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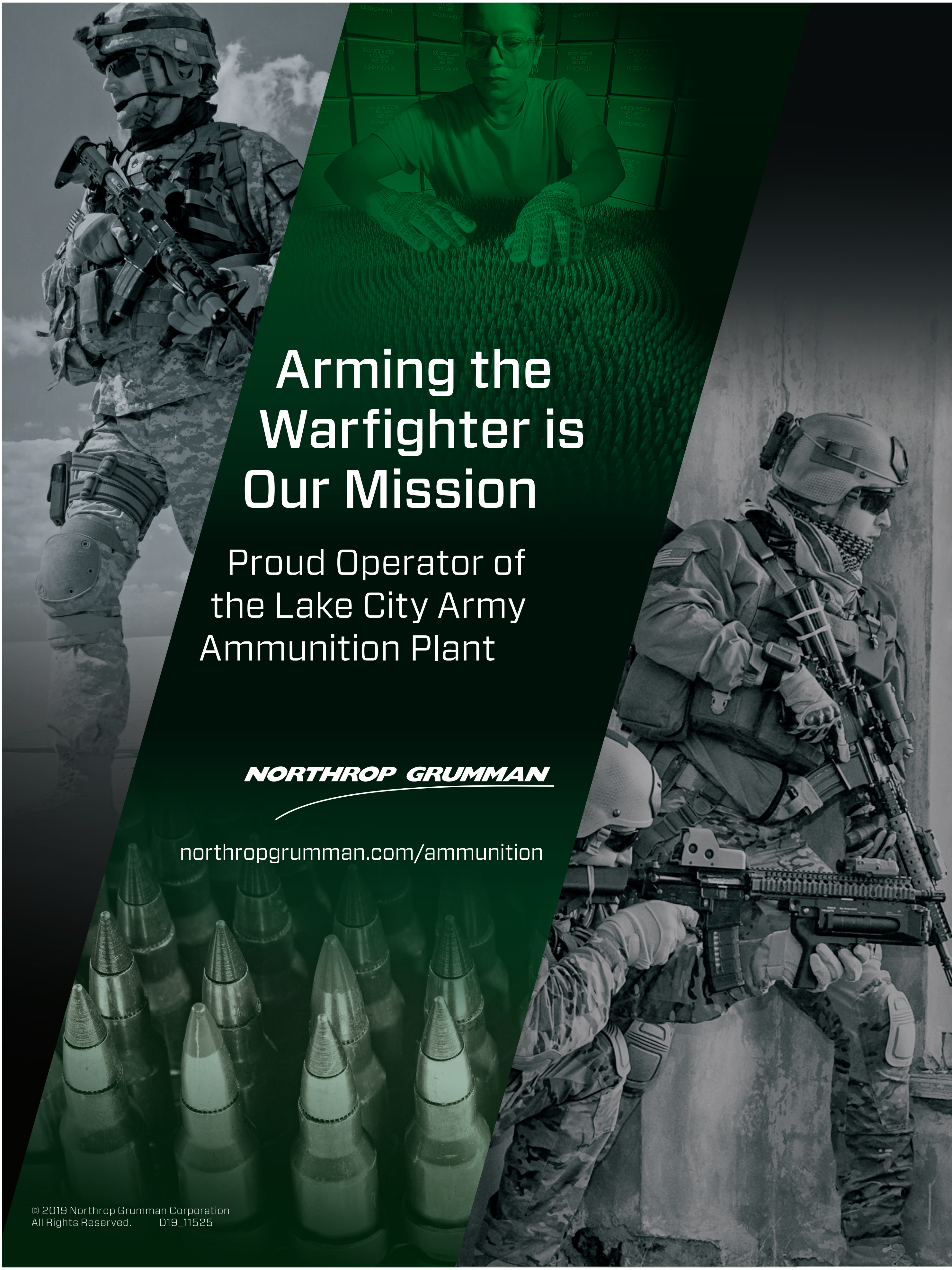
2019 ARMAMENT SYSTEMS FORUM

Leveraging Armament Technology Integration to Achieve Modernization, Overmatch, and Operational Readiness

June 3 – 6 | