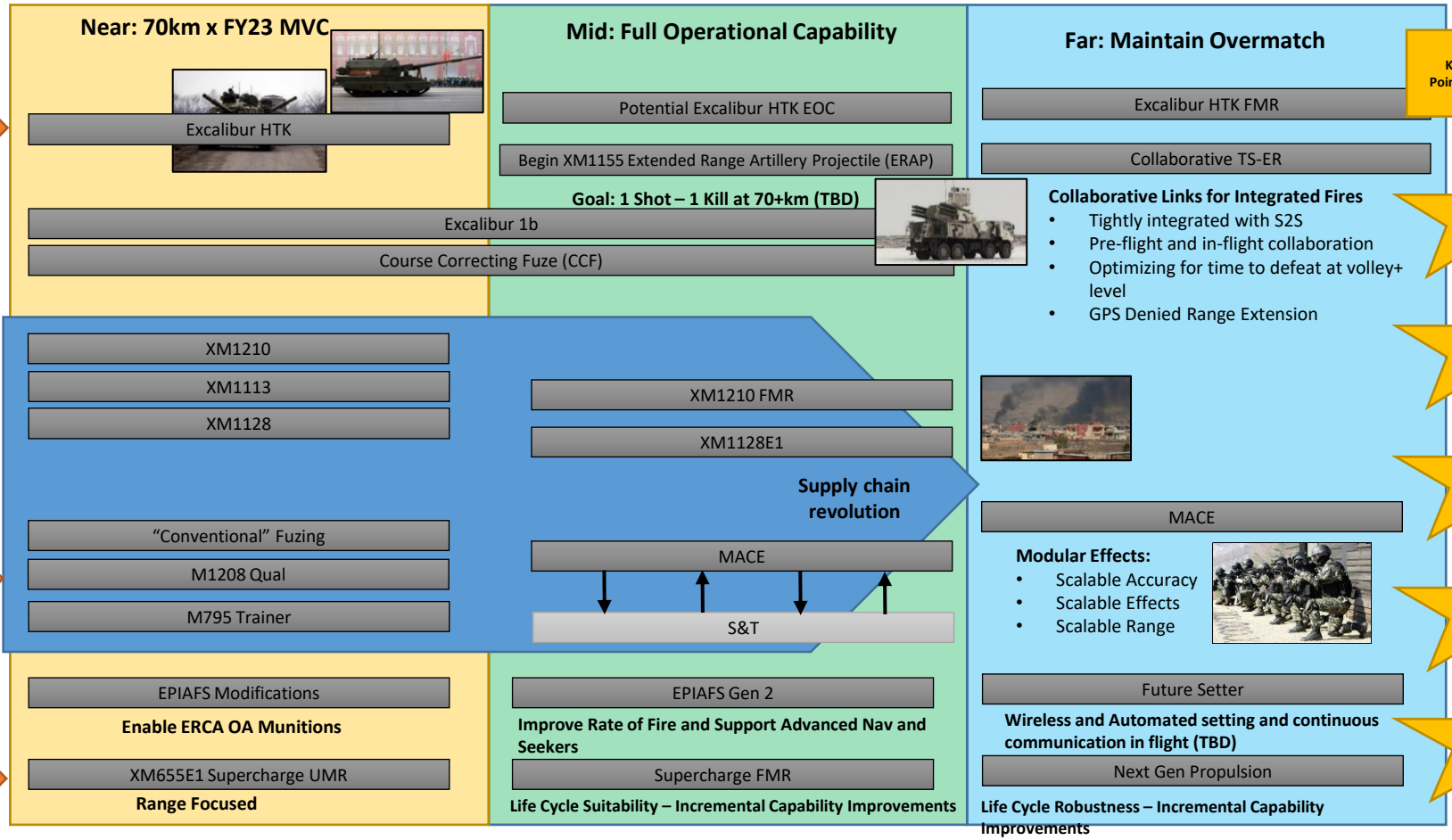
Cannon Artillery Ammo Modernization – Preliminary



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Readiness Roadmap

Near	Mid	Far

• Continue investment in GOCOs
• Extend facility modernization to other key parts of NTIB
• Increase production rate of Excalibur and other precision munitions as they come on-line
• Address obsolescence
• Improve production control and key parameter management
	• Transition “conventional” munition production to Modular Artillery for Combat Effectiveness (MACE) concept
	• Increase surge capacity for Excalibur and other precision munitions
	  • Secure supply chains and/or make “life-time” buys
	• Improve Ballistics Understanding to enable quicker design cycles
		• Invest in highly effective, collaborative munitions
		  • Seekers
		  • Advanced Cargo Payloads for Area Effects
		• Enable Virtual Prototyping
		• Own the Digital Thread and enable diverse and robust supply chains

Increased Knowledge to Increase Agility

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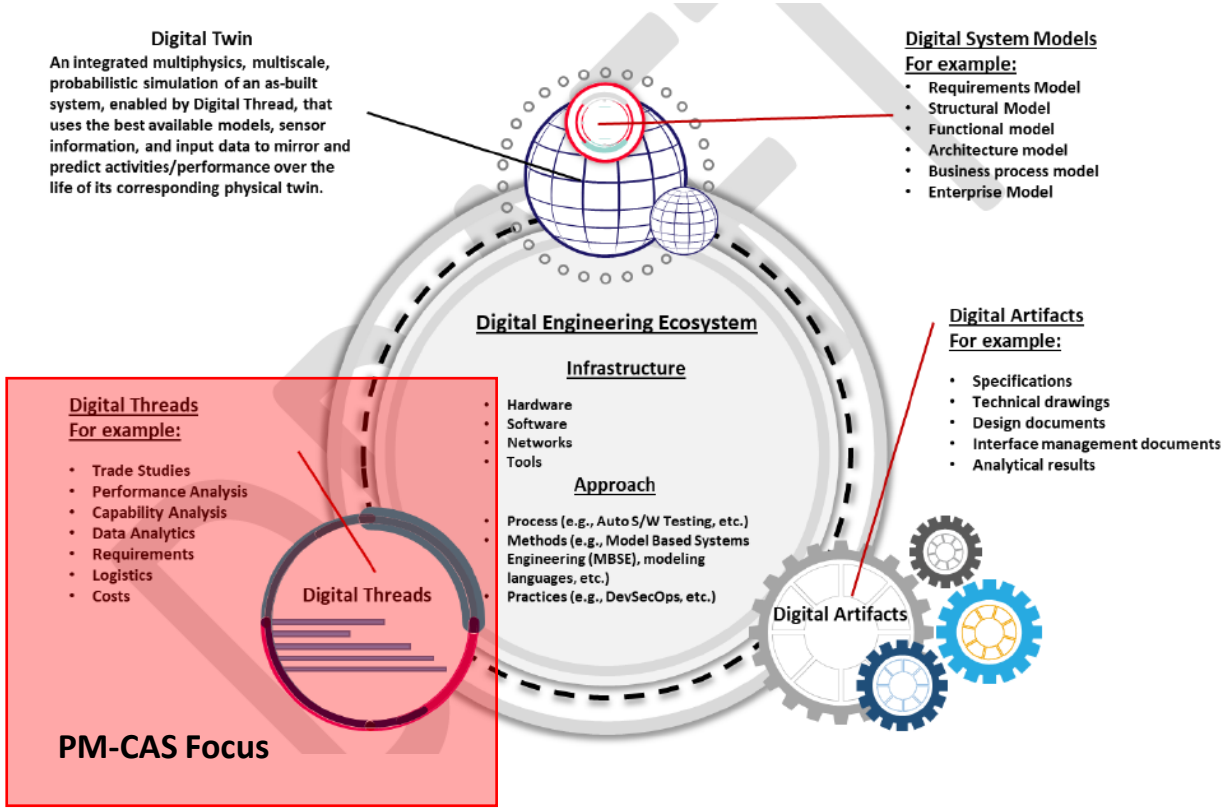
The Ammo Digital Thread



We will not predict the future correctly, but we can predict that Knowledge = Speed and Agility

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Opportunities for Industry

- **Programs**
  - Modular Artillery for Combat Effectiveness (MACE)
    - Training Rounds
    - Future Base bleed and Rocket Motor
    - Cargo
    - Right-sized precision
  - XM1155 Extended Range Artillery Projectile (ERAP)
  - Supercharge FMR and Next Gen Propulsion
  - Increased production, second sources, alternate designs

- **Enablers**
  - Kill Chain Optimization – to include projectile setting and datalinks
  - Flexible Manufacturing Capabilities
  - Digital Thread Development
  - Secure supply chains
  - Second, third…sources

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Summary and Questions

- **<u>Modernization</u>** and **<u>Readiness</u>** do not need to be competing priorities
- Challenge is getting to a future state where these priorities are better aligned, while meeting near term needs
- Plan for Continuous Innovation and Modernization

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PM CCS
PROJECT MANAGER CLOSE COMBAT SYSTEMS

ON EVERY MISSION

Future Force Capabilities Conference

20 September 2022

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(U) Team PM CCS

ON EVERY MISSION

- ***Manage 44% of the Army's conventional munition lethality***
- ***384 products: 316 Class V, 59 Class VII & 9 RDT&E***
- ***Average 60 Contracting Actions/Year***
- ***Oldest PMO in the US Army, 1961 "PM-Selected Ammunition"***

Mission

Provide dominant and innovative lethal and protective capabilities for the Joint Warfighter through acquisition excellence

Vision

Skilled innovative team, empowered to deliver dominating close combat capabilities

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(U) Team PM CCS

ON EVERY MISSION

Provide dominant and innovative lethal and protective capabilities for the Joint Warfighter through acquisition excellence

ON EVERY MISSION

Project Manager
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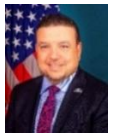
Deputy PM
Joe Pelino

Business Division Manager
Anita Polesky

Chief, Product Support
Fred Willecke



Director, Program Integration & International Division
Michael O'Grady (Actg)

Manager, Technology Management Division
Rob Dressel (Actg)

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Product Manager
LTC Isaac Cuthbertson

Deputy PdM
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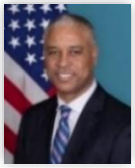
Asst Product Manager(s)
MAJ Manuel Macias

Branch Chiefs
XM343 SAVO: Sean Stevens
TAC2: Eli Vainchenker

Product Director Combat Armaments & Protection Systems



Product Director
David Millette

Deputy PD
Don Palathinkal

Asst Product Manager
MAJ John Pfromm

G&PS Branch Chief
Tinesha Nicholas

Team Leads
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Grenades: Hugh MacMillan
Protection Systems: Derek DeReiter

Product Director Demolitions & Countermeasures

Product Director
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Deputy PD
Stephen McFarlane (Actg)

Asst Product Manager
MAJ Thomas Fite

Branch Chiefs
Pyrotechnics: Harvard Yuen
Demolitions: Phillyp Lawson

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(U) PM CCS Portfolio

ON EVERY MISSION

Protection System

AN/PSS-14C Hand Held Mine Detector

SS-ADT

Taser

Acoustic Hailing Device

Grenades

M67 Fragmentation Hand Grenade

M111 Offensive Hand Grenade

M228 Practice Fuze

M106 SOD-V_R

Smoke Grenades

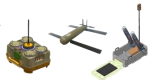
Terrain Shaping Obstacle

XM204 Top Attack

XM343Standoff Activated Volcano Obstacle (SAVO)

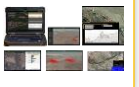
Close Terrain Shaping Obstacle Inc 1

Next Gen. TA Munition System



Remote Control System

Obstacle Planning Tool



Demolitions

SLAM

Claymore

RF-Remote Activation System

Shaped Charge

Sheet Explosive

Det Cord

C-4 Block

Pyrotechnics

Signals

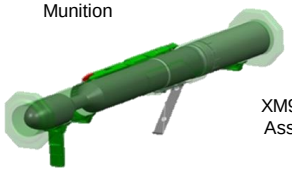
Countermeasure Flares

Simulators

Shoulder Launched Munitions

Bunker Defeat Munition

AT4 & AT4CS



XM919 Individual Assault Munition (Notional)

EOD

Explosive Ordnance Response Kit

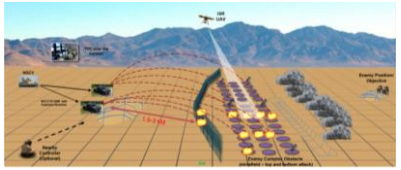
Smart Ray Vision (SRV)

Render Safe – Sets, Kits and Outfits (RS-SKO

Breaching Systems

APOBS

MICLIC



Next Generation Explosive Breacher

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(U) PdM TSO Portfolio

ON EVERY MISSION

XM 204 TOP ATTACK

XM204 Top Attack
(4 munitions per launcher)

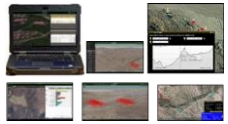
XM343 SAVO

XM343
Standoff Activated
Volcano Obstacle (SAVO)

CTSO Inc 1

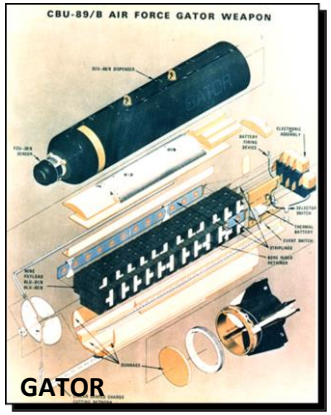
Next Gen. TA Munition System

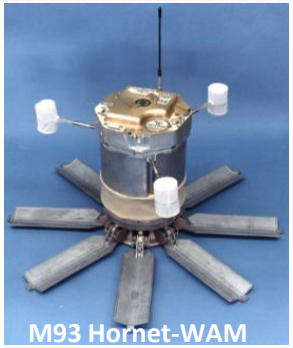
Remote Control System

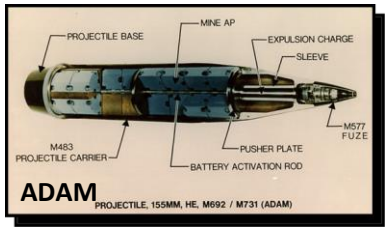


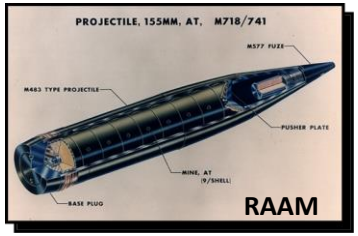
Obstacle Planning Tool

LEGACY MINES









M7 SPIDER Networked Munition System

Spider
Remote Control Station

Spider
Munition Control Unit

CTSO – Close Terrain Shaping Obstacles
ADAM – Area Denial Artillery Munition
RAAM – Remote Anti Armor Munition
WAM – Wide Area Munition
MOPMS – Modular Pack Mine System

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(U) PD CAPS Portfolio

ON EVERY MISSION

HAND GRENADES

M67 Fragmentation w/Confidence Clip

M228 Fuze

M69 Trainer

M111

AN-M14 Incendiary

M8 Smoke Pot

M18 Colored Smoke
M83 White Smoke

SHOULDER LAUNCHED MUNITIONS

XM919 Individual Assault Munition

M141 Bunker Defeat Munition

M136A1 AT4 Confined Space

Mk153 SMAW Ammo

M3 MAAWS Ammo

M72 LAW ONS

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(U) PD CAPS Portfolio (cont'd)

ON EVERY MISSION

PROTECTION SYSTEMS

TASER

Intermediate Force Carbine (IFC)

AN/PSS-14C

Acoustic Hailing Device

Solid State – Active Denial Technology

INTERMEDIATE FORCE CAPABILITIES

66mm LAUNCHED GRENADES

12 gauge

NON-LETHAL HAND GRENADES

40mm

NON-STANDARD SYSTEMS

Handheld Detection Equipment

Passive InfraRed JUONS

Rhino

Jackal

Lightguard Mercury

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(U) PD D&CM Demolitions/Mines Portfolio

ON EVERY MISSION

LANE BREACHING

Explosive Breacher Concept

Neutralization Payload Delivery System

Detection System – UAS and Sensors

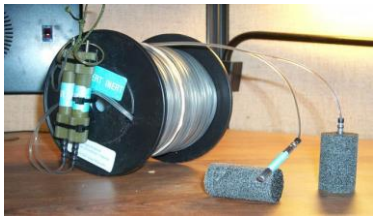
Neutralizer Warheads

DEMOLITION INITIATORS

Remote Activation System (RAMS)

M15 w/Shock Tube

M6 Electric Blasting Cap



Modernized Demo Initiators (MDI)

Time Delay- Sympathetic Detonator (TD-SYDET)

M700 Time Fuse

DEMOLITION DEVICES

CLAYMORE

Cratering Charge

M303 BDK

Shaped Charge

Detonation Cord

PLASTIC EXPLOSIVES

COMP C-4

Sheet Explosive

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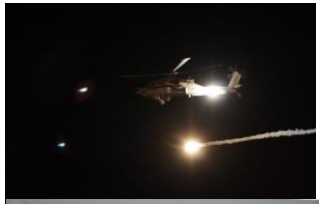
(U) PD Demolitions and Countermeasures Pyrotechnics Portfolio

ON EVERY MISSION

FLARES



SIMULATORS

M117

M119

M116A1

M115A2

SIGNALS

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(U) PD D&CM Explosive Ordnance Disposal Portfolio

ON EVERY MISSION

Small Caliber Dearmer (SCD) MK 38 MOD 0

Stand-Off Disrupter– Unexploded Ordnance Tool (SD-UXO) MK 40 MOD 0

Hook and Line Kit

Render Safe – Enhanced Robotic Payloads

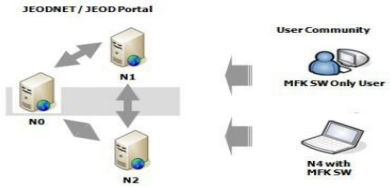
Highly Dexterous Manipulation System

Medium Directional Energy Tool (MDET)

Transmitter, Countermeasure (TCM): AN/PLT- 4

Smart Ray Vision (SRV)

Decision Support System (DSS)

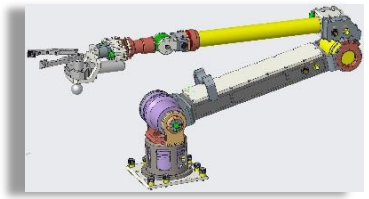


Multi-shot Disrupor

EOD Response Kit

Transmitter, Countermeasure (TCM): AN/PLT- 5

Stand-Off Disrupter IED Tool – PAN Disrupter



Precision Aim Module

Render Safe – Sets, Kits and Outfits

X-Ray Imager, COTS

Buried IED Detection, COTS

X-Ray Generator, COTS

Render Safe Initiation, COTS

Gamma and Neutron Search and Detection, COTS

Dismounted Operations Protection, GOTS

Power Management, COTS

Trace Detection, COTS

Unmanned Aerial System (UAS), COTS

Localized Incident Site Protection, *Development*

Low Light Visual Augmentation System, COTS

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Close Terrain Shaping Obstacles (CTSO) Development Strategy

ON EVERY MISSION

Interim/ONS | **MTA**

Top Attack

ACQ: FY19 | IOC: FY23 | ACQ: FY22 | IOC: FY28 | ACQ: FY26 | IOC: FY31

XM204 Top Attack

Capabilities:

- Affordable, easily trained & employed
- Ground-based, lethal Anti-Vehicle (AV) obstacle w/breach resistance measures
- Detect, Track & Engage Threat Vehicles
- Durable & Versatile: Maneuver Support & Maneuver Missions
- 4 hr, 48 hr, or 15 day Soldier selected self-destruct times

Top Attack

Capabilities:

+ Rapidly Emplaced; Recoverable & Reusable (Close)
+ Improved Lethality and sensing
+ Advanced counter-measure resistance
+ Common Control for networked obstacles
+ ON-OFF-ON Munitions
+ Self Report location of obstacles
+ Self report status, tamper, and/or activation of munition field
+ Remotely modified self-destruct / self-deactivate times
+ Command destruct / deactivate

Full Network Capability

Capabilities:

+ System communications (2-300 km)
+ Automated Cryptography and Command & Control
+ Ground-based, lethal AV complex obstacle (Bottom and Top Attack) with breaching resistance measures
+ All Terrain/Weather Environments and Deliverable at *Close, Mid, and Deep Ranges*
+ Direct Integration to Mission Command. Common Operating Picture.

Bottom Attack

ACQ: FY19 | IOC: FY23 | ACQ: FY25 | IOC: FY29

XM343 SAVO

Capabilities:

- Hand emplaced, man portable alternative means to employ Volcano canisters to form an AV obstacle
- Rapid obstacle emplacement and recovery
- SAVO baseplate (new item) will use existing inventory
  - Initiation System(s): M7 Spider, RAMS, Blasting Machine
  - Munition: M87/M87A1 Volcano munitions

Bottom Attack

Capabilities:

- Rapidly Emplaced
- ON-OFF-ON Munitions
- Increased Lethality against Main-Battle Tanks (MBTs)
- Self Report location of obstacles
- Self report status, tamper, and/or activation of munition field
- Remotely modified self-destruct / self-deactivate times
- Command destruct / deactivate

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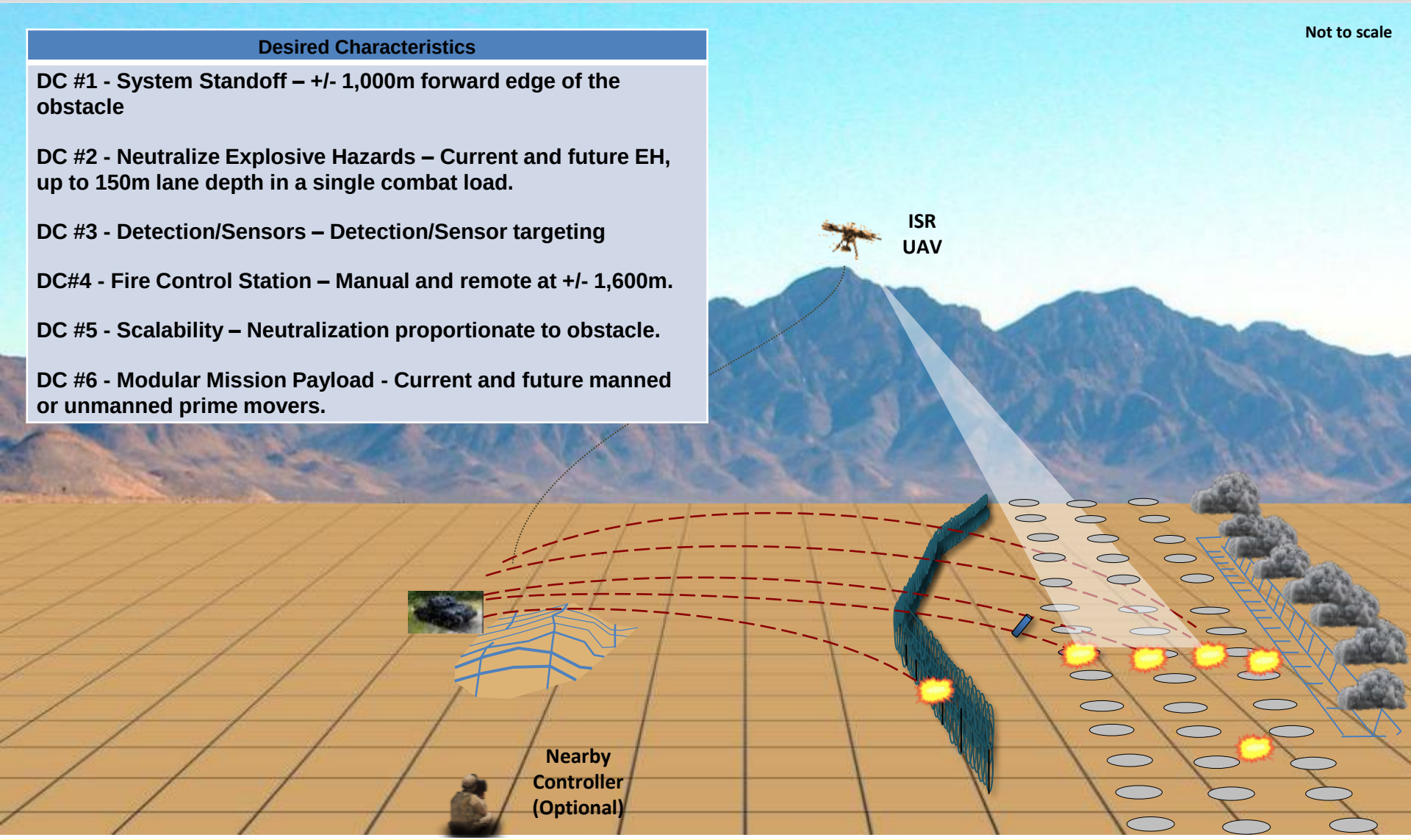
(U) Next Generation Breaching Technologies

ON EVERY MISSION

Desired Characteristics
DC #1 - System Standoff – +/- 1,000m forward edge of the obstacle
DC #2 - Neutralize Explosive Hazards – Current and future EH, up to 150m lane depth in a single combat load.
DC #3 - Detection/Sensors – Detection/Sensor targeting
DC#4 - Fire Control Station – Manual and remote at +/- 1,600m.
DC #5 - Scalability – Neutralization proportionate to obstacle.
DC #6 - Modular Mission Payload - Current and future manned or unmanned prime movers.

Not to scale



Removes Soldiers from the breach. Increases survivability, force protection, and overall mobility.

(U) TMRR Concept Demonstration Hardware

ON EVERY MISSION

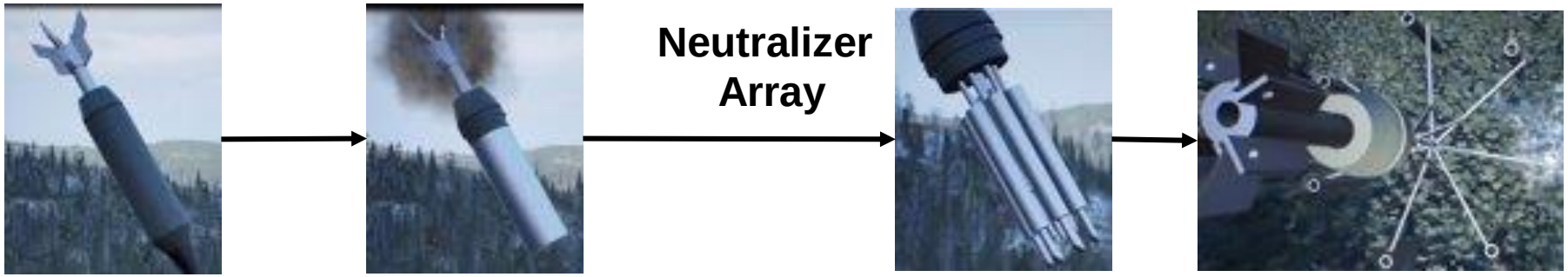
Detection

- Developed by DEVCOM C5ISR & Ft. Belvoir
- Supporting multiple customers including NGCV CFT (Project Convergence)
- FLIR SkyRaider R80D UAS
- Purpose-built electro-optical sensor with on-board processing, data storage, and optional laser designator / range-finder capabilities

Launcher

- Automated Direct/Indirect Mortar (ADIM) developed and demonstrated under S&T effort by DEVCOM AC in 2011-2014
- Fires 81mm Mortar munitions
- Modular (currently integrated onto a HMMWV)
- Recoil mitigation, on-board fire control with weapon auto-laying, and 20-round autoloader

Neutralizer Array



- Explosive Penetrator developed by DEVCOM AC and transitioned to Explosive Breacher Program of Record
- Packaging of penetrator array into 81mm form factor will be completed during TMRR
- Designed for compliance with Cluster Munition Policy
- Will investigate potential need for guidance (i.e. laser, GPS) during TMRR

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(U) Next Generation Breaching Technologies

ON EVERY MISSION

Seek

- UAS
- Manual & Automated control
- Multi-Spectrum Sensor Technologies
- Signal Processing Algorithms
- Small, light & energy efficient electronics

Enablers

- Secure Communications
- Precision Navigation & Timing (PNT)

MOS 12B Army Combat Engineer

Negate

- Stand-off Armament System
- Accurate Delivered Munition
- Neutralizer Payloads
- Multi-Fuze Conditions
- Directed Energy

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(U) FY23 Competitive Opportunities

ON EVERY MISSION

(U) FY22 NEW AWARDS				
(U) Program/ Item/ Description	(U) Planned FY22 Dollars ($M)	(U) Planned Strategy	(U) Contract Type	(U) Anticipated Final RFP Release Date (QtrFY)
Standoff Activated Volcano Obstacle (SAVO)	$2.8	S	IDIQ/FFP	1QFY23
M6/M7 Electric Blasting Caps	$1.0	C	IDIQ/FFP	1QFY23
M039 40lb Cratering Charge	$8.0	S	IDIQ/FFP	2QFY23
M34/M35 Simulators	$1.7	SBSA	IDIQ/FFP	2QFY23
Hand Held Signals	$13M	C	IDIQ/FFP	3QFY23

(U) FY23 DELIVERY ORDERS				
(U) Program/ Item/ Description	(U) Planned FY22 Dollars ($M)	(U) Contractor	(U) Contract Type	(U) Anticipated Award Date (QtrFY)
XM204 - Terrain Shaping Obstacle	$9.00	Textron	IDIQ/FFP	2QFY23
M913 Mines Clearing/Mines Line Charge (MICLIC)	$2.00	American Ordnance	IDIQ/FFP	2QFY23
Anti-Personnel Obstacle Breaching System (APOBS)	$16.00	Nammo Perry/ Ensign Bickford	IDIQ/FFP	2QFY23
Grenade Consolidation (M67 HG, M228 & M201A1 Fuze, M14 Incendiary)	$10.00	Day Zimmerman	IDIQ/FFP	2QFY23

Contract Strategy:
C- Competitive
SBSA - Small Bus Set-Aside
NTIB - National Technology & Industrial Base
S- Sole Source

Contract Type:
DLA- Defense Logistics Agency
FFP -Firm Fixed Price
IDIQ - Indefinite Delivery/ Indefinite Quantitiy
DOTC - DoD Ordnance Technology Consortium
CPFF - Cost-Plus-Fixed-Fee

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(U) Challenges Requiring Industry Partner Help

ON EVERY MISSION

Industrial Base

- Assured Munitions
  - Supply Chain Awareness & Visibility
  - Supply Chain Risk Management
  - Electronic Component Obsolescence
  - Digital Engineering
- Cybersecurity Requirements
  - Products
  - Facilities/Equipment
  - IT Systems
- Modernize/Automate Production & Inspection Methods
- Maintaining Production Capacities with ability to Surge

Technology Base

- Use of Modeling & Simulation
- Advanced Manufacturing
- Breaching Technologies
- Novel Surface-to-Air Missile Countermeasure solutions
- Novel Energetic Formulations
- Improved Chemical Formulation Processes at Affordable Price Point
- Advanced Fuze Design
- Enhance Warheads Performance
- Improved Munition Power Sources

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Closing

DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited. PAO# 688-22

Project Director Joint Services Overview

22 Sep 2022

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Project Director Joint Services
US Army JPEO Armaments and Ammunition
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Distribution Statement A. Distribution Unlimited.

PROJECT DIRECTOR JOINT SERVICES

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COL Jason Bohannon x8759

SFAE-AA-JS

BLDG 1 | PICATINNY ARSENAL, NJ 07806-5000 | 973-724-XXXX

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AF LNO
LtCol WOODBREY
x9579

USMC LNO
MAJ WALKER
x2047

PRODUCT DIRECTOR DEMIL

JIM TERHUNE x2839

- Conventional/Missiles
- RDT&E
- APE

PRODUCTION BASE SUPPORT DIVISION

GREG O'CONNOR x5008

- AAP Mod Requirements
- RDT&E - LCPP
- Environmental
- Section 806
- Single Point Failures
- ARMS

BUSINESS DIVISION

MATTHEW SEAMAN x3311

- Contracting
- Cost Analysis
- Financial
- HQ Ops
- HR

ARMY AMMUNITION PLANTS

HOLSTON AAP	IOWA AAP
CATHY FITCH x7689	VACANT
LAKE CITY AAP	**MILAN/QCCCF AAP**
JEFF FRYE 816.796.7206	VACANT
RADFORD AAP	**SCRANTON AAP**
DR. KIMBERLY GRISWOLD x4680	BRIAN MEIERDIERCKS x4333

Building 1, Picatinny Arsenal

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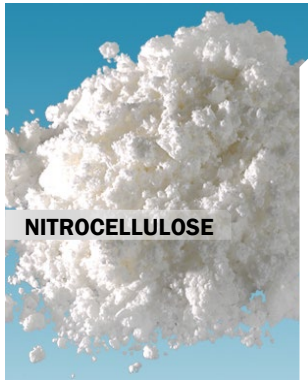
Project Director Joint Services Mission

Enable the acquisition, manufacturing and demilitarization of munitions for the Joint Services

Demilitarization

- Execute All DoD Conventional Ammunition
- Resource, Recovery & Recycle Program
- Ammunition Peculiar Equipment
- RDT&E

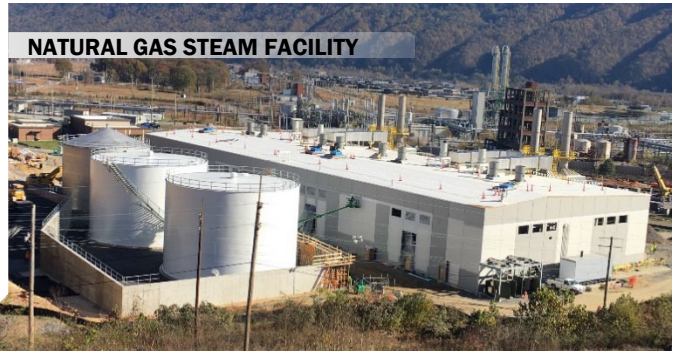


Single Manager for Conventional Ammo (SMCA)

- Coordinate and Integrate the DoD's SMCA Responsibilities
- SMCA & Industrial Base Policy
- SMCA Customer Survey
- Joint Ordnance Commanders Group (JOCG) EXCOM Chair
- SMCA Issue Resolution
- SMCA Industrial Base Strategic Plan

Industrial Base

- Government Owned Contractor Operated (GOCO) Army Ammunition Plant (AAP) Acquisition Strategies
- GOCO AAP Modernization
- Layaway and Maintenance of Inactive Facilities
- Armament Retooling & Manufacturing Support
- Section 806, PL 105-261
- Single Point Failure Program
- RDT&E Life Cycle Pilot Process



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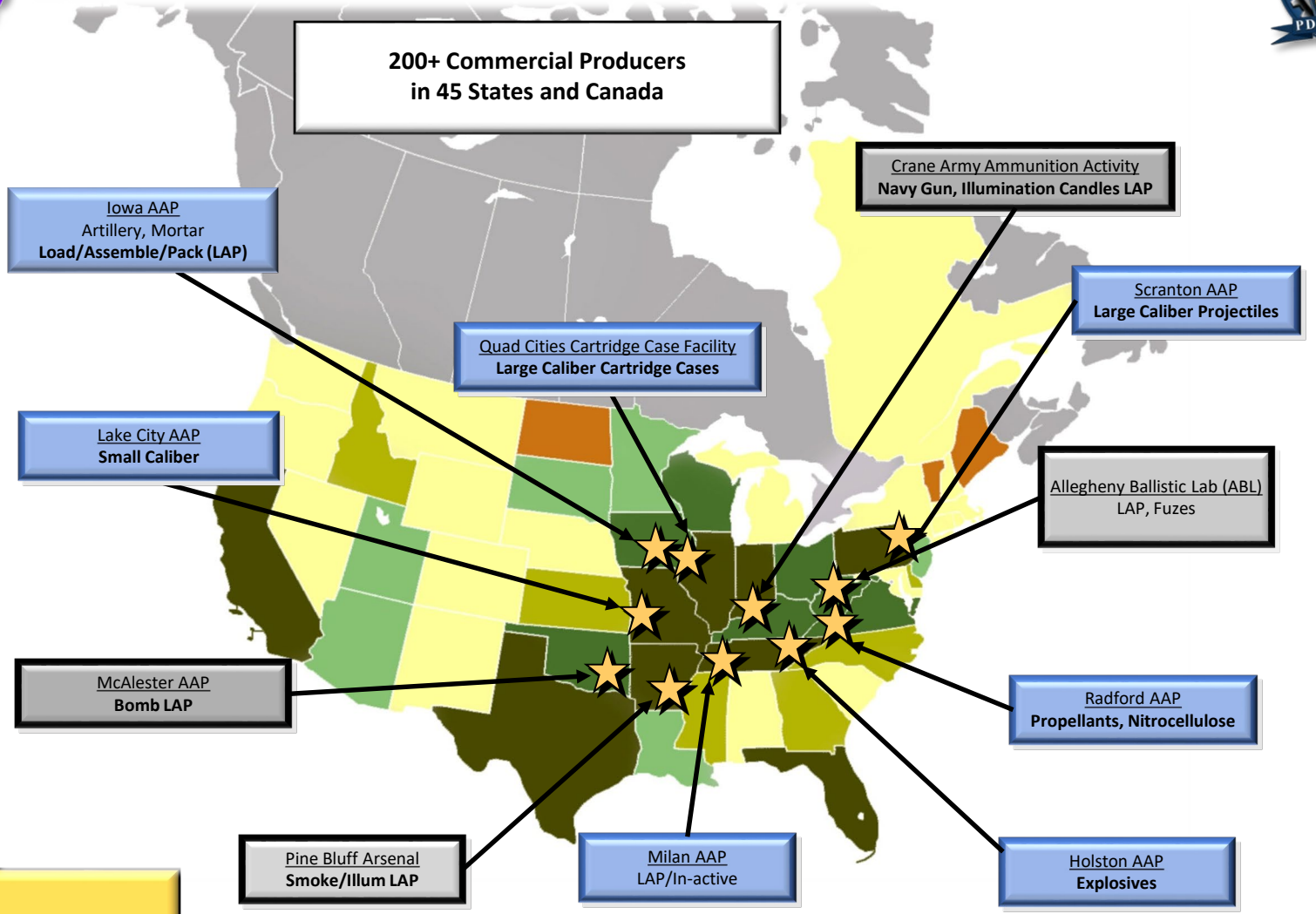
Ammunition Production Base



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P.L. 105-261, Section 806 Law

SEC. 806. PROCUREMENT OF CONVENTIONAL AMMUNITION.

(a) **Authority:** The official in the Department of Defense designated as the Single Manager for Conventional Ammunition shall have the authority to restrict the procurement of conventional ammunition to sources within the National Technology and Industrial Base in accordance with section 2304(c) of title 10, United States Code.

(b) **Requirement:** The official in the Department of Defense designated as the Single Manager for Conventional Ammunition **shall limit** a specific procurement of ammunition to sources within the national technology and industrial base in accordance with section 2304(c)(3) of title 10, United States Code, in any case in which that manager determines that such limitation is necessary **to maintain a facility, producer, manufacturer, or other supplier** available for furnishing an essential item of ammunition or ammunition component in cases of national emergency or to achieve industrial mobilization.

(c) **Conventional Ammunition Defined:** For purposes of this section, the term "conventional ammunition" has the meaning given that term in Department of Defense Directive 5160.65, dated March 8, 1995.

Public Law 105-261 Oct 17, 1998 (from http://www.currentleal.com/LegalNews/uspl1998/105-261.html)

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Single Manager for Conventional Ammunition (SMCA)

Est. 1977

Sec Def ➡ Sec Army ➡ ASA(ALT) ➡ PEO Ammo (est. 2002)

SMCA / Section 806 Delegation, Sep 2018

SMCA Charter:

- ***21 May 2015 – USD(AT&L) & Sec Army***

SMCA Objective:

- ***Achieve the highest possible degree of effectiveness and efficiency in the DoD operations required to acquire conventional ammunition and integrate logistics functions for U.S. Forces***

Updated 15 Mar 2022

DoDI 5160.68 (dated 29 Dec 2008)

SMCA: Responsibilities of the SMCA and Military Services

- Defines SMCA and Service Responsibilities across the SMCA Mission Functions:
  1. RDT&E (Transition in time for first FRP contract)
  2. Acquisition
  3. Production Base
  4. Supply
  5. Maintenance
  6. Demilitarization
  7. Technical Data & Configuration Management
  8. Transportation & Handling
  9. Safety
  10. Security
  11. Financial Management & PPBE
  12. Implementing Regulations
  13. Personnel & Training
  14. Quality Assurance
  15. Security Assistance

- Annually identify and prioritize production base deficiencies and formulate corrective actions to mitigate those deficiencies
- Execute the direct appropriations for the Production Base Support program for munitions
  - Provision of Industrial Facilities (PIF), Layaway of Industrial Facilities (LIF), Maintenance of Inactive Facilities (MIF), Armament Retooling & Manufacturing Support (ARMS)
  - Procurement of Ammunition, Army (PAA)

AR700-90, Army Industrial Base Process, Jan 2020

JOINT CONVENTIONAL AMMUNITION POLICIES AND PROCEDURES (JCAPPs)

- Guidance for execution of DODI 5160.68 responsibilities

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Joint Ordnance Commanders Group (JOCG) Principal Members

BG John T. Reim
JPEO A&A
(JOCG Co-Chair)

COL(P) Landis C. Maddox
Joint Munitions Command
(JOCG Co-Chair)

BGen Arthur J. Pasagian
Marine Corps
Systems Command

RDML Stephen R. Tedford
PEO for Unmanned Aviation
And Strike Weapons

RDML Jason M. Lloyd
Naval Sea Systems Command

Brig Gen Heath A. Collins
AFPEO for Weapons and
Director, Armament Directorate

Mr. William J. Innes
Special Operations
Command

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JOCG Focus

- ☆ Inter-Service Communications
- ☆ Industrial Base
- ☆ Acquisition, Logistics & Technology
- ☆ Joint Policy & Procedures
- ☆ RDT&E synergy
- ☆ International & DoD Policy Implications

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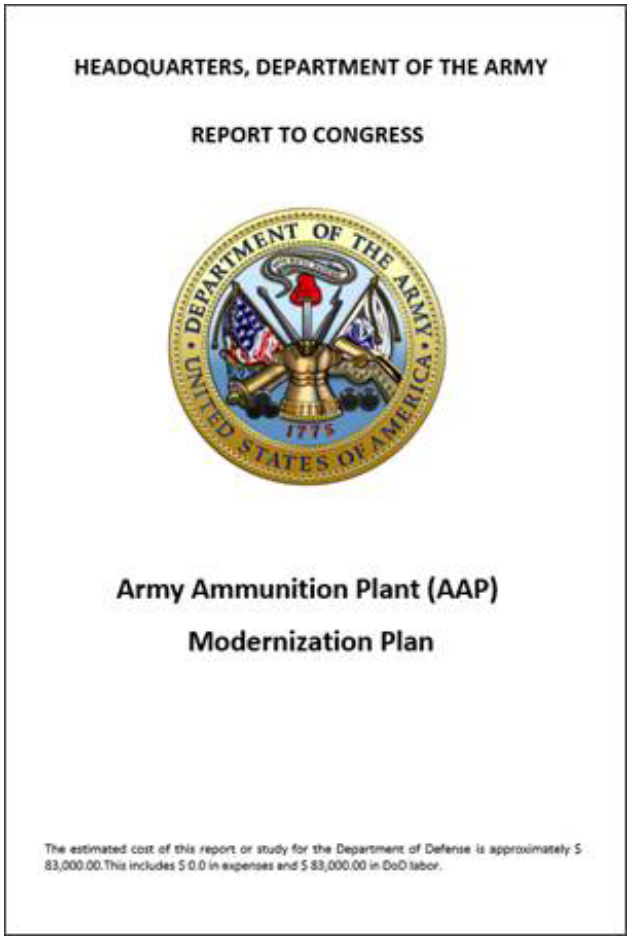
Army Ammunition Plant (AAP) Modernization Plan

- Modernization Plan submitted to Congress on 31 Mar 2022.
- PD JS led the development of the plan with support from DEVCOM, AMC, JMC, Industry, Academia, and Sandia National Laboratories.
- Plan contains over 400 projects structured to transform the AAPs with the latest manufacturing technologies and state-of-the-art process equipment to achieve the Army's modernization objectives.
- Plan accounts for emerging requirements driven by the Army's Cross Functional Teams (CFT).
- Plan currently being updated for submission to Congress: 31 Mar 2023.



HEADQUARTERS, DEPARTMENT OF THE ARMY

REPORT TO CONGRESS

Army Ammunition Plant (AAP)

Modernization Plan

The estimated cost of this report or study for the Department of Defense is approximately $ 83,000.00. This includes $ 0.0 in expenses and $ 83,000.00 in DoD labor.

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Modernization Strategy Objectives

1. Increase manufacturing safety and readiness to meet current and future requirements
2. Isolate energetic mass from people
3. Ensure graceful degradation and resilient operations
4. Improve flexibility, maintainability, and sustainability
5. Reduce cost of operations
6. Secure supply chains

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Example Modernization Projects

Radford AAP

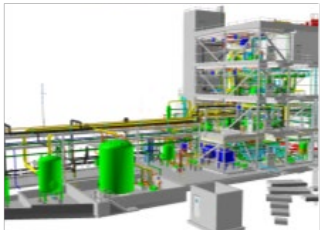
SNA Tank Farm

Package Boilers

Compressor House Upgrades

Holston AAP

Natural Gas Steam Facility



New Filtration and Wash Facility

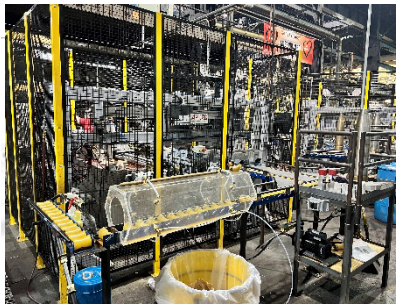
Fluid Energy Mill

Iowa AAP

New Melt Pour Facility
Long Range Fires

Cooling | Remote Bays | X-Ray Bays
Tank LAP

Scranton AAP



Submersible Ultrasonic Inspection

XM1128 Production Line Area

Erie I Press

Lake City AAP

Water Treatment Plant

Industrial Waste Treatment Lagoon & Filter Press

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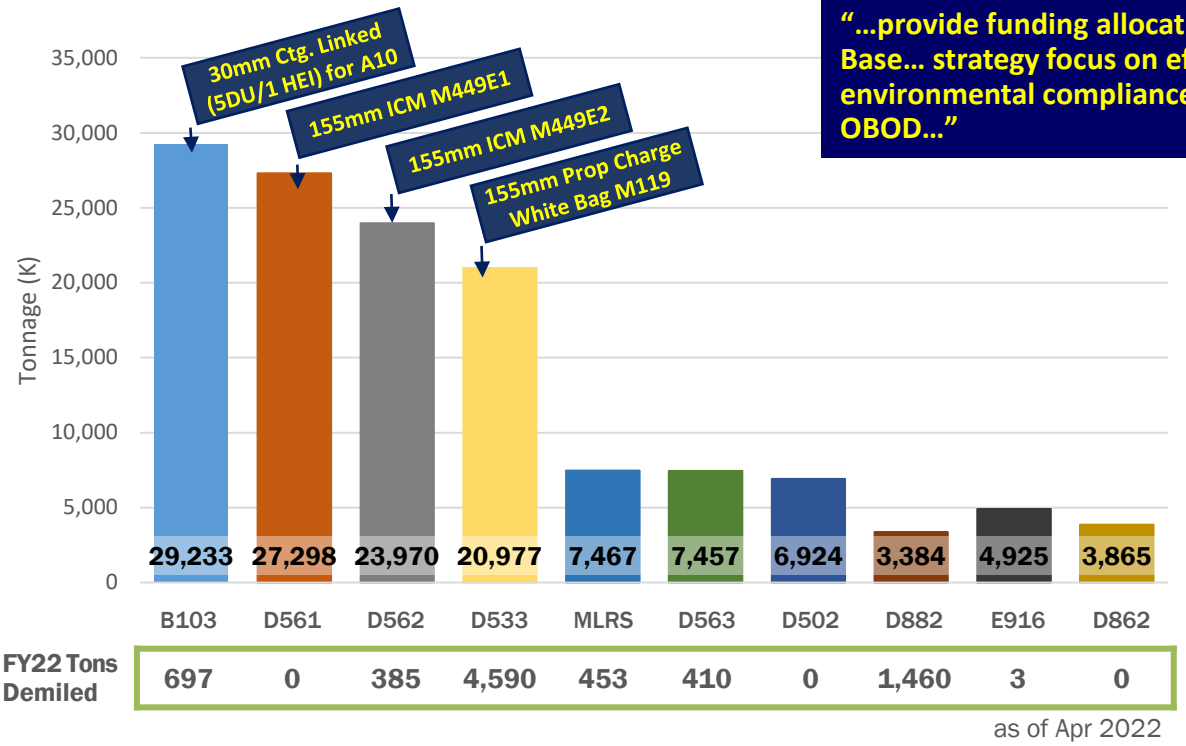
Major Demil Stockpile Items

— Over 7,000 DODICs in the Demil Account —

M483A1 DPICM Projectile

M42/M46 DPICM Grenades



as of Apr 2022

FY22 Appropriations Report Due Jun 2022:

"…provide funding allocation across Industrial Base… strategy focus on efficiency and environmental compliance; efforts to minimize OBOD…"

OBOD (Open Burn Open Detonation)

Demil B5A Account = 373,278 Tons*

*Represents 24% of Total Ammunition Stockpile

36% of B5A Stockpile is in the Top 10 DODICs

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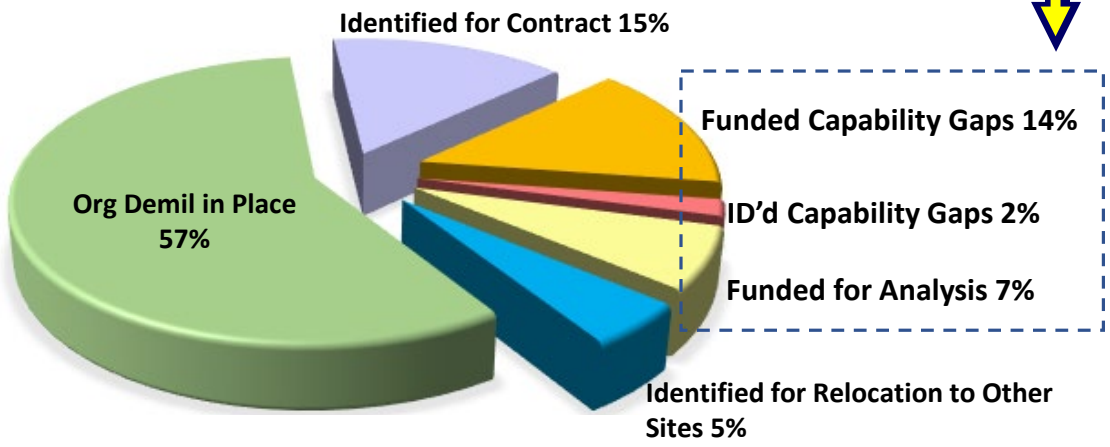
FY23-27 Demil Business Opportunities

Demil Capability Gap Analysis:

Goal: Have capabilities in place to maintain the B5A stockpile <100K ST

Need solutions for 23% of the B5A stockpile



Honest John Warhead

Smoke Munitions

Cluster Bomb and Cluster Bomb Explosion

Current Demil Capability Gaps:

- Various Cluster Bomb Units (CBU)
- Gator CBU
- Various Smoke Munitions
- Asbestos-Containing Munitions
- Misc. Munitions

Demil RDTE ID/IQ Contract FY22

- **Request for Proposal RFP Feb 2022**
- **Small Business Set Aside**
- **Allows the prime contractor to bid on RDTE project during five ordering periods**

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The Marvin Group

The Marvin Group
NDIA
Future Force Capabilities 2022

MARVIN ENGINEERING COMPANY

MARVIN TEST SOLUTIONS

MARVIN LAND SYSTEMS

Evolving Armament Systems to Support Multi-Domain Operations

Unconventional Emerging Armaments
20 September 2022

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INTEGRITY - PARTNERSHIP - CAN-DO ATTITUDE - INNOVATION

What are Multi-Domain Operations?

- Following definition is extracted from the U.S. Army's Training and Doctrine Command:

Multi-Domain Operations (MDO) describes how the U.S. Army, as part of the joint force [Army, Navy, Air Force, Marines, and Space Force] can counter and defeat a near-peer adversary capable of contesting the U.S. in all domains [air, land, maritime, space, and cyberspace] in both competition and armed conflict. The concept describes how U.S. ground forces, as part of the joint and multinational team, deter adversaries and defeat highly capable near-peer enemies in the 2025-2050 timeframe.

MDO provides commanders numerous options for executing simultaneous and sequential operations using surprise and the rapid and continuous integration of capabilities across all domains to present multiple dilemmas to an adversary in order to gain physical and psychological advantages and influence and control over the operational environment.

Key Elements of Multi-Domain Operations

- **Penetrate** enemy anti-access and area denial (A2/AD) systems (layered and integrated long-range precision-strike systems, littoral anti-ship capabilities, air defenses, and long-range artillery and rocket systems) to enable strategic and operational maneuver of U.S. forces.
- **Dis-integrate**—disrupt, degrade, or destroy A2/AD systems to enable operational and tactical maneuver of U.S. forces.
- **Exploit** the resulting freedom of maneuver to achieve operational and strategic objectives by defeating enemy forces in all domains.
- **Re-compete**—consolidate gains across domains and force a return to competition on favorable terms to the United States and allies.

Industry's Role = Facilitate these Objectives!

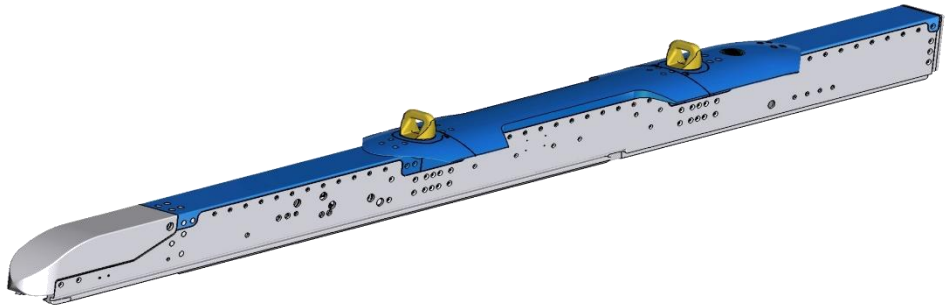
What Armament Solutions are Needed?

- The **speed of warfare and velocity of decision-making** arguably have never been faster than what exists today, and what is likely to exist tomorrow

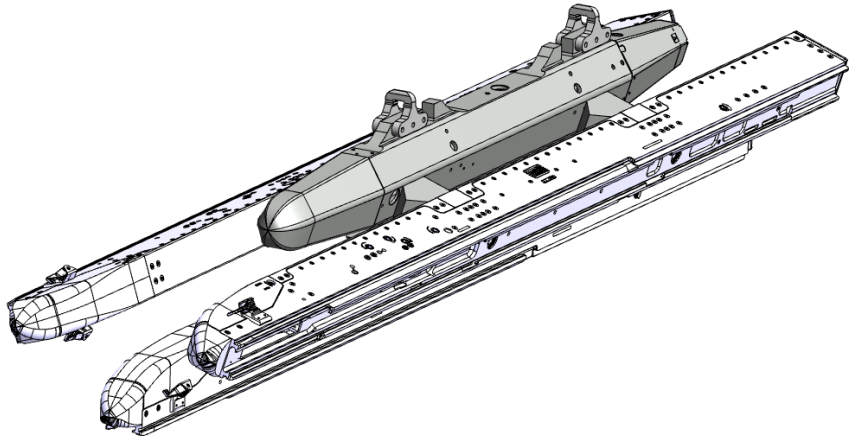
- The close coordination of assets operating on Land, Sea, Air, Space, and even Cyber domains to facilitate ISR activities and a kill chain for hostile targets requires precision, as well as a **capacity for "stowed kills" on various platforms**

- **Commonality in systems can reduce burdens in logistics, simplify training and maintenance, and help to ensure consistent, reliable performance across platforms**

- The **ability to rapidly field solutions based on proven technologies**, and to add additional flexibility and options for warfighters, is a **force multiplier**



LAU-128SE | Universal Missile Launcher (UML)



Multiple Munitions Launcher (MML)

Modified LAU-7

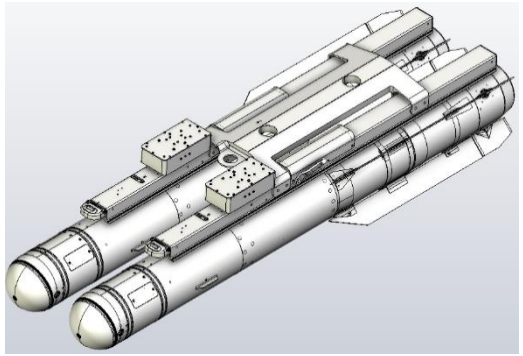
HSRL

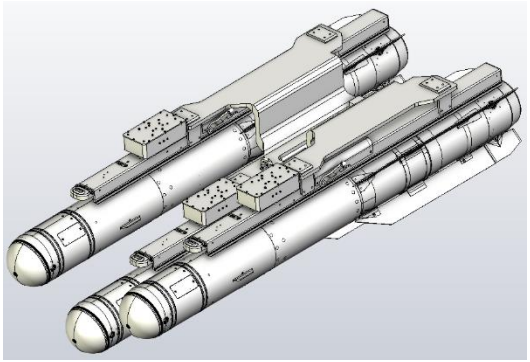
Rail Launcher Solutions

Lighter Weight Hellfire Class Launchers

- **Hellfire Scalable Rail Launcher (HSRL)**

  Adaptation of current M299/M310 (quad/dual rail) Hellfire missile launchers



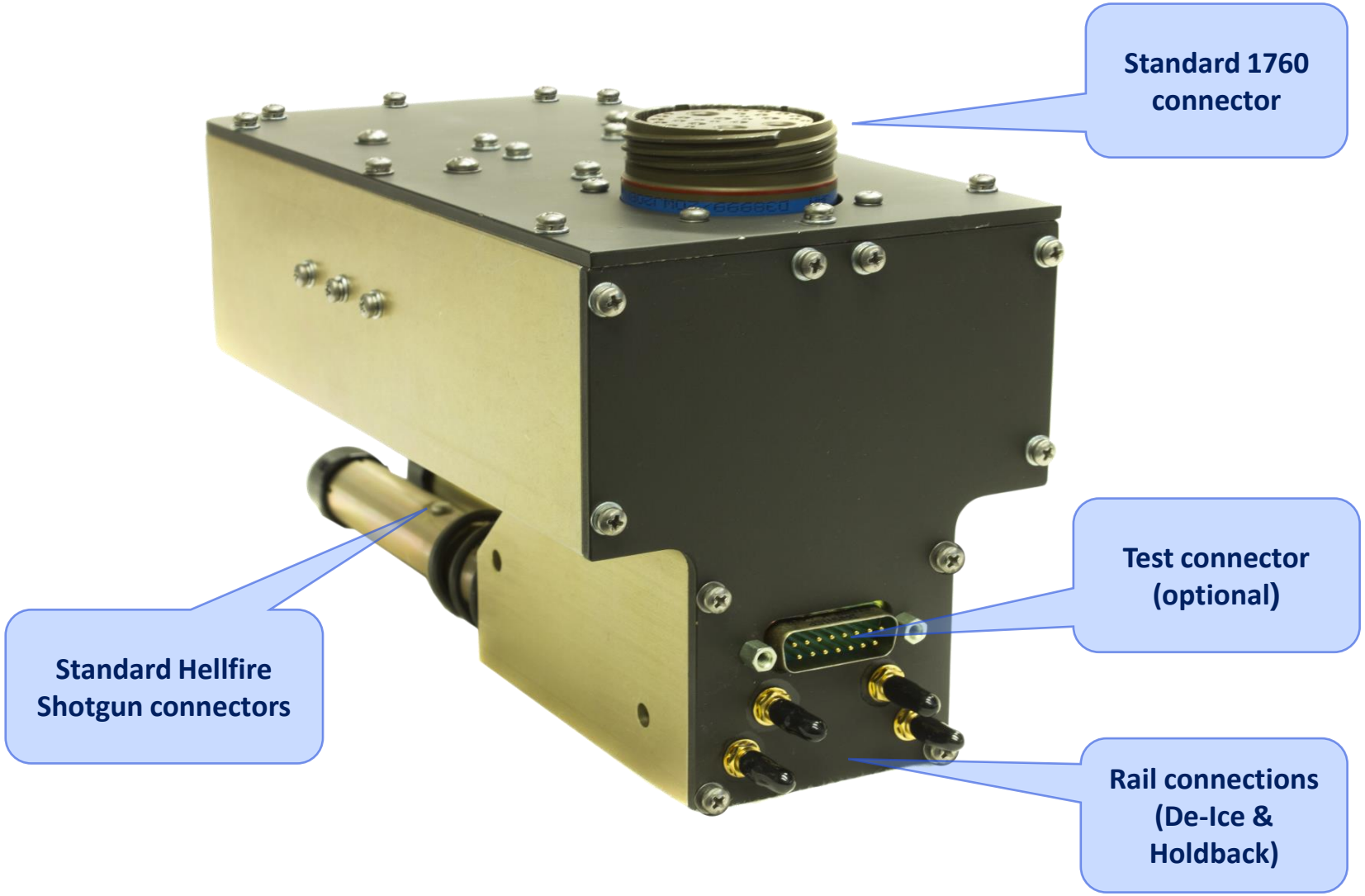


- Offers flexibility for single, tandem, triple, and quad clusters of rails for 100 lb. class (and less) air-to-ground munitions
- Miniaturized electronics significantly reduce weight from the M299/M310 series
- Proven Hellfire (qualified) rail design from the OEM manufacturer
- Ideal for UAV, UGV, Light Attack, Rotary/Tilt Wing, and other weight-sensitive applications
- HSRL is compatible with all Hellfire II, Romeo, Longbow, and JAGM missiles

Hellfire Class Scalable Rail Launcher (HSRL)

- Lightweight scalable Hellfire class launcher that enables integration of Hellfire and similar 100 lb.. or smaller munitions with many platforms including MML and small UAV
- Provides single- and multi-rail launch capability for AGM-114 missiles without the need for external electronics or AC power
- Launcher electronics is a small, self-contained electronics assembly called the **Rail Electronics Unit (REU)**

Rail Electronics Unit (REU) Overview



HSRL features/capabilities:

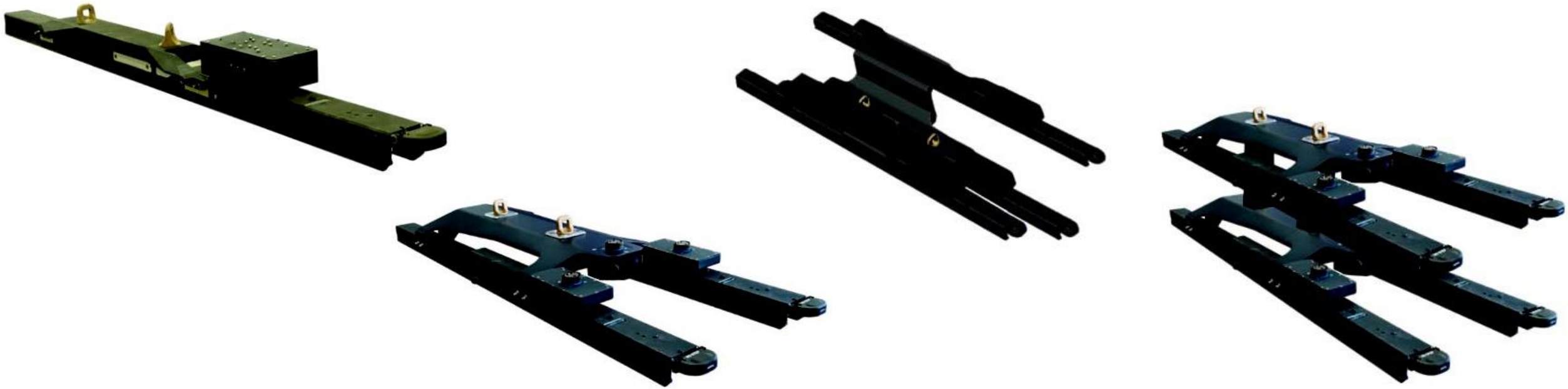
- MIL-STD-1760 interface (same API as M299 launcher)
- Operate from 28VDC sources only (DC1/DC2)
- Multiple adapters available to create single and multi-rail configuration that attach to standard carriage equipment

HSRL/REU Capabilities & Characteristics

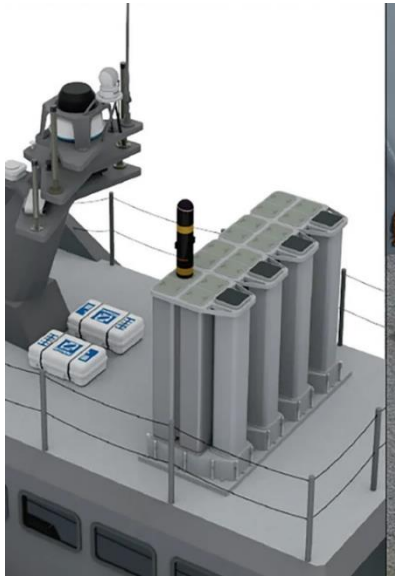
- Platform Interface: MIL-STD-1760
  - Fully compliant with MIL-STD-1760 for Mission Stores (same as M299 launcher – simplifies integration)
  - Uses only 28V DC #1 and 28V DC #2 (115VAC and 270VDC are ***not*** used)
- Missile Interface and Support:
  - Works with existing M299 Rails
  - All Hellfire II (including Romeo) and Longbow Hellfire variants
  - Brimstone and AGM-179 JAGM possible
  - Does ***not*** support Hellfire I (AGM-114A/B/C)
- Significant weight reduction compared with any other solution:
  - ~16.8lb per HSRL
  - In tandem and quad configurations, approx. 50% weight reduction over M310 | M299

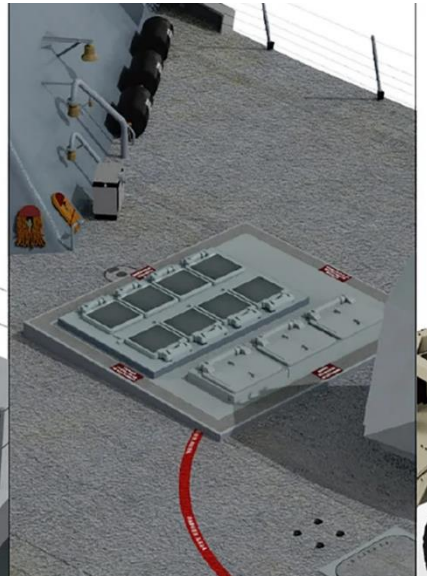
Scalable Launcher Configurations

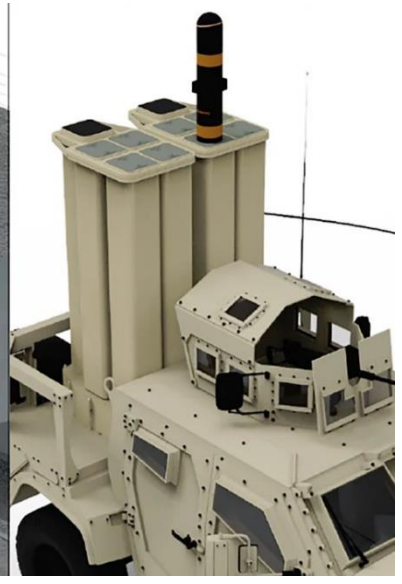
- Individual HSRL may be combined to create adaptable configurations based on the platform's requirements: Single-rail, Tandem-rail, Triple-rail, or Quad-rail (with adapters and hardbacks)
- Multiple-rail configurations include a Multiple-Rail Terminal Unit (MRTU):
  - Fully compatible with the M299
  - Handles all the power, discretes, and communications between the platform and the REUs
  - Electronics based on prior technology used for the Armed Blackhawk program from The Marvin Group



Surface Launch Hellfire | Brimstone







Air Launched Effects (ALE) and APKWS Integration

- HSRL can be integrated with proven 2.75” rocket pod technology to support APKWS or other precision guidance packages in a single or tandem rail configuration

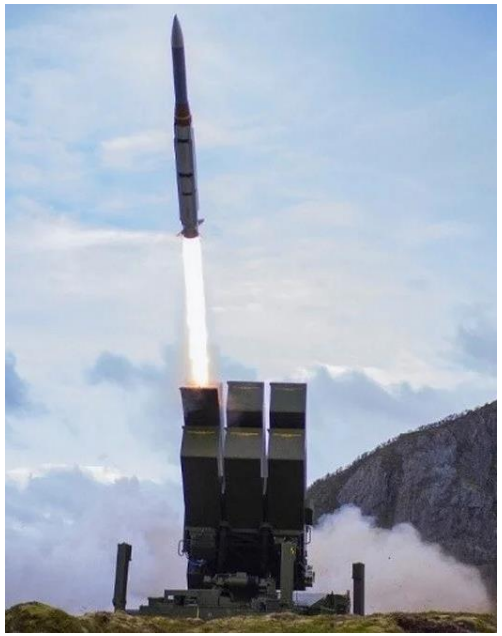
- Various ALE can potentially be compatible with the Hellfire rail for aircraft deployment or an integrated solution with the Common Launch Tube (CLT) is also deemed feasible

HSRL Development Status

- Three rounds of Weapons Integrations completed at RTC
- **Qualification scheduled for completion during 2023; first customer committed (tandem rail rotary wing platform for international platform) for operational use**
- Currently defining scope for Environmental and Platform qualification testing
- Integration units available for developmental programs
- All tools required for the successful integration of the Hellfire Modular Missile System are also available via the Marvin Group:
  - **Hellfire Missile Simulators**
  - **Laser Source Simulators**
  - **Platform Emulators**

Common Ground Rail (CGR) Launcher

- Adaptation of the proven MRL air-to-air launcher for SRAAM/BVRAAM missiles to accommodate heavier weight missiles for Surface-to-Surface or Surface-to-Air applications
- Can be integrated into canisters to protect the munition during transit and from environmental factors, or as an exposed launcher for “high mobility” applications, such as NASAMS configurations
- CGR can also be integrated with RWS technology for containerized solutions such as expeditionary warfare, border security, etc.
- **Ability to safely carry and launch AMRAAM-ER, which weighs approximately 615 lbs. (279 kg)**



Approach to Aircraft Universal Rail Launcher Design

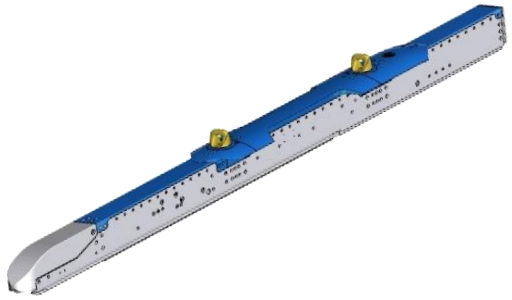
- Leverage over 30 years of consistent and high-volume production experience with air-to-air and air-to-ground launcher systems
- Knowledgeable in multiple weapon systems in fielded environment
- Passionate about delivering high quality, on time, at lowest cost
  - Capabilities for Design, Development, Qualification, and transitioning to Full-Scale Production
  - Robust team of long-tenure subject matter experts
  - Our customer's goals become our own, resulting in long term successful relationships
- Complete solution set including airborne electronics development/production, as well as test equipment for qualification, production, and sustainment.

Active production on all legacy MRL variants as well as newly designed launchers.

Multi-Mission Universal Launchers | In Development

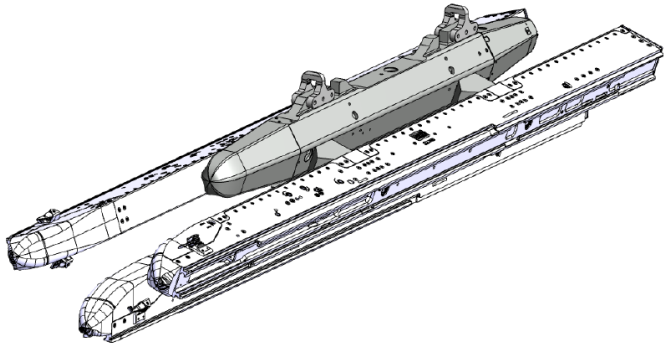
Universal Missile Launcher (UML)

Adaptation of MRL (LAU-127/LAU-128/LAU-129) series of rail missile launchers for carriage/release **of multiple missile types**



Multiple Munitions Launcher (MML)

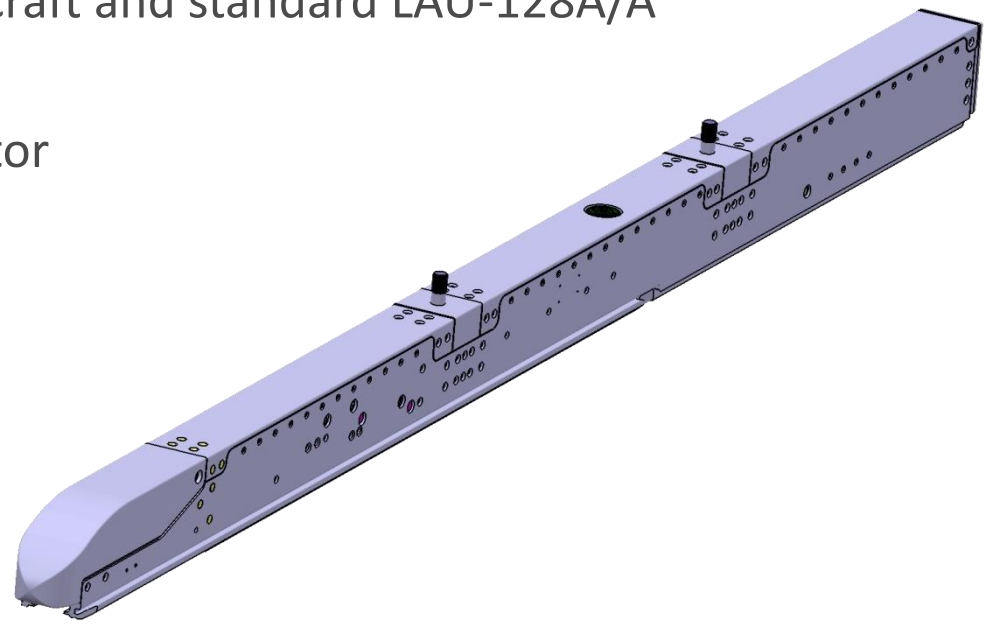
Adaptation of the TER-9/A and MRL series of rail missile launcher for **multiple missile carriage at a single station**



- **Combat capability multiplier with minimal reconfigurations cost**
- **Minimal logistics footprint to support FOB/ACE operations**
- **Suitable for installation on numerous platforms (Fixed Wing/Rotary/UAV) subject to weight limitations**
- **Increased load-out of air-to-air missiles on aircraft with 30” ejector racks**
- **Multi-Service common missile launcher capability**
- **Missile stations capable of domestic and international missile carriage (AIM-9, AIM-120, IRIS-T, Python, Derby, ASRAAM, and Meteor)**

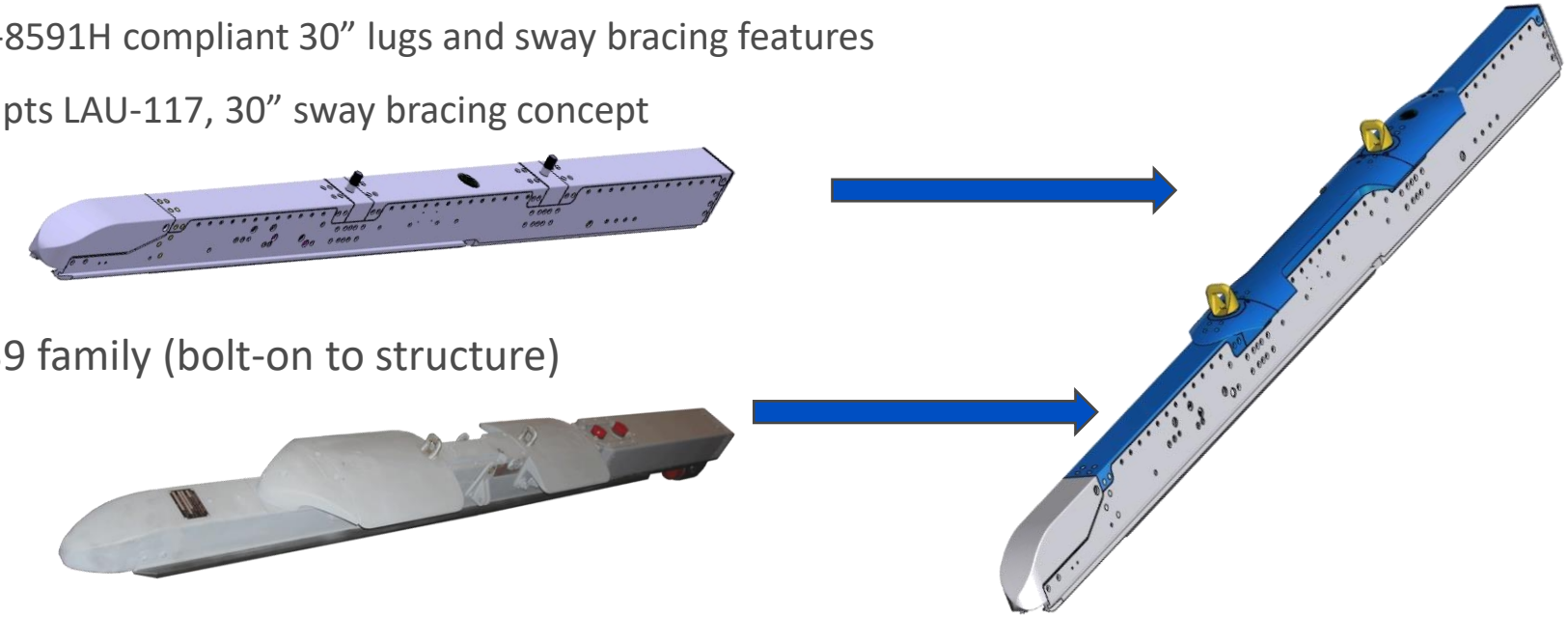
LAU-128SE Universal Missile Launcher Overview

- Based on LAU-128A/A designed proven for carriage of AIM-9 / AIM-120
  - Rail: Uses same geometry as proven MRL family operational on F-15, F-16, and F/A-18
- Supported Missiles: AMRAAM, Sidewinder, ASRAAM, IRIS-T, Python, Derby, A-Darter and Meteor
- Incorporated Modifications
  - Electronics: Power Switching Unit (PSU) to accommodate aircraft and standard LAU-128A/A architecture discrepancies
  - Harness: Modified to accommodate PSU and aircraft connector
  - Mounting: Standard 30” NATO Lugs
- Integration on 30” suspension bomb rack



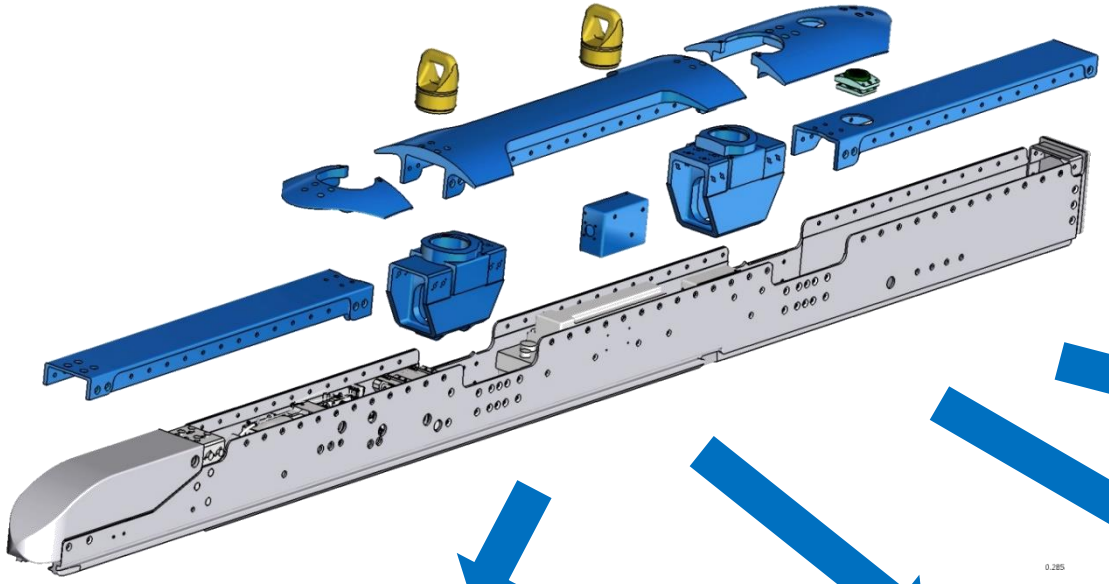
Design Approach

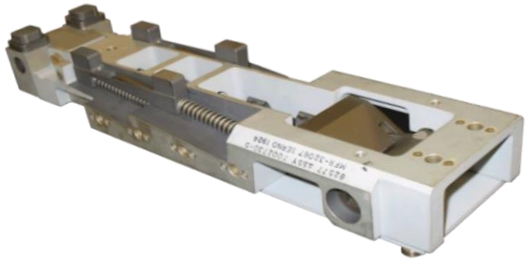
- MEC provides an **affordable low-risk design solution**
  - Our design combines proven concepts and design features to adapt the LAU-128 to 30” lug carriage on 30” Ejector Release Unit
    - Provision MIL-STD-8591H compliant 30” lugs and sway bracing features
    - MEC approach adapts LAU-117, 30” sway bracing concept



  - LAU-127/128/129/139 family (bolt-on to structure)
  - LAU-117 Maverick missile launcher (14/30” lug carriage)
- Design solution based on decades of experience in producing a wide range of missile launchers

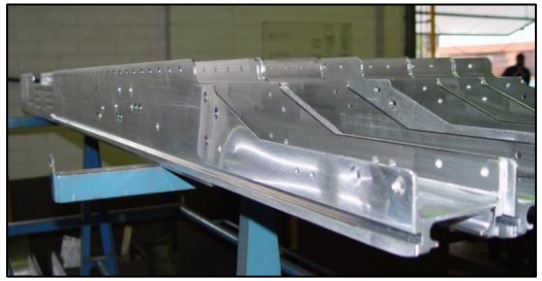
Design Approach (Cont'd)





Rear Snubber Assembly

Standard MRL power Supply



Machined Launcher Rail

Detent Mechanism Assembly

Actuator Assembly

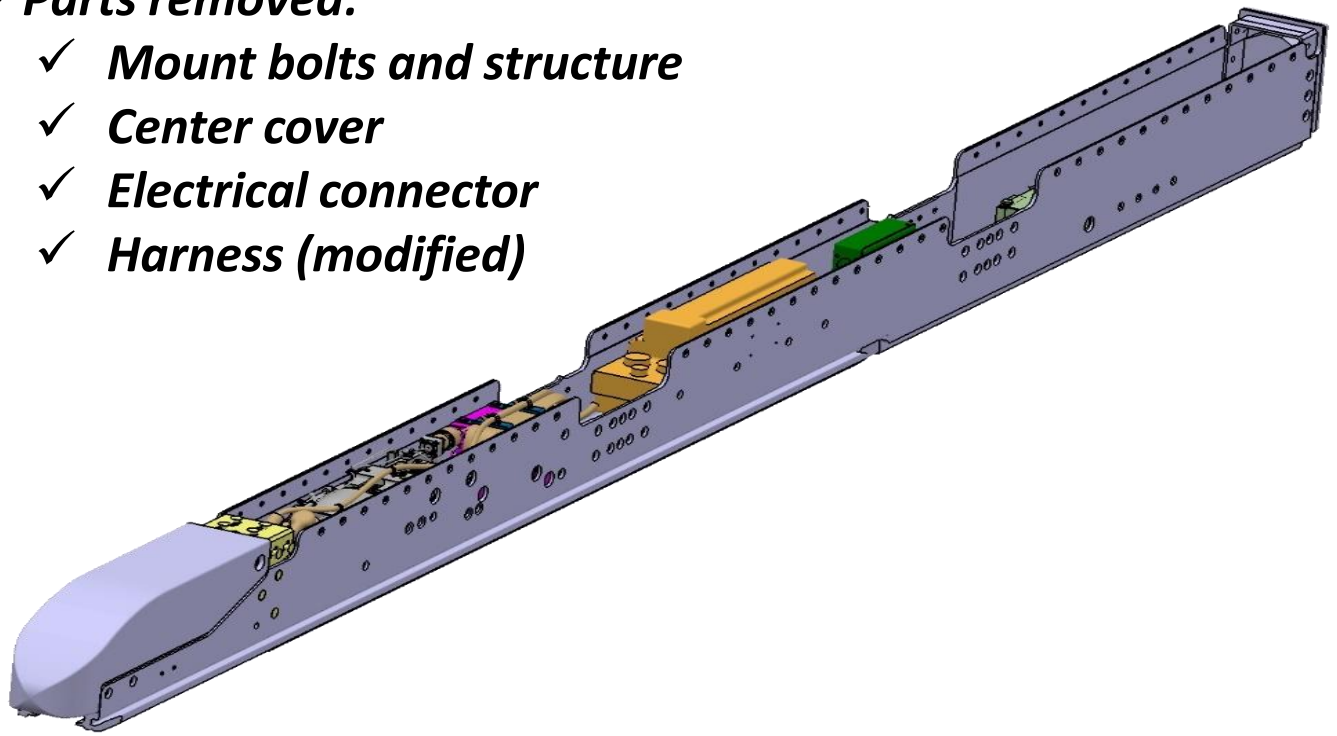
Approximately 90% of commonality to LAU-128

Modifications to LAU-128 Baseline Configuration

MEC modifications to baseline LAU-128 enable 30” lug carriage

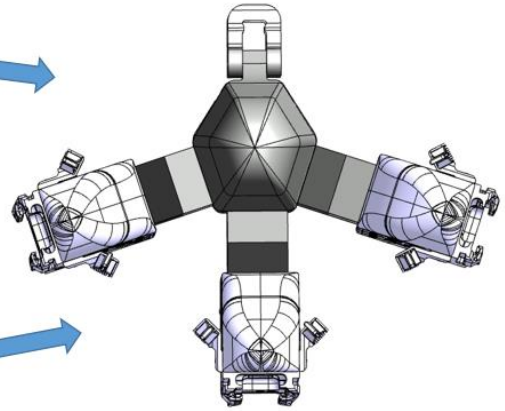
- ***Parts retained:***
  - ✓ ***Rail extrusion/machining***
  - ✓ ***AIM-9 Umbilical retainer assy***
  - ✓ ***Fwd/aft fairings***
  - ✓ ***J9/umbilical retract***
  - ✓ ***Power supply***
  - ✓ ***Detent***
  - ✓ ***Damper***
  - ✓ ***BIT module***
  - ✓ ***Fin retainers***

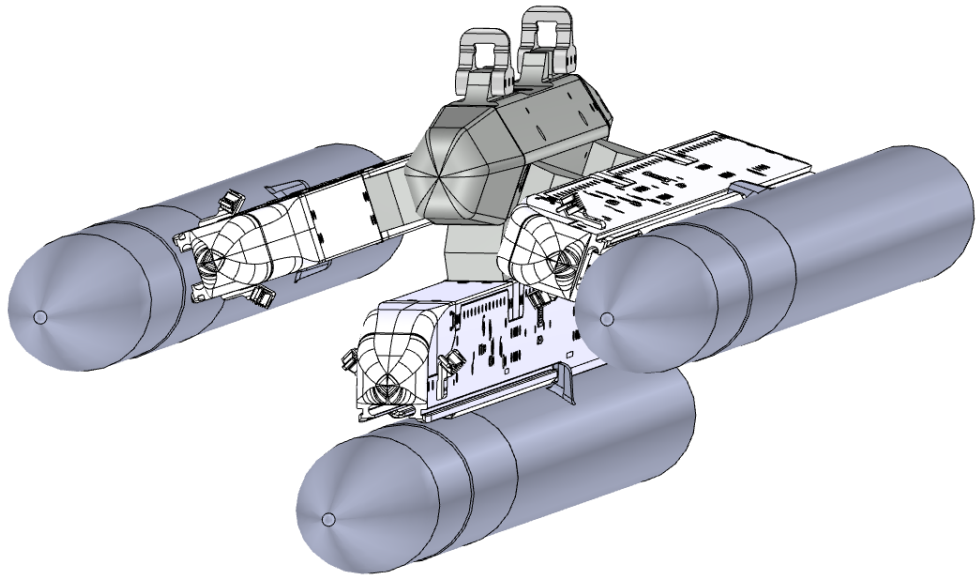
- ***Parts removed:***
  - ✓ ***Mount bolts and structure***
  - ✓ ***Center cover***
  - ✓ ***Electrical connector***
  - ✓ ***Harness (modified)***



Multiple Munitions Launcher (MML)

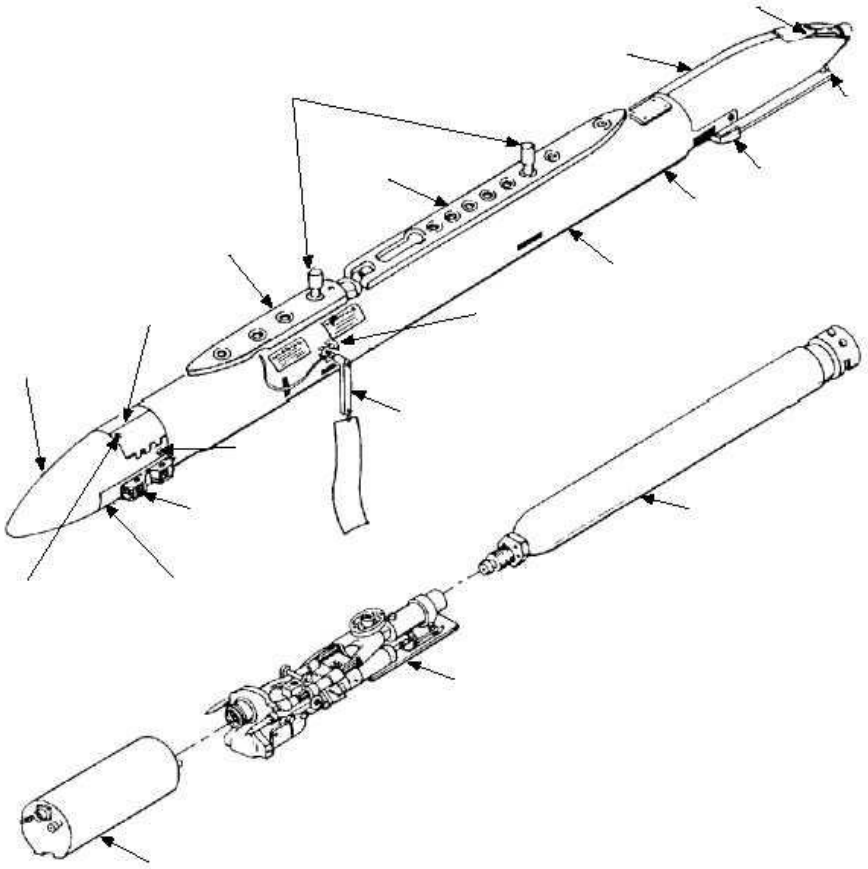
- Concept Development for fixed wing aircraft
- Carries 3 UML's at primary and shoulder stations in one configuration
  - **AMRAAM, Sidewinder, IRIS-T, Python, Derby, A-Darter and Meteor**
- Option for Station 1 bomb rack to carry 500 lbs. class store
- Mounting: Standard 30" NATO Lugs





LAU-7 Modifications

- Working with international end user and international missile manufacturer to adapt the lightweight and proven LAU-7 SRAAM launcher for new applications:
  - ✓ **Carriage of IR guided SRAAM missiles other than AIM-9**
  - ✓ **Jettison capability**
  - ✓ **Integration of sensors to launcher body**
  - ✓ **Integration of launcher on an Indo-Pacific partner's Russia-designed fighter aircraft (State Dept. Approved)**
  - ✓ **Note LAU-7 also found on rotary wing platforms such as AH-1W/Z**



Lightweight Remote Weapons Stations (RWS)

- In partnership with an innovative Israeli company, we are developing a lightweight, 5.56mm/7.62mm/12.7mm/40mm RWS for airborne application, that leverages superior AI capabilities for ***earlier target detection, identification, tracking, and first-round-on-target performance***

- Based on the technology used to develop currently operational RWS for ground and maritime applications

An Overview Of Our Company (2022)

World Leading High Tech Solutions, Products and Services for

The Global Aerospace & Defense Market

Our Values:

Integrity

Partnership

Can-Do Attitude

Innovation

- Currently 1,000 + employees across 3 business units, active via FMS/FMF/DCS channels in 40+ nations worldwide
- Total Square footage: Over 500K square feet in Inglewood and Irvine, California
- Classified as “Small Business” in U.S., but over $350MM annual revenues
- MEC was **Recipient of FY2019 Nunn-Perry Award for Excellence in DoD’s OSBP Mentor-Protégé Program** along with our partner, Lockheed Martin Aeronautics
- Vertically integrated business units covering Air | Land | Maritime Domains

Relevant NAICS Codes:
336413, 334515, 336992, 336999

The Marvin Group's Companies

MARVIN ENGINEERING COMPANY

Armament Equipment
Air-to-Air, Air-to-Ground, Surface Launch

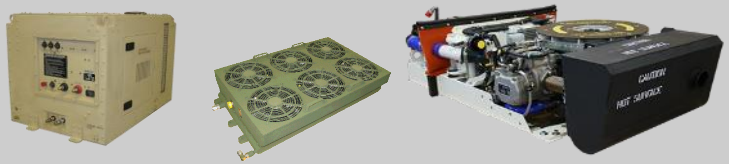
– Bomb & Ejector Racks
– Missile Rail Launchers
– Multiple Stores Carriage Systems
– Pylons
– MRO/Sustainment
– User/Maintainer Training
– Technology Development

MARVIN TEST SOLUTIONS

Multi-Level Test Systems, Electronic Components | Assemblies

– Armament Test Sets
– SMS Test Sets
– Flightline Testers
– O-/I-/Depot-Level Maintenance Testers
– Airborne electronics
– User/Maintainer Training
– Engineering services

MLS
MARVIN LAND SYSTEMS

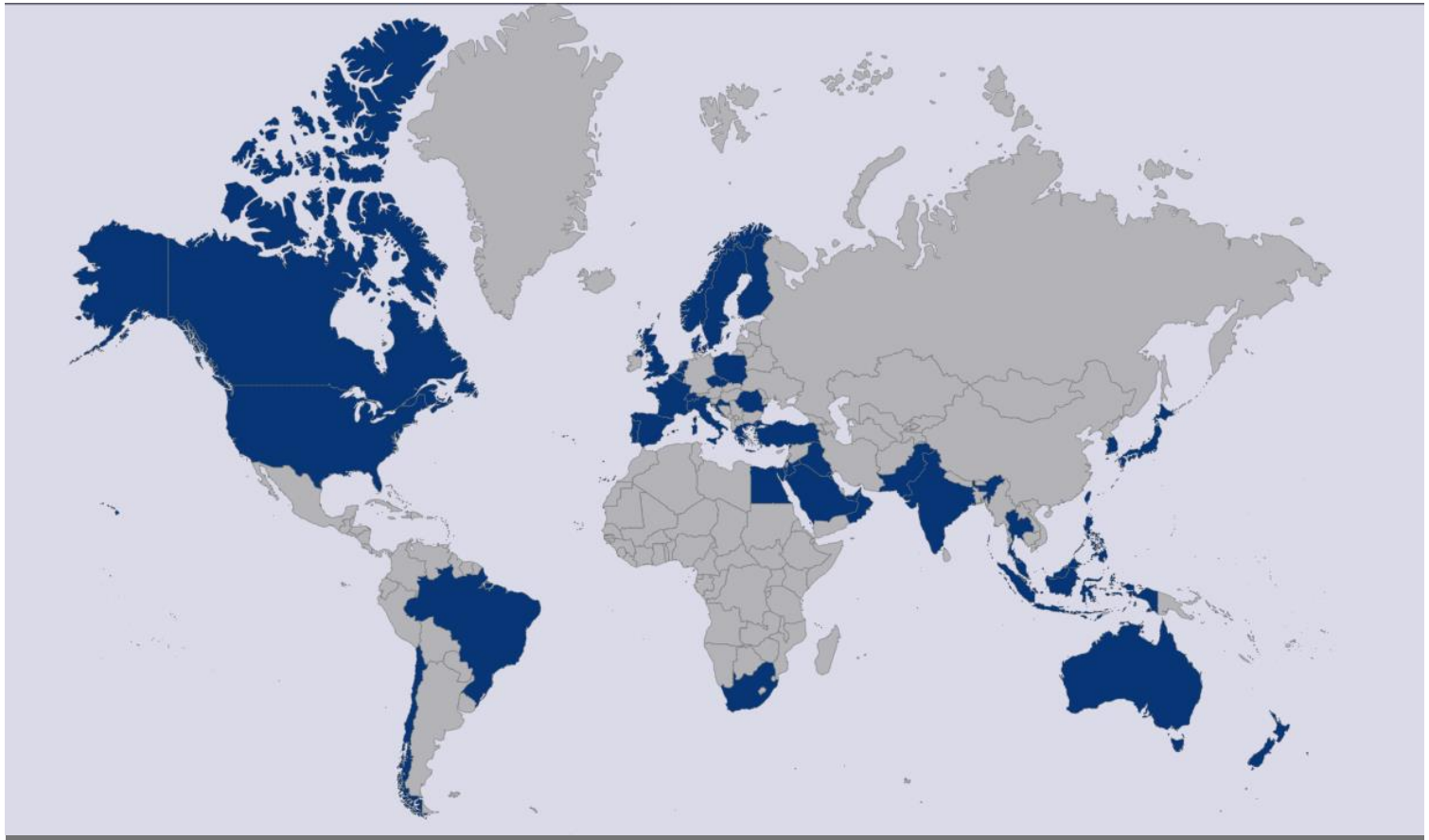


Ground & Maritime Primary | Secondary Support Systems

– Rigid Wall Equipment Shelters
– Environmental Control Units design and production
– Auxiliary Power Units design and production
– Remote Weapons Stations
– Electronics Chillers

The Marvin Group Around the Globe

Australia
Belgium
Brazil
Canada
Chile
Croatia
Czech Republic
Denmark
Egypt
Finland
France
Greece
India
Indonesia
Iraq
Israel
Italy
Japan
Jordan
Korea
Kuwait
Malaysia
Netherlands
New Zealand
Norway
Oman
Pakistan
Philippines
Poland
Portugal
Romania
Saudi Arabia
Singapore
South Africa
Spain
Sweden
Switzerland
Taiwan
Thailand
Turkey
UAE
UK
USA



Currently supporting customers and end users in 40 plus countries via FMS, FMF, and DCS

5 Global Regions: The Americas | Western Europe & Scandinavia | Central, Eastern and Southeastern Europe | Africa, Middle East & Central Asia | Indo-Pacific

Select Customers Around the Globe

LOCKHEED MARTIN
BOEING
EMBRAER
GENERAL ATOMICS
GENERAL DYNAMICS
KAI
한국항공우주산업주식회사
KOREA AEROSPACE INDUSTRIES, LTD.
Defense Acquisition Program Administration
LEONARDO
BAE SYSTEMS
MBDA
MISSILE SYSTEMS
NORTHROP GRUMMAN
RAFAEL
ADVANCED DEFENSE SYSTEMS LTD.
Raytheon
SAAB TECHNOLOGIES
SIKORSKY
A LOCKHEED MARTIN COMPANY

QUESTIONS?

THANK YOU FOR YOUR TIME!

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sales@marvineng.com

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Fax: 949.263.1203
sales@marvintest.com

Marvin Land Systems
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USA
310.674.5030
Fax: 310.673.9472
sales@marvinland.com

Hypersonic Aerial Gunnery Ammunition

Dr. Ron Barrett, Professor
Mr. Nathan Wolf, MS Candidate
Aerospace Engineering Department
The University of Kansas, Lawrence, Kansas USA

NDIA Future Force Capabilities Exhibition
Austin, Texas 19 – 22 September 2022
Paper No 24706

Distribution A: Approved for Public Release Unlimited Distribution

Outline:

i. Motivation

ii. Aerial Gunnery History… Condensed

iii. Technology Breakthrough: Flight Safe Sabots

iv. BASS & MASS Round Design Philosophies

v. Aerodynamics, Aeromechanics, FEM, Bench Testing

vi. Range Shots, Performance, Trades

vii. Intellectual Property Filings, Claims & Status

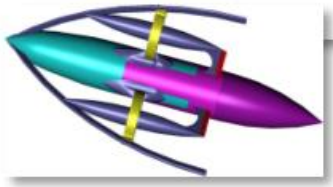
viii. Opportunities

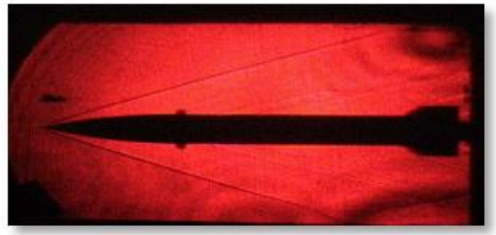
Distribution A Unlimited Distribution

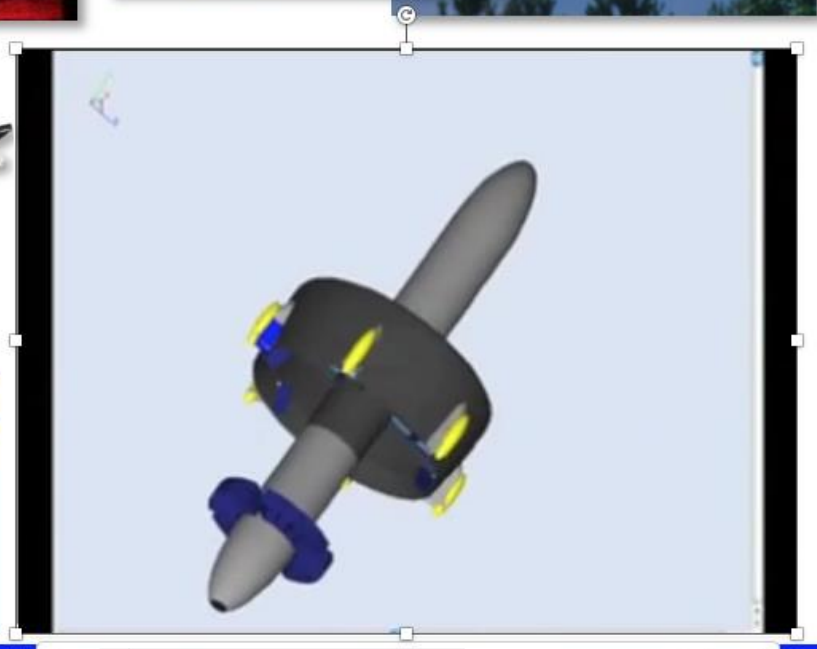
KU Aerospace Engineering Department

Adaptive Aerostructures Laboratory

- *Specialize in "Prime Mover" Military Technologies:*
  - *-Ultra-high performance drones*
  - *-Invisible drones*
  - *-Hovering missiles*
  - *-Guided ammunition 4 – 155mm*
  - *-Hypersonic ammunition*
  - *-Acoustic Vector Sensors*
- *Advanced Commercial Technologies:*
  - *-Adaptive Aerocompliant Surfaces*
  - *-Commercial Drones*
  - *-Toys*
- *IP Protection & Litigation*







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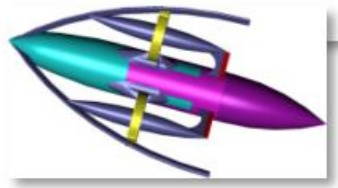

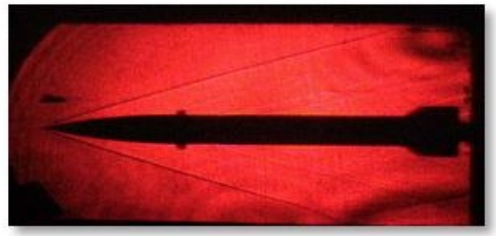

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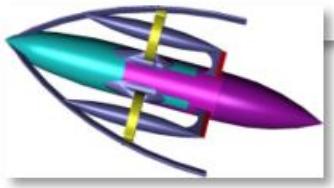

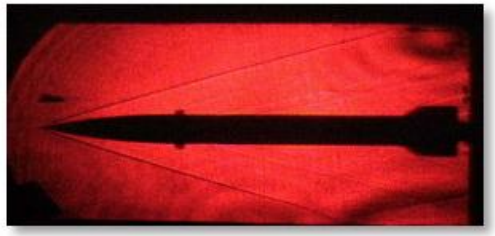

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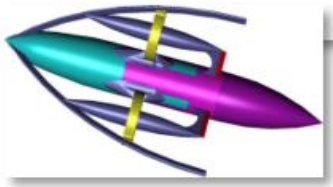

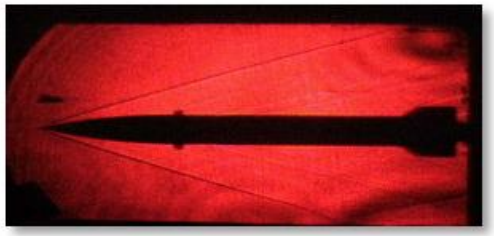

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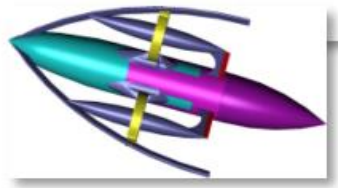

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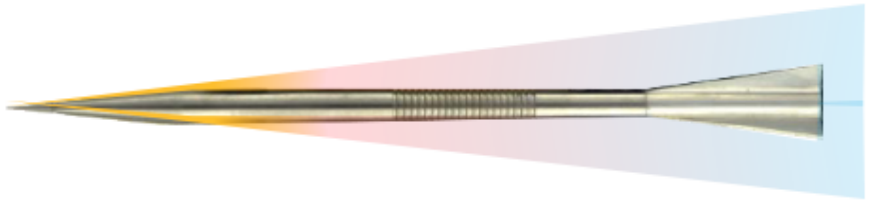
1.Motivation: Why Hypersonic Aerial Gunnery Ammunition?

- **Large expansion in mission effectiveness & force multiplication**
- **Increased range, KE, lethality, P_k, flat fire**



- **Reduced TOF, CEP, system weight, volume, airframe MGWTO & LCC**

Distribution A Unlimited Distribution

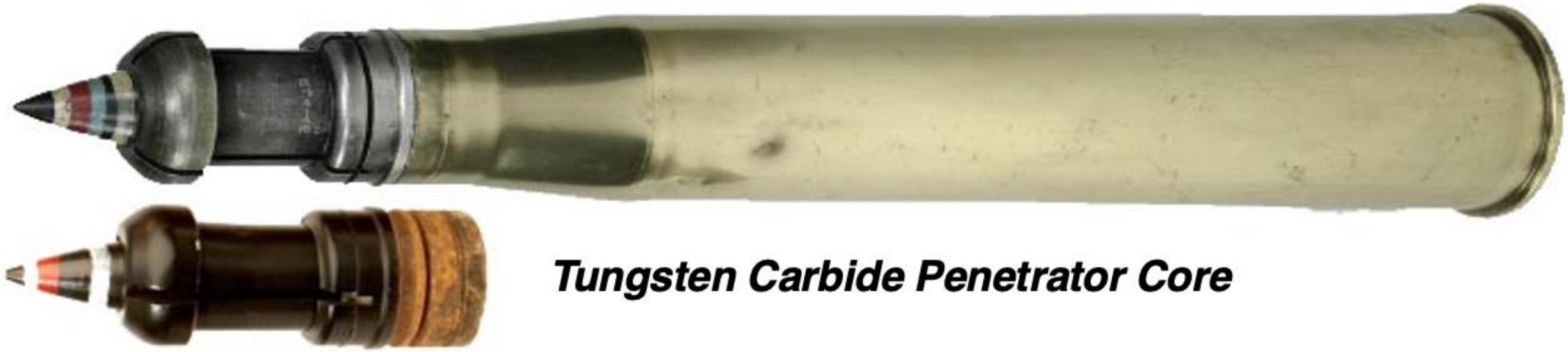
2. Aerial Gunnery History (condensed)

- 1st Recorded saboted rounds: 1326
- 1913: 1st Air-to-Ground Strafing, Bombardment, Air-to-Air Combat from Heavier-than-Air Craft
- Critical during WWI, II

2. Aerial Gunnery History (condensed)

British QF 6-Pounder Antitank Gun 1944

Armor-Piercing Discarding Sabot (APDS Round)

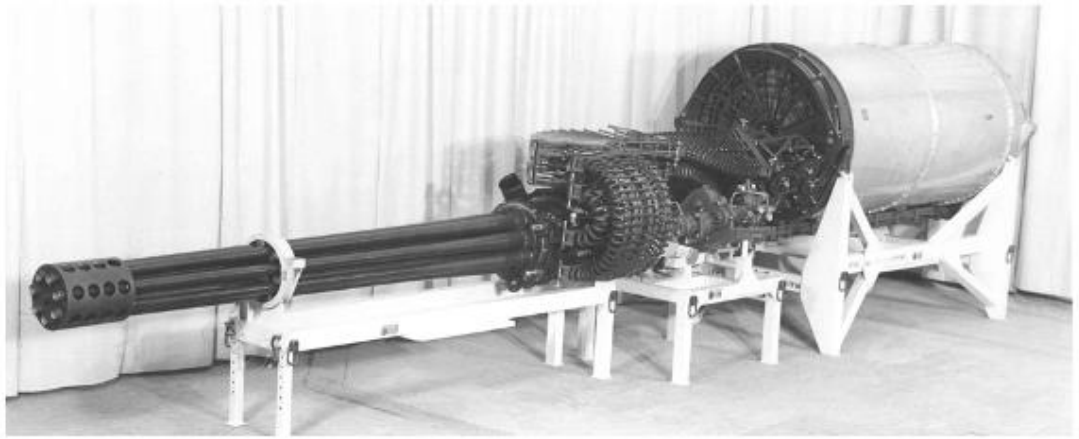


Tungsten Carbide Penetrator Core

Distribution A Unlimited Distribution

2. Aerial Gunnery History (condensed)

- Post-War, 949.5/1130.25 (84%) of aerial victories are gun kills
- Specialized rounds for aerial combat developed 1950's (M50 family)
- M61 & derivative Gatling guns evolved 1950's forward
- GAU-8 & PGU-13/14/15 developed for A-10

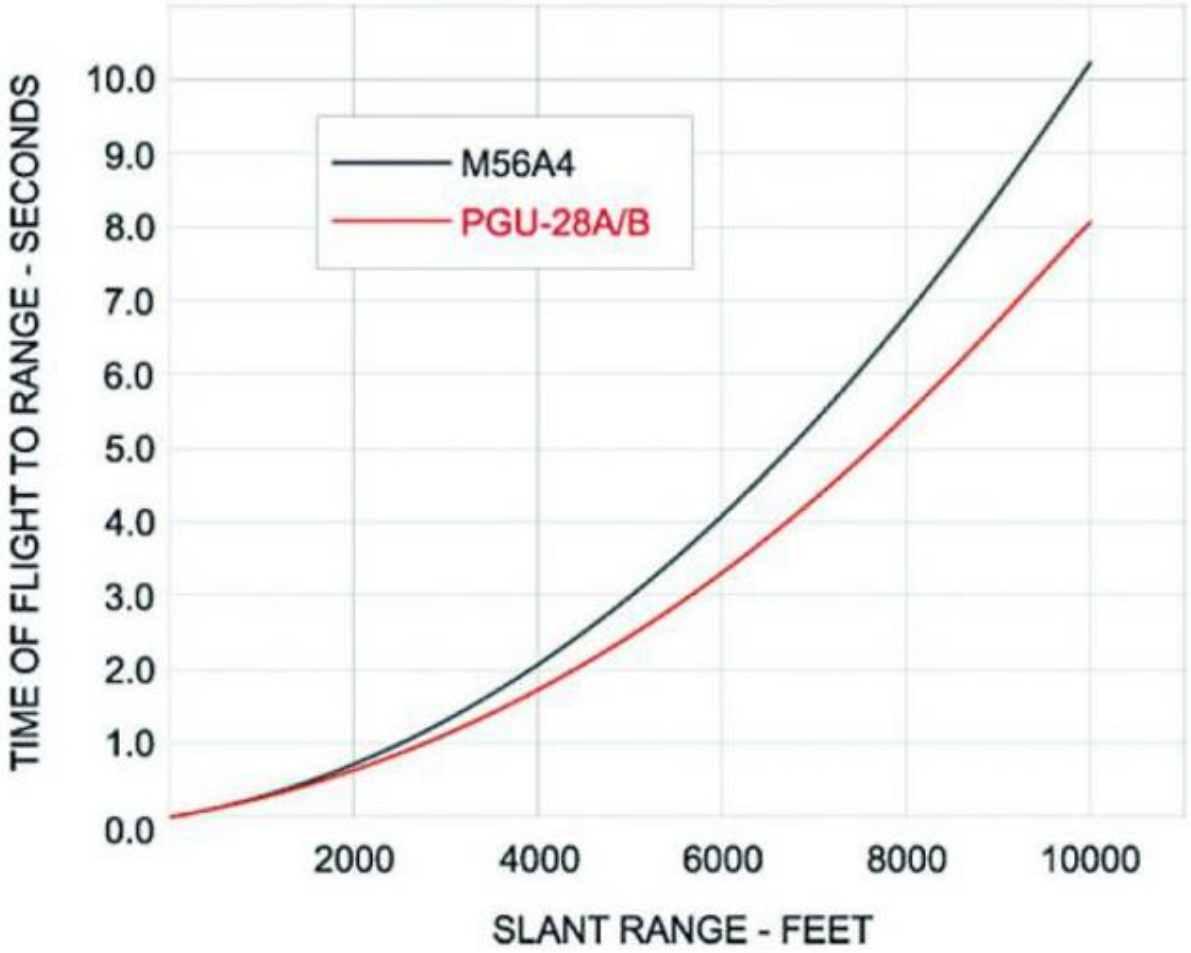


Distribution A Unlimited Distribution

2. Aerial Gunnery History (condensed)

- **PGU-28 fielded 1992**

Ammunition for the More Modern Jets:
Better Form Factor, Reduced HE



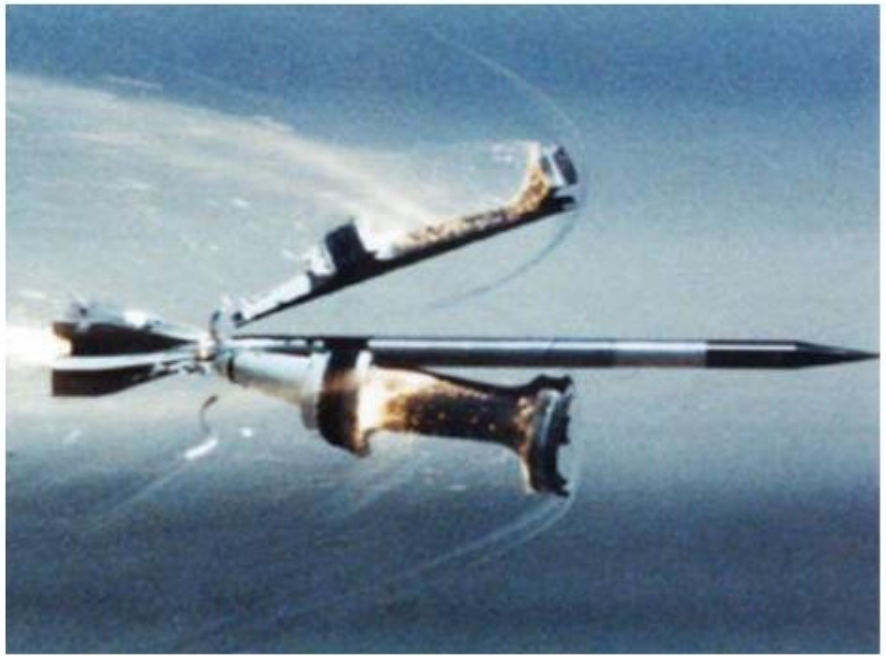
Distribution A Unlimited Distribution

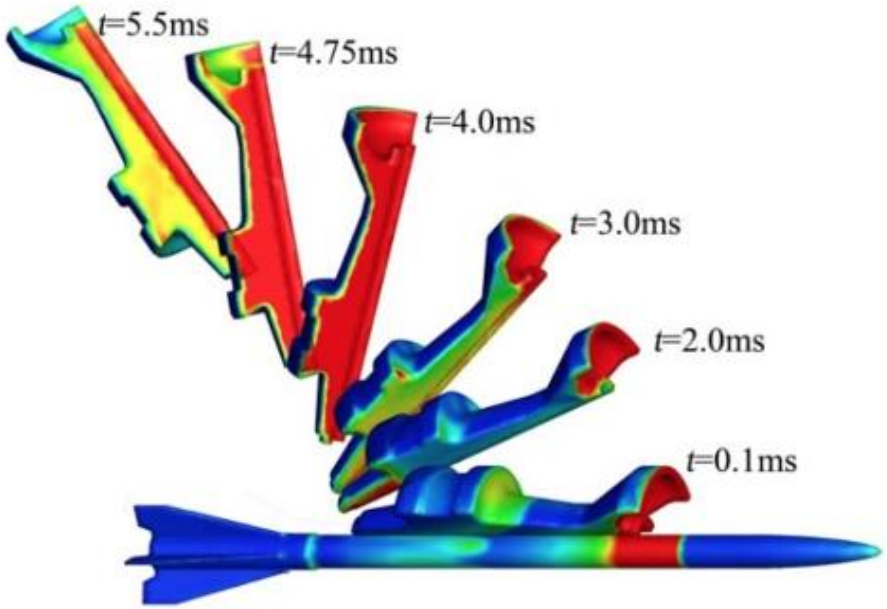
2. Aerial Gunnery History (condensed)

Problems with Aircraft & Sabots

Conventional Discarding Sabot

Aeromechanically unstable by necessity…





Distribution A Unlimited Distribution

2. Aerial Gunnery History (condensed)

- **USAF worked hard to develop saboted aerial gunnery rounds 1970 – 1998**

Conventional Discarding Sabot Design Philosophy and Aeromechanics

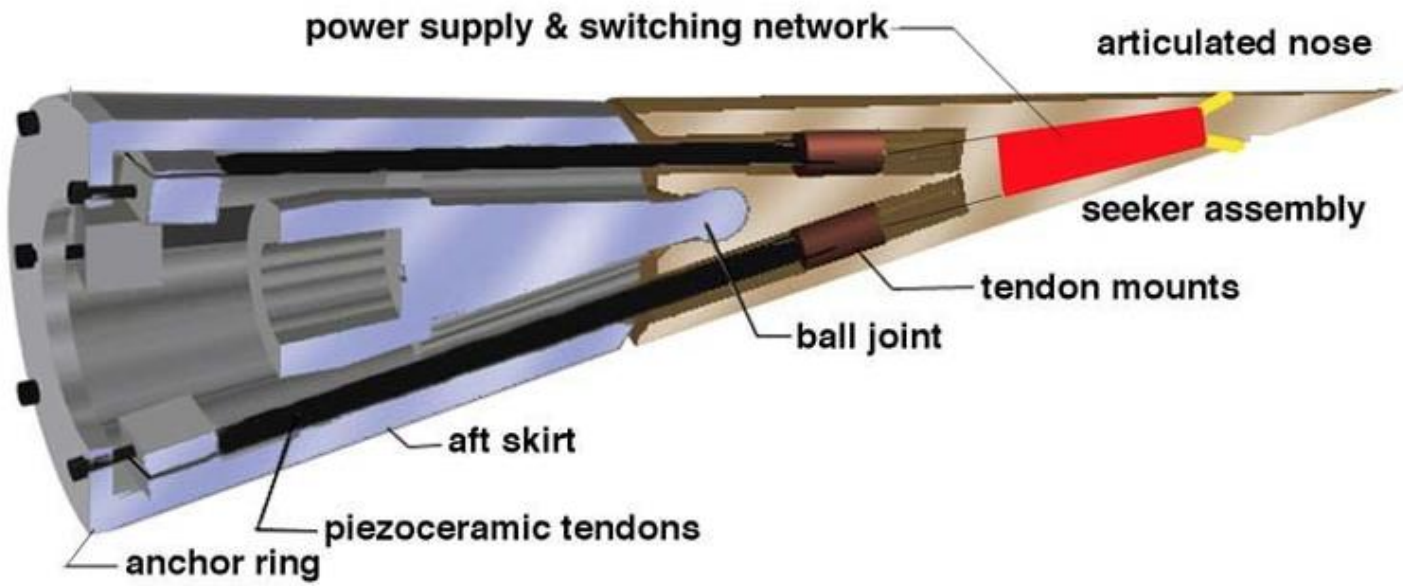
The disadvantage of sabots is that they must be discarded at muzzle exit, and these rapidly decelerating sabots pose an unacceptable hazard to launching aircraft.

-**Dale Davis**, Director, USAF Munitions Directorate 1984
Historical Development of Automatic Cannon Caliber Ammunition 20 – 30mm 1952 - 1983

Distribution A Unlimited Distribution

2. Aerial Gunnery History (condensed)

- **USAF developed 1st guided aerial gunnery round prototypes 1995 - 1998**
  - ***Barrel-Launched Adaptive Munition (BLAM) Program 1995 - 1998***



Distribution A Unlimited Distribution

2. Aerial Gunnery History (condensed)

1948 Key West Agreement:

Section VI - Functions of the United States Army
Primary Functions
1. a. To defeat enemy land forces.
   b. To seize, occupy and defend land areas.

Section VI - Functions of the United States Air Force
Primary Functions
1. b. To gain and maintain general air supremacy.
   c. To defeat enemy air forces.
   d. To control vital air areas.
   e. To establish local air superiority except as otherwise assigned herein.

Distribution A Unlimited Distribution

2. Aerial Gunnery History (condensed)

1948 Key West Agreement:

Section VI - Functions of the United States Army
Primary Functions
1. a. To defeat enemy land forces.
   b. To seize, occupy and defend land areas.

Section VI - Functions of the United States Air Force
Primary Functions
1. b. To gain and maintain general air supremacy.
   c. To defeat enemy air forces.
   d. To control vital air areas.
   e. To establish local air superiority except as otherwise assigned herein.

1998: USAF ceases all advanced/guided aerial gunnery & saboted ammo. RDT&E

Distribution A Unlimited Distribution

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1998: USAF ceases all advanced/guided aerial gunnery & saboted ammo. RDT&E

The AFRL does not have an S&T portfolio in ammunition.
-David Lambert AFRL Munitions Directorate Chief Scientist, (via J. Ellison) 2021

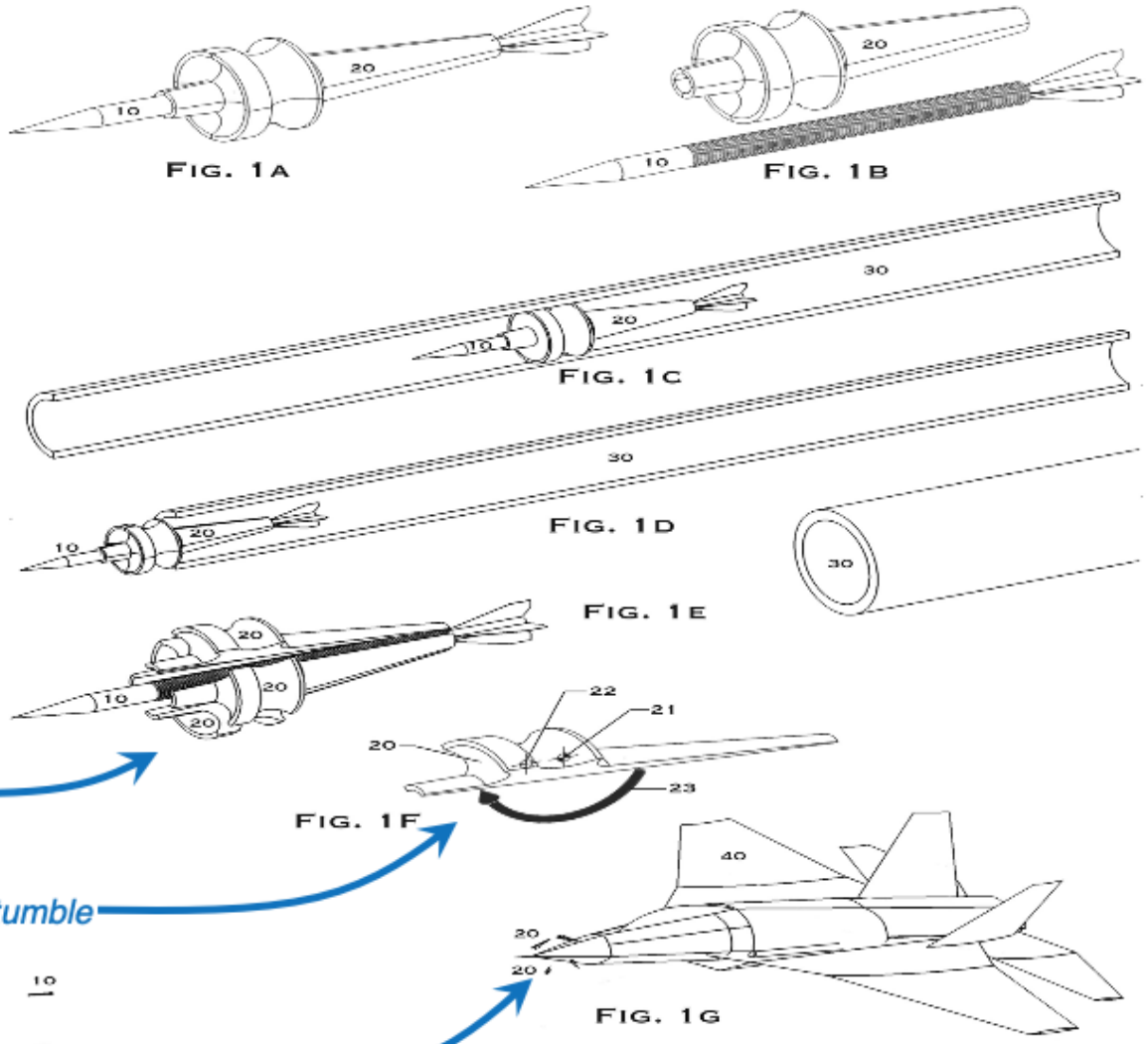
Distribution A Unlimited Distribution

3. Breakthrough:

Problems with Aircraft & Sabots

Why a conventional sabot won't work for aerial gunnery

Dale Davis' Observations:



Conventional sabot pieces are designed to be aeromechanically unstable, by necessity, to separate from projectile

Aeromechanically unstable sabot pieces tumble

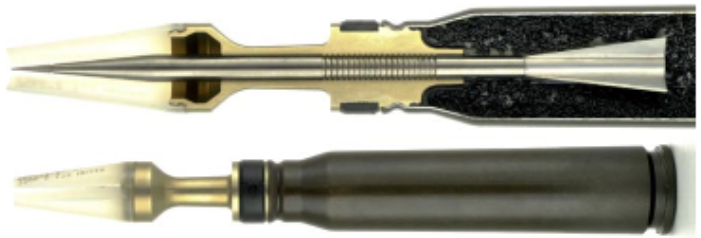
...and strike airframe/engine

Image Source: PCT/IB2020/053899

Distribution A Unlimited Distribution

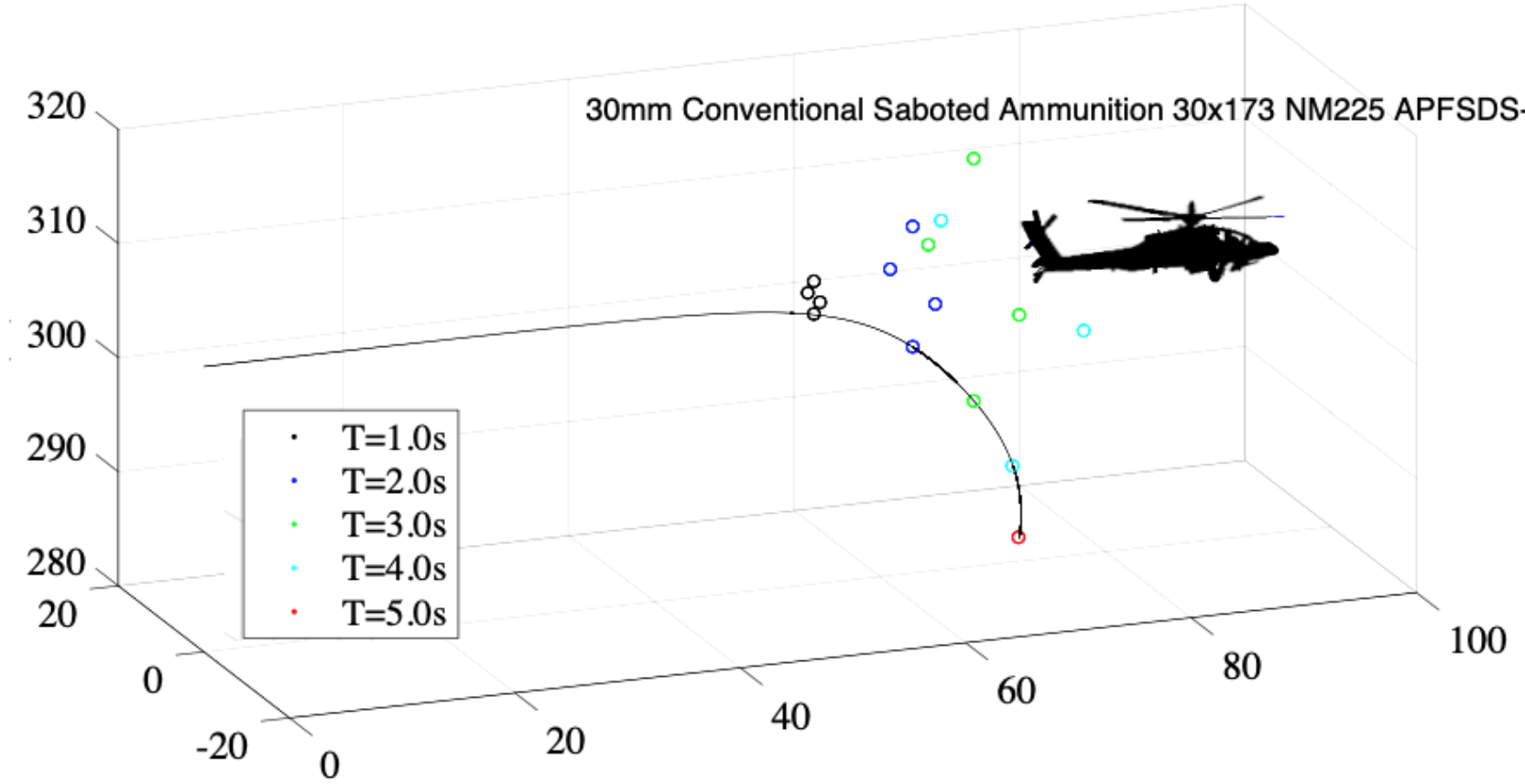
3. Breakthrough:

Problems with Aircraft & Sabots



The Great Show Stopper for conventional sabots:

Flight Safety



Distribution A Unlimited Distribution

3. Breakthrough:

Ms. (now Dr.) Lauren Schumacher

2016 Co-Inventor
Ballistic Aeromechanically Stable Sabot (BASS) Ammunition
Maneuvering Aeromechanically Stable Sabot (MASS) Ammunition

Senior Systems Engineer, Raytheon

Distribution A Unlimited Distribution

3. Breakthrough:

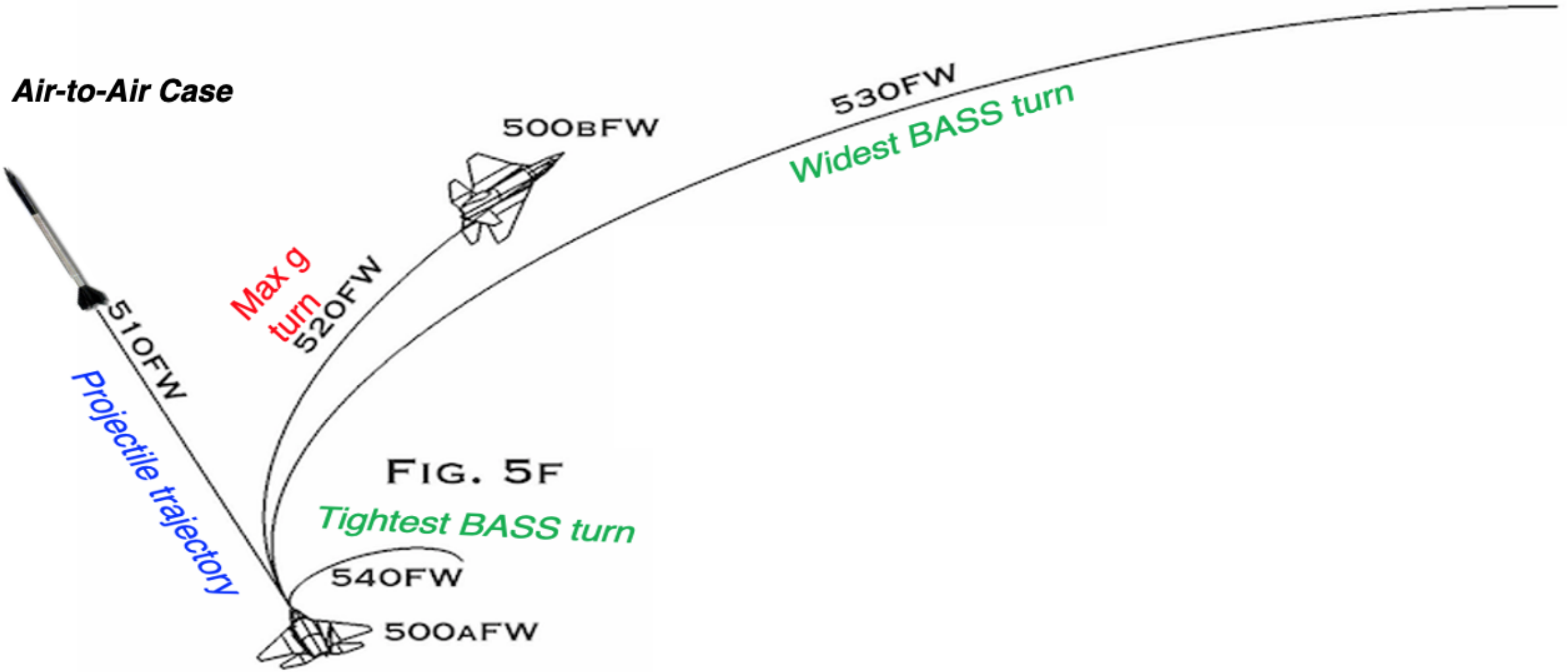
BASS Rounds: Design the Sabot to clear the launching aircraft

Distribution A Unlimited Distribution

3. Breakthrough:

BASS Rounds: Design the Sabot to clear the launching aircraft

Air-to-Air Case

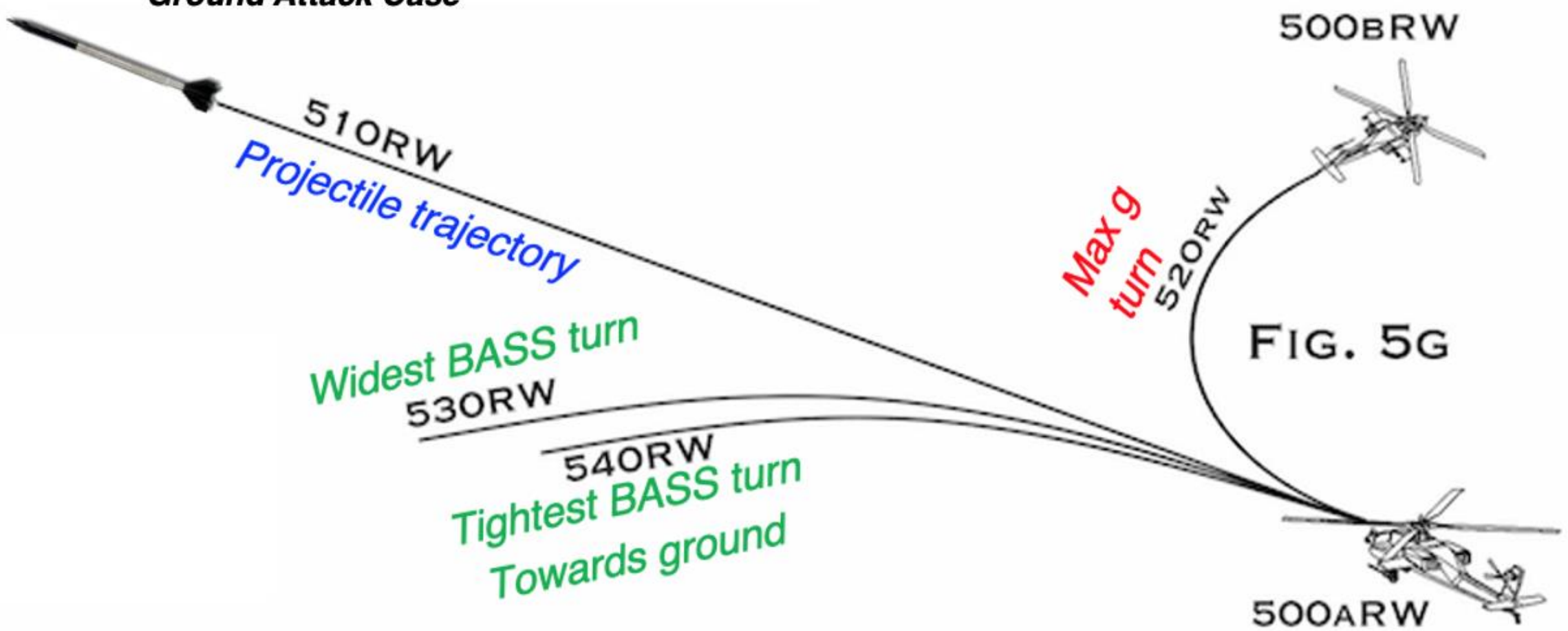


Distribution A Unlimited Distribution

3. Breakthrough:

BASS Rounds: Design the Sabot to clear the launching aircraft

Ground Attack Case

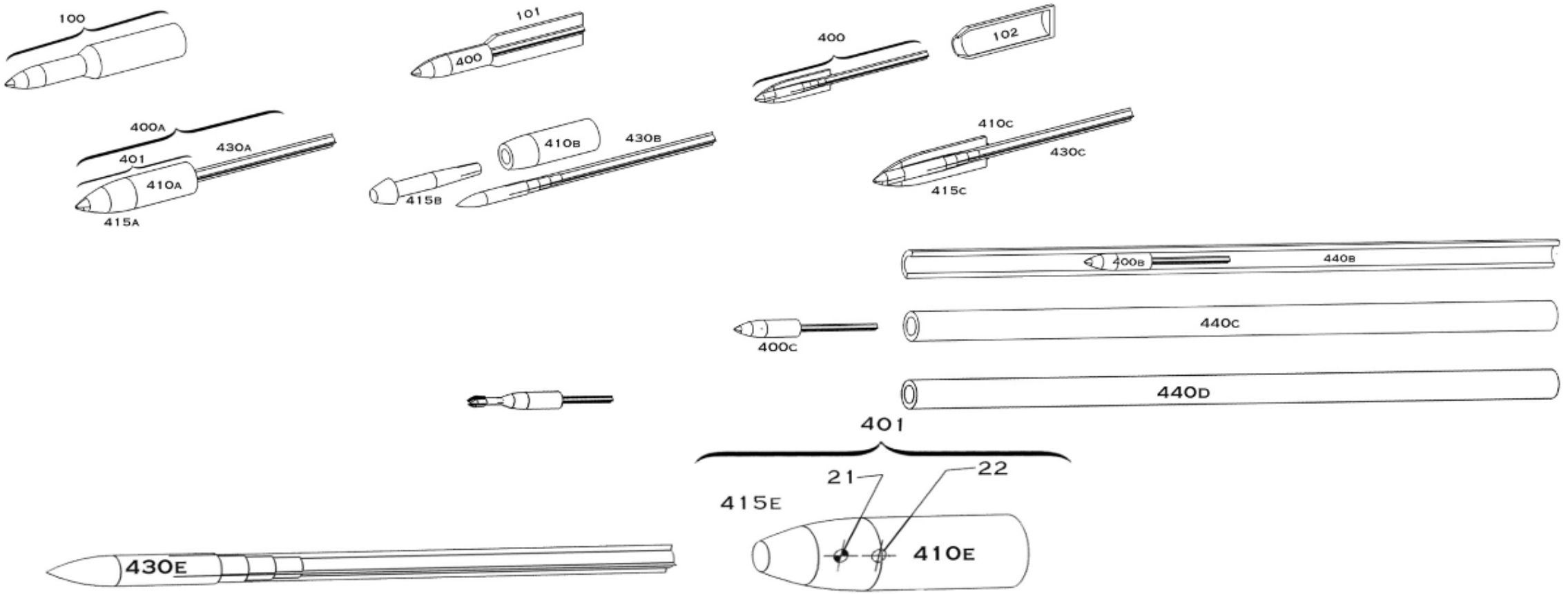


Distribution A Unlimited Distribution

4. MASS & BASS Rounds

What is claimed is:

1. An aeromechanically stable sabot...



54 major families, >1,000 species covered in expansive patent filings

Distribution A Unlimited Distribution

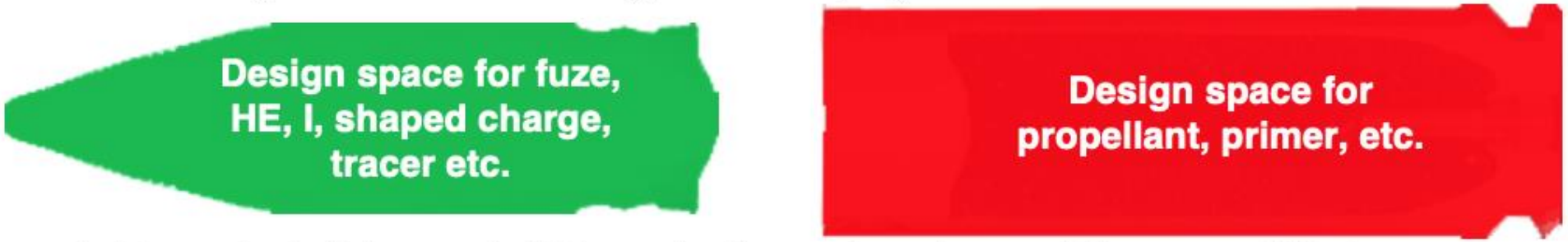
4. MASS & BASS Rounds

Today's Aerial Gunnery Ammunition Design Philosophy

Distribution A Unlimited Distribution

4. MASS & BASS Rounds

Today's Aerial Gunnery Ammunition Design Philosophy

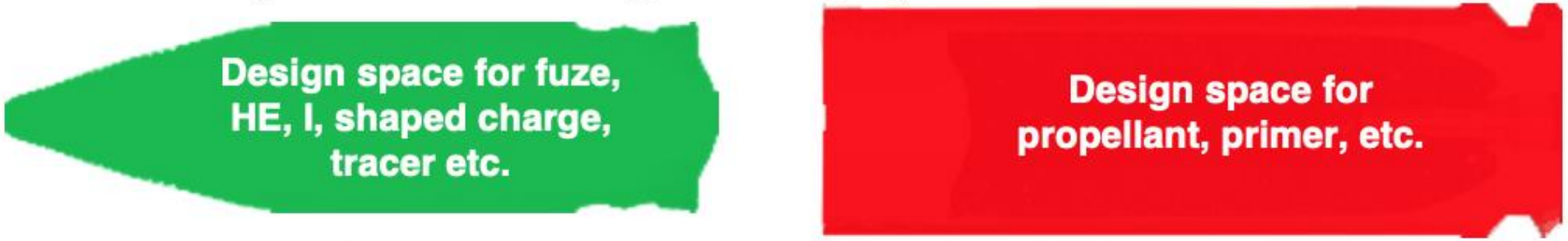


Components laid out in full-bore shell for mission at hand, cartridge case filled

Distribution A Unlimited Distribution

4. MASS & BASS Rounds

Today's Aerial Gunnery Ammunition Design Philosophy



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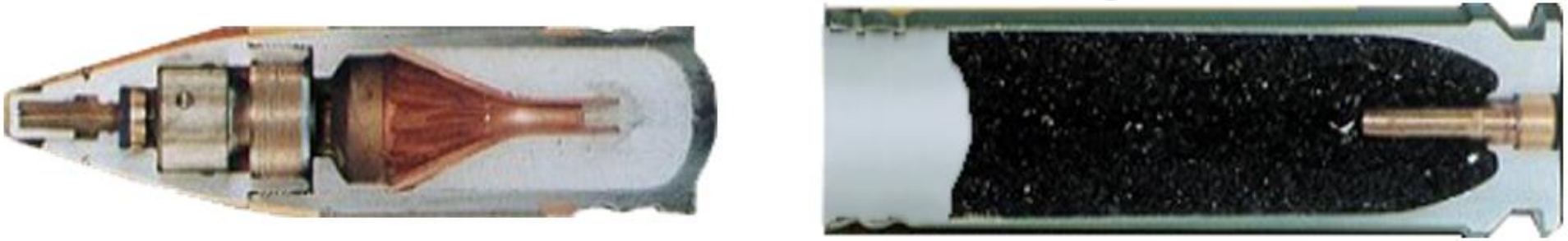
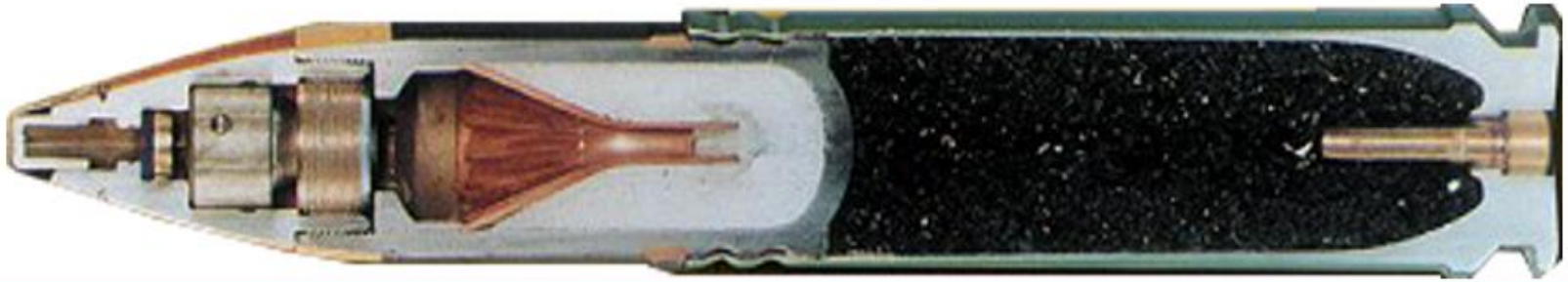


Band(s) fitted to shell, then mate to cartridge case & crimped at case joint



Distribution A Unlimited Distribution

4. MASS & BASS Rounds

MASS & BASS Design Philosophy

- HE/I volume set by blast effects requirements
- Armor penetration & longer ranges achieved by high ballistic coefficient flechette
- Use decoupling of bore & projectile to maximize objectives while minimizing cost, recoil, caliber, etc.

Distribution A Unlimited Distribution

4. MASS & BASS Rounds

MASS & BASS Design Philosophy

Start Point: M789 HEDP

Distribution A Unlimited Distribution

4. MASS & BASS Rounds

MASS & BASS Design Philosophy

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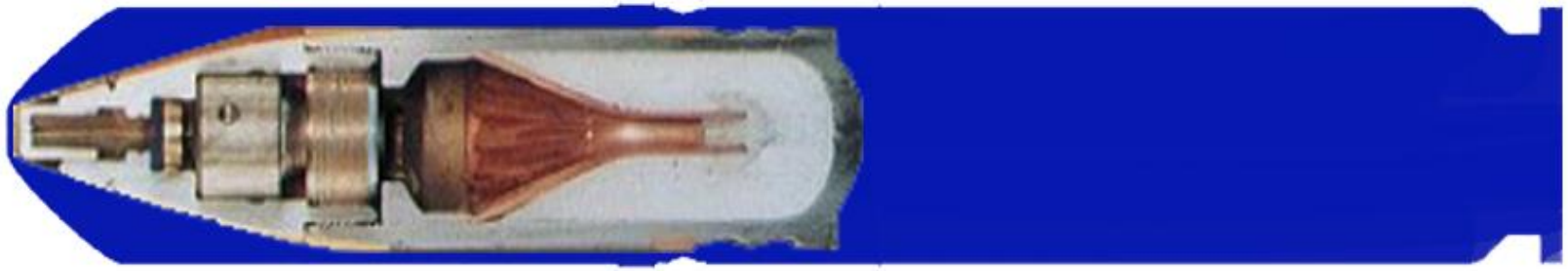

Eliminate air, low-stress metal, shrink fuze, stretch HE, add W or DU nose

Distribution A Unlimited Distribution

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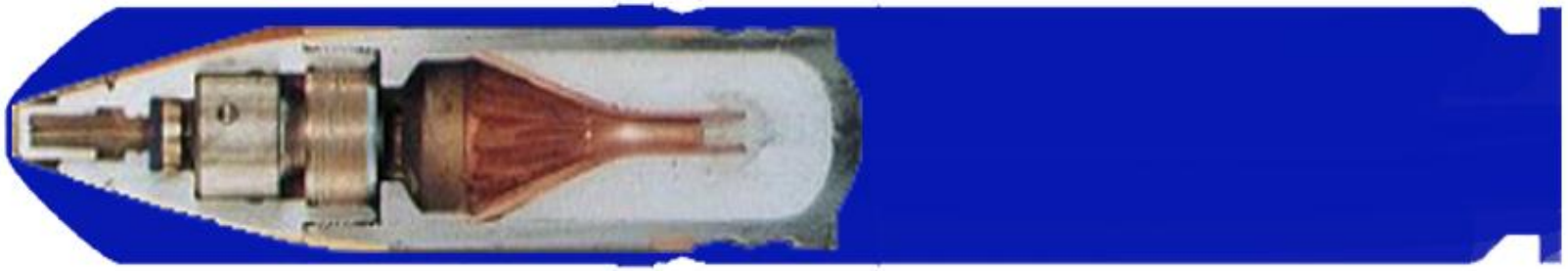


Eliminate air, low-stress metal, shrink fuze, stretch HE, add W or DU nose

Stretch more to full length, maintaining HE volume & effects, leave clearance for flash hole

Distribution A Unlimited Distribution

4. MASS & BASS Rounds

MASS & BASS Design Philosophy

Reshape flechette for sabot compatibility

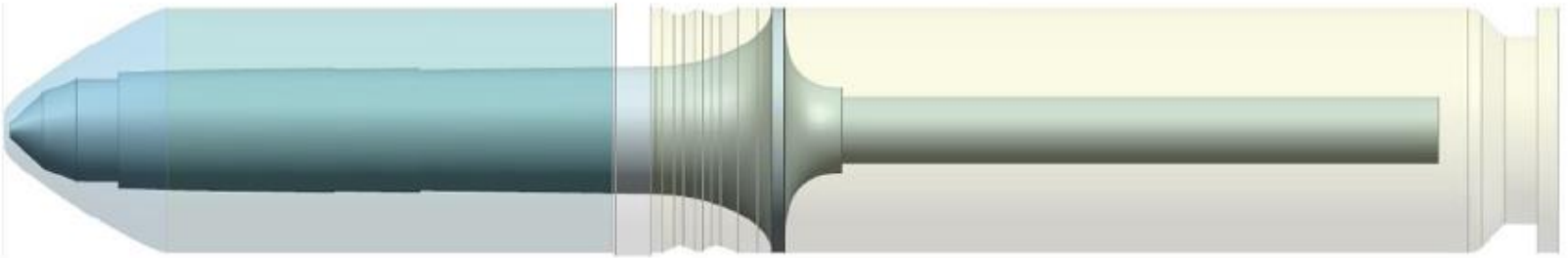
Distribution A Unlimited Distribution

4. MASS & BASS Rounds

MASS & BASS Design Philosophy

Reshape flechette for sabot compatibility

Run MDO including sabot, flechette, gun(s), aircraft and optimization vector



Distribution A Unlimited Distribution

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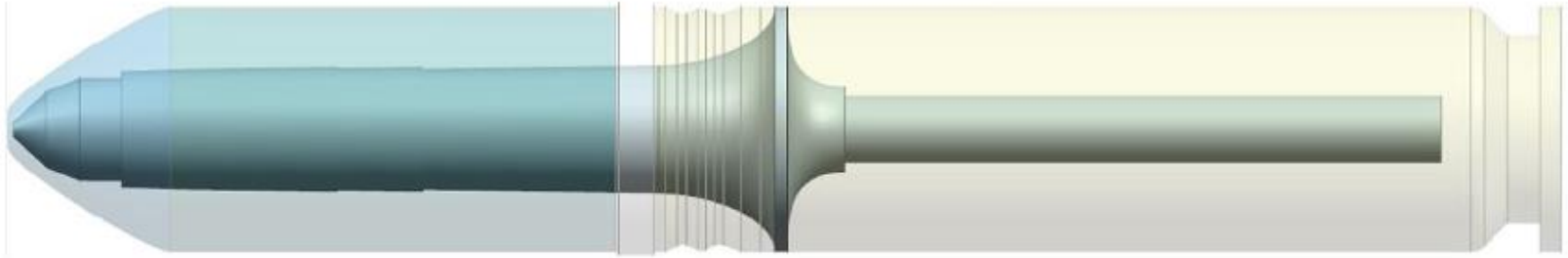
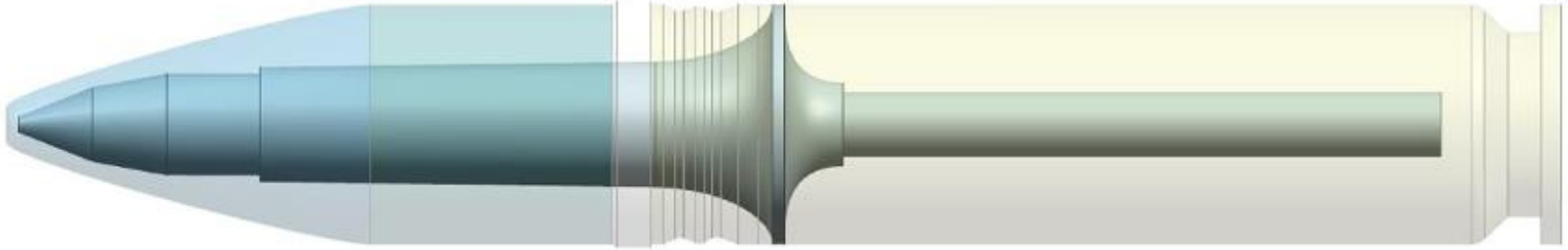


Send to Class II analysis & optimization

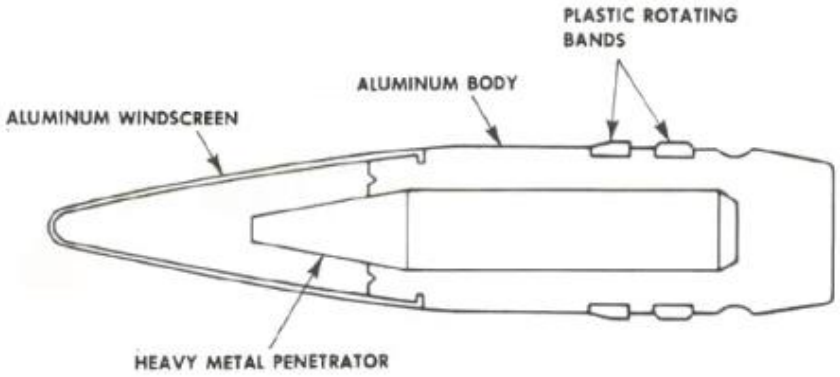


Distribution A Unlimited Distribution

4. MASS & BASS Rounds

Today's Aerial Gunnery Round

PGU-14



BASS 2081 Flechette/penetrator

Distribution A Unlimited Distribution

5. Modeling & Testing

- *Conceived 2016 & reduced to practice*
- *Modeled in CFD, FEM, DATCOM & PRODAS*
- *Tested on Shock Table, Wind Tunnel, Range*
- *>100 rounds fired, currently @ TRL-6*

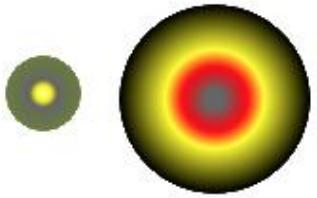
Distribution A Unlimited Distribution

5. Modeling & Testing

Top-Level Drag and Stability Characteristics

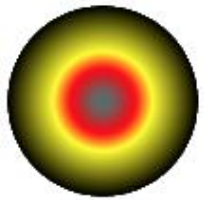
Flechette

X-Sectional Area of PGU-14 >> Flechette



Supersonic Drag ~ proportional to X-Sectional Area, $Drag_{PGU14} >> D_{Flechette}$

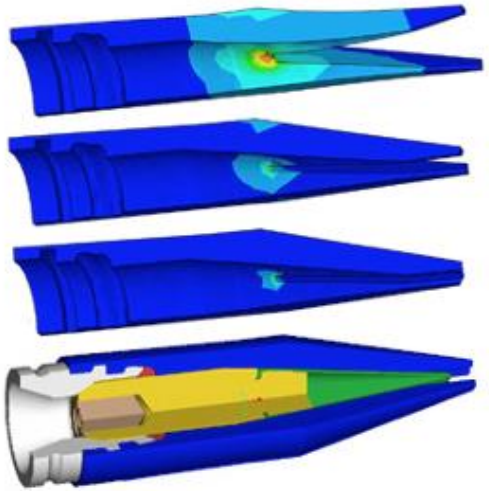
PGU-xx



Distribution A Unlimited Distribution

5. Modeling & Testing

Interior Ballistics:



System Modeling & Design:

- FEM calibrated with fielded-round dynamic shock modeling;

- Numerical simulation of sabot and projectile assembly through muzzle exit with initial dynamic perturbation.

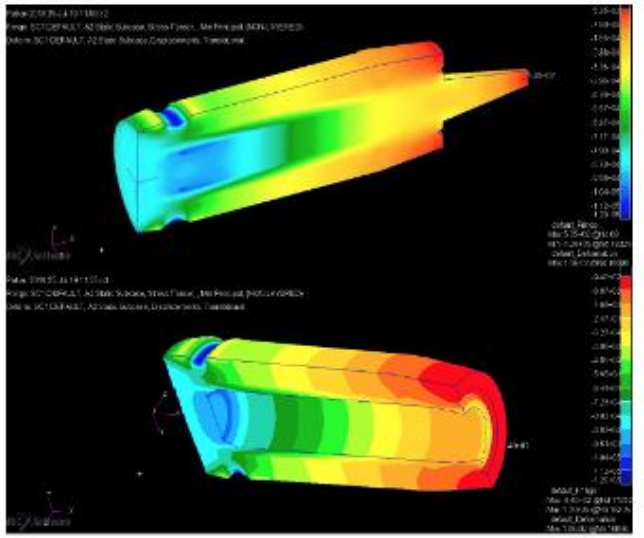


Image Sources:
https://www.sws-llc.com/structuralanalysis1.htm
http://www.mycity-military.com/uploads2/154453_716860609_Zecevic_Dispersion_PGU-14_ammunition%5B1%5D.pdf

Distribution A Unlimited Distribution

5. Modeling & Testing

Aeromechanics:

- Six-degree of freedom aeromechanical modeling of munitions of varied geometry and stability schemes through high angles and angular rates with the potential for deploying surfaces;

- Initial structural and aeromechanical design of a preferred configuration of the BASS system for penetrator and cargo rounds.

Earth Fixed

$$\begin{bmatrix}\dot{X}\\ \dot{Y}\\ \dot{Z}\end{bmatrix} = q_b^* \begin{bmatrix}U\\ V\\ W\end{bmatrix} q_b$$

Body Linear Momentum

$$\begin{bmatrix}\dot{U}\\ \dot{V}\\ \dot{W}\end{bmatrix} = \frac{1}{m}(m\bar{g} + \bar{F}) - \bar{\Omega} \times \bar{V}_b$$

Body Angular Momentum

$$\begin{bmatrix}\dot{P}\\ \dot{Q}\\ \dot{R}\end{bmatrix} = [J]^{-1}\left(\begin{bmatrix}L\\ M\\ N\end{bmatrix} - \begin{bmatrix}0 & -R & Q\\ R & 0 & P\\ -Q & -P & 0\end{bmatrix}[J]\begin{bmatrix}P\\ Q\\ R\end{bmatrix} + \sum_{i=1}^{N}\left(J_i\dot{\bar{\Omega}}_i + J_i\bar{\Omega}_i + \bar{\Omega}_i \times \bar{H}_i\right)\right)$$

Body Orientation

$$\begin{bmatrix}\dot{q}_0\\ \dot{q}_1\\ \dot{q}_2\\ \dot{q}_3\end{bmatrix} = \frac{1}{2}\begin{bmatrix}0 & -P & -Q & -R\\ P & 0 & R & -Q\\ Q & -R & 0 & P\\ R & Q & -P & 0\end{bmatrix}\begin{bmatrix}q_0\\ q_1\\ q_2\\ q_3\end{bmatrix}$$

Fin to Body Orientation

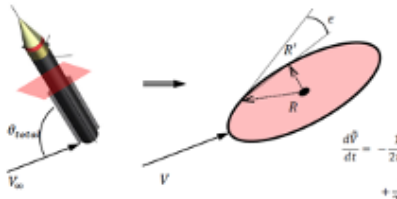
$$\begin{bmatrix}\dot{q}_0\\ \dot{q}_1\\ \dot{q}_2\\ \dot{q}_3\end{bmatrix}_i = \frac{1}{2}\begin{bmatrix}0 & 0 & 0 & -r\\ 0 & 0 & r & 0\\ 0 & -r & 0 & 0\\ r & 0 & 0 & 0\end{bmatrix}\begin{bmatrix}q_0\\ q_1\\ q_2\\ q_3\end{bmatrix}_i \qquad r_i = n_i\left(I_{zz_i} + \frac{mb^2}{4}\right)^{-1}$$

Source of relationships:
http://www.songho.ca/math/quaternion/quaternion.html
https://en.wikipedia.org/wiki/Rotation_formalisms_in_three_dimensions

$$\Phi_b = \rho_\infty V_\infty \sin(\theta)$$

$$\frac{F}{A} = \Delta P = \rho_\infty V_\infty \sin(\theta)^2$$

$$c_p = \frac{\Delta P}{\bar{q}} = 2\sin^2(\theta)$$



$$c_{P_{0,2}} = \frac{P_{0,2} - P_\infty}{\bar{q}} = \frac{P_{0,2} - P_\infty}{\frac{\gamma}{2}P_\infty M_\infty^2} = \frac{2}{\gamma M_\infty^2}\left(\frac{P_{0,2}}{P_\infty} - 1\right)$$

$$c_P = c_{P_{0,2}}\sin^2(\theta)$$

$$c_P = c_{P0}\sin^2\theta = \left(\left[\frac{(\gamma+1)^2}{4\gamma}\right]^{\frac{\gamma}{\gamma-1}}\frac{4}{\gamma+1} - \frac{2}{\gamma M_\infty^2}\right)\sin^2\theta$$

$$\frac{d\bar{V}}{dt} = -\frac{1}{2m}\rho S v C_0 \bar{V} + \frac{1}{2m}\rho S C_{L_\alpha}\left(V^2\hat{X} - (\bar{V}\cdot\hat{X})\bar{V}\right) - \frac{1}{2m}\rho S D C_{M_{pa}}\left(\frac{I_{yy}}{I_{xx}}\right)(\hat{n}\cdot\hat{X})(\hat{X}\times\bar{V}) + \frac{1}{2m}\rho S V D\left(C_{M_q} + C_{M_{\dot{\alpha}}}\right)(\hat{n}\times\hat{X}) + \bar{g} + \bar{\Lambda}$$

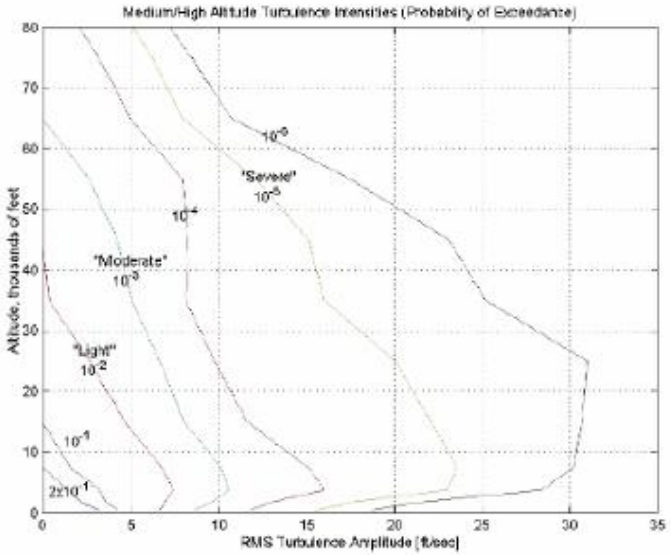
$$\frac{d\hat{n}}{dt} = -\frac{1}{2I_{yy}}\rho S V d C_{M_\alpha}(\bar{V}\times\hat{X}) + \frac{1}{2I_{xx}}\rho V S d^2 C_{M_{pa}}(\hat{n}\cdot\hat{X})(\bar{V} - (\bar{V}\cdot\hat{X})\hat{X}) + \frac{1}{2I_{yy}}\rho S V D^2\left(C_{M_q} + C_{M_{\dot{\alpha}}}\right)(\hat{n} - (\hat{n}\cdot\hat{X})\hat{X}) + \frac{1}{2I_{xx}}\rho S V D^2 C_{l_p}(\hat{n}\cdot\hat{X})\hat{X} + \frac{1}{2I_{yy}}\rho S V^2 C_{l_\delta} D\delta_F\hat{X}$$

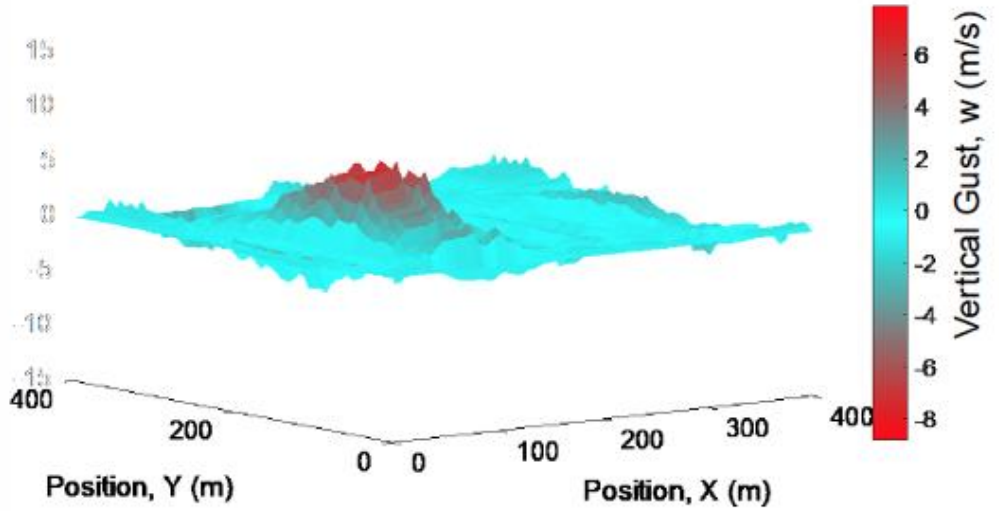
Distribution A Unlimited Distribution

5. Modeling & Testing

Aeromechanics:

- Quaternion DE until small angle assumption oscillation
- Pseudo-steady state 6DOF exterior ballistics model for projectile and sabot
- Von-Kármán gust field for scatter analysis downrange (MIL-F-8785C)
- Conventional sabot modeling with empirical data





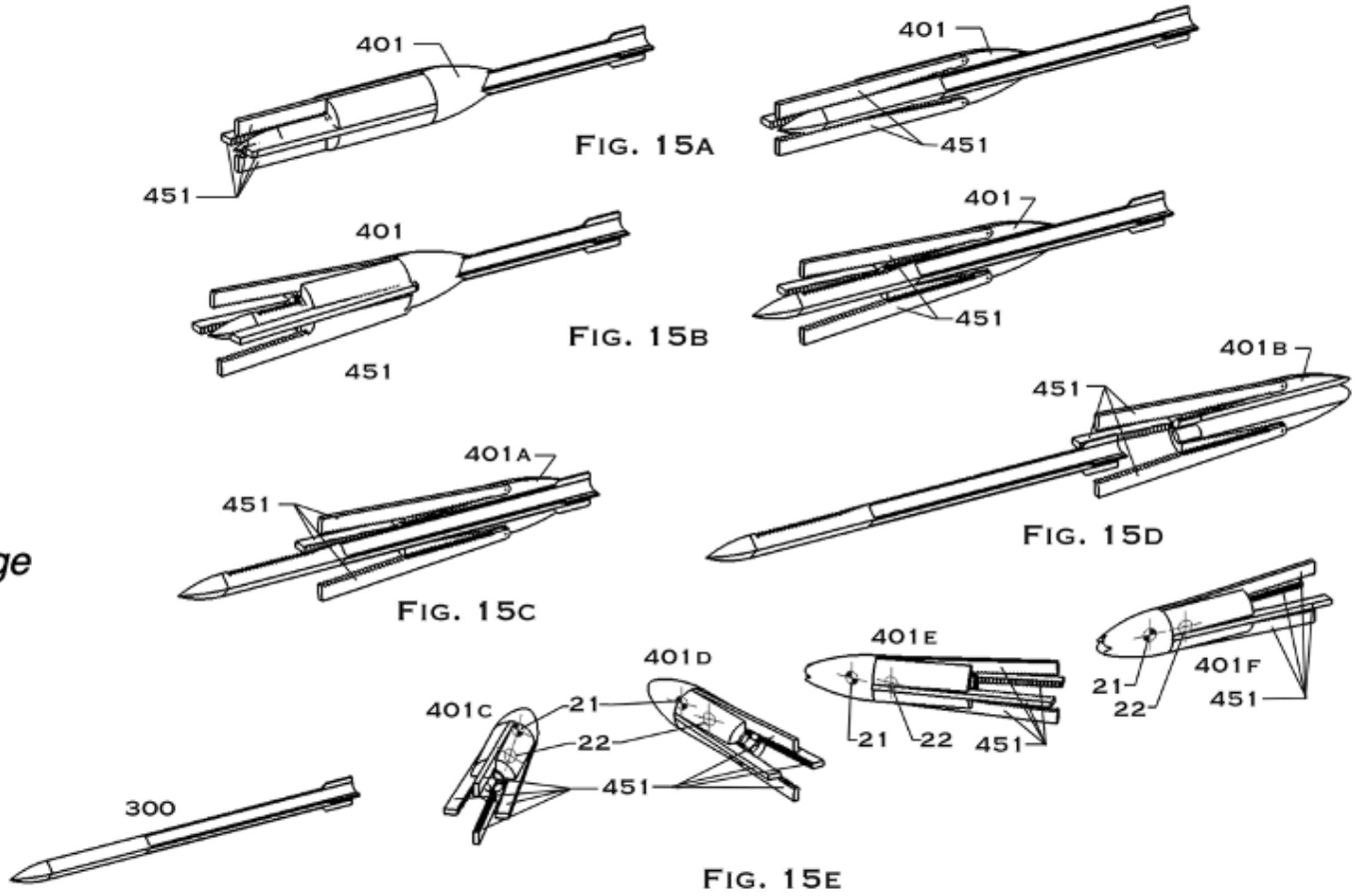
Distribution A Unlimited Distribution

5. Modeling & Testing

Exit Dynamics

Sabot Separation event

- *Transfers loads during launch*
- *Separates cleanly from projectile*
- *Clears launching aircraft & proceeds downrange in an aeromechanically stable configuration*



FIGURES 15

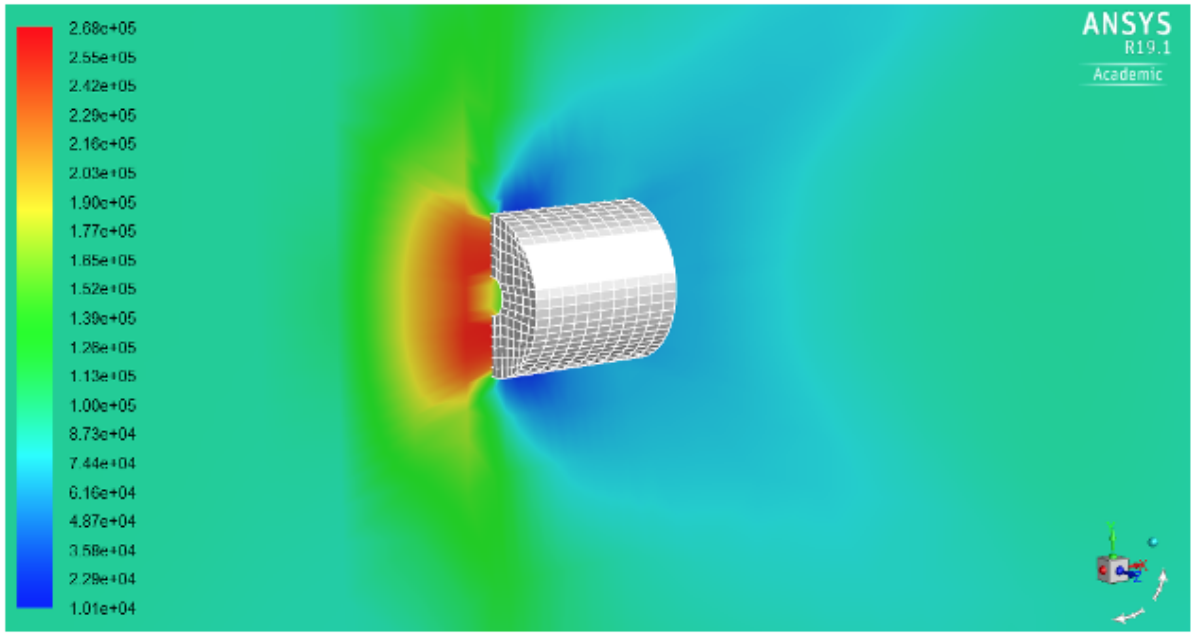
Image Source: PCT/IB2020/053899

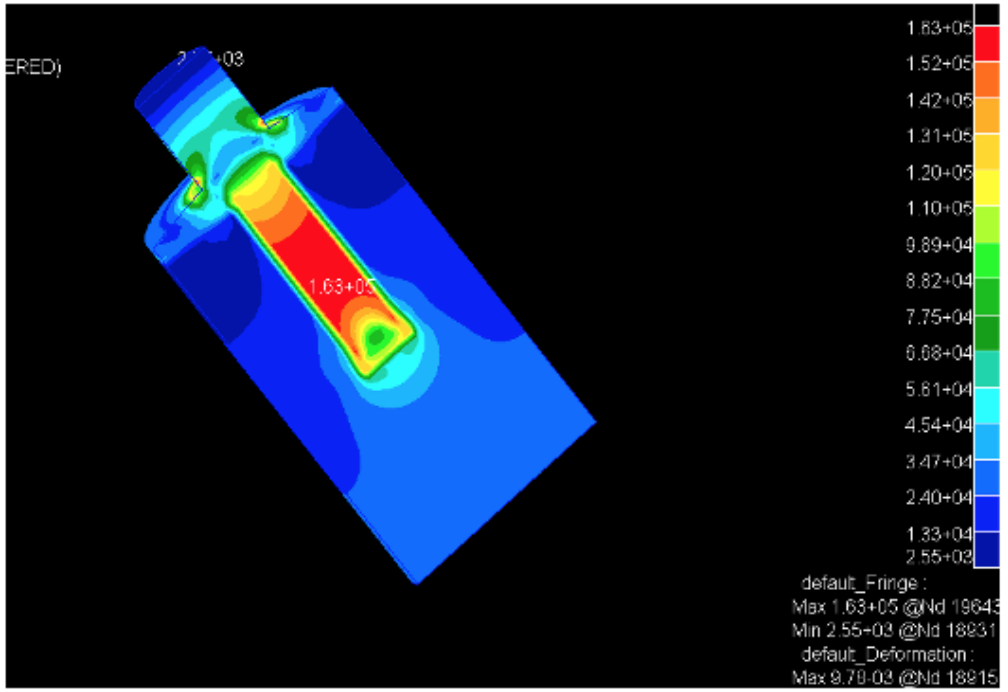
Distribution A Unlimited Distribution

5. Modeling & Testing

Computational Fluid Dynamics (CFD)

- Drag, center of pressure and aerodynamic center locations identified with α sweeps



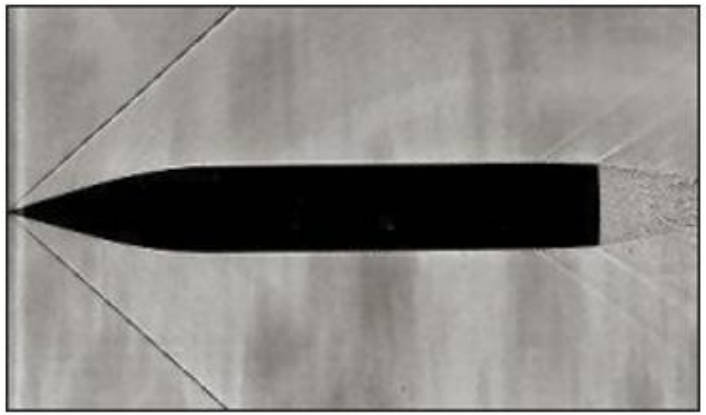


Distribution A Unlimited Distribution

5. Modeling & Testing

Wind Tunnel Verification:

- Center of pressure and aerodynamic center locations identified with α sweeps



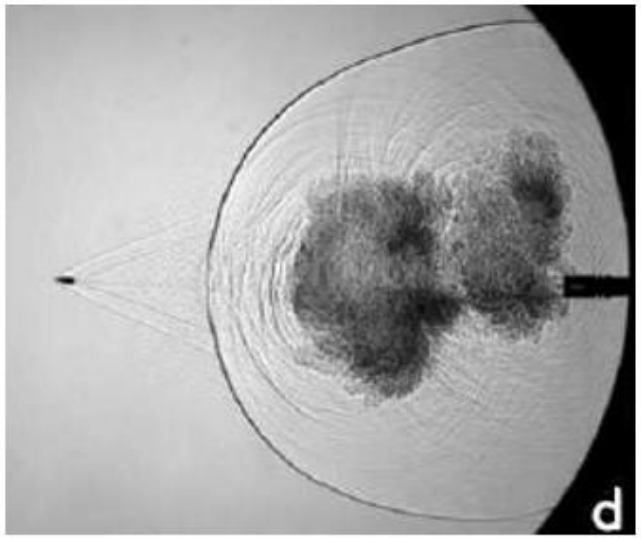


Image Sources:
https://nuclearprojects.com/blog/schlieren-flow-visualization/
https://www.researchgate.net/figure/Focused-shadowgrams-of-223-automatic-rifle-fire-a-sharply-focused-b-defocused-1m_fig3_226053639

Distribution A Unlimited Distribution

5. Modeling & Testing

Range Testing

Distribution A Unlimited Distribution

5. Modeling & Testing

Range Testing

Distribution A Unlimited Distribution

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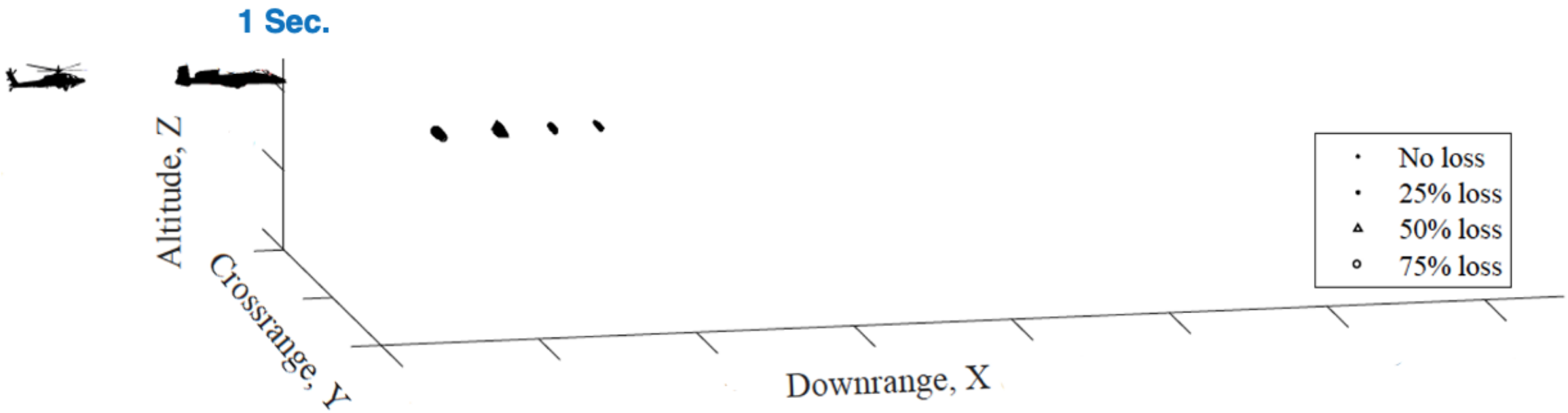
Range Testing

Distribution A Unlimited Distribution

6. BASS Performance

Flight Safety/Airframe Strike Check

AH-64 & A-10 Sabot separation Modeling (99% atmospherics)



Source: Schumacher, L. N., "BASS Medium Caliber System Modeling: Proof-of-Concept and the Future of Aerial Gunnery with Advanced Munitions," Ph.D. Dissertation Defense, 29 June 2020, The University of Kansas Aerospace Engineering Department, Lawrence, Kansas.

Distribution A

6. BASS Performance

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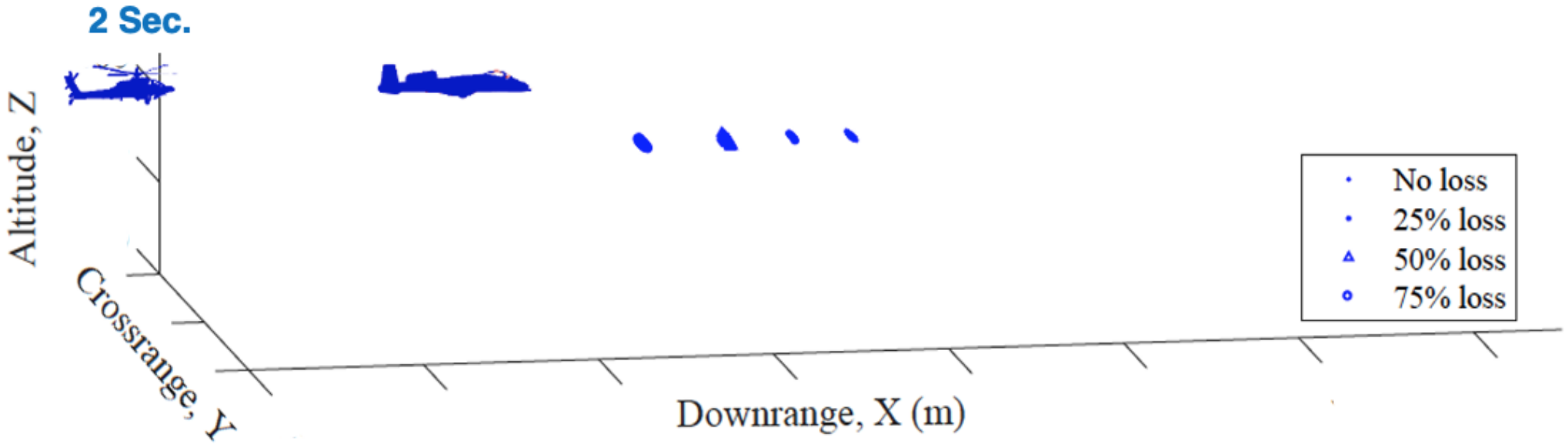

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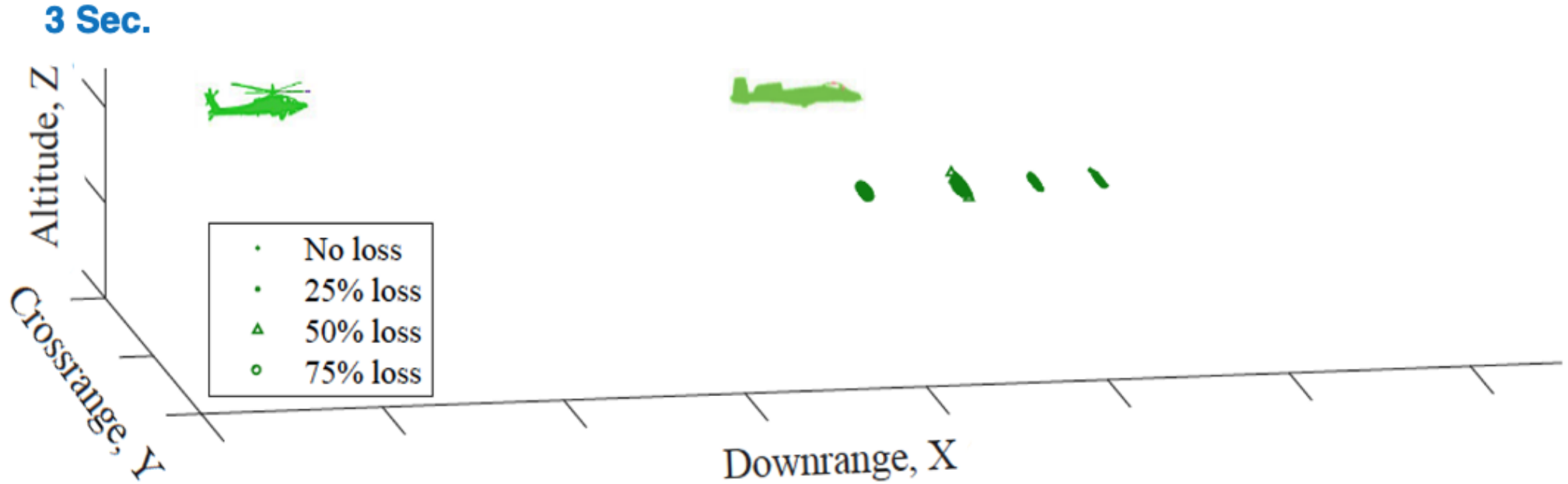

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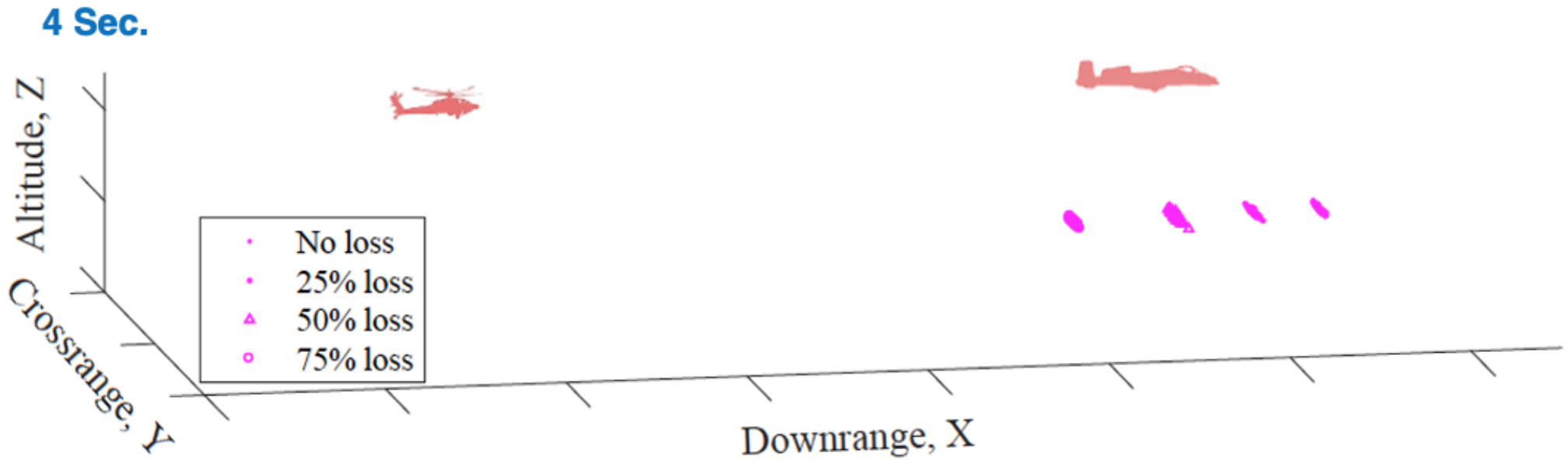
6. BASS Performance

Flight Safety/Airframe Strike Check

AH-64 & A-10 Sabot separation Modeling (99% atmospherics)



Source: Schumacher, L. N., "BASS Medium Caliber System Modeling: Proof-of-Concept and the Future of Aerial Gunnery with Advanced Munitions," Ph.D. Dissertation Defense, 29 June 2020, The University of Kansas Aerospace Engineering Department, Lawrence, Kansas.

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6. BASS Performance

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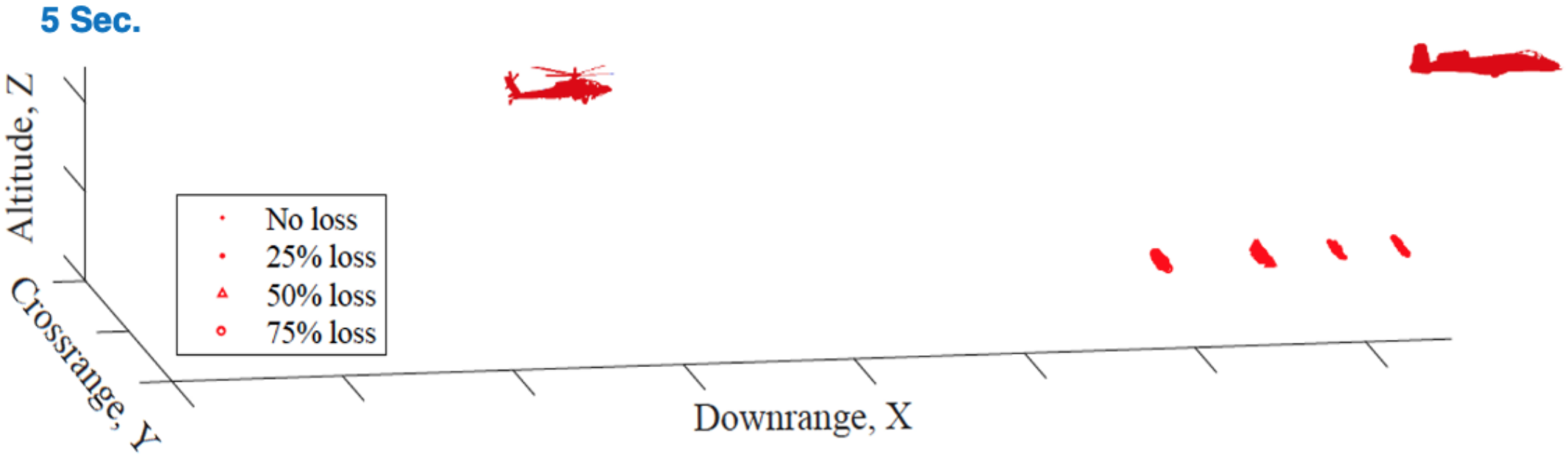

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6. BASS Performance

Relative Ballistic Coefficients

45 cal. 1st Aerial Combat 1913

20mm USMC/M53/56

20mm USAF/PGU-28

25mm USAF/PGU-47

30mm Army AH-64 M789

Aerial Gunnery Ammunition

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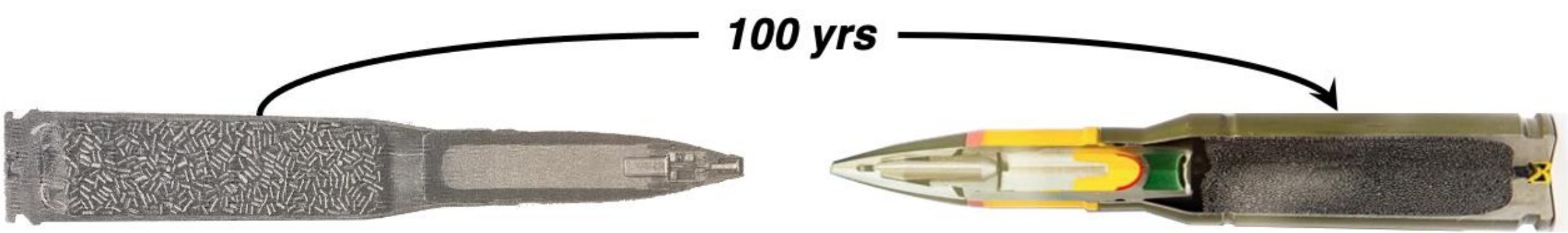
6. BASS Performance

Relative Ballistic Coefficients



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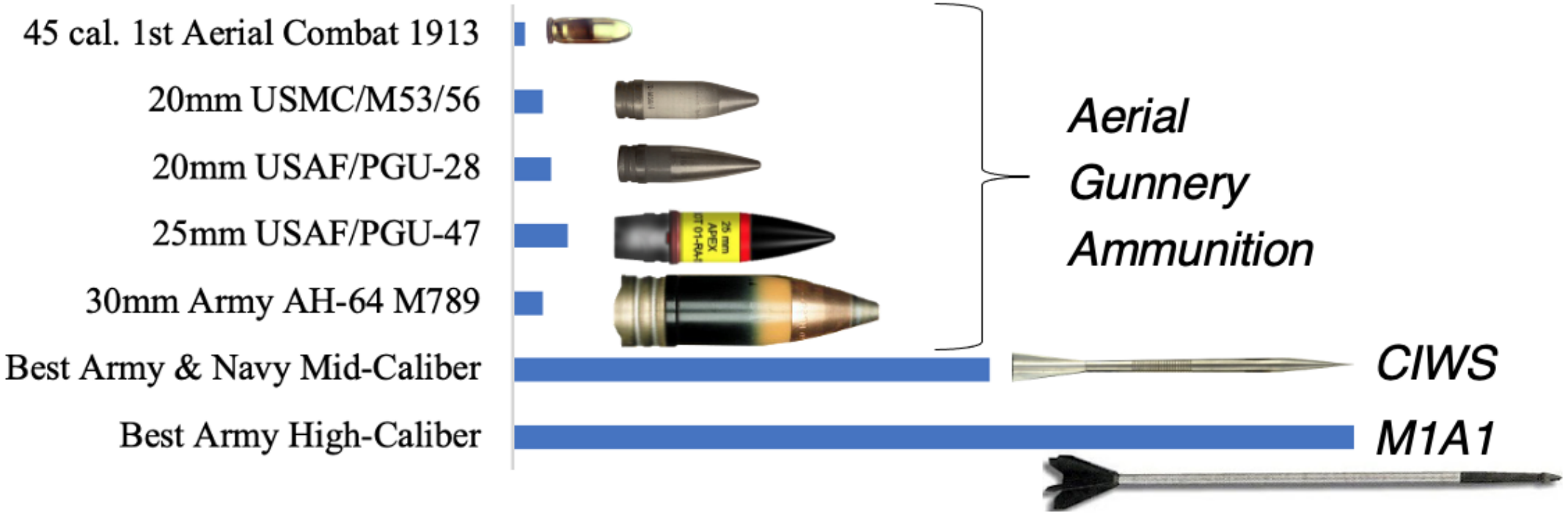
6. BASS Performance

Relative Ballistic Coefficients



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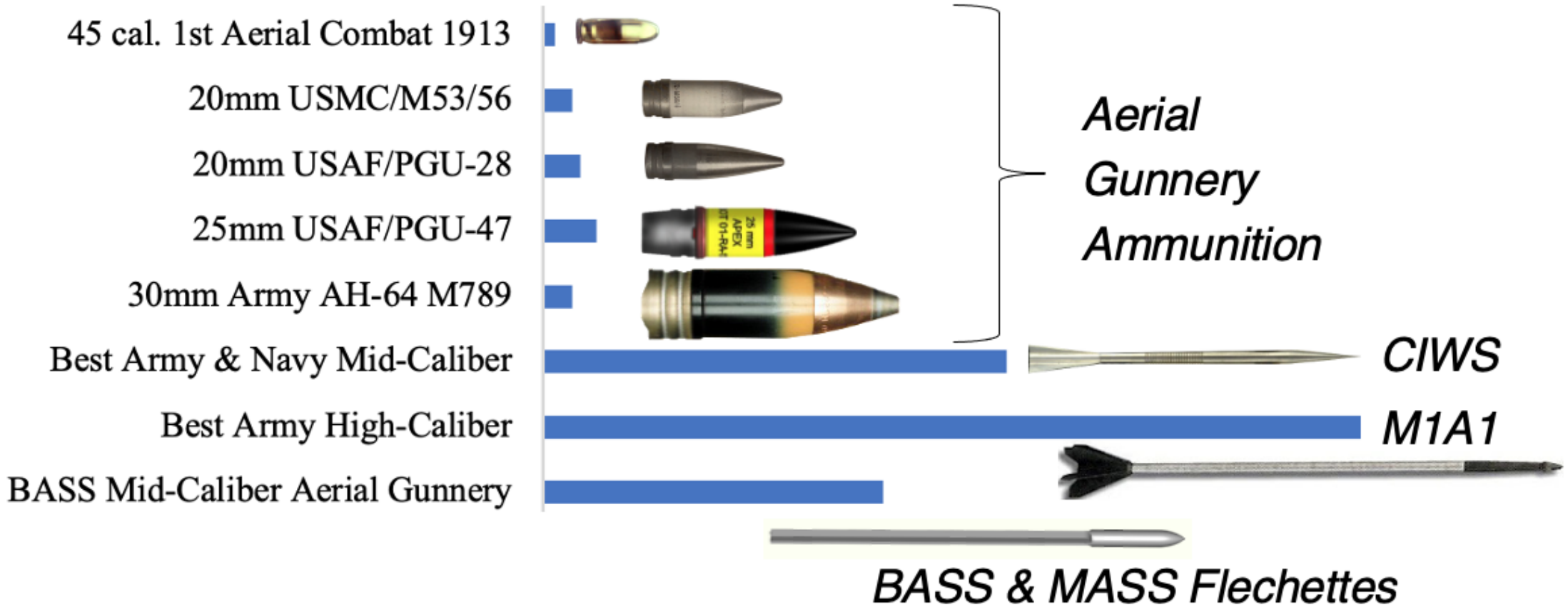
6. BASS Performance

Relative Ballistic Coefficients



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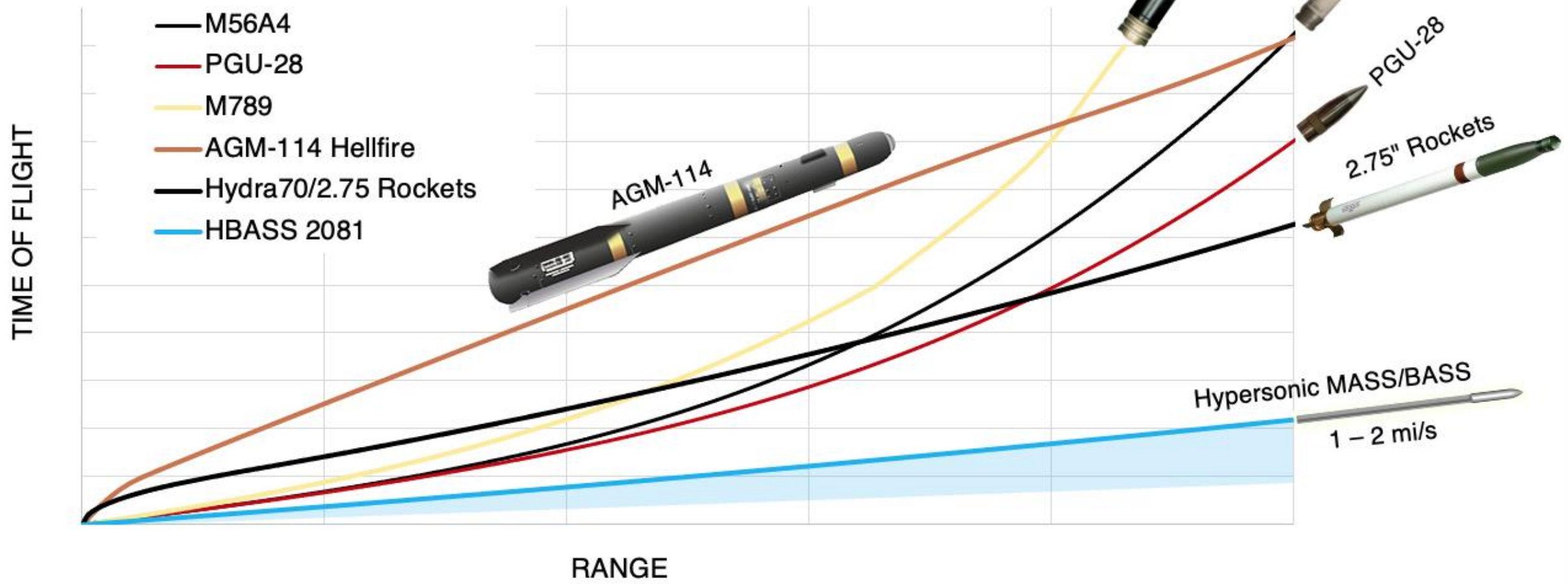
6. BASS Performance

Relative Weapon Times of Flight from USA/USMC Aircraft



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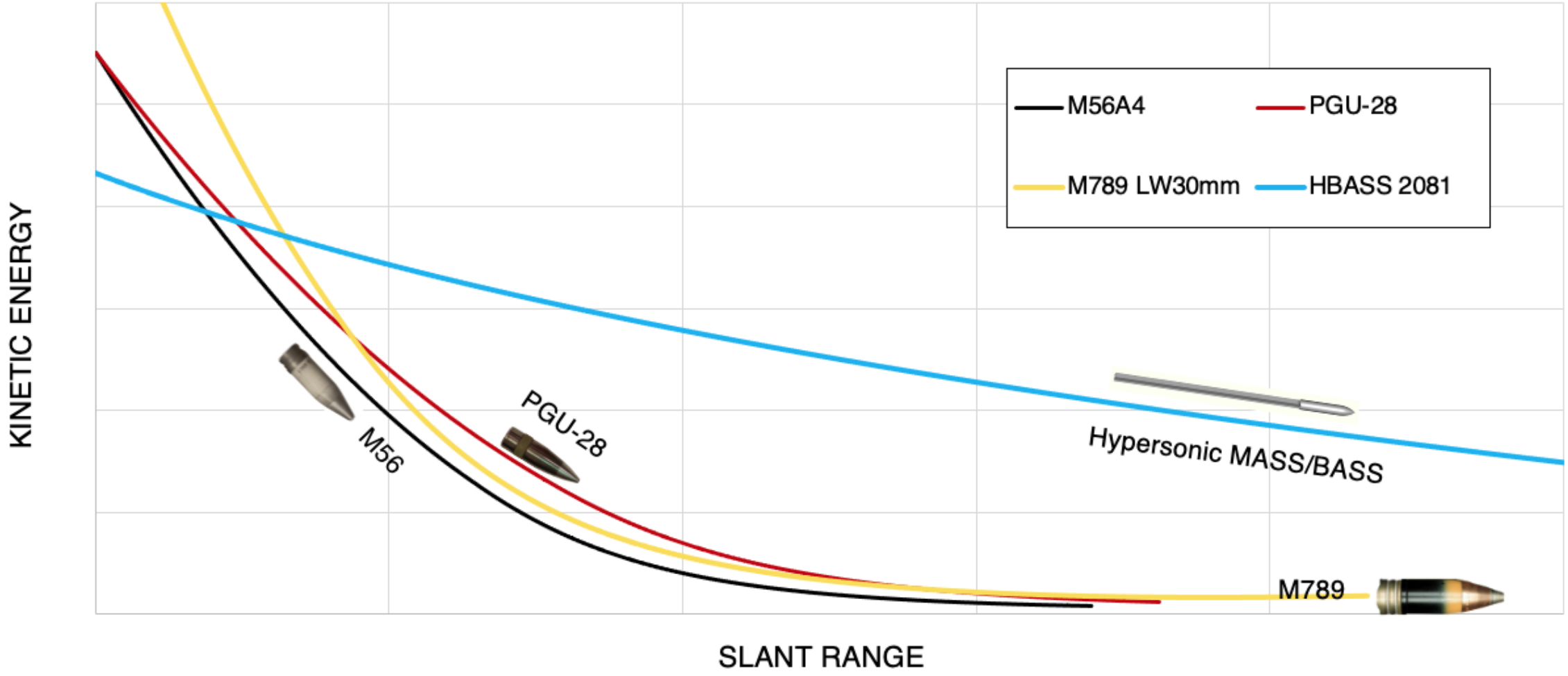
6. BASS Performance

Relative Weapon Kinetic Energy from USA/USMC Aircraft



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7. Intellectual Property Staatus

What is claimed is:

1. An aeromechanically stable sabot…

2. The aeromechanically stable sabot of claim 1, wherein the assembly includes at least one aeromechanically stable segment…

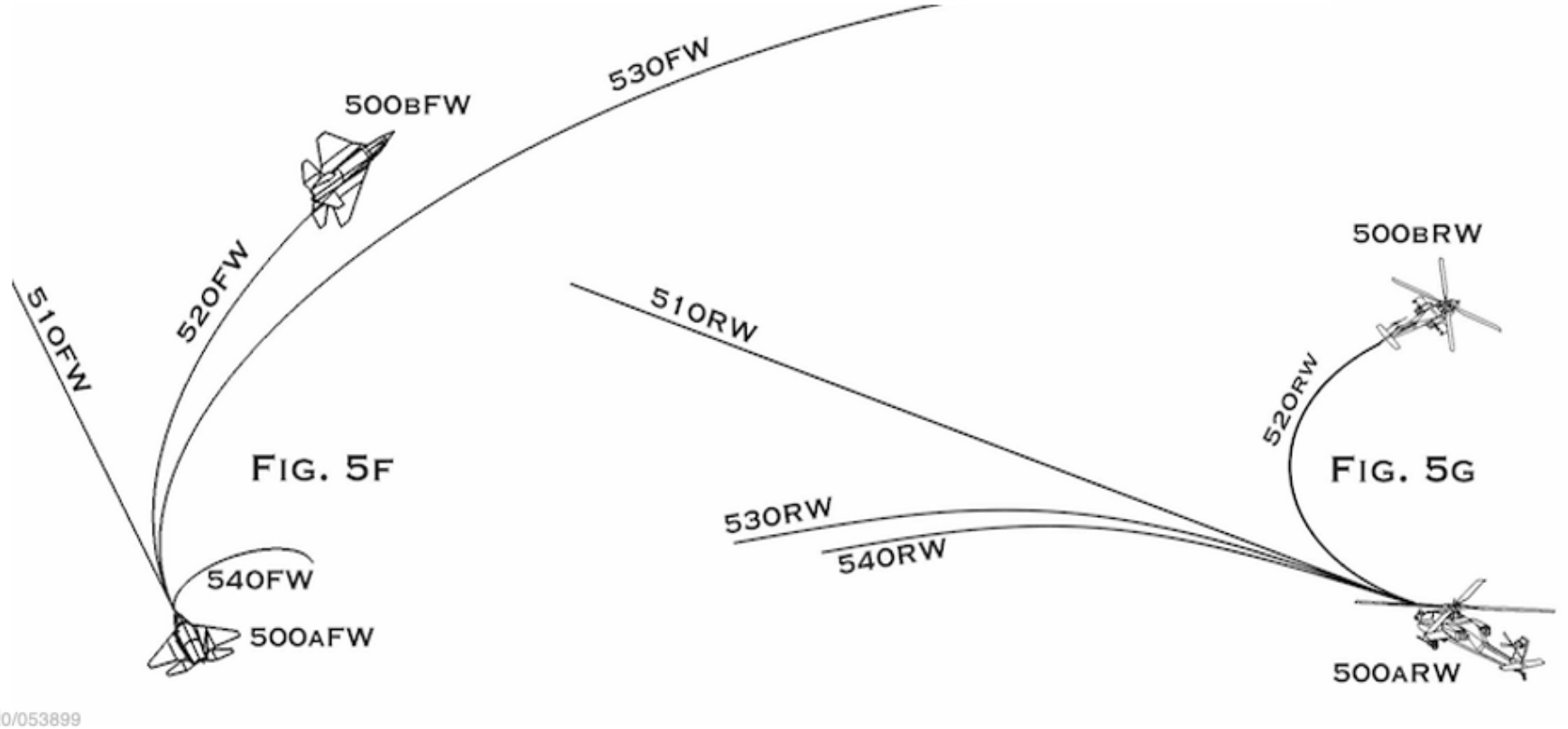

Image Source: PCT/IB2020/053899

Invented 2016 *Modeled 2017* *Reduced to practice 2018* *Pat. priority date: 4/26/2019*

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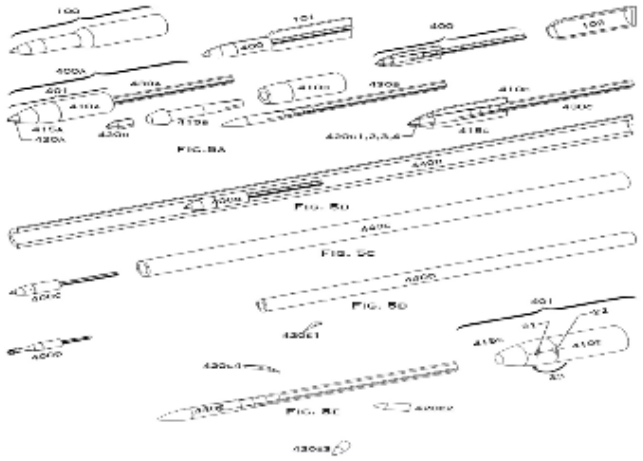
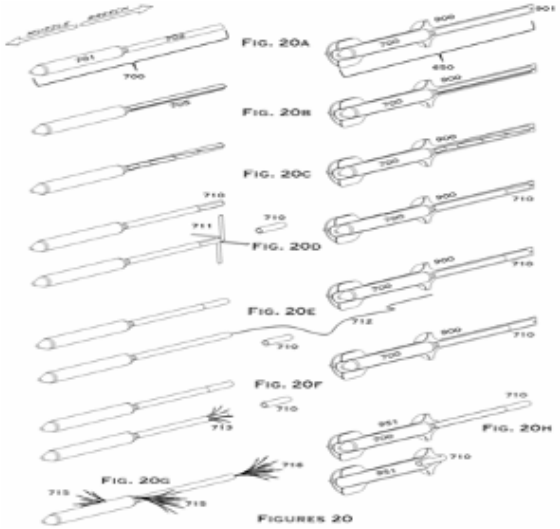
7. Intellectual Property Staatus

- **Strong, Broad US Patents Filed 2019, 2020**
- **Fed. Government Granted Export License & Exported**
- **Patents filed in: US, Europe, Germany, Norway, Australia, UK, Netherlands, France, Belgium, Italy, Spain, Japan, Korea, Singapore**





PROVISIONAL PATENT APPLICATION 62/839,551 26 APRIL 2019 PRIORITY DATE 25 FIGURES, 83 CLAIMS, 80 PAGES

PCT FILING PCT/IB2020/053899 24 APRIL 2020 > 54 FAMILIES 3+ SPECIES WITHIN EACH FAMILY: 33 FIGURES, 130 CLAIMS, 106 PAGES

FEDERAL GOVERNMENT APPROVED FOR EXPORT & EXPORTED ENABLING BASS TECHNOLOGY & DESIGNS

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8. Opportunities

Attack Rotorcraft

AH-64 (M789 30 x 113mm) AH-1 (M56 20 x 102mm) FARA

Fixed-Wing Attack Aircraft

A-10 (PGU-14 30 x 173mm)

Multi-Role Fixed-Wing Aircraft

F-15, F-16, F-18, F-22 (PGU-28 20 x 102mm)

F-35 (PGU-47 25 x 137mm)

Gunships

AC-130 (25mm, 40mm, 105mm)

Armed Drones

MQ-9, MQ-?, Bayraktar TB2, Shadow...

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8. Opportunities …Nontrivial chance of capturing a substantial part of the market

US Army: *(DoD FY 2019 Budget Exhibit P-1 FY 2019, P. A-17C)*

20, 25, 30mm $113M/yr

USMC: *(DoD FY 2019 Budget Exhibit P-1 FY 2019, P. N-20C)*

20, 25, 30mm $34M/yr

US Air Force: *(DoD FY 2019 Budget Exhibit P-1 FY 2019, P. F-19C)*

20, 25, 30mm+ $193M/yr

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8. Opportunities KU Aerospace: open for business...

- ***Exclusive & non-exclusive licenses available for:***

  -US, Europe-Wide, Germany, Norway, Australia, UK, Netherlands, France, Belgium, Spain, Italy, Japan, Korea, Singapore

  Approved by the Federal Government for export

- ***Engineering support: 3+ yr acceleration, data sets*** *(as allowed by law)*

  -On site support up to 2 yrs

- ***Operational Units:***

  -"What's possible – whole new mission sets" briefings (ITAR restricted)

- ***Corporate Labs:***

  -"What's possible" briefings (ITAR restricted & open)

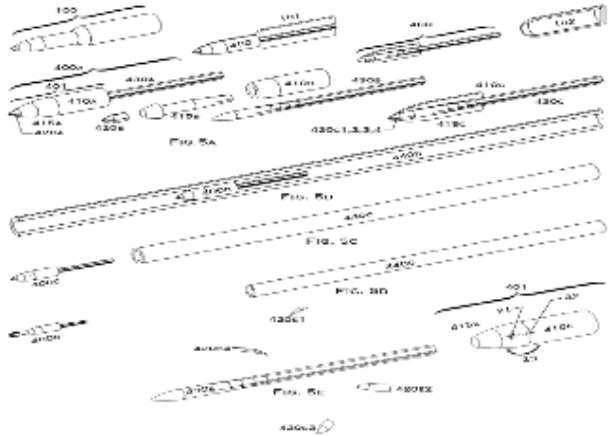
  -Short courses (1 hr to 2 days)

  -Patent/IP structure, legal offense/defense planning & weaponization

- ***Government Labs:***

  -Next research steps & navigating 15 CFR § 700 to 700.93 DPA

  -Short courses (1hr to 2 days)



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Questions?
Visit us at Booth 412
Wed. 21 Sept. 3:30 – 3:50pm Level 4, Room 18D
Outgunning the A-10 With an Apache or Fara:
New Flight-Safe Discarding Sabot Ammunition for Attack Rotorcraft
KU
THE UNIVERSITY OF
KANSAS

Modernized GPS & Digital Anti-Jam Contributions to the Range and Lethality Challenge of MDO

Future Force Capabilities Conference
Unconventional Emerging Armaments
20 Sep 2022

Justin R. Wymore Sr., BAE Systems/NSS

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BAE SYSTEMS

Agenda

- Role of precision in achieving weapons lethality at extended range
- Role of precision geolocation for autonomous/semi-autonomous loitering munitions
- Guidance, Navigation, and Control (GNC) trade space
- Assured Position, Navigation, and Timing (APNT) Threat Model, technologies, and trade-offs
- Available APNT Hardening Solutions

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Role of Precision

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Problem to be Solved

Problem: GPS jamming and spoofing by adversaries severely impacts the precision and lethality of our weapon systems

- GPS is the predominant method of attaining absolute precision guidance due to its accuracy (sub-2 meter), availability (worldwide), accessibility (unlimited number of simultaneous users), reliability, and per-user cost (free)
- Adversaries continue to evolve their threat systems against GPS
- Absolute precision is becoming even more critical in an MDO environment (Multi-Domain Operations / Maritime Distributed Operations (MDO) / Joint All-Domain Operations (JADO))
- Weapons precision is highly correlated to lethality, mission success, and reduced costs

Adversary Navigation Warfare (NAVWAR) systems threaten our ability to execute MDO/JADO

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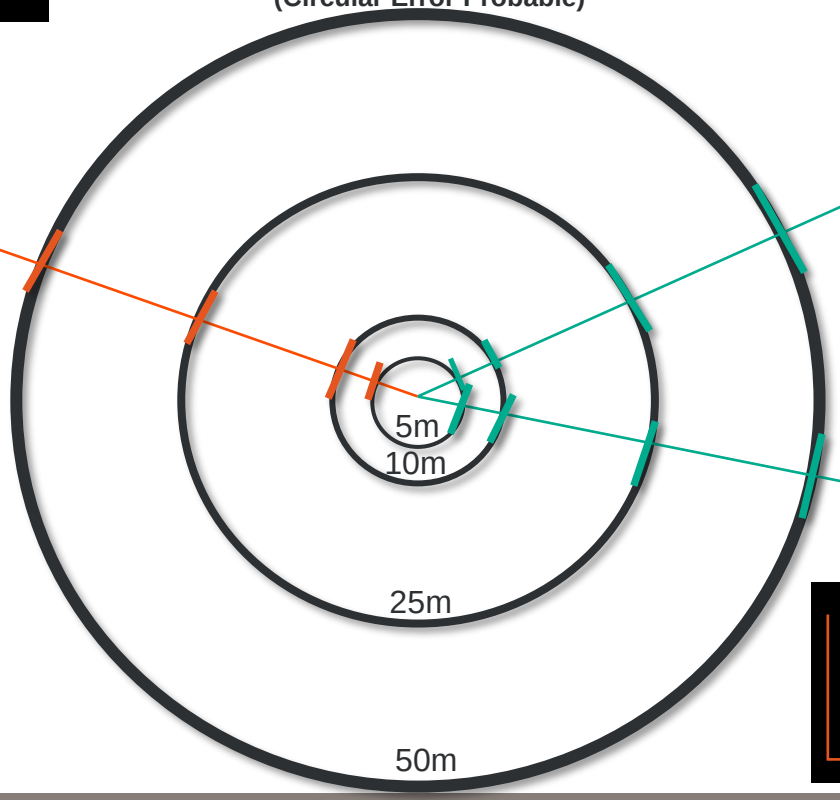
Relationship Between Precision & Lethality

Frag Effects (Dispersion Factor)

CEP (m)	N_{hits}
5	579
10	145
25	23
50	6

- These numbers represent the number of hits expected from a fragmentation warhead with 182K fragments against a single, man-sized target.
- A standard 500-pound Mk 82 bomb produces <3000 fragments.

Frag kinetic effect is not generalized here, though armor is unlikely to be stopped by a general purpose fragmentary warhead



Blast Effects (Dynamic Pressure)

CEP	Warhead
5	82
9.16	502
10	653

CEP	Warhead
18.32	4017
25	10208
50	81667

- To achieve 7psi with a 500lb-class warhead requires CEP < 9.16m.
- Doubling CEP to 18.32m, requires a warhead of 4017lbs
- 500lb warhead yields 7psi dynamic pressure at a range of 9.16m but only 0.875 psi at 18.32m

5 psi will kill troops in the open, while 7 psi will kill a light armored vehicle

CEP	PSI
5	43.04022
9.16	7
10	5.380027
18.32	0.875
25	0.344322
50	0.04304

Precision is the primary influence on lethality of weapons at range

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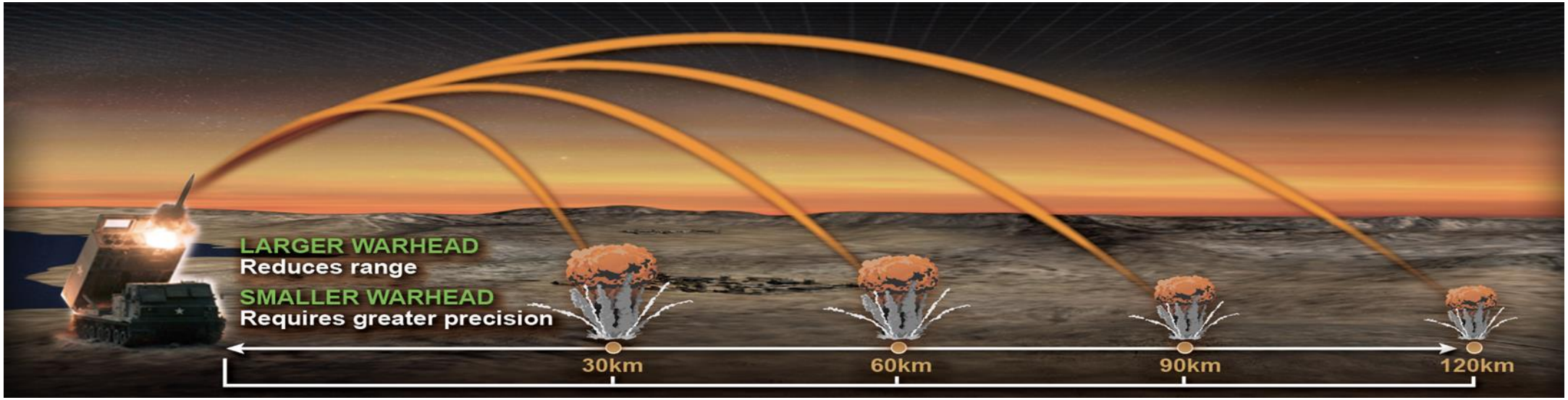
Role of Precision in Weapons Effects (Range)

Precision v. Lethality: Function of the mass & volume required by the warhead's damage mechanism and the mass and volume required by the guidance set



Precision v. Range : Adds the complication of the mass required for the additional propellant

Larger warhead reduces range ⟷ Smaller warhead requires greater precision to have effect

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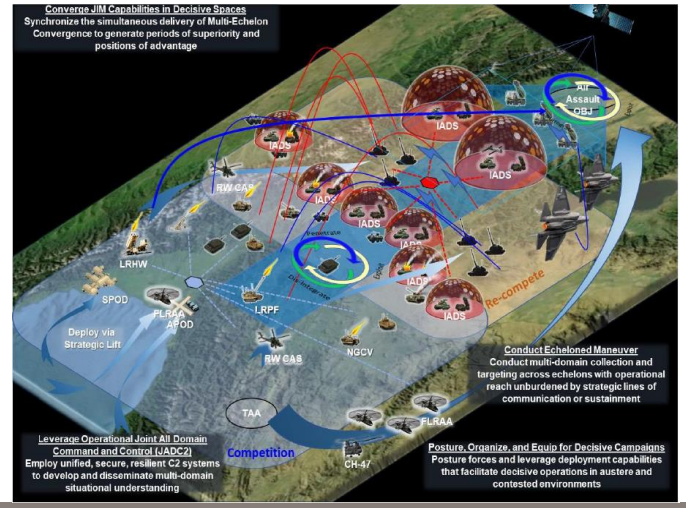
Role of Precision in MDO

- Multi-Domain Operations changes current “fire-enabled maneuver” concept to “maneuver-enabled fires” - disaggregated and dispersed forces able to mass forces or effects while remaining mobile
- Precision and the associated shot-doctrine significantly impacts logistics and battlefield mobility
- Without precision munitions, each weapon has a larger CEP and correspondingly lower P_k, which:
- Requires more shots per target to achieve P_k >1
- Requires additional time to prosecute each target
- Increases vulnerability to counter-battery fire
- Limits the lethality of an individual fires platform
- Increases the requirement for battlefield replenishment



MDO requires precision to achieve required maneuver-enabled fires

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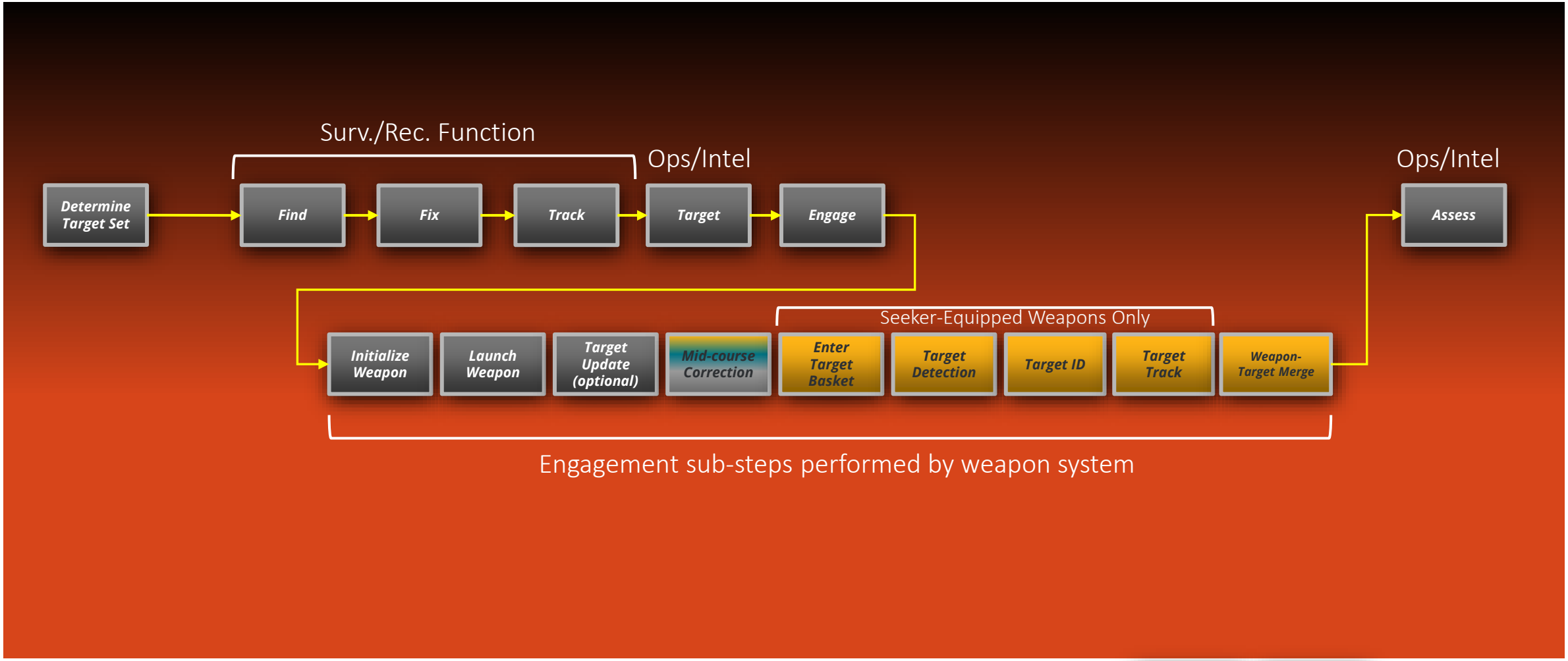
Traditional Kill Chain



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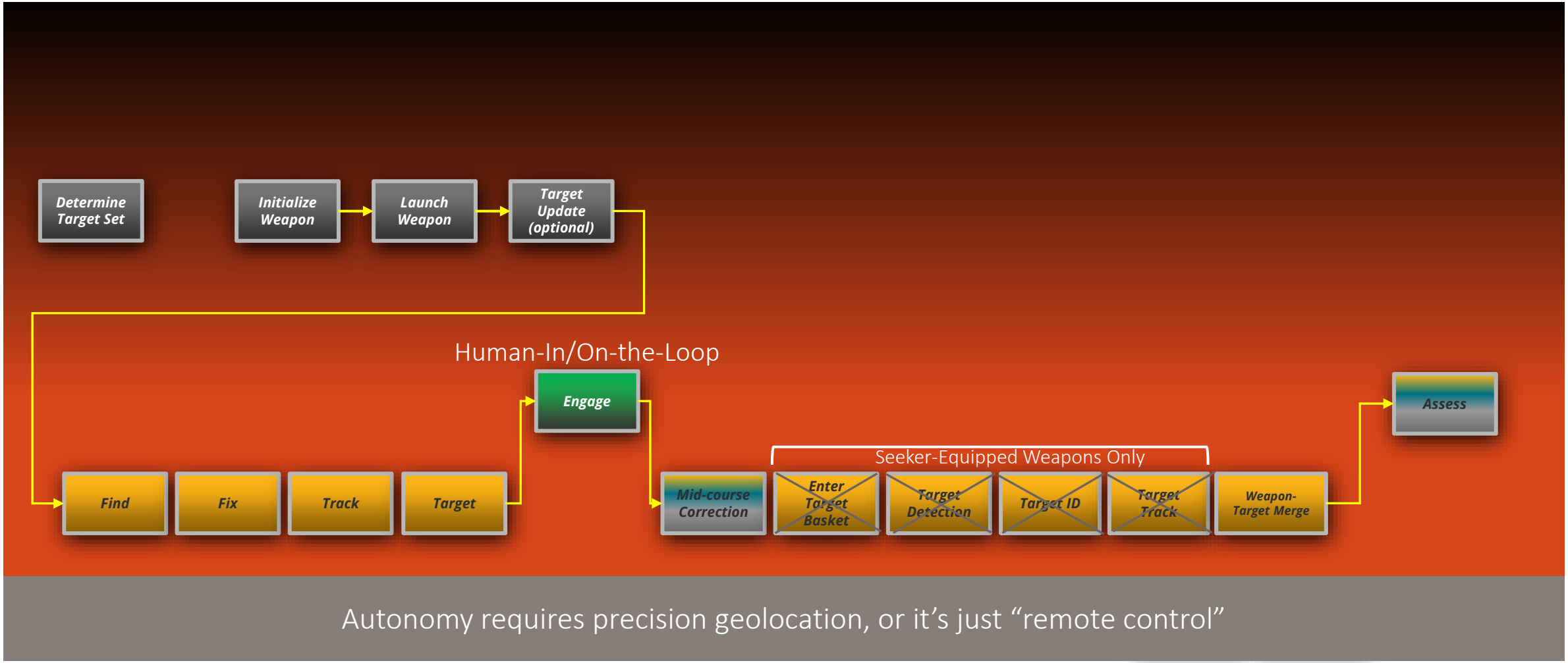
Off Weapon | Weapon

Autonomous/Semi-Autonomous Loitering Munitions Kill Chain



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Off Weapon | Weapon

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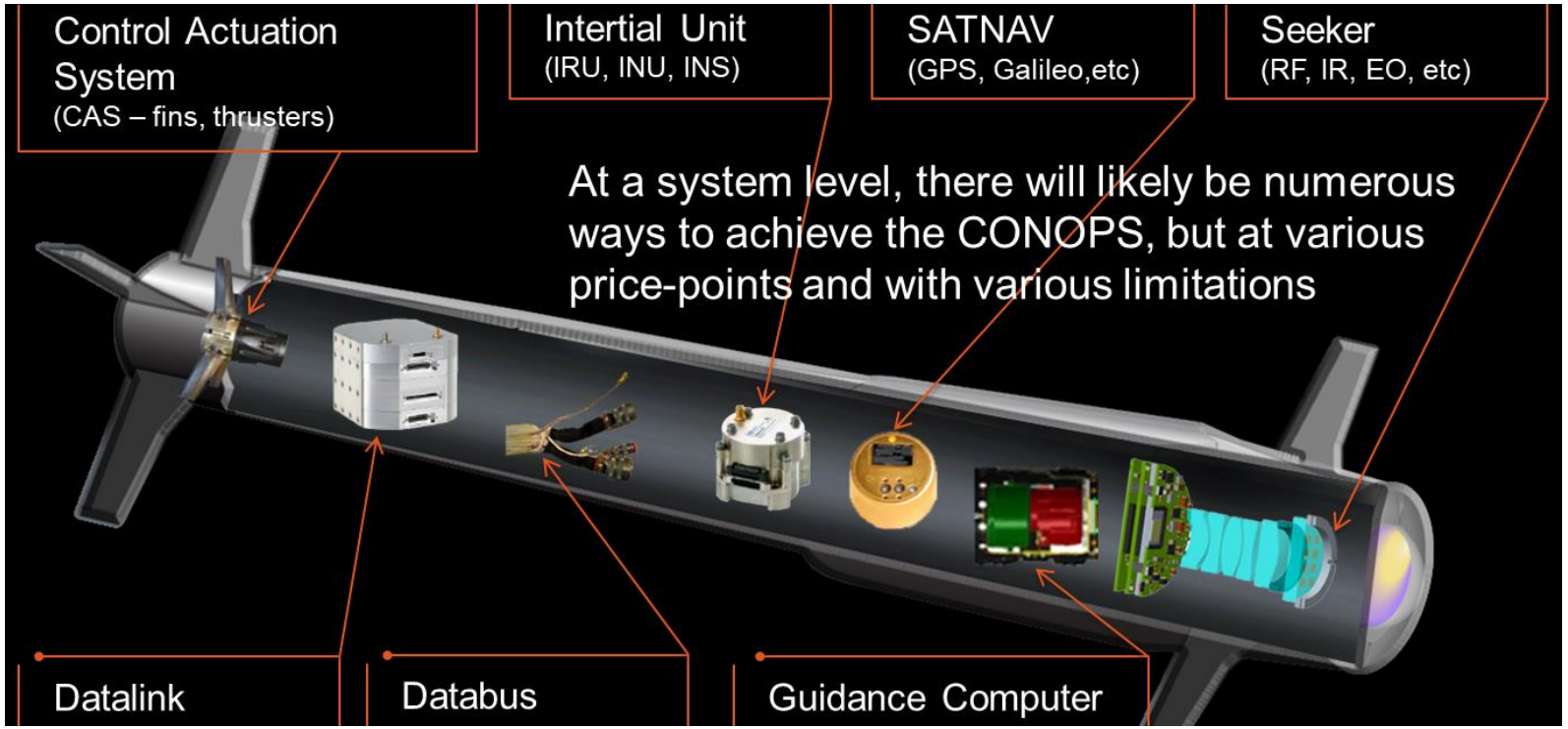
GNC Trade Space



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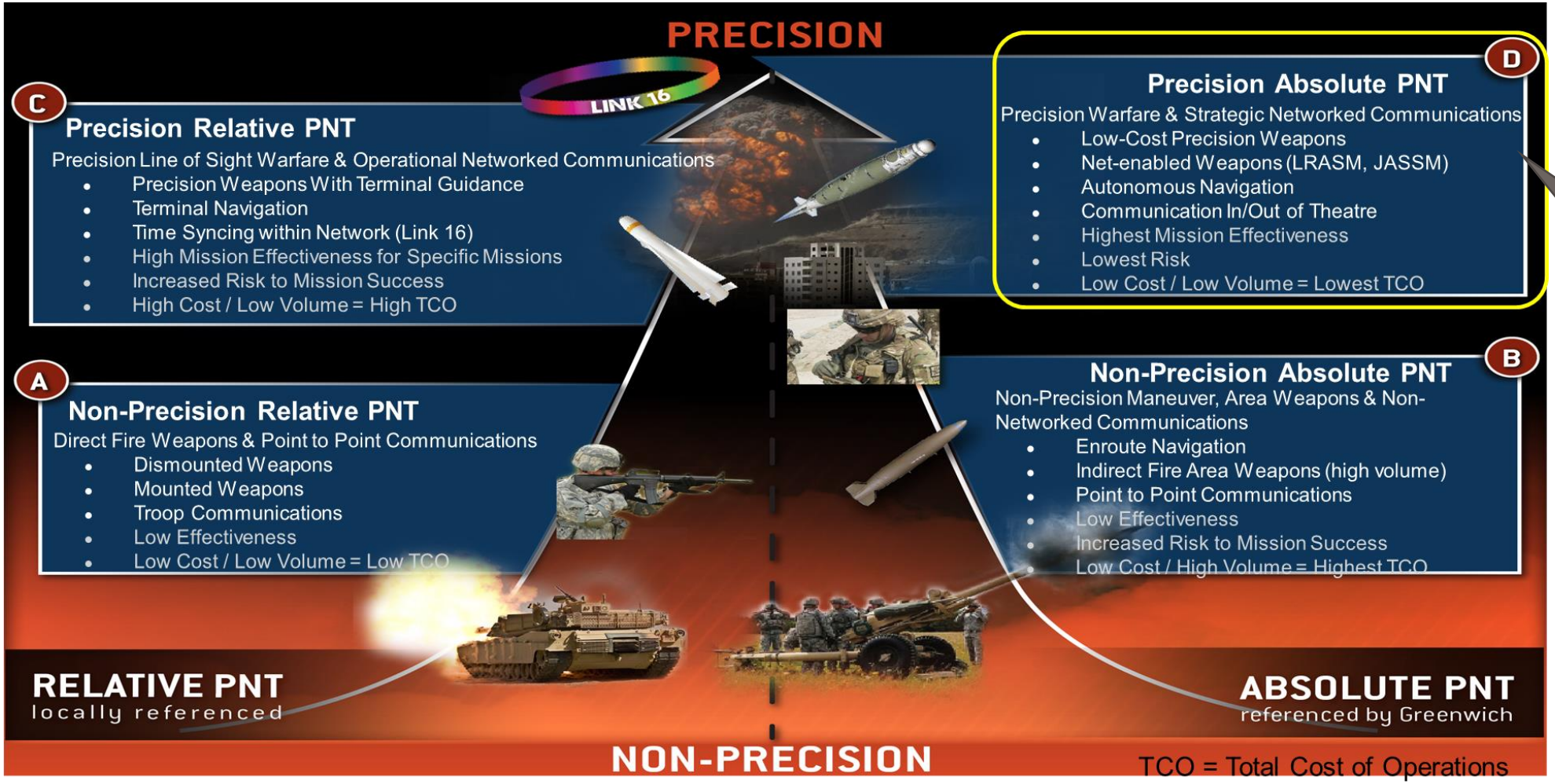
Precision v. Non-Precision / Absolute v. Relative Reference Frame



Quadrant D, precision absolute PNT, is what enabled the RMF and will likewise enable MDO/JADO

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Guidance, Navigation, and Control Trade Space

- There are two general approaches to precision guidance: Guide-onto-Target (GoT) (“Quadrant C”) and Guide-onto-Location-in-Space (GoLiS) a.k.a. Coordinate-Seeking Weapon (CSW) (“Quadrant D”)
- There are up to seven key elements of a modern GNC system that make a “smart” weapon smart - control actuation system (CAS), inertial unit, guidance computer, seeker, databus, SATNAV, and datalink
- The interplay between the various elements constitutes the trade space in achieving the target discrimination, desired CEP, and resultant P_k
- At extended ranges, achieving affordable precision is dependent on a SATNAV capability
- SATNAV remains the least expensive and most effective PNT source at the user-equipment level to get the weapon to the target or close enough for affordable terminal seekers to resolve the target and complete the engagement

SATNAV is necessary to achieve affordable precision in support of MDO / JADO

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Assured PNT Threat Model, Technologies, and Trade-Offs

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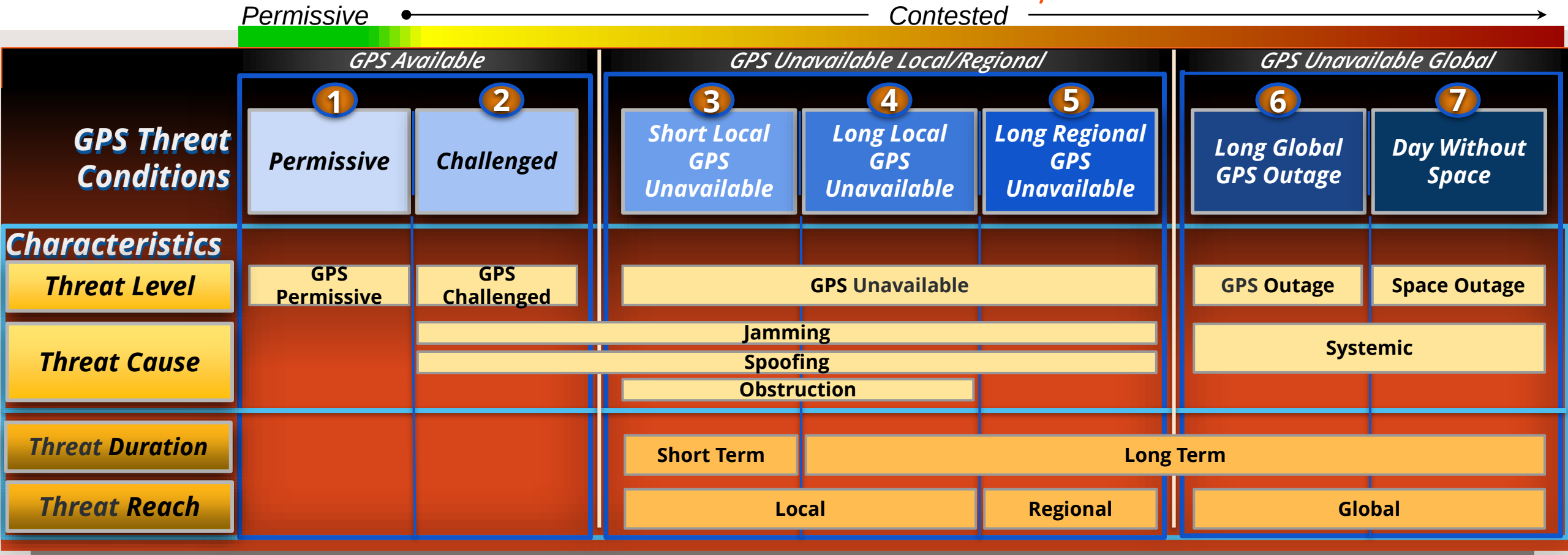
PNT Threat Environment - Common Model for Analysis



This is the basic threat model that we use for our PNT threat analysis. . .

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Non-Proprietary

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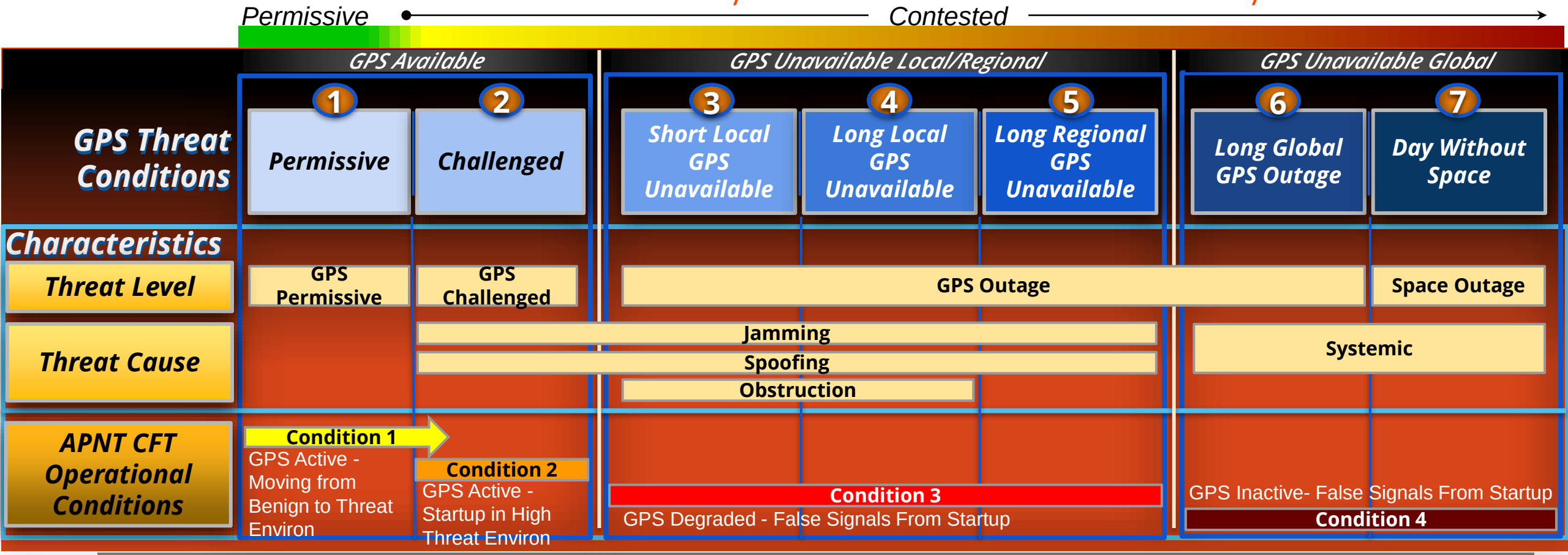
PNT Threat Environment – US Army PNT CFT Conditions Overlay



. . .with PNT CFT Threat Conditions overlayed: Column 3 thru 5 threats and 6/7 are combined in the Army model

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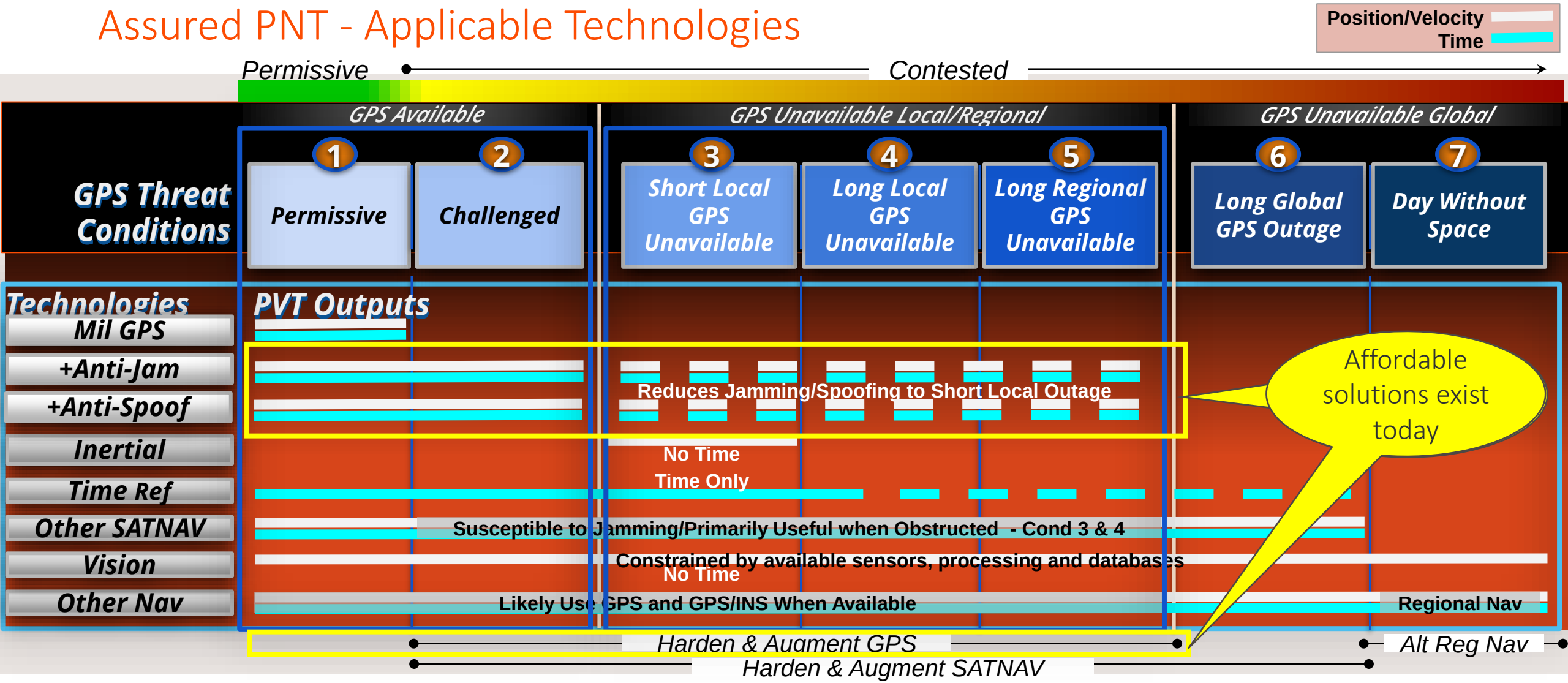
Assured PNT - Applicable Technologies



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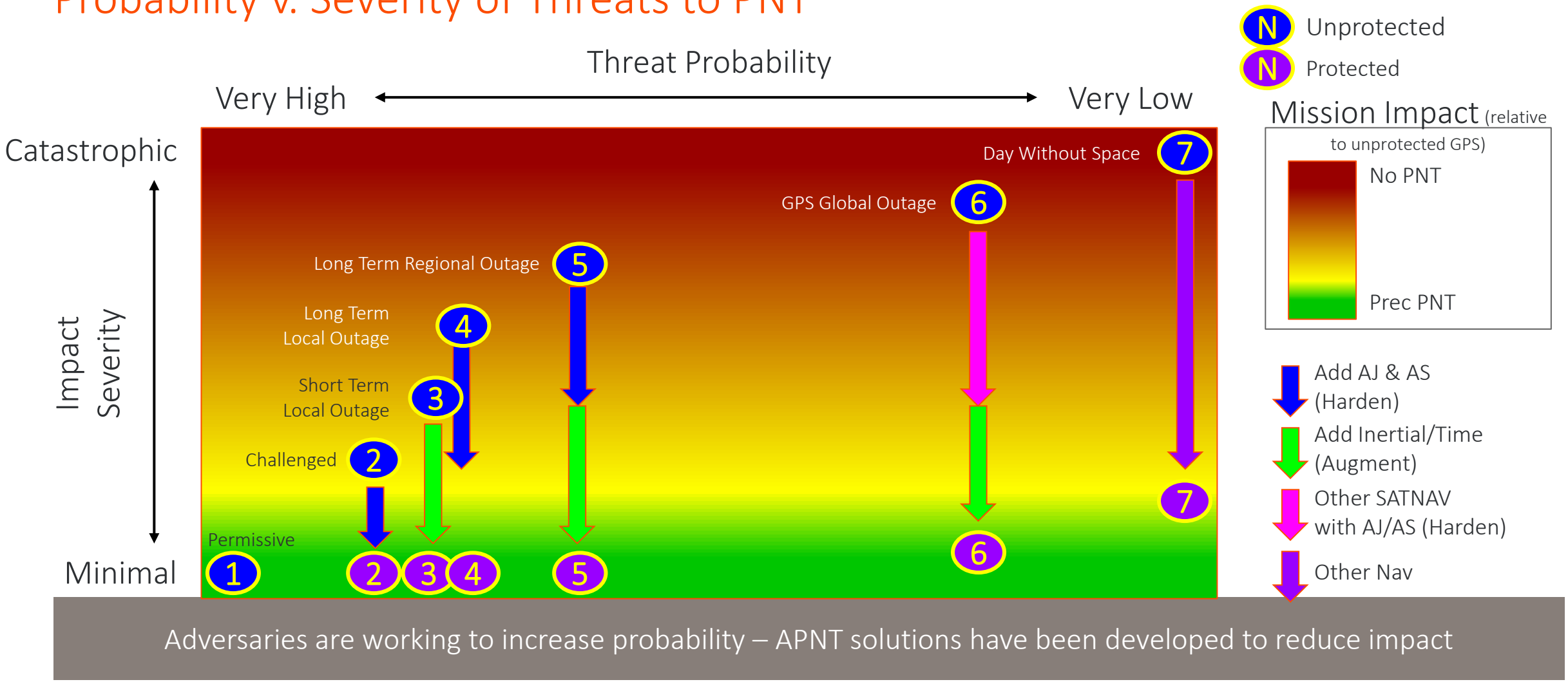
Probability v. Severity of Threats to PNT



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Available APNT Hardening Solutions

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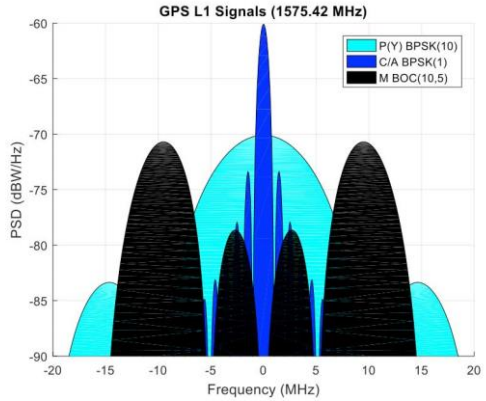
1. Modernized GPS with Military Code ("Toughen")

- Significantly enhanced crypto key handling
- Improved anti-spoofing (AS) over Selective Availability/Anti-Spoofing Module (SAASM) with Resilient Software Assurance Modification (RSAM)
- Improved cybersecurity
- Compatibility with Blue Force Electronic Attack (BFEA)
- System-level improvement in anti-jamming

→ M-Code Mandate



Modernized hardware with Military Code (M-Code) provides several improvements at the system level

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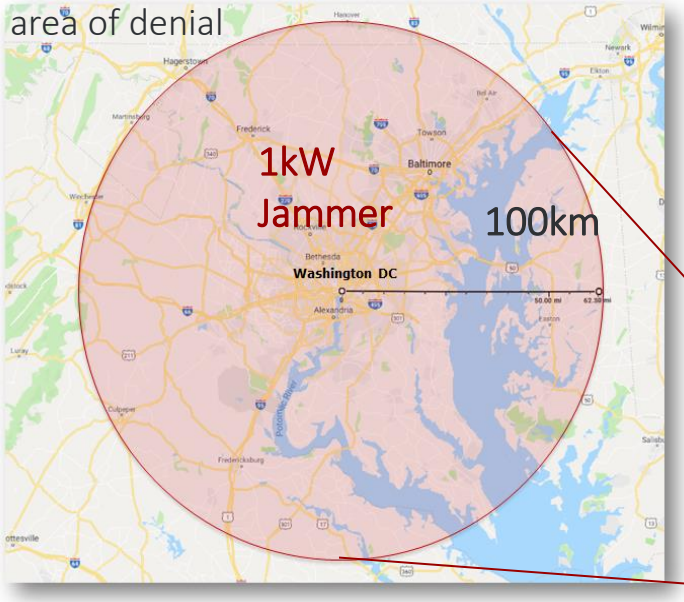
2. Digital Spatial Anti-Jamming Hardening ("Toughen")

Military GPS
area of denial



> +50dB J/S Improvement over M-Code alone

Maps are at same scale

99% Reduction in Jammer Range

Anti-Jam electronics greatly reduce the effective area of GPS jamming

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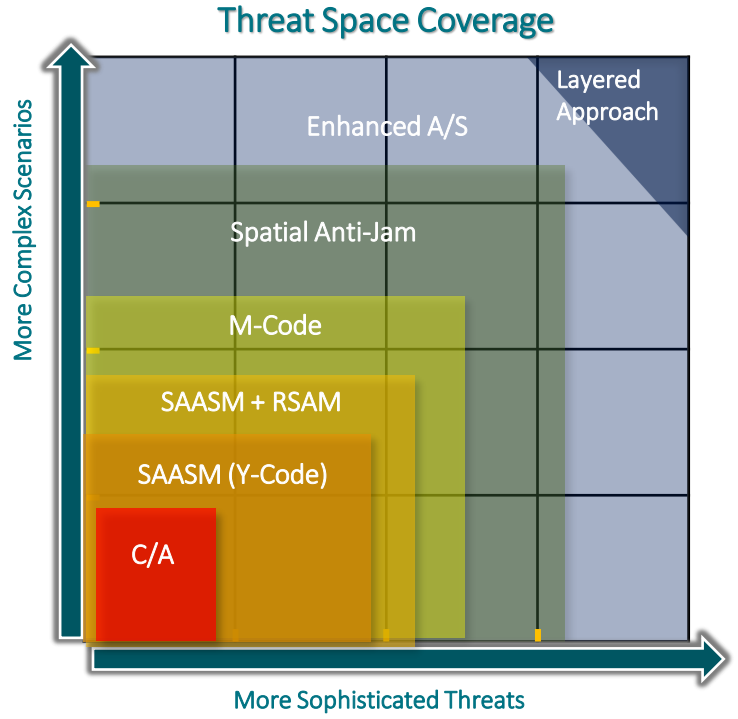
3. PNT Integrity (Anti-Spoofing) Technologies ("Toughen")

Enhanced anti-spoofing technologies – beyond those inherent in the M-Code signal – when layered on top of M-Code and digital anti-jamming technologies offers the most robust GNSS solution available

- BAE has anti-spoofing technologies beyond those created for RSAM and the Modernized GPS User Equipment (MGUE) Program of Record
- The specifics of these technologies quickly become classified and will not be further discussed here
- However, be aware that they are available, are being implemented, and have been validated by government testing



A layered approach – M-Code, digital anti-jamming & enhanced anti-spoofing provides highest level of integrity

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4. “Augment”

- Add inertial and/or high-stability clock (depending on application) to dead-reckon through local GPS outages
- Add other SATNAV sources to GPS receivers (e.g. Galileo, QZSS, AltNav etc.) as hedge against GPS system-level outage (see MGUE Increment 2 requirement)
- Add non-SATNAV augmentation (e.g. vision, celestial, parabolic, datalink navigation) as hedge against “Day Without Space” (DWoS)

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Summary

- Precision weapons are critical achieving the range and lethality required for mission success in the MDO/JADO battlespace
- PNT is essential to affordable precision weapons
- Solutions are available to maintain NAVWAR overmatch by toughening and augmenting GPS

- Contact Information
  - BAE Systems Weapons PNT Customer Requirements Manager – Justin Wymore
    - Justin.wymore@baesystems.com, (319) 317-5617

"Toughened", and in some cases, "Augmented" GPS is a critical to successful implementation of MDO / JADO

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Modernized GPS & Digital Anti-Jam Contributions to the Range and Lethality Challenge of MDO

Future Force Capabilities Conference
Unconventional Emerging Armaments
20 Sep 2022

Justin R. Wymore Sr., BAE Systems/NSS

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PM CCS
PROJECT MANAGER CLOSE COMBAT SYSTEMS

ON EVERY MISSION

Negating Explosive Hazards through the use of Explosive Ordnance Disposal (EOD) Guns, Ammunition, Rockets and Missiles (GARM) Unconventional and Emerging Armament Systems (UEA)

Future Force Capabilities Conference
20 September 2022

COL Russell Hoff
Project Manager, Close Combat Systems
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Michael Burke (Actg)
Product Director, Demolitions and Countermeasures
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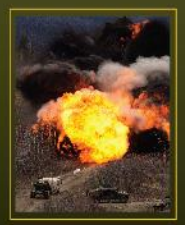

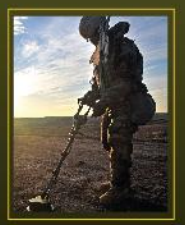

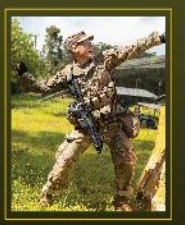

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(U) Team PM CCS

ON EVERY MISSION

- ***Manage 44% of the Army's conventional munition lethality***
- ***384 products: 316 Class V, 59 Class VII & 9 RDT&E***
- ***Average 60 Contracting Actions/Year***
- ***Oldest PMO in the US Army, 1961 "PM-Selected Ammunition"***

Mission

Provide dominant and innovative lethal and protective capabilities for the Joint Warfighter through acquisition excellence

Vision

Skilled innovative team, empowered to deliver dominating close combat capabilities

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(U) Team PM CCS

ON EVERY MISSION

Provide dominant and innovative lethal and protective capabilities for the Joint Warfighter through acquisition excellence

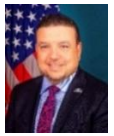
ON EVERY MISSION

Project Manager
COL Russell Hoff

Deputy PM
Joe Pelino

Business Division Manager
Anita Polesky

Chief, Product Support
Fred Willecke



Director, Program Integration & International Division
Michael O'Grady (Actg)

Manager, Technology Management Division
Rob Dressel (Actg)

Product Manager Terrain Shaping Obstacles

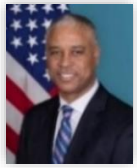
Product Manager
LTC Isaac Cuthbertson

Deputy PdM
Frank Altamura

Asst Product Manager(s)
MAJ Manuel Macias

Branch Chiefs
XM343 SAVO: Sean Stevens
TAC2: Eli Vainchenker

Product Director Combat Armaments & Protection Systems



Product Director
David Millette

Deputy PD
Don Palathinkal

Asst Product Manager
MAJ John Pfromm

G&PS Branch Chief
Tinesha Nicholas

Team Leads
Shoulder Launched: Aza Villar (Actg)
Grenades: Hugh MacMillan
Protection Systems: Derek DeReiter

Product Director Demolitions & Countermeasures

Product Director
Michael Burke (Actg)

Deputy PD
Stephen McFarlane (Actg)

Asst Product Manager
MAJ Thomas Fite

Branch Chiefs
Pyrotechnics: Harvard Yuen
Demolitions: Phillyp Lawson

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(U) PM CCS

ON EVERY MISSION

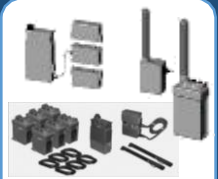
Sustainment | 0-5 Years FUE | 5+ Years FUE

Current Products

MICLIC

M67 Grenade

APOBS


RF RAMS

Acoustic Hailing Device

Simulators

VOLCANO

AT4-TW

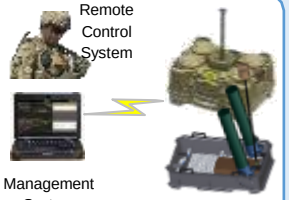
Countermeasure Flares

AN/PSS-14C

Product Concepts

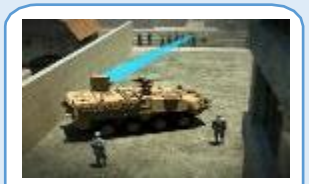
- **Program Manager Top S&T Priorities**
  - ✓Breaching
  - ✓Robotic Payloads
  - ✓Denial Technologies

Explosive Breacher



CTSO

Improved EOD Robotic Payloads


Solid State Active Denial Technologies

New Products

- Individual Assault Munitions
- Close Terrain Shaping Obstacles
- Explosive Detection

XM919 - IAM

M111 – Offensive Hand Grenade

XM343 Standoff Activated Volcano Obstacle

XM20/XM215

EOD Tool and Equipment Kit (ETEK)

X-Ray Imager, *COTS*

X-Ray Generator, *COTS*

Dismounted Operations Protection, *GOTS*

Trace Detection, *COTS*

Low Light Visual Augmentation System, *COTS*

Buried IED Detection, *COTS*

Render Safe Initiation, *COTS*

Gamma and Neutron Search and Detection, *COTS*

Power Management, *COTS*

Unmanned Aerial System (UAS), *COTS*

Localized Incident Site Protection, *Development*

XM204

Provide dominant and innovative lethal and protective capabilities for the Joint Warfighter through acquisition excellence

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(U) PD D&CM Demolitions / Breaching Portfolio

ON EVERY MISSION

LANE BREACHING

Explosive Breacher Concept

Neutralization Payload Delivery System

Detection System – UAS and Sensors

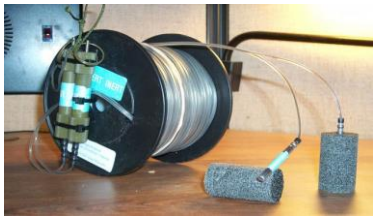
Neutralizer Warheads

DEMOLITION INITIATORS

Remote Activation System (RAMS)

M15 w/Shock Tube

M6 Electric Blasting Cap



Modernized Demo Initiators (MDI)

Time Delay- Sympathetic Detonator (TD-SYDET)

M700 Time Fuse

DEMOLITION DEVICES

CLAYMORE

Cratering Charge

M303 BDK

Shaped Charge

Detonation Cord

PLASTIC EXPLOSIVES

COMP C-4

Sheet Explosive

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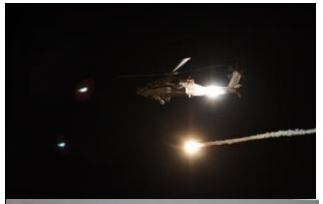
(U) PD D&CM Pyrotechnics Portfolio

ON EVERY MISSION

AVIATION AIRCRAFT EXPENDABLE COUNTERMEASURES



TRAINING SIMULATORS

M117

M119

M116A1

M115A2

SIGNALS

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(U) PD D&CM Explosive Ordnance Disposal Portfolio

ON EVERY MISSION

Small Caliber Dearmer (SCD) MK 38 MOD 0

Stand-Off Disrupter– Unexploded Ordnance Tool (SD-UXO) MK 40 MOD 0

Hook and Line Kit

Render Safe – Enhanced Robotic Payloads

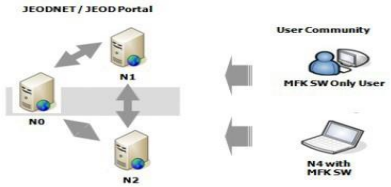
Highly Dexterous Manipulation System

Medium Directional Energy Tool (MDET)

Transmitter, Countermeasure (TCM): AN/PLT- 4

Smart Ray Vision (SRV)

Decision Support System (DSS)

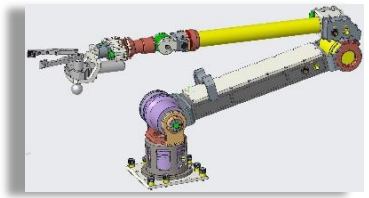


Multi-shot Disrupor

EOD Response Kit

Transmitter, Countermeasure (TCM): AN/PLT- 5

Stand-Off Disrupter IED Tool – PAN Disrupter



Precision Aim Module

Render Safe – Sets, Kits and Outfits

X-Ray Imager, COTS

Buried IED Detection, COTS

X-Ray Generator, COTS

Render Safe Initiation, COTS

Gamma and Neutron Search and Detection, COTS

Dismounted Operations Protection, GOTS

Power Management, COTS

Trace Detection, COTS

Low Light Visual Augmentation System, COTS

Localized Incident Site Protection, *Development*

Unmanned Aerial System (UAS), COTS

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Negating Explosive Hazards

through the use of

Explosive Ordnance Disposal (EOD)
Guns, Ammunition, Rockets and Missiles (GARM)
Unconventional and Emerging Armament Systems (UEA)

DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited. PAO#

(U) Explosive Ordnance Disposal (EOD)

ON EVERY MISSION

Seek

Smart Ray Vision (SRV)

Buried IED Detection,

X-Ray Generator,

X-Ray Imager,

Low Light Visual Augmentation System

Unmanned Aerial System (UAS)

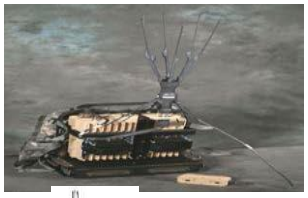
Trace Detection

Gamma and Neutron Search and Detection

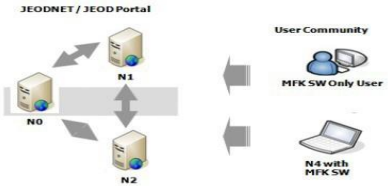
Enablers

Transmitter, Countermeasure (TCM): AN/PLT- 4

Transmitter, Countermeasure (TCM): AN/PLT- 5



Decision Support System (DSS)



Localized Incident Site Protection

Dismounted Operations Protection

Power Management

MOS 89D Army Explosive Ordnance Disposal (EOD) Specialist

Negate

Small Caliber Dearmer (SCD) MK 38 MOD 0

Stand-Off Disrupter– Unexploded Ordnance Tool (SD-UXO) MK 40 MOD 0

Hook and Line Kit

Render Safe – Enhanced Robotic Payloads

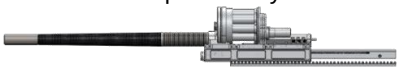
Medium Directional Energy Tool (MDET)

Render Safe Initiation

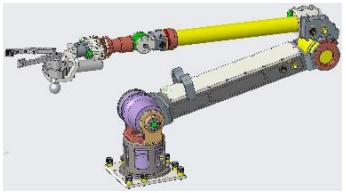
EOD Response Kit

Stand-Off Disrupter IED Tool – PAN Disrupter

Highly Dexterous Manipulation System



Multi-shot Disruptor



Precision Aim Module

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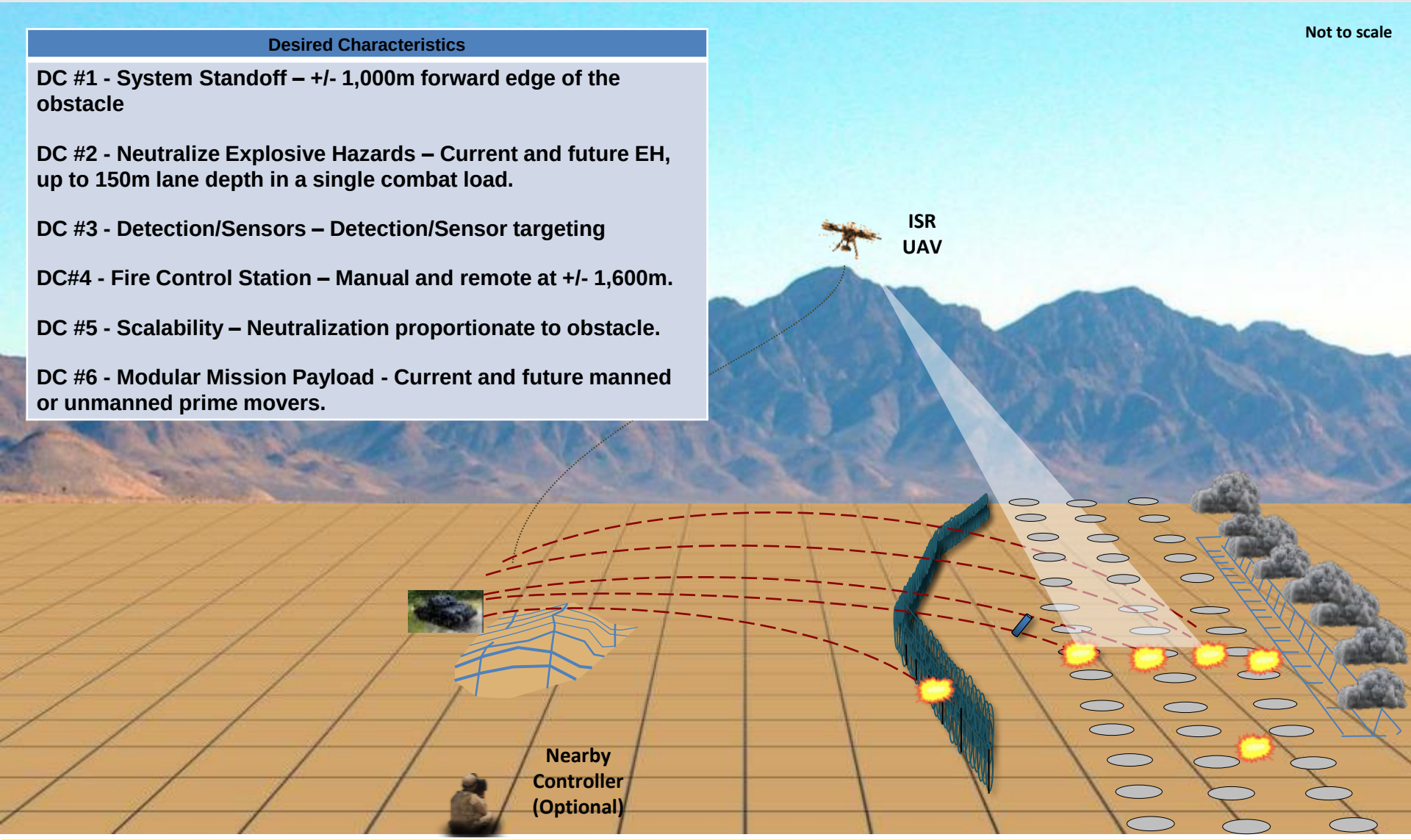
(U) Next Generation Breaching Technologies

ON EVERY MISSION

Desired Characteristics
DC #1 - System Standoff – +/- 1,000m forward edge of the obstacle
DC #2 - Neutralize Explosive Hazards – Current and future EH, up to 150m lane depth in a single combat load.
DC #3 - Detection/Sensors – Detection/Sensor targeting
DC#4 - Fire Control Station – Manual and remote at +/- 1,600m.
DC #5 - Scalability – Neutralization proportionate to obstacle.
DC #6 - Modular Mission Payload - Current and future manned or unmanned prime movers.

Not to scale



Removes Soldiers from the breach. Increases survivability, force protection, and overall mobility.

(U) TMRR Concept Demonstration Hardware

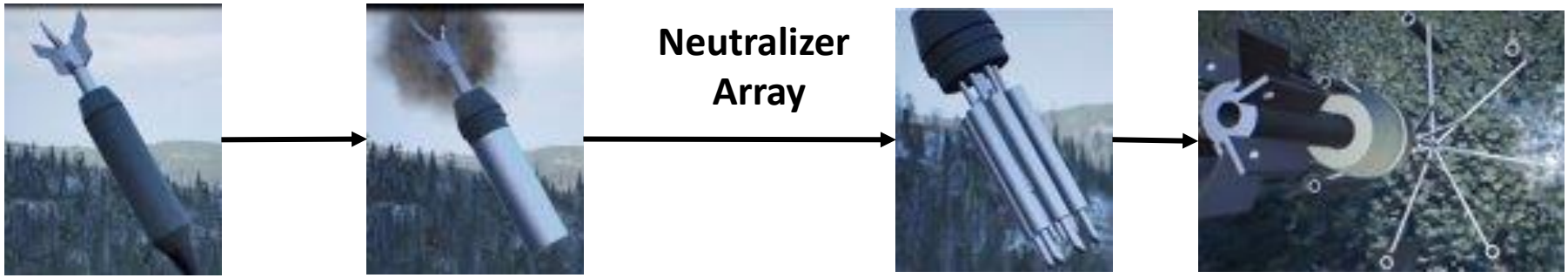
ON EVERY MISSION

Detection

- Developed by DEVCOM C5ISR & Ft. Belvoir
- Supporting multiple customers including NGCV CFT (Project Convergence)
- FLIR SkyRaider R80D UAS
- Purpose-built electro-optical sensor with on-board processing, data storage, and optional laser designator / range-finder capabilities

Launcher

- Automated Direct/Indirect Mortar (ADIM) developed and demonstrated under S&T effort by DEVCOM AC in 2011-2014
- Fires 81mm Mortar munitions
- Modular (currently integrated onto a HMMWV)
- Recoil mitigation, on-board fire control with weapon auto-laying, and 20-round autoloader



- Explosive Penetrator developed by DEVCOM AC and transitioned to Explosive Breacher Program of Record
- Packaging of penetrator array into 81mm form factor will be completed during TMRR
- Designed for compliance with Cluster Munition Policy
- Will investigate potential need for guidance (i.e. laser, GPS) during TMRR

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(U) Next Generation Breaching Technologies

ON EVERY MISSION

Seek

- UAS
- Manual & Automated control
- Multi-Spectrum Sensor Technologies
- Signal Processing Algorithms
- Small, light & energy efficient electronics

Enablers

- Secure Communications
- Precision Navigation & Timing (PNT)

MOS 12B Army Combat Engineer

Negate

- Stand-off Armament System
- Accurate Delivered Munition
- Neutralizer Payloads
- Multi-Fuze Conditions
- Directed Energy

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Open Request to Industry and Other Government Agencies: What technologies can you provide?

NGBT Industry Day
Parsippany, NJ

18 Oct 2022

TMRR: FY22-24
EMD: 1QFY25

Solicitation notice:
https://sam.gov/opp/2769714a85194fd094f9793c84991b86

Contract Opportunity:
Next Generation Breaching Technology – Explosive Breacher (NGBT-EB)
Notice ID: W15QKN-22-Z-0QSP

Michael Burke
(Actg) Product Director, Demolitions and Countermeasures
PM CCS
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Amit Makhijani
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PM CCS, PD D&CM
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USD(R&E)

Rapid Defense Experimentation Reserve (RDER)

Overview

Prototypes & Experiments
Office of the Under Secretary of Defense for Research & Engineering

Washington, DC
18 July 2022

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What is RDER?

Pronounced “Raider,” it’s an initiative that will facilitate more rapid modernization by focusing prototyping and experimentation efforts on multi-Component missions.

“RDER will drive efforts to compete with peer and near-peer adversaries through the development of capabilities that support the Joint Warfighting Concept (JWC) including, but not limited to, fires, command and control, logistics, and capabilities that will drive information advantage.” – Deputy Secretary of Defense Dr. Kathleen Hicks

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How does RDER work?

The Secretary of Defense has created a budget reserve for allocation in the FY 2023 President's Budget request to expand multi-Component experimentation in a structured, multi-year campaign of learning.

The Secretary selects among proposed experiments based on alignment to Joint missions and potential to yield demonstrable warfighting utility.

Demonstrations and experiments will be conducted at key exercise venues.

Successful demonstrations and experiments will be quickly transitioned to the Components for fielding as new systems or approaches.

Lifecycle costs will be considered for any RDER initiative that has the potential to result in a new capability.

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What will RDER do for the DOD?

RDER will bring three benefits to the DOD:

- It will enable the Department to bring new capabilities to the Joint Force, transitioning systems and approaches more quickly.
- It will better align current experimentation efforts to the Joint Warfighting Concept (JWC).
- It will leverage end-to-end mission analysis and experimentation to capitalize quickly on innovative ideas.

RDER results inform the JWC, Joint Requirements, and the Department's Senior Leaders to enable rapid modernization

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How to participate in RDER

RDER's initial projects in Fiscal Year 2023 (FY23) are already selected and under coordination for funding.

RDER will soon issue a call for proposals for FY24 projects from the Military Services, Combatant Commands, other DOD and U.S. Government entities, Coalition partners, academia, and industry. RDER will screen these proposals and select those most highly aligned for multi-Component experimentation for DOD senior leader approval.

For more information:

- Visit the RDER website (requires a CAC): https://www.dodtechipedia.mil/dodwiki/x/oQYzLg
- Send an email to the RDER Program Office group account: osd.pentagon.ousd-r-e.mbx.joint-experimentation-proposal-submiss@mail.mil

Distribution Statement A. Approved for public release. Distribution is unlimited.

Variable Trajectory - Fixed Launcher Grenade Technology:

For Armored Vehicles, Remote Turrets And Ground Robotics

By:

Howard D. Kent, ADG, LLC

&

Vincent Battaglia, Accurate Mag/BML Tool, Inc.

B.M.L. Tool & Manufacturing Corp. TOOLS-DIES-AUTOMATION 67 Enterprise Dr. Monroe, Connecticut

www.Accurate-Mag.com

NOTE: Unclassified, Approved For Public Release

Contents:

3. Introduction
5. Problem: Actually ***Aiming*** Munitions From Fixed Launchers
7. Most Vehicles Already Have Defensive Smoke Launchers
9. A Variable Velocity / Multiple Trajectory Technology
12. Integrated Variable Velocity Cartridge Or Booster
13. Potential Applications; Frag vs. Smoke, Ground Robotics
16. Conclusions
20. Recommendations
21. Credits

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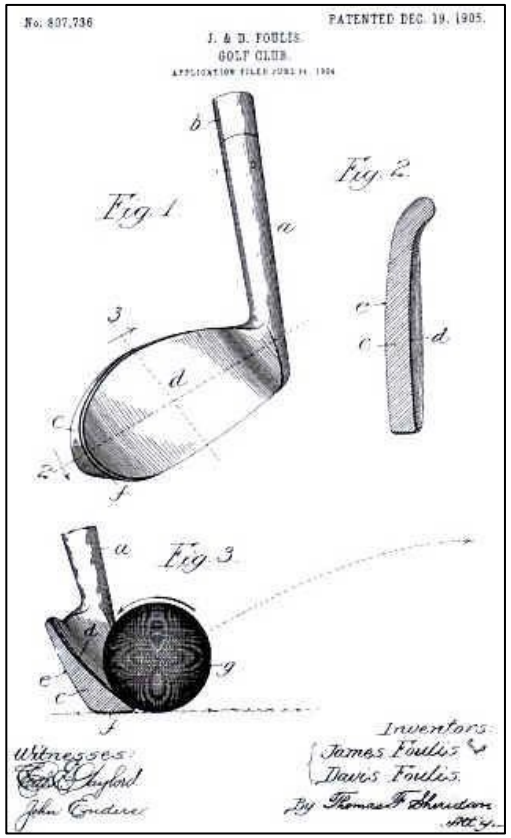
Introduction:



USPTO Mashie Niblick Golf Club

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Introduction:

Why Do Golfers Carry All These Different Clubs And More? T*he Original 40mm Was Called The "Niblick" Or "Pitching Wedge" From Golf…*

To Make Different Shots? To Hit At Different Speeds And Angles?

Might We Want To Make Different Grenade Shots, Except All With The Same Round?

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NOTE: Unclassified, Approved For Public Release

Introduction:

"There Are Thousands Of Available Offensive Multiple Grenade Launch Tubes On The Battlefield Already…Mounted To Armored Vehicles, Remote Turrets And Ground Robots"

- The Theory Pursued Is Utilization Of Existing Launchers For New Applications.
- The Focus Is On 66mm Vehicle Mounted Defensive Smoke Launching Systems.
- Proposed Are Adjustable, Variable Trajectories For Grenades To Allow Fixed Angle Launchers To Fire At Multiple Distances To Enable Target Coverage.
- New Lethal And Less Lethal Payloads Would Be Possible Including Airburst Fragmentation Grenades, Riot Agents, Flash Bang Less Lethal, Marking…

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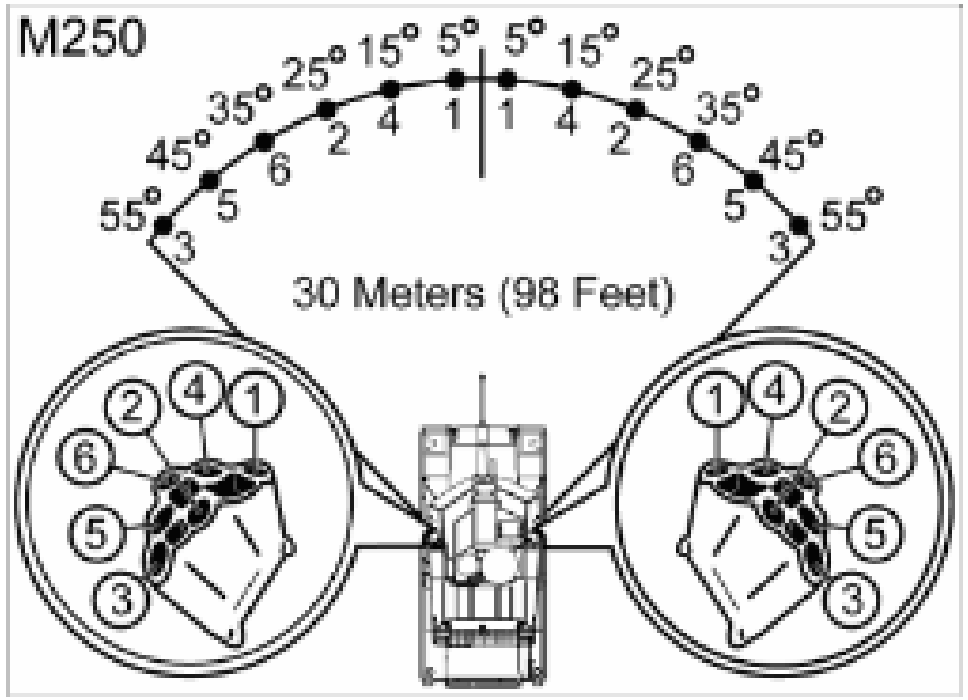
NOTE: Unclassified, Approved For Public Release

Problem: Actually ***Aiming*** Munitions From Fixed Launchers



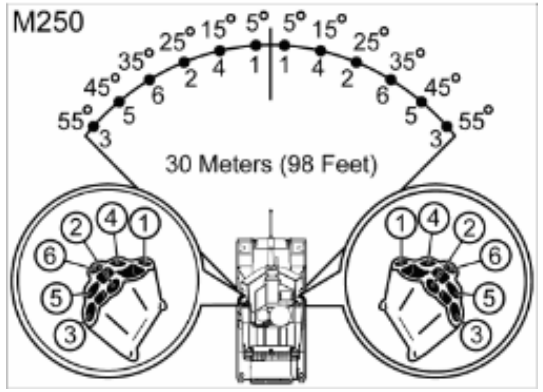
US DoD Via Sciendo.com Obscurant Dischargers

NOTE: Unclassified, Approved For Public Release

Problem: Actually ***Aiming*** Munitions From Fixed Launchers

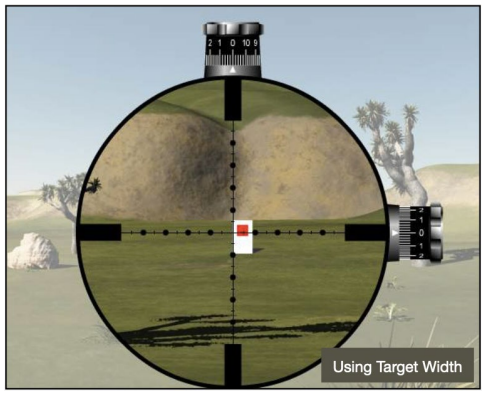
Many Systems Can Launch To Specific Angles…What They Need Now Is Variable Distance To Cover Any Target Within The Maximum Range:

Bearing → Range → Fire!



US DoD Via Sciendo.com Obscurant Dischargers

+



Dark Earth Tactical Graphic

=

Firing Solution:
Fire Right Hand Tubes
1 & 4 With Ranged
Fragmentation Grenade

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Most Vehicles Already Have Defensive Smoke Launchers:

US Army JPEO Abrams Photo

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Most Vehicles Have Defensive Launchers:

Variable Range Projectiles Offer Defense ***AND*** Offensive Action With Different Payloads…

Clockwise From Upper Left: US DoD Via Sciendo.com Obscurant Dischargers, Defense-Industries.com 66mm, Russian T90s, US Army Photo, GES Launcher Modules, GES Installation, Wegmann 66mm Launchers.

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Most Vehicles Have Defensive Launchers:

Remote Turrets Are Also Frequently Equipped With Multi-Tube Launchers…

Clockwise From Upper Left: US ROWS, EOS Model 400,KMW RWS, Russian RWS, Belgian RWS, German RWS From Eurosatory 2022.

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NOTE: Unclassified, Approved For Public Release

Most Vehicles Have Defensive Launchers:

Several Forms Of Suitable Vehicle Mounted Non-Lethal Launchers:

From Left to Right: Demonstratable 66MM VENOM® MC Launcher and Smoke Munition Left, 40MM VENOM® Launching AWM from Kongsberg RWS at Crane NSWC 2012, VENOM® V-10 Tube Launcher Displayed on IRobot UGV Modern Day Marine 2010.

CSI VENOM MC, Multi-Caliber Less Lethal Launcher & Munitions

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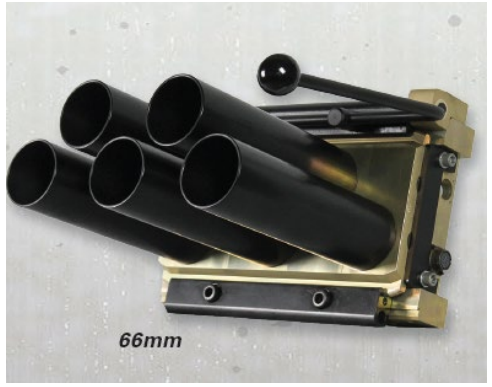
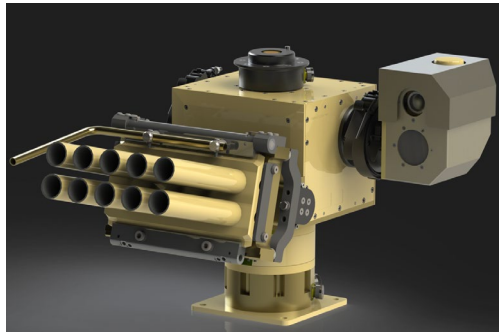
www.Accurate-Mag.com

NOTE: Unclassified, Approved For Public Release

VENOM® MC, Multi-Caliber Interface System Concept:



VENOM MC



Operational

- Deploy Remotely or Direct Tethered Fire
- Interchangeable from Vehicles, ROWS, UGVs, Static Installations
- Supports Escalation of Force, Determination of Intent, Crowd Dispersal, Area Denial, and Obscuration Objectives
- Capable of Delivering Non-Lethal AWM, Smoke, Irritant, & Blunt Trauma Effects

Technical

- Electronically Primed Munitions
- Fire Control with Master Arm and Ready Trigger, also IP Addressable
- Area Impact & Aerial Burst Payloads
- Variable Range, Dependent on Munition
- Unloaded Weight 27 lbs.
- Dimensions: Width 15.9” Depth 17.7”
- Internal Power 9V Battery, Auxiliary Power Options
- Operating Temps -25° to +175° F
- Shock Resistance 1000 Shocks @ 200g Force

B.M.L. Tool & Manufacturing Corp. TOOLS-DIES-AUTOMATION 67 Enterprise Dr. Monroe, Connecticut

www.Accurate-Mag.com

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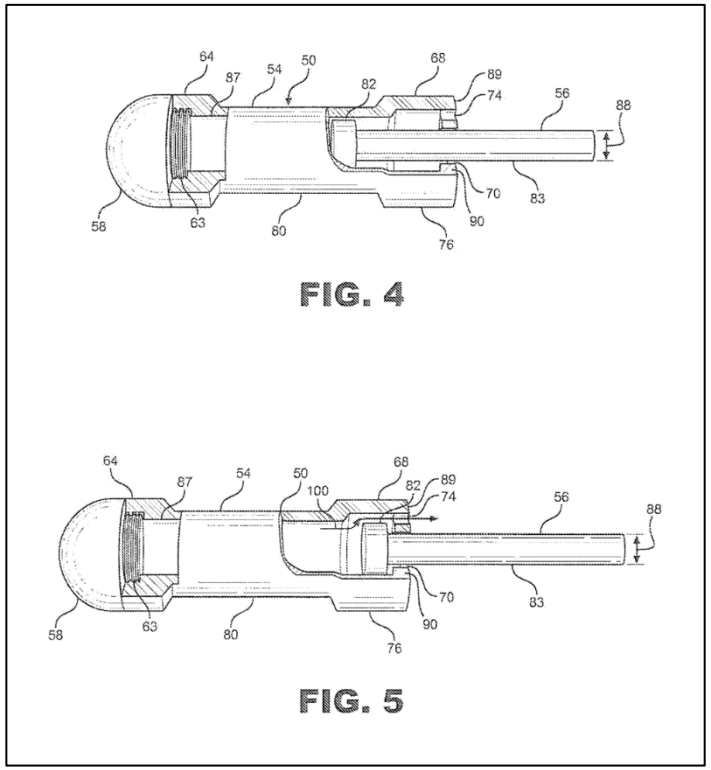
A Variable Velocity / Multiple Trajectory Technology:



USPTO Dr. Jeffery Widder, Battelle

NOTE: Unclassified, Approved For Public Release

A Variable Velocity / Multiple Trajectory Technology:

An Electrically Fired, Internal Charge Pedestal Launching System For Projectiles…

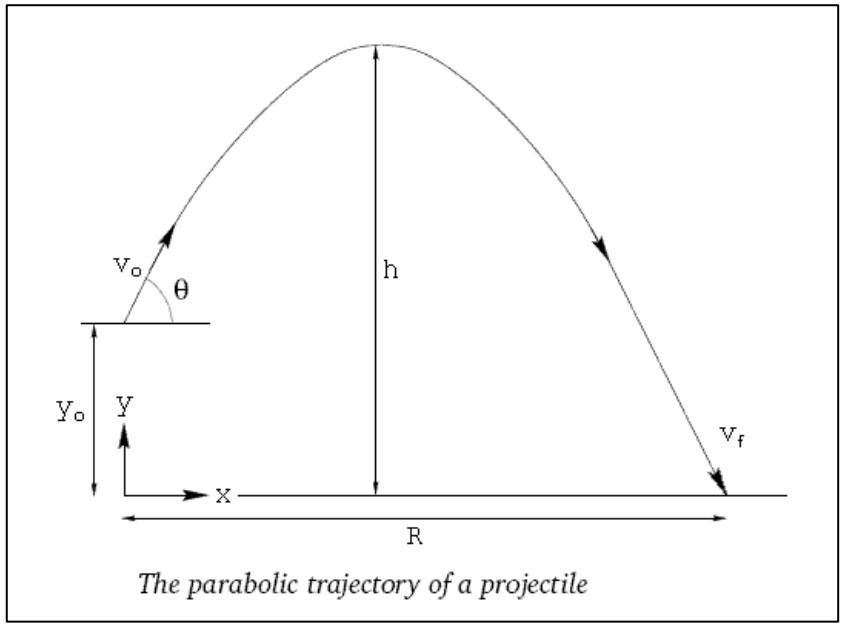
"Scalable From 0.50 Caliber Less Lethal To Two Pound 66mm Canister Grenades"

Clockwise From Upper Left: Wired Pogo-Jet Illustration, Battelle Fired CTNLS Round, Battelle Rifle Mounting, CAA Roni Pistol Conversion, Battelle Pistol-Roni Overlay, Lancer Stick Magazine, Pro-Mag Drum Magazine.

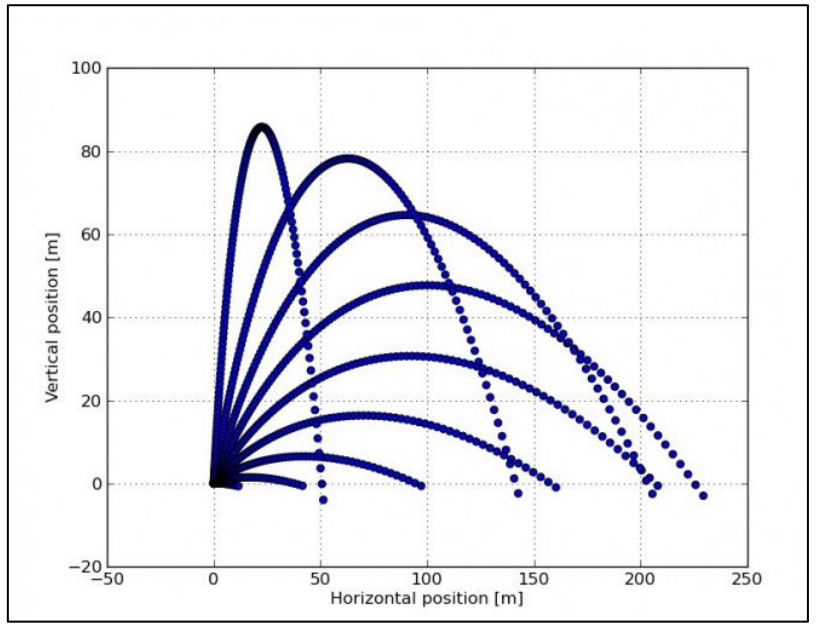
NOTE: Unclassified, Approved For Public Release

A Variable Velocity / Multiple Trajectory Technology:

What We Have: One Velocity / High Trajectories vs. Range:



The parabolic trajectory of a projectile



When You Launch At One Velocity, You Must Change Angle To Vary Range

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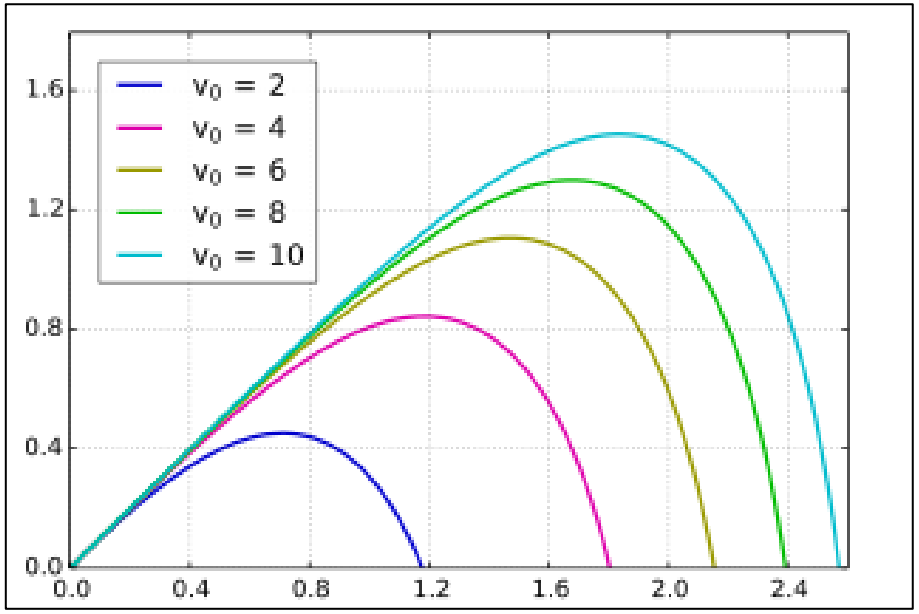
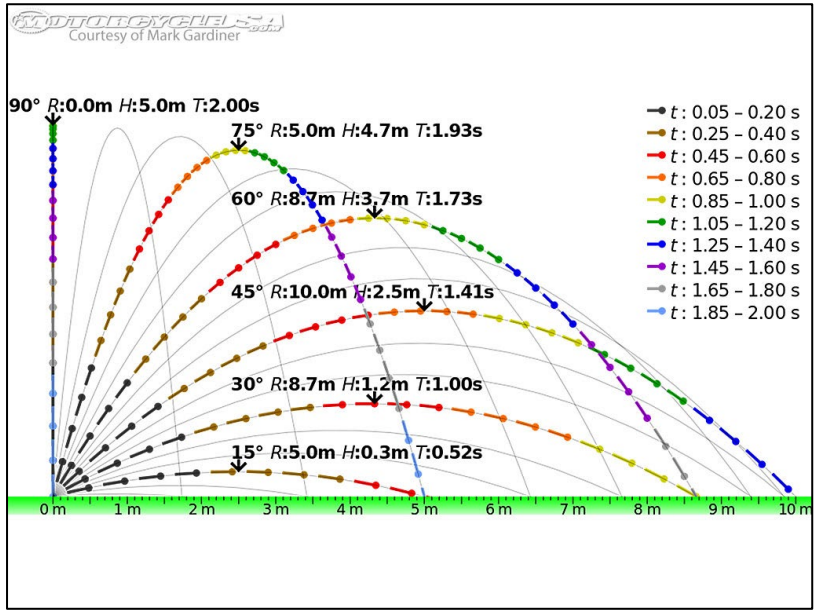
A Variable Velocity / Multiple Trajectory Technology:

What We Can Have: Multiple Velocities / Variable Trajectories:





When You Launch At Many Velocities, You Don't Have To Change Angle To Vary Range

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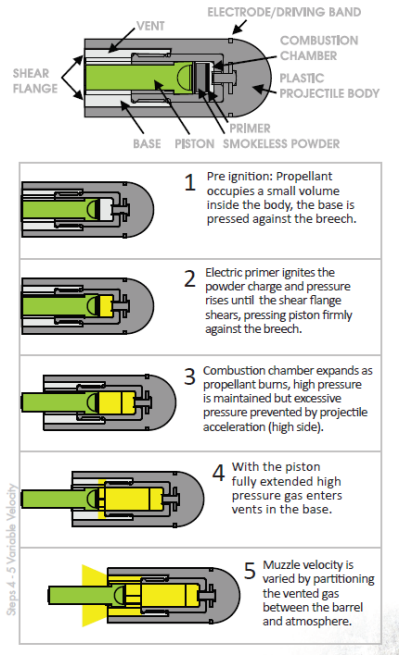
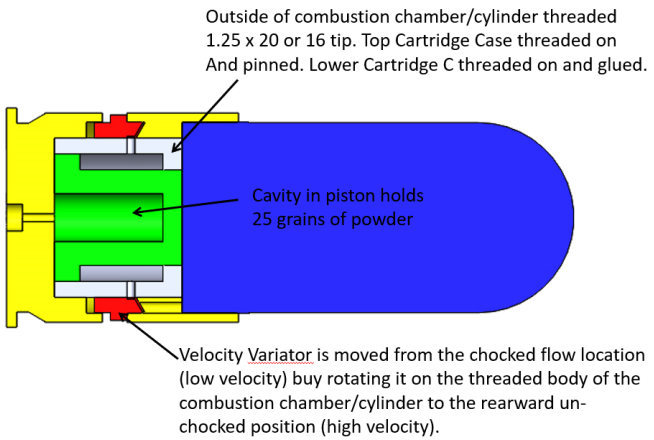
A Variable Velocity / Multiple Trajectory Technology:

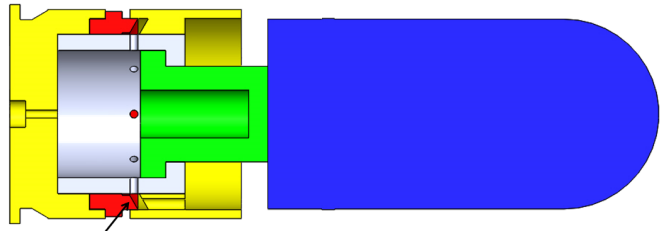
What We Can Have: Multiple Velocities / Variable Trajectories:





The Greater The Force The Piston May Use To Boost The Payload…The Longer The Range Of The Projectiles.

In The Less Lethal Variant The Breech Face Is Moved Forward And Backward From Impacting The Piston…In The Grenade The Range Is Set By Detent Rotation



Featuring: The **BML Tool *Variable Velocity Grenade Concept***

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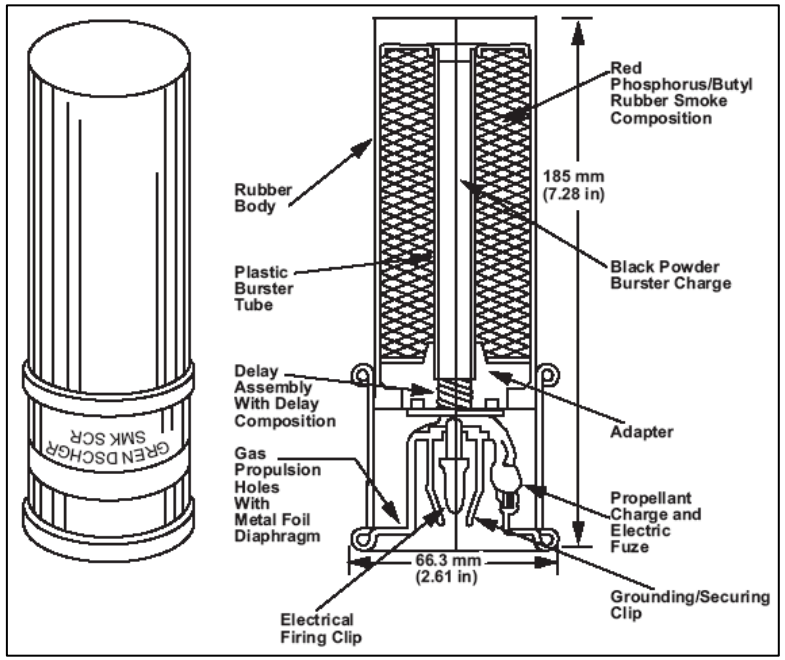
Integrated Variable Velocity Cartridge Or Booster:

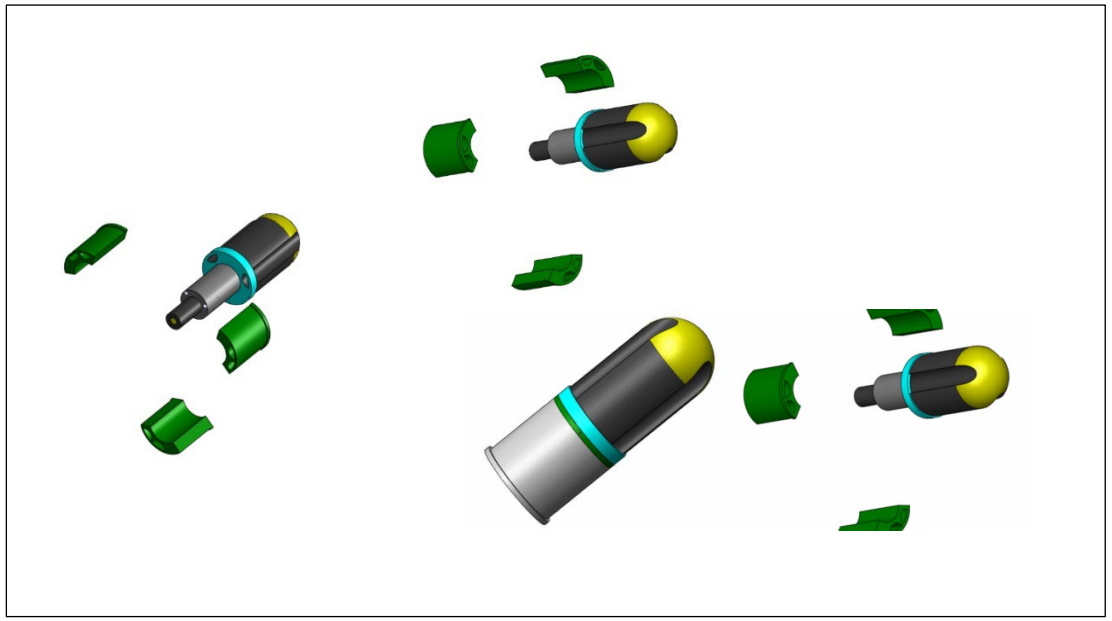


US DoD Via Sciendo.com Smoke Discharger Cartridge

NOTE: Unclassified, Approved For Public Release

Integrated Variable Velocity Cartridge Or Booster:

What We Can Have: Multiple Velocities / Variable Trajectories:



- Grenade Body Twists To Range Detent Positions.
- Identical Loading And Firing Procedure As Smoke Round.
- Booster Is Cartridge Without Grenade Body To Launch Existing 66mm Payloads.

The Concept Is Identical 66mm Cartridges that Adjust For Multiple Ranges…

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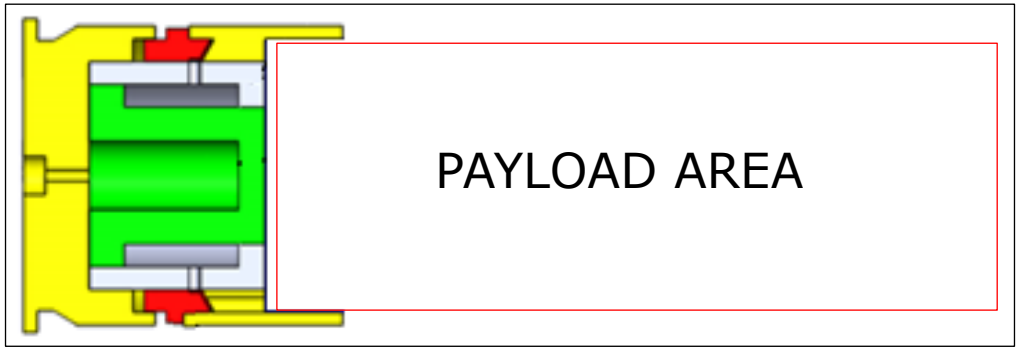
Integrated Variable Velocity Cartridge Or Booster:

Booster Assembly For 66mm Provides A Huge Area For Multiple Payloads…



Booster Assembly May Be Packaged As A Completed Round Or A Separate Body For Use With Fragmentation, Smoke, Riot Agent, Drone, Surveillance Or Any Other Type Of Munition, Device, Etc. That Will Fit Within The Payload Area.

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Potential Applications; Vehicles, Remote Turrets And Ground Robotics

1. Provide An Additional Offensive Capability To Vehicles With Existing Launchers.

2. Provide Small Robots And Remote Turrets With Aimable Weapon And Payload Capability For Non-Trainable Fixed Base Defensive Smoke Launchers.

3. Make Economical Fixed Site Land And Marine Based Launchers For Lethal Or Less Lethal Applications Utilizing Multiple Range / Velocity Capability.

Army Recognition Abrams Raphael Trophy, Textron Ripsaw M5, AP Somali Pirates, Times Of London US Embassy Cairo Egypt

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Conclusions:

- The Variable Velocity Grenade Concept Can Greatly Augment The Offensive Firepower Of Large And Small Vehicles, Using Payloads Boosted From Their 66mm Launchers.
- Similarly, Ground Robotic Vehicles And Fixed Sites May Use Existing 66mm Launchers Which May be Aimed Via The Angle And Bearing Of Their Tubes Plus Variable Velocity.
- As Technology Advances Which Erodes The Protection Of Smoke Launchers, They May Be Used To Deploy Offensive Weapons, Drones, Surveillance Electronics, Etc.

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Recommendations:

- Develop The Variable Velocity Grenade And Booster Technology For General Use In 40mm And 66mm Diameters.
- Initiate Programs For Weapons, Electronics And Drones Compatible With 66mm Smoke Launch Cartridge Tubes For Boosting Downrange.
- Find Additional Applications For The Tens Of Thousands Of Existing Smoke Launcher Systems To Add Combat Power To Previously Defensive Usage.

US Army Sierra Depot

NOTE: Unclassified, Approved For Public Release

Credits:

POC: Howard D. Kent, CEO, ADG LLC, Phone: 818-314-8636, e-Mail: HKent@Peak.org

---

POC: Vincent Battaglia, CEO, Accurate Mag/BML Tool Corporation, Phone: 203-880-9485
URL: www.accurate-mag.com

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Credits:

With Special Thanks To:

COMBINED SYSTEMS

POC: Paul Ford, VP Sales & Marketing, **Combined Systems, Inc.** (***CSI)***
Phone: 512-584-3710, e-Mail: PaulFord@CombinedSystems.com

Designers And Manufacturers Of Less Lethal Systems
Used Around The World…

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NOTE: Unclassified, Approved For Public Release

Air Force Civil Engineer Robotic Applications

Steve Bailey, GS-13, DAF

Research Engineer

Air Force Civil Engineer Center

Requirements, R&D, and Acquisition Division

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Overview

- Airbase Acquisition Branch (CXAE)
- Airfield Damage Repair (ADR) Processes
- Robotics and Unmanned Systems
- Small Unmanned Aerial Systems
- Robotics and Autonomous Systems Roadmap
- Takeaways
- Questions

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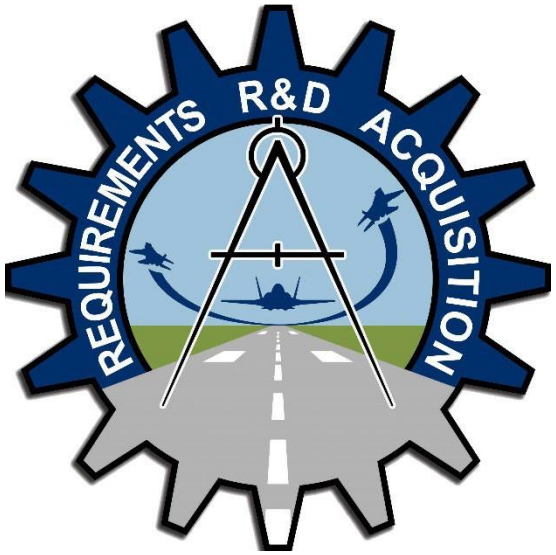
Airbase Technologies Branch

Acquisition: develop, evaluate, and field technology

- Develop (RDT&E) and field new technology/prototypes
- Provide CE unique test & evaluation facilities/ranges
- Evaluate commercially available technology/equipment (COTS)
- Modify existing equipment
- Procure and sustain material solutions
- Provide expert technical advice and reach back support
- Focused on 6 primary technical areas that encompass the entire scope of airbase technology needs



"Air bases are a determining factor in the success of air operations. The two-legged stool of men and planes would topple over without this equally important third leg." General of the Air Force Henry H. *"Hap"* Arnold

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AFCEC/CXAE Capability Areas

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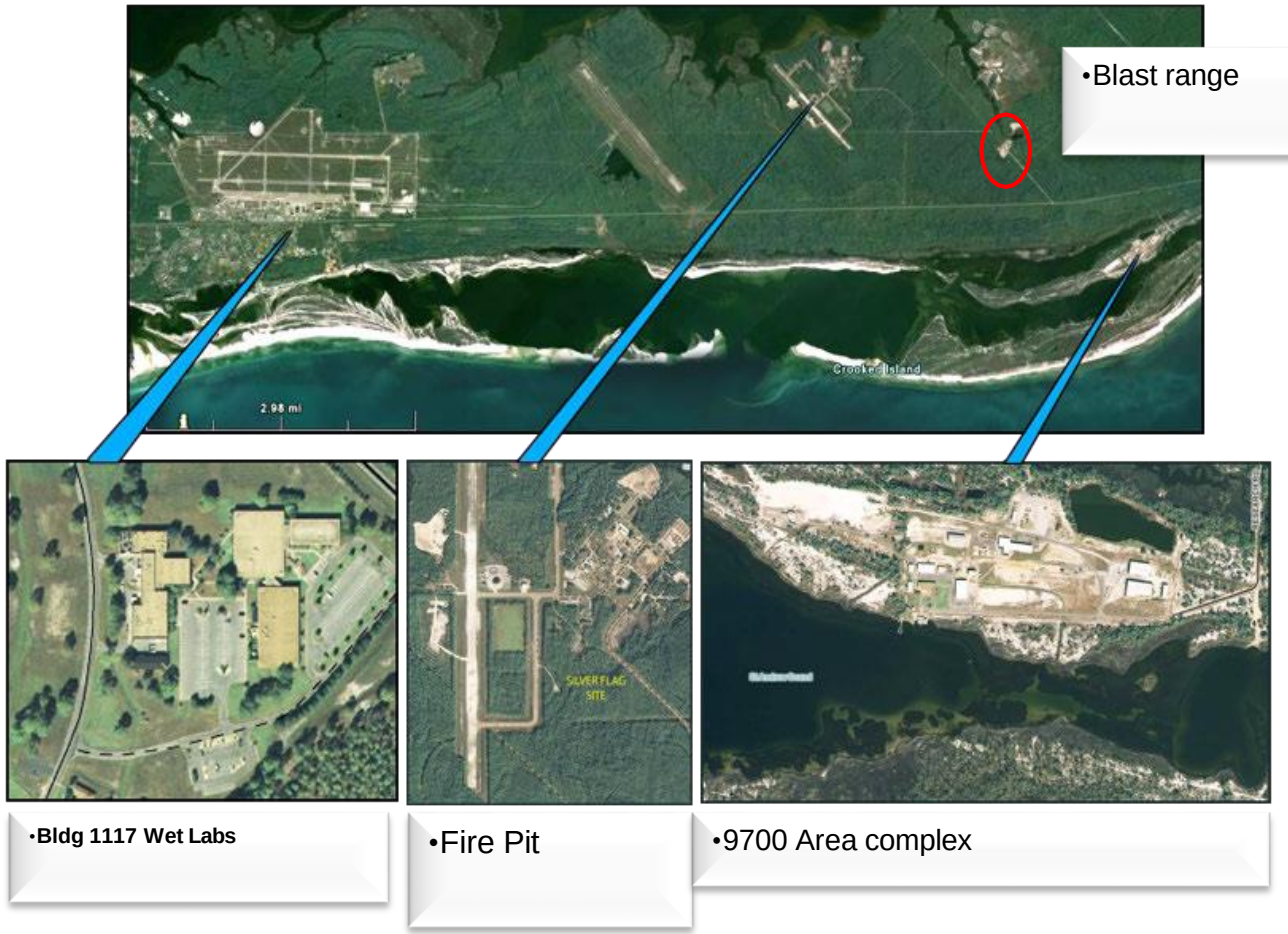
Facilities Overview

- 4 compounds, 20 facilities, 143 acres of T&E ranges
- 250,000+ sq ft of laboratories and industrial facilities
- 100+ RDT&E vehicles
- $25M+/- equipment
- 12 miles between facilities
- Defense Research & Engineering Network
- Silver Flag Exercise Site
- SUAS Operations - Restricted airspace
- Amphibious—open water access



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Airfield Damage Repair (ADR) Processes

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Robotics & Unmanned Systems

Unmanned systems & technologies to support the full range of CE Missions

- Agile Combat Support
- Airfield Damage Repair & UXO Response
- EOD Robotics & Technologies
- Fire & Emergency Services
- Robotics for Airbase Operations & Support

Remote Mass Mechanical Clearance

Drive By Wire Applique

Load Cart

Tele-operated Genie Telehandler

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Explosive Ordnance Disposal Robotics

Modified NIST evaluations for AF requirements

Small EOD robot selection completed 2015

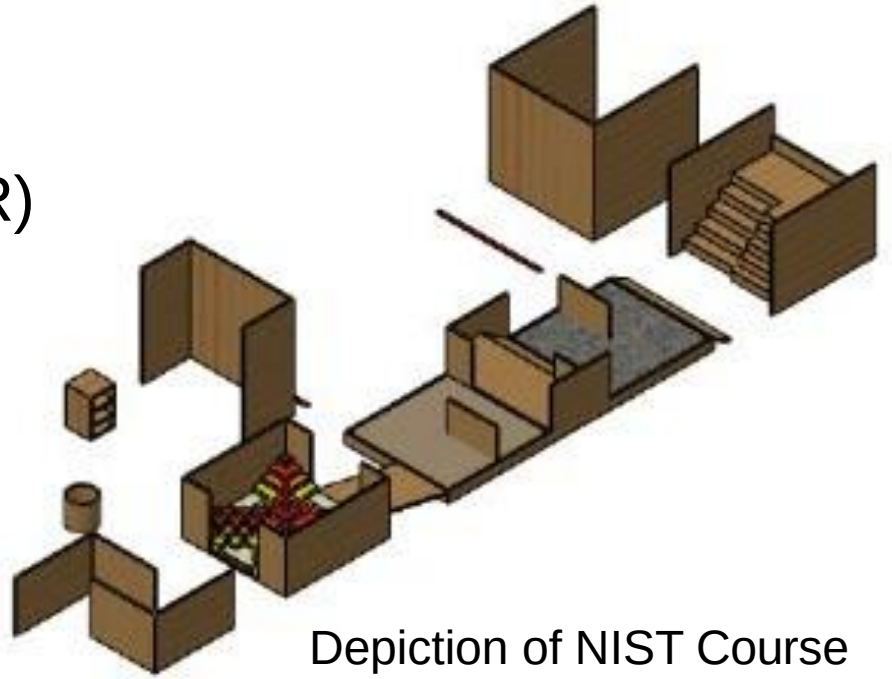
- Selected the Micro Tactical Ground Robot (MTGR)

Base support EOD robot selection completed 2021

- Selected L3Harris T7 Robotic System

L3Harris T7

MTGR



Depiction of NIST Course

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Unmanned Ground Systems

Tele-operated and semi-autonomous ground systems to perform Civil Engineer Operations: EOD, airfield repair, firefighting, emergency management

- **Test, evaluate and integrate appliques for USAF platforms**

In-Seat (RADR-T)

In-Seat (RADR-A)

Drive by wire (OTONOS)

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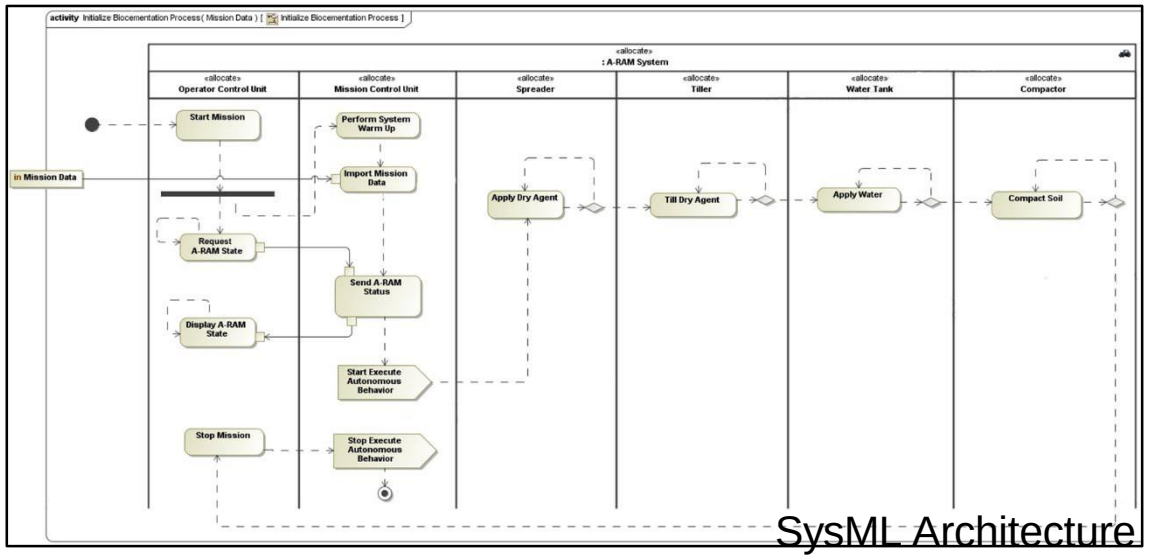
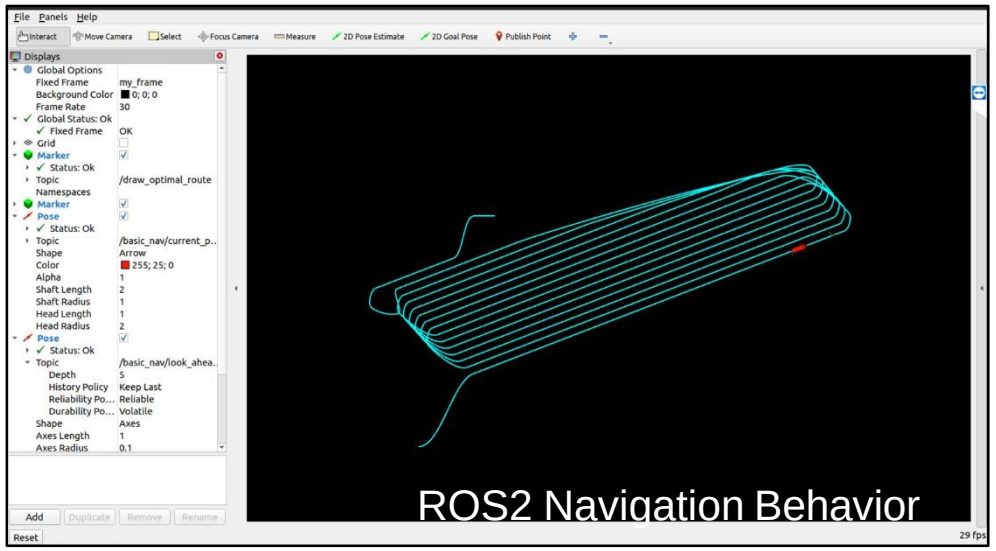
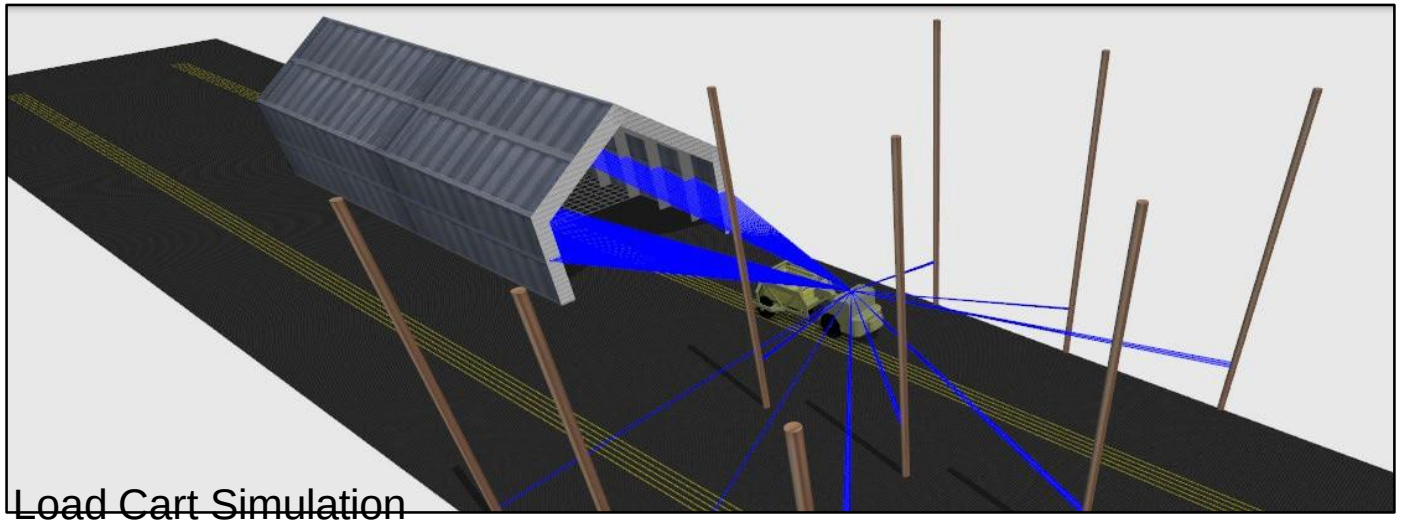
Digital Engineering & Autonomy

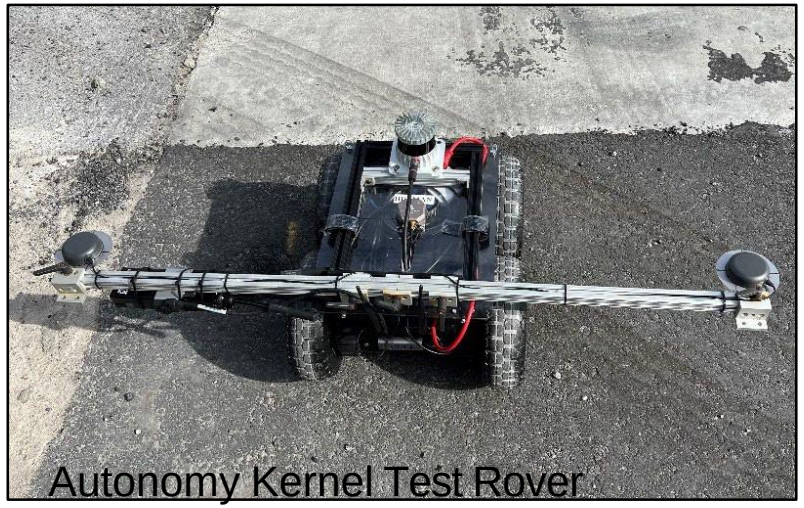


SysML Architecture



ROS2 Navigation Behavior


Load Cart Simulation


Autonomy Kernel Test Rover

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Other Applications

Free personnel from *Dull*, *Dirty*, or *Dangerous* jobs

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Small Unmanned Aerial Systems (SUAS)

- **Used for AF Missions**
  - Perimeter security
  - Force Protection
  - Surveying
  - Building Inspections
  - Many other uses
- **Teledyne FLIR Aeryon SkyRanger R60**
- **Teledyne FLIR SkyRaider R80**
- **DIU Blue UAS**
- **Future Capabilities?**

SkyRanger R60

Source: Defense Visual Information Distribution Service, photo by Smith, J

Vantage Robotics Vesper

Source: Defense Visual Information Distribution Service, photo by Smith, J

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Robotics and Autonomous Systems Roadmap

	Short-Term (0-2 years)	Medium-Term (2-5 years)	Long-Term (5-10 years)
APOF	APOF ConOps	Auto APOF Loader	
RDA	RDA Draft FRD	RADAS v 0.7x	RADAS v 1.0
REHM	REHM FRD, AFTTP 3-32.5 V1	RADBO/REHM C3 Integration	SLAM Bot
ADR	ADR FRD/CONOPS/CDD	Robotic ADR Equipment	Next Gen RADBO Auto ADR
1.1. Sensing and Perception	Crater ID Surface UXO ID Development Subsurface UXO Locate	Subsurface UXO ID Development Surface UXO ID Maturation	Subsurface UXO ID Maturation Surface UXO ID Maturation
1.2. Mobility	GPS Degraded Navigation	Crater and Depression Avoidance UXO and Obstacle Avoidance	
1.3. Manipulation	Auto Pallet Handling	Coring, drilling, & boreholing Highly Dexterous Manipulation	
1.4. Human System Interaction	RMMC Applique APOF TAK IOC REHM TAK IOC	ADR Applique TAK Spiral	TAK Spiral
1.5. System-level Autonomy	Load Cart Autonomy Kernel A-RAM Autonomy Kernel	APOF Autonomy Kernel RMMC Autonomy Kernel	ADR Autonomy Kernel
1.6. Rapid CBRNE Mitigation	L-CBA S-CBA	Subsurface UXO Access	Subsurface UXO Mitigation
1.7. Systems Engineering	Robot M&S Environment T&E Interoperability DE Environment	Robot M&S Environment T&E DE Environment	Robot M&S Environment T&E DE Environment

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Takeaways

- AFCEC is advancing robotics with developmental partners in many RDT&E projects
  - Robotics and Unmanned Systems, applique kits, platforms/sensors testing and software interface
- Multiple test/explosive ranges and facilities to evaluate systems “full operational capability” on-site
- Laboratories for controlled environmental testing
- Ability to support new robotics technology for AF enterprise missions
- Enabling the CE Warfighter to be more agile, flexible efficient and effective!

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Questions?

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

NDIA FFCCE – Signature Suppression Session
21 SEP 2022

Adam M. Jacob

Chairman, Joint Service Signature Suppression IPT

Joint Service Small Arms Program (JSSAP) office

21 SEP 2022

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NDIA FFCCE – SIGNATURE SUPPRESSION SESSION

Background of Sound, Light, and Human Factors		
Dr. Michelle Swearingen	US Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory	BANG or pop: A Tutorial on Sound Propagation in the Environment
Ms. Ruth Foutz	US Army, Public Health Center	Effects of Sound on the Human Ear
Dr. David Dye	NSWC Crane	Human Eye Perception of Flash
Applied Studies in Human Perception and Operational Relevance		
Dr. Paul Fedele	US Army, DEVCOM ARL	Localization of Shooter Position Based on Weapon Signature
Mr. Tim Cler	US Army, DEVCOM ARL	Outdoor Acoustics
Mr. Lewis "Cole" Cochran	US Army, MCDID	Tactical Advantage by Sound and Visual Suppression
Technology Development and Related Studies		
Mr. Dan Baechle	US Army, DEVCOM ARL	High-Temperature Evaluation of Suppressor Covers
Mr. Ernest Bray	X2 Dev Group	Flow Through and Reverse Flow Suppressors - Advanced Designs to Address Modern Suppression Challenges
Mr. Barry Dueck Mr. Ryan Steven Glasby	SureFire Oak Ridge National Lab	Surefire's Advanced Suppressor Program - Blending Science, Technology, and Experience to bring Next Generation Signature Suppression to the Warfighter
QUESTIONS		

BANG or pop: A Tutorial on Sound Propagation in the Environment

NDIA-FFCCE Suppressor Summit

Prepared by Michelle E. Swearingen, Ph.D.

21 September 2022

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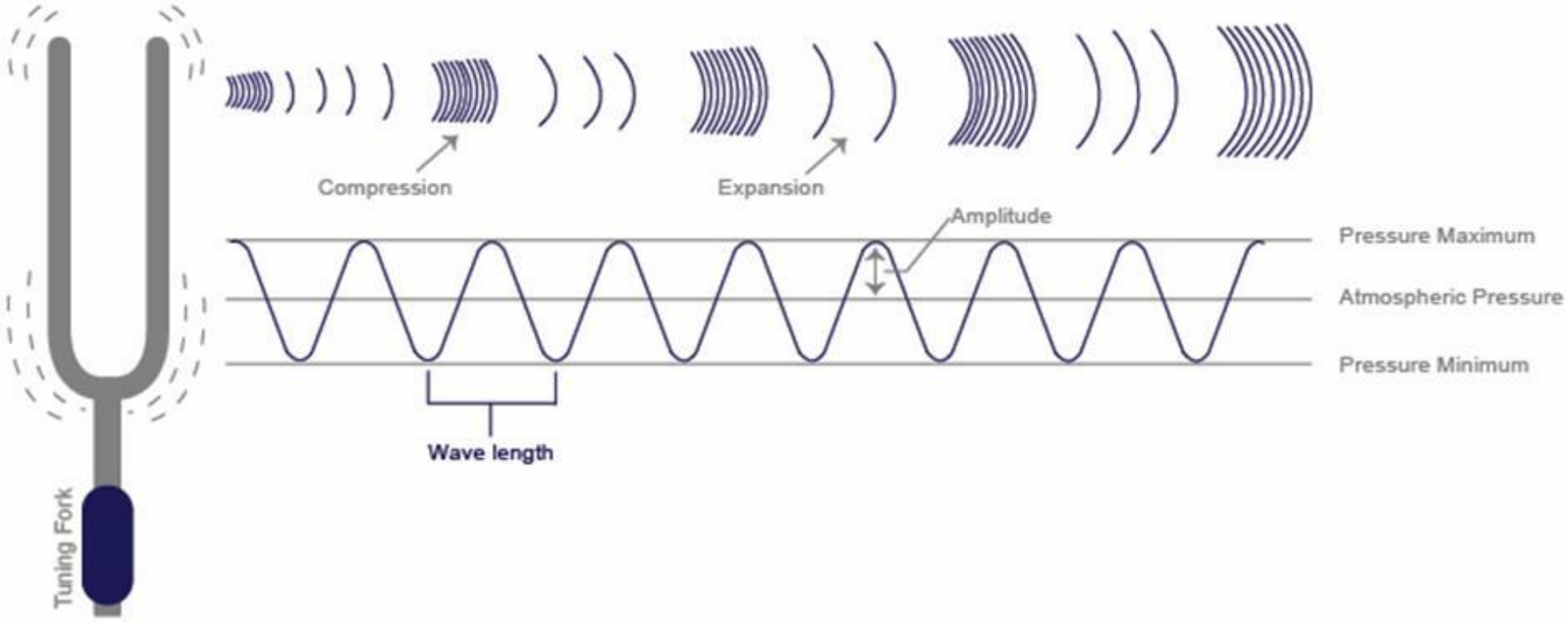
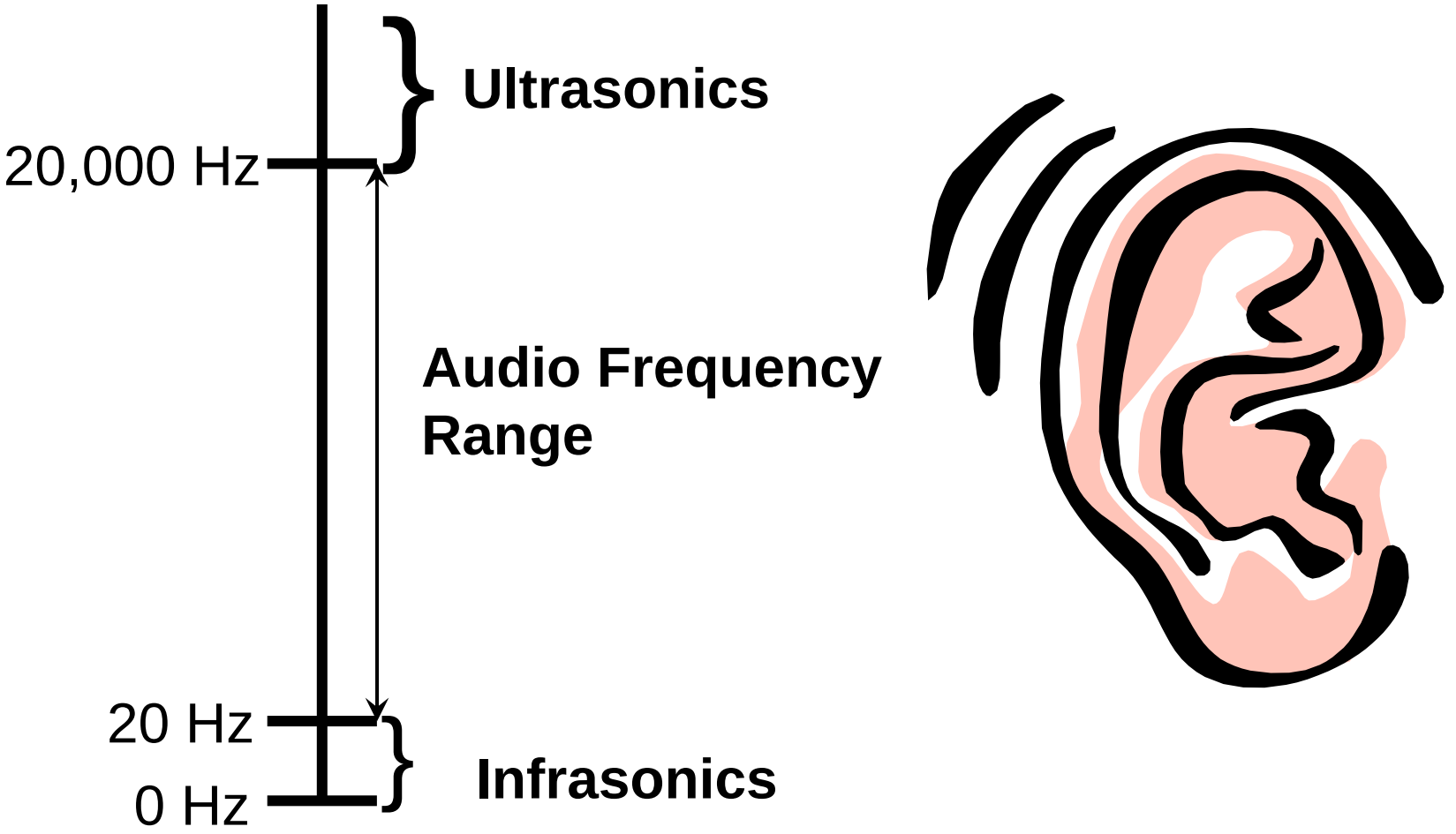
Agenda

- **Terminology**
- **Characteristics of different types of sources**
- **Ground-to-ground propagation effects**
  - **Refraction:** Temperature and wind variations increase or decrease signature propagation distance
  - **Ground Interaction/Surface Reflection:** Hard surfaces reflect signatures/soft surfaces attenuate signatures
  - **Atmospheric Absorption:** Low frequency signals less impacted
  - **Diffraction:** Large structure/terrain features block or redirect sound
  - **Turbulence Effects:** Introduces variability
- **Putting it all together**

Terminology



Hearing and Perception



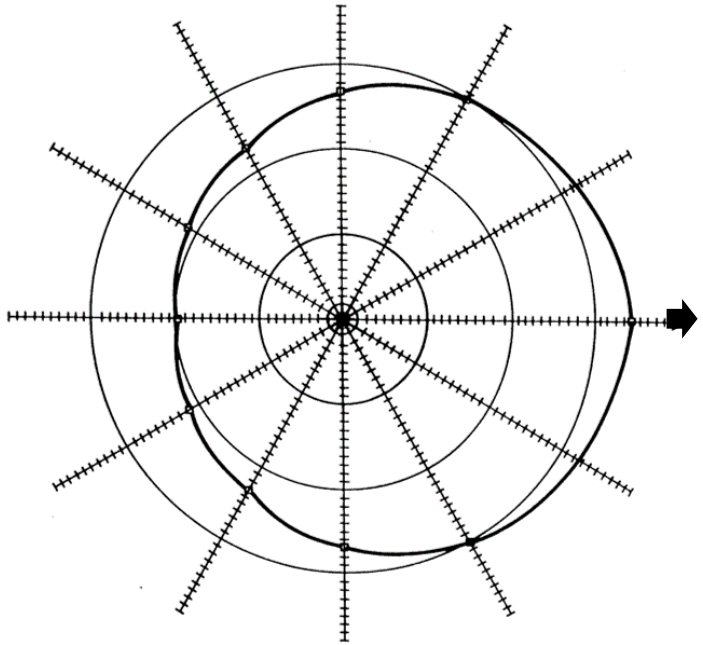
Directivity

Most sources are louder in some directions than in others; this is called directivity

Examples: loudspeaker, human voice, rifle

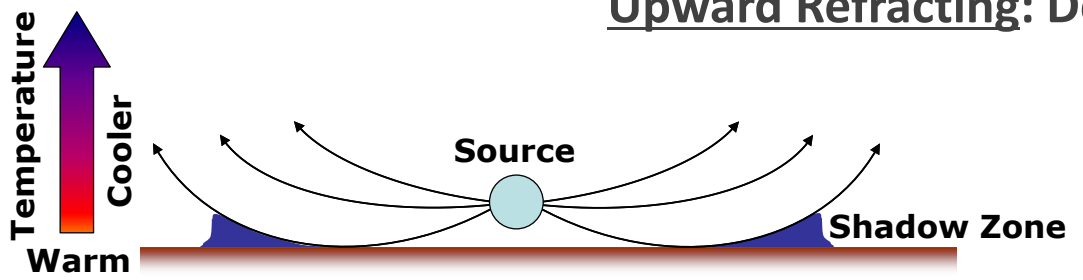
Directivity can be significant

In large weapons, it can be up to 15 dB louder in front!



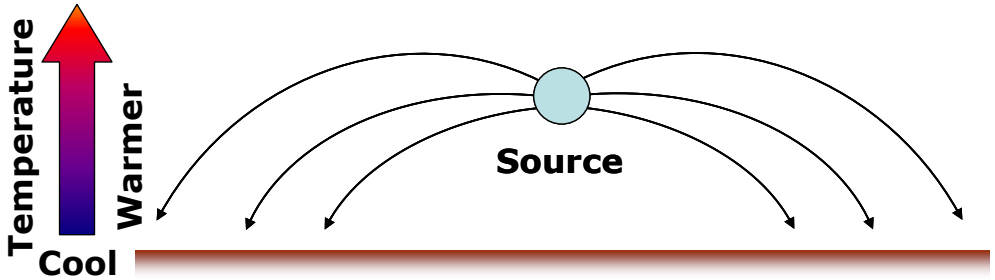
Refraction Summary

Upward Refracting: Detection ranges decreased



- Typically occurs late morning to early evening
- Temperature cools with increasing altitude
- Sound waves are bent upward
- Creates shadow zones away from source

Downward Refracting: Detection ranges increased

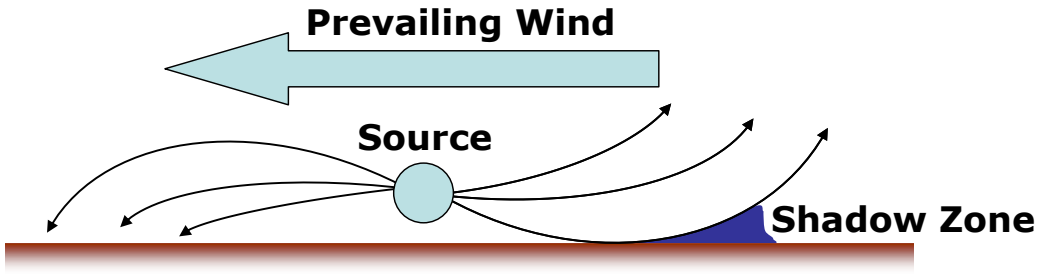


- Typically occurs early evening to mid morning and/or overcast conditions
- Temperature warms with increasing altitude
- Sound waves are bent downward
- Can propagate farther along the ground

Wind Effects: Enhanced signature propagation downwind from the source, decreased upwind

Downwind

- Bends sound downwards
- Enhances propagation along the ground
- Increases detection range



Upwind

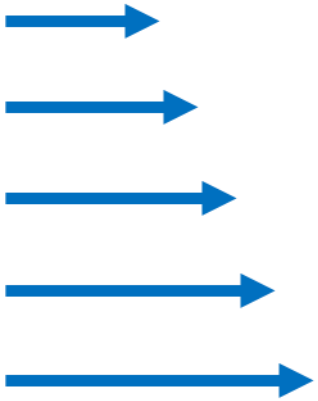
- Bends sound upwards
- Creates shadow zones
- Decreases detection range

US Army Corps of Engineers • Engineer Research and Development Center

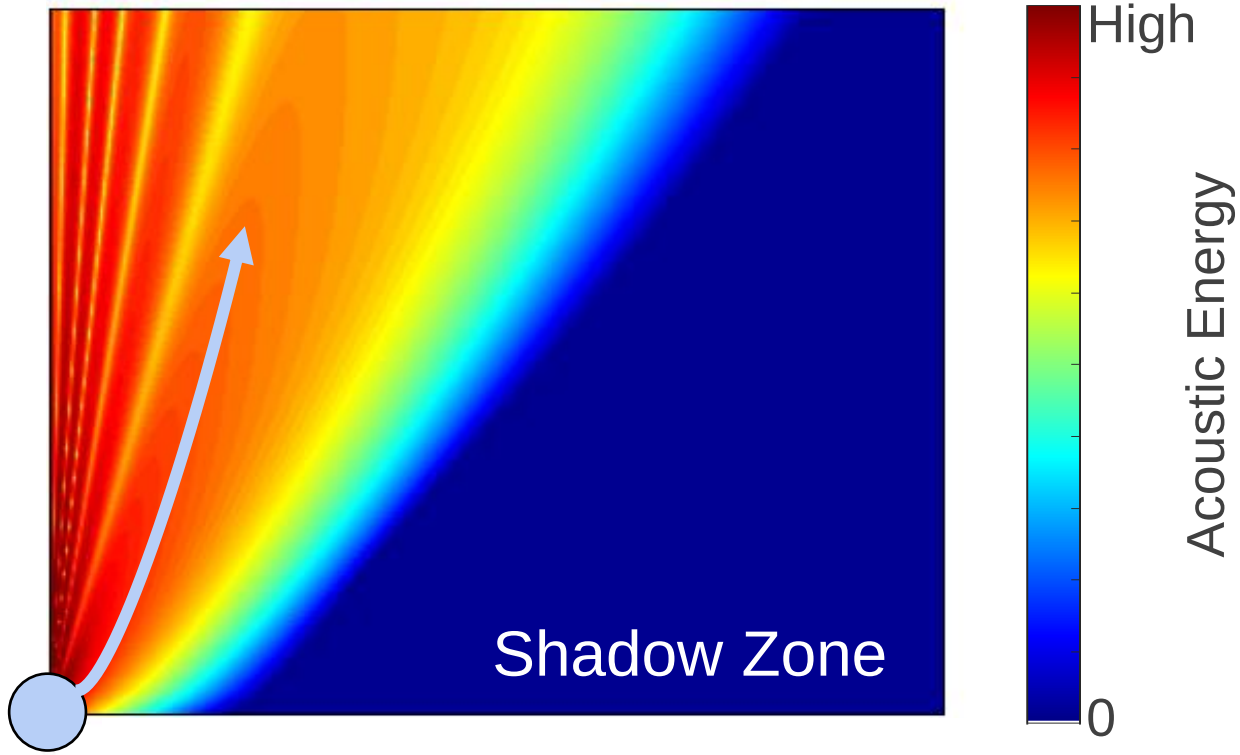
Upward Refracting

Common on bright, sunny days and upwind conditions
Example is idealized – in reality, shadow zones are not this clear-cut!

Sound Speed Profile
Decreasing



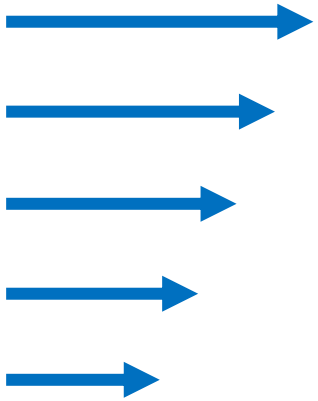
Propagation Effects



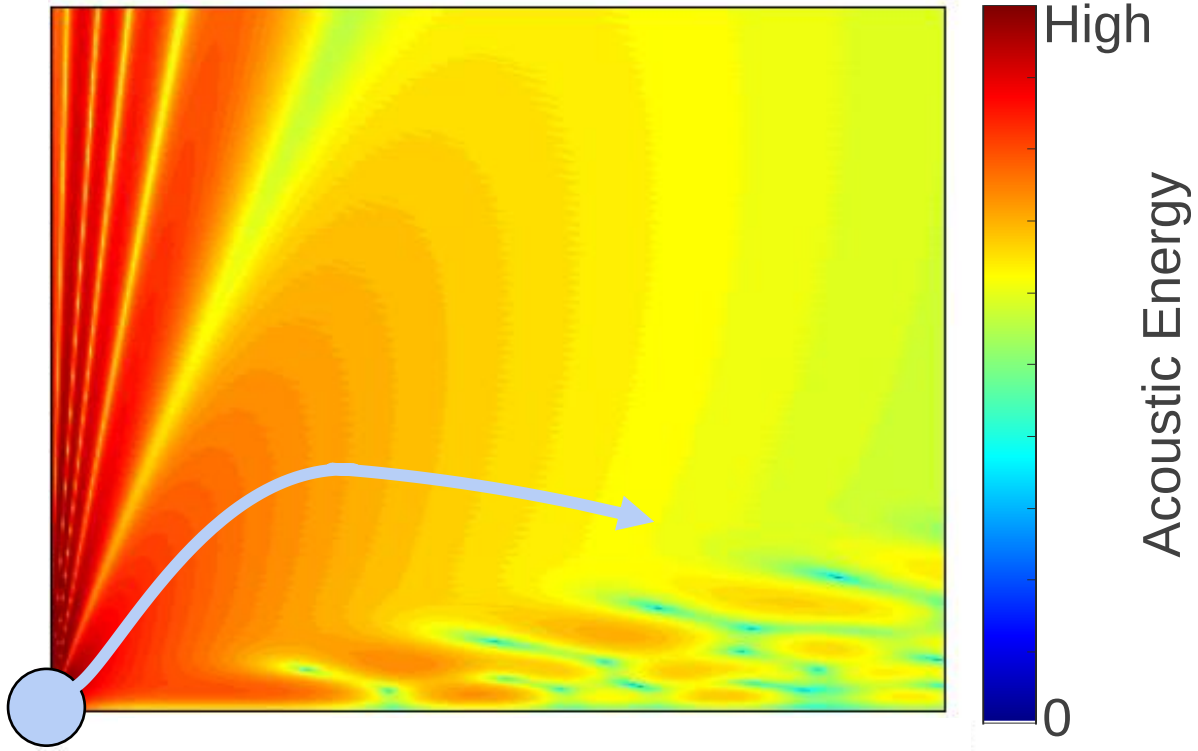
Downward Refracting

Common during nighttime, overcast, and downwind conditions

Sound Speed Profile
Increasing

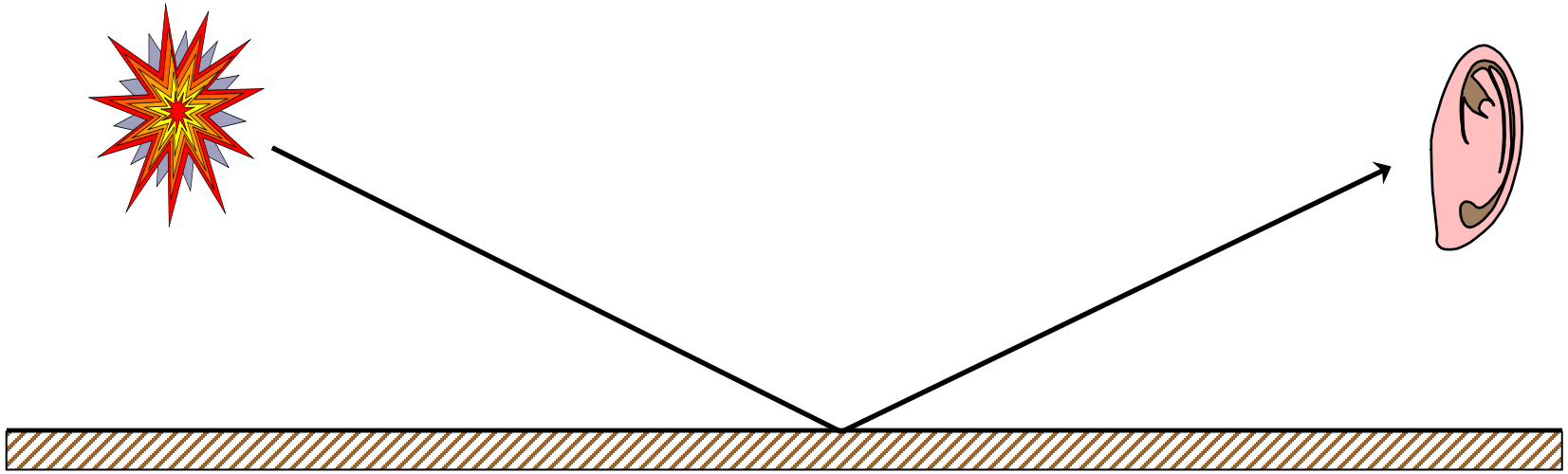


Propagation Effects



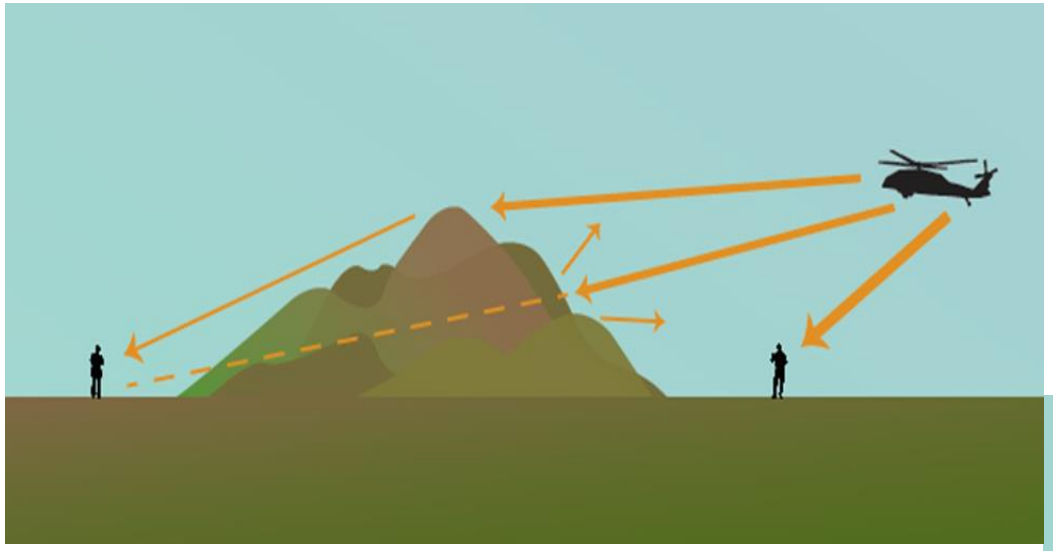
Ground/Surface Reflections

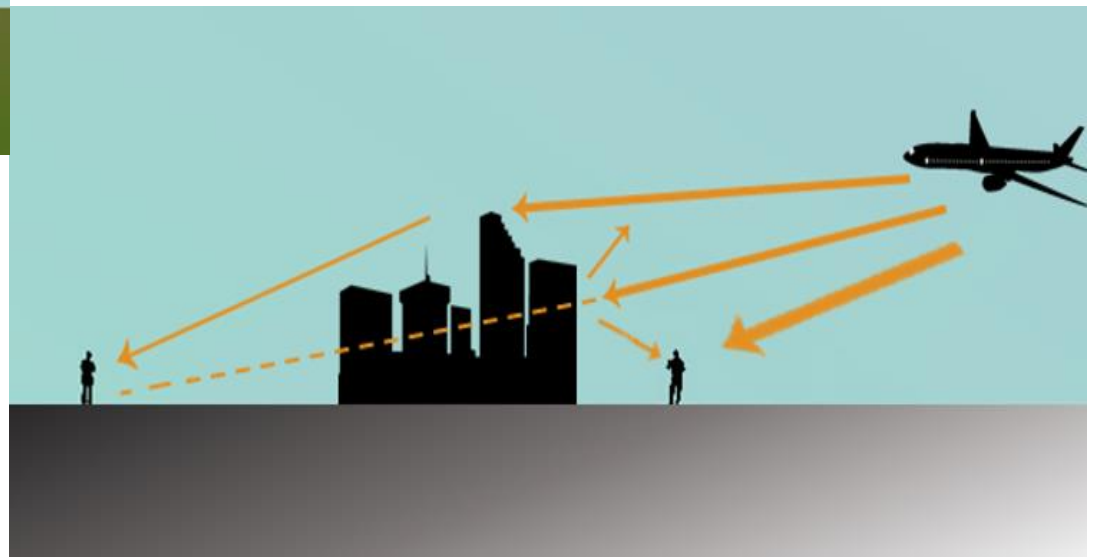
“Hard” grounds, such as water and asphalt, reflect signals with minimal attenuation.
“Soft” grounds, such as grass, snow, and forest floors, attenuate signals



Diffraction/Terrain Effects

Large structures and terrain features can block and redirect signals



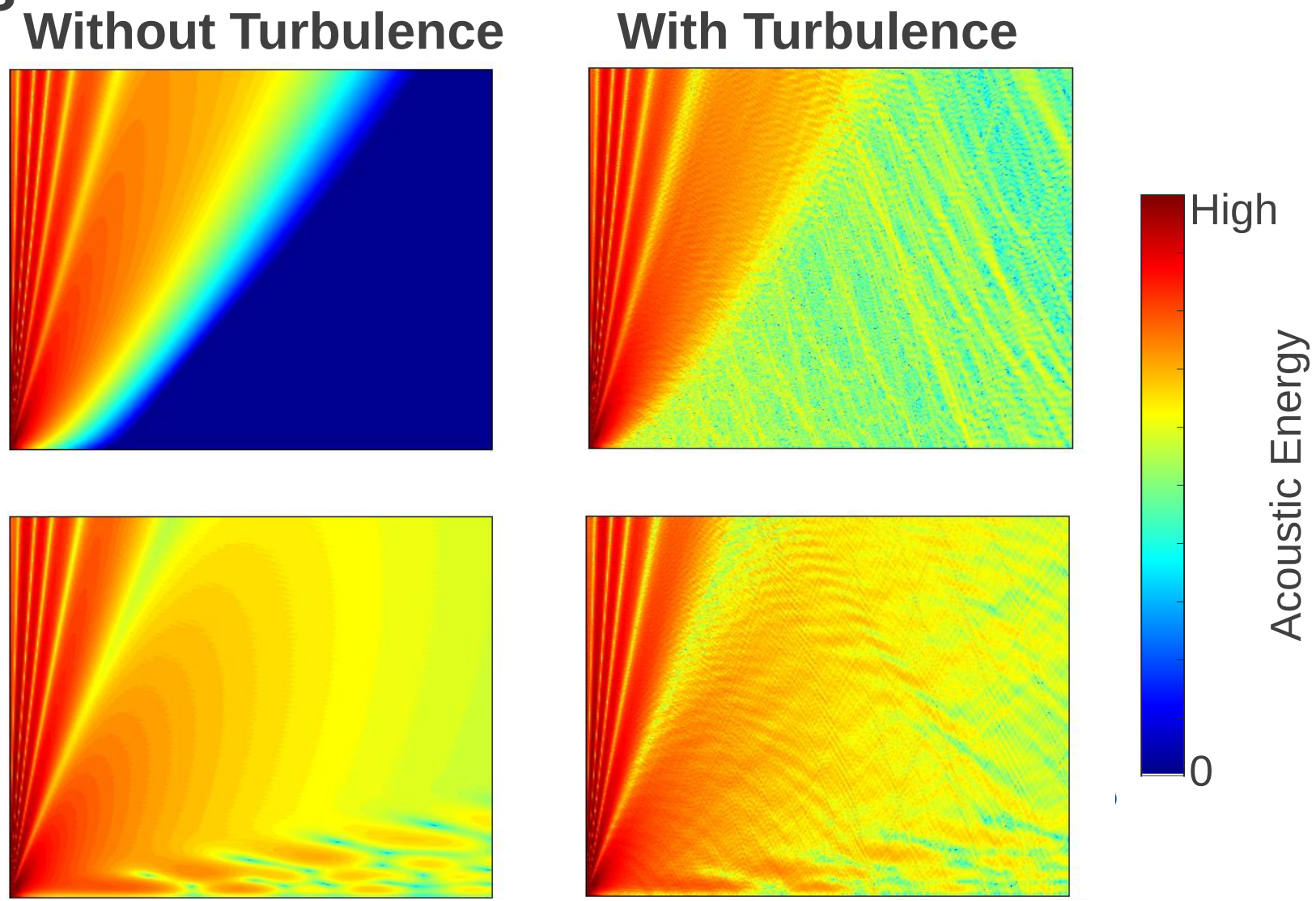


Turbulence Effects

Turbulence causes variability in received signals and can “fill in” a shadow zone.

Upward Refracting

Downward Refracting



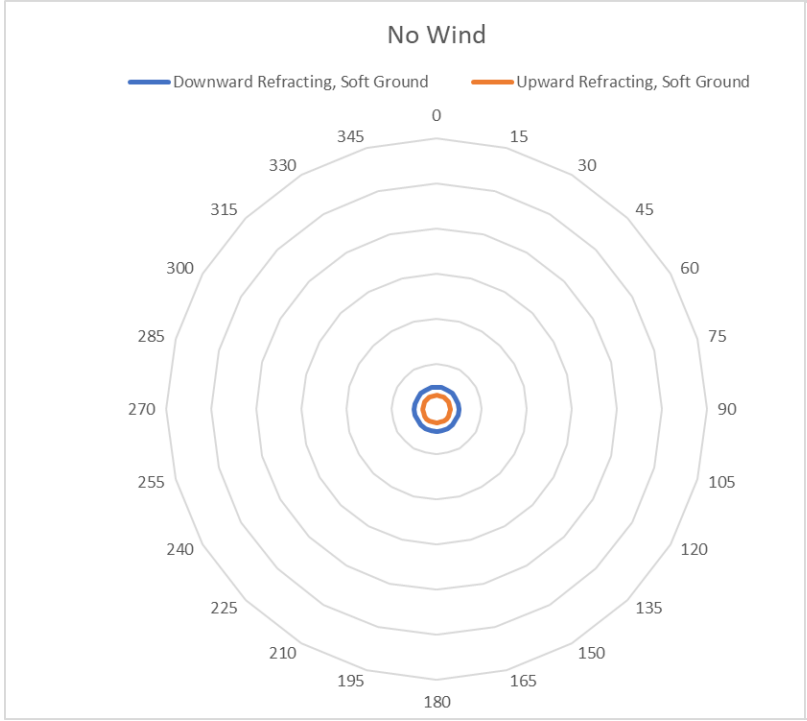
Putting it all together…

Simplified examples to show coupled effects

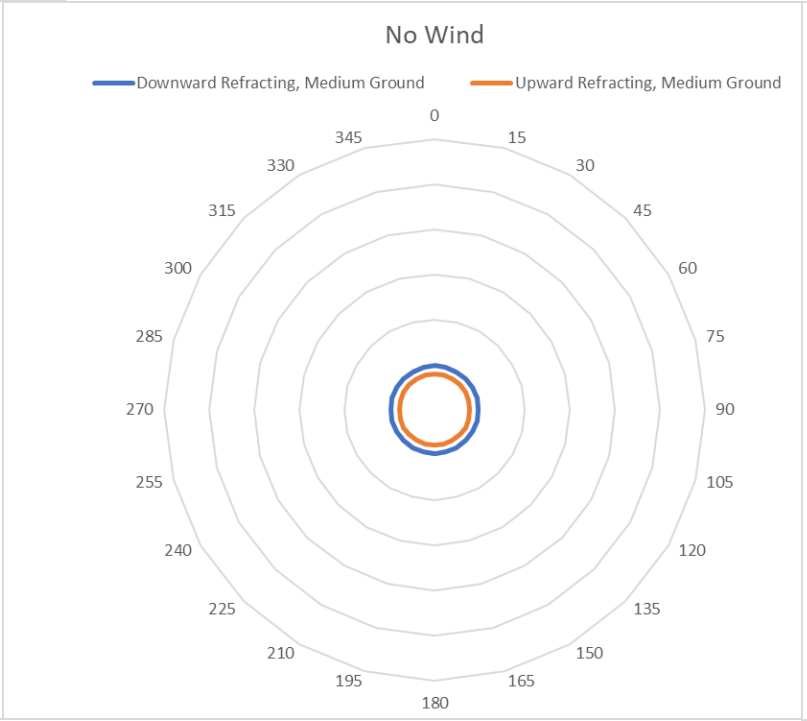
- Upward and Downward refracting temperature profiles
- With and without wind
- Three ground impedance values (soft, medium, hard)
- Atmospheric absorption included
- Turbulence not included
- Source is in the center

Temperature Only (no wind)

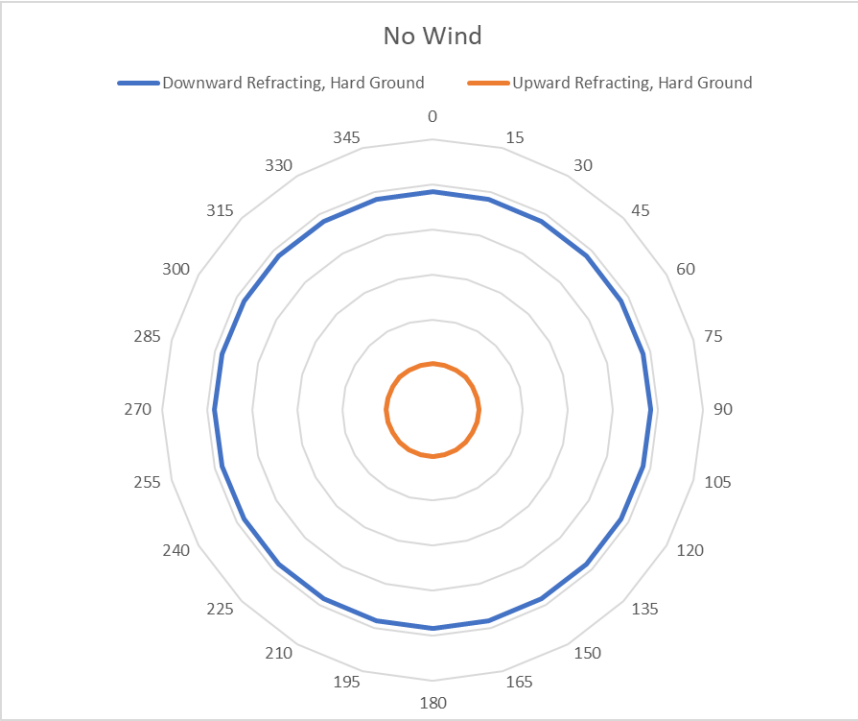
- Downward Refracting
- Upward Refracting



Soft Ground (Grass)



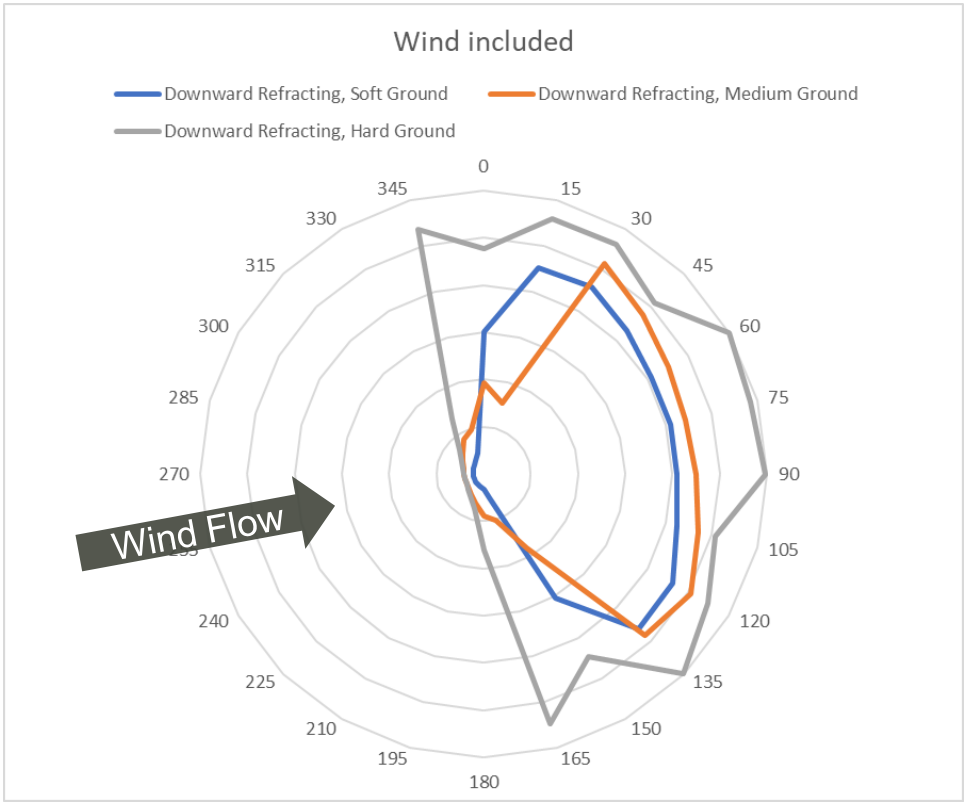
Medium Ground (Sand)



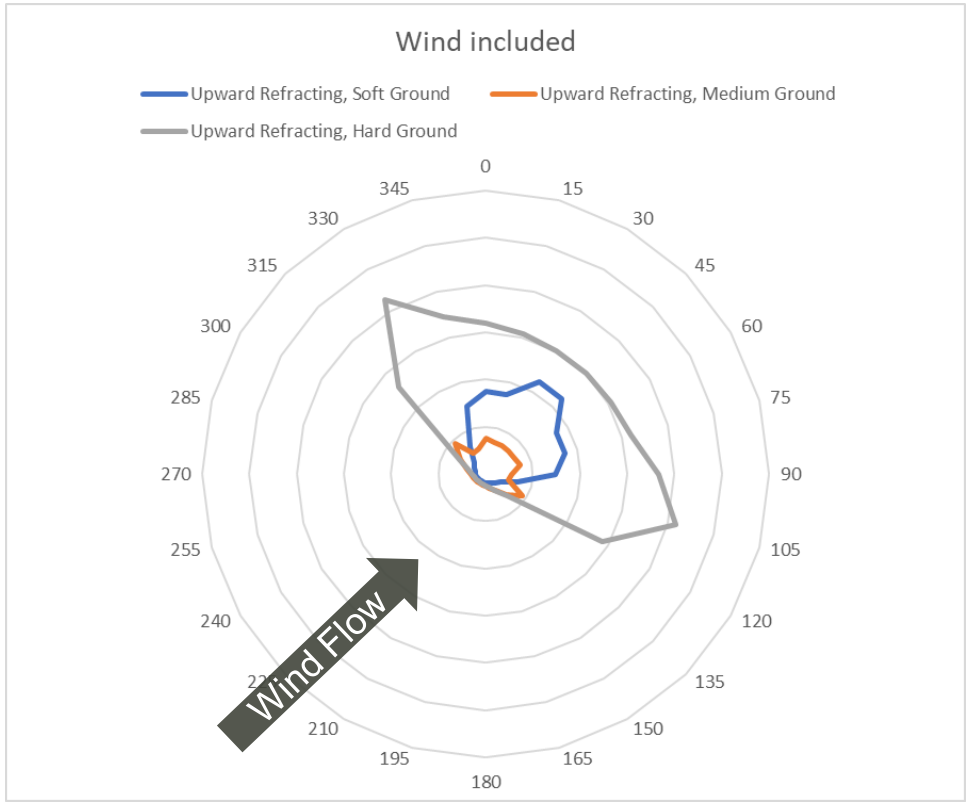
Hard Ground (Asphalt)

Wind Included

- Soft Ground
- Medium Ground
- Hard Ground



Downward Refracting (night)



Upward Refracting (day)

Additional Questions?

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Army Futures Command

Effects of Sound on the Human Ear

Ruth Foutz

21 September 2022

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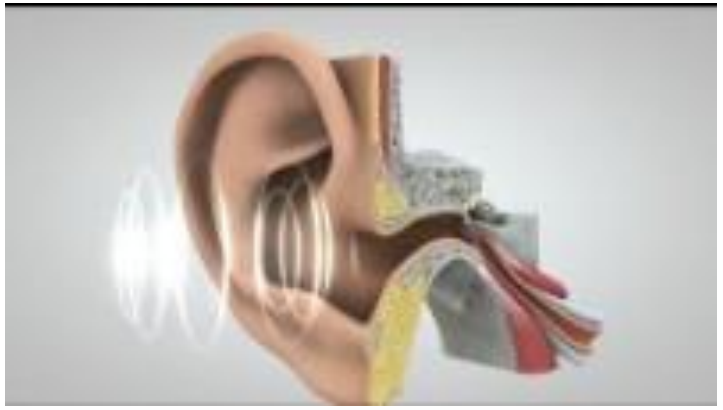
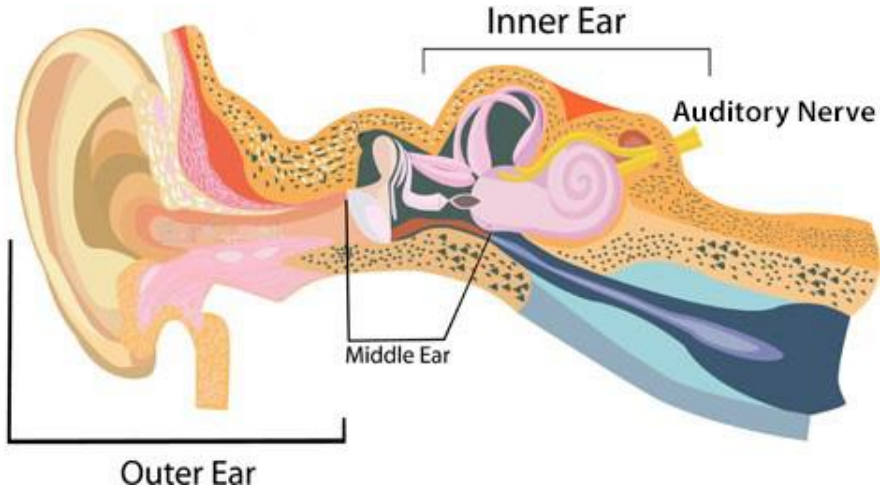
JOURNEY OF SOUND TO THE BRAIN





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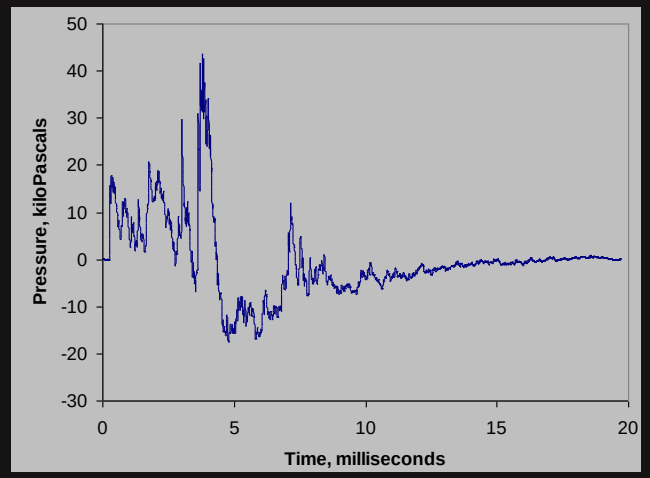
ACOUSTIC ENERGY–IMPULSE NOISE

Action Level per DA Pamphlet (DA Pam) 40-501 and Military Standard (MIL-STD) 1474E is impulse noise at or above

140 dBP



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IMPULSE NOISE EFFECTS ON THE EAR

Normal Hair Cells

Damaged Hair Cells

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Human Eye Response to Flash

Dr. David F. Dye, david.f.dye2.civ@us.navy.mil

CAPT Duncan McKay, USN
Commanding Officer

Dr. Angela Lewis, SES
Technical Director

NAVSEA WARFARE CENTERS CRANE

NSWC Crane Small Arms Signature Laboratory

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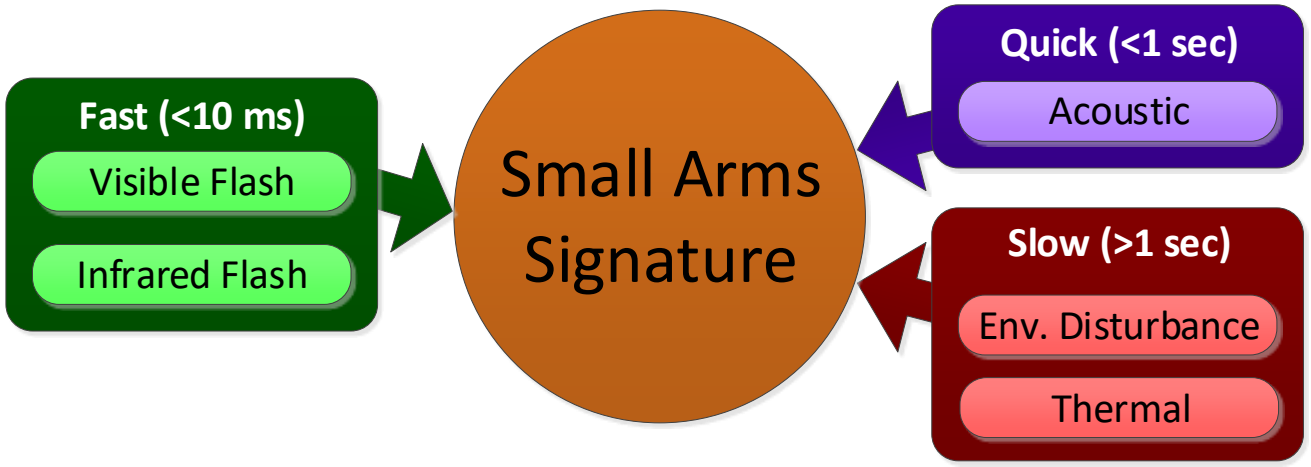
Small Arms Weapon Signatures



Signature Type	Day			Night		
	Shot Fired	Shooter Position	Track Shooter	Shot Fired	Shooter Position	Track Shooter
Flash, Visible				Eye	Eye	
Flash, Infrared	Imager	Imager		Imager	Imager	
Acoustic	Ear, Mic.	Ear, Mic.		Ear, Mic.	Ear, Mic.	
Environmental Disturbance	Eye	Eye				
Thermal (Infrared)		Imager	Imager		Imager	Imager

Low Concern, Medium Concern, High Concern

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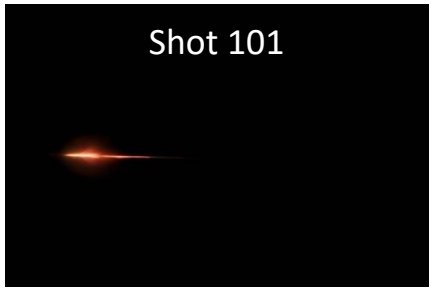
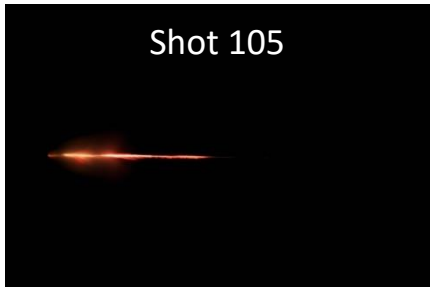
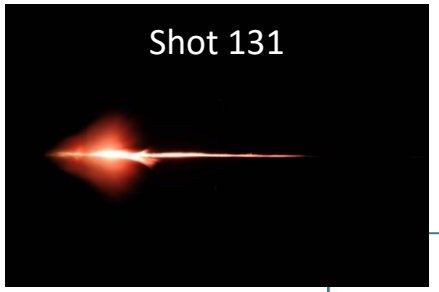
Radiometric Flash Measurement

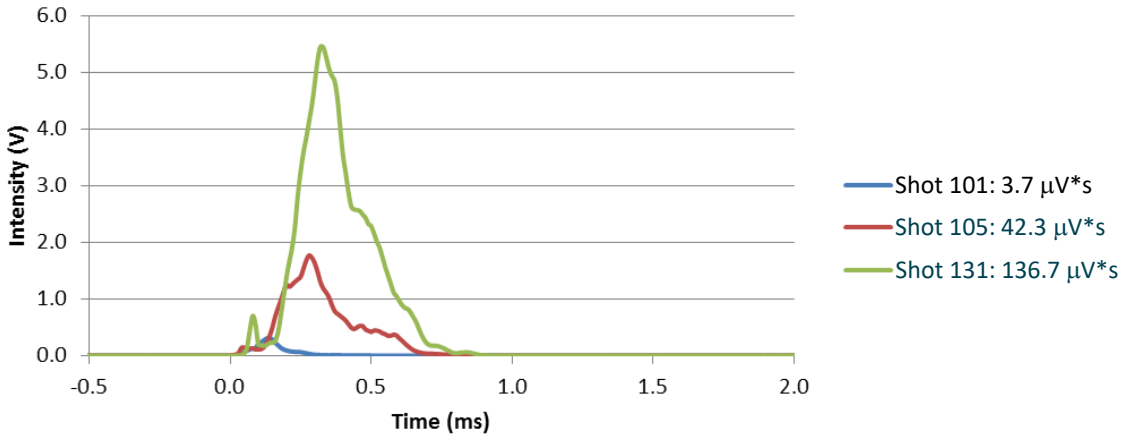
Old Method: Comparing Pictures

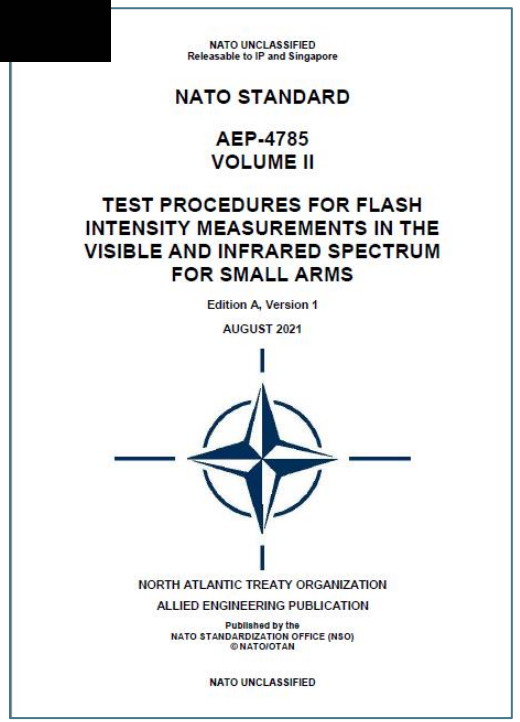






AEP-4785 Method: Radiometric Measurement

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NATO STANDARD

AEP-4785
VOLUME II

TEST PROCEDURES FOR FLASH INTENSITY MEASUREMENTS IN THE VISIBLE AND INFRARED SPECTRUM FOR SMALL ARMS

Edition A, Version 1

AUGUST 2021

NORTH ATLANTIC TREATY ORGANIZATION
ALLIED ENGINEERING PUBLICATION

Published by the
NATO STANDARDIZATION OFFICE (NSO)
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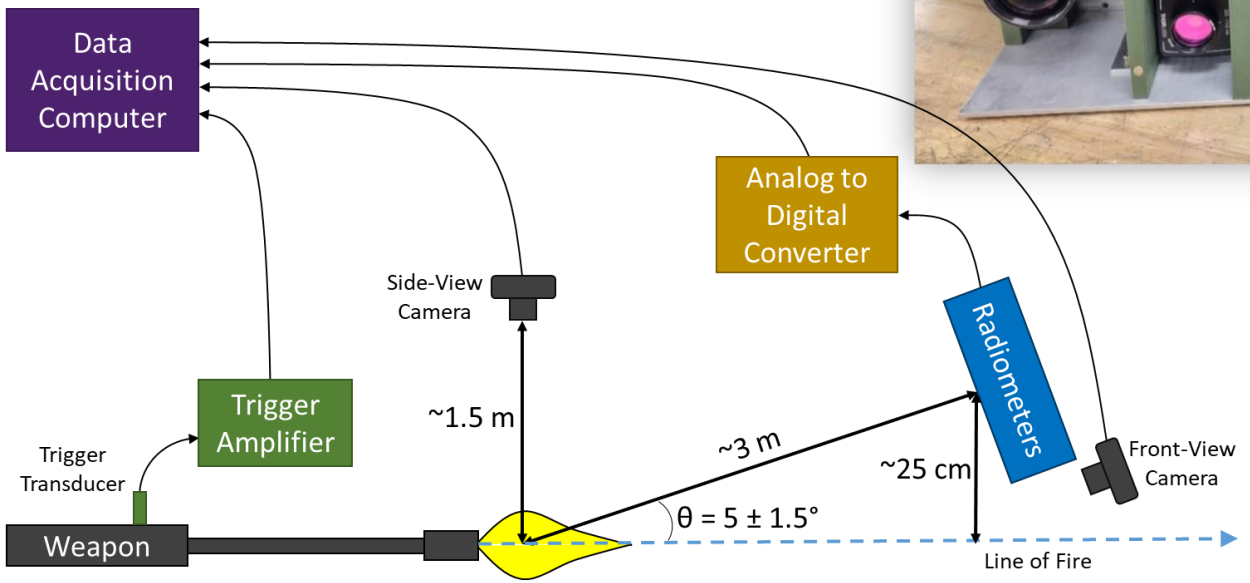
Flash Signature

NSWC Crane's Integrated
Flash Characterization Array

- Simultaneously collects flash in multiple spectral bands
- Images flash from front & side



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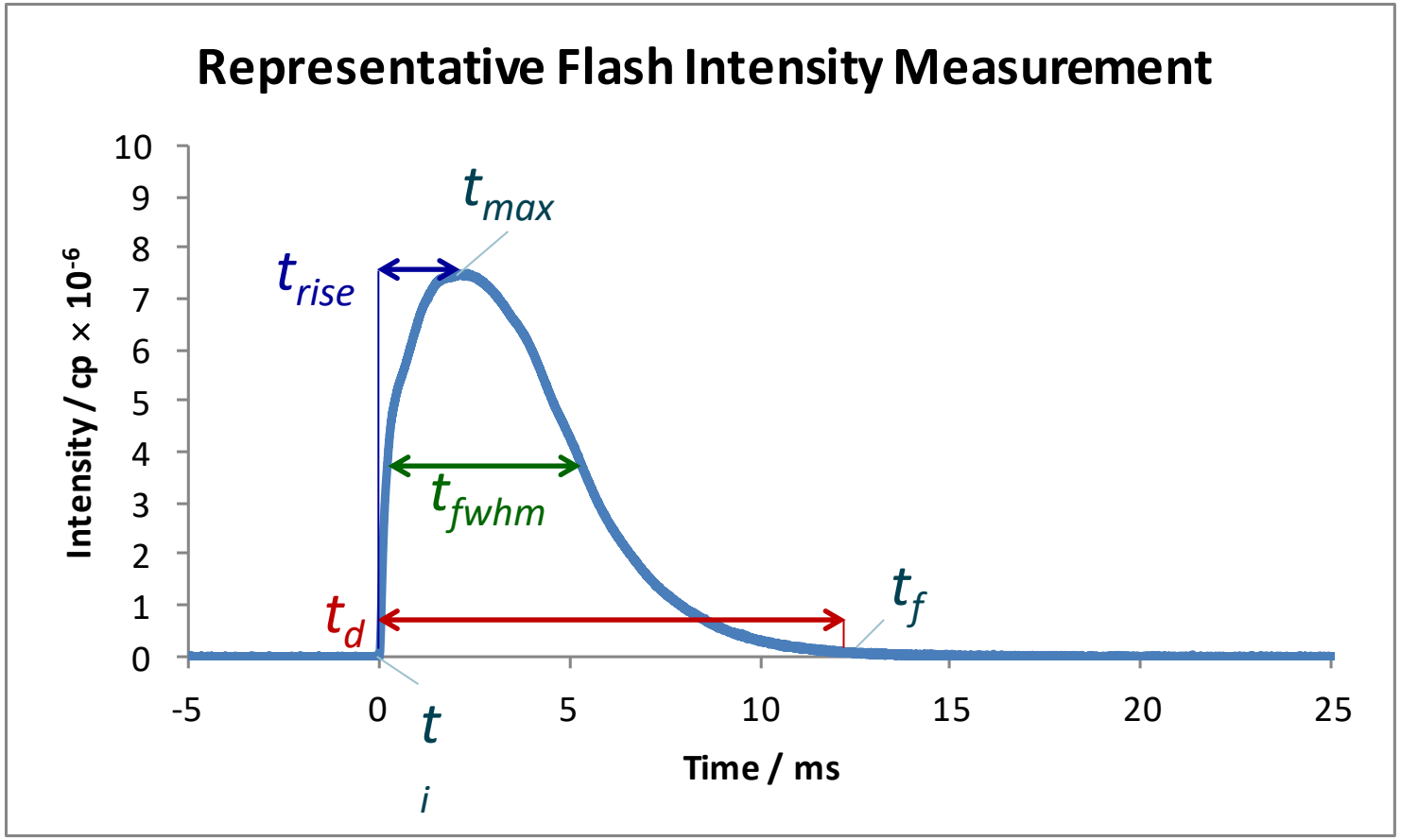
Which Measurements Matter?



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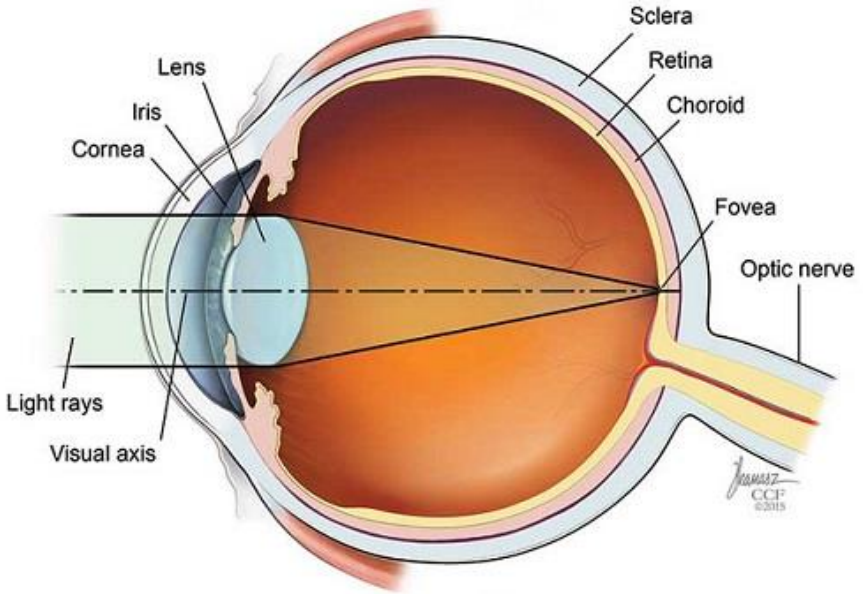
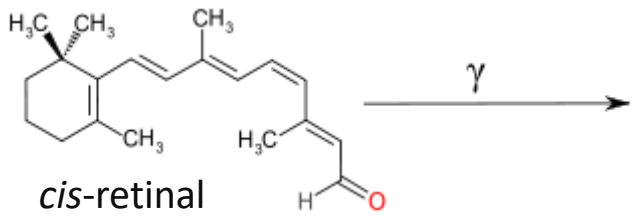
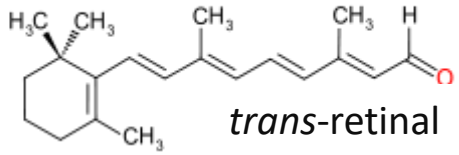
Anatomy of the Human Eye



Source: https://www.magrabi.com.sa/blog/faq-about-farsightedness/

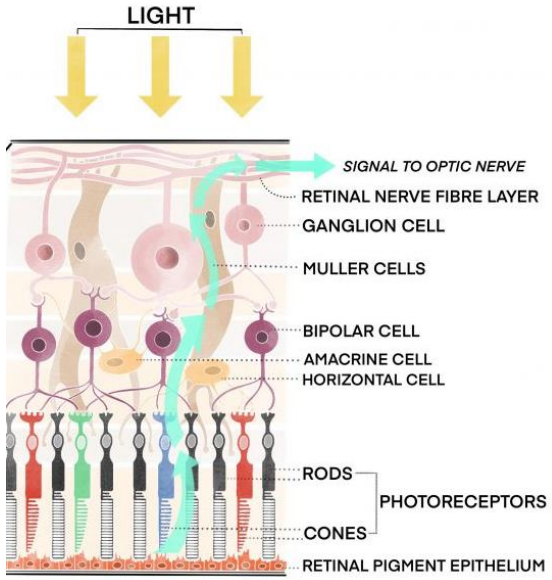


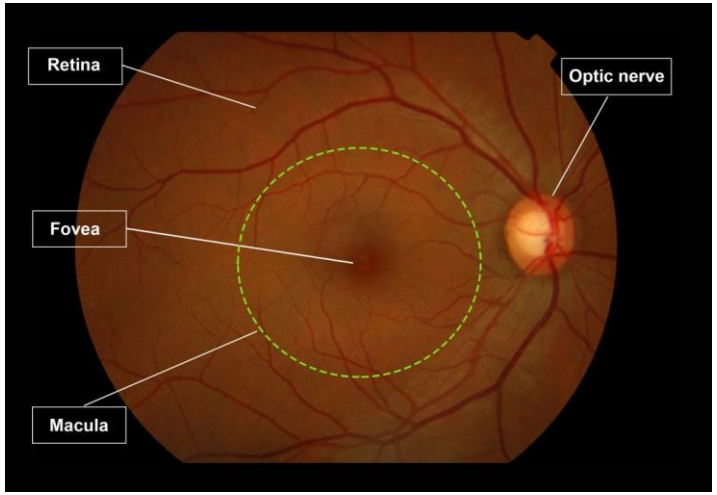
cis-retinal



trans-retinal

Source: Wikimedia.org





Source: https://gene.vision/retina/

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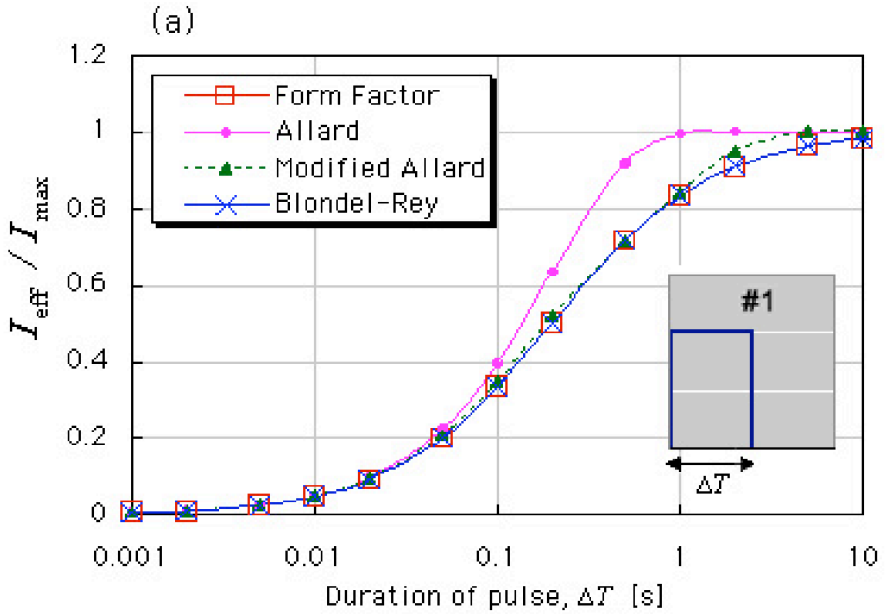
Eyes as Photon Integrators

- For weapon flash timescales, all major models agree: brightness is proportional to the integrated flash energy.
  - Multiple human tests confirm these models
- Chemical reason: it takes time to convert *trans*-retinal to *cis*-retinal



Source: Ohno, Couzin, & Dennison, NIST White Paper, "Modified Allard Method for Effective Intensity of Flashing Lights"

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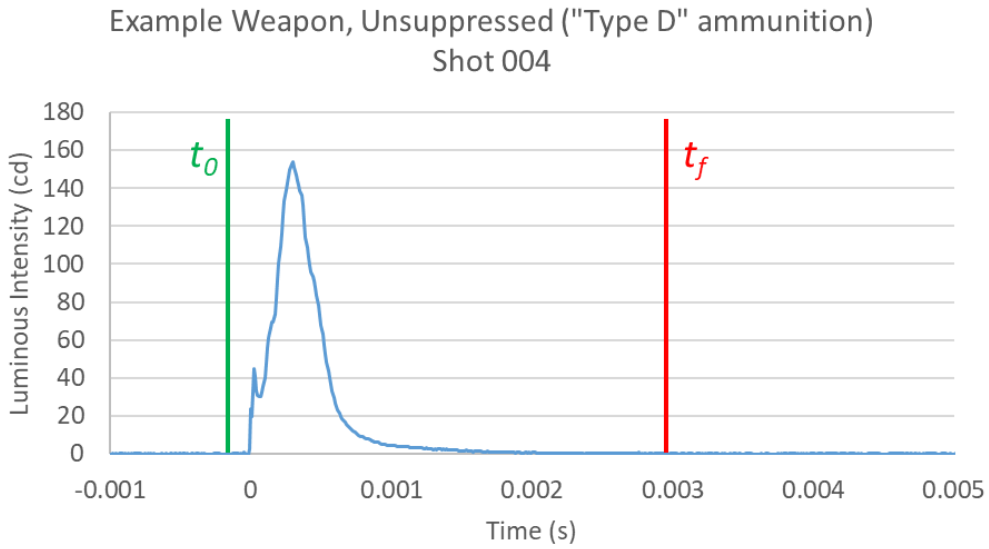
Flash Signature

NATO AEP 4785 Flash Measurement Methodology:

1. The visible and IR emission from a flash is measured by an array of radiometers.
2. Instantaneous luminous intensity (I_v) is integrated over the duration of the flash to give luminous energy (Q_v, reported in millicandela seconds).
3. **Luminous energy is proportional to perceived brightness.**



$$Q_v = \int_{t_0}^{t_f} I_v(t)\, dt$$

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Detectability is Linked to Contrast

- Detection of a point source is dependent on contrast with the background
- For detection of muzzle flash, some basic rules of thumb can be used for detection thresholds.
  - 100% detection: contrast ratio of 10:1
  - 50% detection: contrast ratio of 2:1

Slide courtesy Daniel Cler, CCDC – Armaments Center

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Common Illuminance Background Levels

Lighting condition	Foot-candles	Lux
Full daylight	1,000	10,000
Overcast day	100	1,000
Very dark day	10	100
Twilight	1	10
Deep twilight	0.1	1
Full moon	0.01	0.1
Quarter moon	0.001	0.01
Starlight	0.0001	0.001

Source: https://en.wikipedia.org/wiki/Illuminance

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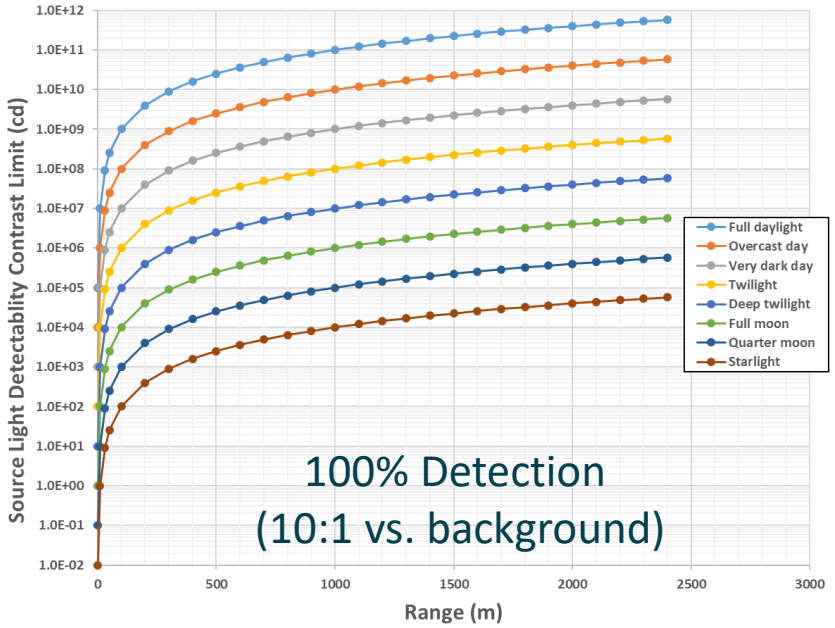
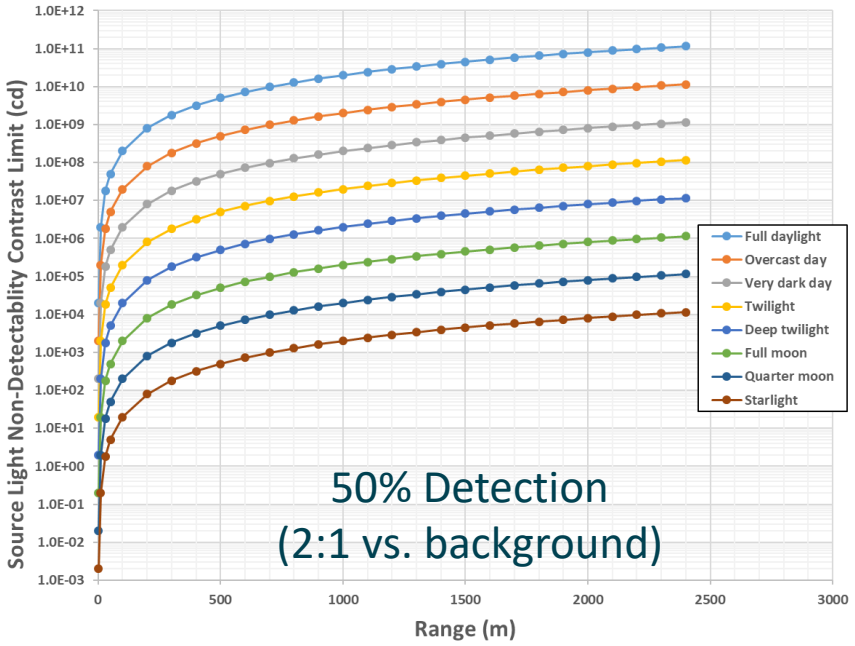
Detectability is Linked to Contrast



- Detection probability models can be constructed using established rules of illuminance at the observer vs. distance



- Studies to correlate theoretical with empirical observational data are planned at Crane

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Conclusions

- AEP-4785 Flash Measurement methods utilize luminous energy as a "brightness" metric
  - Chosen based on physiology of the human eye
  - Works well for many electronic sensors as well

- Measurement of perceived flash brightness will allow use in environmental contrast models
  - Goal is to provide probability of detection models to decision makers

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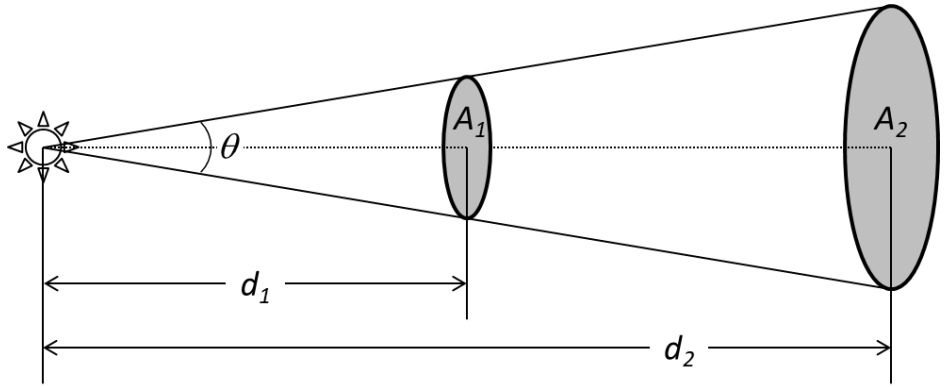
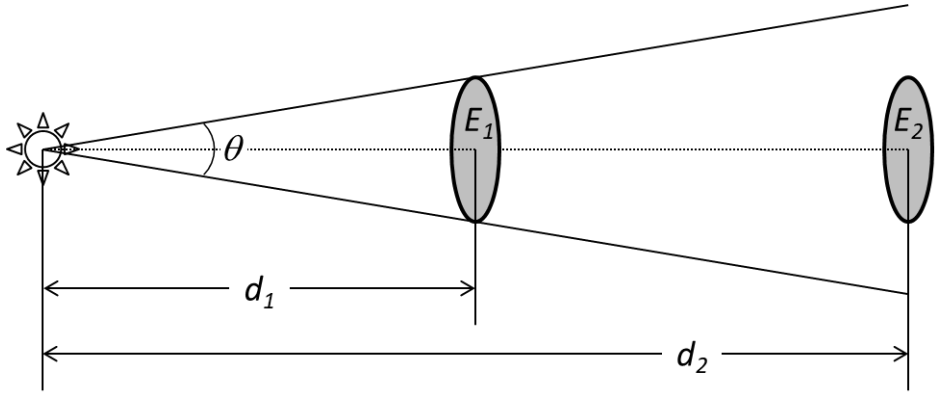
Light and Distance



- **Radiant or luminous intensity (*I*) describes the light emitted by a source**
  - **Independent of distance to the source**
  - **Units are Watts per steradian (W/sr) or candela (cd)**



- **Irradiance (*E*) describes the light projected onto a surface**
  - **Decreases as a function of d^2**
  - **Units are W/m^2 or cd/m^2**
  - **Radiometers can ONLY measure irradiance**

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Radiometry vs. Photometry Terminology

SI Radiometry Units

Quantity	*Photopic Equivalent*	*Symbol*	*SI Unit*	*Unit Symbol*	*Notes*
Radiant Energy	Luminous Energy	Q_e	joule	J	energy (W · s)
Radiant Flux	Luminous Flux	Φ_e	watt	W or J/s	radiant energy per unit time, also called radiant power
Spectral Power		$\Phi_{e\lambda}$	watt per meter	$W \cdot m^{-1}$	radiant power per λ
Light Emitted by a Source					
Radiant Intensity	Luminous Intensity	I_e	watt per steradian	$W \cdot sr^{-1}$	power per unit solid angle
Spectral Intensity		$I_{e\lambda}$	watt per steradian per meter	$W \cdot sr^{-1} \cdot m^{-1}$	radiant intensity per spectral wavelength range (Δλ)
Radiance	Luminance	L_e	watt per steradian per square meter	$W \cdot sr^{-1} \cdot m^{-2}$	power per unit solid angle per unit projected source area
Spectral Radiance		$L_{e\lambda}$	watt per steradian per $meter^3$	$W \cdot sr^{-1} \cdot m^{-3}$	commonly measured in $W \cdot sr^{-1} \cdot m^{-2} \cdot nm^{-1}$
Radiant Exitance / Emittance	Luminous Emittance	M_e	watt per square meter	$W \cdot m^{-2}$	power emitted from a surface
Spectral Radiant Exitance / Emittance		$M_{e\lambda}$	watt per $meter^3$	$W \cdot m^{-3}$	power emitted from a surface per Δλ
Radiosity		J_e	watt per square meter	$W \cdot m^{-2}$	emitted plus reflected power leaving a surface
Spectral Radiosity		$J_{e\lambda}$	watt per $meter^3$	$W \cdot m^{-3}$	emitted plus reflected power leaving a surface per Δλ
Light Incident on a Surface					
Irradiance	Illuminance	E_e	watt per square meter	$W \cdot m^{-2}$	power incident on a surface, also called radiant flux density
Spectral Irradiance		$E_{e\lambda}$	watt per $meter^3$	$W \cdot m^{-3}$	commonly measured in $W \cdot m^{-2} \cdot nm^{-1}$
Radiant Exposure	Luminous Exposure	H_e	joule per square meter	$J \cdot m^{-2}$	also referred to as fluence
Radiant Energy Density	Luminous Energy Density	ω_e	joule per $meter^3$	$J \cdot m^{-3}$	

SI Photometry Units

Quantity	Radiometric Equivalent	Symbol	SI Unit	Unit Symbol	Notes
Luminous Energy	Radiant Energy	Q_v	lumen second	lm · s	units are sometimes called talbots
Luminous Flux	Radiant Flux	F_v	lumen (= cd · sr)	lm · s	Also called luminous power
Light Emitted by a Source					
Luminous Intensity	Radiant Intensity	I_v	candela (= lm/sr)	cd	SI base unit for light measurements
Luminance	Radiance	L_v	candela per square meter	cd/m^2	Light emitted by an area of a large object
Luminous Emittance	Radiant Emittance	M_v	lux (= lm/m^2)	lx	used for light emitted from a surface
Light Incident on a Surface					
Illuminance	Irradiance	E_v	lux (= lm/m^2)	lx	used for light incident on a surface
Luminous Exposure	Radiant Exposure	H_v	lux second	lx · s	
Luminous Energy Density	Radiant Energy Density	w_v	lumen second per meter	$lm \cdot s \cdot m^{-3}$	
Luminous Efficacy		h	lumen per watt	lm/W	ratio of luminous flux to radiant flux
Luminous Efficiency		V			also called luminous coefficient (unitless)

Source: https://en.wikipedia.org/wiki/radiometry

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U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND ARMY RESEARCH LABORATORY

Localization of shooter position based on weapon signature

Research and modeling-based considerations of human factors benefits for Soldiers from applications of small arms suppressors

Paul D. Fedele

Research Physical Scientist DB04

US Army DEVCOM Army Research Laboratory

Controlled by: US Army

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CUI Category: Public Release

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POC: Paul Fedele (410) 278-5984

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Localization of shooter position based on weapon signature

Potential Soldier benefits from small arms suppressors

Need –

The enemy can too quickly localize shooter position and too accurately return direct fire.

Solution –

Increase Soldier stealth against unaided human detection by using suppressors to reduce visible muzzle flash and auditory muzzle blast.

Soldier stealth – model human localization of shot position based on weapon fire signature.

All material is available in ARL Technical Report 9277, August 2021
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Localization of shooter position based on weapon signature

Visual Flash Detectability Threshold Research

Dark Condition Detection Baseline

Flash Visibility Measurements

Early Work

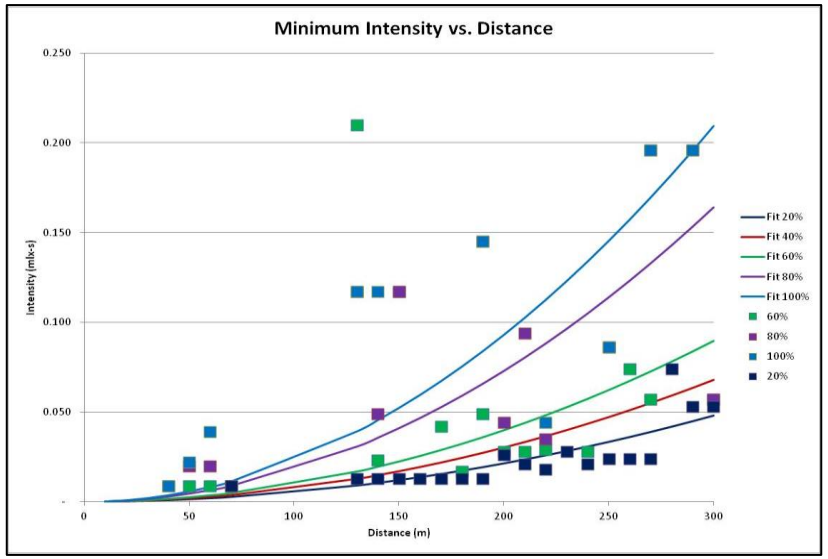
Hecht, S., Shlaer, S., & Pirenne, M. H. (1942). Energy, quanta, and vision. *The Journal of general physiology, 25*(6), 819-840.

Minimum photopic energy - 3.84 to 10.44 10^-7 mlux.s

Recent Work

Hennage, John (c2012). Unpublished Data, Aberdeen Test Center, APG, MD

Minimum photopic energy - 8.74x10^-7 mlux.s



Data is scattered – there are outliers.
Goal is NOT to prove line is quadratic.
Goal is FIT single parameter parabola to half of the subjects. (Green Line)

Final model will include adjustment for primary wavelength and daylight conditions. Spatial resolution based on 20/20 vision: 1 minute of arc for source spatial extent, Barton formula.

Very low levels can be seen when dark adapted.
Operational values being determined.

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Visual Flash Detection

- Human visual detection of muzzle blast luminance
  - Based on total time-integrated luminance
    - Luminance is the total perceived brightness: radiation integrated over all wavelengths, weighted by standard human-perceived brightness – basically ‘visible’ wavelengths.
    - Units: milli-lux.seconds.
    - Thresholds adapted to total darkness are low: ~ 1E-5 mlux.s.
    - At threshold, flash time-envelope and color influences are small.
    - Field data is needed - background illumination (contrast and visual noise) influences for specific small arms configurations and environments.

Flash standard measurement methods - Dr. David Dye, US NSWC, Crane.

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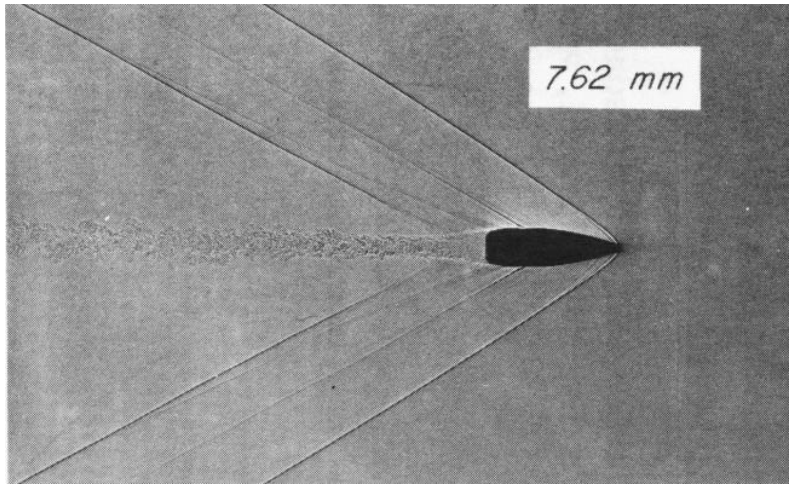
Localization of shooter position based on weapon signature

Auditory Stimuli - Ballistic Crack Waveforms and Muzzle Blast

1)



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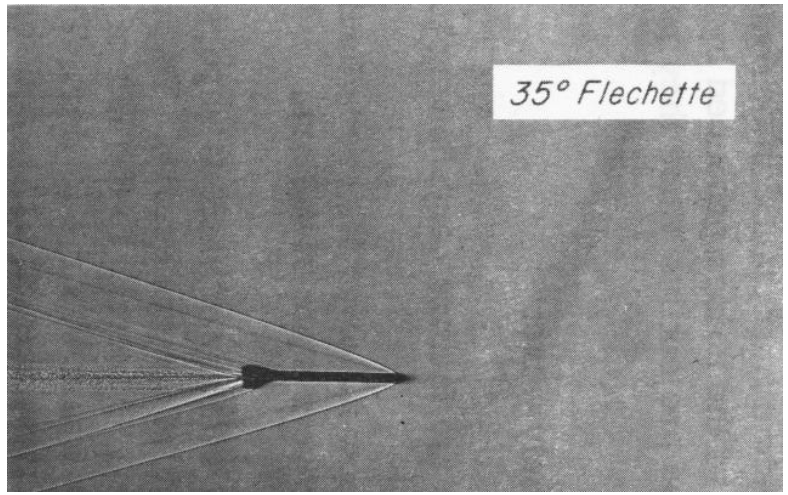
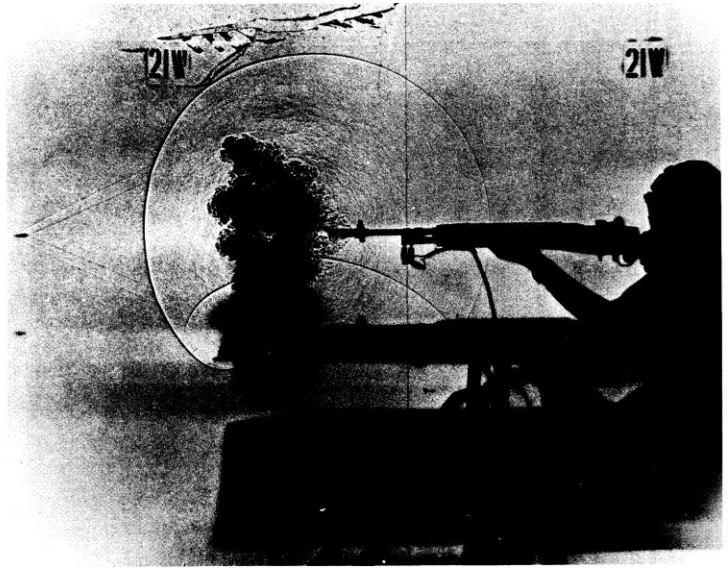


3)



Example Waveform Pictures

1) 7.62 mm Bullet N-Wave ~ 1.5c
2) 35° Flechette ~ 3c
3) Combined muzzle blast & bullet N-wave

Garinther, G., & Moreland, J. (1966). Acoustical considerations for a silent weapon system: A feasibility study. *Aberdeen Proving Ground, Maryland, USA*.

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Localization of shooter position based on weapon signature

Research on Auditory Impulse Detection

Law of the First Arriving Wave Front

Sound is localized on the direction of arrival of the first wave front.

1. Lindemann, W. (1986). Extension of a binaural cross-correlation model by contralateral inhibition. II. The law of the first wave front. *The Journal of the Acoustical Society of America, 80*(6), 1623-1630.
2. Bishop, C. W., London, S., & Miller, L. M. (2012). Neural time course of visually enhanced echo suppression. *Journal of neurophysiology, 108*(7), 1869-1883.
3. Blauert, J., & Braasch, J. (2005). *Acoustic communication: The precedence effect.* Paper presented at the Forum Acousticum.

Precedence Effect

First-arriving sounds have perceptual ‘precedence’. Echo sounds are suppressed in the inner ear and in the brain, to support perception of sound source toward the direction of the first arriving sound.

1. Wallach, H., Newman, E. B., & Rosenzweig, M. R. (1949). A precedence effect in sound localization. *The Journal of the Acoustical Society of America, 21*(4), 468-468.
2. Divenyi, P., & Blauert, J. (1987). On creating a precedent for binaural patterns: When is an echo an echo? *Auditory Processing of Complex Sounds*, 146-155.
3. Divenyi, P. L. (1992). Binaural suppression of nonechoes. *The Journal of the Acoustical Society of America, 91*(2), 1078-1084.
4. Brown, A. D., Stecker, G. C., & Tollin, D. J. (2015). The precedence effect in sound localization. *Journal of the Association for Research in Otolaryngology, 16*(1), 1-28.

Issue: Perception of real-environment stimuli (echoes) versus laboratory stimuli (clean clicks)

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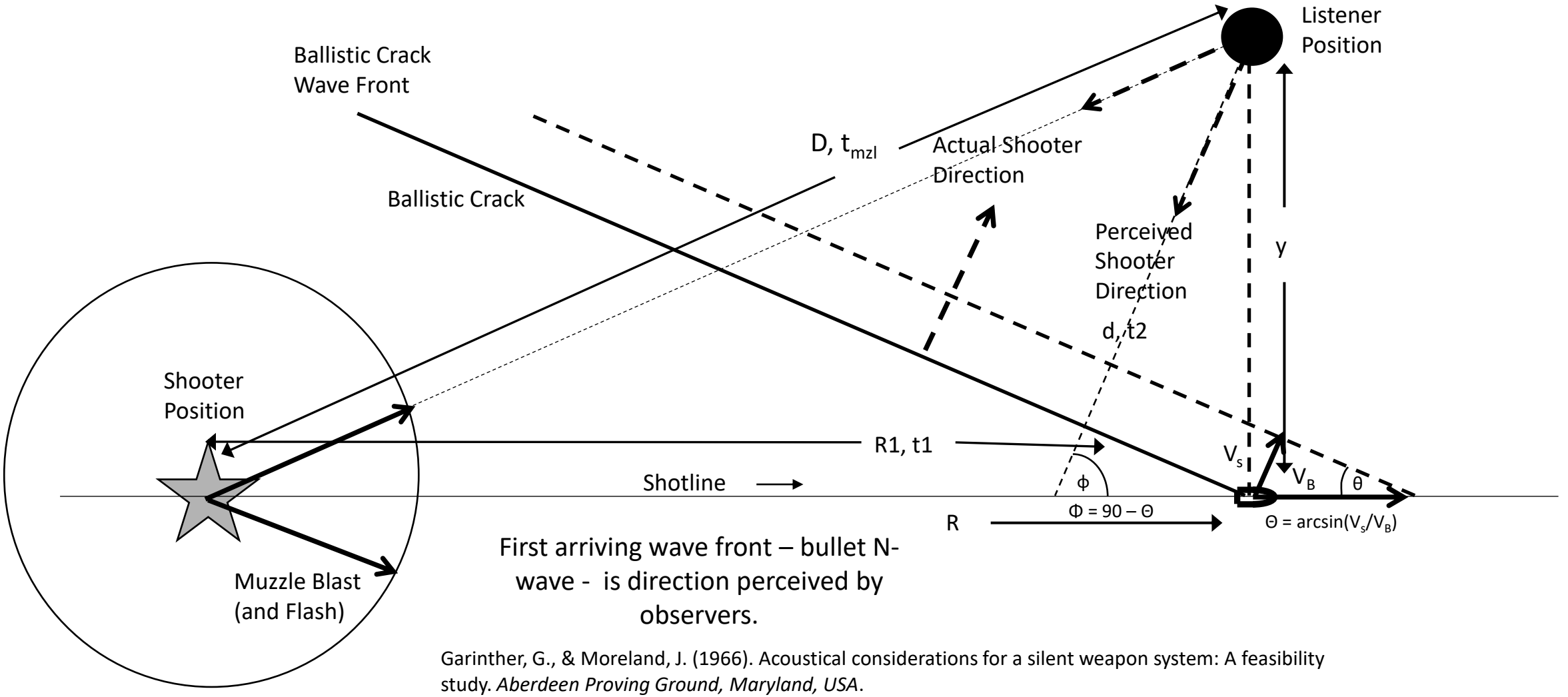
Localization of shooter position based on weapon signature

Auditory Stimuli Geometry – Bullet N-Wave and Muzzle Blast



First arriving wave front – bullet N-wave - is direction perceived by observers.

Garinther, G., & Moreland, J. (1966). Acoustical considerations for a silent weapon system: A feasibility study. *Aberdeen Proving Ground, Maryland, USA*.

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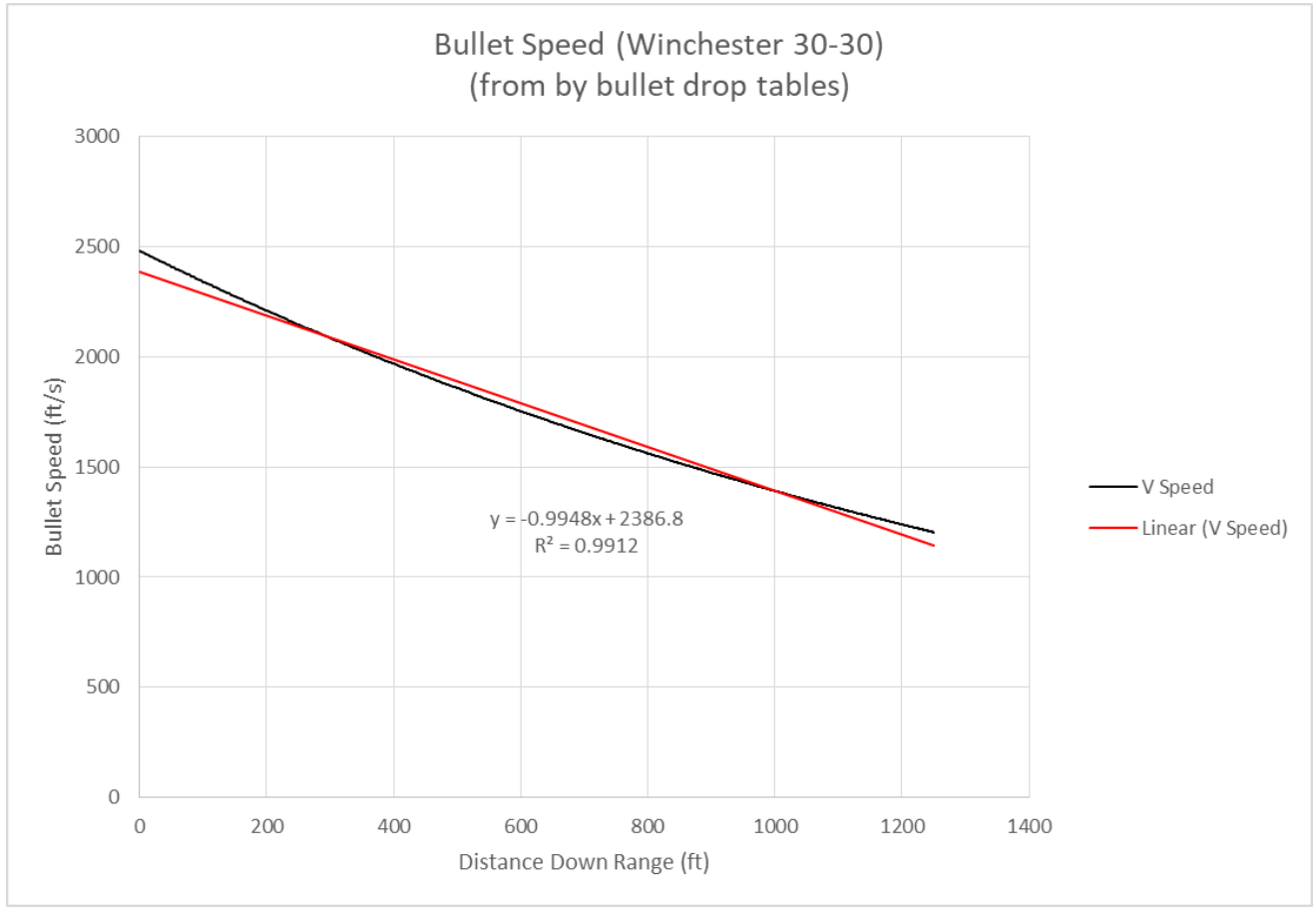
Localization of shooter position based on weapon signature

Bullet Trajectory Approximation – Linear Velocity Decrease with Distance



For bullet crack calculation, bullet speed versus range approximated by linear relation.

$$V(r) = V_0 - \alpha r$$

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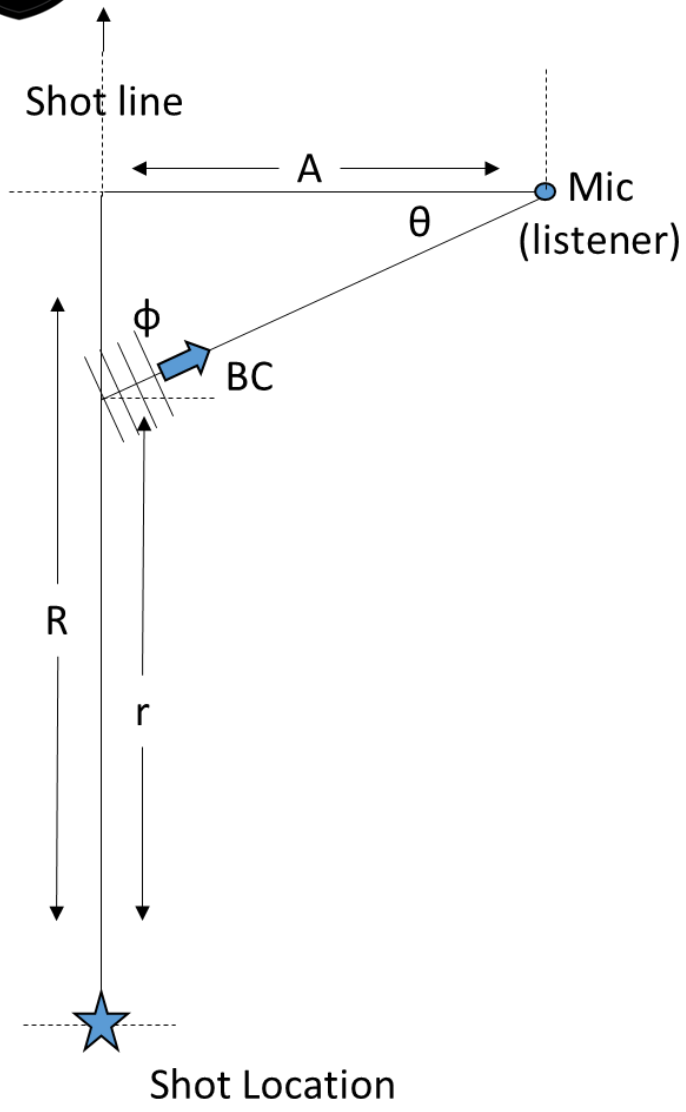
Localization of shooter position based on weapon signature

Auditory Stimuli Bullet N-Wave Arrival Direction



Variational Method

Approximate bullet speed linearly with range

$$V(r) = V_0 - \alpha r$$

Time to release of BC

$$t_1 = \frac{r}{V_0 - \frac{\alpha}{2} r}$$

Time BC reaches (R, A) down- across- range

$$t_2 = \frac{[(R-r)^2 + A^2]^{1/2}}{c}$$

Total arrival time of BC is

$$t_T = t_1 + t_2$$

Differentiate wrt r, set to zero, and obtain

$$r = R - \frac{A}{\left[\left(\frac{V_0}{c}\right)^2 \left(1 - \frac{\alpha r}{2V_0}\right)^4 - 1\right]^{\frac{1}{2}}}$$

Start with α = 0; iterate r to convergence.

Example – Win 30-30

V_0 = 756 m/s
(α = 0.9948 s^{-1})

	R (m)	400
	A (m)	100
	r first (m)	349.0985
	Tan(Theta)	0.509015
	Theta	26.97676
	Phi	63.02324
	r second	281.3911
	r-3	306.4368
	r-4	298.6842
	r-5	301.2338
	r-6	300.4113
	r-7	300.6783
	r-8	300.5918
	r-9	300.6199
(final)	r-10	300.6108
	Tan(Theta)	0.993892
	Theta	44.82449
	Phi	45.17551
view: x=0	intercept	-302.458

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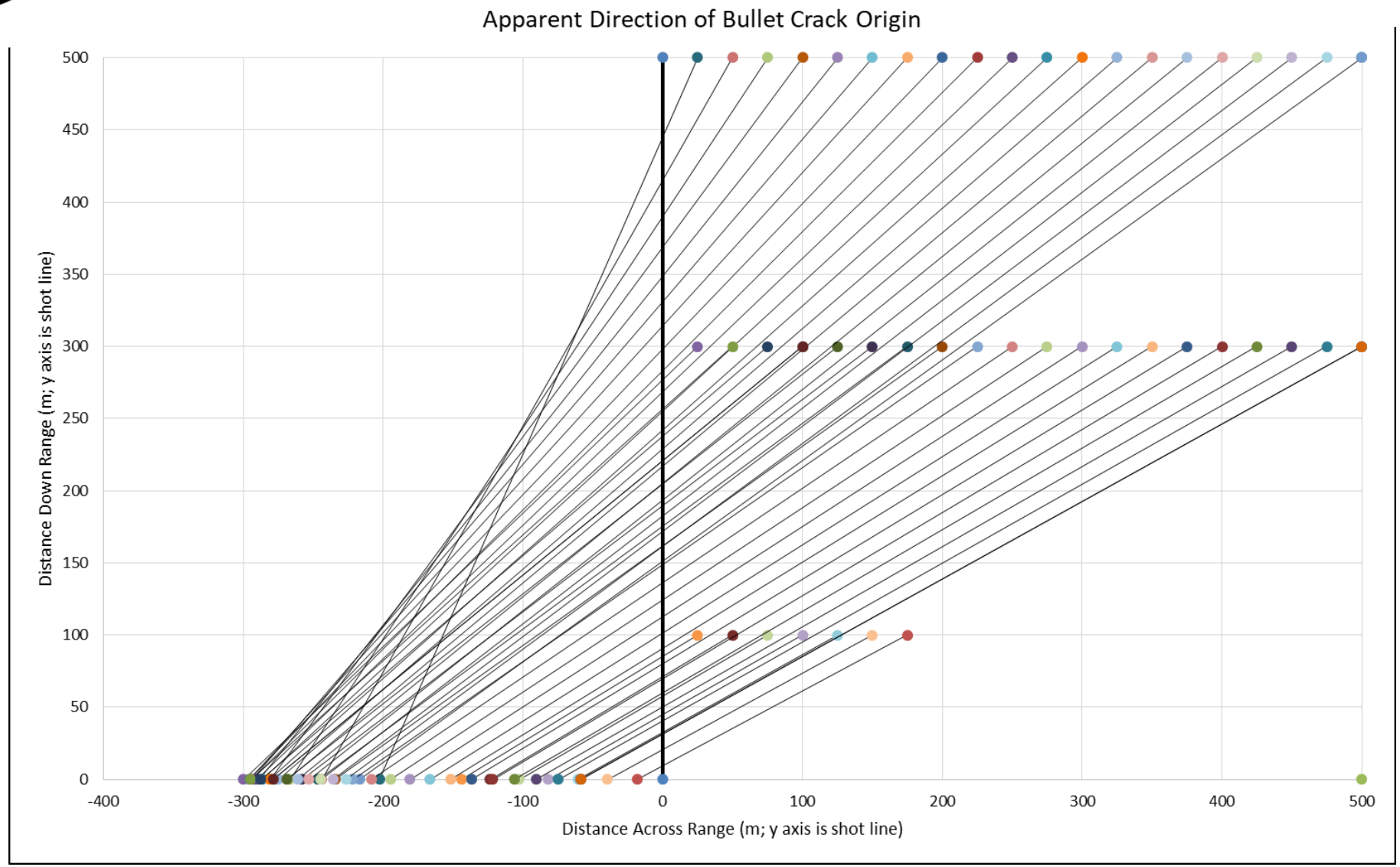
Localization of shooter position based on weapon signature

Auditory Stimuli Bullet N-Wave Arrival Direction



More detailed modeling, ARL Blast-Crack Model: Gregory S Oberlin, CIV USARMY DEVCOM ARL (USA)

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Localization of shooter position based on weapon signature

Observations from Research, Modeling, and Previous Field Studies (1966)

People hearing a ballistic crack often mistake it for muzzle blast.

(Garinther G, Moreland J. Acoustical considerations for a silent weapon system: a feasibility study. Army Research Laboratory (US); 1966.)

Suppressors will not attenuate bullet ballistic crack, but …

Arrival direction of the ballistic crack is not from the shot location.

- Direction is from across the shot line.
- Direction bends back as bullet slows down further down-range.

Ballistic crack, echoes, and muzzle blast suppression make it more difficult to localize shot position based on the auditory muzzle blast.

Auditory direction misperception can provide a basis for improving Soldier stealth.

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Localization of shooter position based on weapon signature

Directions for on-going field studies

Behavioral Validation of Perception Models

Flash visibility validation trials

- Multiple flash locations
- Weapon muzzle flashes and flash simulator flashes
- Night (dark) and day (light) conditions
- Suppressed and unsuppressed weapons

Auditory localization validation trials

- Trained and untrained observers
- Day (light) trials and night (dark) trials
- Multiple shot locations with ballistic crack design
- With and without false-flashes

Field behavior data is needed to adjust and validate research models.

Military tactical advantage analysis – L. C. (Cole) Cochran, USA MCDID CDD S&T, Ft. Benning.

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Localization of shooter position based on weapon signature

Questions?

Potential Soldier benefits from small arms suppressors

Presented material is available in ARL Technical Report 9277, August 2021 Approved for public release: distribution unlimited

Report also addresses concepts for

- Auditory Communication
- Auditory Environmental Awareness
- Hearing Damage Risk
- Potential Marksmanship Influences

U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – ARMY RESEARCH LABORATORY

Outdoor Acoustics

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Armaments Technology & Evaluation Division
Weapons Science & Technology Directorate

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BACKGROUND

- **Purpose:** Assess the near field and far field acoustics of small caliber weapons, suppressors and ammunition in a large, outdoor open field for application to detection models and other needs.
- **Location:** Army Research Lab, M-Range, APG, MD
- **Field Size:** 200 m x 600 m
- **Weapons:** Various
- **Muzzle Devices:** Suppressed and Unsuppressed
- **Instrumentation:**
  - *Microphones* - PCB microphones near gun and down range up to 400+ m from gun
  - *Data Acquisition* - Separate gun location and downrange location, NI Field DAQ, data acquisition systems time synced over a directional Wi-Fi network

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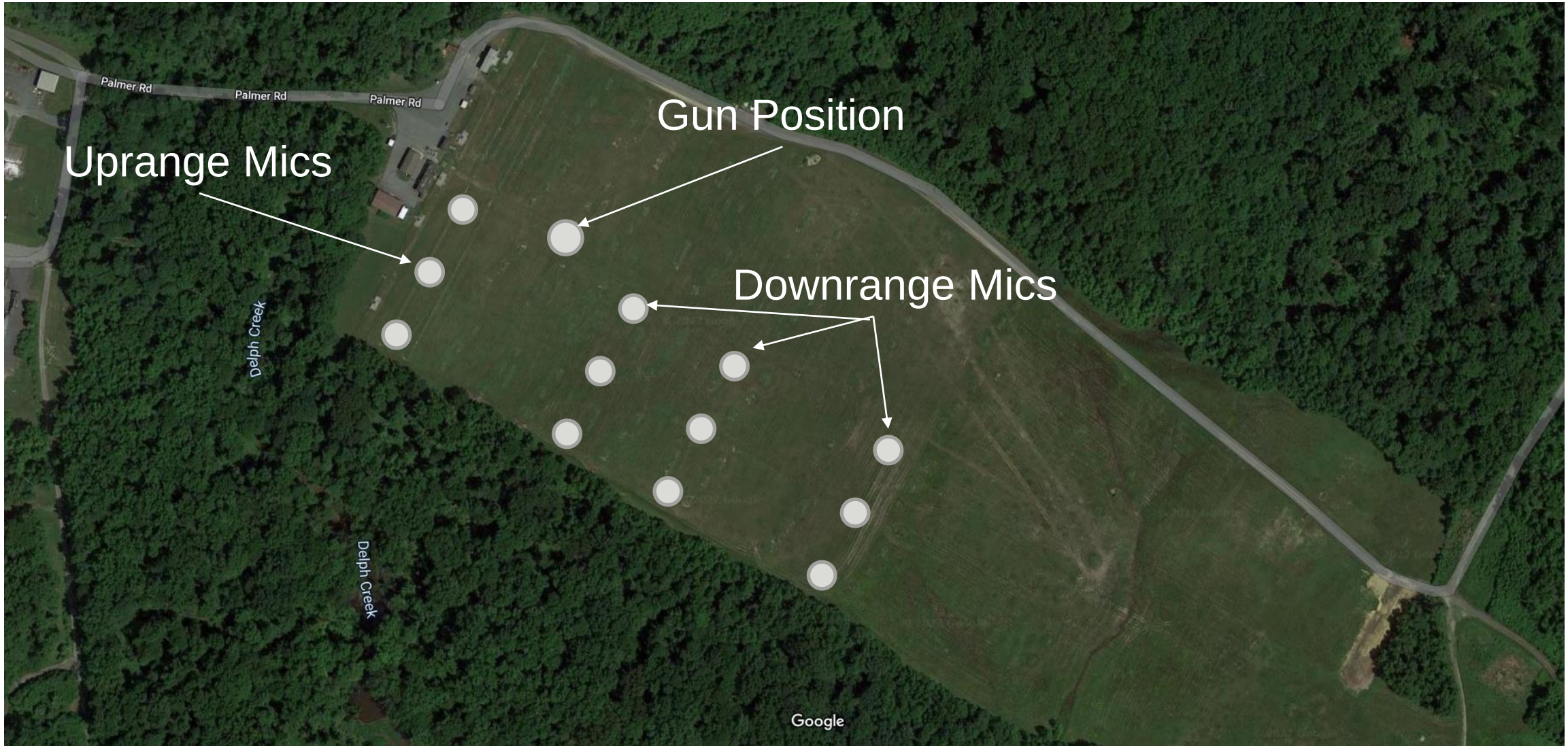
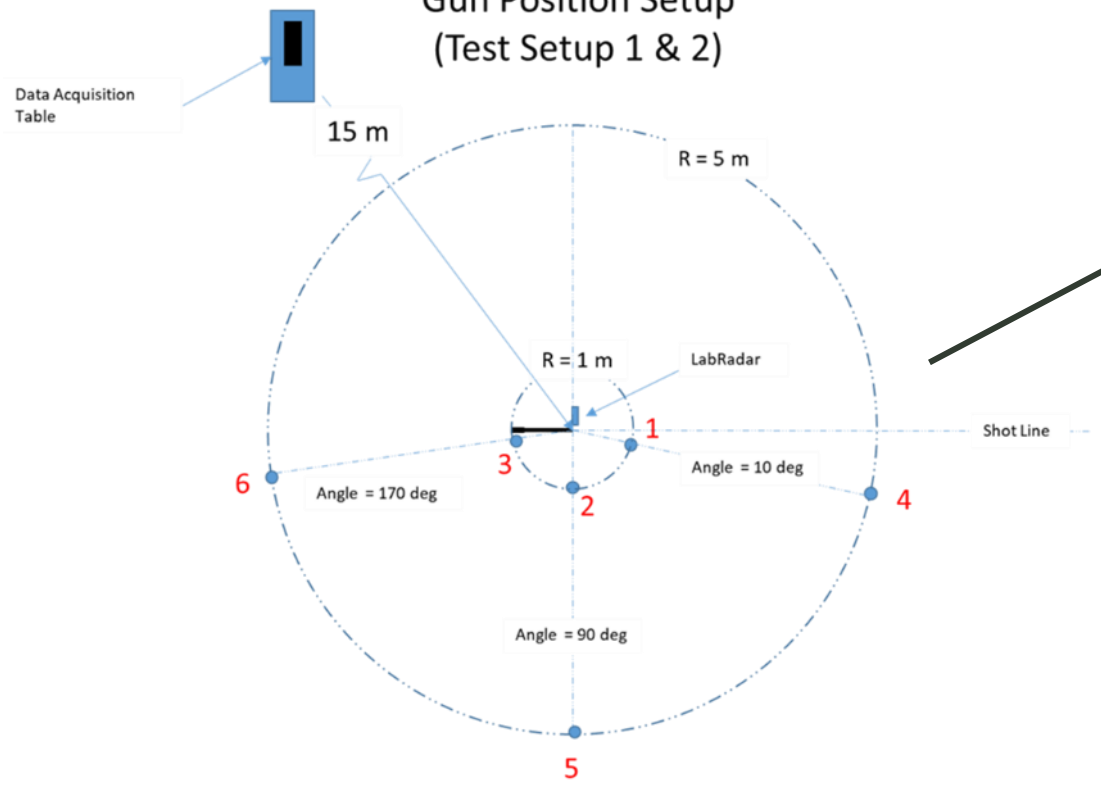
ARL M-RANGE - GOOGLE MAPS

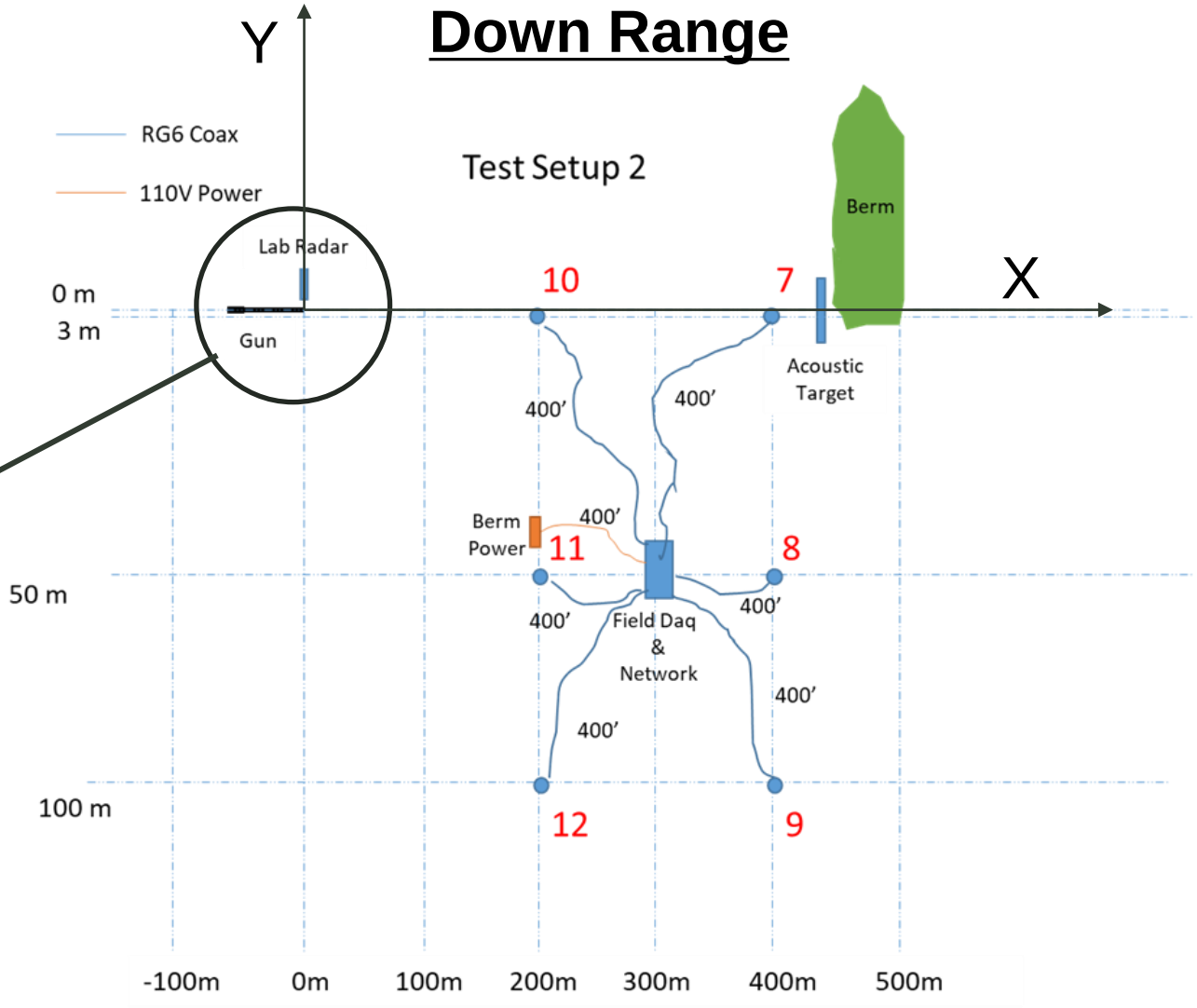


NEAR FIELD AND DOWN RANGE MICROPHONE LOCATIONS

Gun Location



Down Range



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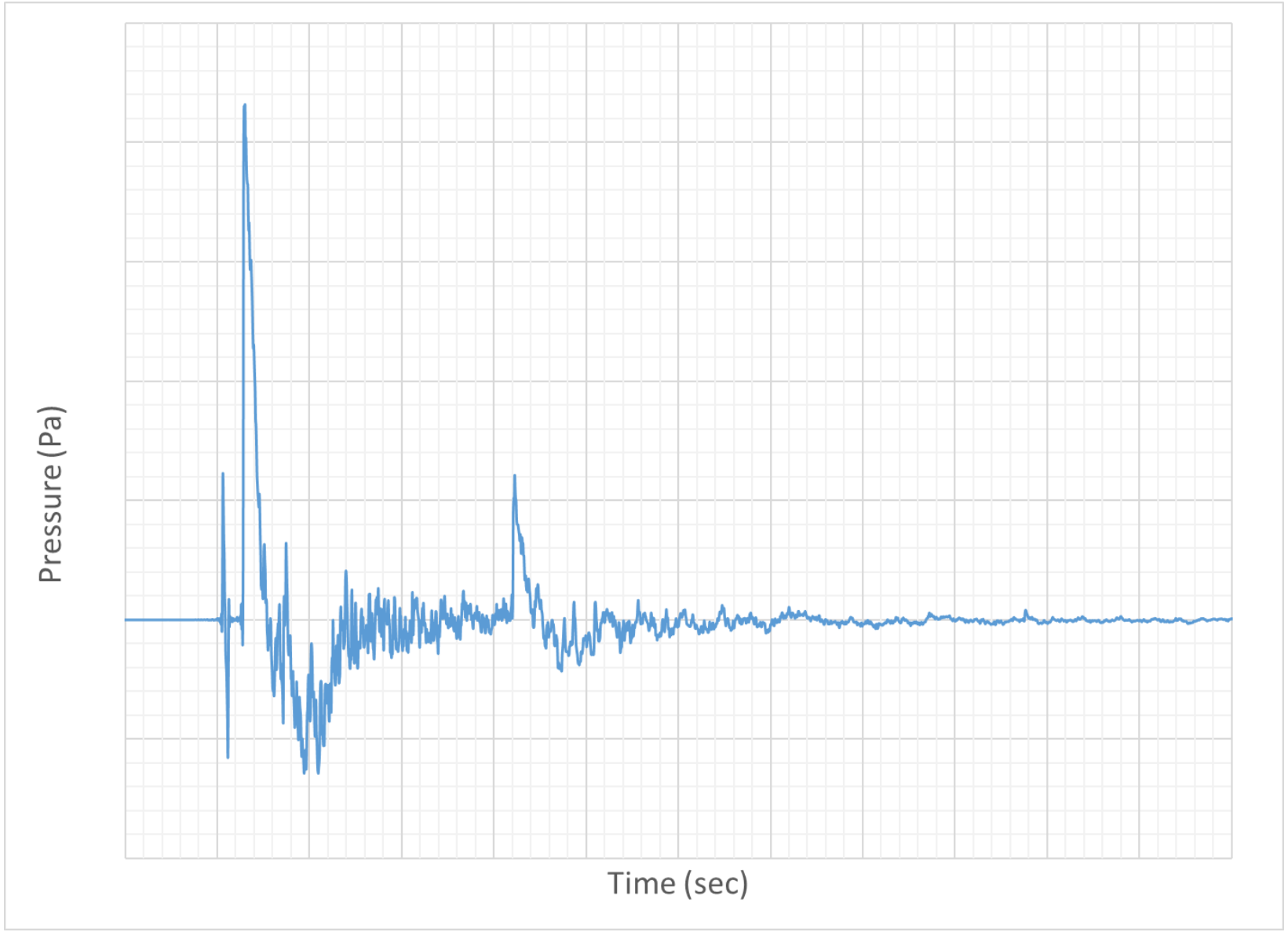
MICROPHONE SETUP

Gun Location

Down Range

GUN LOCATION EXAMPLE
PRESSURE AT 1M FROM GUN – 10 DEGREES OFF SHOT LINE



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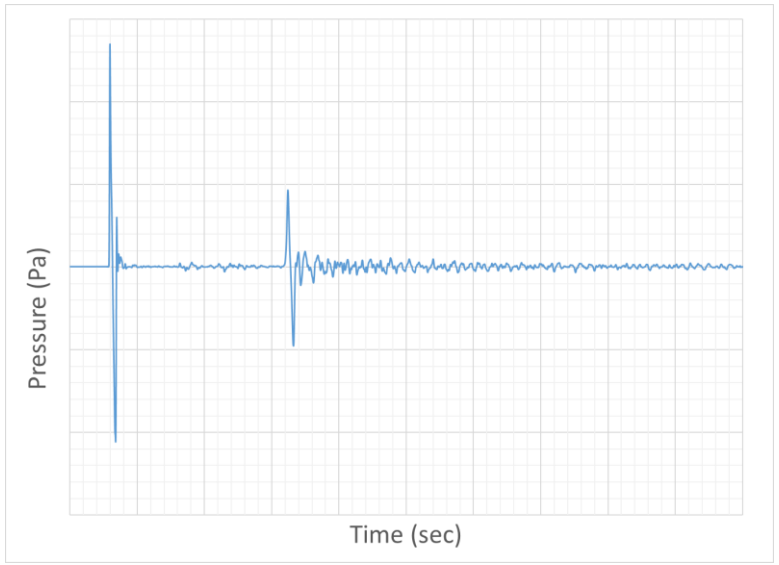
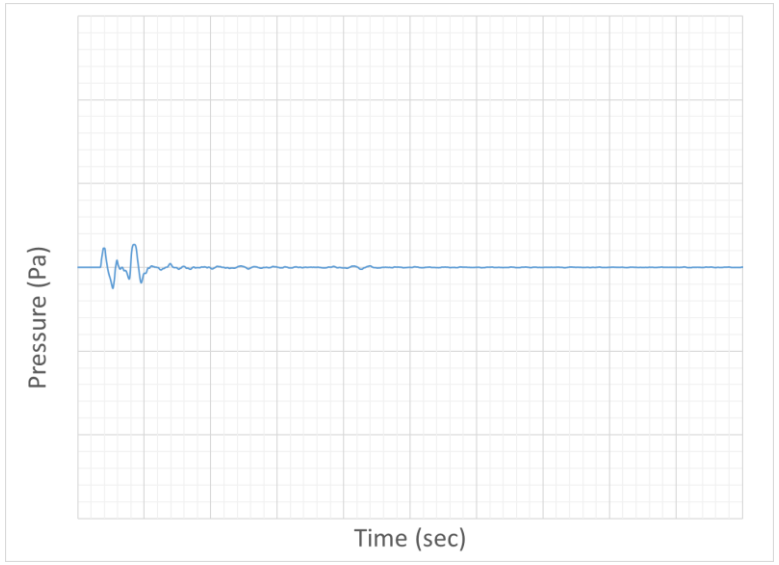
DOWN RANGE EXAMPLE
BALLISTIC CRACK COMPARISON

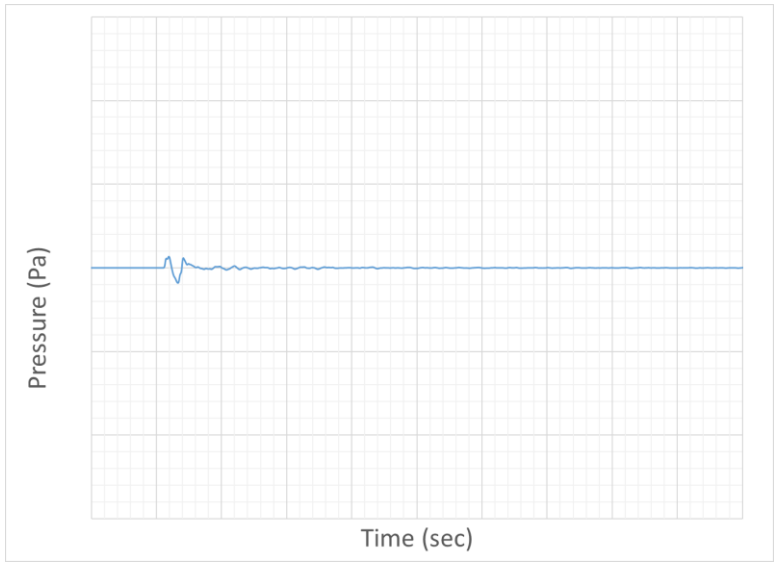
+200m, -3m



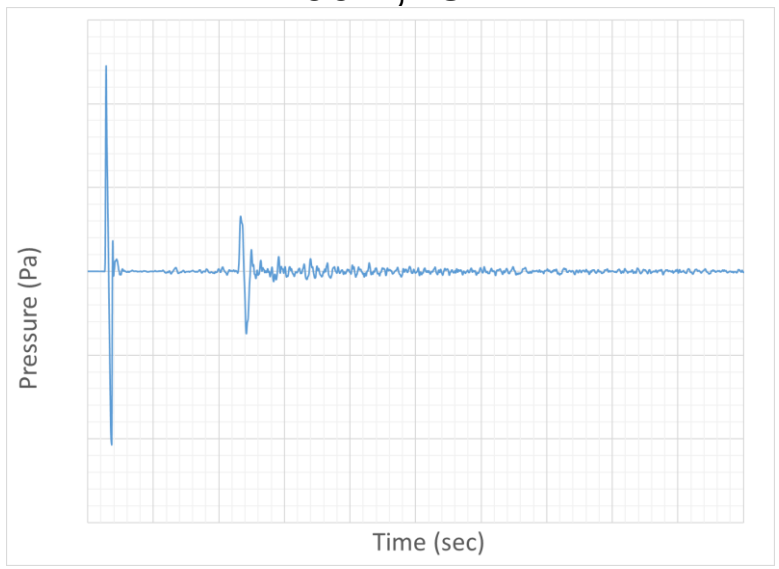
+200m, -50m



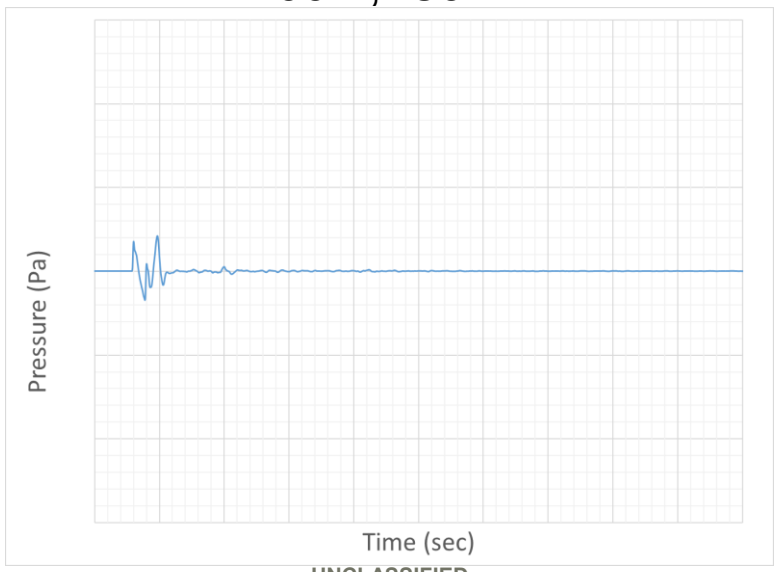
+200m, -100m



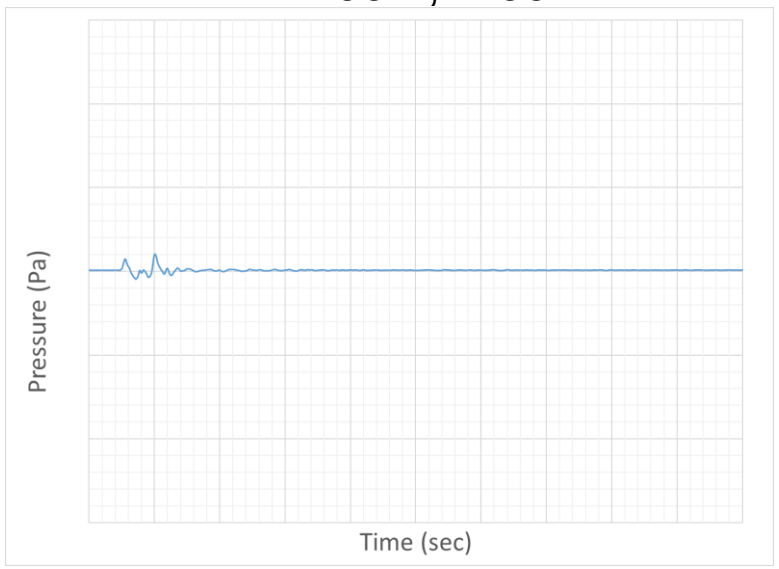
+400m, -3m



+400m, -50m



+400m, -100m



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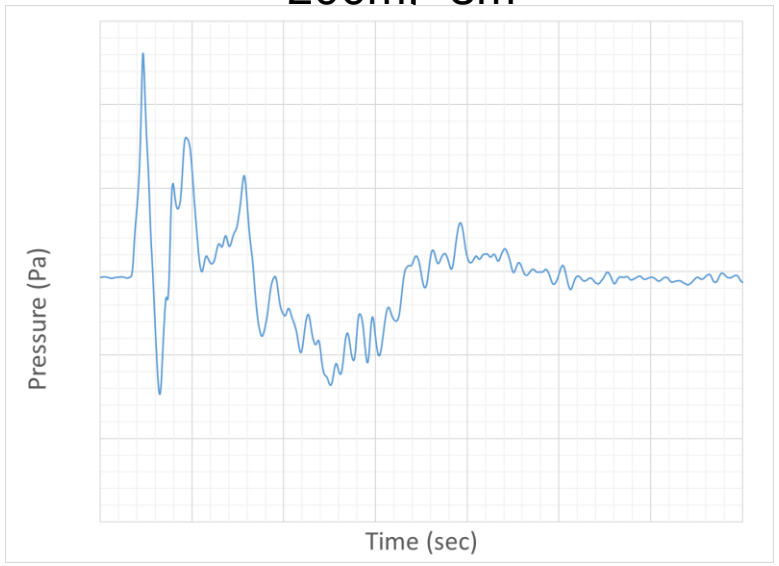
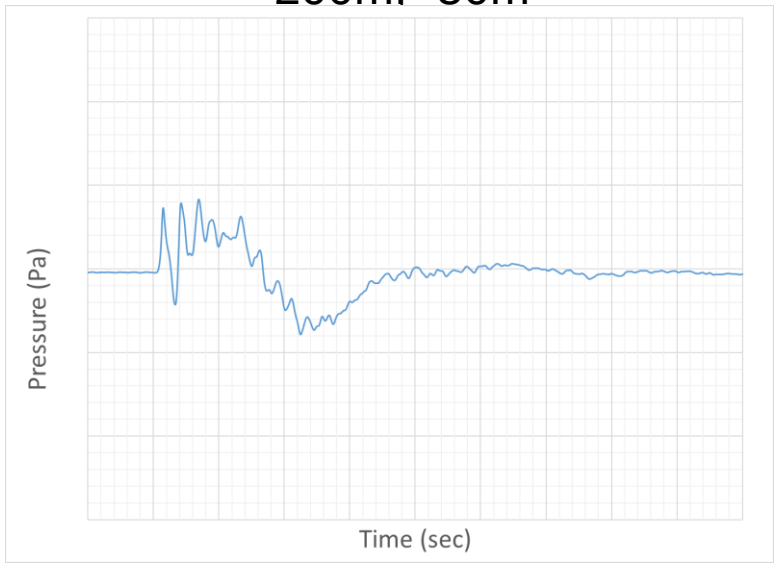
DOWN RANGE EXAMPLE

MUZZLE REPORT COMPARISON (SCALE - 20X LOWER THAN BALLISTIC CRACK)

+200m, -3m



+200m, -50m



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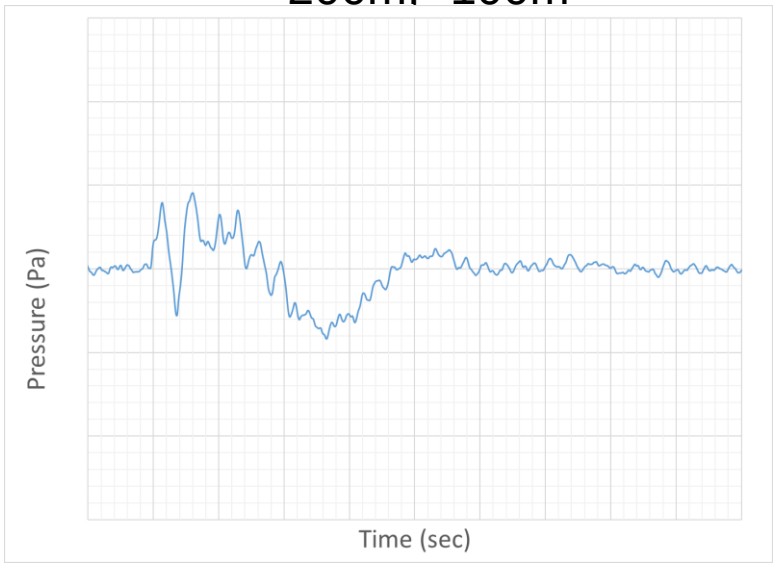

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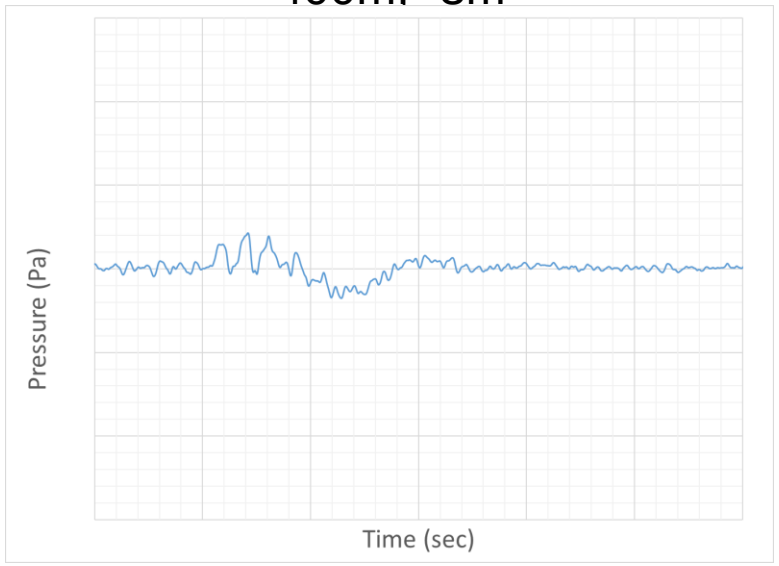
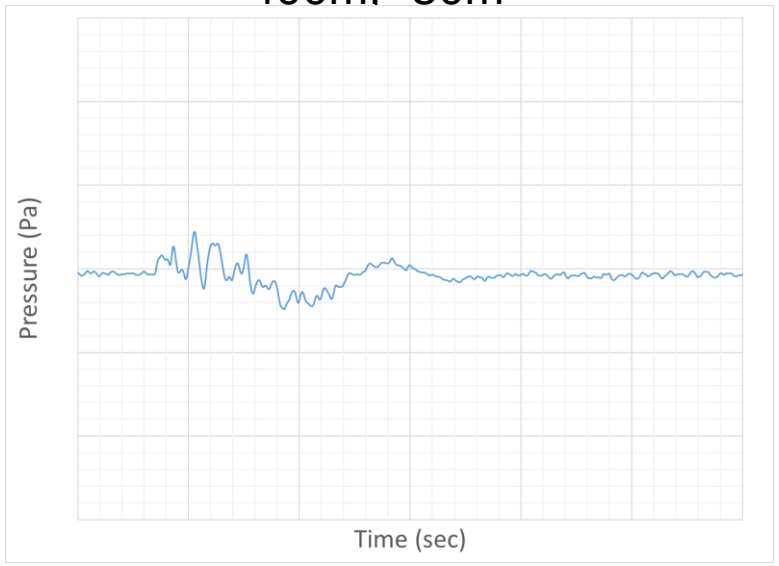
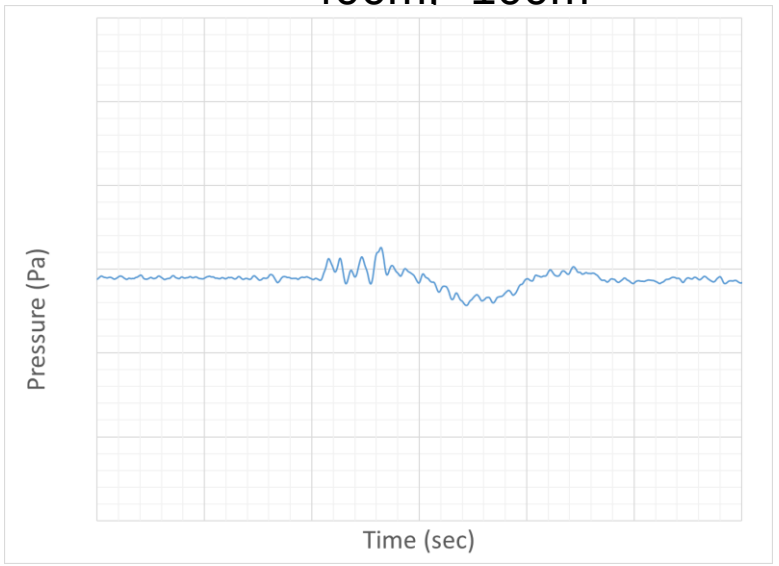


+400m, -50m



+400m, -100m



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CONCLUSIONS

- Time syncing down range and near gun data systems is difficult.
- Ballistic crack is order of magnitude higher pressure than muzzle report at 200 m or farther down range
- Significant delay (0.3-0.5 sec) in time was observed between ballistic crack and muzzle report (thump) at 200-400 m
- Type of testing has limited application but can help assess detectability of weapons at various locations
- Test provides measurements that help to validate the “Crack and Thump Technique” discussed in M14 / M14A1 Rifles – FM23-8 Rifle Marksmanship

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Infantry Platoon and Squad Tactical Advantage (Signature Management) Enabling Capabilities Assessment Process (ECAP) 21 September 2022

Author: Mr. Cole Cochran, MCDID
Briefer: Mr. Adam Jacob, JSSAP

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Tactical Advantage ECAP Background

- **What is ECAP:** Enabling Capabilities Assessment Process (ECAP) uses operationally informed systems engineering based analysis to examine current or projected capability gaps, decompose components of solutions, identify potential solution sets, and compare these needs to existing and projected technologies. *Minimizes Professional Military Judgement (PMJ)*
- ECAP initiated to provide analysis to explore S&T approaches to the creating tactical advantage problem.
- Previous, on-going and planned work by JSSAP provided valuable insight for desired future capabilities that assisted, but did not restrict the analysis.
- ECAP analysis took 9 months to complete (Nov 21-Sep 22).
- Threshold and Objective measures for some decomposition elements still need identification.
- Conducting surveys to provide more understanding of weighting of decomposition elements, and “tactical advantage” on-going.

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UNCLASSIFIED

Who was on the ECAP CCWS Team?

Regular participants:

- JSSAP
- SRD
- ARL
- CDD OE
- Armaments Center
- ERDC
- Soldier Center
- SL-CFT
- USAMED Public Health Center

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Problem Statement

How do Infantry and Weapons squads reduce or optimize weapon system signatures in order to gain tactical advantage against a near peer threat in all environments in 2028, and 2035 and beyond?

What is "tactical advantage?" In order to gain tactical advantage via weapon signature reduction is defined in three ways:

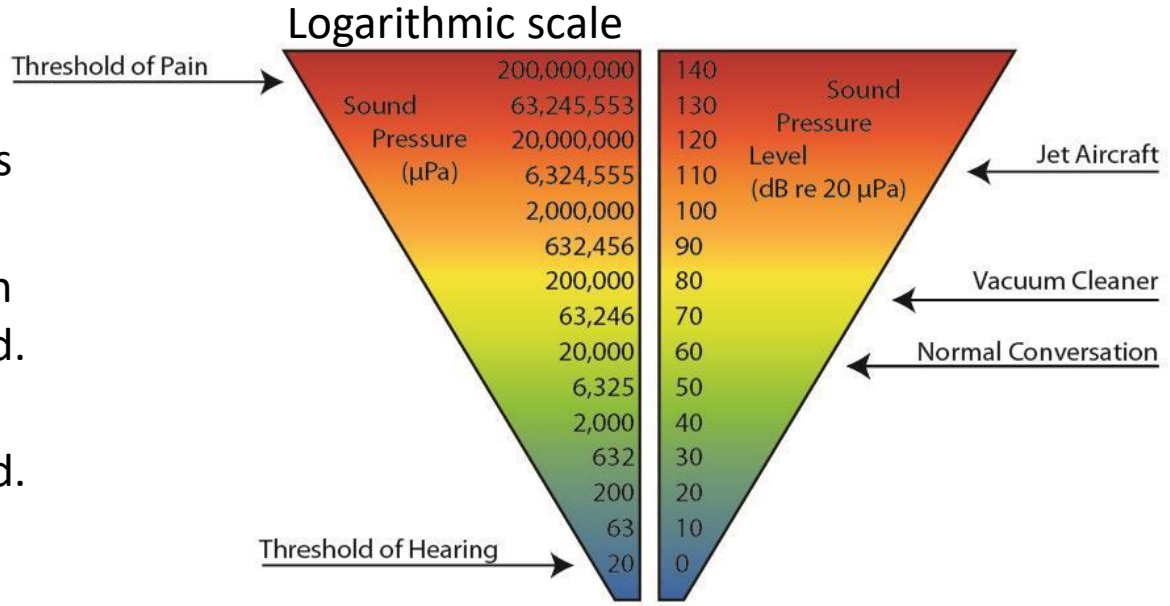
1. Longer time to locate the firing weapon by the person being fired upon results in more time to engage and cause casualties. This encompasses at least three elements: Supersonic wave, muzzle blast - sound made by the firing of the round, and light (visible and other) made by muzzle blast - the firing of the round.
2. Increased ability to command and control friendly forces.
3. Reduced hearing loss both short and long term to the Soldier.

Considerations are: Environmental conditions: jungle, wooded, urban, desert, wind, night or day (unaided and aided).

Infantry Platoon weapons – M4, M249 (SAW), M240, XM5 and XM250 (Next Gen Squad Weapon and Automatic Rifle)

Sound pressure levels

- We actually 'hear' things in decibels (which is pressure).
  - 0.000,000,003 psi = 0 dB
  - 0.03 psi = 140 dB
- A 10 dB increase is perceived as twice as loud.
- In real life, people generally can detect a 3 dB change in a sound.
- In a laboratory, someone can detect a 1 dB change in a sound.
- Single event (single shot fired): 140 dB Peak
- Steady state noise: 85 dBA steady level for 8 hours
- Automatic and multiple weapons fire presents a more difficult problem to analyze because it potentially combines single event noise and steady state noise



Example: Automatic weapon firing for 1 minute at 112 dBA is the threshold for damage to an unprotected ear

Analysis

- Developed understanding of the technical and medical aspects for supersonic crack, pressure/sound created by muzzle blast, and flash created by muzzle blast
- Able to identify <140 dB peak as the threshold for Soldier hearing damage
- <140 dB peak for muzzle blast is challenging @ 1m from the weapon
- <85 dBA as the threshold for Soldier hearing loss from steady-state noise
- Not able to determine if multiple firing events constitutes >85 dBA threshold problem
- Reduction of visible and IR flash are the most important factors in creating tactical advantage
- C2 of the unit is a close second important consideration – this includes Soldier SA
- Acoustic signature is less important than flash, difficult (but not impossible) to reduce to hearing safe levels
- Future Squad and Platoon weapons will increase the challenge because of a change in ammunition configuration
- Standardized methodology for sound and flash exist, however improvements for consistent application and methodology are on-going
- Correlation between standardized measurements and operational capability has not yet been established

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Decomposition Categories and Sub Elements

- **Signature Reduction/visible light and across EM Spectrum** (37.4%)
  - Flash (visible)
  - Flash (Infrared)
  - Thermal signature Black-body radiation
  - Disturbed earth/ground
  - Heating of weapon connected devices interfering with target acquisition
- **Command and Control of Unit** (35.9%)
  - Unit leaders effectively communicating verbally
  - Unit leaders effectively communicating visually
  - Soldiers able to detect location of incoming fires
  - Soldiers able to monitor external environment for SA
- **Noise Reduction/Acoustic Signature (Ability to Locate Source of Fire)** (15.8%)
  - Supersonic crack
  - Subsonic noise
  - Muzzle blast
  - Bullet impacting downrange
  - (can noise be produced that cause enemy confusion?)
- **Reduce Hearing Loss** (7.5%)
  - Single event
  - Repetitive event
- **Other** (3.4%)

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Conclusions and Recommendations

- Initial analysis leads to the conclusion that signature suppression provides tactical advantage: increases Soldier lethality and survivability, increases C2, and reduces hearing loss
- Operational context is needed to measure the necessary reduction of sound and flash to judge tactical advantage
- Surveying Soldier experience to confirm/modify weighting and measuring tactical advantage is important – lots of Soldier experience in combat with these technologies
- Industry provided suppressor technology can meet current the threshold requirements for both sound and visible flash decomposition elements
- Correlation between standardized measurements and operational capability are needed in order to inform emerging and future signature requirements
- Combined dB peak and dBA in an operational environment needs study
- Further work to provide hearing protection that does not interfere with C2 and Soldier/leader situational awareness is needed

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U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – ARMY RESEARCH LABORATORY

High-Temperature Evaluation of Suppressor Covers

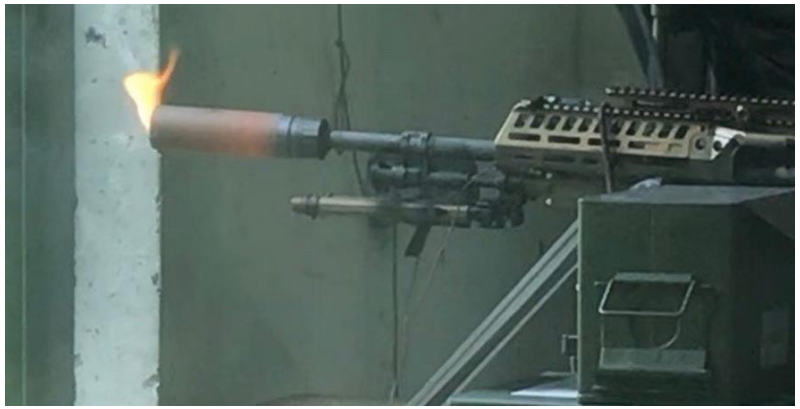
Dan Baechle, daniel.m.baechle.civ@army.mil, 410-306-0721

Composite & Hybrid Materials Branch

Approved for public release: Distribution is unlimited

Objective

- **Next Generation Squad Weapon will feature suppressor by default**
- **Suppressor gets extremely hot, can cause mirage, burns, toxic fumes**
- **Investigate commercial & ARL-developed suppressor covers for potential use**

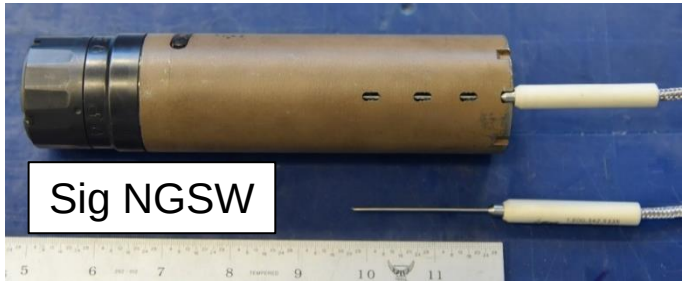


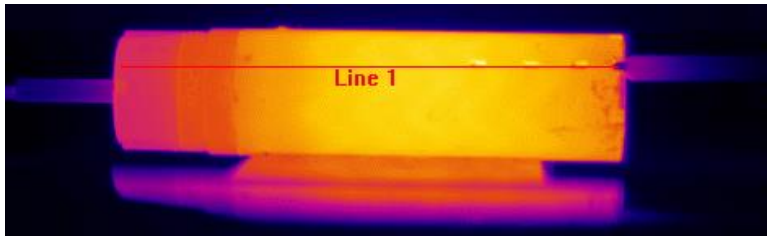
XM250

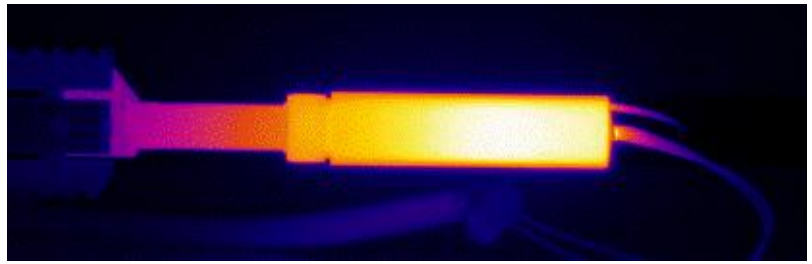
XM5

Heat Simulator

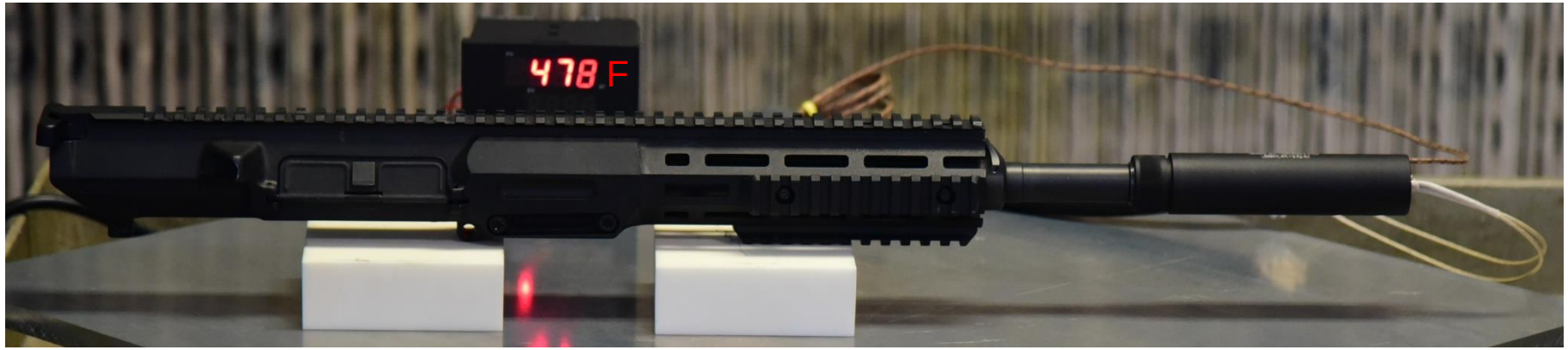
- **Closed-loop system can heat suppressor & barrel separately**
- **Cartridge heaters: 0.247” diameter, up to 7” long, 600 W**
- **Thermocouple inserted into suppressor**



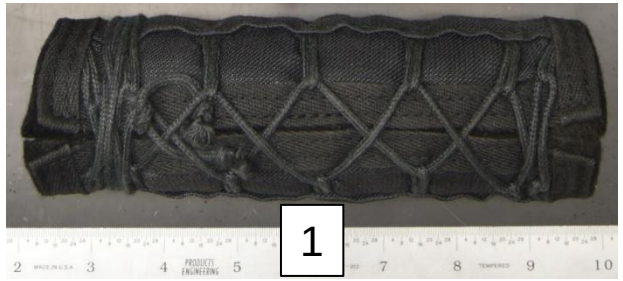


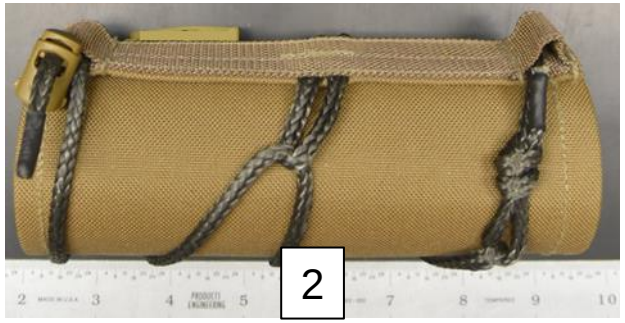


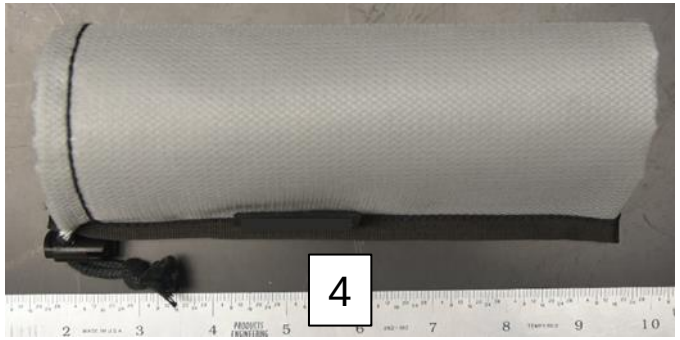
Rapidly test different thermal solutions on different weapon systems without ammo, range time



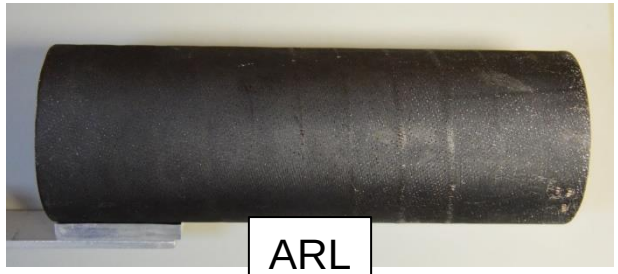
NGSW Candidate Covers

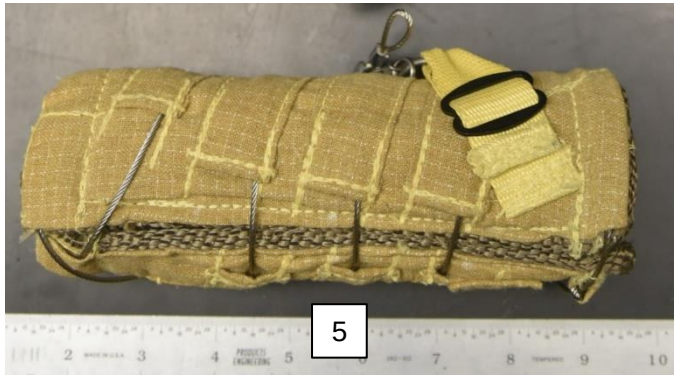


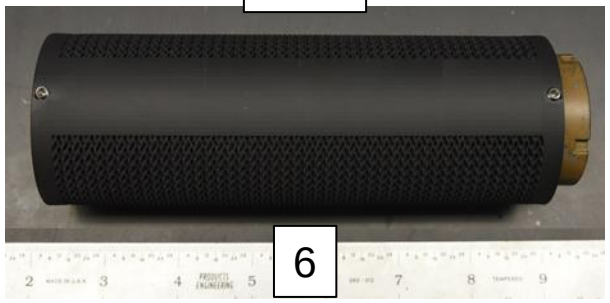




Manufacturer	Mass (g)
1	43.5
2	213.0
3	112.9
4	61.3
5	219.7
6a	103.0
6b	76.2
6c	60.8
ARL	212*
ARL 3	145**



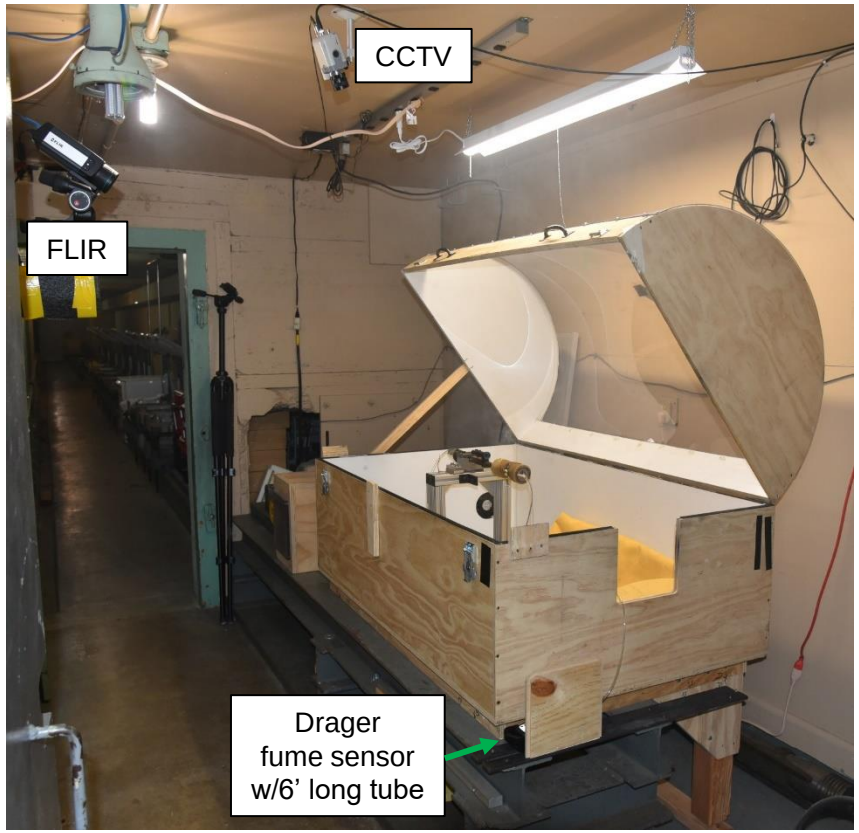




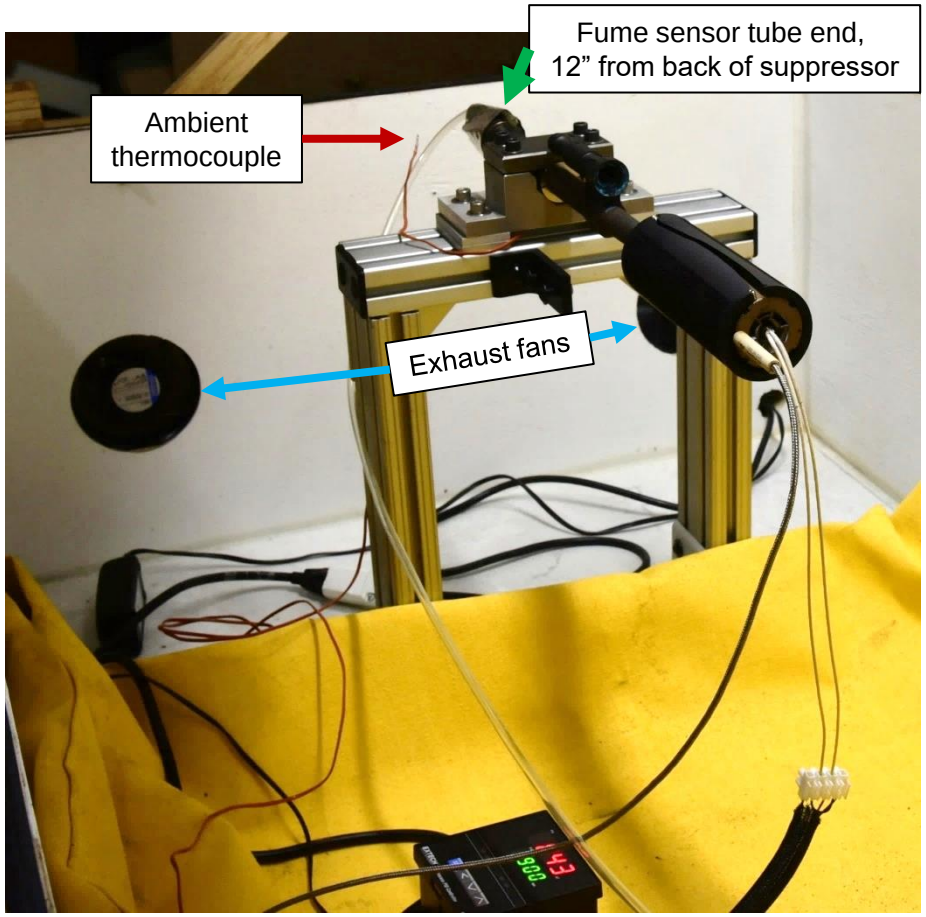
Broke apart during heat up

To fit AR: *229g, **172g, since longer mounting arm is needed.
Design is not yet optimized.

Test Setup



- **Fans create ~1mph flow under suppressor when box closed**

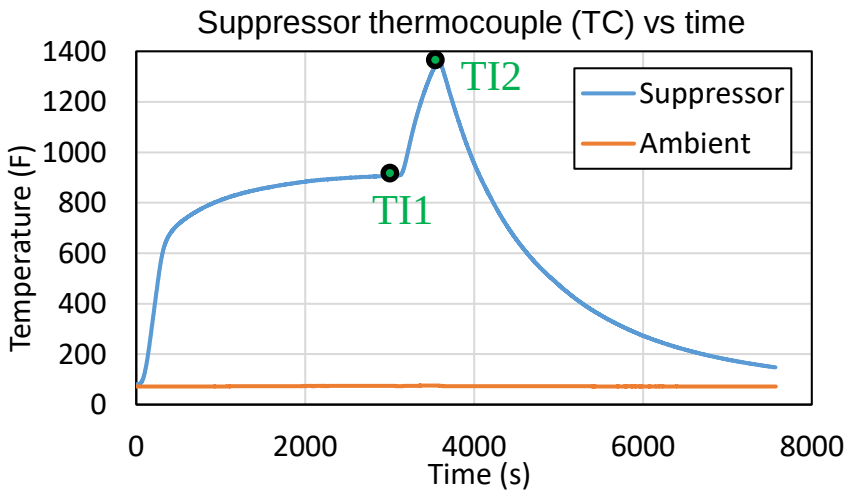


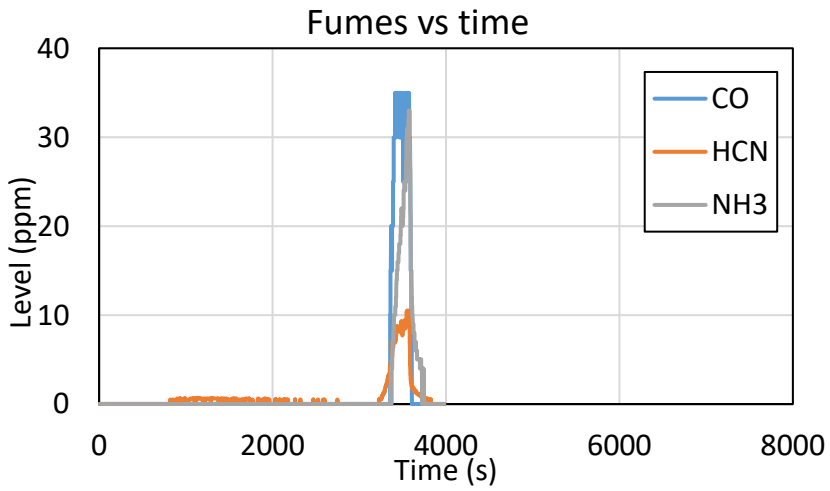
- **Drager records fumes for duration of test**
- **FLIR 655sc, 58" from suppressor**

Procedure

- **Determined heat levels that produce 500 F and 900 F with bare suppressor**
  - 500 F = “Mid power”, 900 F = “High power”
- **Apply those heat levels to suppressor with each cover**
- **Record suppressor internal temperature (TC), cover external temperature (FLIR), fume levels**
- **FLIR thermal images at Mid power (TI1) and High power (TI2)**
- **Stop test if 1350 F reached, or if cover catches fire**
- **Record cool-down time**

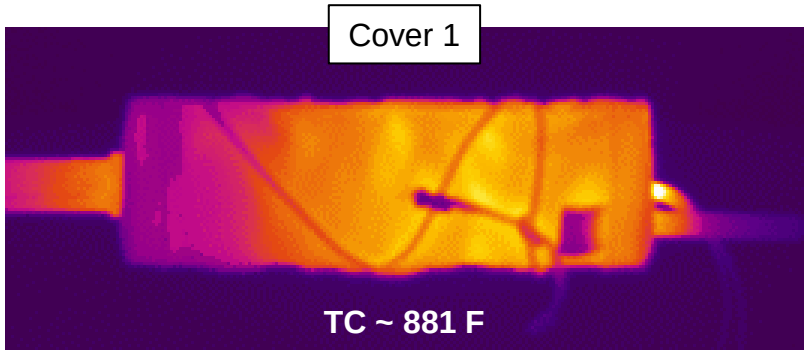
Example temperature & fume data

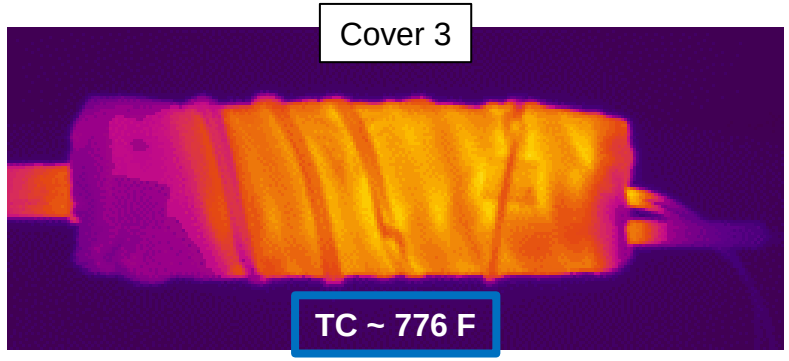


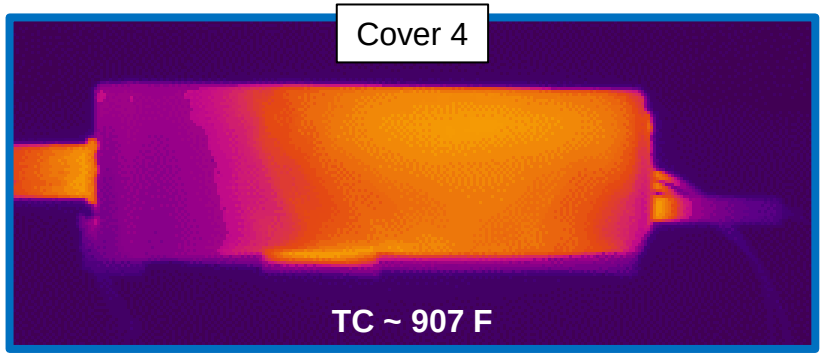


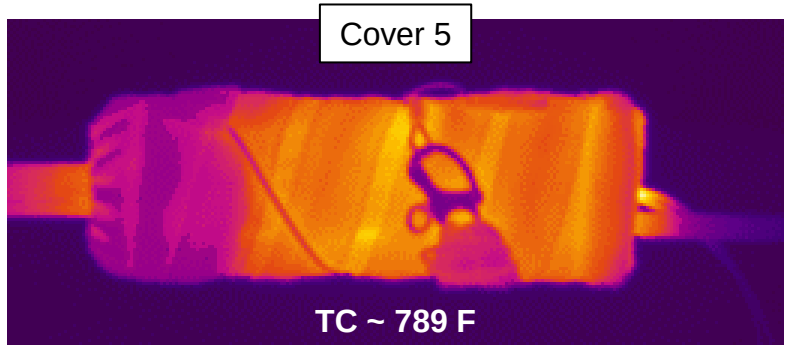
Constant Power: Mid-level

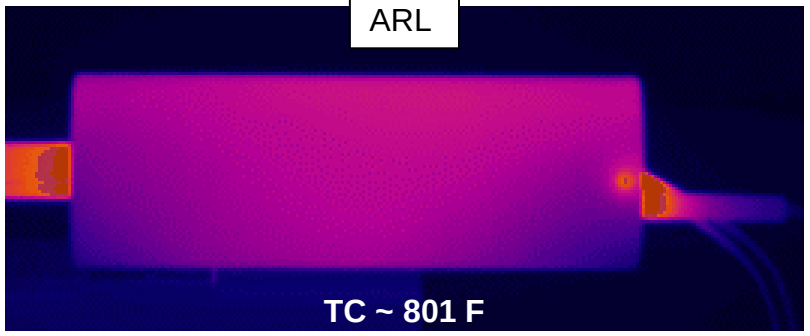
Power set to recreate 500F without any cover.

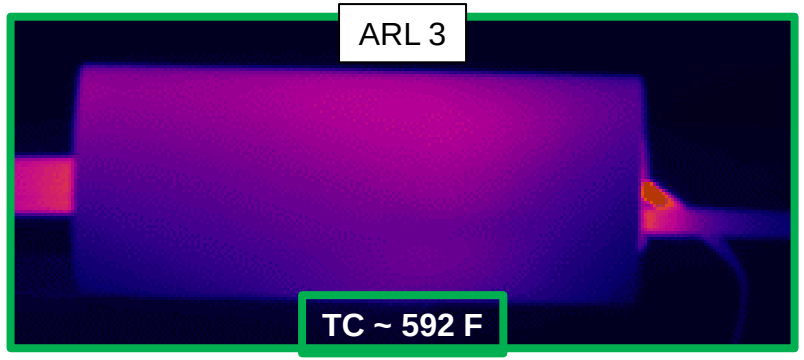










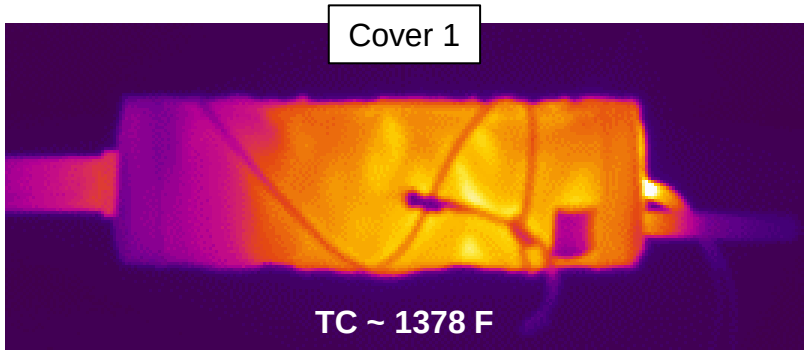


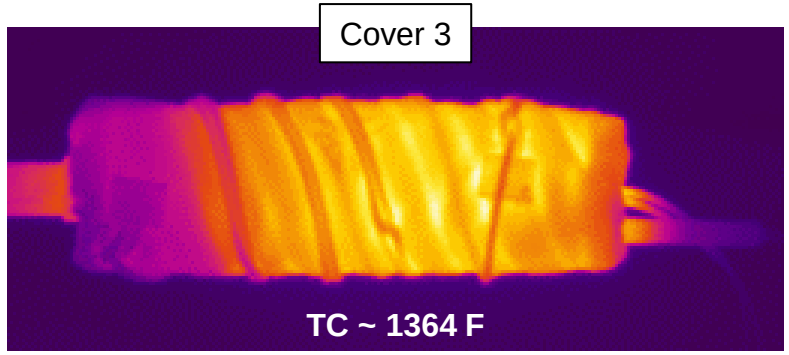
ARL exterior 98-123F cooler (avg) than commercial covers

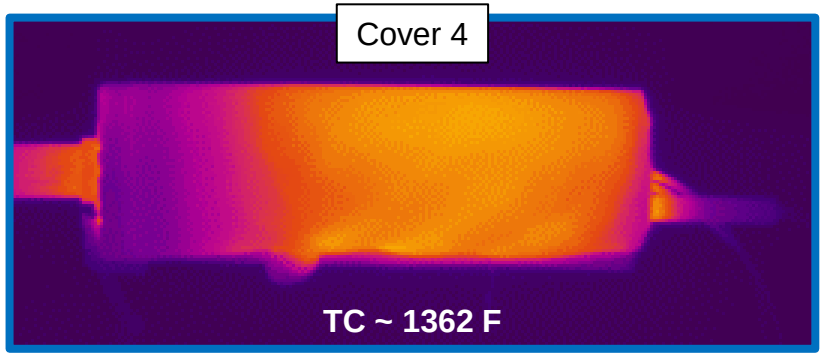
ARL3 exterior 130-163F cooler (avg) than commercial covers

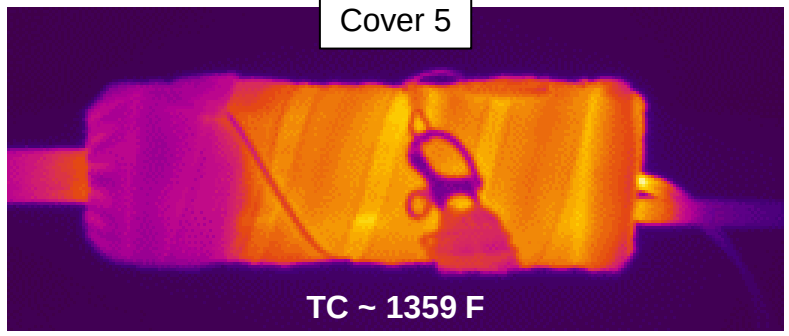
Constant Power: High-level

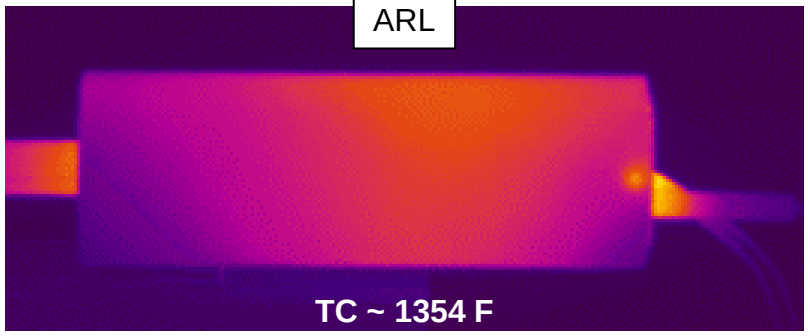
Power set to recreate 900F without any cover. Shut off power at 1350F

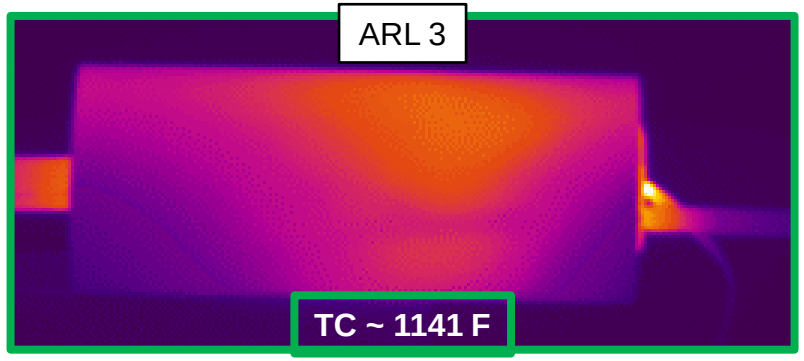












ARL exterior 97-175F cooler (avg) than commercial covers

ARL3 exterior 111-188F cooler (avg) than commercial covers

Results

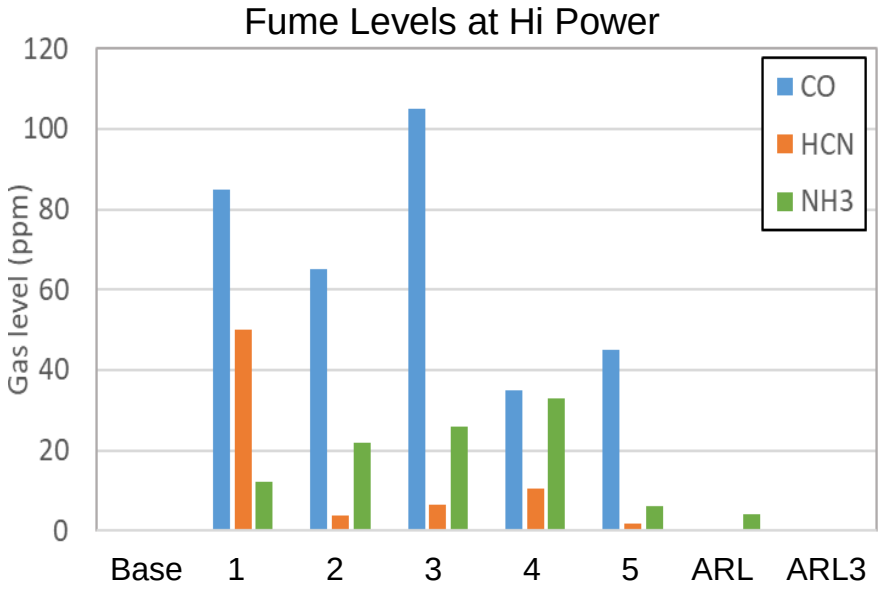
Condition	Mid power Max TC Temp (F)	Hi power Max TC Temp (F)	Mid power (ppm) CO	Mid power (ppm) HCN	Mid power (ppm) NH3	Hi power (ppm) CO	Hi power (ppm) HCN	Hi power (ppm) NH3	Cool to 160F from hi-power
Baseline	501.3	904.5	0	0	0	0	0	0	22m36s
1	881.4	1378.6	0	3.6	0	85	50*	12	56m9s
2	~~746.4~~	1358.2	0	1.3	0	65	3.9	22	N/A
3	776.5	1364.0	0	0	1.5	105	6.5	26	58m2s
4	907.5	1362.2	0	0.5	0	35	10.5	33	62m25s
5	789.6	1358.8	0	0	0	45	1.9	6	57m44s
ARL	801.5	1354.3	0	0	0	0	0	4	59m1s
ARL 3	592.5	1141.0	0	0	0	0	0	0	39m8s

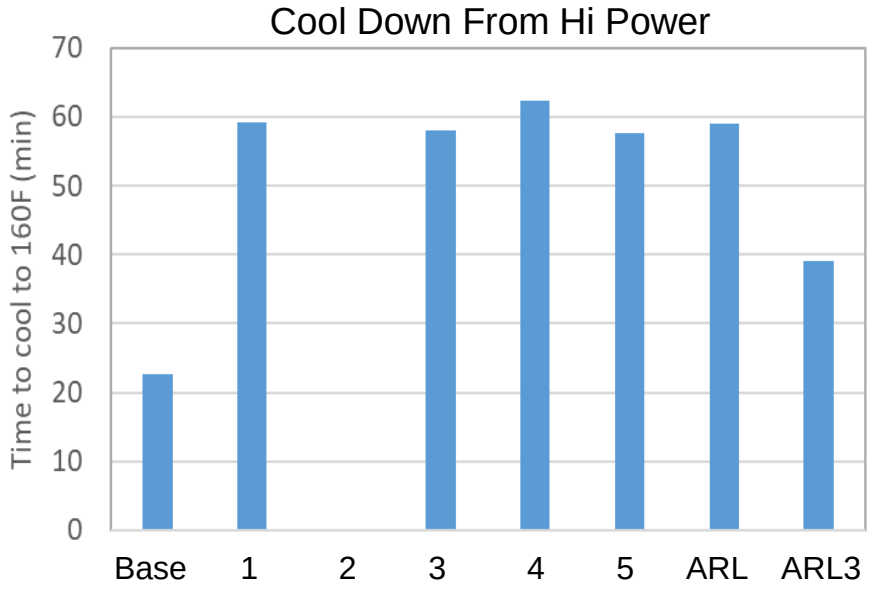
Test stopped before max temp

*1 maxed out HCN sensor

Best

Best commercial





Conclusion & Future Work

- **Demonstrated heat control system for small arms testing**
- **Best cover will depend on priority of weight, fumes, $$, ext & int temps**
- **Test commercial cover similar in design to ARL's**

ARL cover

- **Improve design for thermal management**
- **Durability testing**
- **Live fire testing; likely with 7.62 mm surrogate rifle**

ARL suppressor covers on Sig NGSW weapons

SOLVING WEAPONS SUPPRESSION CHALLENGES
WITH
MULTI-FLOW PATH FLOW-THROUGH
AND
REVERSE FLOW DESIGNS

X2 DEVELOPMENT GROUP, LLC
ERNIE BRAY – CEO

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NDIA
FUTURE FORCE CAPABILITIES CONFERENCE 2022

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CURRENT WEAPONS SUPPRESSION ISSUES

- Most suppressor designs are driven by consumer market dynamics and considerations = Performance for military applications is often compromised
  1) "One size fits all" – consumer suppressors must work on a wide array of weapons and ammunition. Optimized for none – compromised on all
  2) Extreme emphasis on decibel reduction at the expense of *all* other metrics
  3) Lack of required design and engineering expertise
  4) 100+ years of trapping designs and simple flow – coax bypass designs (follow the leader)
     Email me for whitepaper: "*The Coaxial Suppressor: Evolution, Design Analysis and Prior Art 1890's to The Present" -- by Neil R. Parker*
  5) Designs and manufacturing engineering not focused on meeting military suppression requirements
  6) Many military goals and requirements go unmet

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WEAPONS AND MISSION FOCUSED PERFORMANCE METRICS

- Suppressor should be benign and not negatively effect weapon's operational reliability without requiring gas regulation for suppressed operation
- ***It doesn't matter how quiet a suppressor is, if reliability, muzzle flash, toxic gas, thermal signature etc. metrics aren't met***
- **KEY SUPPRESSION METRICS:**
  1) Backpressure and Blowback = Operational Reliability and Toxic Gas Blowback
  2) Flash Suppression
  3) Point-of-Impact (POI) Shift
  4) Consistent performance across service life (Carbon loading and erosion)
  5) Thermal Signature
  6) Size and Weight
  7) Service life and user serviceability (100k plus rounds)

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SUPPRESSORS SHOULD BE WEAPONS OPTIMIZED WITH MISSION-DRIVEN PERFORMANCE METRICS

- **LEGACY TRAPPING DESIGNS:**
  - Have high pressure differentials – gases are accelerated during blow-by up to several mach. This *increases heat and wear significantly!*
  - Lack of circumferential flow cores and efficient bypass flow leads to *rapid carbon loading*
  - Need to be *longer and heavier to achieve a high level of sound reduction*
  - Few are optimally effective in both *subsonic and supersonic flow regimes*
- **ADVANCE FLOW DESIGNS must adhere to core suppression and flow dynamics principals:**
  - Effectively expand, slow and cool gasses = High degree of thermal and suppression efficiency
  - Optimal balance of open volume and metal heat transfer surfaces
  - Gas flow efficiency = *Use of flow directing structures* to efficiently direct gasses and balance pressure
  - Optimize initial pressure blowdown, use progressive gas clamping and minimize pressure stacking to meet the weapons system and mission requirements

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OPTIMIZING SUPPRESSORS FOR WEAPONS SYSTEMS AND MISSION REQUIREMENTS

- Multi-Flow-Path™ and Reverse Flow™ = Designed to meet these optimization challenges
- Blowdown must be matched to:
  - *Operating system, barrel length, ammunition, exit pressure, gas volume and un-burnt propellant*
  - *With sufficient blowdown, an active scavenge effect is possible = reduced weapons cleaning*
  - *Multiple controlled flow paths required to optimize/balance blowdown and sound signature*
- Multi-Flow-Path™ allows for highly flexible gas clamping = progressive and variable clamping
  - *Tailor sound signature to mission requirements- Multiple exit flows reduces sound signature*
  - *Flash Suppression: Distributed gas flow exit timing reduces the chances of Mach disks forming outside the suppressor – Combined with end cap venting can virtually eliminate all flash*
  - *Use of flow directing elements move gasses through the desired flow paths.*
  - *Allows suppressor to be equally efficient in subsonic flow regimes in the same suppressor*
  - *Pressure stacking can be effectively managed and kept within reasonable operating parameters*

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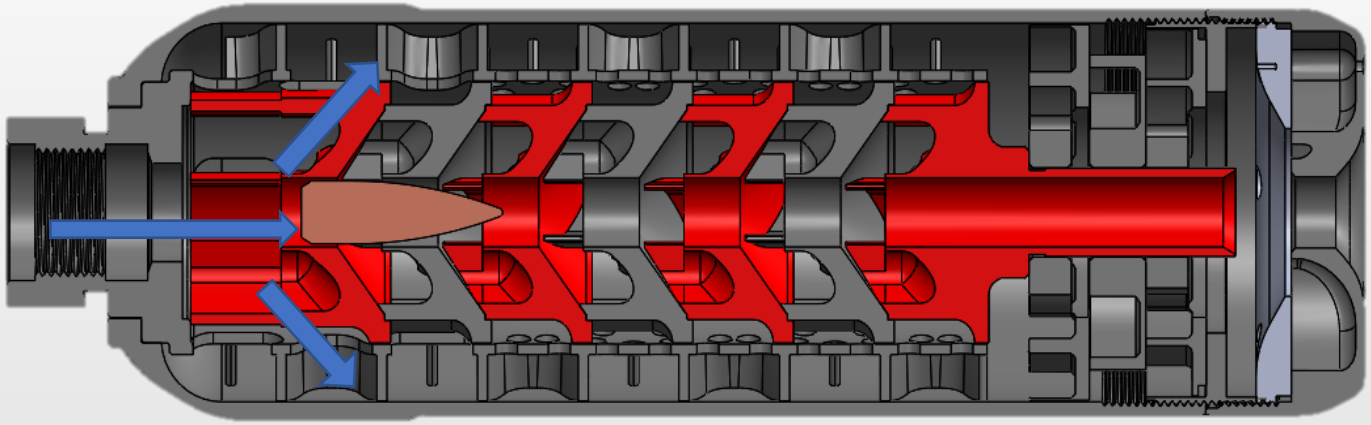
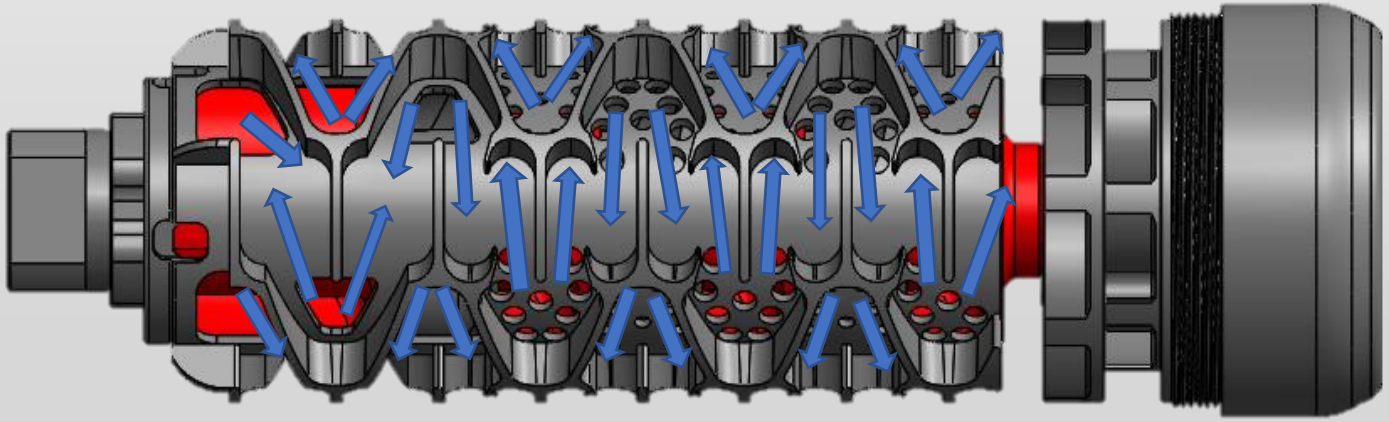
Multi Flow Path Examples: X2 ORION™ Suppressor



Above: Extended bore of the flow director creates a longer high-pressure zone, diverting gasses into the coax flow paths. Core has circumferential flow. Flow director spacing, direction of rotation and bore length (HP zones) are all variables for optimization.



Above: Multiple outer chamber fluid pathways (4) can have different levels of clamping structures. Time and distance of travel. Gas expansion volume. Amount and location of, inner and outer chamber fluid communication variables, etc.

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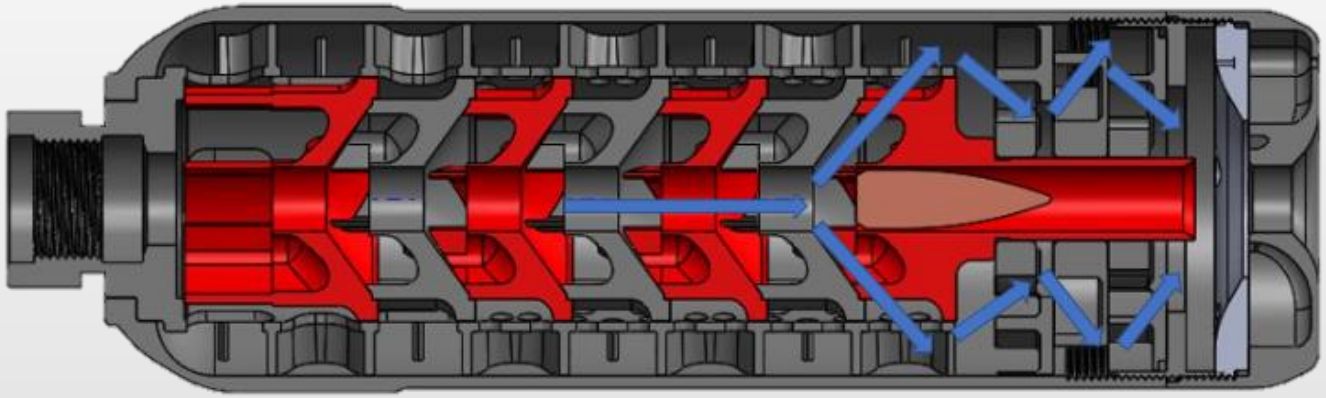
Multi Flow Path Examples X2 ORION™ Suppressor



Above: Flow Diversion Tube provides prolonged high-pressure zone directing gasses to circumferential exits, reducing flow velocity. Separate pressure zone in endcap with different venting options for weapons and mission requirements

Highly modular CNC machined design. Provides flexible platform for weapons and mission optimization. Core flow rate, flow director spacing, bore HP zones, clamping, inner and outer chamber communication, outer chamber fluid paths, end cap, etc. are all customizable. Rapid prototyping

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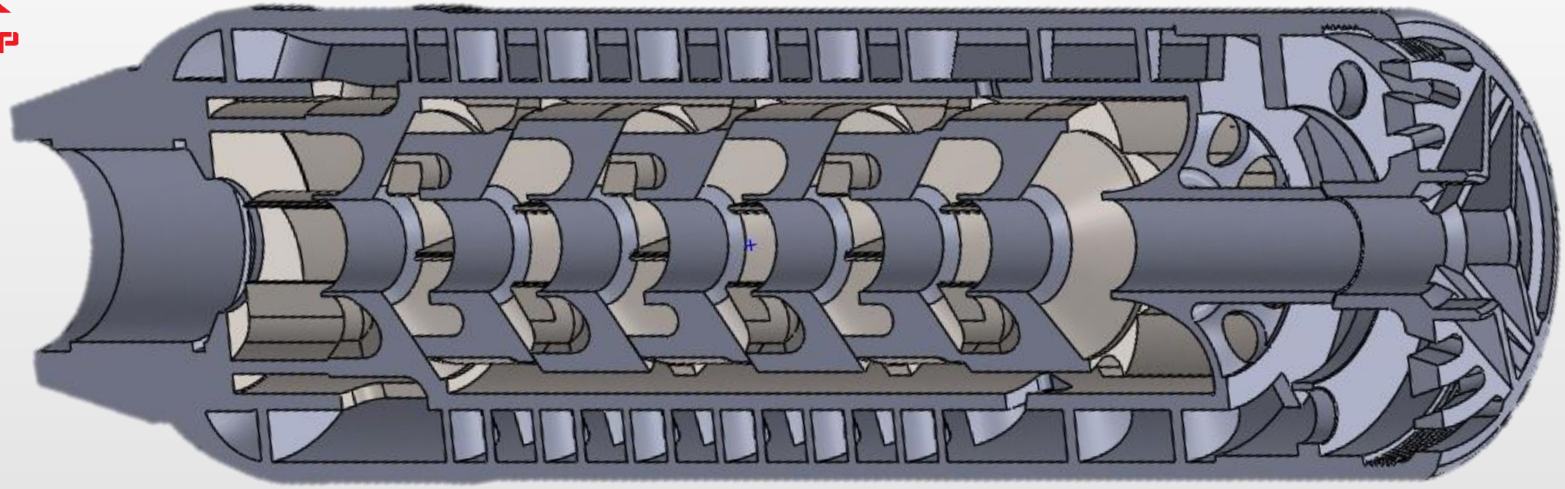
M2A1 50 BMG High-Flow X2 ORION™ Suppressor



- Very high flow-rate to eliminate backpressure & blowback on bursts
- Reduce pressure stacking during sustained fire
- High-Flow Hemicycle Array™ in coax flow paths = Delivers high gas flow turbulence w/ minimized resistance
- Flow directors in core provide circumferential flow path = Prevents pressure build-up & high velocity blow-by
- Flow director spacing optimized to accommodate SLAP / SLAP-T rounds
- Design allows suppressor to be purged of oxygen to reduce or eliminate first-round pop and flash
- Multiple flow-paths, varied gas flow exit timing, and end-cap vectored exit flow = Help sound reduction and flash suppression by reducing chances of external Mach disk formation and secondary flash
- Maximized thermal efficiency = reduced thermal signature and rapid cooling
- High flow-rate design resists carbon loading and performance degradation. Can be mfg. in serviceable format

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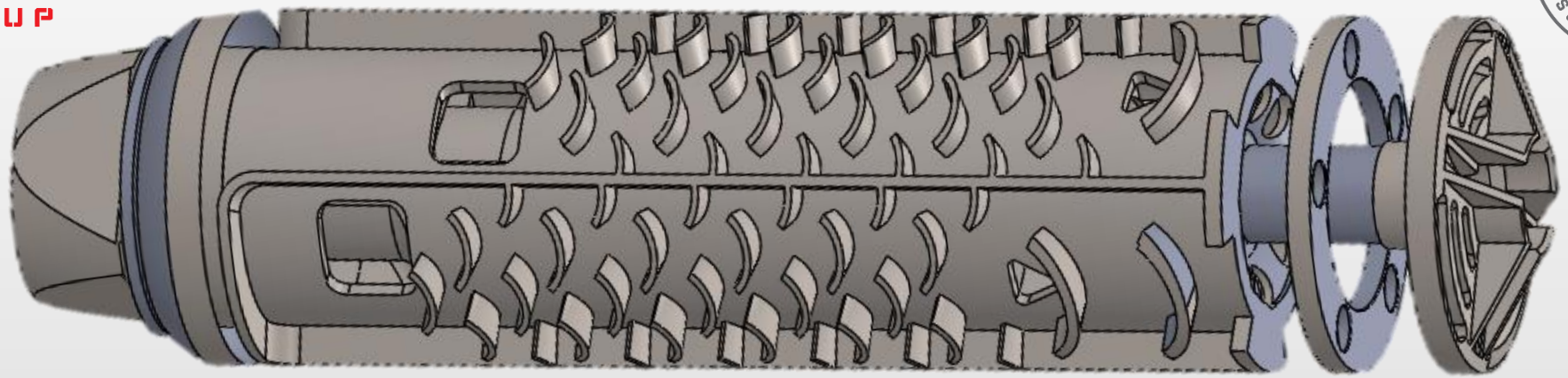
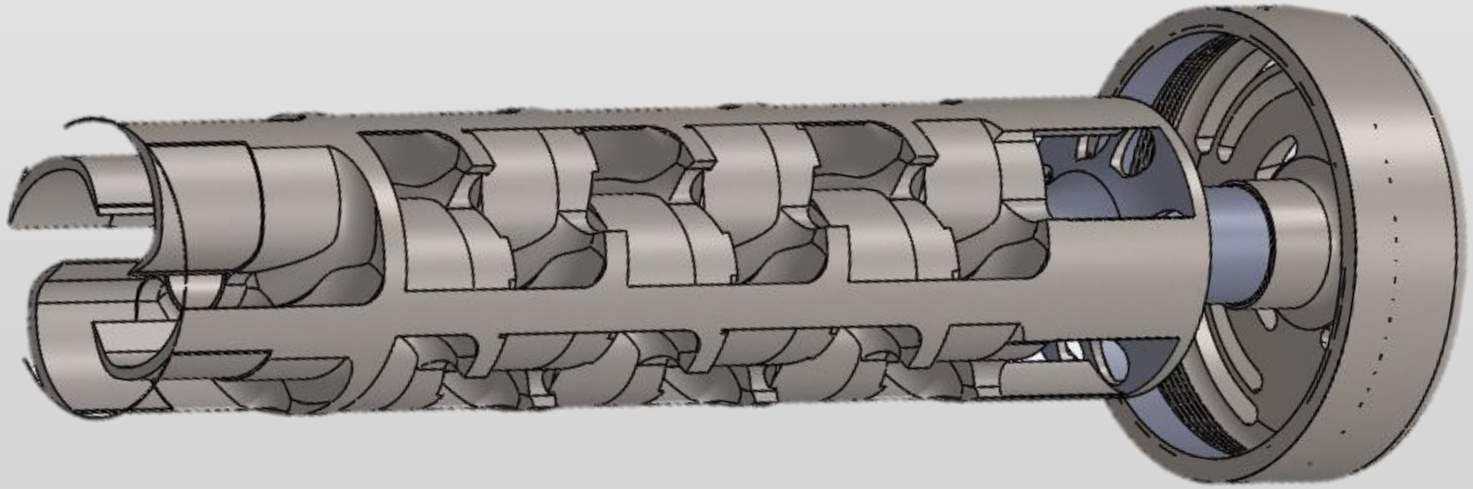
M2A1 50 BMG High-Flow X2 ORION™ Suppressor



Above: Hemicycle flow pathways provide high flow turbulence with consistent flow rate and no trapping



Above: Flow directors in core have a circumferential flow-path to prevent pressure buildup and accelerated gas blowby

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THERMAL EFFICIENCY AND ACTIVE SCAVENGE EXAMPLE: X2 ARTEMIS-X™ SUPPRESSOR

Left: ARTEMIS after 60rds @ 1 round per sec firing sequence. Less than 10° temp variance end-to-end. Cool-down time to 90° approx. 12min. 14 traditional design suppressors hit 300° in approx. 20rds and nearly 600° at 60rds w/ cool-down approx. 30-40min. Right: Ruger asked X2 to test if we could get 100rds through the 57 pistol (5.7x28mm) without pistol ceasing to function. Most suppressors tested stopped in less than 40rds. ARTEMIS is at 2060rds without cleaning, and still going… Increased operational reliability through rapid blowdown scavenge effect. Note:135-137db comparable or better than other suppressors tested.

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"X2 REVERSE FLOW™"
PINNACLE OF ADVANCED SUPPRESSOR DESIGN

- **TRADITIONAL TRAPPING DESIGN** suppressors achieve sound reduction through 1) length, 2) added volume and structures = longer drain times at lower pressures
- **"X2 REVERSE FLOW™" DESIGN** achieves *maximum sound suppression in shorter, lighter suppressors*
  - Outer coax chamber divided into front and rear sections – can be adjusted for desired attributes
  - *80+ percent of gases reversed into outer coax fluid pathways at the distal end* by extended high pressure zone Flow Diversion Tube and laminar flow gas turnarounds
  - Multiple reverse flow pathways can have different lengths, volume and restrictive structures
  - Each pathway re-diverts gases forward and exits gases into the endcap chamber at different time intervals where the endcap diffuses those exit flows
- Reverse Flow has *longer drain times* and *lower pressure exits than suppressors 3"- 4" longer*
  - Longer drain times at lower pressures also help with *flash reduction*
- Proximate end portion of outer coax chamber provides volume for initial blowdown = *reduced backpressure*. Purge ports in blowdown chamber purge core to *reduce first round pop and flash*
- Suppressor core has circumferential flow paths to *eliminate pressure buildup* and accelerated blow-by

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“X2 REVERSE FLOW™”
PINNACLE OF ADVANCED SUPPRESSOR DESIGN

Coax outer chamber divided into rear pressure zone for initial pressure blowdown and back pressure reduction. Front has one or more reverse flow pathways. Length, volume and exit segment structures are all variables for exit flow timing. = Long drain time with staggered, lower pressure exits. Reverse Flow pathways vent into a separate endcap pressure chamber where exit flows are diffused.

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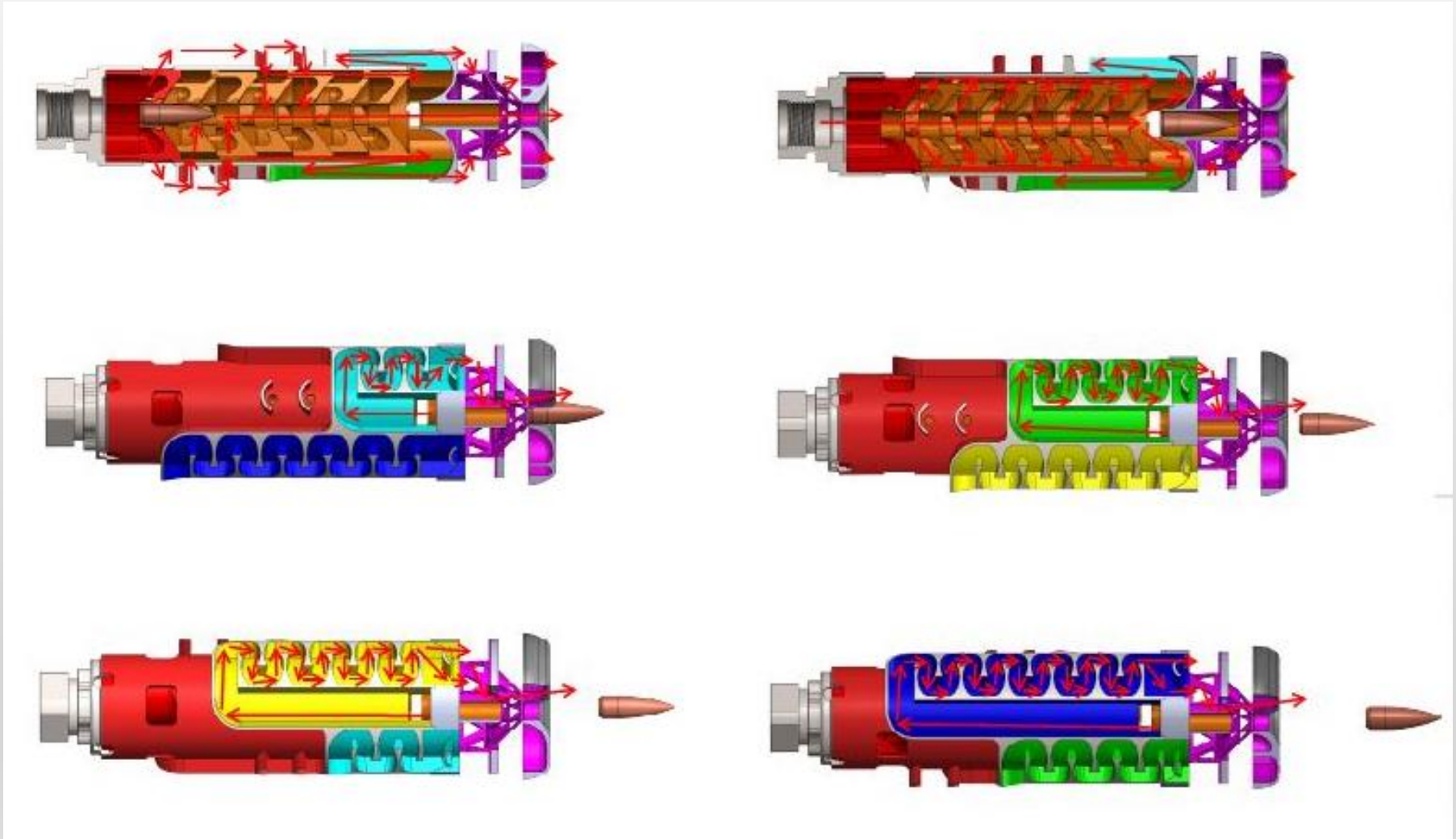
“X2 REVERSE FLOW™”
PINNACLE OF ADVANCED SUPPRESSOR DESIGN



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MANUFACTURING OF COMPLEX - ADVANCED FLOW DESIGNS ISSUES AND SOLUTIONS

- **Advanced Manufacturing Technology** and *specific expertise using it* are *critical* components in achieving full potential and desired performance metrics of advanced flow designs
- **Popular consensus is that advanced flow designs need to be 3D Printed. *This is wrong!***
  - Typically, the more complex the flow design, the more incompatible it is with 3D printing
  - Carbon loading is a major issue = More complex flow pathways ***will carbon load more quickly***
  - As critical flow-paths carbon load, ***performance can exponentially decrease***
  - ***Performance degrades across a shorter service life (often in an unpredictable manner)***
  - As pathways plug and volume decreases, ***backpressure and blow back increase*** = ***degradation of weapon's operational reliability and increased toxic gas blowback***
  - ***Sound levels increase*** as volume decreases, ***POI shift likely*** as weight increases, ***muzzle flash increases***
- **Advanced Flow Designs** can be fully CNC machined and deliver:
  - **Service life in excess or 100K rounds** with minimal or no service
  - Designs can be **user serviceable** and, if desired, **mission configurable**
  - Manufacturing **costs can be comparable to 3D printing** (or even less…)
  - More **design flexibility**, such as mixed metals. Inconel, stainless steel, titanium and aluminum, etc. can be combined in one suppressor to **achieve optimal metrics**

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MANUFACTURING OF COMPLEX – ADVANCED FLOW DESIGNS

EXAMPLES:

- Left: X2's ORION™ suppressor. Fully CNC machined. Inconel first flow director, grade 5 titanium all other parts. Highly modular and fully user serviceable. Production costs nearly the same as 3D printing.
- Right: 5.56mm ORION with 14k + rounds. No carbon loading and no bore erosion. (other detailed pics available)

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CONCLUSION

- AVAILABLE FOR PRIVATE BRIEFINGS
- X2's PROPRIETARY PRODUCT TECHNOLOGIES INCLUDE:
  - *THREE GRANTED SUPPRESSOR PATENTS WITH FIVE PENDING (3 ON TRACK 1)*
  - *PRIORITIES TO JAN 2016 (3) JAN 2019 (3) and Apr. 2022 (2)*
  - *6 SMALL ARMS TECHNOLOGY PATENTS AND 4 PENDING (non-suppressor)*
- ADVANCED MANUFACTURING PROCESS ENGINEERING & TURN-KEY IMPLEMENTATIONS
- **X2's BUSINESS MODEL** = *PARTNERING, JOINT VENTURES, TECHNOLOGY LICENSING*

X2 DEVELOPMENT GROUP, LLC

CAGE:8MHQ1

ENTITY ID: FD85QV5T9294

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Small Arms Point Defense System (SAPDS)

Presented by: Matthew Thompson & Dr. Mark Thoreson

CAPT Duncan McKay, USN
Commanding Officer

Dr. Angela Lewis
Technical Director

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Small Arms Point Defense System

- **The US Navy commonly fields crew-served weapons from mounted positions**
  - Manned “bent-metal” mounts (Mk93, Mk97)
  - Remote Weapon Stations (RWSs), (Mk49, Mk50)

- **New and growing threats warranted investigating technology which could improve capabilities.**

- **Opportunity space to bridge capability between cost effective manned mounts and RWSs.**

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Weapon Opportunity Space

Manned Mounts

- **Pros:**
  - Situational Awareness
  - Cost effective
  - Dismountable
- **Cons**
  - Relies solely on shooter's skills
  - Shooter exposed to elements/weapons fire

RWSs

- **Pros:**
  - Advanced fire control
  - Electro-optic systems
  - Active stabilization
- **Cons:**
  - Costly
  - Permanent install and power
  - Location for operator's station

There is an opportunity for advanced weapon technology to bridge the gap between existing cost effective manned mounts and expensive RWSs.

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Sources of Error

The principal error in manned, crew-served weapons fire is weapon pointing error induced from multiple sources

Shooter Aim Error

Weapon Burst Recoil

Vessel Motion

Target Speed and Range (Lead)

- **Other Errors**
  - Meteorological conditions
  - Wind (crosswind, range wind), Ranging
  - Weapon and ammunition dispersion, Zeroing error

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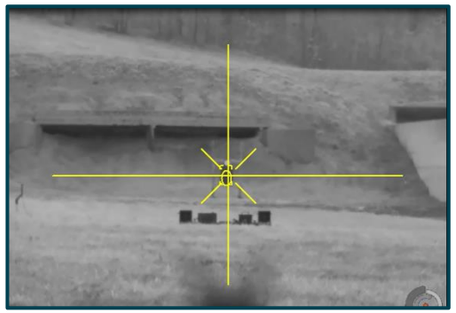
Capability Demonstrators* in SAPDS

- **Fire-on-Coincidence/Trigger Interrupt**
  - Reduces shooter aim error and lead error
  - Demonstrator: SMASH weapon sight (Smart Shooter)



- **Active Stabilization**
  - Compensates for weapon recoil and vessel motion
  - Demonstrator: ASP (Flex Force)

- **Other Technologies**
  - Improved Optics to reduce shooter aim error
  - Target/Bullet Tracking to reduce lead error

*Technologies are for manned crew-served positions

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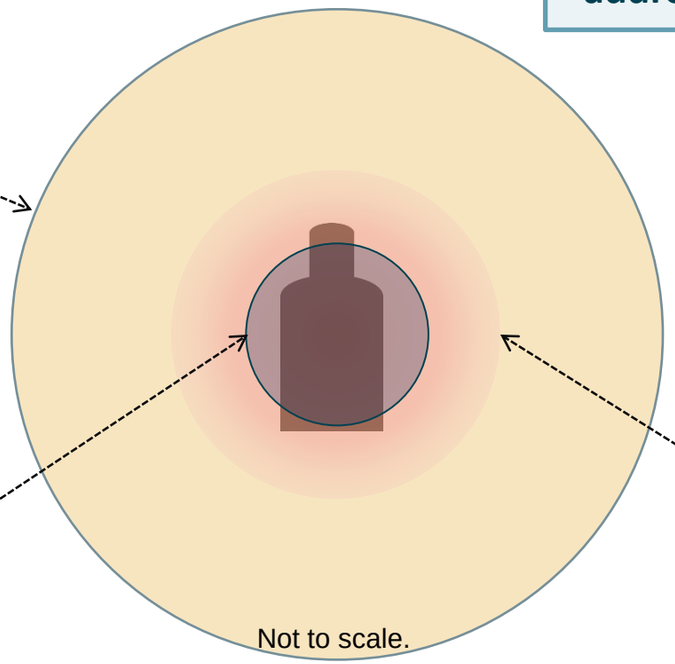
Precision (Dispersion) Effects of SAPDS Tech

SAPDS capabilities should improve performance of manned mounts by addressing weapon pointing error.

Outer circle

MK93



Inner circle

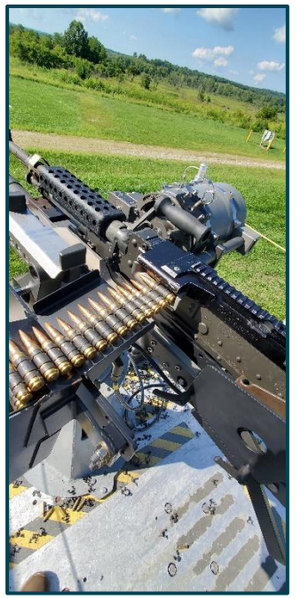
MK49 (similar for MK50)

Middle circle

SAPDS Technologies

Live-Fire Comparison Testing

- **Conducted live-fire testing of technology demonstrators**
  - Fire on coincidence
  - Active stabilization
  - Combination of capabilities



- **Multiple platform motion levels on the Mobile Motion Platform System**

- **Collected dispersion and qualitative performance data for comparative analysis**
  - Data and conclusions can be made available to US government agencies

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Next Steps

- **The SAPDS project is in its final year**
  - Processing data from recent testing
  - Report capability levels that can improve manned, crew-served weapon performance for different threats.
- **Refine and mature technology demonstrators through industry teaming**
- **Feed future weapon system technology research**

Questions?

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Suppressor Condemnation - Sustainment

Dr. Les Flemming – Small Arms Signature Lab

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Commanding Officer

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Small Arms Suppressor Metrics

- **Condemnation**
  - **Test & Evaluation**
  - **In Service**
- **Sustainment**
  - **Maintenance**
  - **Development / Design**

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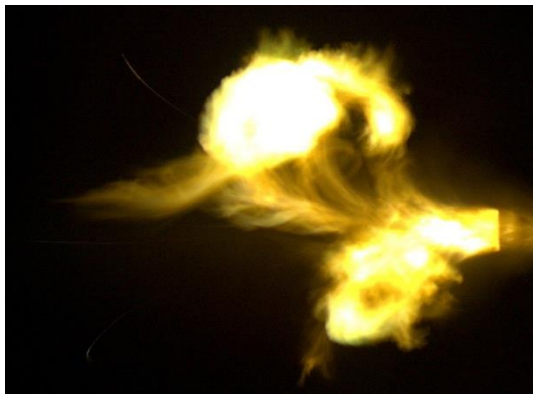
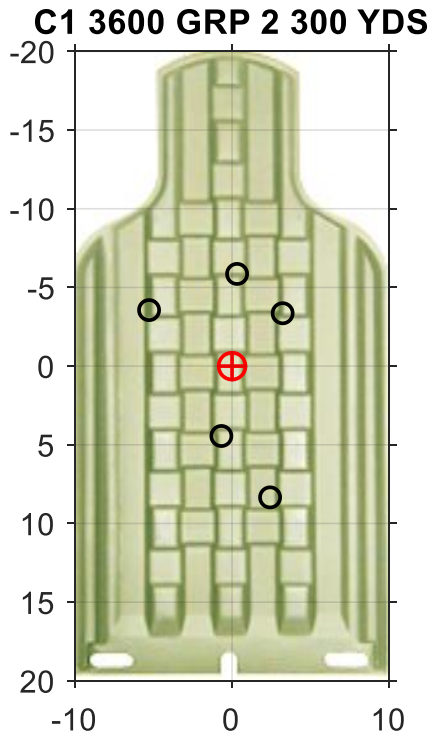
Development & Evaluation

- **Performance**
  - Dispersion
  - POI Shift
- **Characteristics**
  - Mass
  - Geometry – Visual Inspection
- **Signature**
  - Sound
  - Blowback
  - Flash
  - Thermal





Condition Codes

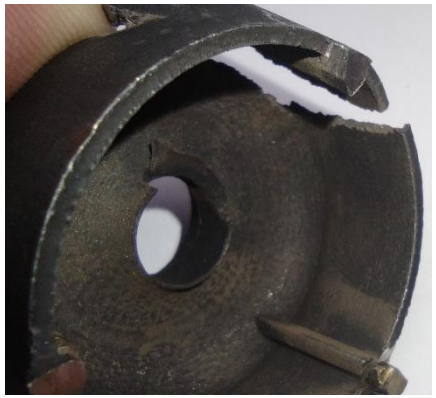
Excess property is a source of affordable and proven equipment for other DoD activities and Foreign Military Sales (FMS) countries and it provides the U.S. government an opportunity to potentially recoup a return on investment. Accurate condition coding and property descriptions provide Disposition Services the ability to maximize the return on excess/surplus through either sales or reutilization.

Code	Description	Condition
A	Serviceable issuable without qualification	New, used, repaired, or reconditioned material which is serviceable and issuable to all customers without limitation or restrictions. Includes material with more than 6 months shelf liferemaining.
B	Serviceable issuable with qualification	New, used, repaired, or reconditioned material which is serviceable and issuable for its intended purpose but which is restricted from issue to specific units, activities,or geographical areas by reason of its limited usefulness or short service life expectancy. Includes material with 3 through 6 months shelf life.
C	Serviceable priority issue	Items which are serviceable and issuable to selected customers, but which must be issued before Condition A and B material to avoid loss as a usable asset. Includes material with less than 3 months shelf life remaining.
D	Serviceable test modification	Serviceable material which requires test, alteration, modification, conversion or disassembly. This does not include items which must be inspected or tested immediately prior to issue.

Fielded Weapons

- **Performance**
  - Dispersion
  - POI Shift
- **Characteristics**
  - Geometry – Visual Inspection
  - Mass
- **Signature**
  - Sound
  - Flash
  - Blowback
  - Thermal

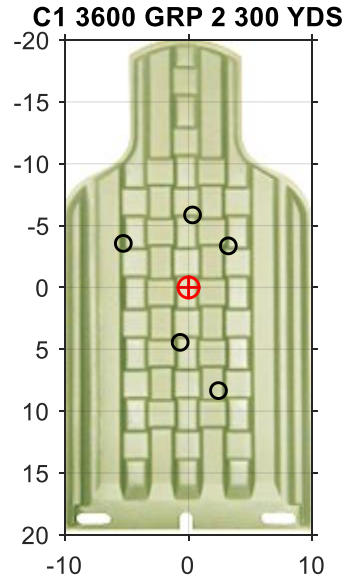
End Cap Strikes

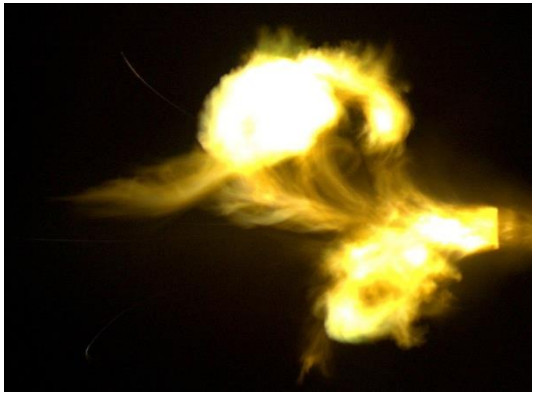


Baffle Strikes

Condemnation Testing

- **Performance**
  - Dispersion
  - POI Shift
- **Characteristics**
  - Mass
  - Geometry – Visual Inspection
- **Signature**
  - Sound
  - Blowback
  - Flash
  - Thermal





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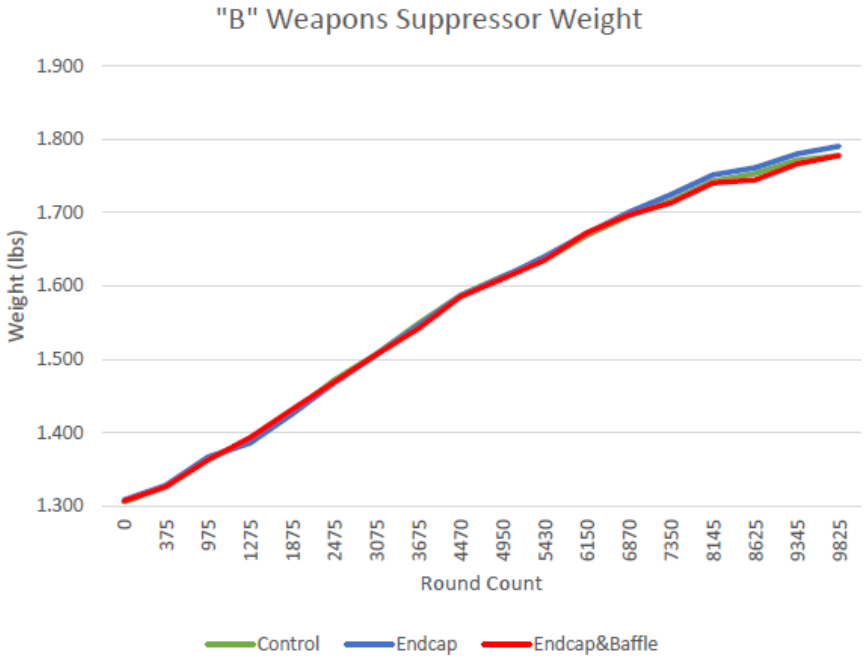
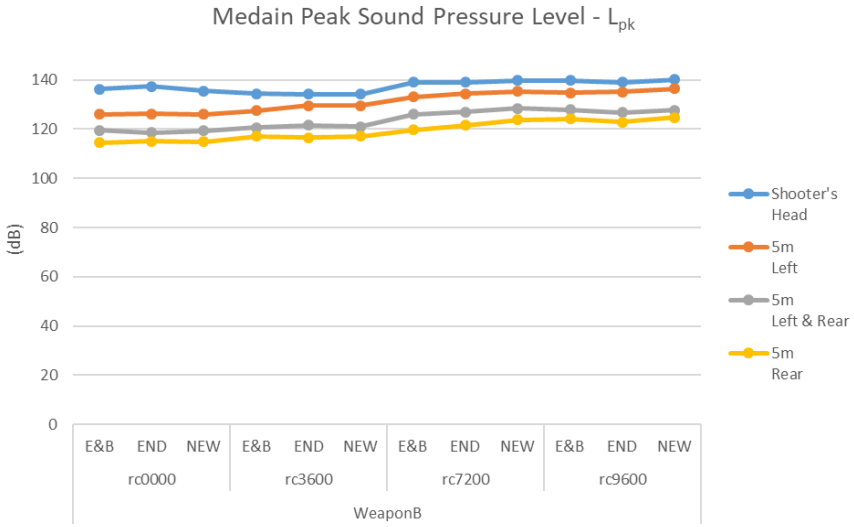
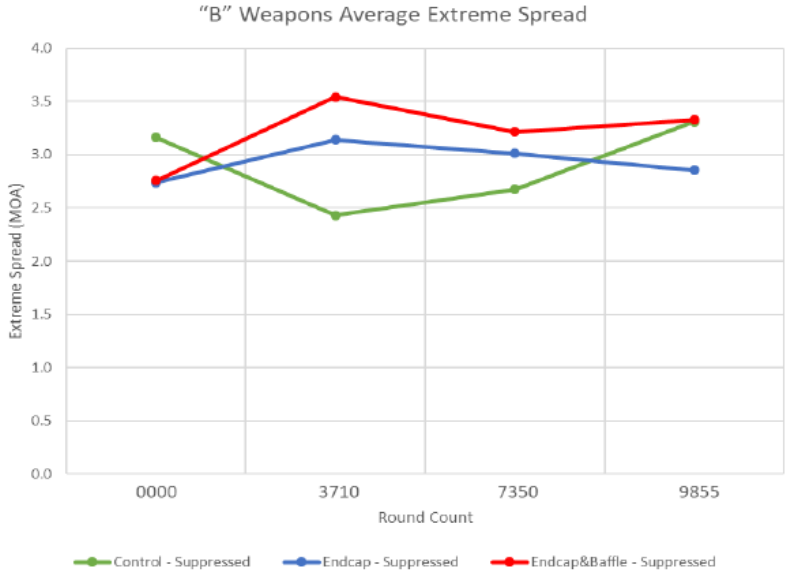
Suppressor Condemnation Summary







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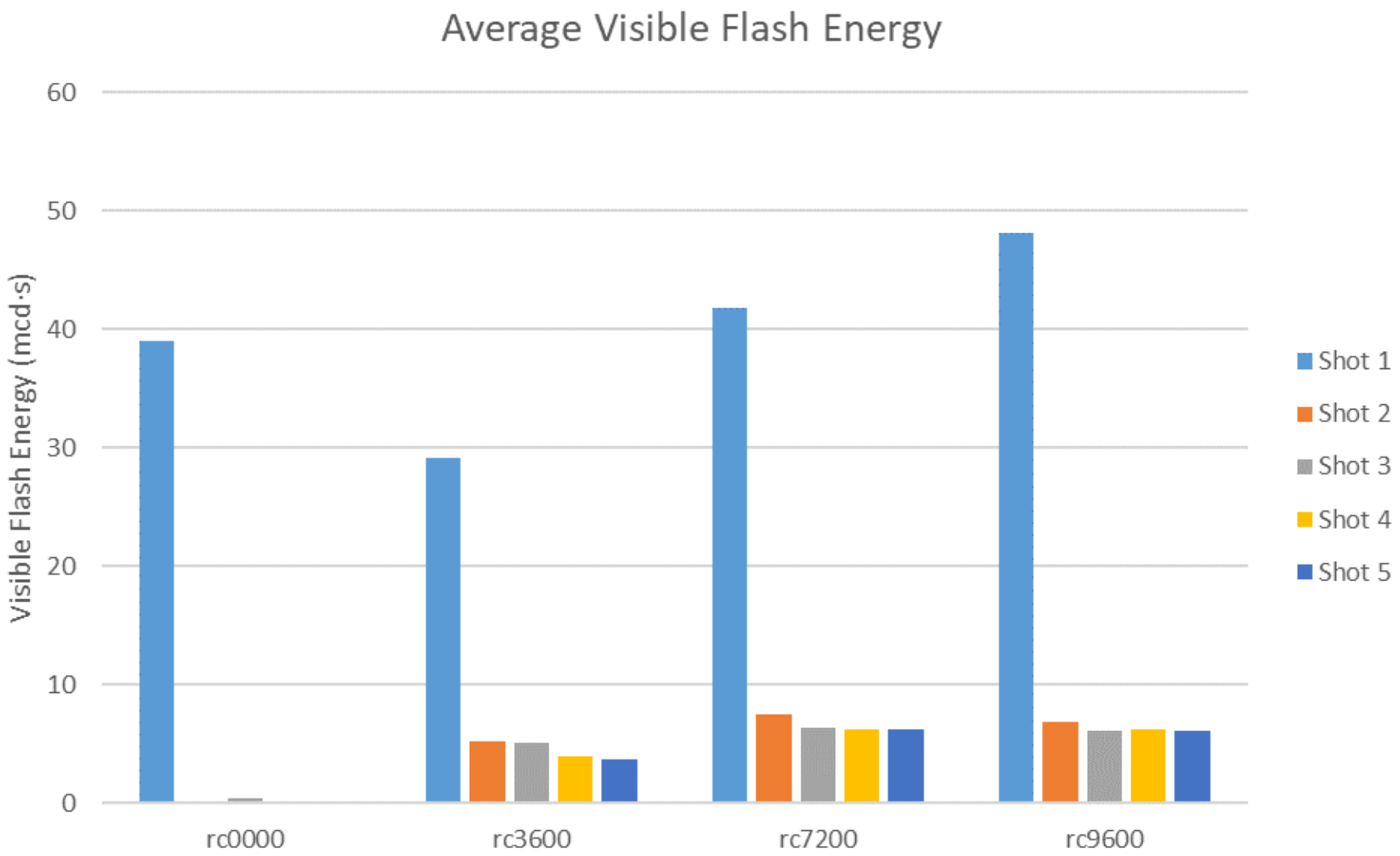
Suppressor Condemnation Summary



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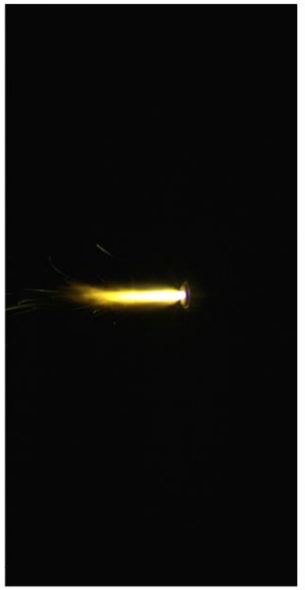
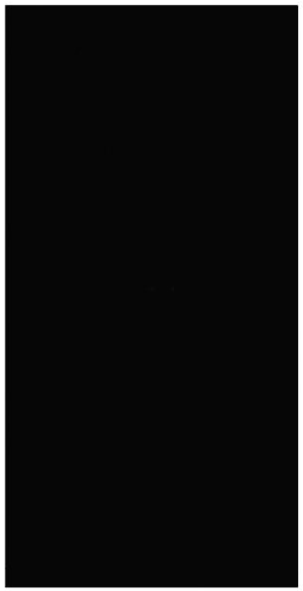
Suppressor Condemnation Example

Round Count 0
Shot 1

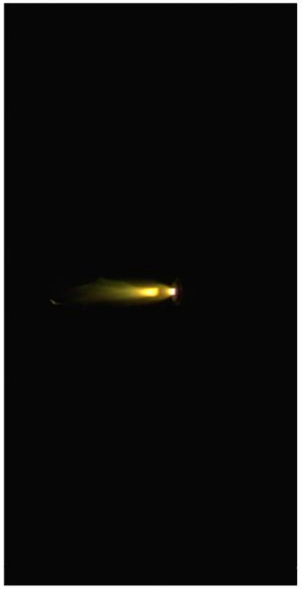
Round Count 3600
Shot 1



Round Count 0
Shot 2



Round Count 3600
Shot 1



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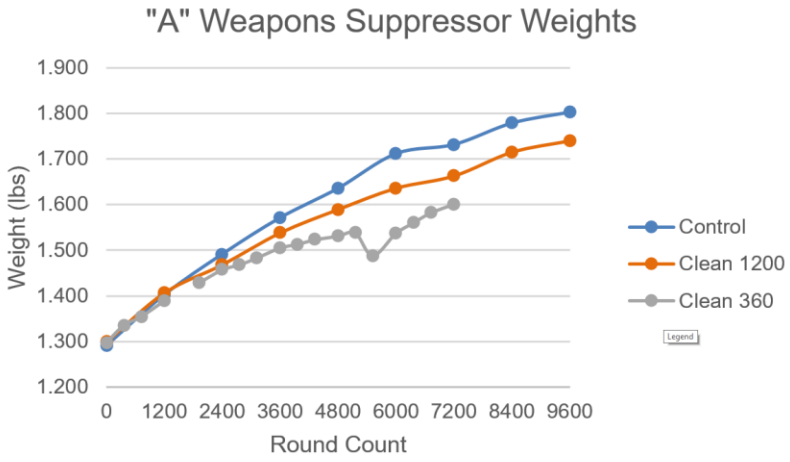
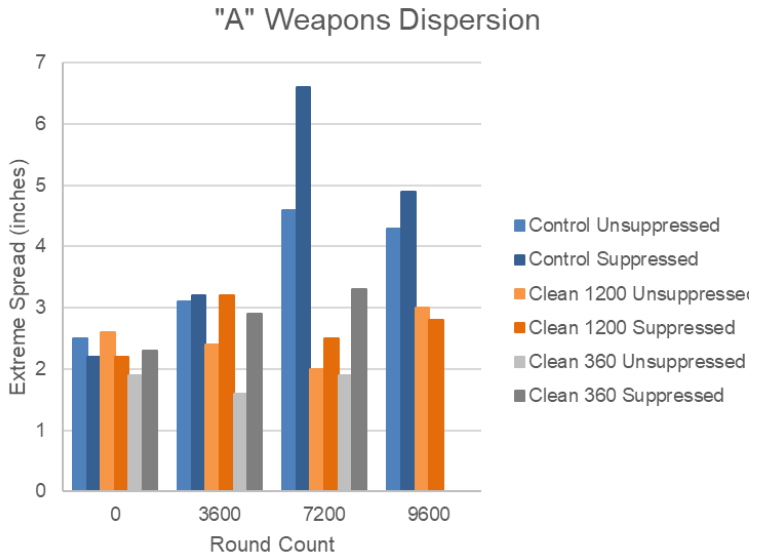
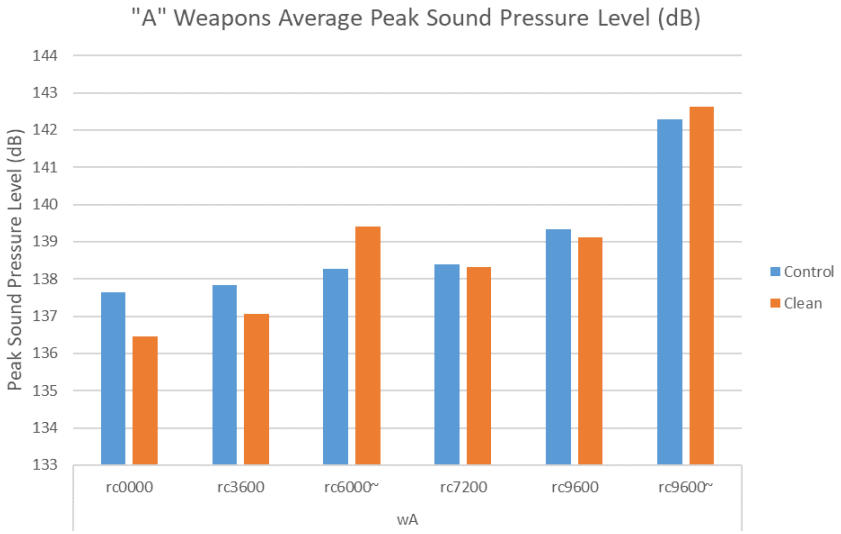
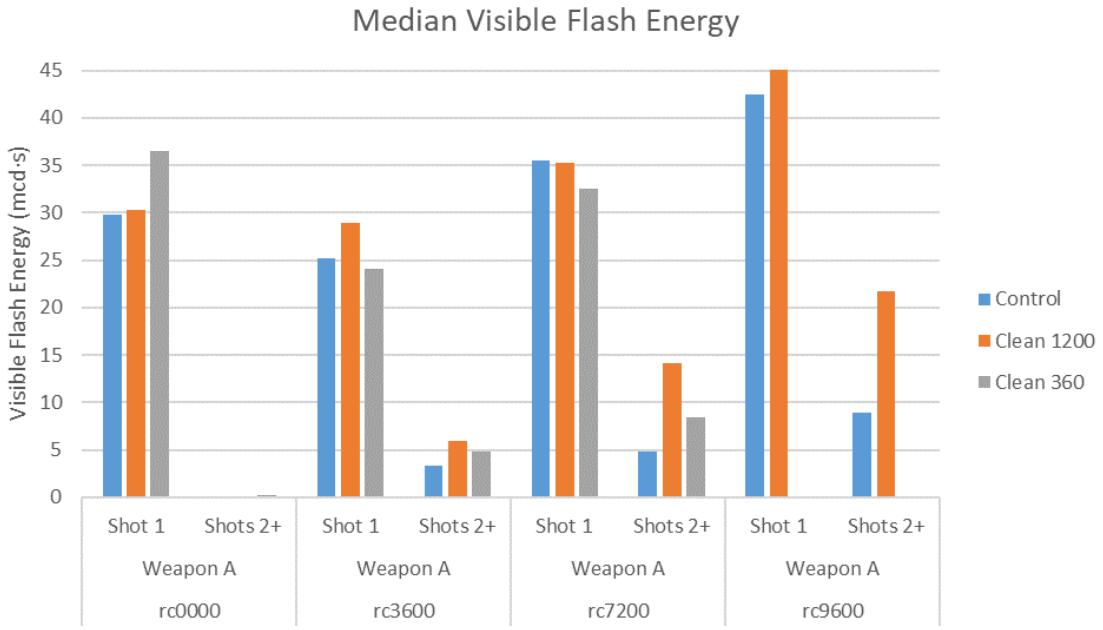
Suppressor Cleaning Example









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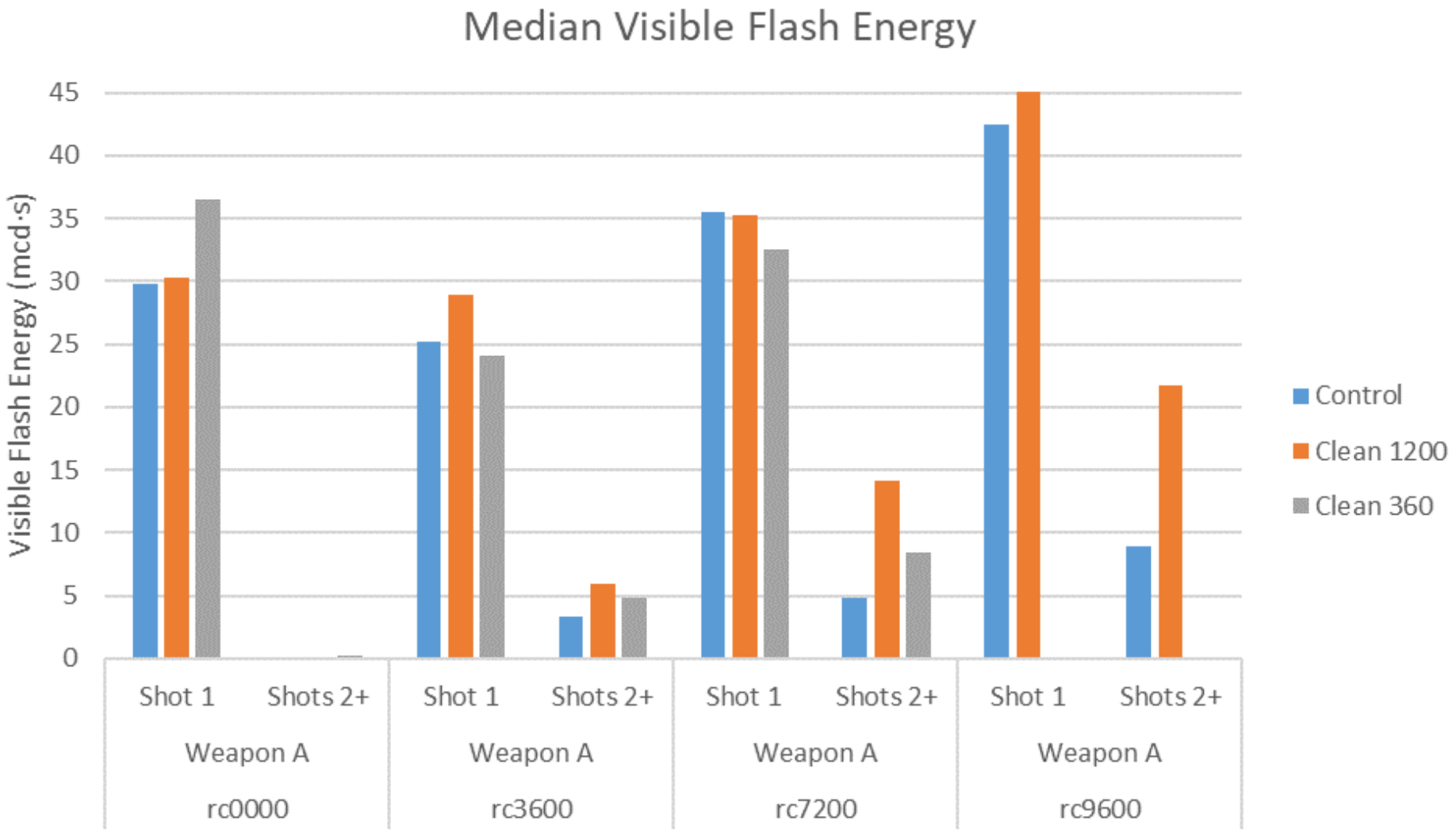

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Sustainment

- Methods
  - Mechanical
    - Brush / Impact
    - Thermal
    - Ultrasonic Cleaner
  - Chemical
- Execution Level
  - Soldier
  - Armorer
  - Depot
  - Vendor
- Cost / Benefit

Sustainment & Condemnation

- **Sustainment Cost**
  - Tools and Material
  - Hazardous Material
  - Reconditioning Labor
  - Replacement
- **Condemnation**
  - Round Count
  - Duration
  - Mass

Development / Design

- Identify stagnate air flow
  - Computational Fluid Dynamics (CFD) Modeling
  - CT Scan (x-ray)
- Coatings
  - Material & Application Process
- Testing & Data Analysis
  - NATO STANREC4785 - TEST PROCEDURES FOR SMALL ARMS SUPPRESSORS

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An Alternative Method for Determining Penetration Limit Velocities Using Residual Velocity Data

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

Kenneth Hohnecker, Christopher Drake, Michael Cataldi

US Army, DEVCOM, Picatinny Arsenal, NJ

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Controlled by: DEVCOM AC
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CUI Category: UNCLASSIFIED
Distribution Statement A: Approved for Public Release; Distribution is Unlimited
POC: Ken Hohnecker, (973) 724-7633

Presented at the 2022 2022 Future Force Capabilities Conference and Exhibition
Sept. 2022

PRESENTATION OUTLINE

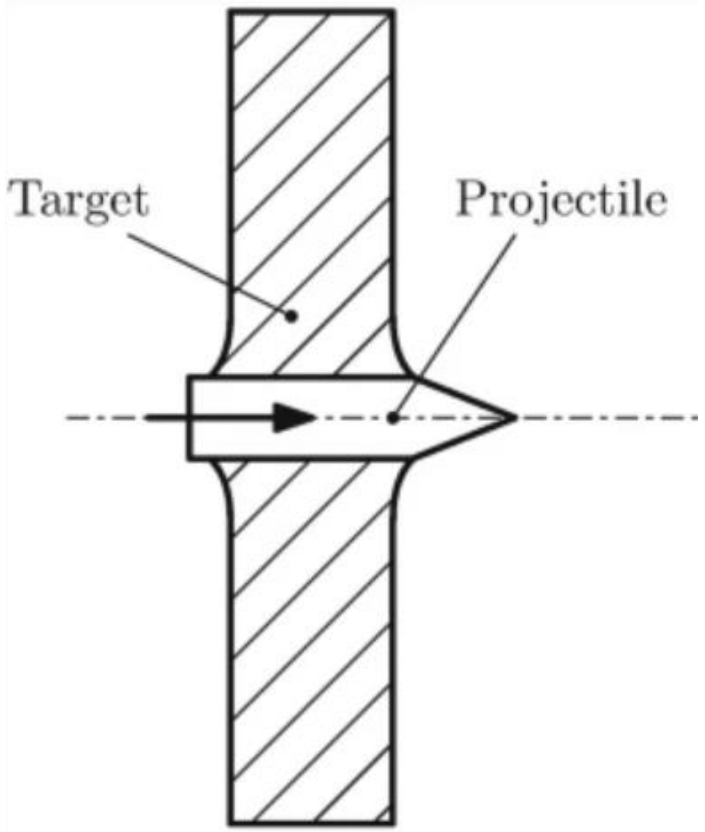
- Problem Statement
- Binary Data
- Current Methods
- Proposed Methodology
- Experimental Results
- Conclusion
- Future Work

PROBLEM STATEMENT

Determine the velocity at which a projectile will penetrate a target with some given probability (known as a *limit velocity (LV)*

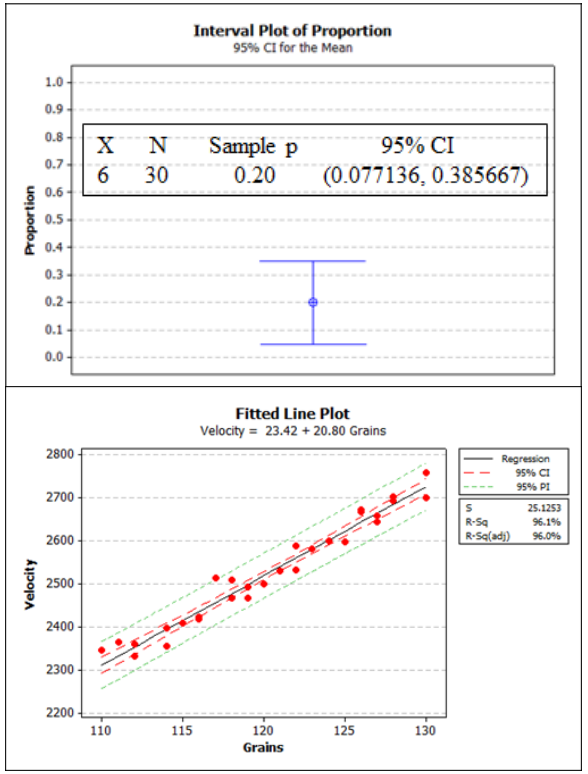
- *The* limit velocity is typically associated with the V50 (i.e., velocity at which a projectile penetrates 50% of the time) but other limit velocities may also be deemed important (e.g., V10, V90, etc.)

- LVs are commonly found in small arms requirement documents since they are a minimum requirement for terminal effectiveness behind a protective barrier



BINARY DATA

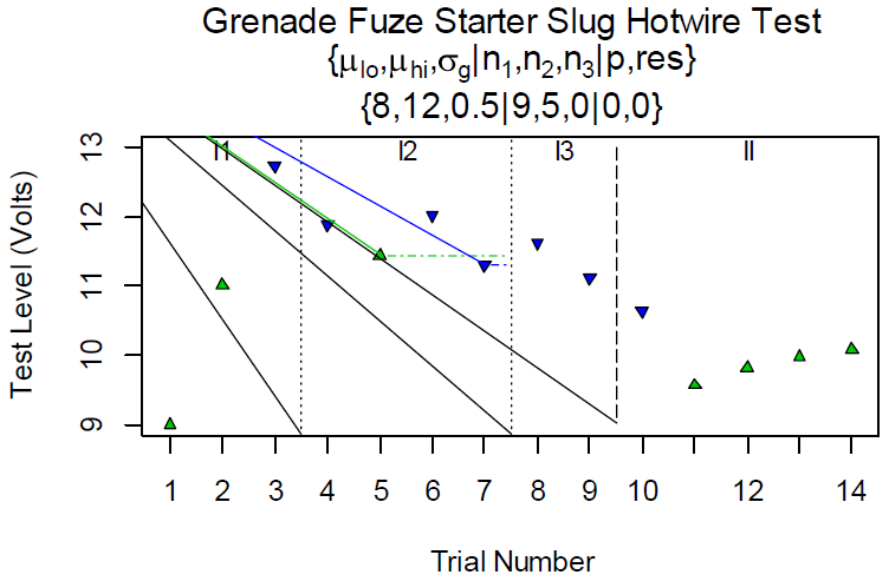
- **The issue with *binary* data:**
  - Information sparse (0/1, yes/no, go/no-go); *continuous* data contains more information (velocities, weights, etc.)
  - Requires many more samples than continuous data to acquire statistically meaningful results or build surrogate models
- **Are we leaving information on the table?**
  - Can we extract more information from the test?
  - Are there other things we can measure in parallel?



Is there any way we can avoid collecting only *binary* data?

CURRENT TESTING METHODS

- **3 Phase Optimal Design (3POD) [adaptive]**
  - The most efficient binary data gathering methodology we have today
  - [Phase 1] Finds go and no-go
  - [Phase 2] Establish overlap
  - [Phase 3] Strengthen overlap
  - Hone area of interest (V50, V90, etc.)



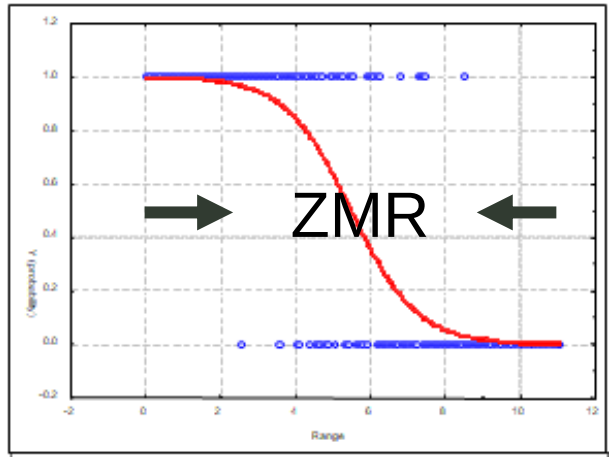
- **Langlie [adaptive]**
  - Common DoD method of sequentially gathering binary data developed in 1962

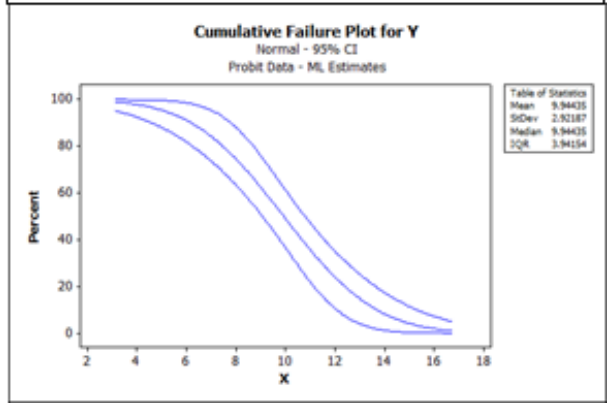
- **Brute force array [static]**
  - Build test assets at varying and equal spacing to cover area of interest (could potentially miss ZMR)

CURRENT MODELING METHODS

- **Binary logistic regression**
  - Looks at penetration / no penetration data only (Ex: logit, probit models)
  - Generates probabilistic model which requires many samples to obtain useful confidence bounds and predictions
  - Models may sometimes struggle at the far tails
  - Zone of Mixed Results (ZMR) historically necessary (although new methods exist to bypass this requirement using Firth bias-adjusted estimates)

$$\pi(x) = \frac{e^{\beta_0+\beta_1 x_1}}{1+e^{\beta_0+\beta_1 x_1}}$$

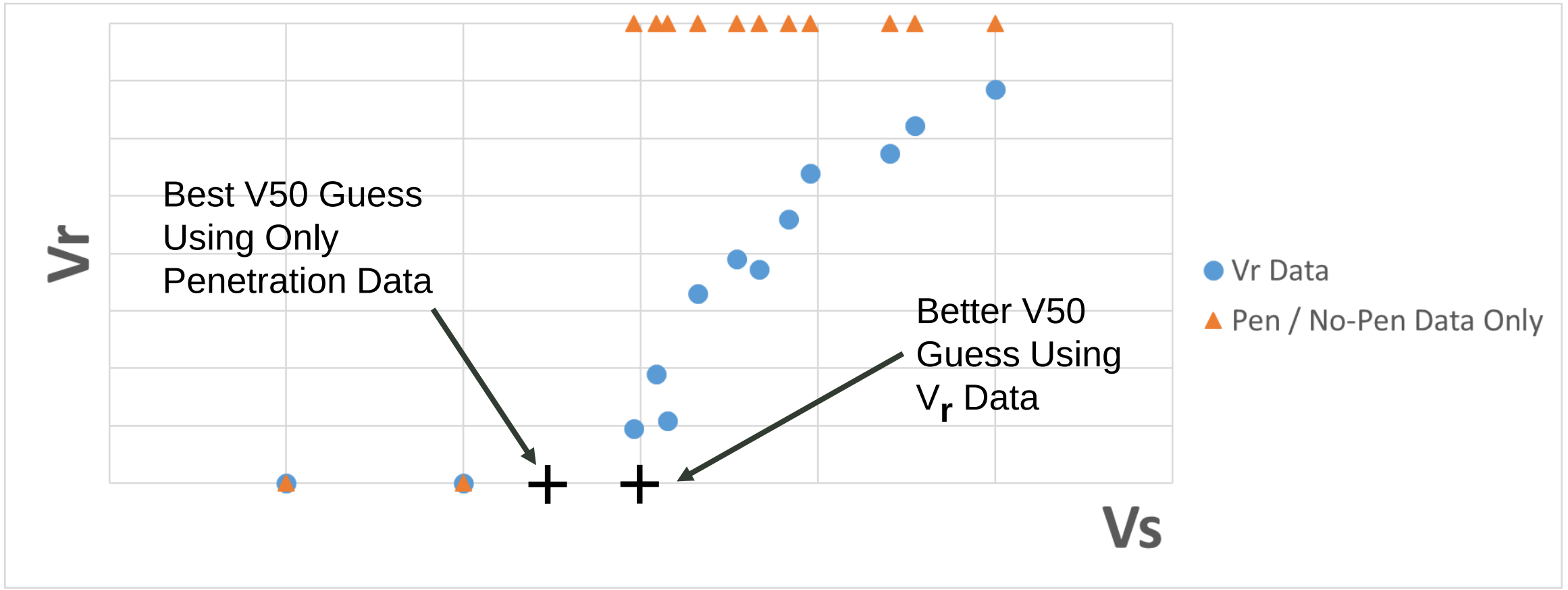




- **Residual velocity**
  - Looks at residual velocity data
  - Ex: Jonas-Lambert
  - No proposed means of computing confidence intervals
  - Current methods do not work for limit velocities other than V50

PROPOSED METHODOLOGY DISCUSSION

The proposed method uses projectile residual velocity (V_r) data in order to maximize "information" obtained from test



PROPOSED METHODOLOGY DISCUSSION (CONT.)

- **Need to model V_r as a function of striking velocity (V_s);** while there are existing models, the proposed V_r model was derived with the express purpose of being amenable to statistical analysis

- Current V_r models cannot accept non-penetrating test shots as data; **proposed method addresses this issue, thus eliminating "discarded" test shots**

PROPOSED METHODOLOGY DISCUSSION (CONT.)

- **Use standard non-dimensionalization techniques and application of first principles (i.e., Newton's Law)**
  - Assume instantaneous target resistance is a function of projectile velocity, contact area, and a "strength" parameter
- **Apply constraints**
  - No resistive force when projectile comes to rest; finite-time penetration event
- **Assume "average effective deformation" of projectile changes approximately linearly across small changes in impact velocity**
- **Define residual velocity as the amount of "unconsumed" velocity when the projectile reaches the back of the target**
  - This permits "negative" residual velocities if the projectile does not penetrate

PROPOSED METHODOLOGY DISCUSSION (CONT.)

- **Assume variation in residual velocity is dominated by projectile yaw, mass erosion, and the "strength" parameter; this results in the below distribution of V_r:**

$$\begin{cases} V_r \sim \text{sign}(X)\,|X|^{\frac{1}{2-\alpha}} \\ X \sim v_s^{2-\alpha} - \dfrac{U^2}{v_\tau^{\alpha}\left[1 - c\left(\dfrac{v_s}{v_\tau} - 1\right)\right]} \end{cases}$$

v_s = striking velocity on the target
v_τ = limit velocity of interest (e.g., τ can be 50, 90, etc.)
α, c = empirical coefficients
U = random variable

- **The distribution of V_r is reduced to a 1D distribution**

- **It can be shown by the Central Limit Theorem implies that U is approximately log-normally distributed**

PROPOSED METHODOLOGY DISCUSSION (CONT.)

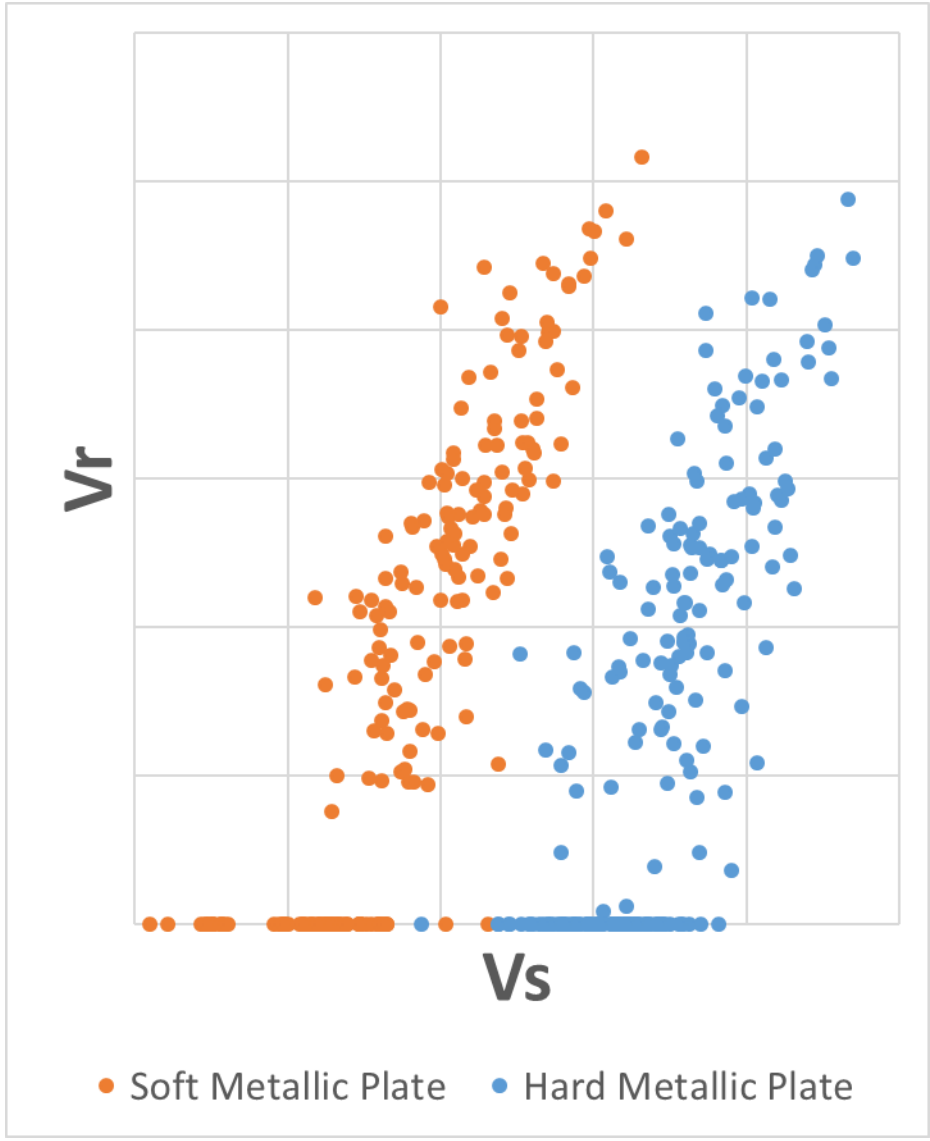
- **Use Maximum Likelihood Estimator (MLE) to approximate limit velocity**
- **For test shots that do not penetrate, use the probability of penetration in the likelihood function in place of the residual velocity distribution** (mixed continuous-discrete likelihood function)
- **Use parametric bootstrapping to determine confidence interval around estimated limit velocity**

EXPERIMENTAL RESULTS

- **Obtained sizable data set of a non-monolithic projectile against both hard and soft metallic target plates** (enough data to get “true” limit velocities)

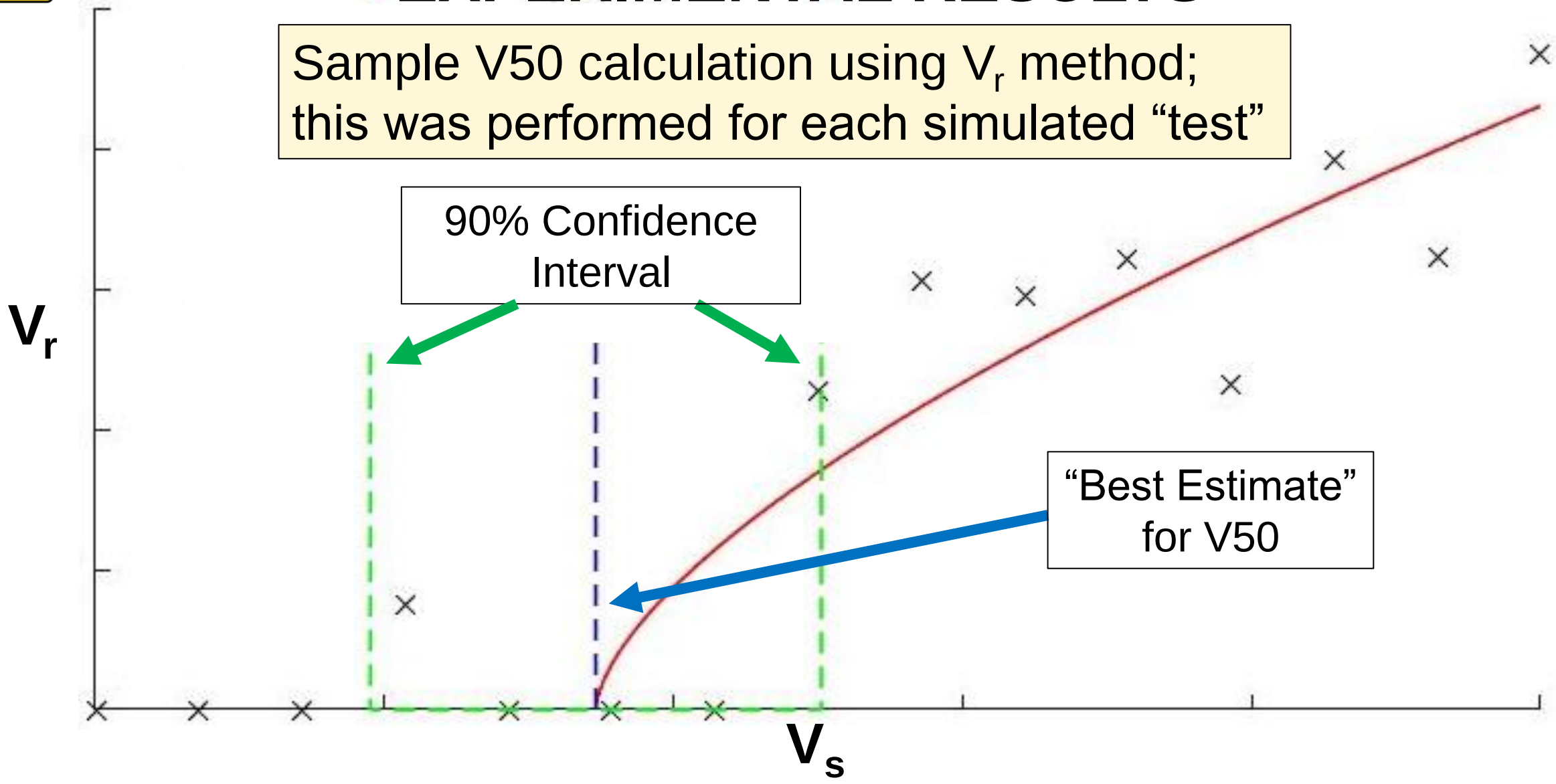
- **Performed Monte Carlo simulations of typical plate penetration tests**
  - Residual velocities were randomly drawn from data set; V50, V90, and confidence intervals were calculated for each “test”

  - Residual velocities were sampled using two methods (Gaussian kernel, log-normal distribution of U)

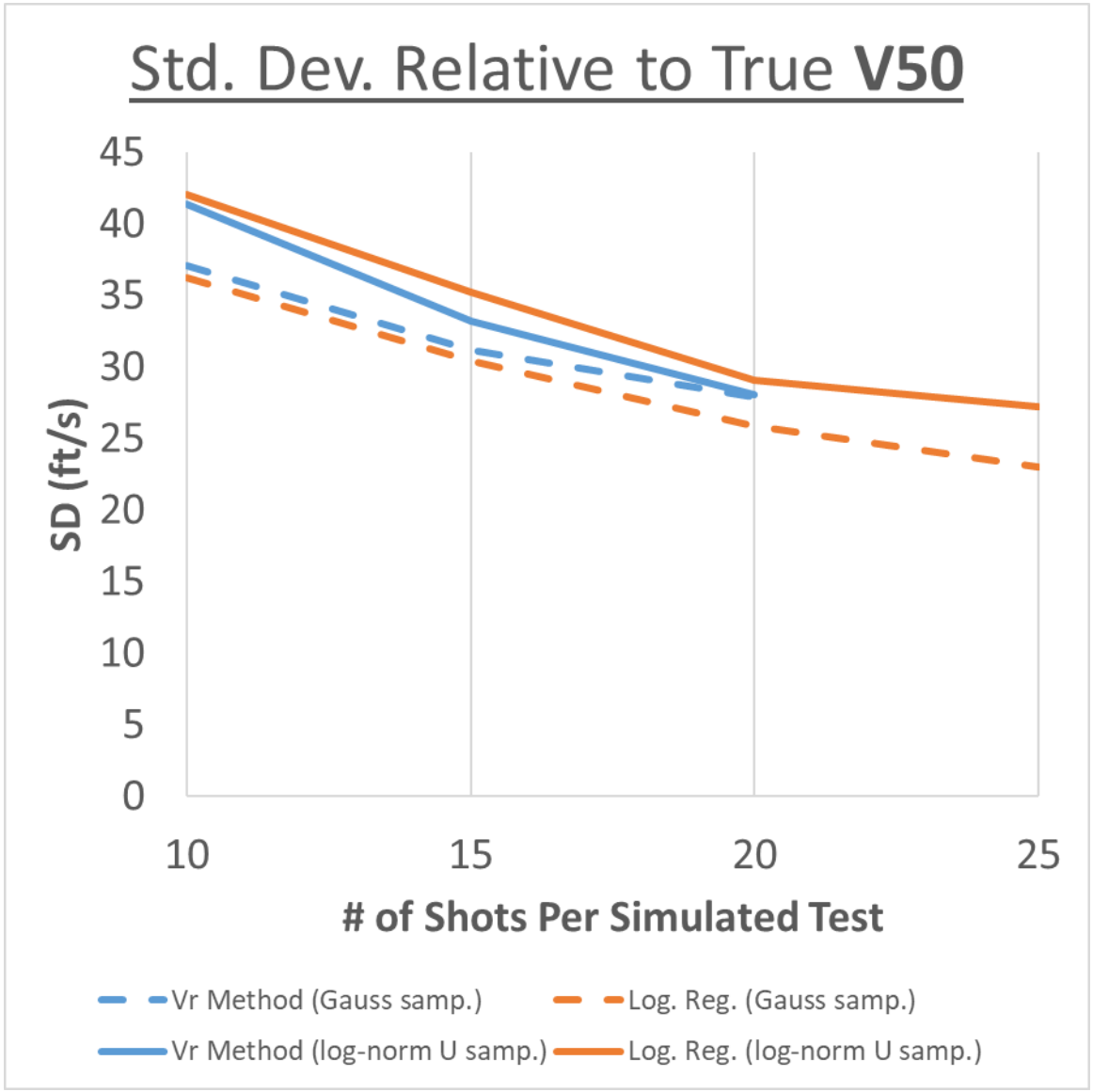


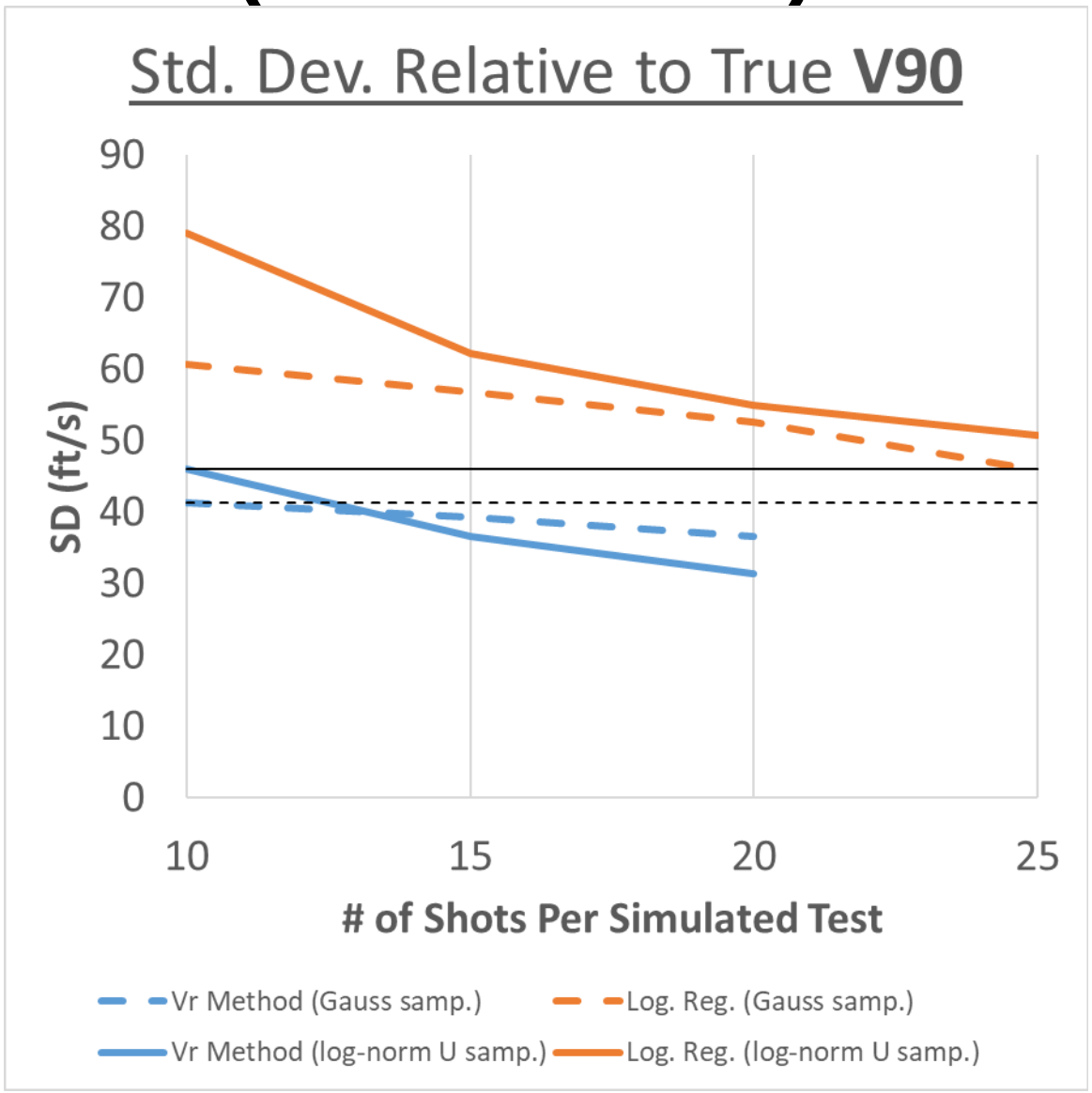
EXPERIMENTAL RESULTS

Sample V50 calculation using V_r method; this was performed for each simulated "test"

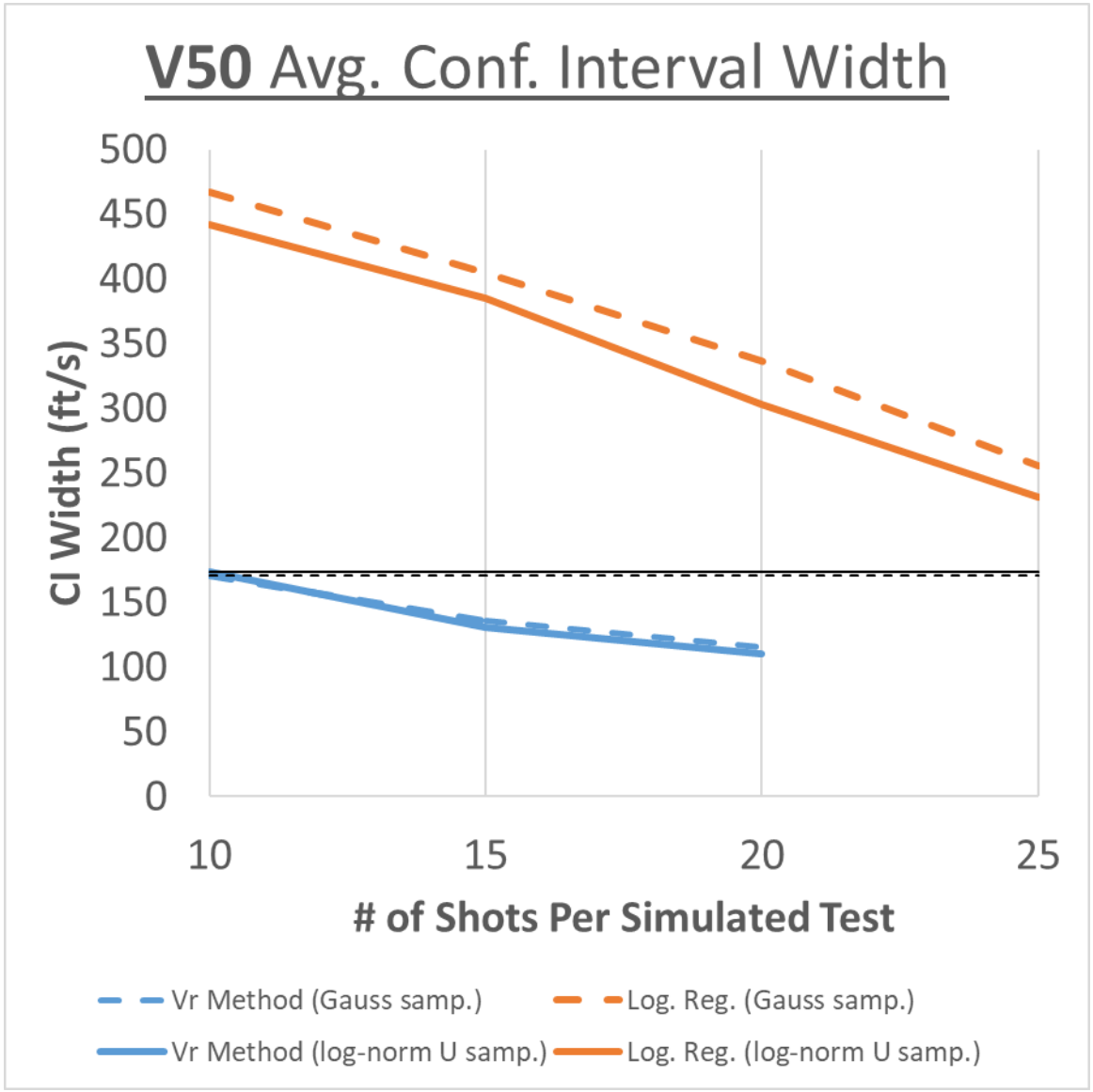


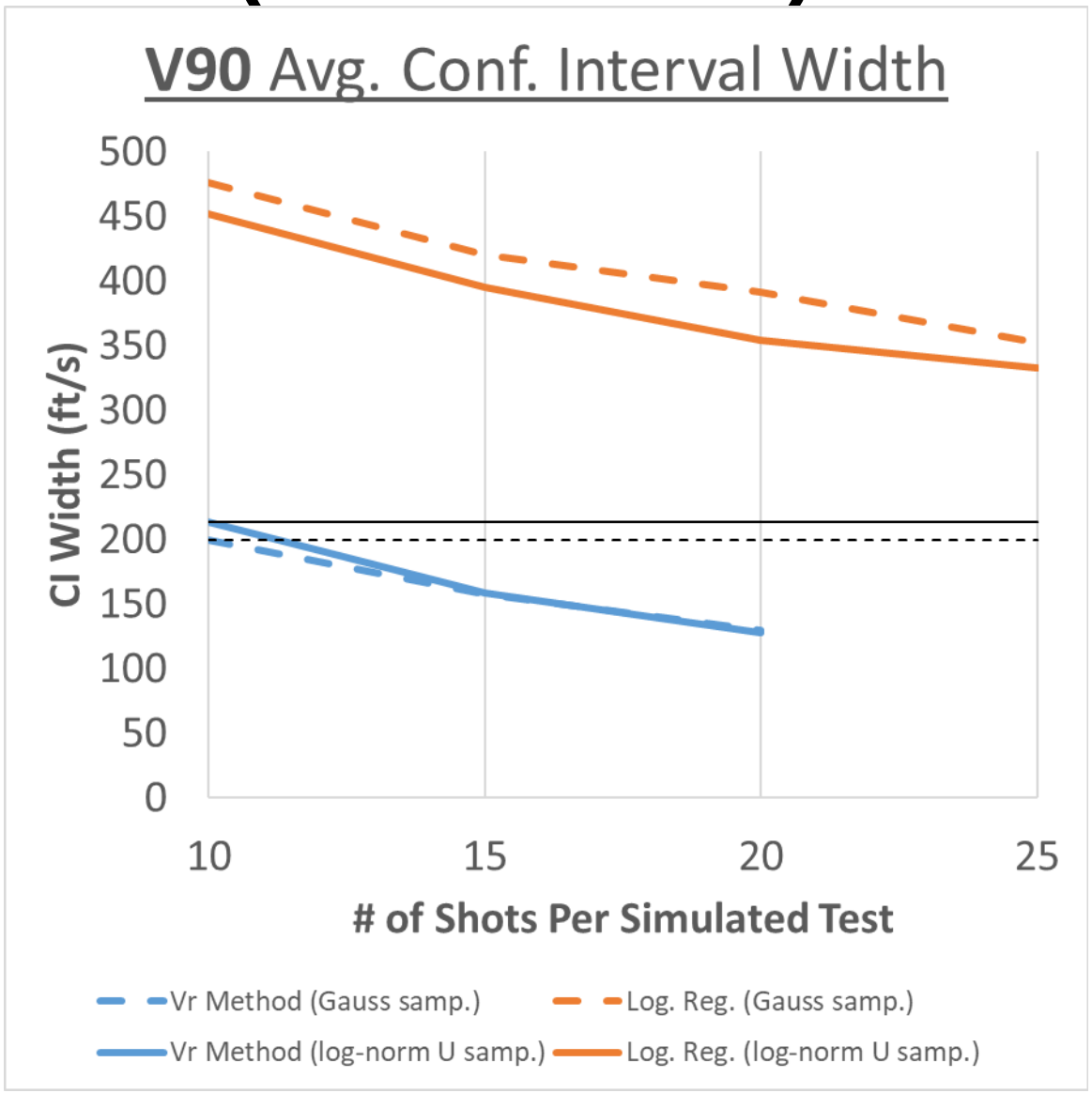
EXPERIMENTAL RESULTS (SOFT PLATE)



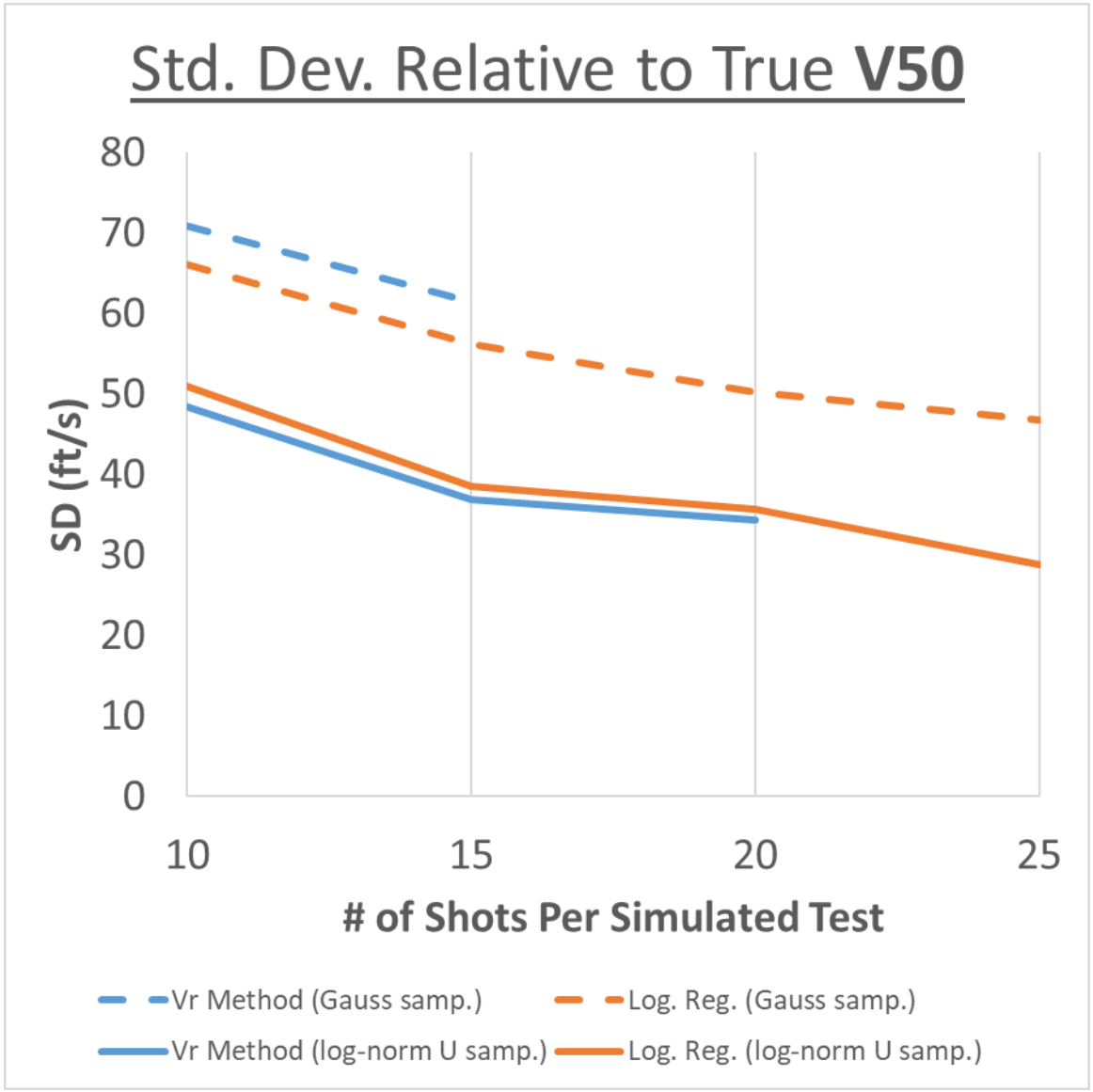


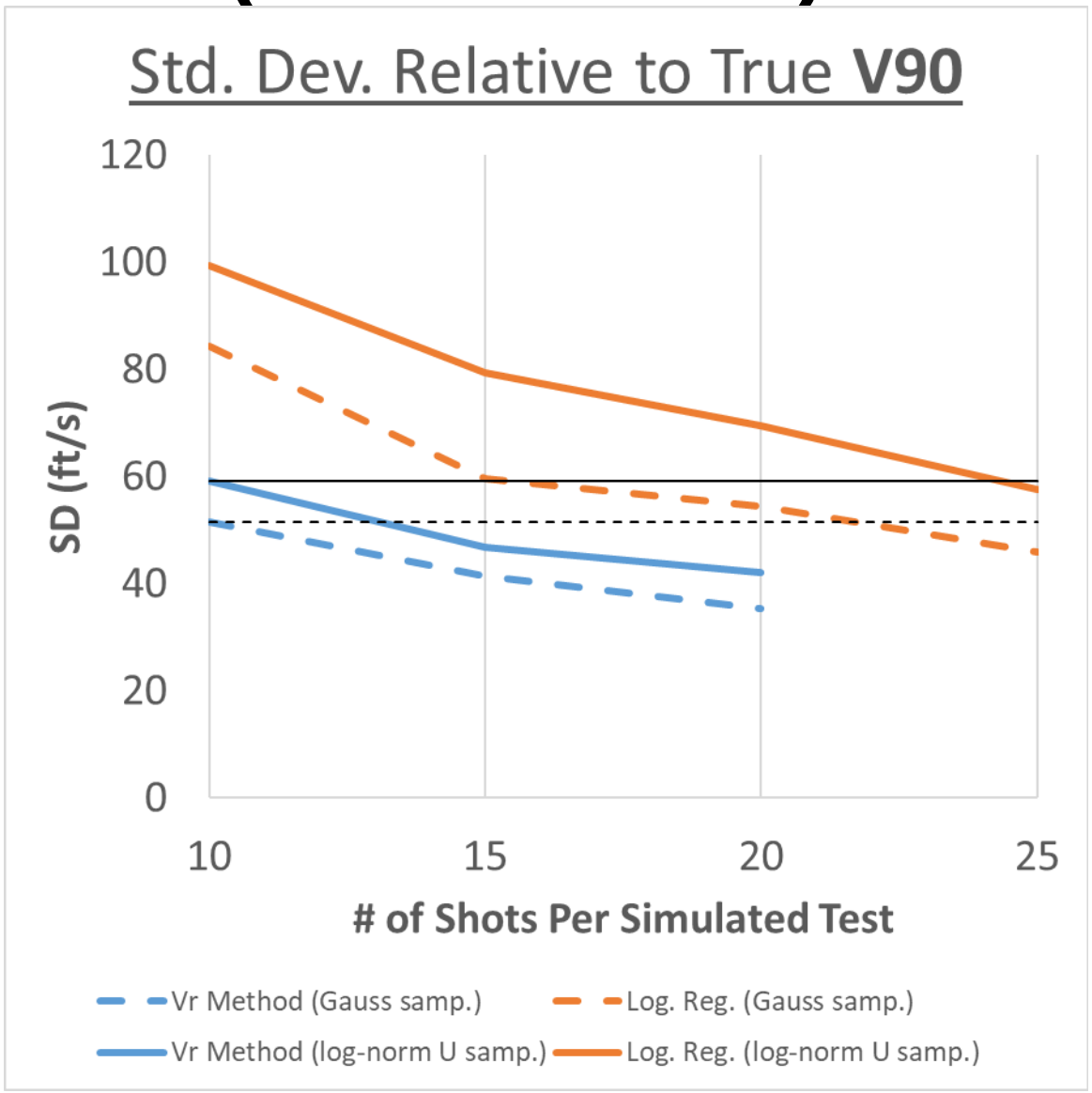
EXPERIMENTAL RESULTS (SOFT PLATE)



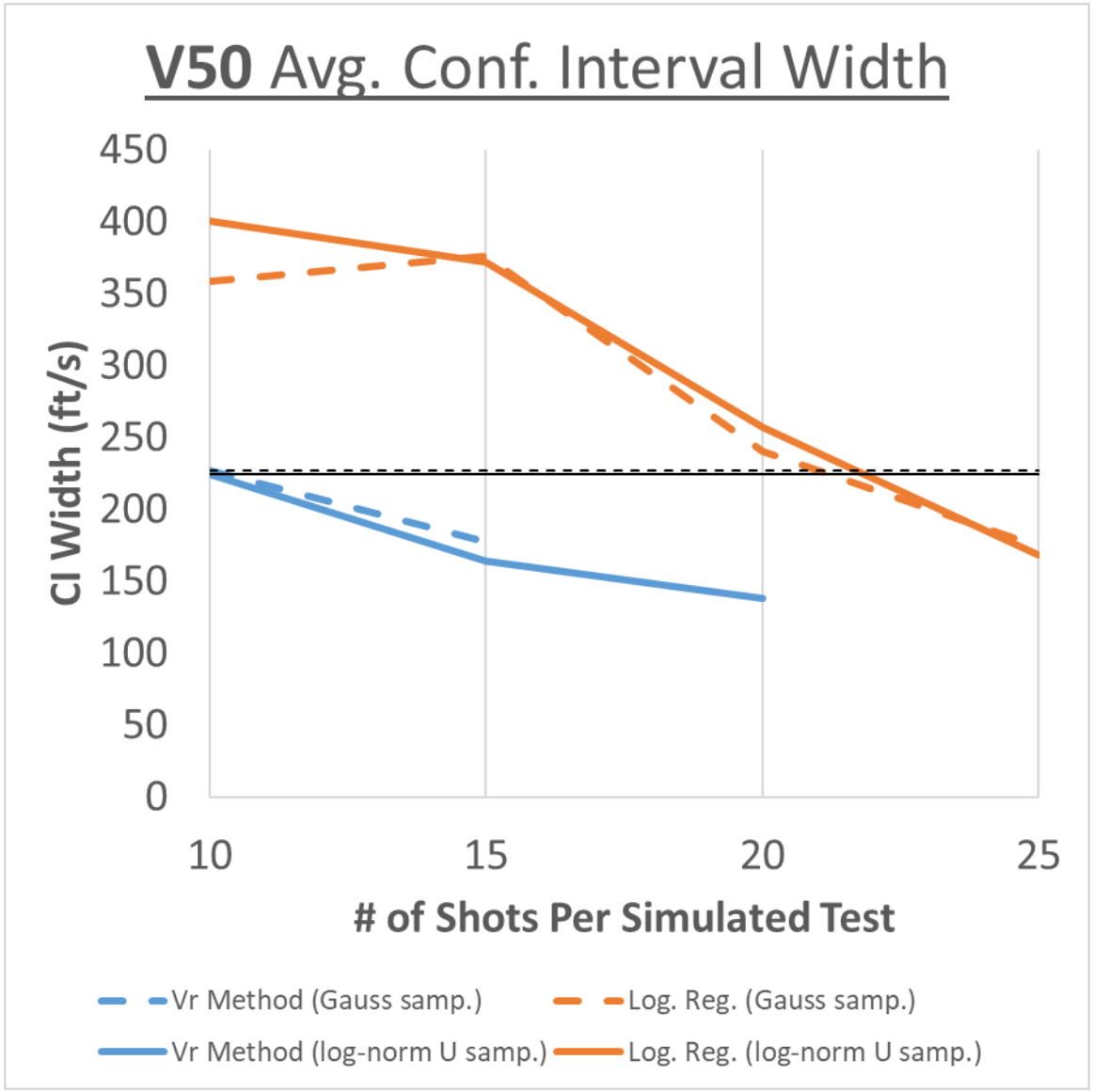


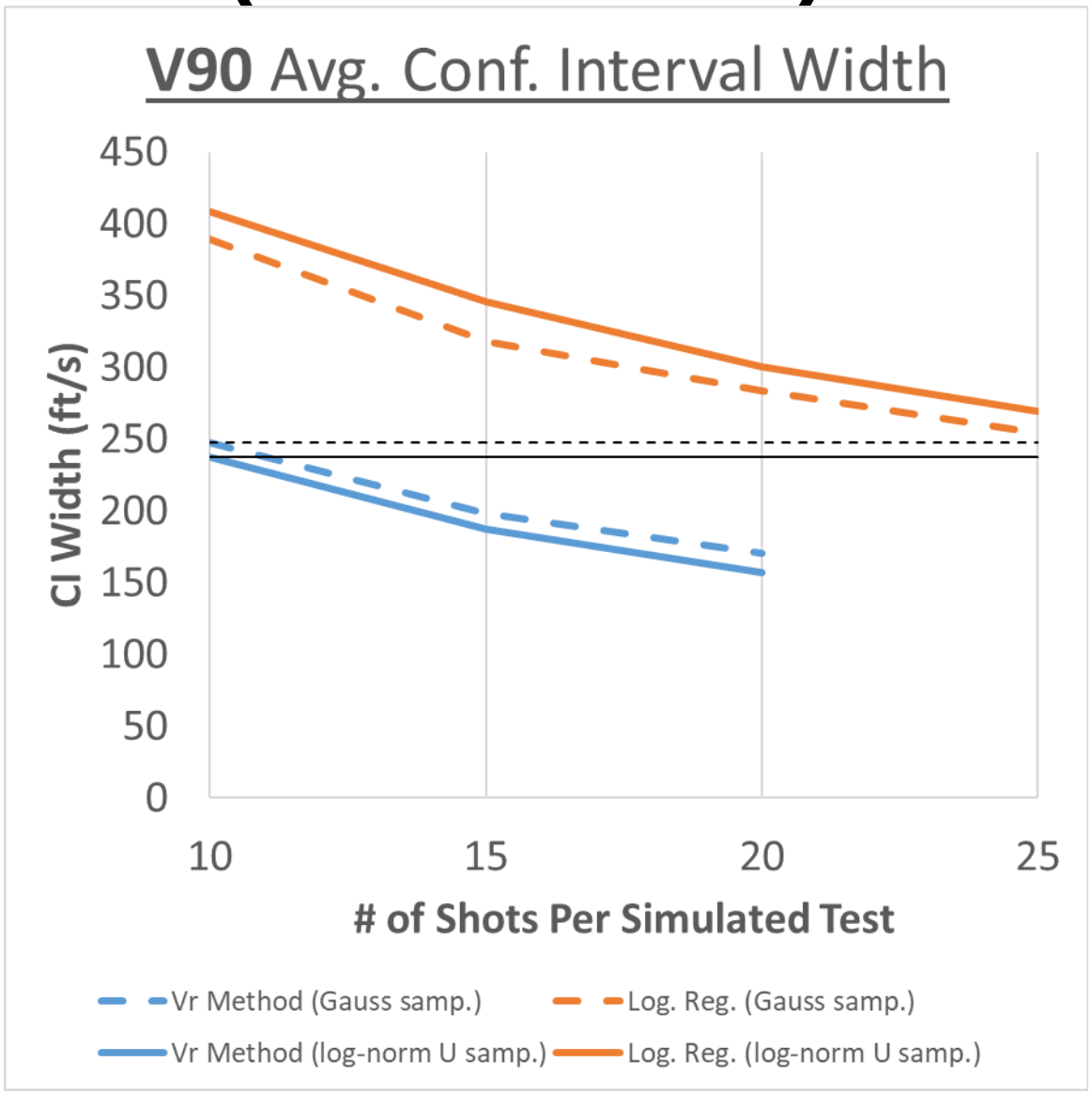
EXPERIMENTAL RESULTS (HARD PLATE)





EXPERIMENTAL RESULTS (HARD PLATE)





CONCLUSION

Initial investigation shows V_r method has potential to be on the order of ***2 to 3 times more efficient*** (in terms of shots required per penetration test) than current binary regression methods for small-sample penetration tests

FUTURE WORK

- Perform additional large-scale penetration tests across multiple calibers, projectiles, and target sets to test generality of V_r method

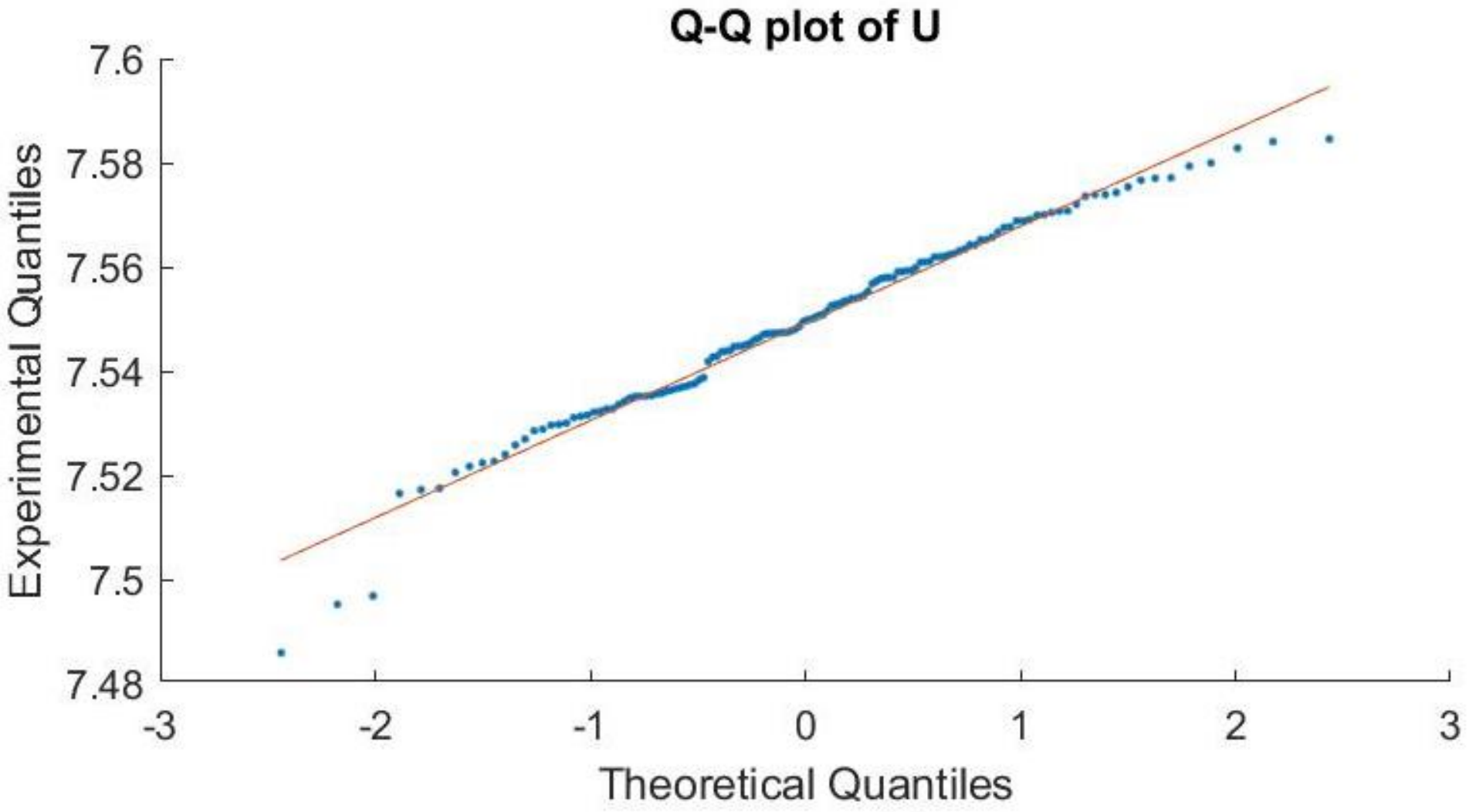
- Research and develop new V_r companion testing method (adaptive data gathering algorithm) to further optimize efficiency

Questions?

Back-ups

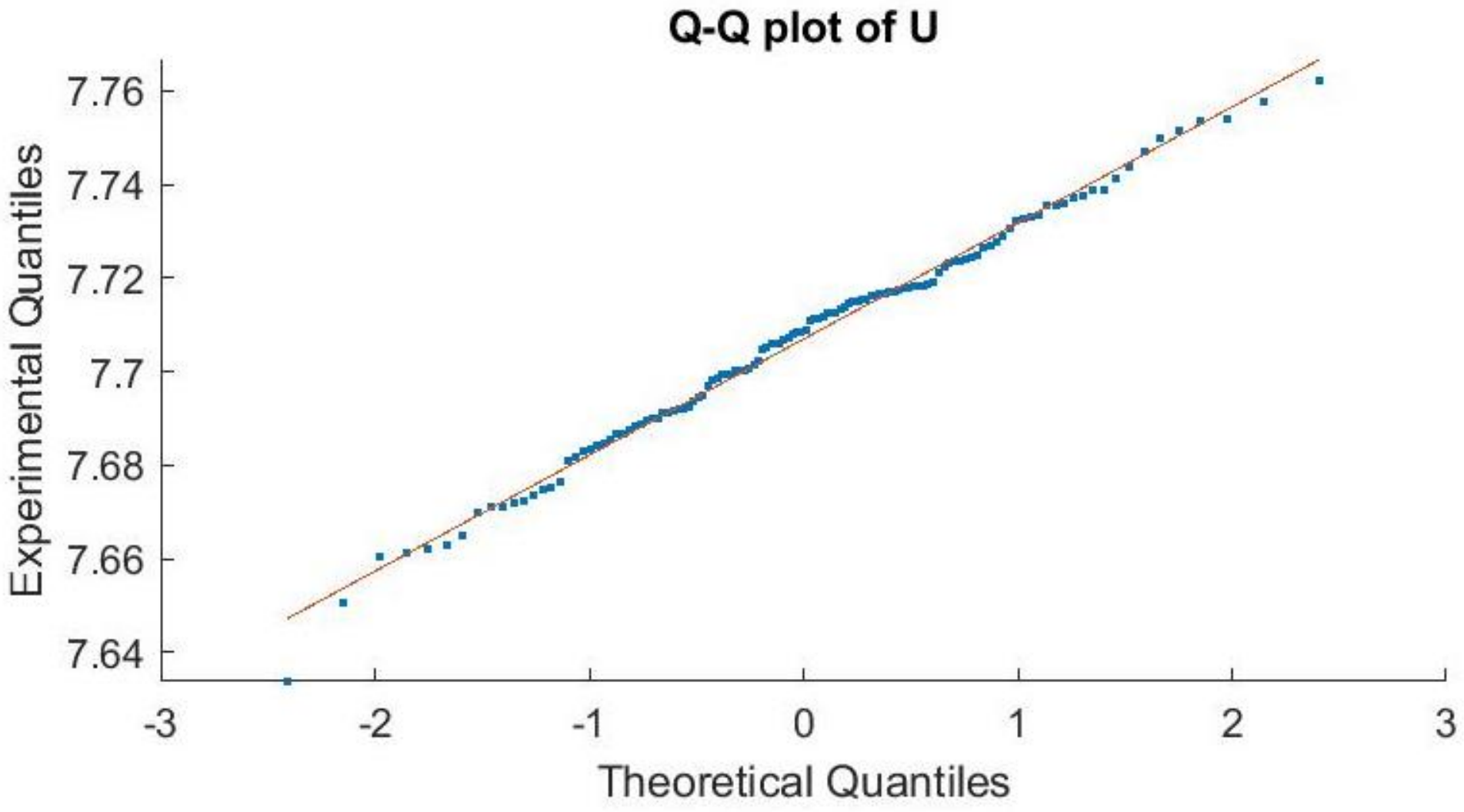
BACK-UPS

Soft Plate
V_r results



BACK-UPS

Hard Plate V_r results



24554 - Blast Amplifying Projectile Bodies For Medium And Large Caliber Projectiles:

By:

Howard D. Kent, ADG LLC,
Robert Folaron, nP Technology LLC

&

AM General And Mandus Group
"The Mobile, Agile, Lethal Artillery Team"

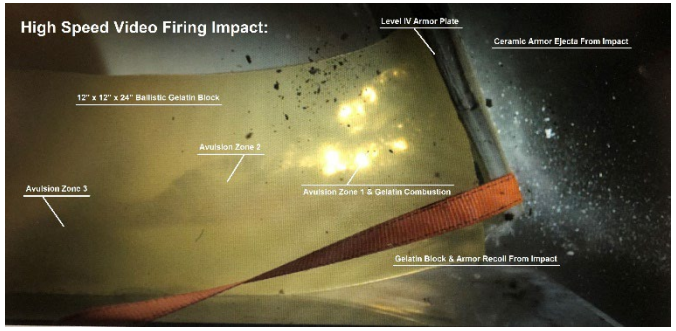
NOTE: Unclassified, Approved For Public Release

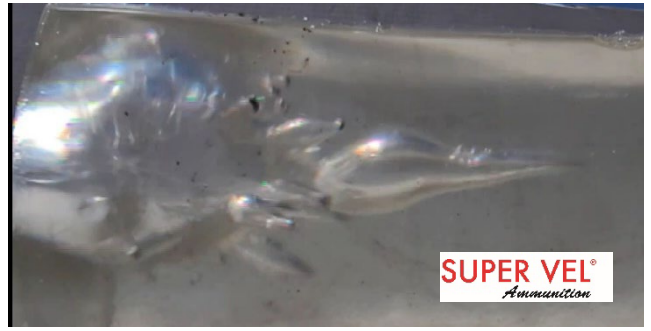
Contents:

3. Introduction To nP Technology Molded Projectiles
6. nP Technology Molded vs. Forged Projectiles
11. Theory Of Blast Amplifying Projectile Bodies
16. NATO IM Standards Discussion
17. Conclusions
18. Recommendations
19. Credits

Presenting: The AM General / Mandus Group Hawkeye Weapon System

Introduction To nP Technology Molded Projectiles:





L-R: **nP** Molded AP Defeating NIJ IV, 3 Foot Diameter Flash From **nP** 0.50 SOT, ***Super Vel "FRAP"*** 9mm Photo **nP** Projectile

nP TECHNOLOGY

NOTE: Unclassified, Approved For Public Release

Introduction:

Colorado Springs, CO

Made In The USA

nP Technology LLC Develops And Manufactures Small Caliber Projectiles In Support Of Military, Law Enforcement, Government Agencies, And Commercial Needs. **nP** Specializes In Rapid Projectile R&D, Developed And Built On Process-Matched High Volume Molding Systems, Ready-To-Load.

"Supporting Our Warfighters With Projectile Technology"

NOTE: Unclassified, Approved For Public Release

Introduction:

https://np-technology.com/

National Armaments Consortium Member

US Army CCDC ARDEC ARL CRADA: Molded Projectile Technology
Armor Defeating FR-AP, Training, Energetic SOT, SRTA, Marking

NDIA Armaments, Small Arms, Guns & Missiles Committee Presenters

NOTE: Unclassified, Approved For Public Release

nP Technology Molded vs. Forged Projectiles:

nP Technology 20mm Low Collateral Damage Training Round

NOTE: Unclassified, Approved For Public Release

nP Technology Molded vs. Forged Projectiles:

Consistent And Accurate Polymerized Nano-Particle Construction

Copper Or Brass Nano-Particles

Tungsten Nano-Particles

Iron Or Steel Nano-Particles

Metallic Powders May Be Blended To Achieve The Desired Cost, Weight And Performance

nP TECHNOLOGY

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nP Technology Molded vs. Forged Projectiles:

With Molded-In Features For Aerodynamics And On-Target Effects

Ballistic And Penetrative Tips, Tracer Cups, Gas Checks And Semi-Jackets

Clockwise From Top Left: Winchester Silvertip, Benjamin Nosler Pellets, ALCO Bullets, Barnes TSX, CVDS Windscreens, US M80A1 Projectile, US 0.50 Spotting Round, Corbin Bullet Cups, Corbin Gas Checks, Swagedies.com Bullet Jackets

NOTE: Unclassified, Approved For Public Release

nP Technology Molded vs. Forged Projectiles:

If Pre-Fragmented Outperforms Natural Fragmentation, What Is The Steel Case For?

FORGING:

*Massive Infrastructure
*High Energy Costs
*High Labor Costs
*Generally A Single Production Line
*Limited Output

MOLDING:

*Minimal Infrastructure
*Lower Energy Costs
*Lower Labor Costs
*High Volume Production

Want More Output?
Just Add Another Machine…

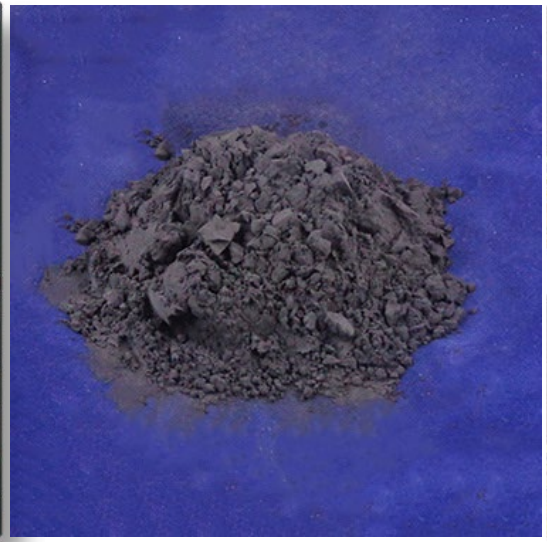
Above Left: Command-SMFI Photo, Above Right: nP Technology Photos

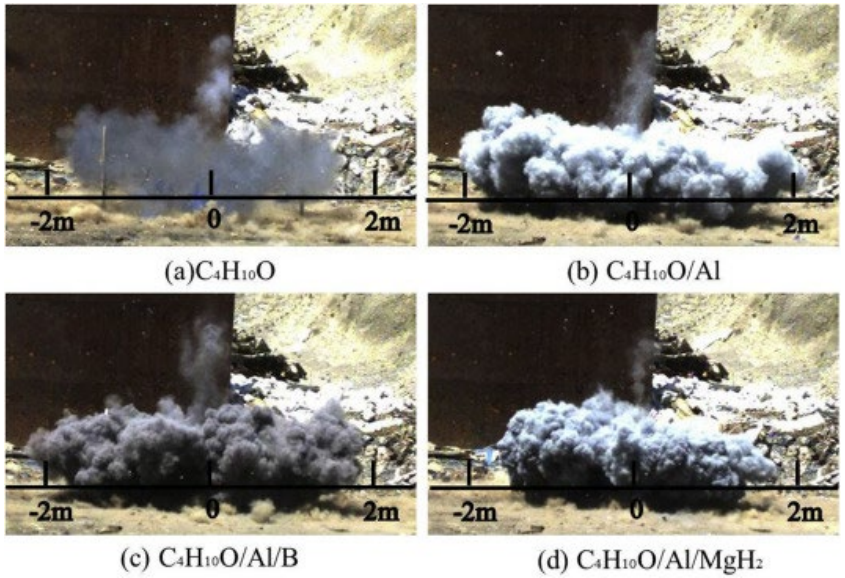
nP TECHNOLOGY

NOTE: Unclassified, Approved For Public Release

nP Technology Molded vs. Forged Projectiles:

And In This Case An Entire Molded Projectile Body Made Of Energetic Material…

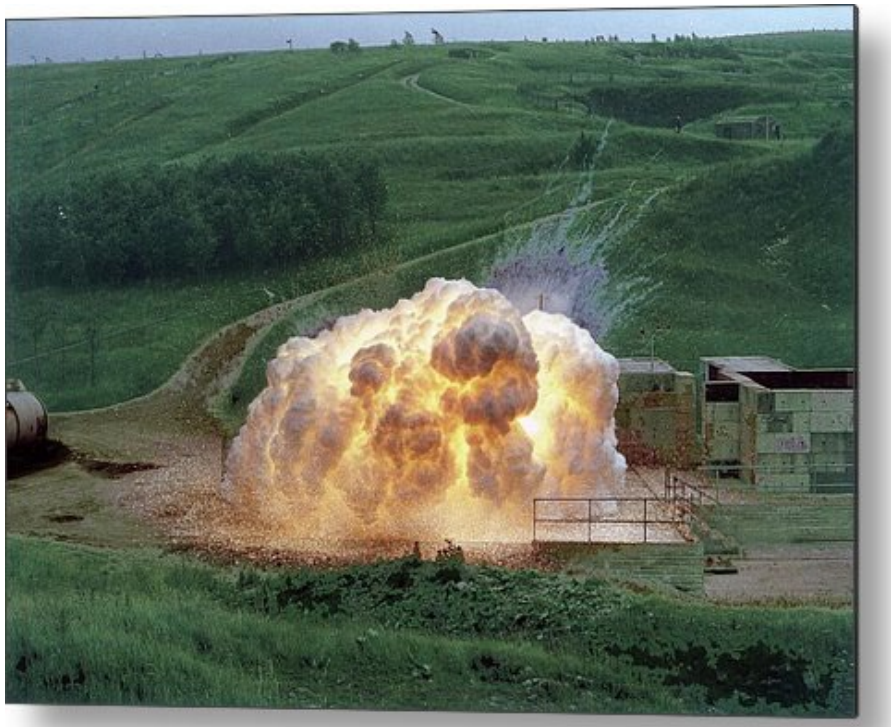




Above L-R: Aluminum Powder-The Health Safety Laboratory Science, Belmont Metals Black Aluminum, Science Direct Metal Powders

NOTE: Unclassified, Approved For Public Release

Theory Of Blast Amplifying Projectile Bodies :



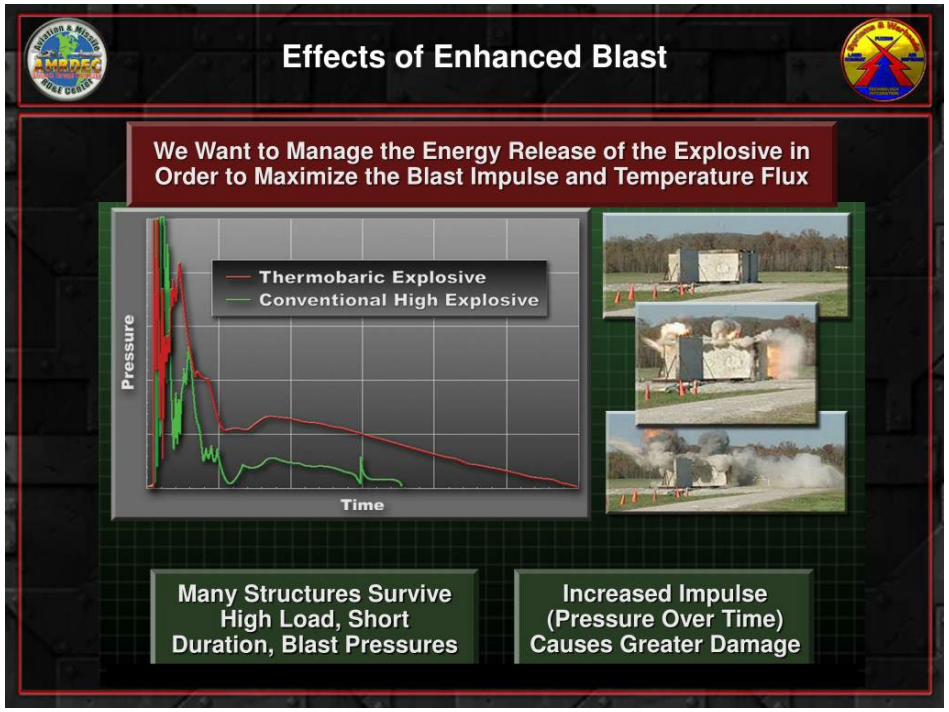
Aluminum Powder Explosion-The Health Safety Laboratory Science

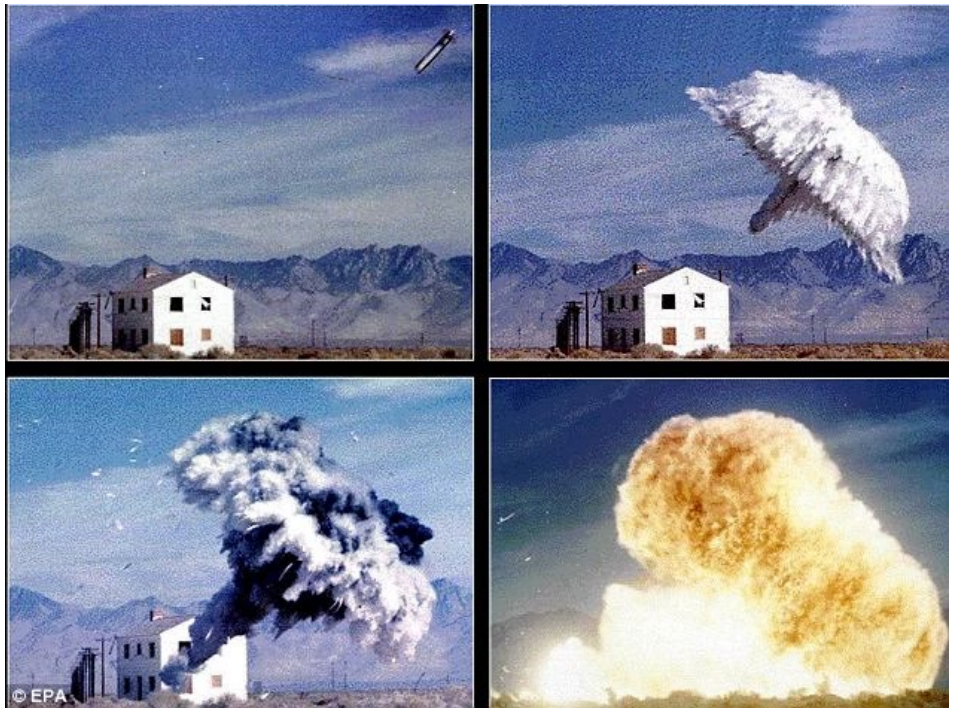
nP TECHNOLOGY

NOTE: Unclassified, Approved For Public Release

Theory Of Blast Amplifying Projectile Bodies :

The Shock Of The Initial Explosion Creates A Flammable Particulate Cloud…





Above L-R: US Department Of Defense Graphics And Images, Fuel Air Explosives

nP TECHNOLOGY

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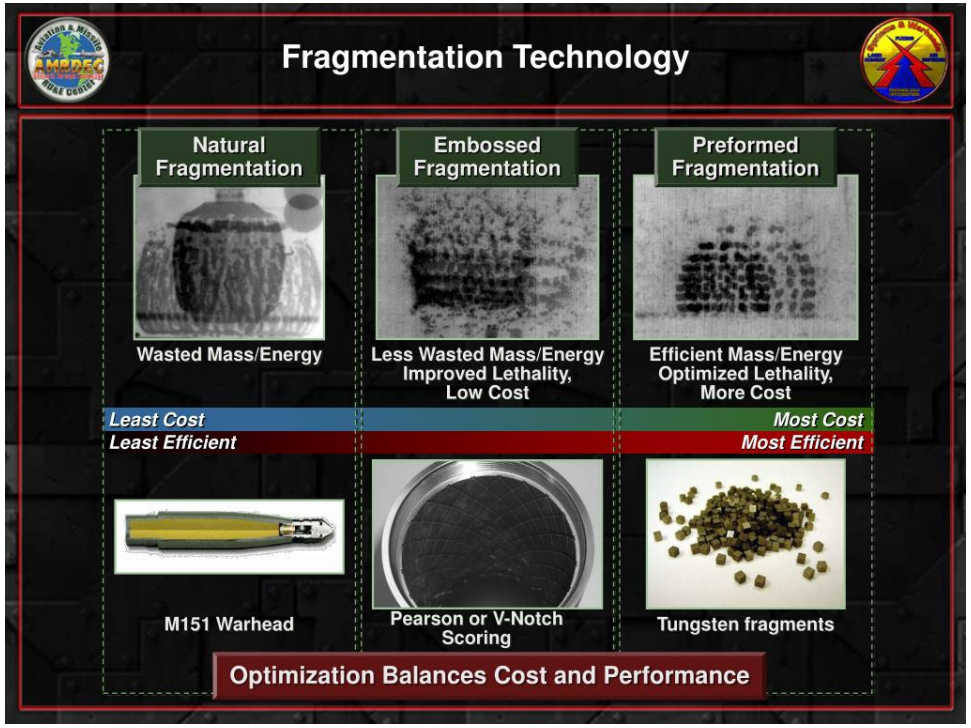
Theory Of Blast Amplifying Projectile Bodies :

Preformed Fragmentation With Lower Cost Assembly Is The Future…



Above: US Department Of Defense Graphics

Clockwise From Upper Left: Epoxy Matrix Science Direct Widener et al, Dreamstime.com Magnetics, Bowman International Roller Type Bearings, SKF Polymer Cage Ball Bearings.

nP TECHNOLOGY

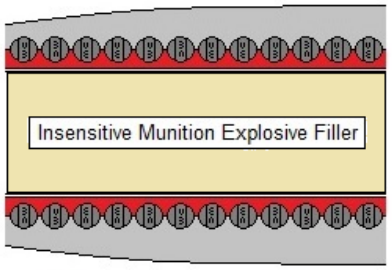
NOTE: Unclassified, Approved For Public Release

Theory Of Blast Amplifying Projectile Bodies:

Theory Behind Projectile Body Blast Participation:

The Same Metals Used To Construct Fuel Air Munitions Are Incorporated Into The Molded Projectile Which Bursts Into Nano-Particles Post Detonation Ahead Of The Blast Wave...

Energetic Metallic Nano-Particulate Molded Body



Preformed Tungsten Fragments In Plastic Matrix

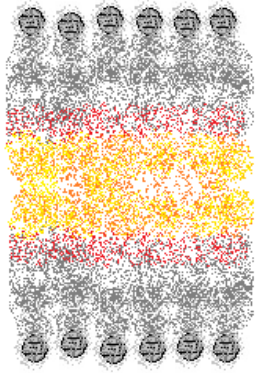
Fragments Expelled

Molded Body Bursts

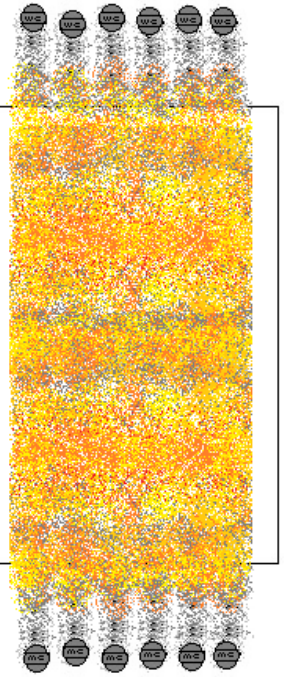
Matrix Vaporizes

IM Filler Explodes

Micro-Seconds Post-IM Filler Detonation



Blast Wave Expands Into Cloud Of Nano-Particles Of Fuel For IM Detonation



HKent/2022

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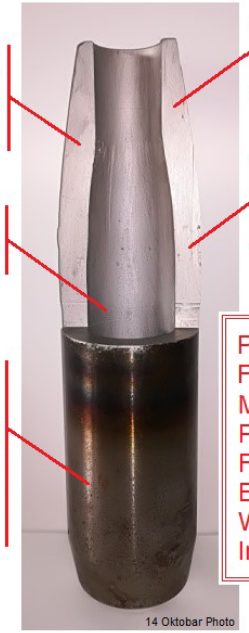
NOTE: Unclassified, Approved For Public Release

Theory Of Blast Amplifying Projectile Bodies:

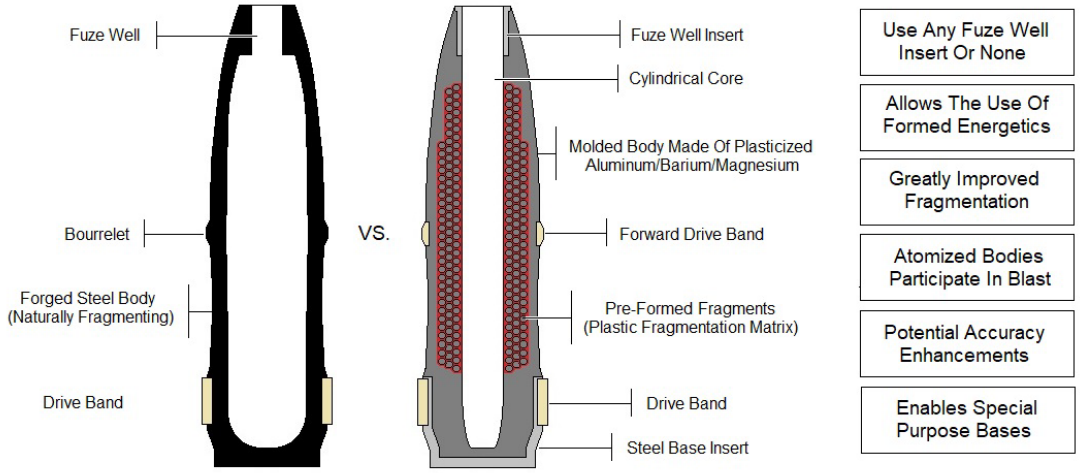
U.S. 105mm M-1 Cutaway:

Heavy Steel Forged Naturally Fragmenting Body



Design Freedom Elements Of **nP** Molded vs. Traditional Projectiles:

"Using A Molded Body Frees The Artillery Shell Designer From Forging Constraints"



Traditional M-1
105mm HE

Proposed **nP** Molded Projectile Technology
105mm Enhanced Blast/Fragmentation

nP TECHNOLOGY

NOTE: Unclassified, Approved For Public Release

Compatible With NATO Standards For Insensitive Munitions:

Discussion Of: **AOP-39**

POLICY FOR INTRODUCTION AND ASSESSMENT OF INSENSITIVE MUNITIONS (IM)

Basic Features Of IM As Applied To Artillery Projectiles Include:

1) Casualty Of Burning Only If Subject To Heating, Fragmentation And Small Arms Fire To 12.7mm @ 850ms.

2) Historically Methods Are Reducing Density And/Or Confinement.

3) Basis For Generalization Of Greater Volume Needed For IM For Identical Effect Of Standard Munitions.

nP TECHNOLOGY

NOTE: Unclassified, Approved For Public Release

Conclusions:

- **The Future** Is Clearly More Accurate, Longer Ranged And More Effective Ammunition For Large Caliber Artillery Which Will Require "Match Grade" Performance.
- **The Method For Increasing The Blast** Of A Lighter, Pre-Formed Fragment Body While Precisely Encapsulating The Contents Can Only Be Performed By Molded Projectiles.
- **Insensitive Munition Standards** May Be Advanced By Using A Smaller Amount Of Actual Core IM Explosives With The Addition Of Fuel And Oxidizer Externally.

Recommendations:

Make A Less Expensive, Lighter Projectile With Increased Range, Lethality And Accuracy:

1. The Molded Projectile Body Is Lighter, Contributes To Enhanced Blast And It Allows For Increased Velocity Without Excessive Pressure.

2. Increased Velocity, All Other Things Being Equal, Means Increased Range.

3. Lighter Projectiles With Enhanced Fragmentation And Blast That Can Accommodate Advanced Features Means: All Things Are Not Equal…

4. Suitable For RAP And Base Bleed, Offsetting Balance For Guided Fuze Bodies.

nP TECHNOLOGY

NOTE: Unclassified, Approved For Public Release

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Credits:

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e-Mail: SamK@mandusgroup.com Phone: 888-988-8502

POC: COL Michael Evans, USA-Ret., Director of Soft Recoil Technology & Mobile Fires Capabilities, AM General Corporation
e-Mail: Michael.Evans@AMGeneral.com Phone: 574-237-6222, 734-502-8322

NOTE: Unclassified, Approved For Public Release

Abstract:

24554 Blast Amplifying Projectile Bodies For Medium And Large Caliber Projectiles:
A Molded Projectile Application Which Enhances Explosive Filler Effects…

There is a need for solutions to the problem in high explosive projectiles where insensitive formulations may need to occupy more space to accomplish the same effects as earlier types…which leads to a crowding out of the metallic body area for designers. So we are then left with either weaker rounds with less explosive power behind reduced fragmentation or ones with more blast effect and reduced fragmentation due to a loss of material.

Typically, the projectile body is made of a solid metal forging or casting which blasts apart creating variously sized fragments, frequently requiring multiple operations for pre-fragmentation. These contain the blast momentarily, but do not otherwise combust or contribute to the explosion. Insensitive explosives reportedly require thinner or smaller amounts of body to even make fragments of. But ***what if this bulkier or smaller quantity of explosive could rely on a performance boost from the projectile body itself?***

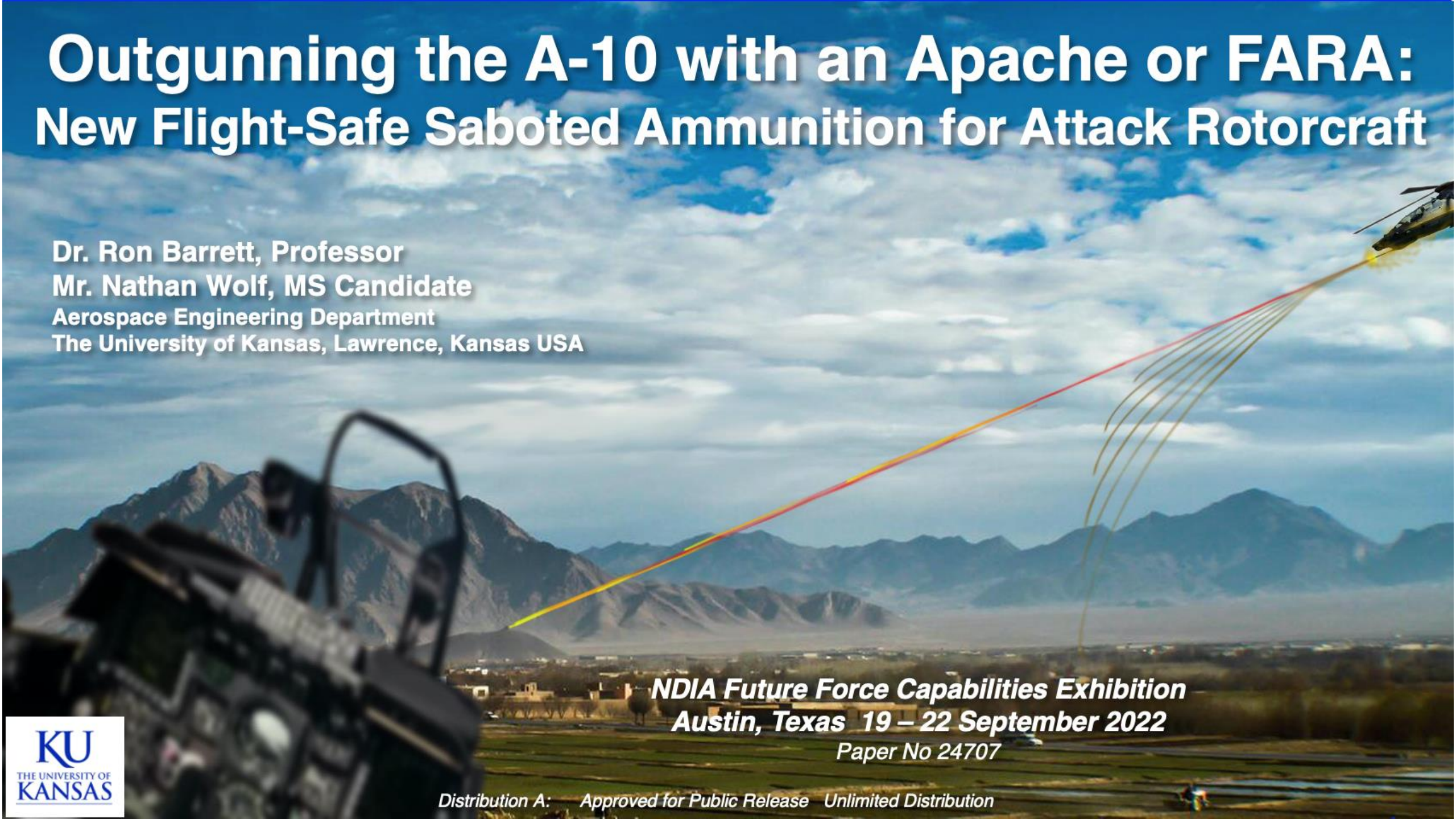
Proposed is a Molded Projectile Body which consists, in part or entirety, of nano-particulate metallic components typically found in explosive formulations. This would replace other forms of projectile body with one that actively participates in the explosion of the core and amplifies the weapon effect.

A molded projectile of this type can also incorporate pre-formed fragments within the body structure which can be used to generate more uniformly shaped fragmentation patterns as well. The round would then burst more powerfully, scatter uniformly shaped and perhaps less massive fragments in predictable patterns, potentially also reducing the range that collateral damage is done.

For example, one could encapsulate a hundred Tungsten balls in a plastic matrix over-molded with polymerized Aluminum as a 30mm projectile body structure filled with precisely arrayed fragments and made of a fuel precursor of the high explosive Amatol. High explosive fillers of traditional or insensitive designs would be applied as usual, but both would benefit from the molded projectile material addition. The body could also contain threaded wells and fuzed as in previous models or be designed for use of structural epoxy which may also contain blast enhancing components.

Outgunning the A-10 with an Apache or FARA:
New Flight-Safe Saboted Ammunition for Attack Rotorcraft

Dr. Ron Barrett, Professor
Mr. Nathan Wolf, MS Candidate
Aerospace Engineering Department
The University of Kansas, Lawrence, Kansas USA



NDIA Future Force Capabilities Exhibition
Austin, Texas 19 – 22 September 2022
Paper No 24707

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Outline:

i. Motivation

ii. The Close Air Support History, Army Challenges

iii. Struggles & Breakthrough: Flight Safe Sabots

iv. BASS & MASS Round Design Philosophies

v. Aerodynamics, Aeromechanics, FEM, Bench Testing

vi. Range Shots, Performance, Trades

vii. Intellectual Property Filings, Claims & Status

viii. Opportunities

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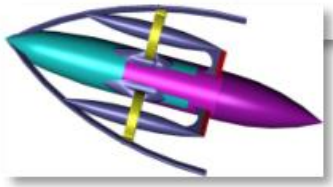
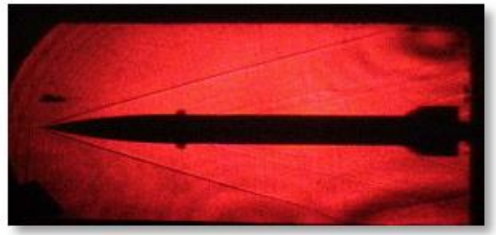
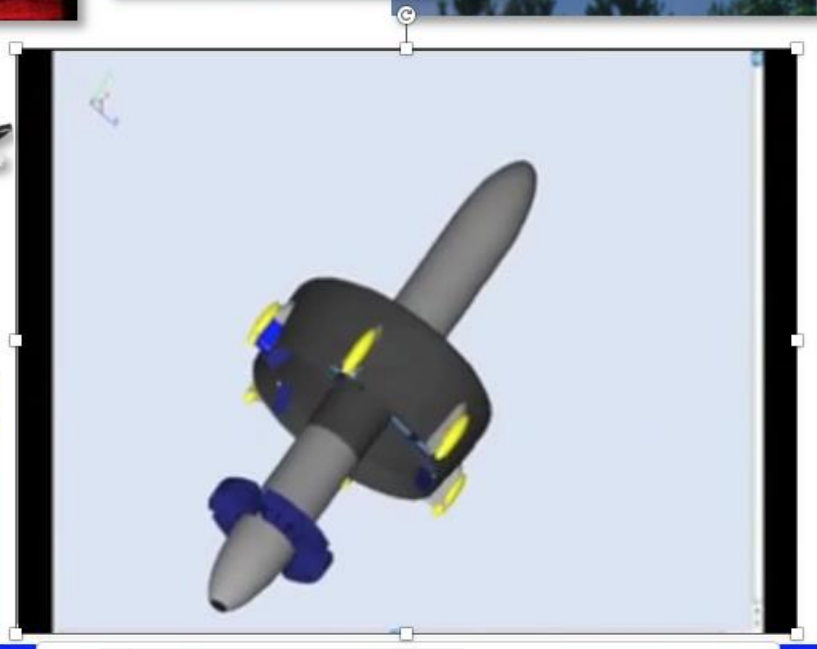
KU Aerospace Engineering Department

Adaptive Aerostructures Laboratory

- *Specialize in "Prime Mover" Military Technologies:*
  - *-Ultra-high performance drones*
  - *-Invisible drones*
  - *-Hovering missiles*
  - *-Guided ammunition 4 – 155mm*
  - *-Hypersonic ammunition*
  - *-Acoustic Vector Sensors*
- *Advanced Commercial Technologies:*
  - *-Adaptive Aerocompliant Surfaces*
  - *-Commercial Drones*
  - *-Toys*
- *IP Protection & Litigation*







45 min. West of Kansas City

Distribution A Unlimited Distribution

KU Aerospace Engineering Department

Adaptive Aerostructures Laboratory

- *Specialize in "Prime Mover" Military Technologies:*
  - *-Ultra-high performance drones*
  - *-Invisible drones*
  - *-Hovering missiles*
  - *-Guided ammunition 4 – 155mm*
  - *-Hypersonic ammunition*
  - *-Acoustic Vector Sensors*
- *Advanced Commercial Technologies:*
  - *-Adaptive Aerocompliant Surfaces*
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  - *-Toys*
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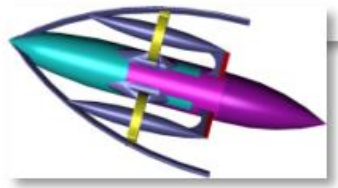
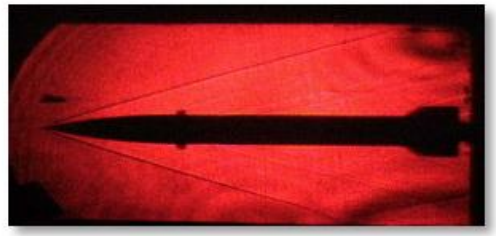
45 min. West of Kansas City





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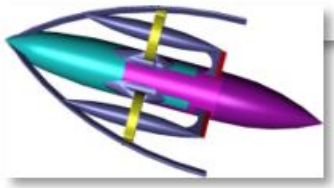

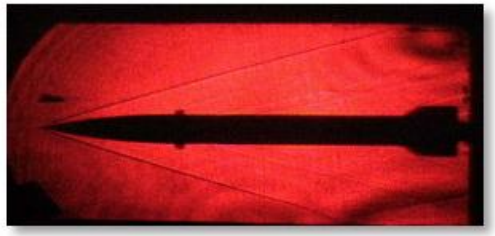

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Distribution A Unlimited Distribution

KU Aerospace Engineering Department

Adaptive Aerostructures Laboratory

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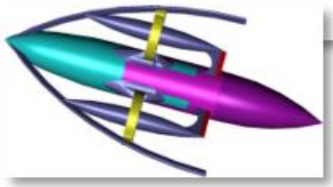

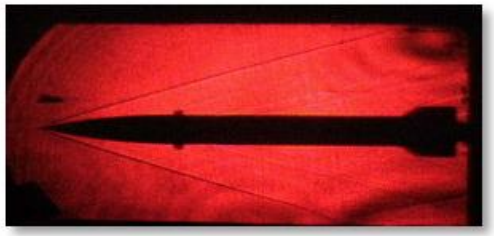

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Distribution A Unlimited Distribution

KU Aerospace Engineering Department

Adaptive Aerostructures Laboratory

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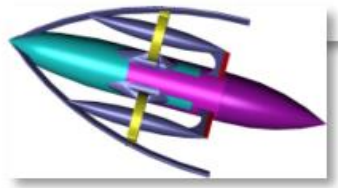
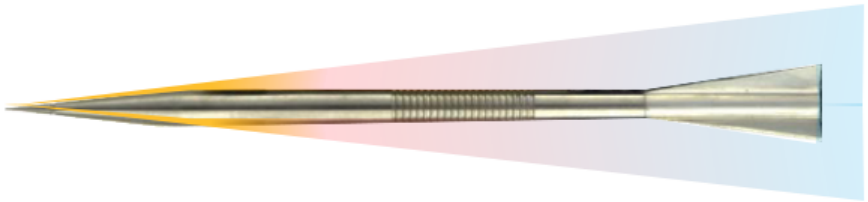


45 min. West of Kansas City

Distribution A Unlimited Distribution

1.Motivation: Why use flight-safe discarding sabot ammunition?

- Endows AH-64 & FARA with better than A-10 gunnery firepower
- Increased range, KE, lethality, P_k, flat fire



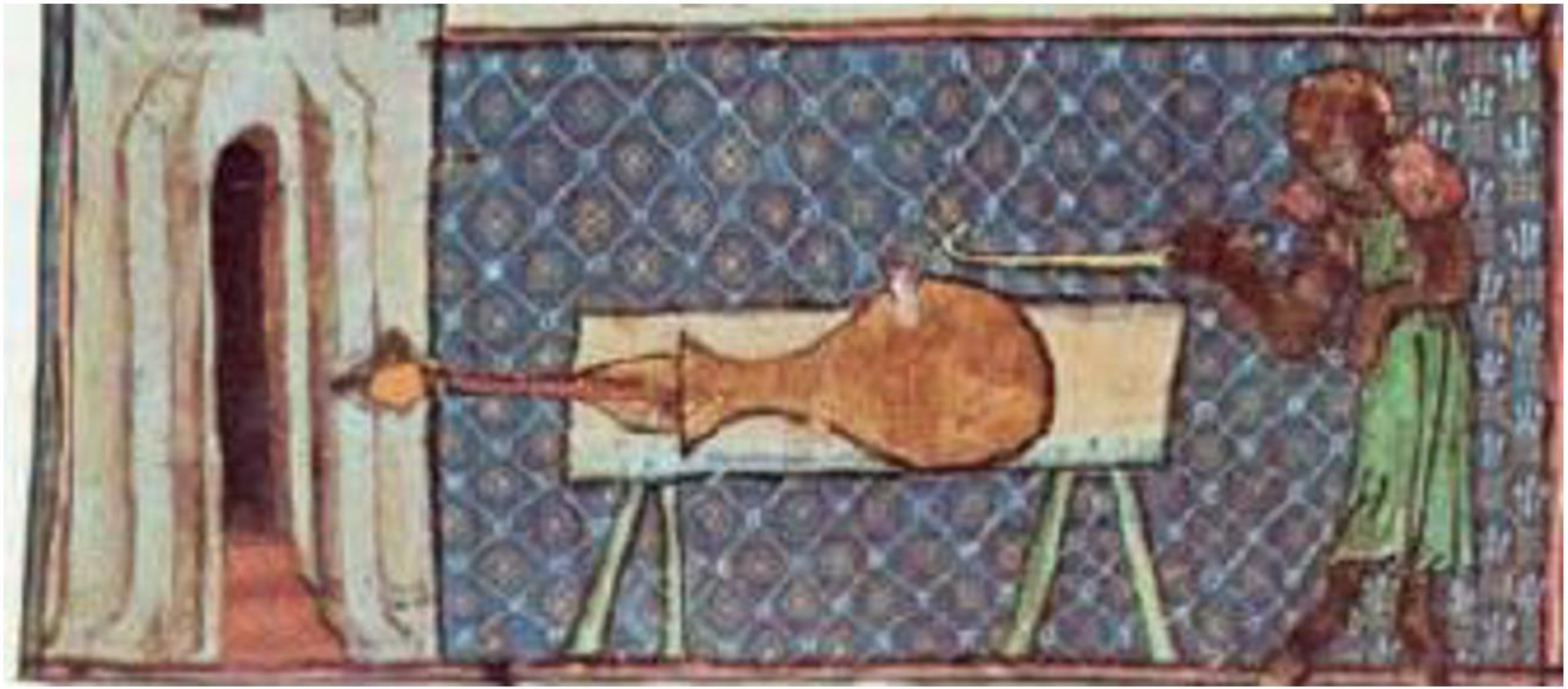
- Reduced TOF, CEP, system weight, volume, airframe MGWTO & LCC
- Enables both unguided and guided variants through hypersonic speeds

Distribution A Unlimited Distribution

2. Saboted Round & Aerial Gunnery History (condensed)

1st Archival Document Describing a Sabot

1326 Treatise of Walter de Milemete



W. de Milemete, "The Treatise of Walter de Milemete: de Nobilitatibus, Sapientiis, et Prudentilis Regum," Christ Church, Oxford; digital ID: 3590ddc7-1ae2-4b23-b576-ec716fb24d01, 1326-1327.

Image Source:
https://catalog.hathitrust.org/Record/002098083

Distribution A Unlimited Distribution

2. Saboted Round & Aerial Gunnery History (condensed)

- **Increasing Chamber Pressures & Functions of Early Sabots – 1850's**

L. HOUGHTON.

No. 12,629. Loading Ordnance. Patented Apr. 3, 1855

Fig. 1.

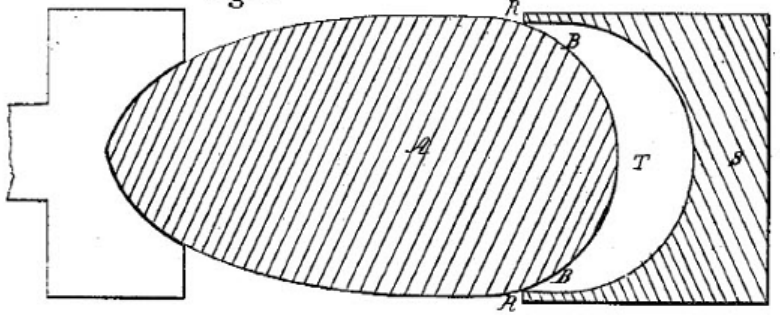


Fig. 3.

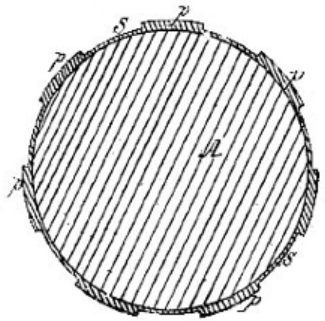
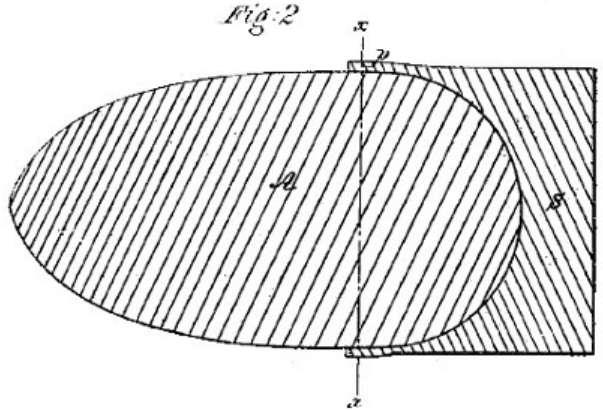


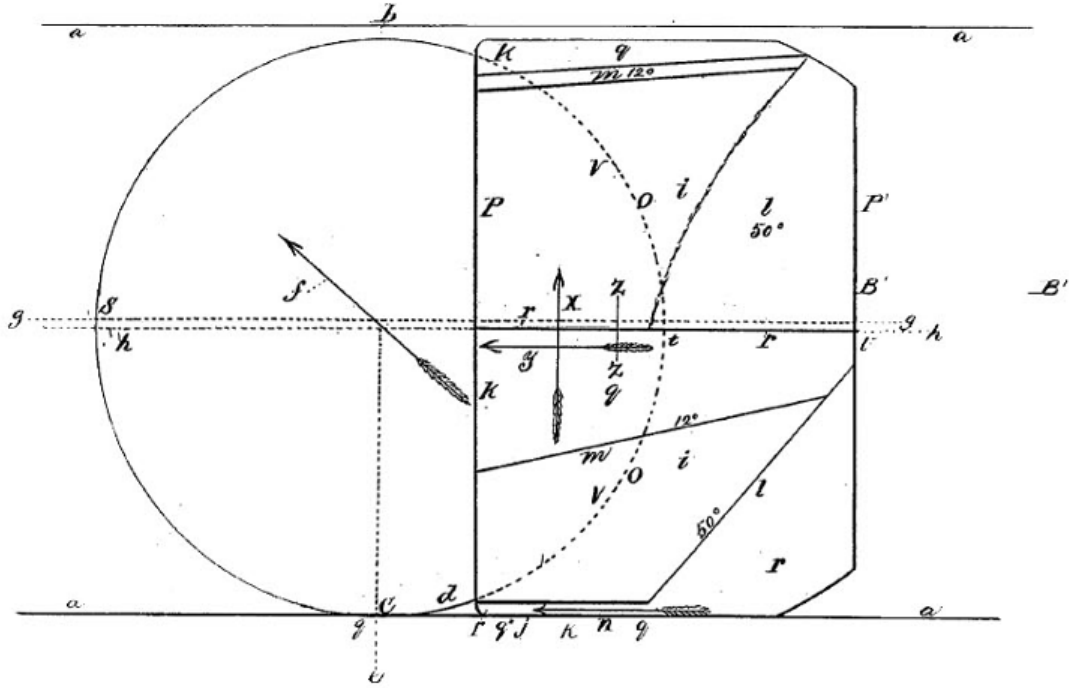
Fig. 2



W. W. HUBBELL.

No. 15,075. Sabots and Wads. Patented June 10, 1856.

Fig. 1.



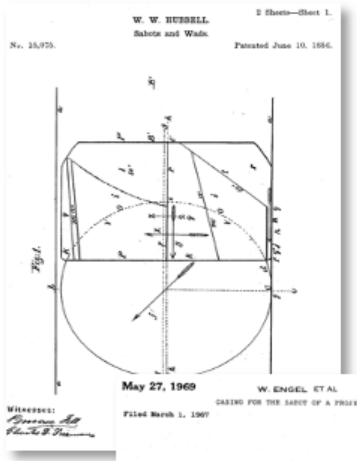
Distribution A Unlimited Distribution

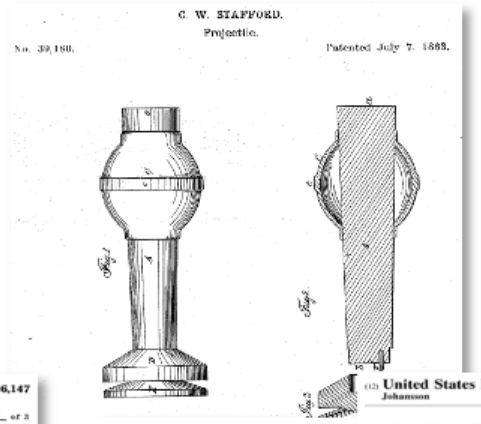
2. Saboted Round & Aerial Gunnery History (condensed)

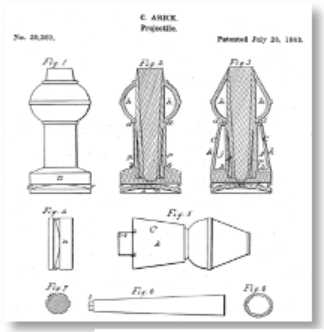
695 Years of Sabots…

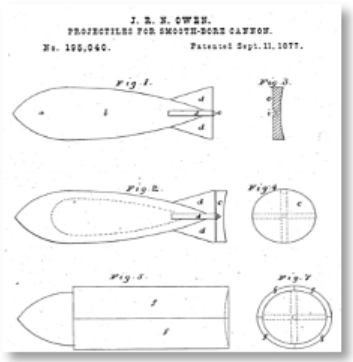
US Civil War – Modern Sabots

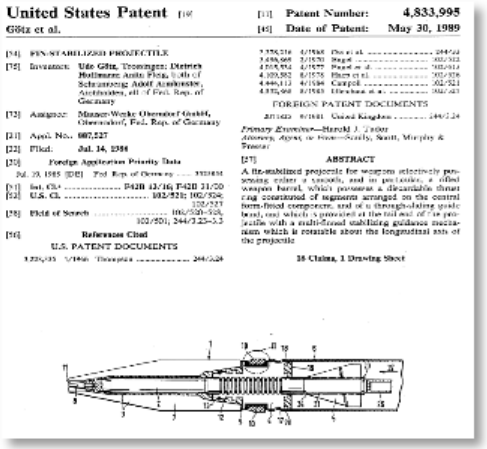
Not one suitable for aerial gunnery

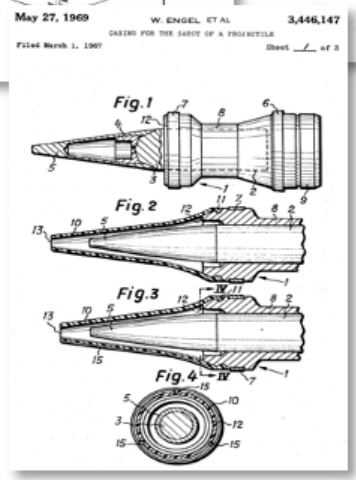


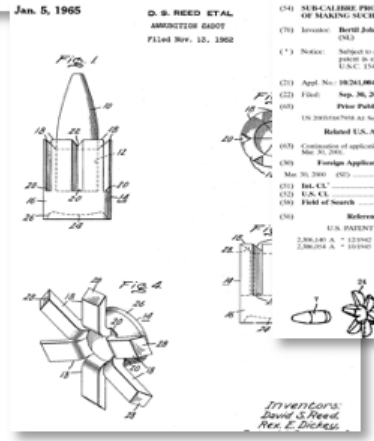


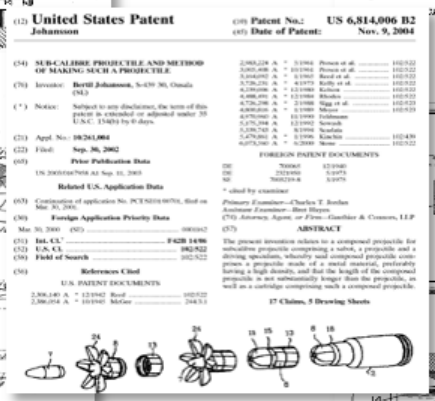


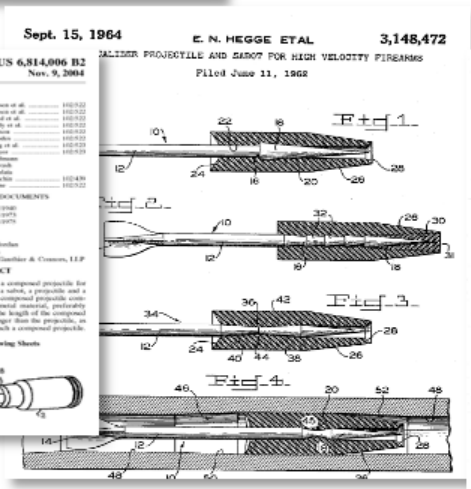


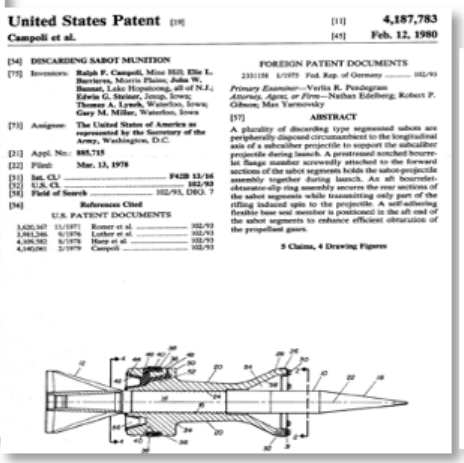


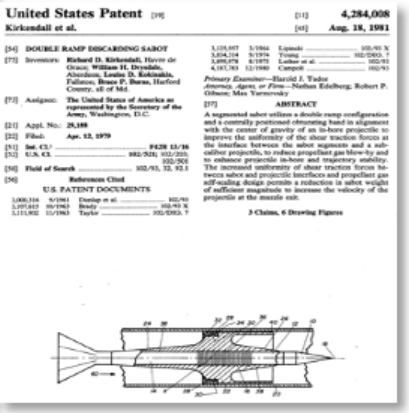








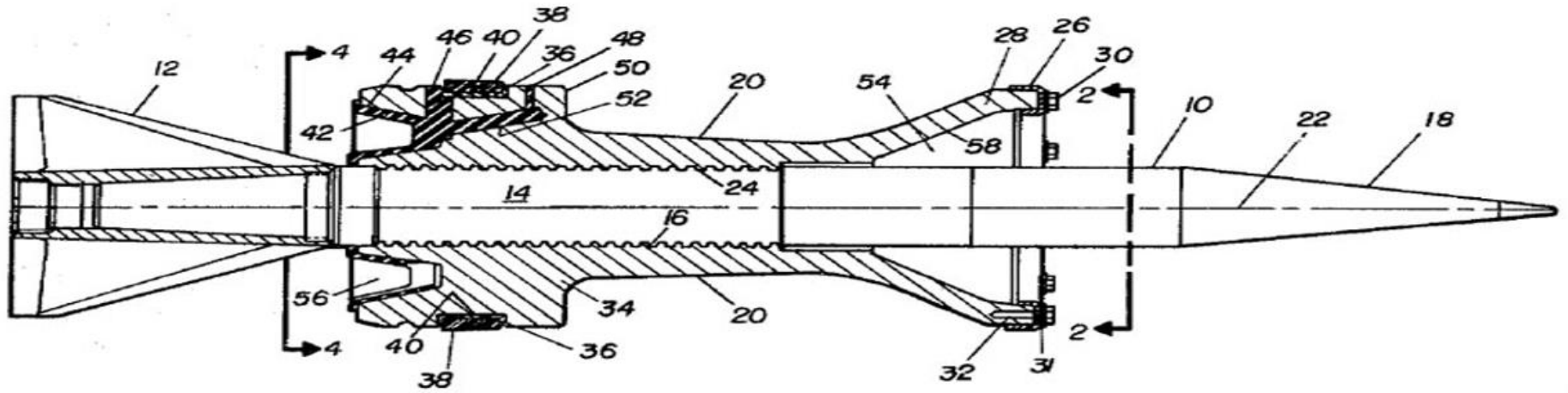


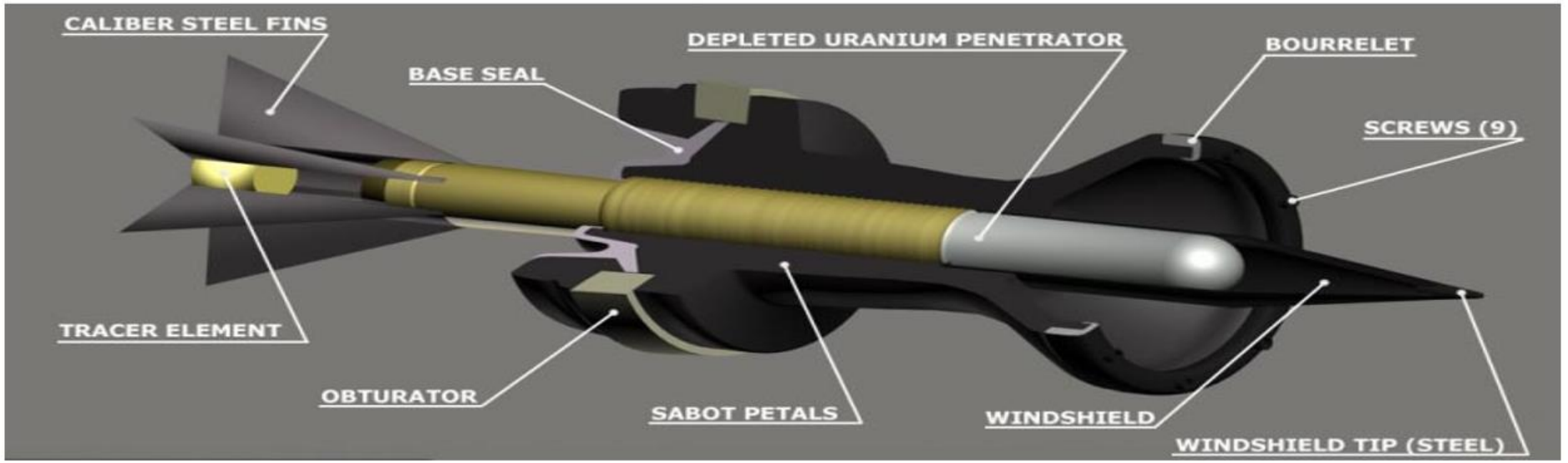


Unlimited Distribution
Distribution A

2. Saboted Round & Aerial Gunnery History (condensed)

Modern Armor-Piercing Discarding Sabot Munition





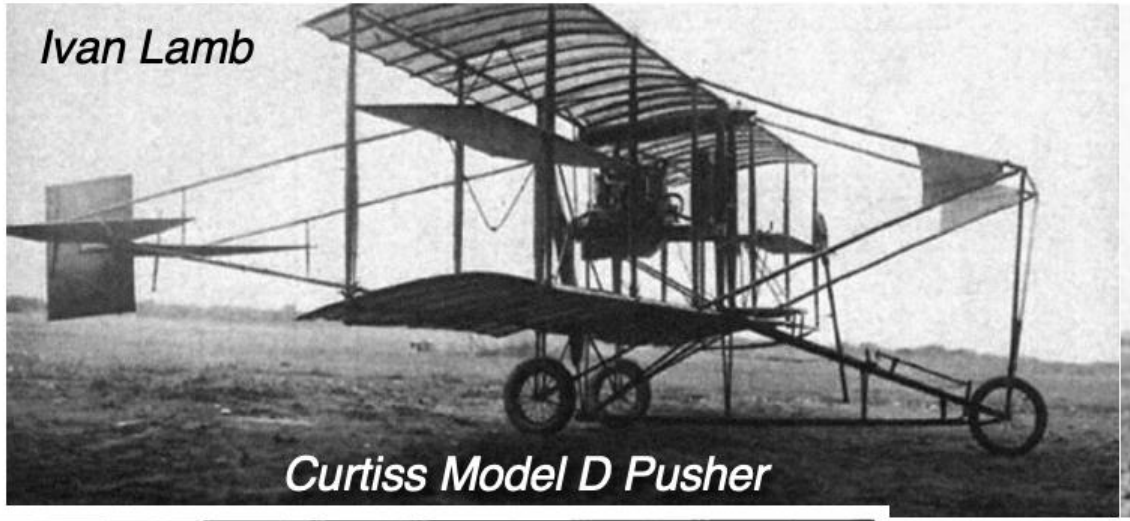
Distribution A Unlimited Distribution

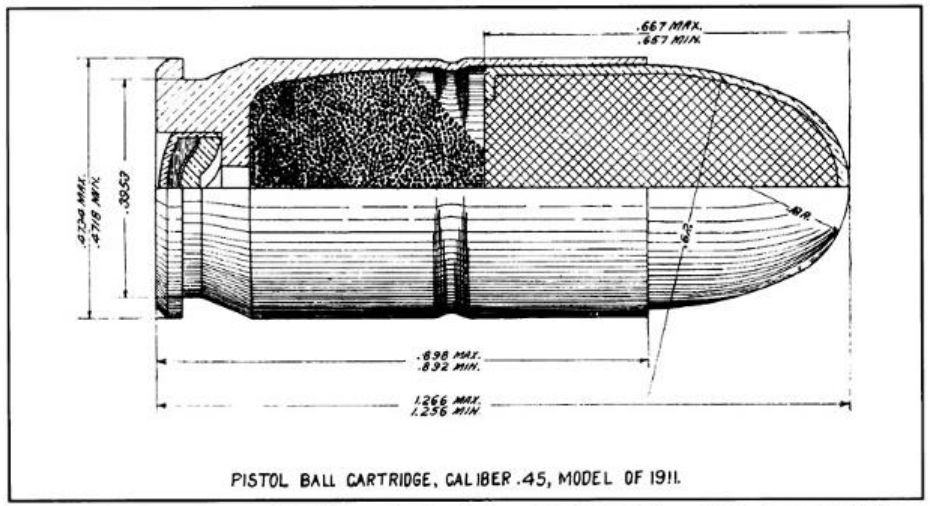
2. Saboted Round & Aerial Gunnery History (condensed)

Dean Ivan Lamb & Phil Rader
Soldiers of Fortune
Naco, Sonora & Naco, Arizona

2. Aerial Gunnery History (condensed)

1st Gun Duel





The drawing above, from a 1918 "Manual of the Automatic Pistol Caliber .45 Model of 1911," illustrates components of the original military .45 ACP loading—a 230-gr. bullet traveling at 855 f.p.s.

Model 1906 .45 Revolver Ball cartridge

US Army Colt 0.45 1909

Image Source https://en.wikipedia.org/wiki/M1911_pistol

Distribution A Unlimited Distribution

2. Aerial Gunnery History (condensed)

1st Air-to-Ground Strafing:

US Customs House, Naco, Arizona

Distribution A Unlimited Distribution

2. Aerial Gunnery History (condensed)

1st Air-to-Ground Strafing:

US Customs House, Naco, Arizona

"Customs people are always irritating."
–Dean Ivan Lamb

Distribution A Unlimited Distribution

2. Aerial Gunnery History (condensed)

Aerial Gunnery WWI

20mm Becker Autocannon in the Front of a Gotha G.1

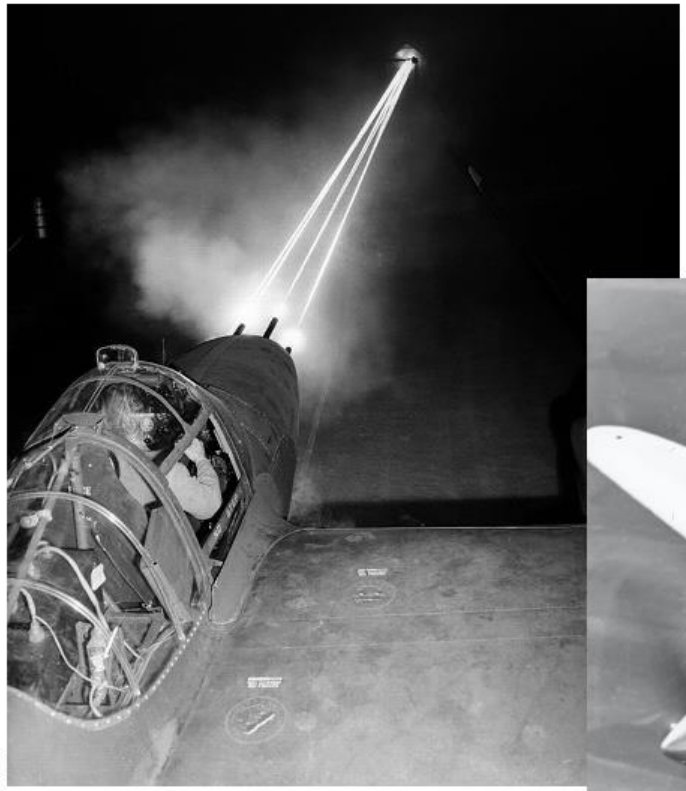
Distribution A Unlimited Distribution

2. Aerial Gunnery History (condensed)

JU-87G-1 with 37mm Cannon (1937 – 1945)

Distribution A Unlimited Distribution

2. Aerial Gunnery History (condensed)



WWII

20mm P-38 Lightning Autocannon

Distribution A Unlimited Distribution

3. Struggles & Breakthrough

Post-Key West Drive for Army CAS:

US Army's 1st Gunship: YAH-32 Hornet

Distribution A Unlimited Distribution

3. Struggles & Breakthrough

Post-Key West Drive for Army CAS:

OV-1… Symptom of the Unmet Need

Distribution A Unlimited Distribution

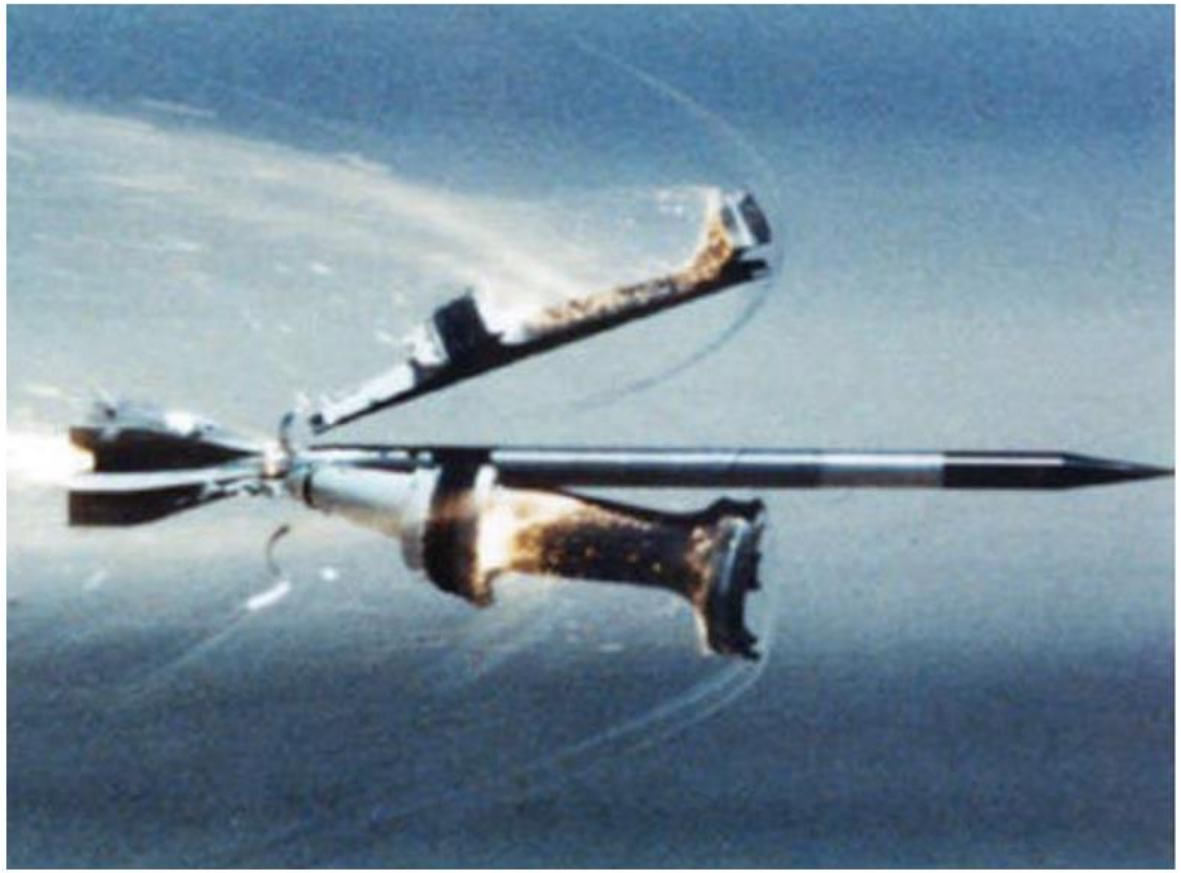
3. Struggles & Breakthrough

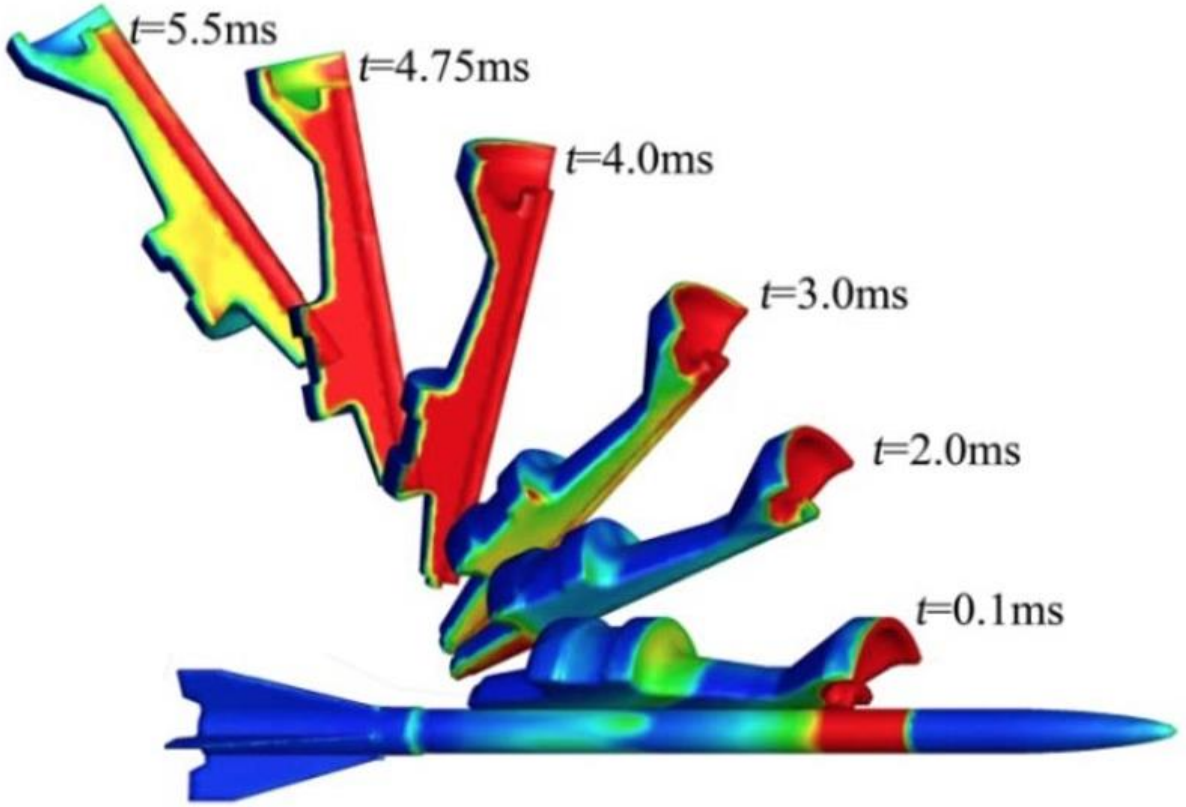
Post-Key West Drive for Army CAS: AH-1 Cobra

Distribution A Unlimited Distribution

3. Struggles & Breakthrough

Conventional Discarding Sabot Design Philosophy and Aeromechanics

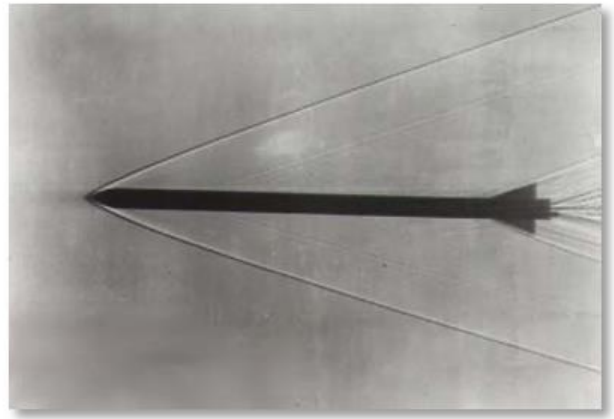




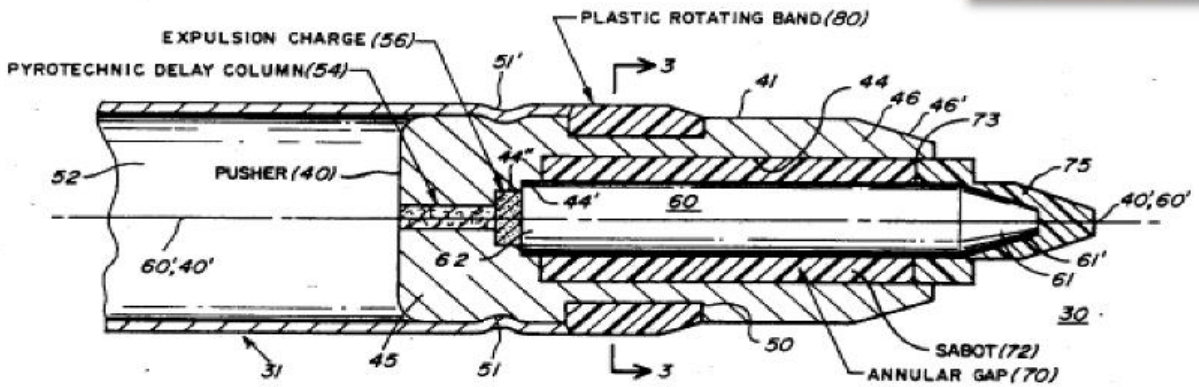
Distribution A Unlimited Distribution

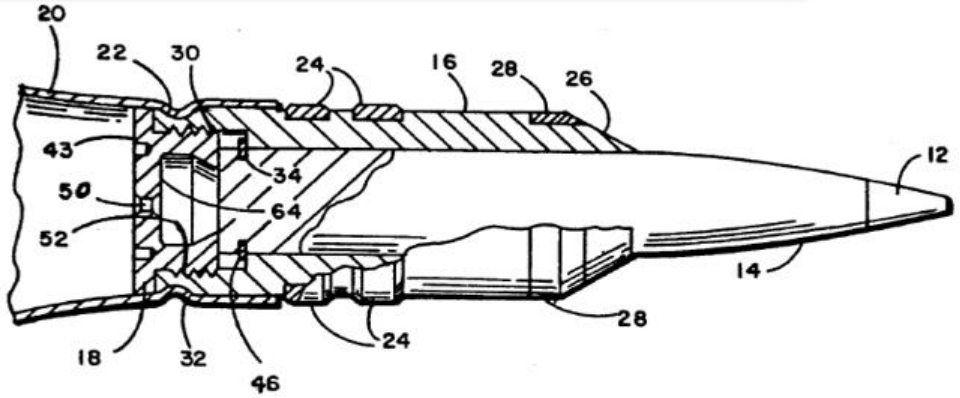
3. Struggles & Breakthrough

- *Tremendous Activitiy 1952 – 1998*
- *Sabot Diverters*
- *Hybrid Rocket-Assisted Projectiles*
- *Drag Fumers*
- *Rotating Bands*
- *Tubular Projectiles*
- *Disentegrating Sabots*
- *Meyer & Burnette Sabots*



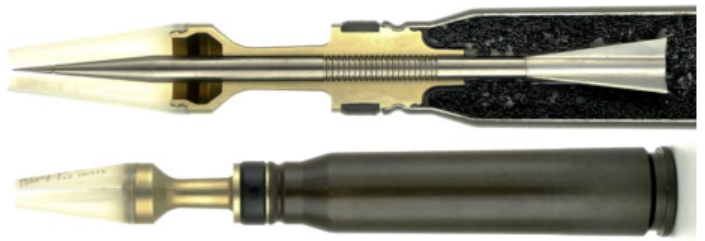
Aeroballistic Research Facility





Distribution A Unlimited Distribution

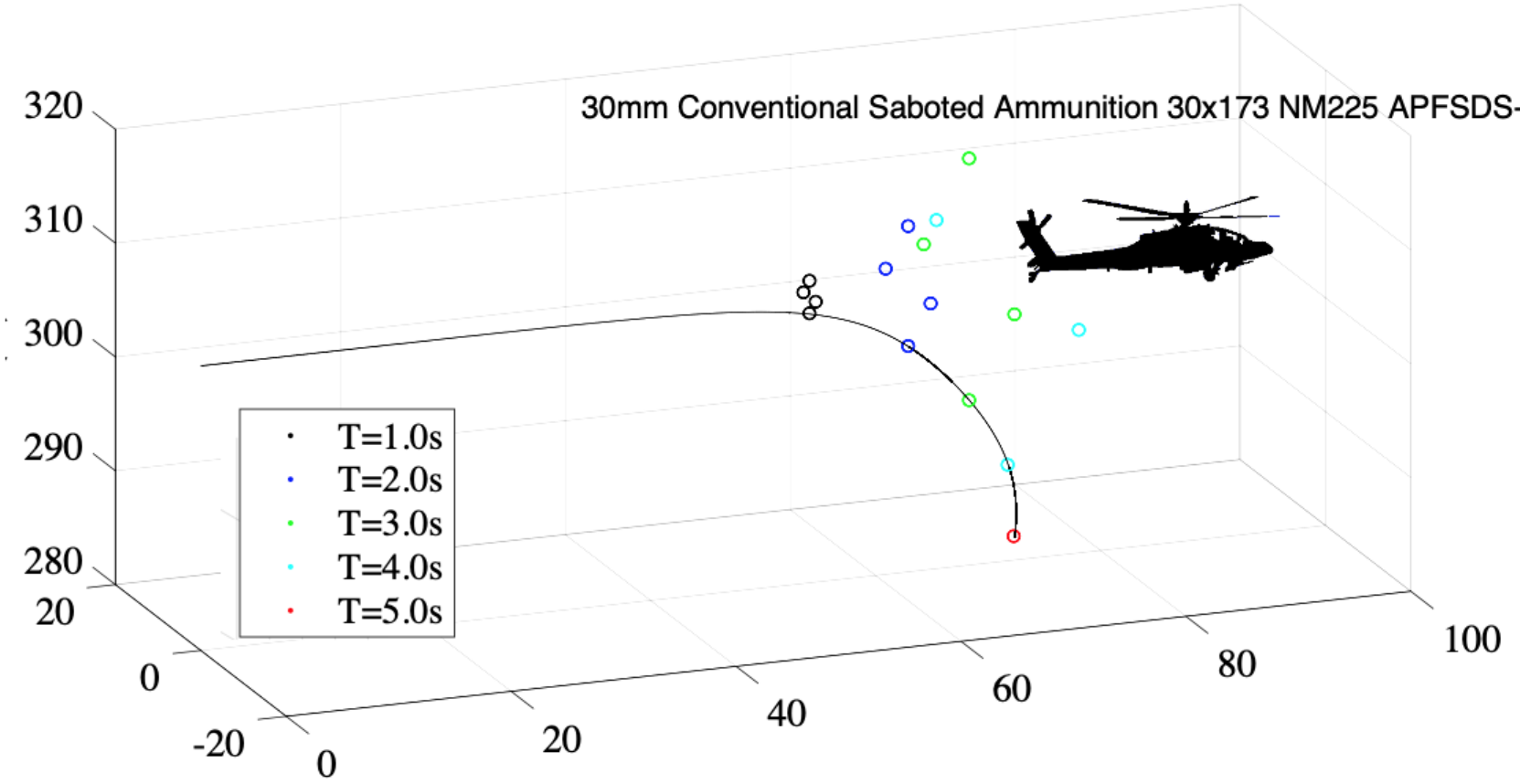
3. Struggles & Breakthrough



Struggles with Aircraft & Sabots

The Great Show Stopper for conventional sabots:

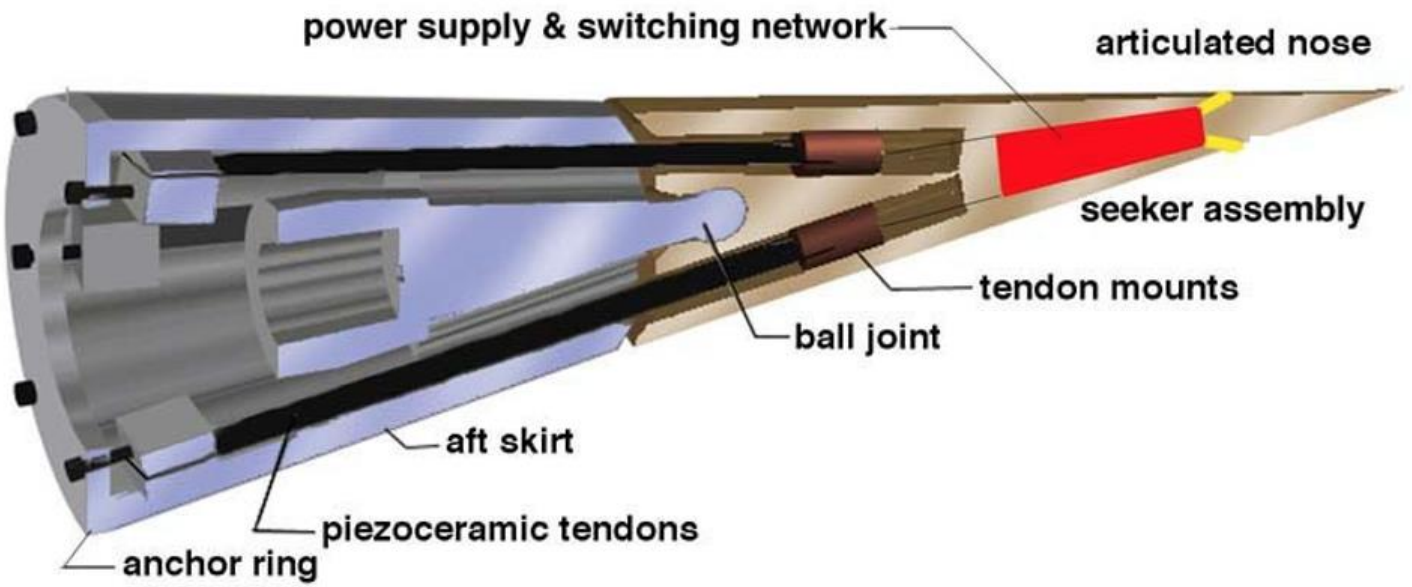
Flight Safety



Distribution A Unlimited Distribution

3. Struggles & Breakthrough

- **USAF developed 1st guided aerial gunnery round prototypes 1995 - 1998**
  - ***Barrel-Launched Adaptive Munition (BLAM) Program 1995 - 1998***



Distribution A Unlimited Distribution

3. Struggles & Breakthrough

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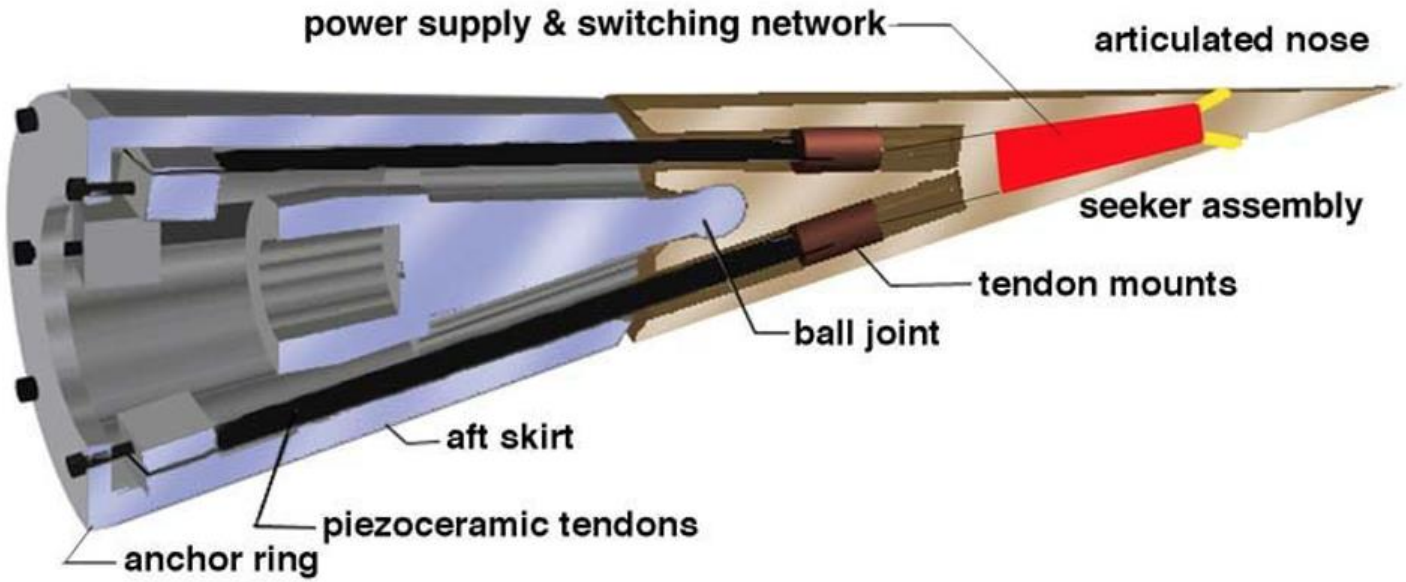


1998: USAF ceases all advanced/guided aerial gunnery & saboted ammo. RDT&E

The AFRL does not have an S&T portfolio in ammunition.
-David Lambert AFRL Munitions Directorate Chief Scientist, (via J. Ellison) 2021

Distribution A Unlimited Distribution

3. Breakthrough

Ms. (now Dr.) Lauren Schumacher

2016 Co-Inventor
Ballistic Aeromechanically Stable Sabot (BASS) Ammunition
Maneuvering Aeromechanically Stable Sabot (MASS) Ammunition

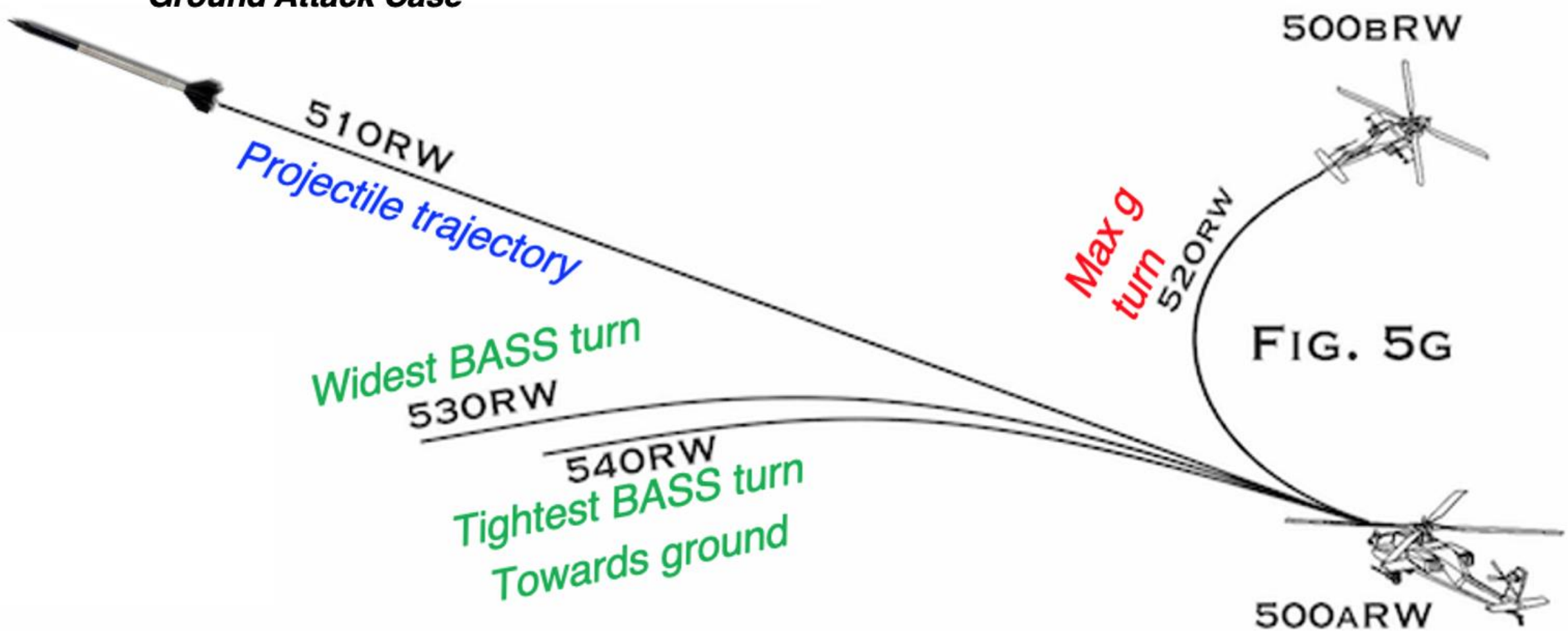
Senior Systems Engineer, Raytheon

Distribution A Unlimited Distribution

3. Breakthrough:

BASS Rounds: Design the Sabot to clear the launching aircraft

Ground Attack Case

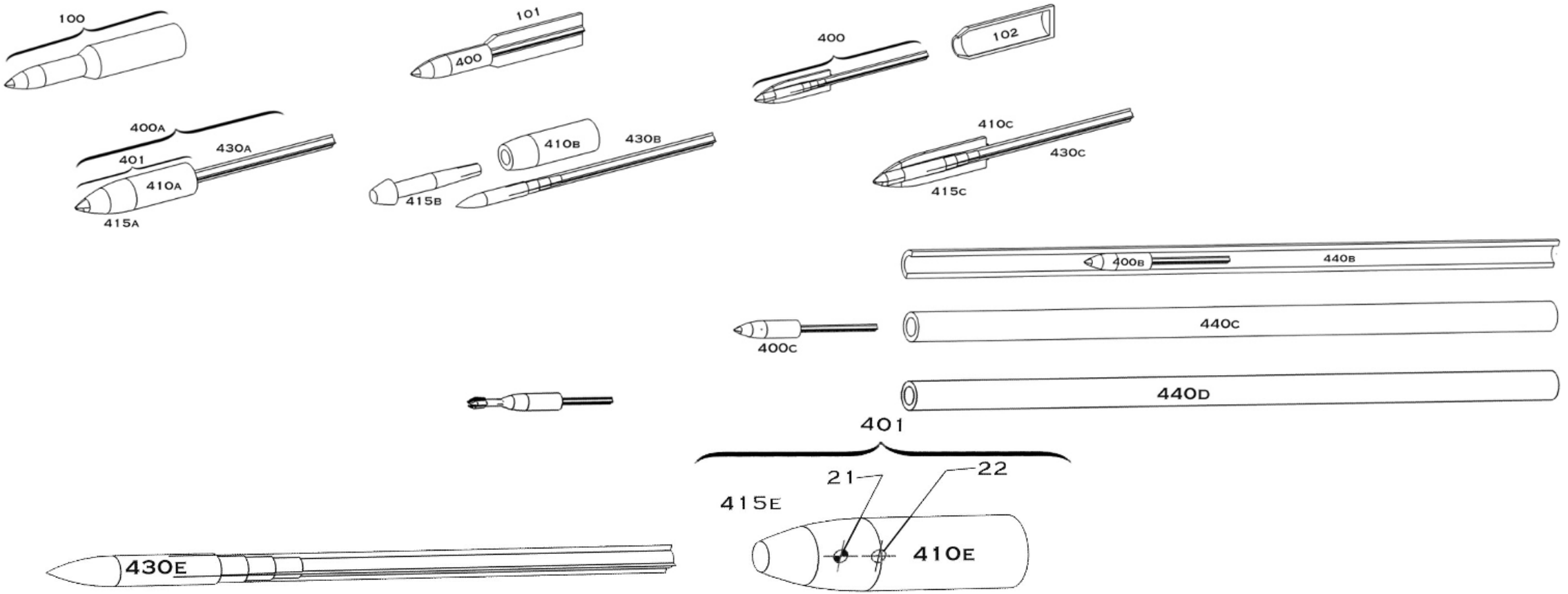


Distribution A Unlimited Distribution

4. MASS & BASS Rounds

What is claimed is:

1. An aeromechanically stable sabot...



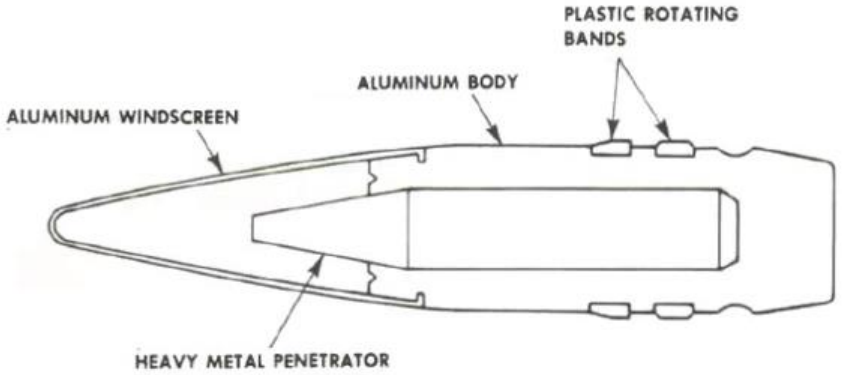
54 major families, >1,000 species covered in expansive patent filings

Distribution A Unlimited Distribution

4. MASS & BASS Rounds

Today's Aerial Gunnery Round

PGU-14



BASS 2081 Flechette/penetrator

Distribution A Unlimited Distribution

5. Modeling & Testing

- *Conceived 2016 & reduced to practice*
- *Modeled in CFD, FEM, DATCOM & PRODAS*
- *Tested on Shock Table, Wind Tunnel, Range*
- *>100 rounds fired, currently @ TRL-6*

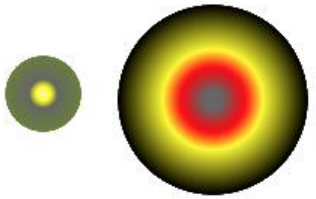
Distribution A Unlimited Distribution

5. Modeling & Testing

Top-Level Drag and Stability Characteristics

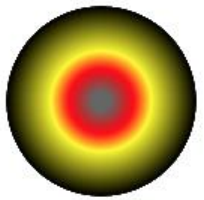
Flechette

X-Sectional Area of PGU-14 >> Flechette



Supersonic Drag ~ proportional to X-Sectional Area, $Drag_{PGU14} >> D_{Flechette}$

PGU-xx



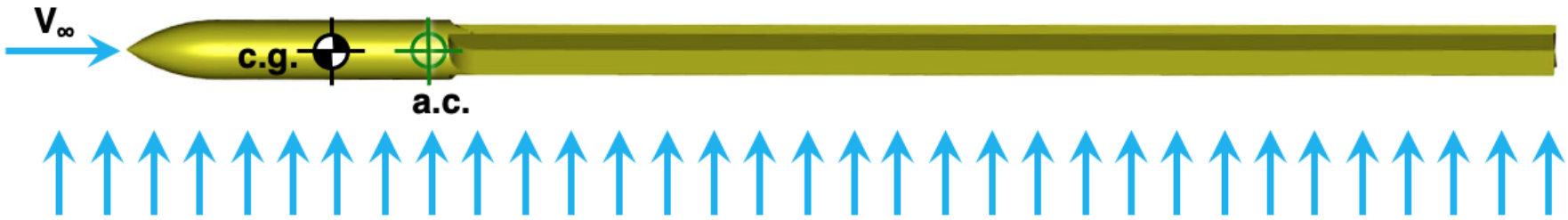
Distribution A Unlimited Distribution

5. Modeling & Testing

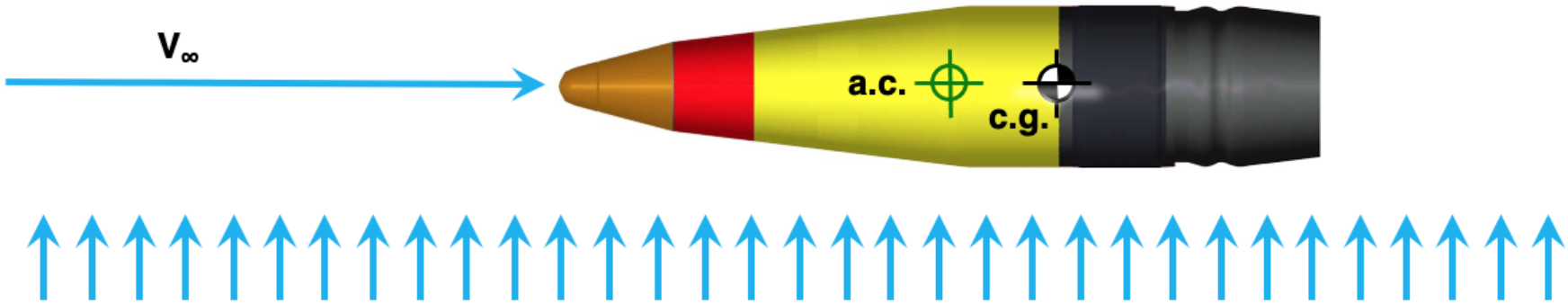
Projectile Aeromechanics & CEP Fundamentals

Flechette

Instantaneous introduction of lateral gust



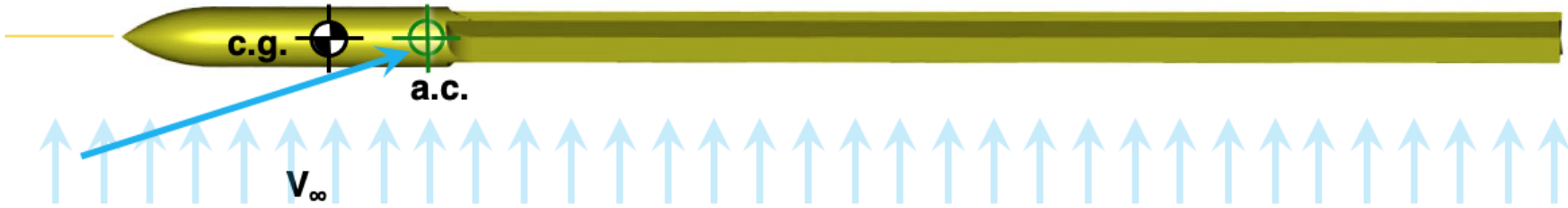
PGU-xx



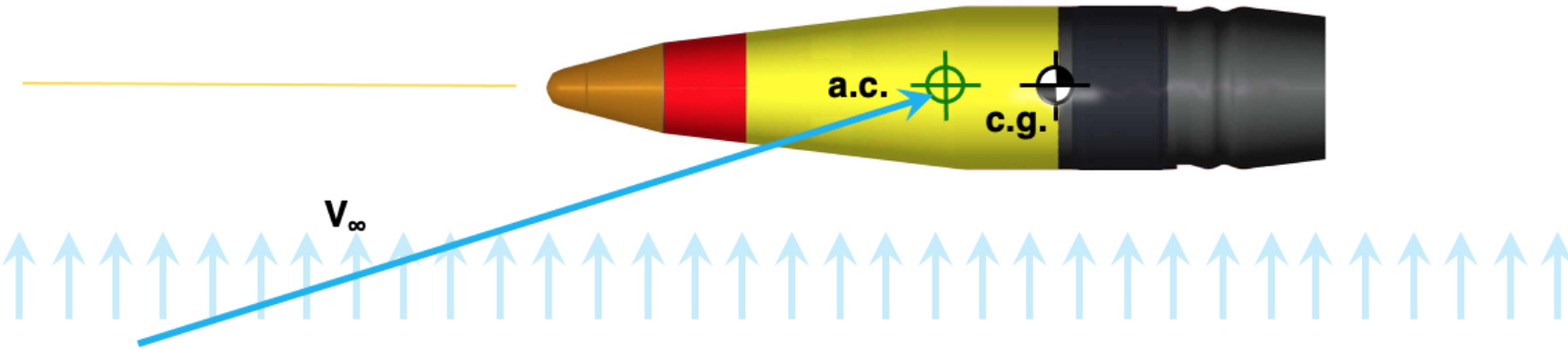
Distribution A Unlimited Distribution

5. Modeling & Testing

Projectile Aeromechanics & CEP Fundamentals



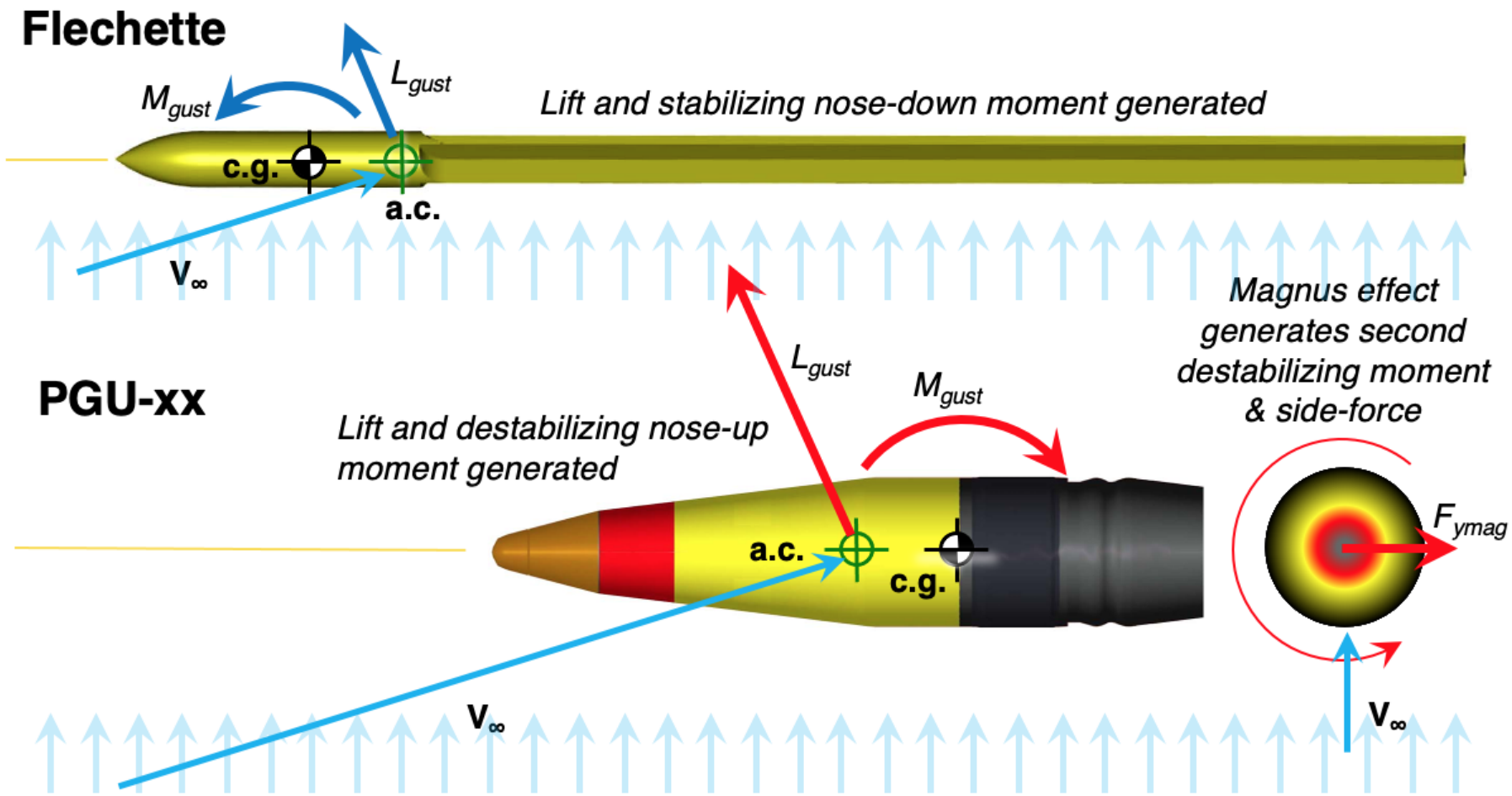
PGU-v



Distribution A Unlimited Distribution

5. Modeling & Testing

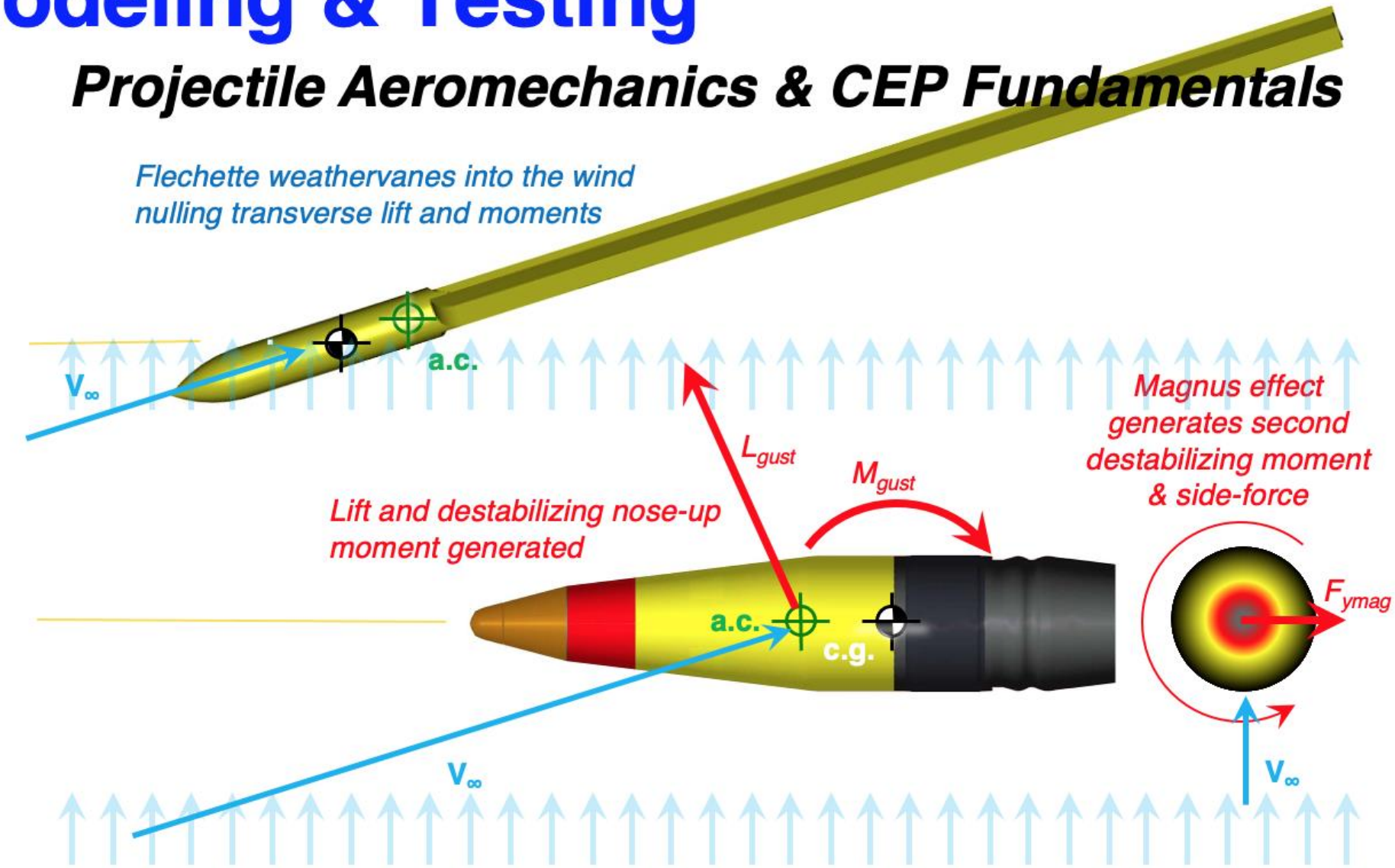
Projectile Aeromechanics & CEP Fundamentals



Distribution A Unlimited Distribution

5. Modeling & Testing

Projectile Aeromechanics & CEP Fundamentals

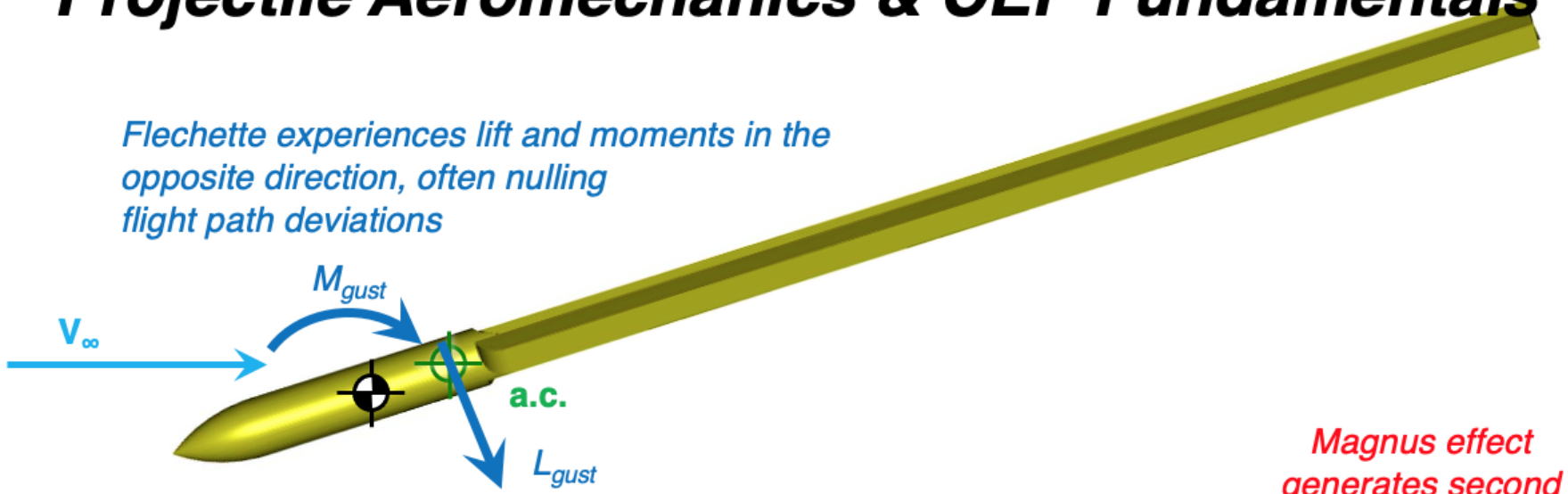


Distribution A Unlimited Distribution

5. Modeling & Testing

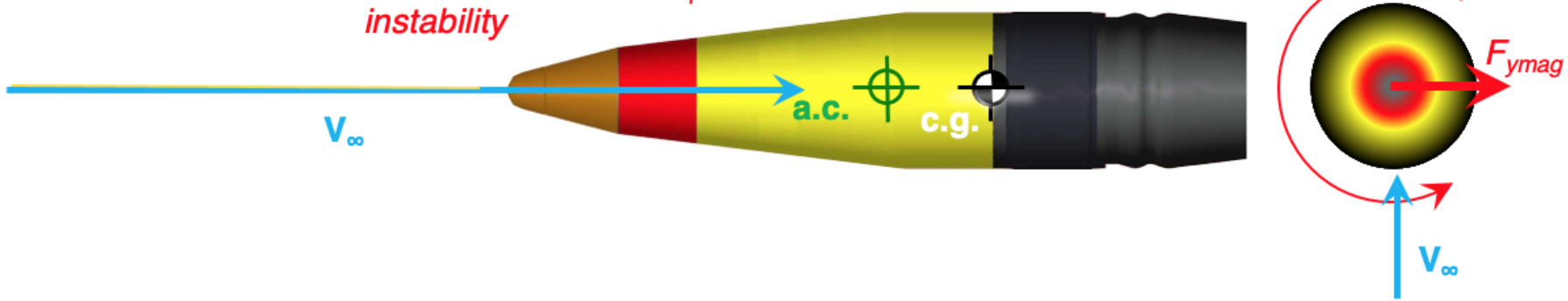
Projectile Aeromechanics & CEP Fundamentals

Flechette experiences lift and moments in the opposite direction, often nulling flight path deviations



Dynamic modes (precession, nutation) excited given low C_{mq} & inherent instability

Magnus effect generates second destabilizing moment & side-force



Distribution A Unlimited Distribution

5. Modeling & Testing

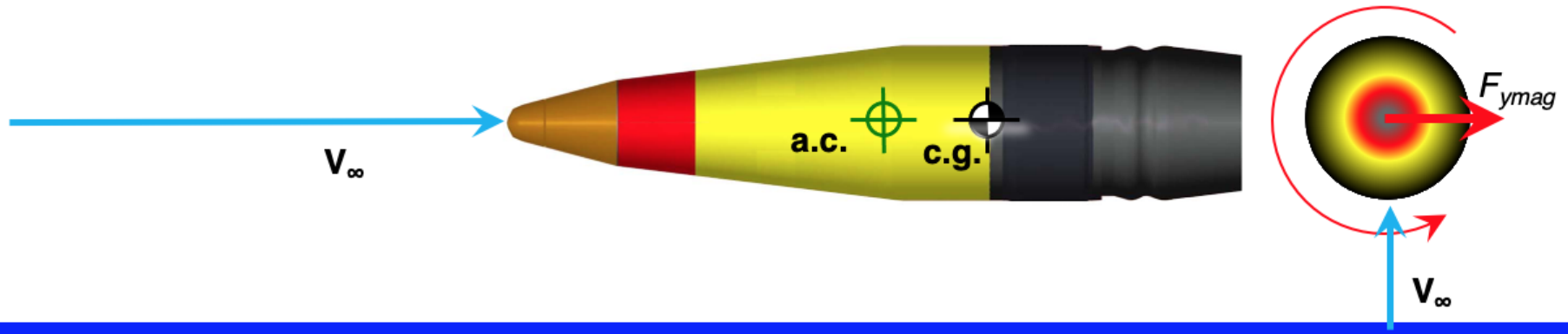
Projectile Aeromechanics & CEP Fundamentals

Flechette

Flechette returned to steady-state flight close to original flight path (maintaining very small CEP)

PGU-xx

CEP greately increased due to steady-state and dynamic effects

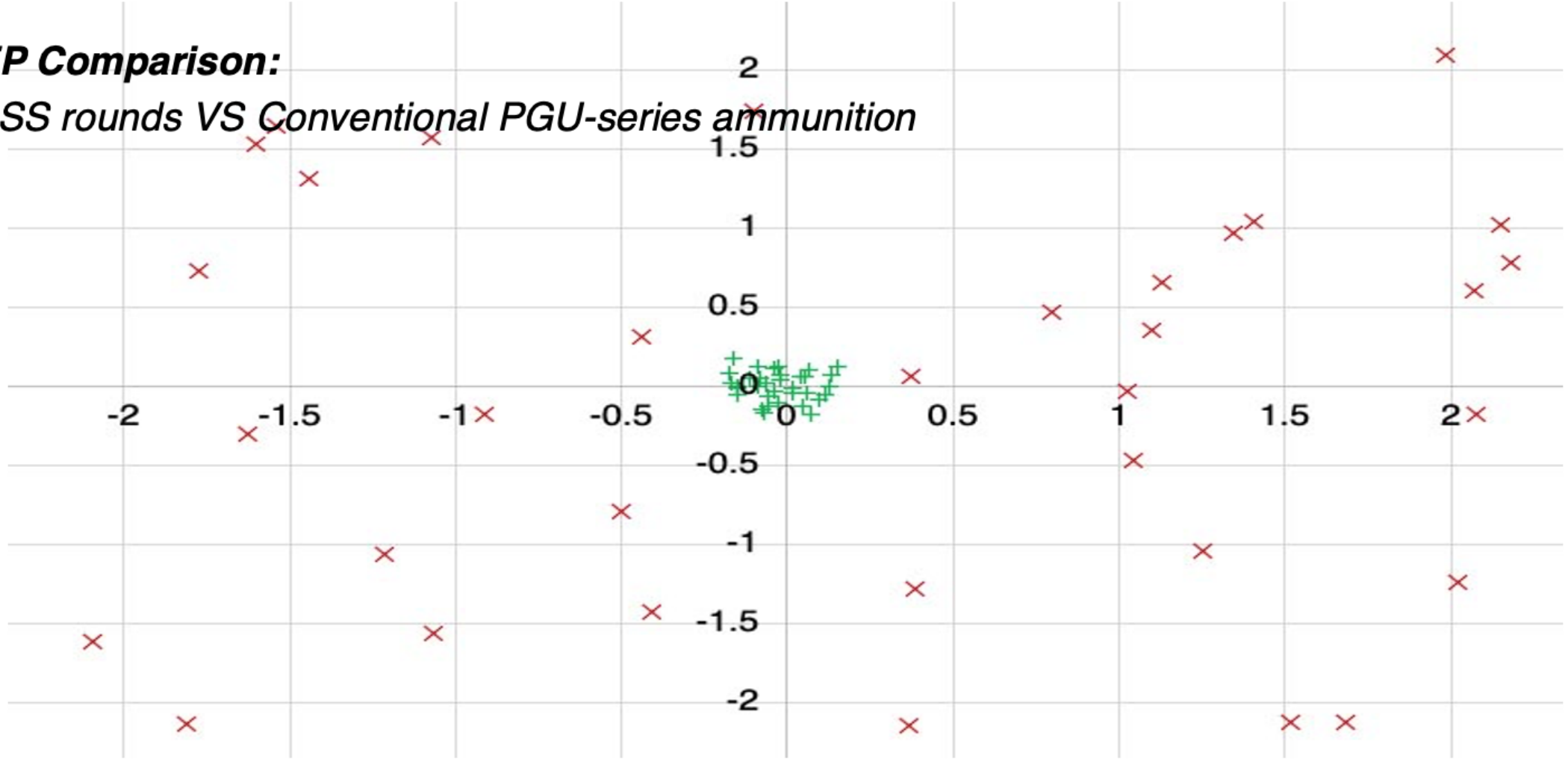


Distribution A Unlimited Distribution

5. Modeling & Testing

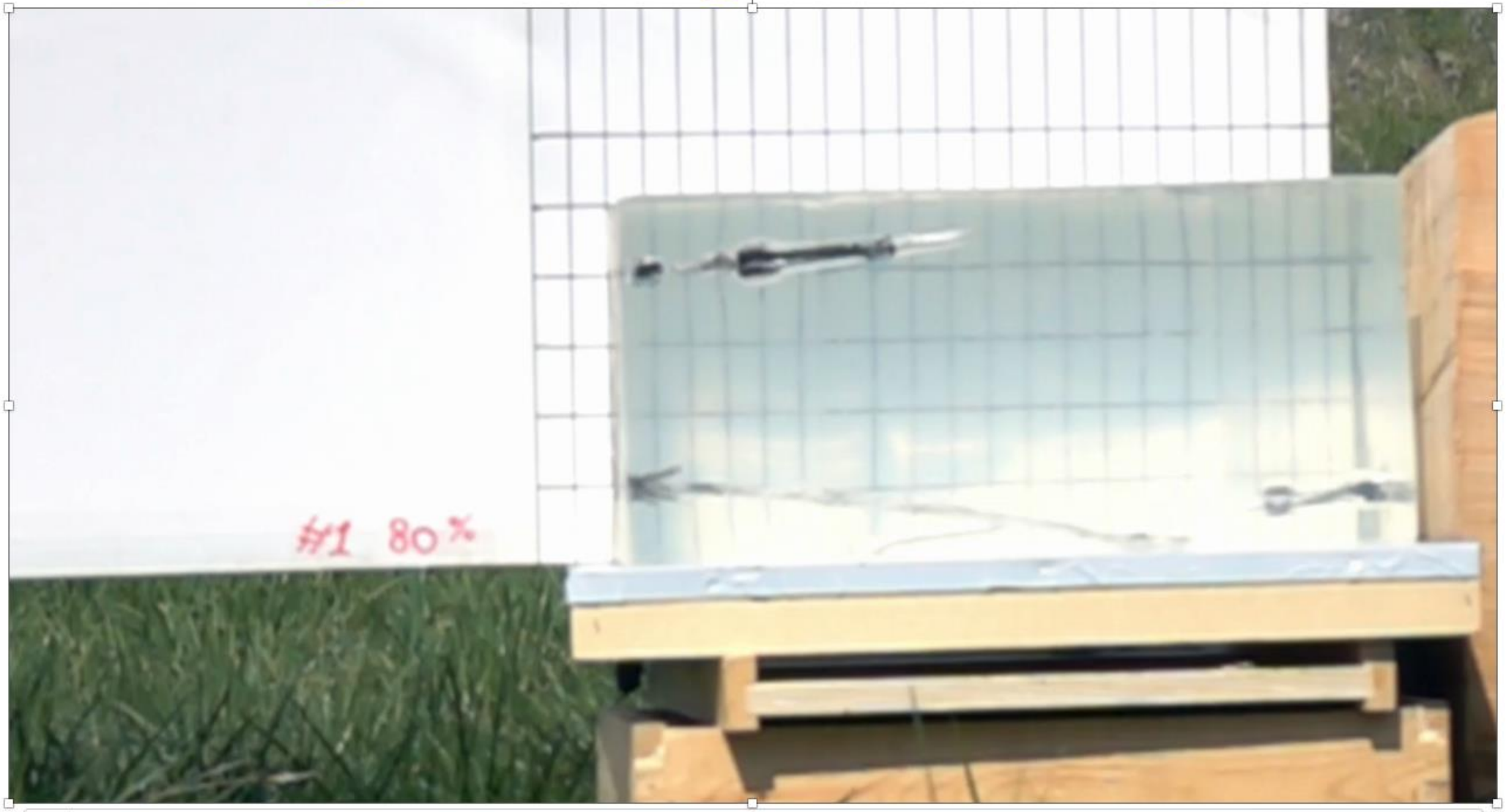
CEP Comparison:

BASS rounds VS Conventional PGU-series ammunition



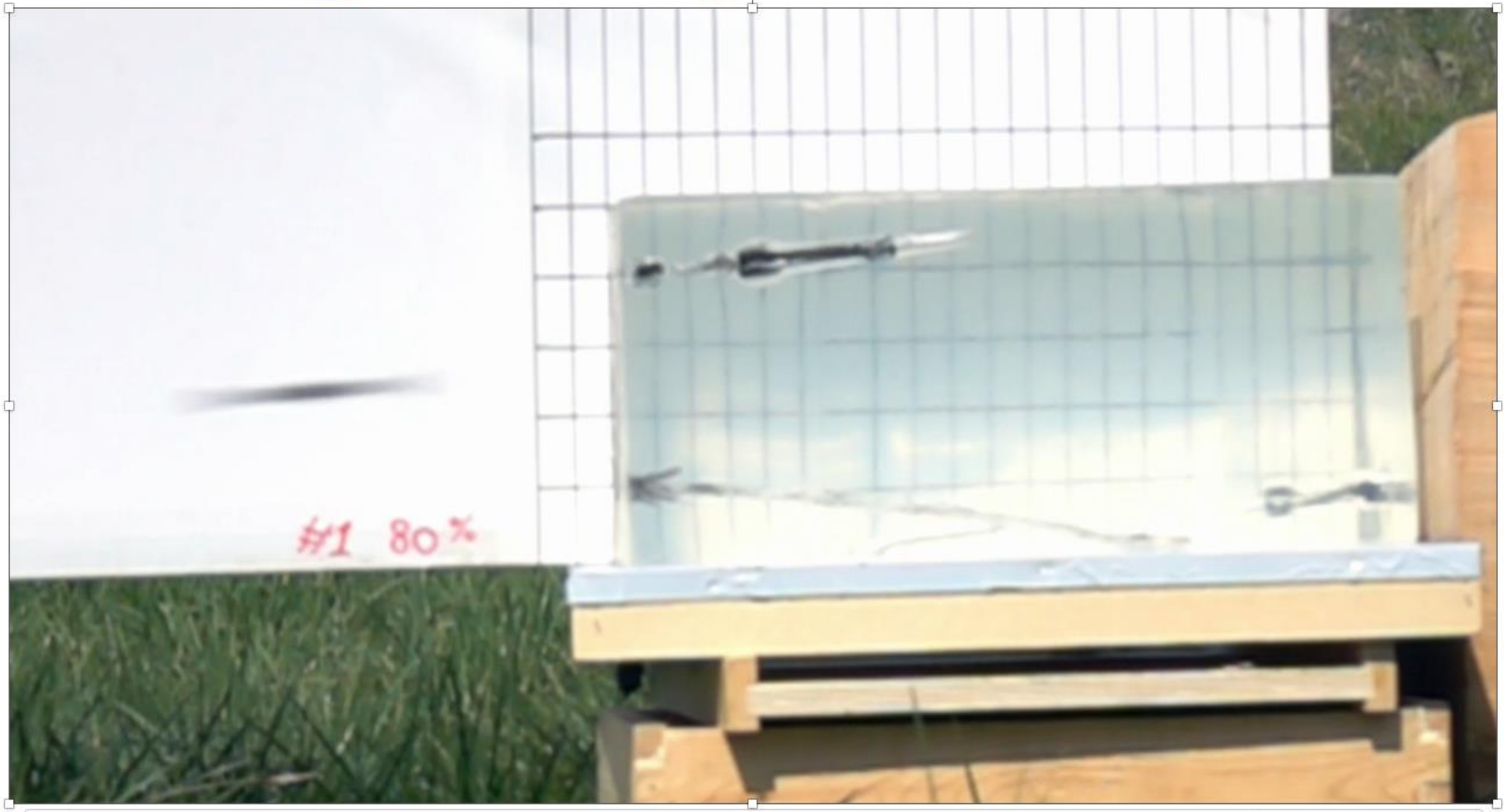
Distribution A Unlimited Distribution

5. Modeling & Testing



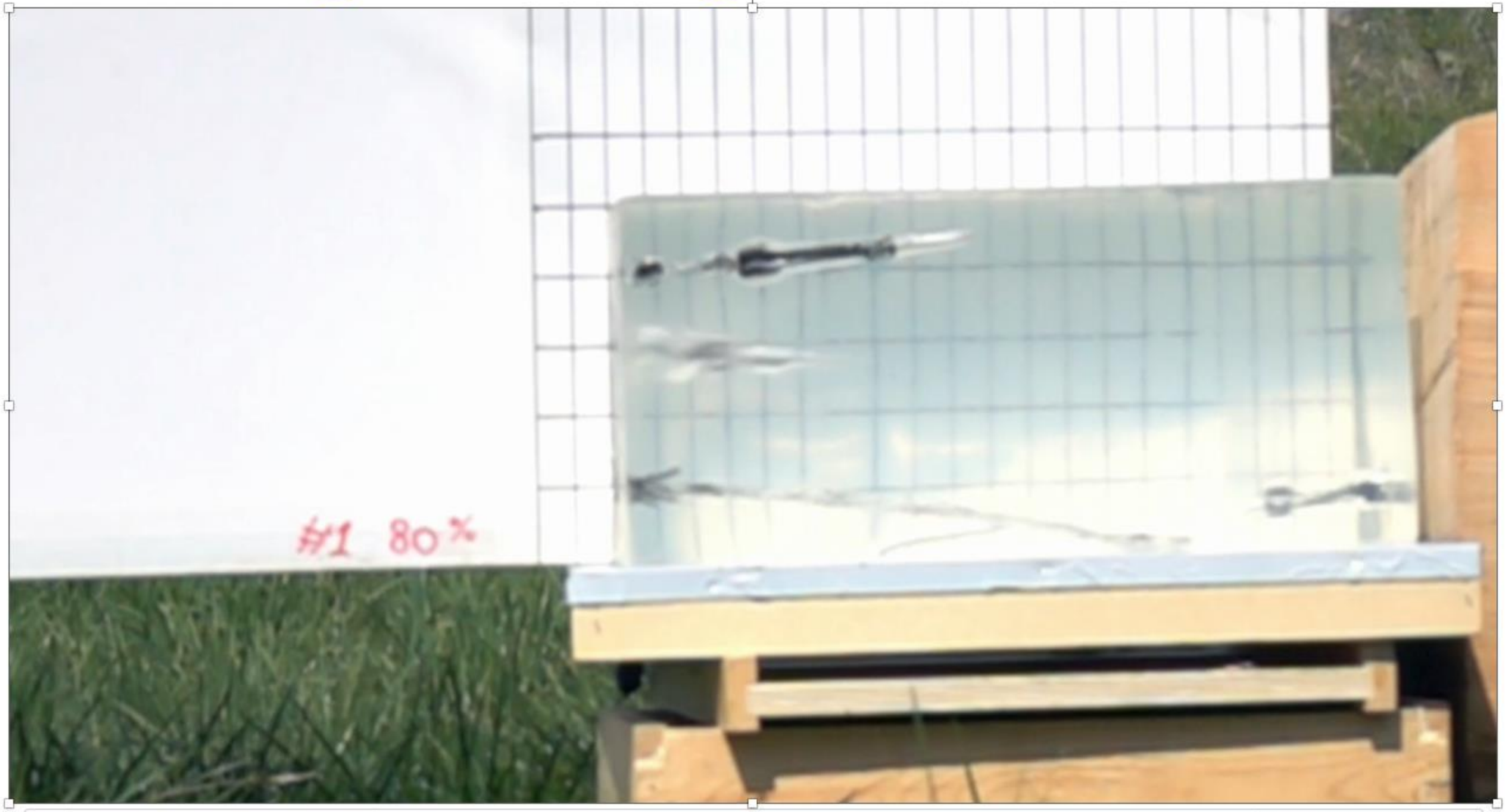
Distribution A Unlimited Distribution

5. Modeling & Testing



Distribution A Unlimited Distribution

5. Modeling & Testing



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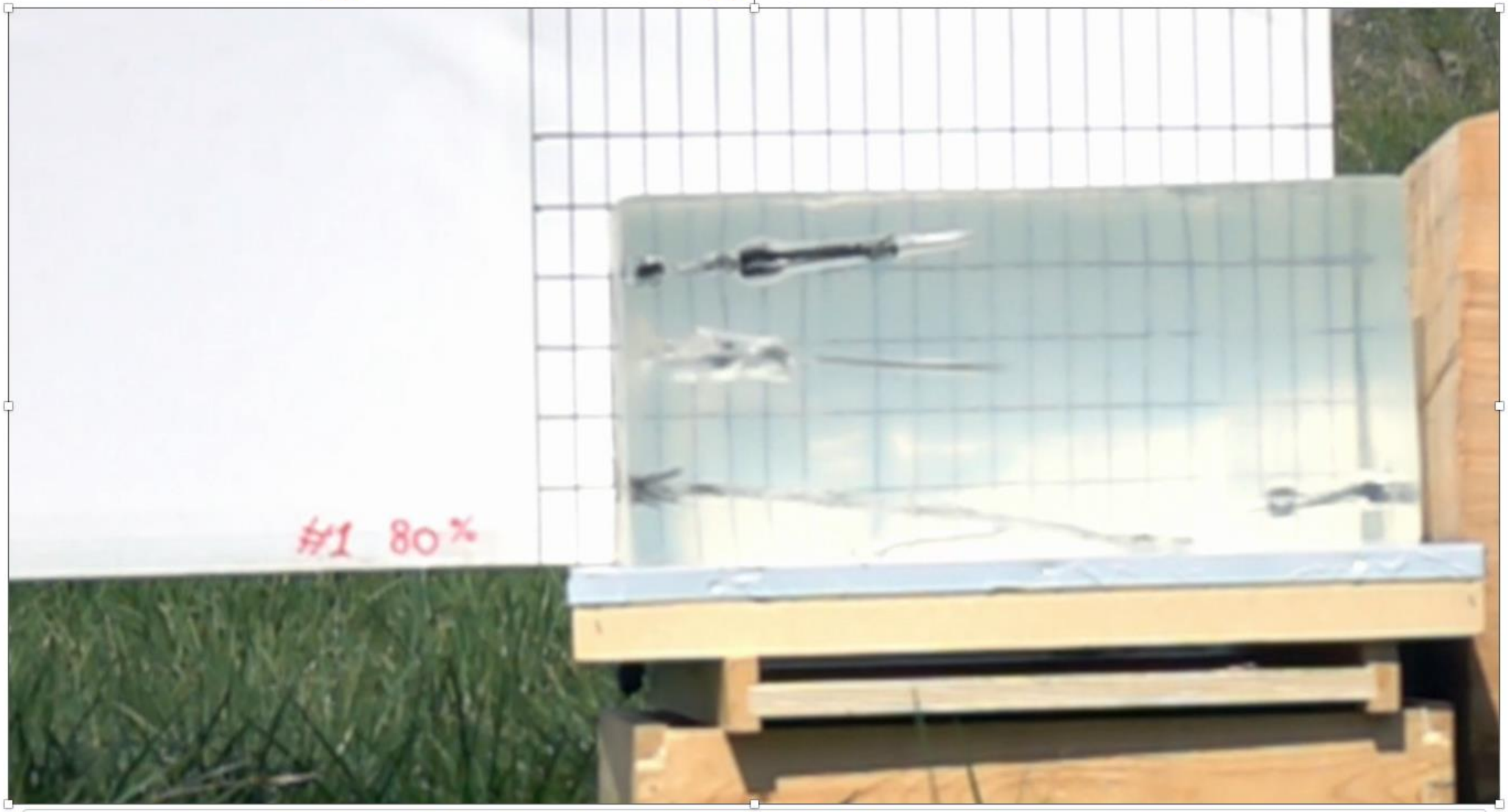

Distribution A Unlimited Distribution

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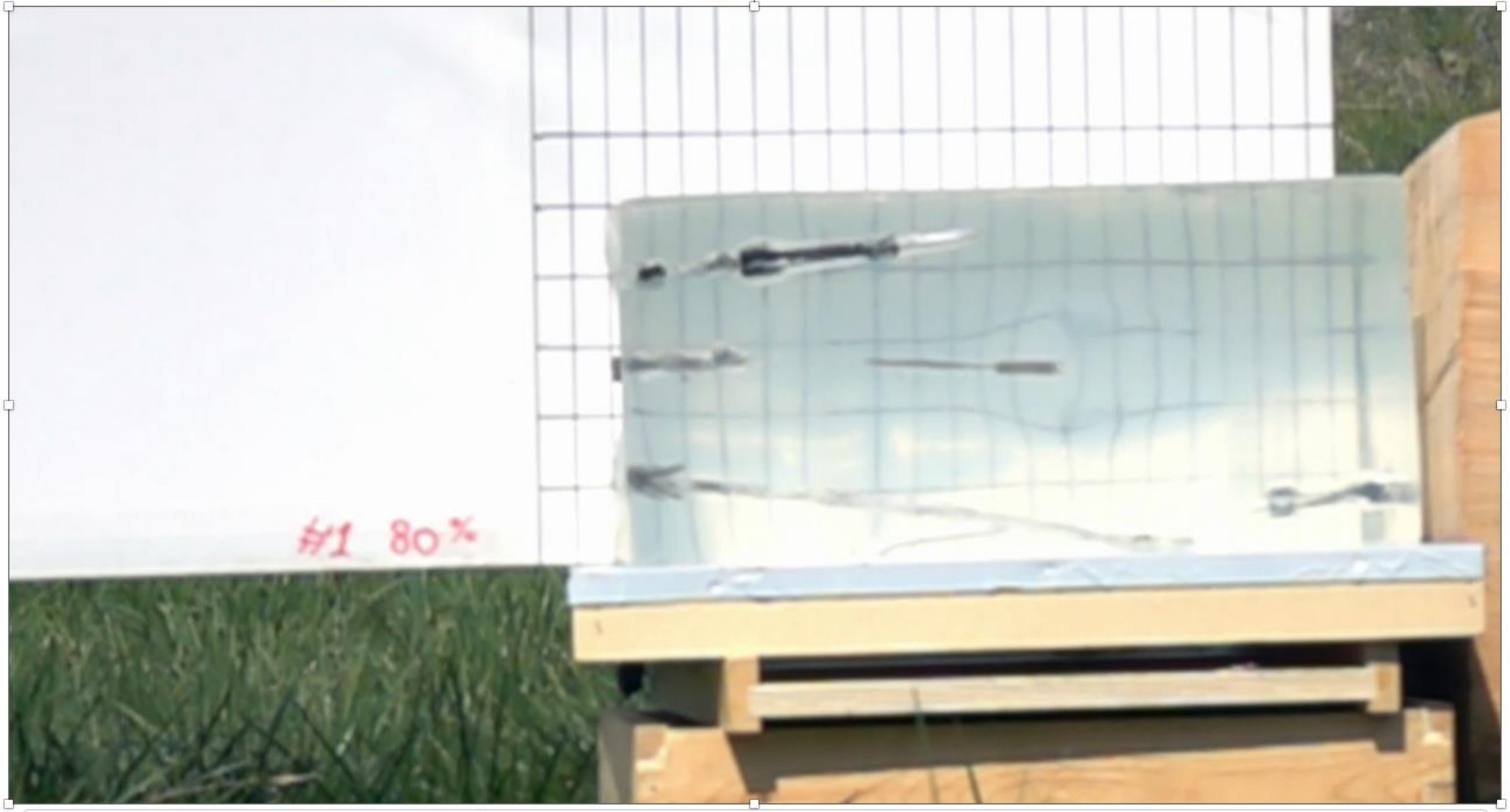

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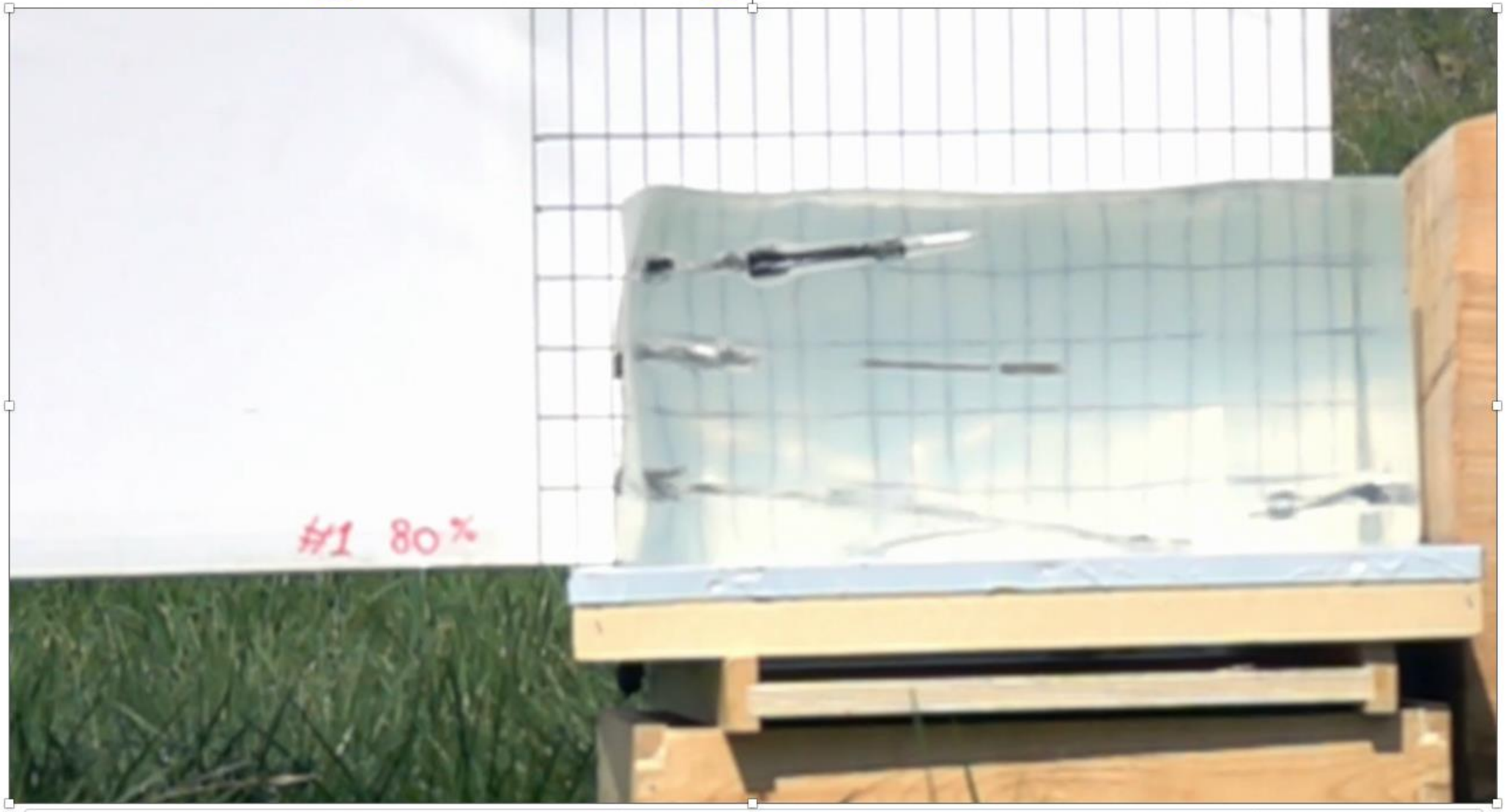

Distribution A Unlimited Distribution

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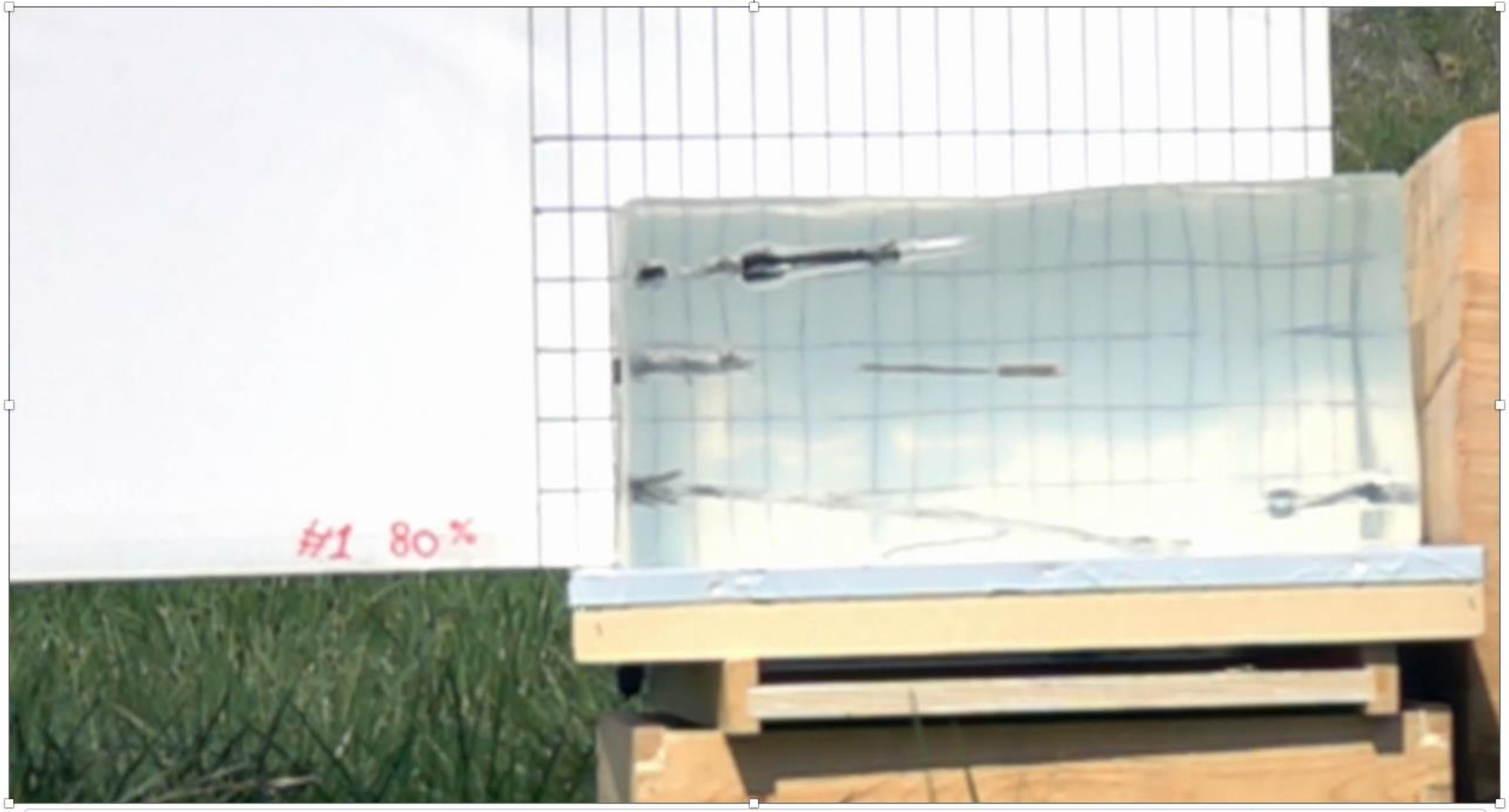
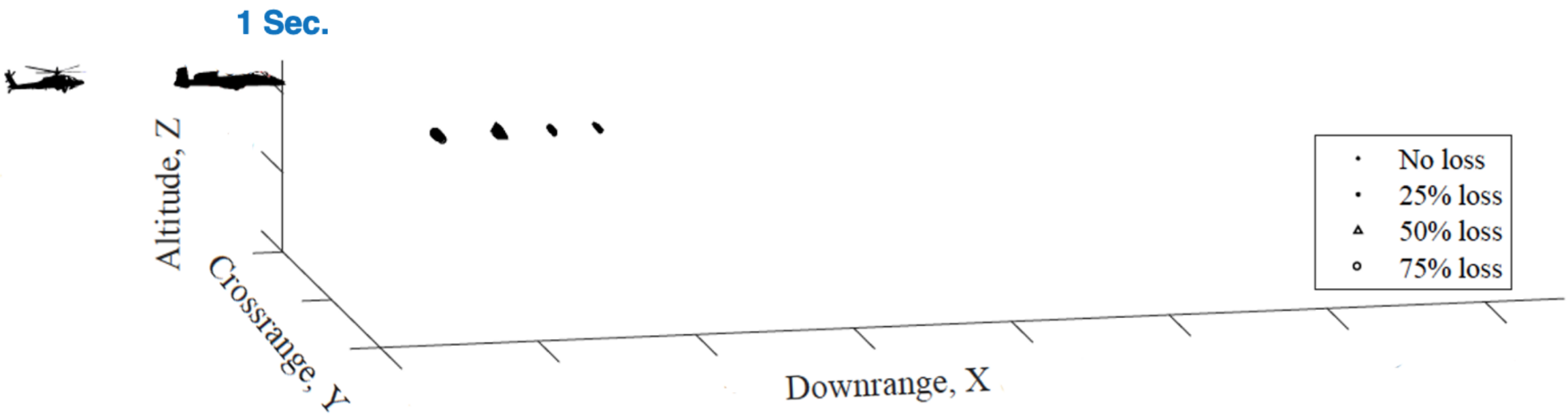


Distribution A Unlimited Distribution

6. BASS Performance

Flight Safety/Airframe Strike Check

AH-64 & A-10 Sabot separation Modeling (99% atmospherics)



Source: Schumacher, L. N., "BASS Medium Caliber System Modeling: Proof-of-Concept and the Future of Aerial Gunnery with Advanced Munitions," Ph.D. Dissertation Defense, 29 June 2020, The University of Kansas Aerospace Engineering Department, Lawrence, Kansas.

Distribution A

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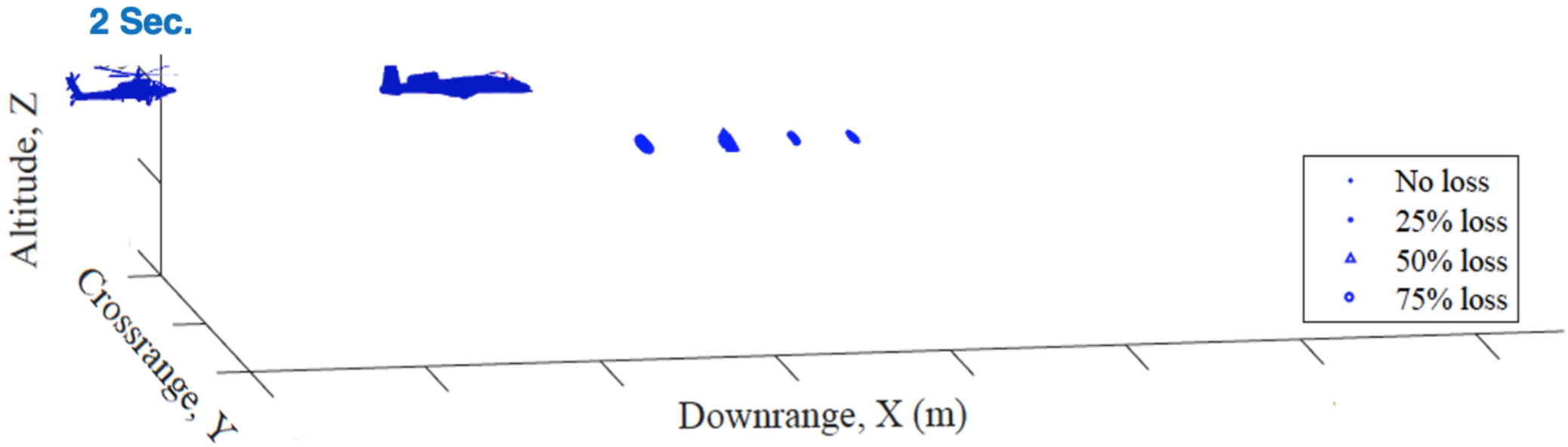

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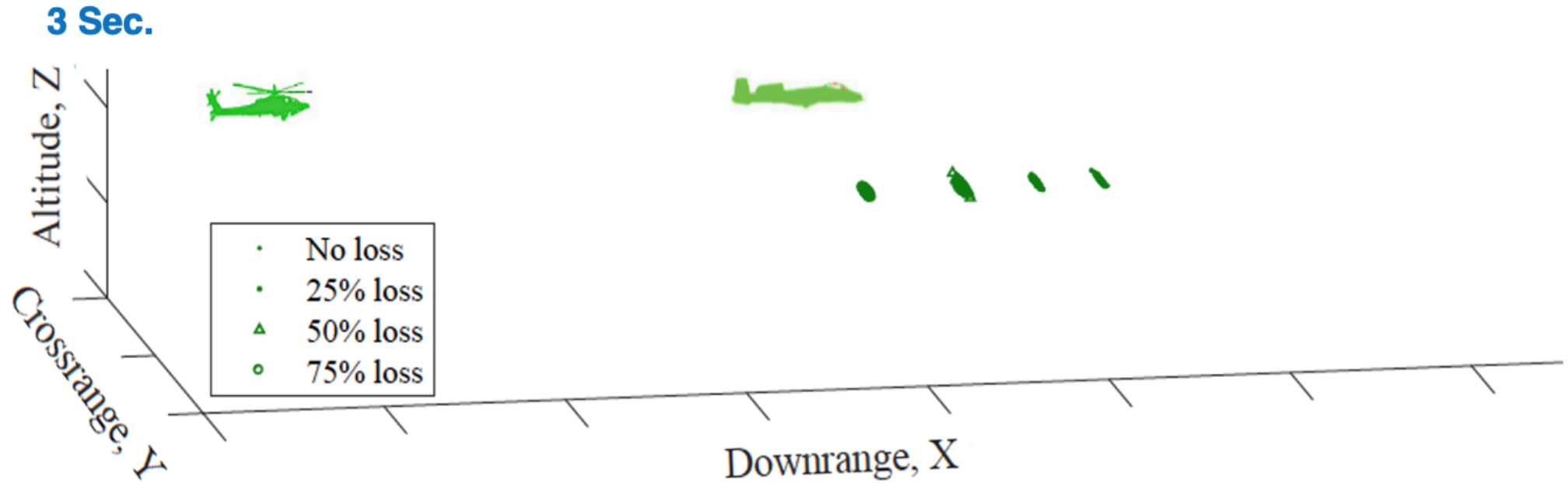

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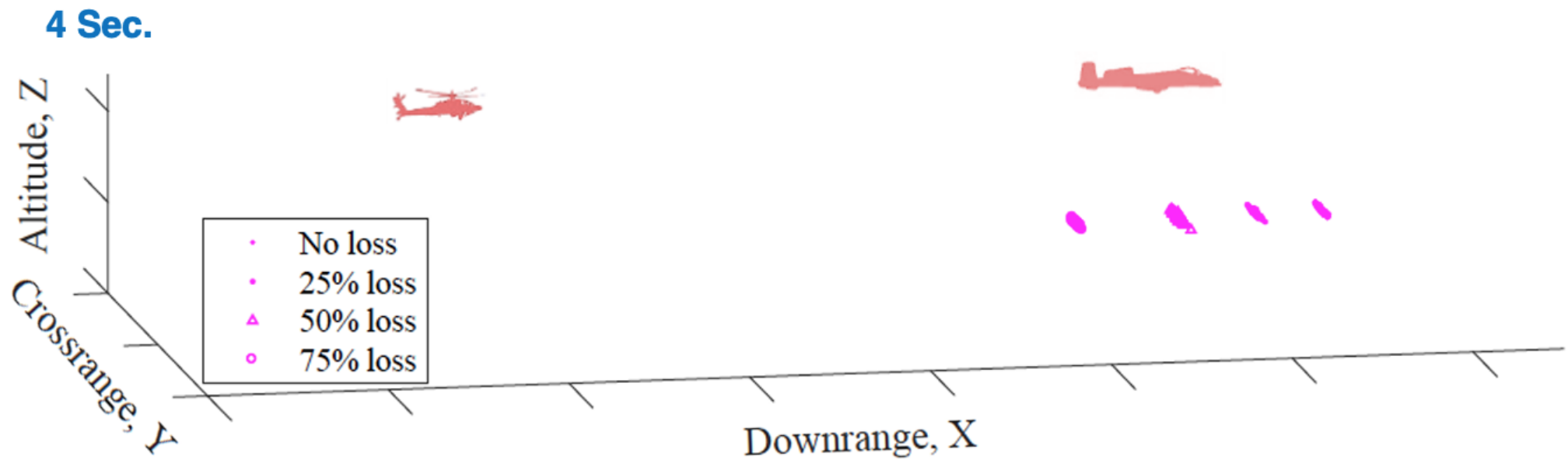

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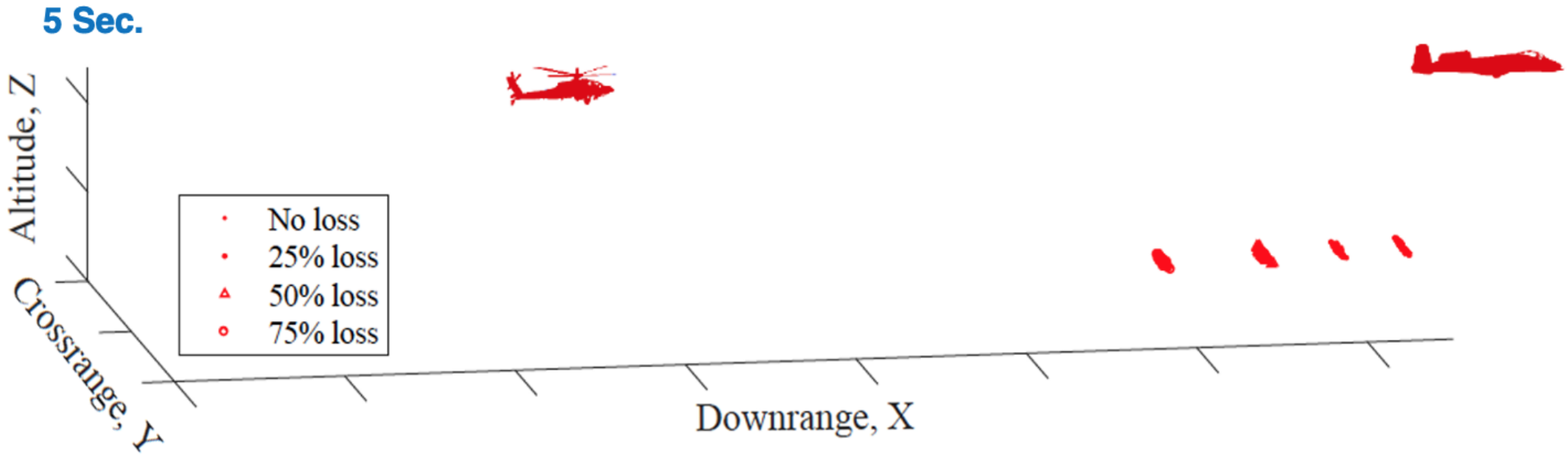

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Distribution A Unlimited Distribution

6. BASS Performance

Relative Ballistic Coefficients

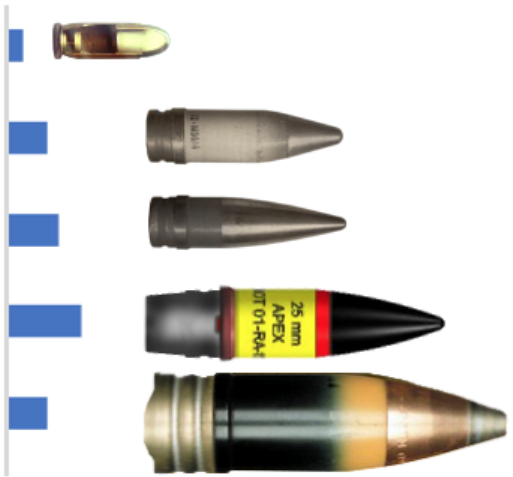
45 cal. 1st Aerial Combat 1913

20mm USMC/M53/56

20mm USAF/PGU-28

25mm USAF/PGU-47

30mm Army AH-64 M789



Aerial Gunnery Ammunition

Distribution A Unlimited Distribution

6. BASS Performance

Relative Ballistic Coefficients

45 cal. 1st Aerial Combat 1913

20mm USMC/M53/56

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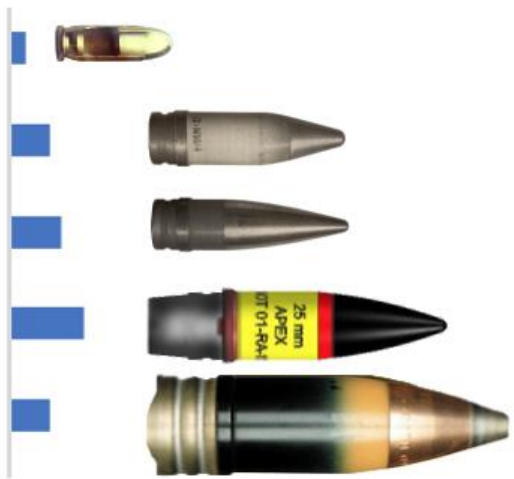
30mm Army AH-64 M789



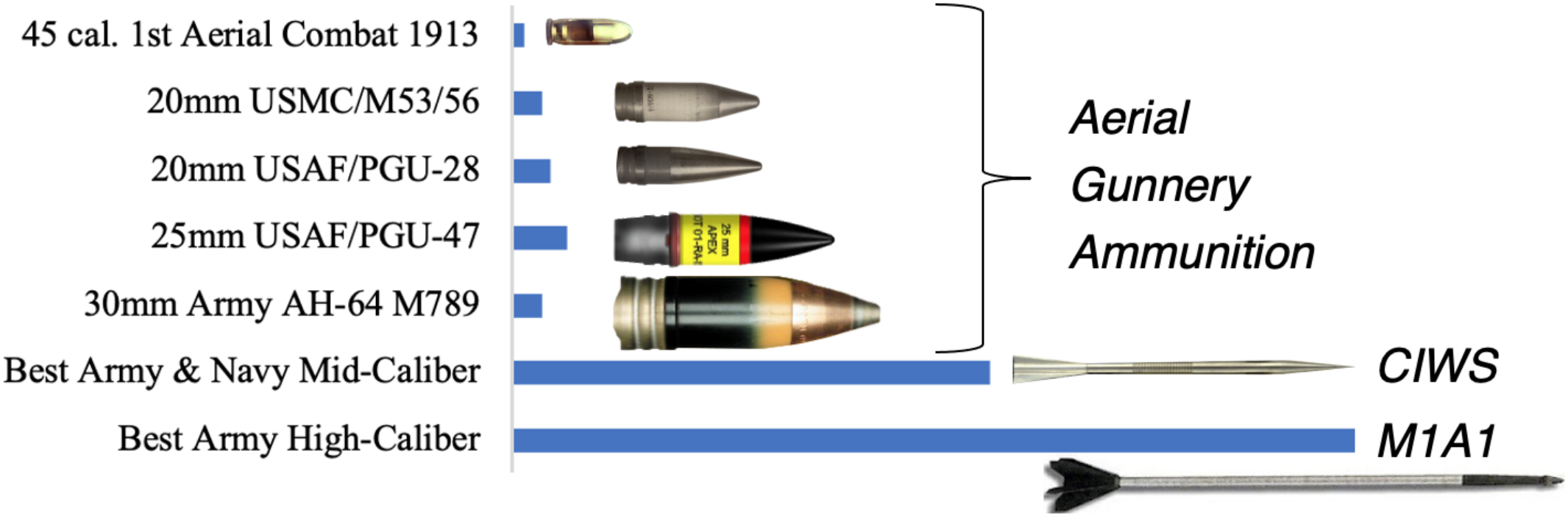
Aerial Gunnery Ammunition

100 yrs

Distribution A Unlimited Distribution

6. BASS Performance

Relative Ballistic Coefficients



Distribution A Unlimited Distribution

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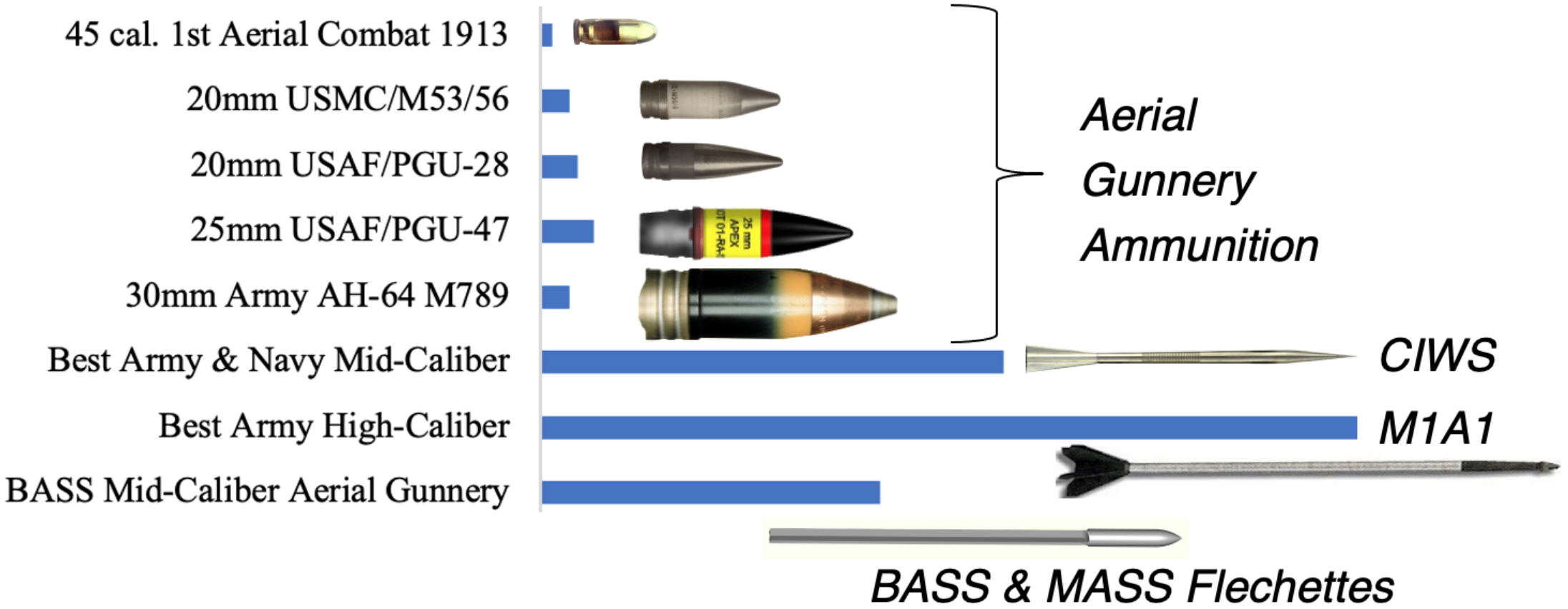
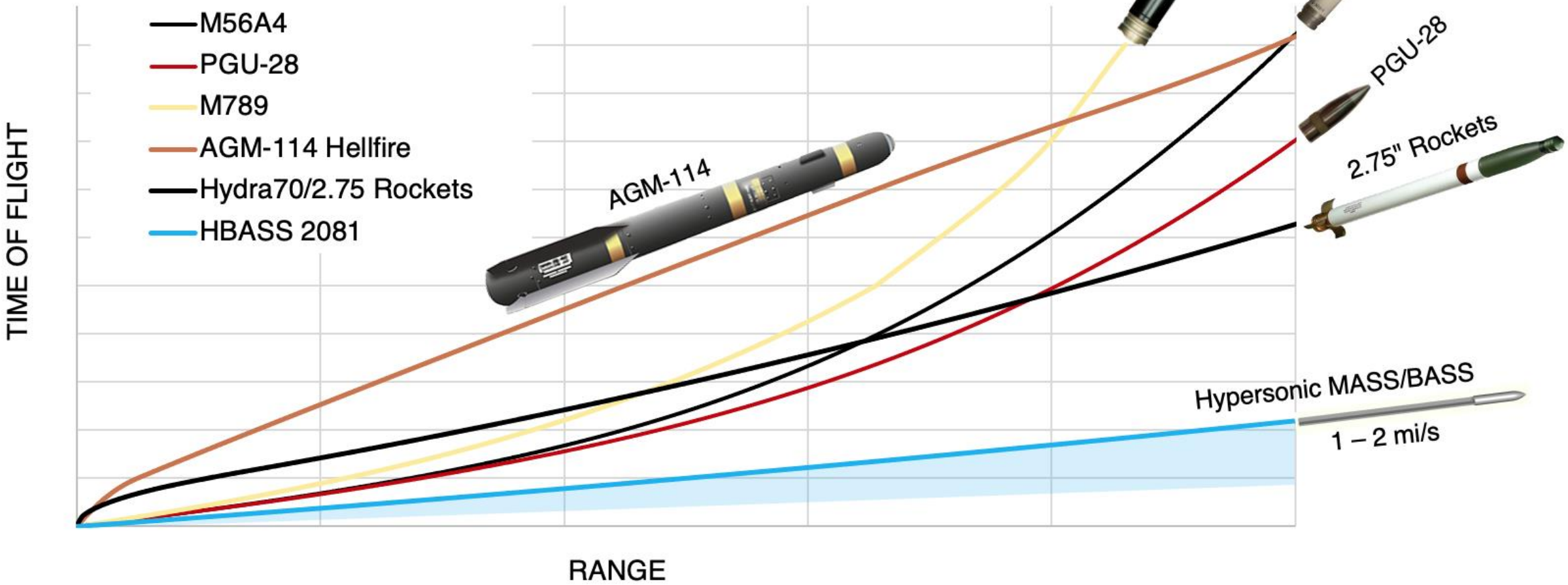


Distribution A Unlimited Distribution

6. BASS Performance

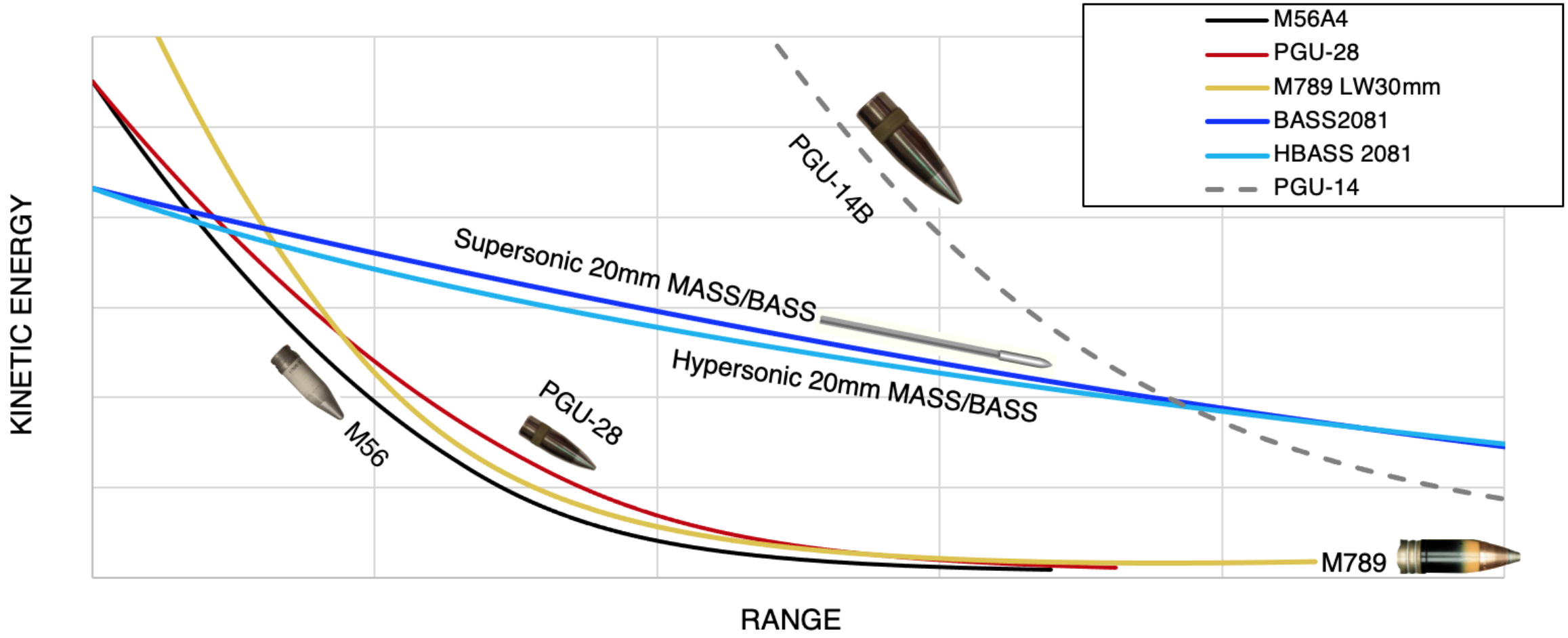
Relative Weapon Times of Flight from USA/USMC Aircraft



Distribution A Unlimited Distribution

6. BASS Performance

Relative Weapon Kinetic Energy from USA/USMC Aircraft



Unlimited Distribution
Distribution A

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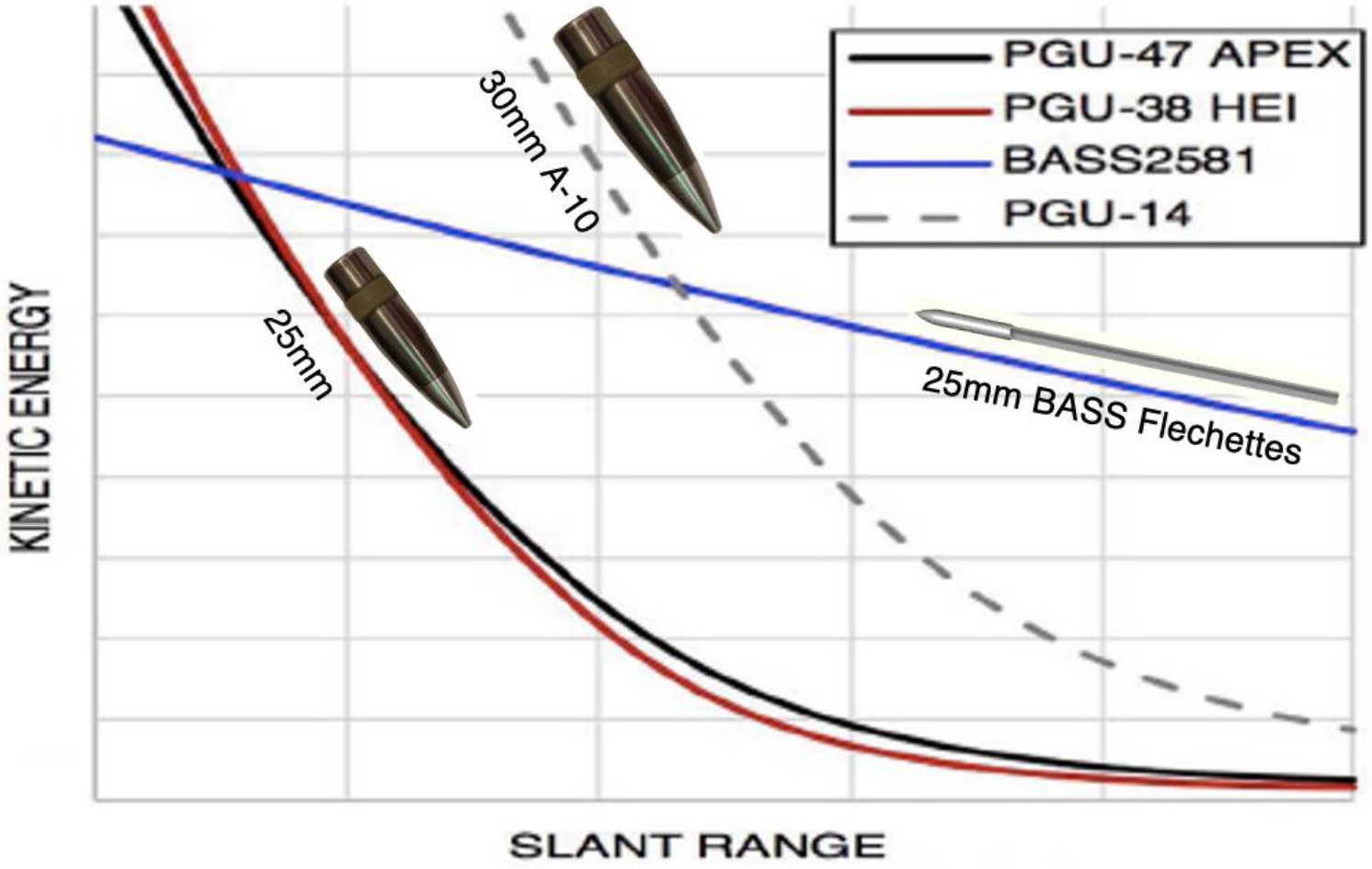
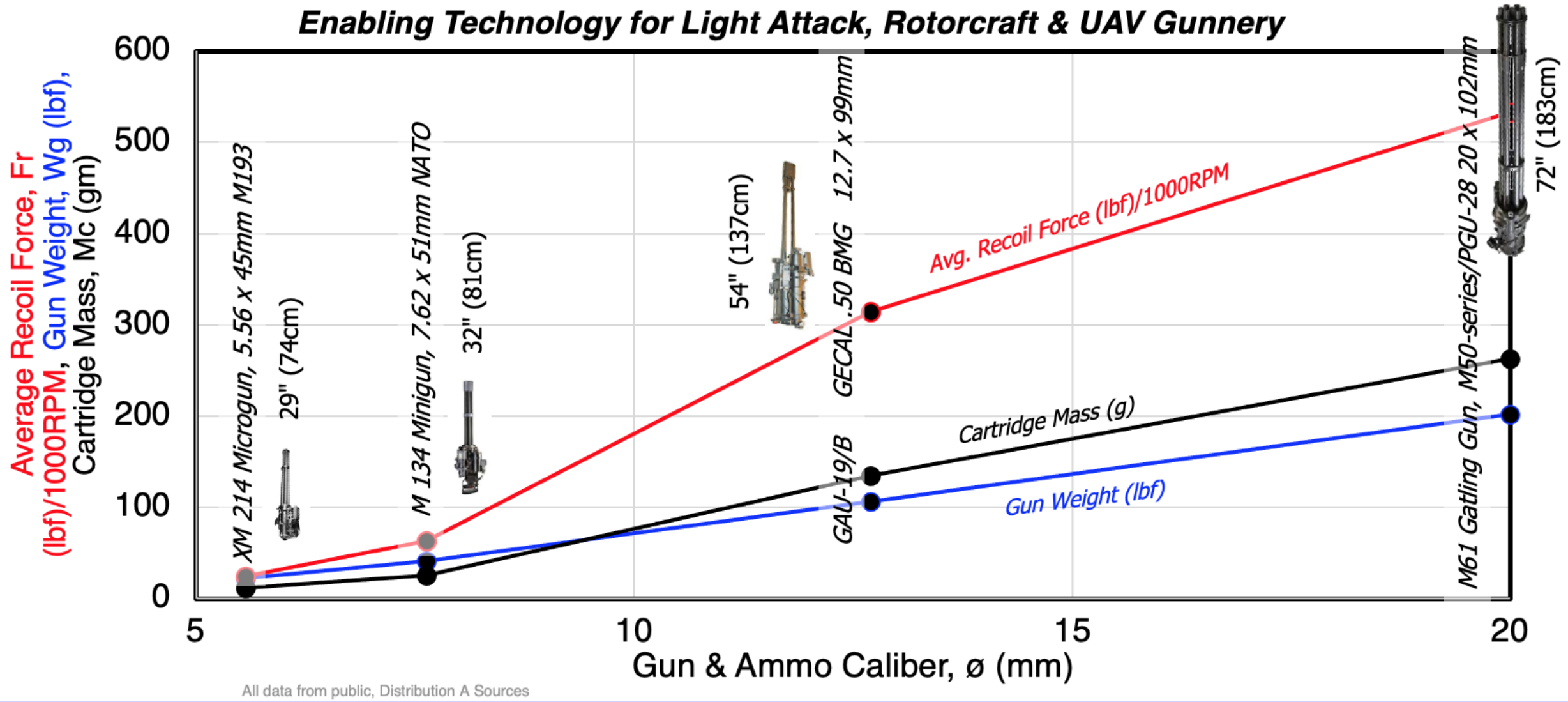


Distribution A Unlimited Distribution

6. BASS Performance

Smaller guns w/BASS rounds do the job of larger guns w/conventional rounds



All data from public, Distribution A Sources

Distribution A Unlimited Distribution

6. BASS Performance

Enabling Technology for Light Attack, Rotorcraft & UAV Gunnery

Smaller guns w/BASS rounds do the job of much larger guns w/conventional rounds

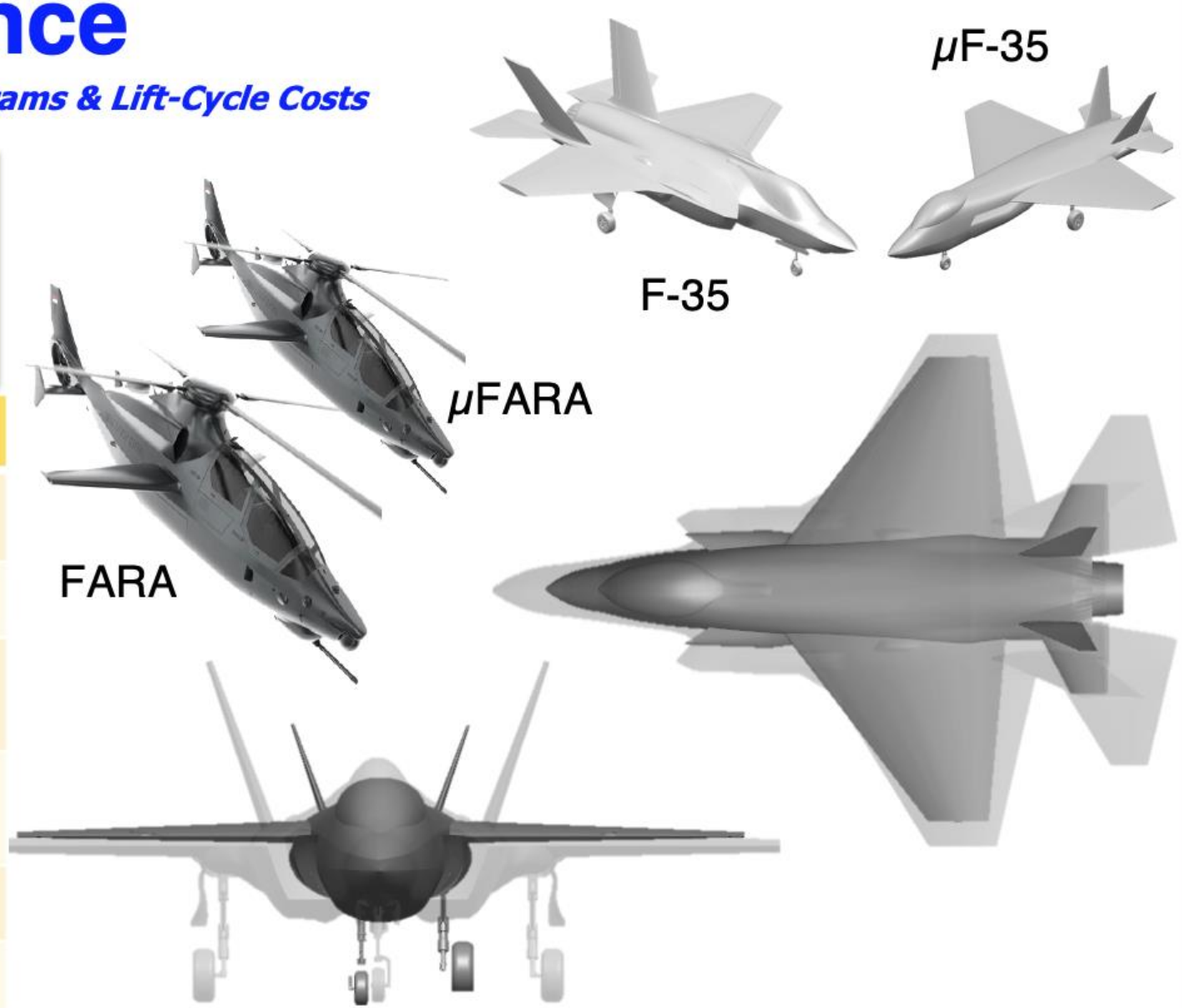
Distribution A Unlimited Distribution

6. BASS Performance

Guided MASS Rounds Shrink Entire Airframes, Programs & Lift-Cycle Costs

Airframe Level Costs		
	F-35A	μF-35
Unit Price (millions)	$ 80.0M	$ 56.5M
Operating Cost per Flight Hour	$ 29,600	$ 28,400

Parameter	F-35A	μF-35	% Change
MGTOW (lb)	70,000	57,000	-19%
Wing Area, S (ft^2)	447	375	-16%
Stealth Payload Required (lb)	5,700	1,171	-79%
Stealth Targets Engaged	4	14	250%
Max Range (nmi)	1,200	1,200	0%
Max Speed, Mach	M 1.61	M 1.79	12%



Unlimited Distribution
Distribution A

7. Intellectual Property Staatus

What is claimed is:

1. An aeromechanically stable sabot…

2. The aeromechanically stable sabot of claim 1, wherein the assembly includes at least one aeromechanically stable segment…

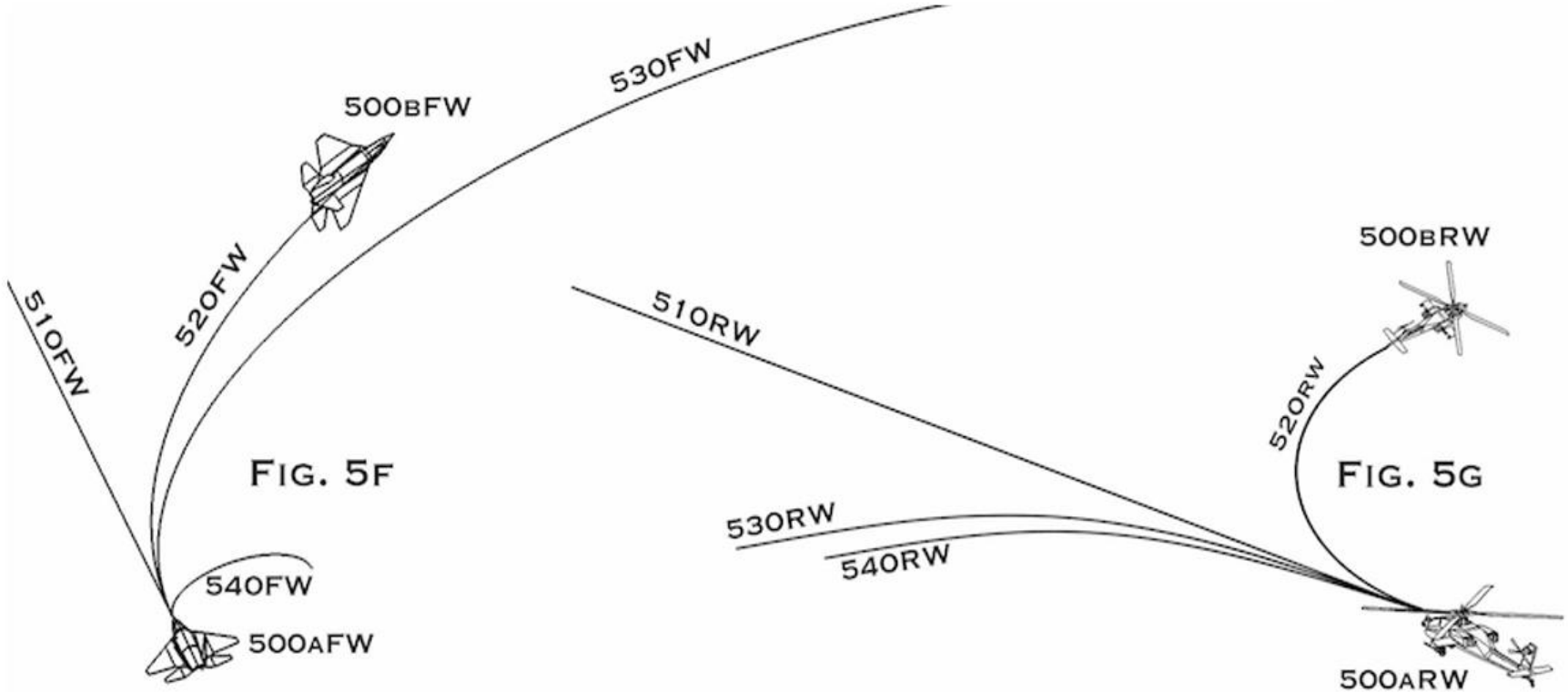


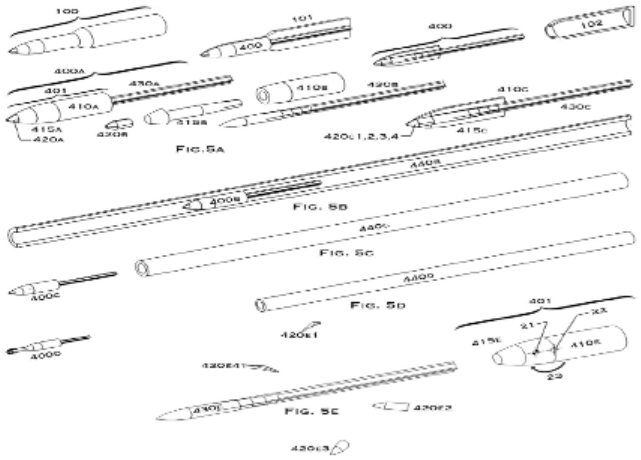
Image Source: PCT/IB2020/053899

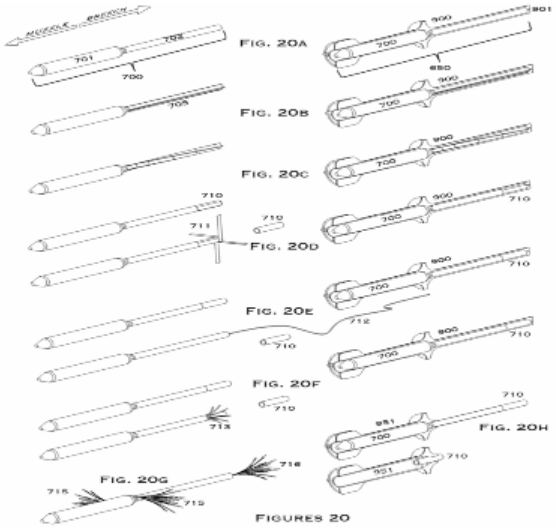
Invented 2016 *Modeled 2017* *Reduced to practice 2018* *Pat. priority date: 4/26/2019*

Distribution A Unlimited Distribution

7. Intellectual Property Staatus

- **Strong, Broad US Patents Filed 2019, 2020**
- **Fed. Government Granted Export License & Exported**
- **Patents filed in: US, Europe, Germany, Norway, Australia, UK, Netherlands, France, Belgium, Italy, Spain, Japan, Korea, Singapore**





PROVISIONAL PATENT APPLICATION 62/839,551 26 APRIL 2019 PRIORITY DATE 25 FIGURES, 83 CLAIMS, 80 PAGES

PCT FILING PCT/IB2020/053899 24 APRIL 2020 > 54 FAMILIES 1000+ SPECIES: 33 FIGURES, 130 CLAIMS, 106 PAGES

Distribution A Unlimited Distribution

8. Opportunities

Attack Rotorcraft

AH-64 (M789 30 x 113mm) AH-1 (M56 20 x 102mm) FARA

Fixed-Wing Attack Aircraft

A-10 (PGU-14 30 x 173mm)

Multi-Role Fixed-Wing Aircraft

F-15, F-16, F-18, F-22 (PGU-28 20 x 102mm)

F-35 (PGU-47 25 x 137mm)

Gunships

AC-130 (25mm, 40mm, 105mm)

Armed Drones

MQ-9, MQ-?, Bayraktar TB2, Shadow...

Distribution A Unlimited Distribution

8. Opportunities …Nontrivial chance of capturing a substantial part of the market

US Army: *(DoD FY 2019 Budget Exhibit P-1 FY 2019, P. A-17C)*

20, 25, 30mm $113M/yr

USMC: *(DoD FY 2019 Budget Exhibit P-1 FY 2019, P. N-20C)*

20, 25, 30mm $34M/yr

US Air Force: *(DoD FY 2019 Budget Exhibit P-1 FY 2019, P. F-19C)*

20, 25, 30mm+ $193M/yr

Distribution A Unlimited Distribution

8. Opportunities KU Aerospace: open for business...

- ***Exclusive & non-exclusive licenses available for:***

  -US, Europe-Wide, Germany, Norway, Australia, UK, Netherlands, France, Belgium, Spain, Italy, Japan, Korea, Singapore

- ***Engineering support: 3+ yr acceleration, data sets*** *(as allowed by law)*

  -On site support up to 2 yrs

- ***Operational Units:***

  -"What's possible – whole new mission sets" briefings (ITAR restricted)

- ***Corporate Labs:***

  -"What's possible" briefings (ITAR restricted & open)

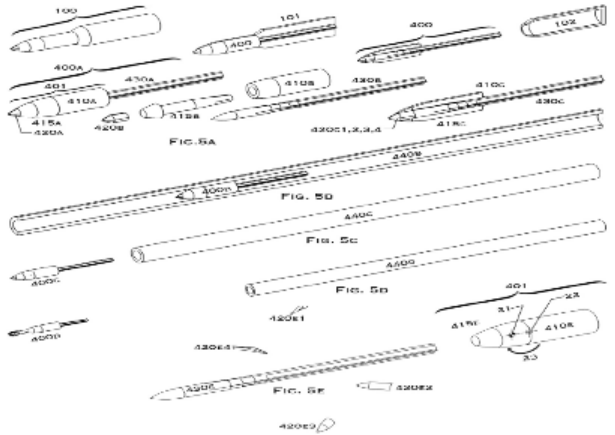
  -Short courses (1 hr to 2 days)

  -Patent/IP structure, legal offense/defense planning & weaponization

- ***Government Labs:***

  -Next research steps & navigating 15 CFR § 700 to 700.93 DPA

  -Short courses (1hr to 2 days)



Distribution A Unlimited Distribution

Questions?

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Assessing Potential Capability Enhancements of Hand Grenades Filled with CL-20 Compared to Current Mk3A2 & M67 Hand Grenades

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Abstract

- Hand grenades have served the US Military as essential offensive and defensive weapons for decades.
- CL-20 has shown significant potential as an advanced explosive material for both US and foreign applications.
- We modeled a comparison between well-known and currently used hand grenades of the US military against a hypothetical CL-20 fill.
- Calculations performed show up to 52% increase in lethal fragmentation radius.
- The net result is a potential doubling of Lethal Area by using a CL-20 formulation fill versus a current formulation fill.

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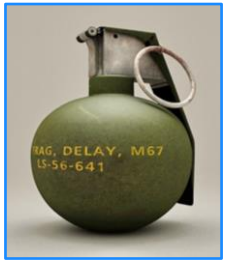
An ARA Model of M67 Capability, A Look at Current Comp B Fill Versus Potential CL-20 Fill

Current Fill
Comp B
TNT + RDX



CL-20 Fill
95% CL-20
5% Viton

Current Comp B (TNT + RDX)
5.0 meters Lethality Radius
75 square meters Lethality Area
Relative Lethal Area = **X**

CL-20 (95% CL-20 + 5% Viton)
7.6 meters Lethality Radius
180 square meters Lethality Area
Relative Lethal Area = **2X**

Results and Discussion

In the next few charts, we present the following modeling results:

- Overpressure Comparison (Mk3A2 vs CL-20)
- Overpressure Effects
- Peak Underwater Pressure
- M67 Fragmentation Velocity
- Energy of Fragments
- Lethality and Injury from Fragments
- Lethal Area Comparison

Please also find a link to our underpinning paper in the Summary and Conclusion chart.

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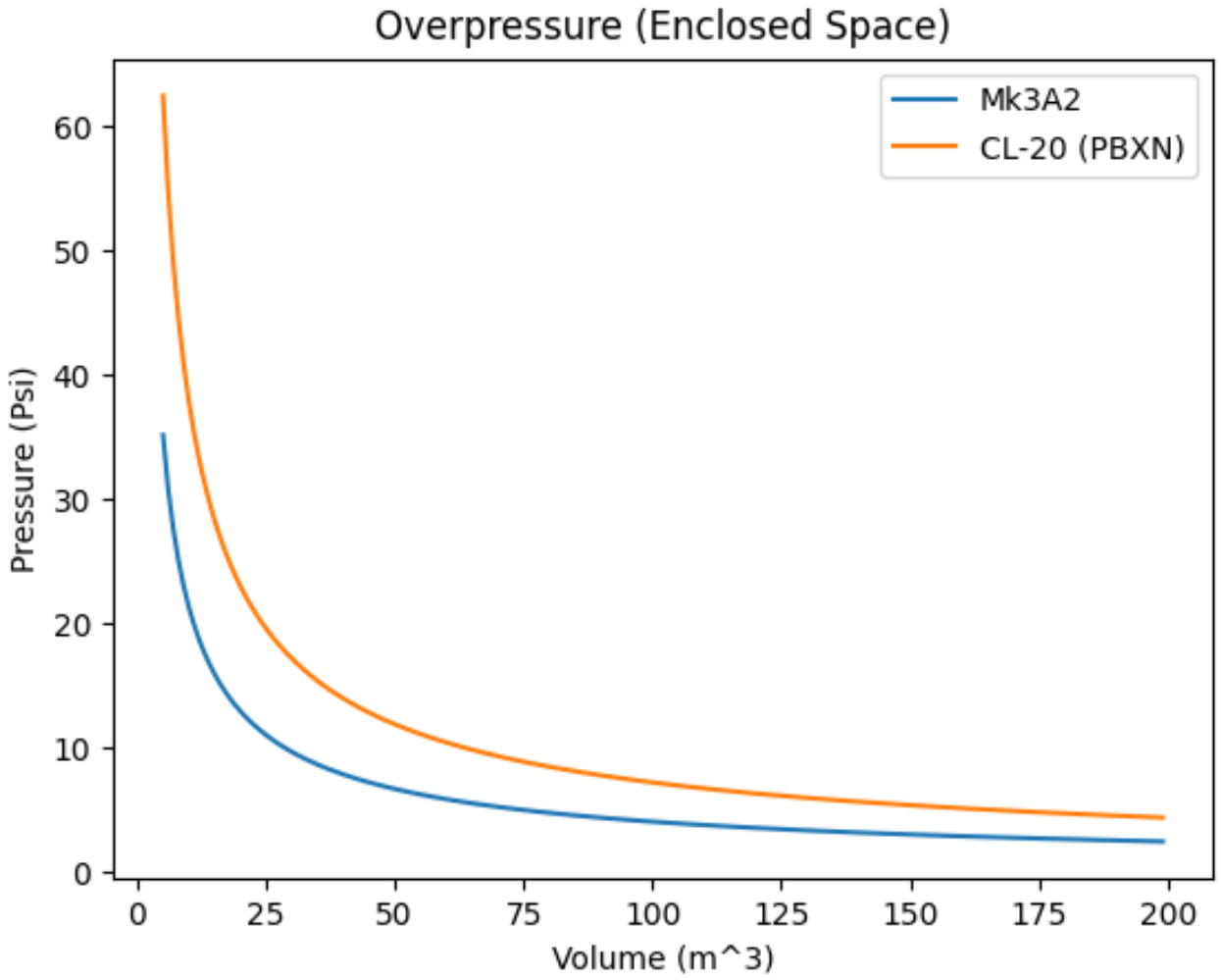
Overpressure Comparison (Mk3A2 vs CL-20)



Overpressure Effects

Peak Overpressure	Max Wind Speed	Effects on Structures	Effect on Human Body
1 psi	38 mph	Window glass shatters	Light injuries from fragments
2 psi	70 mph	Moderate damage to houses	Injuries common
3 psi	102 mph	Residential Structures Collapse	Fatalities may occur
5 psi	163 mph	Most buildings collapse	Injuries are universal, fatalities occur
10 psi	294 mph	Reinforced concrete buildings are severely damaged	Most people are killed

Improvements with CL-20

122% Volume increase over Mk3A2 to reach same overpressure effects

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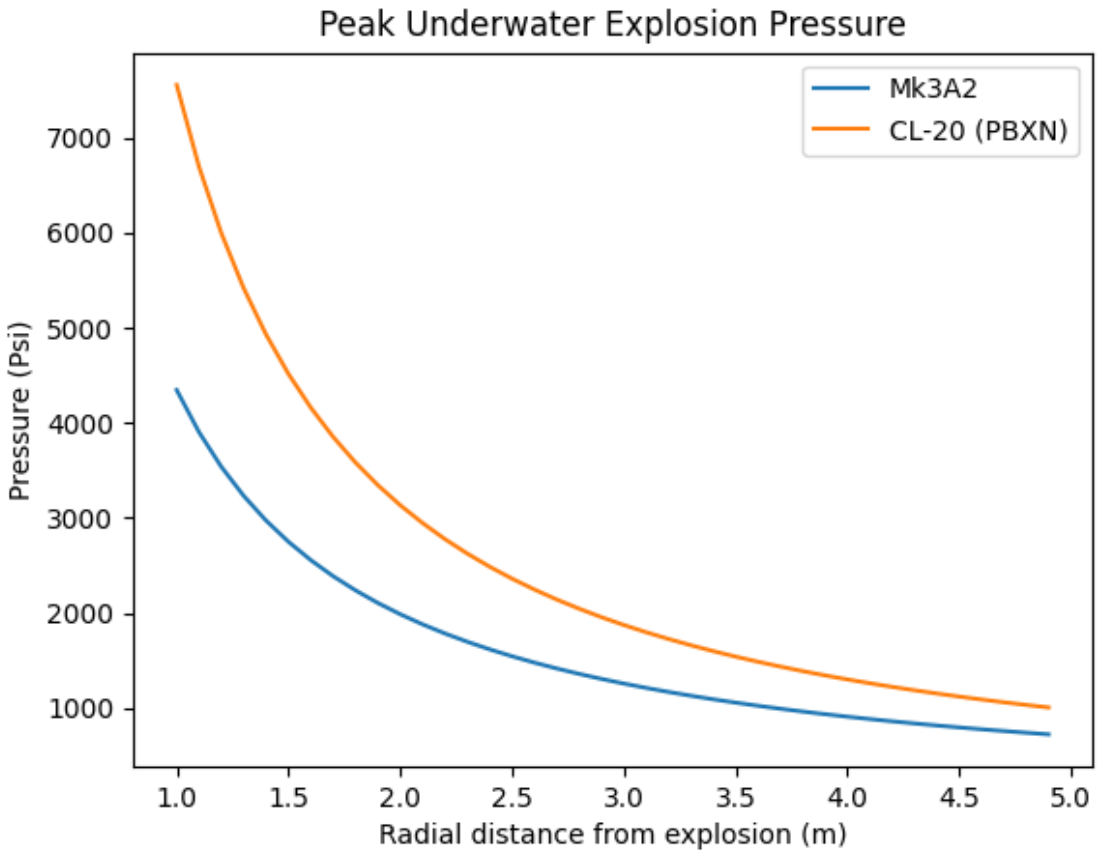
Underwater Application

51% Increase in Average Pressure (0 - 5 m)



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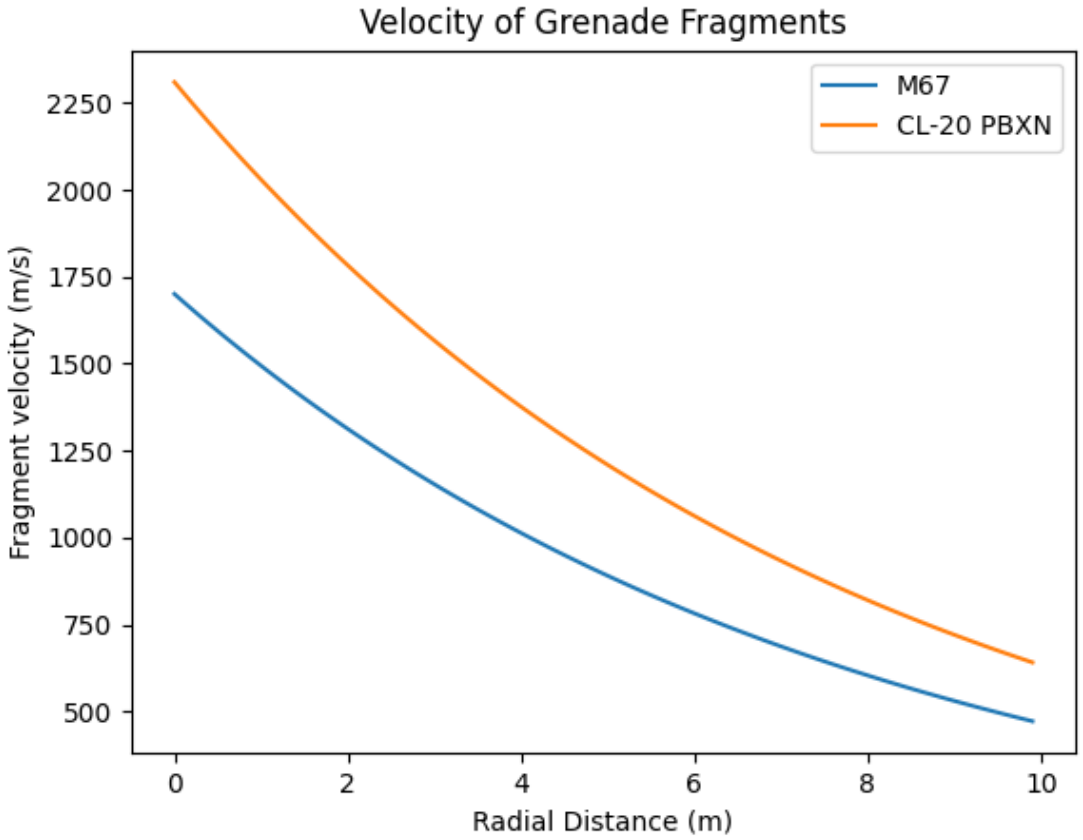
M67 Fragmentation Velocity

Initial Velocity		Increase
M67	1700.66 m/s	35.8%
CL-20	2309.97 m/s	



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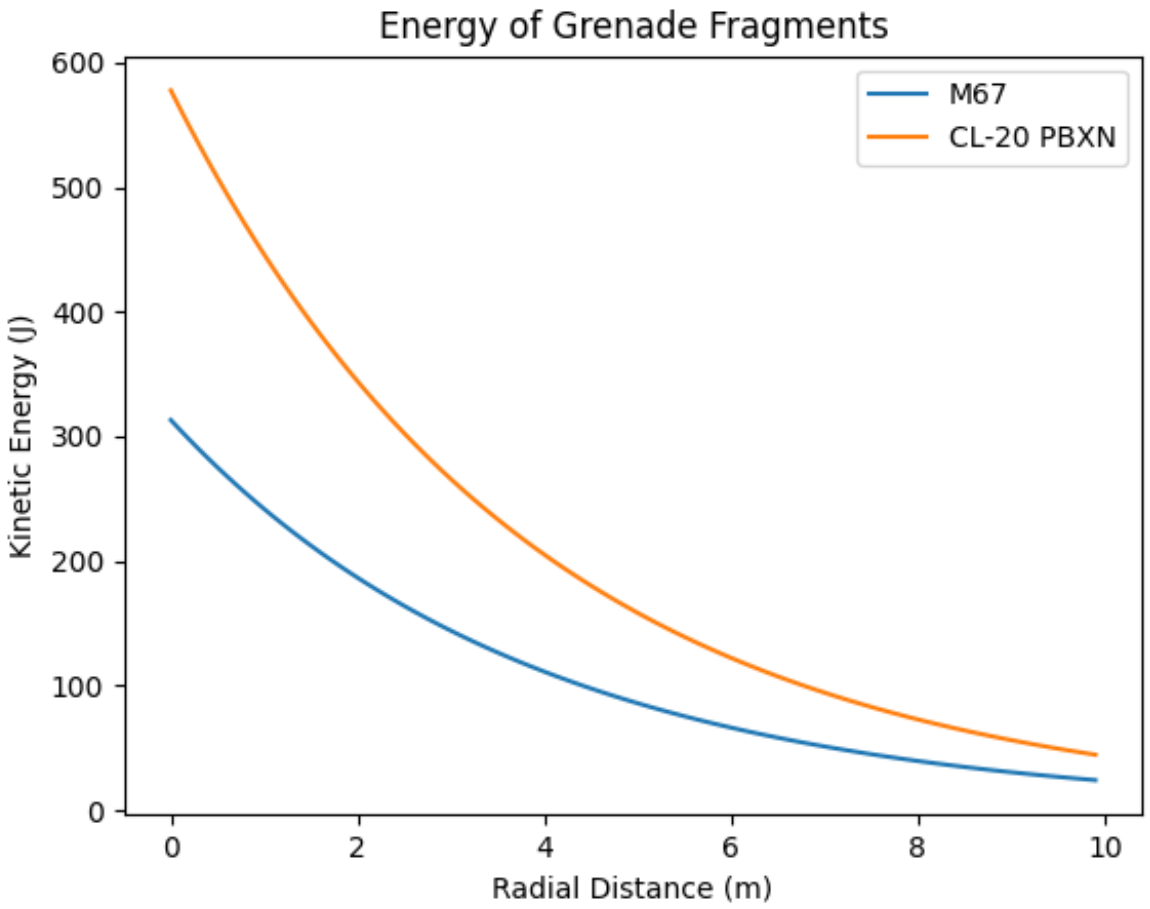
Energy of Fragments

84.5% Increase in Fragment Energy



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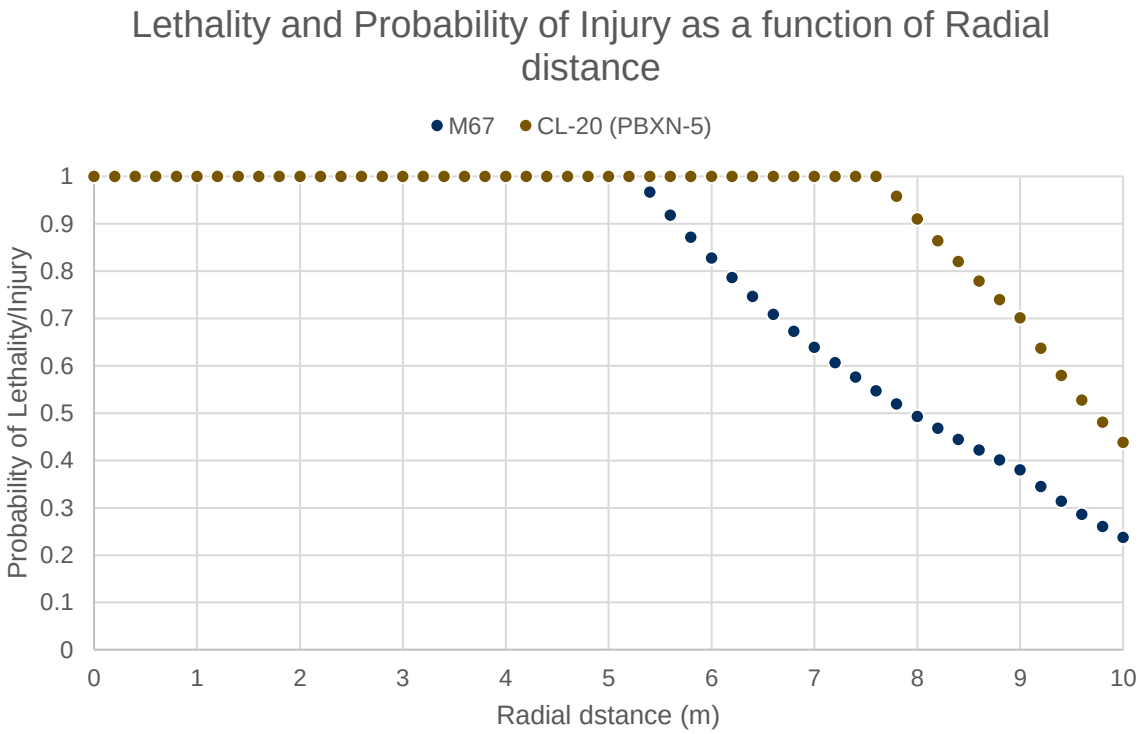
Lethality and Injury from Fragments

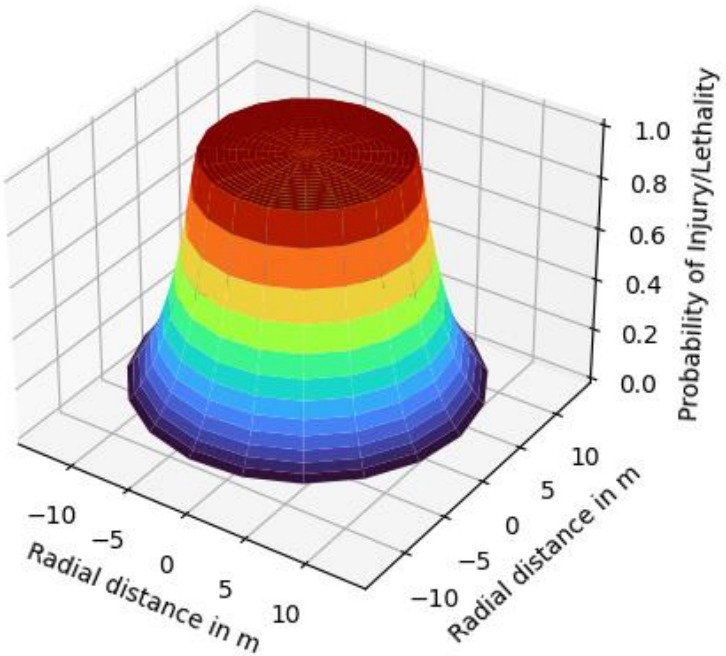
- Only Lethal if graph is equal to 1 (> 80 J and > 1 Fragment/m^2)
  - Otherwise probability of Injury



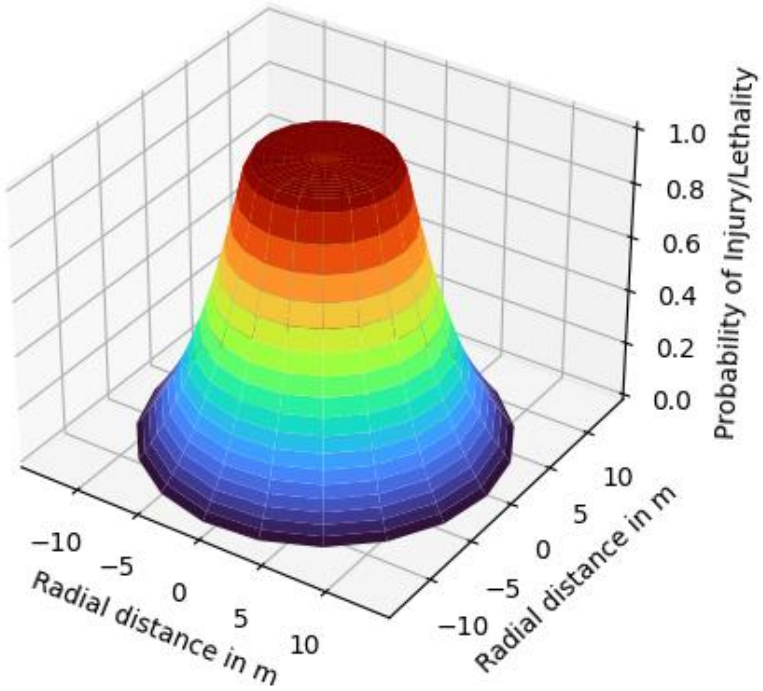
Lethal Area Comparison

Lethal Area		Increase
M67 (R = 5 m)	78.54 m^2	131%
CL-20 (R = 7.6 m)	181.46 m^2	

CL-20 (PBXN-5)



M67



Summary and Conclusion

- In our modeling of a comparison between well-known and currently used hand grenades of the US military against a hypothetical CL-20 fill, we found the potential for a 52% increase in lethal fragmentation radius.
- The net result is a potential doubling of Lethal Area by using a CL-20 formulation versus a current formulation.
- Costs for upgrade would be relatively small for capability afforded.
- The results of modeling suggest the appropriateness for taking next steps.

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ARA Paper on "Assessing Potential Capability Enhancements of Hand Grenades Filled with CL-20 Compared to Current Mk3A2 & M67 Hand Grenades": https://acrobat.adobe.com/link/review?uri=urn:aaid:scds:US:c44f0204-bcc9-374c-83e1-197513c91b0c

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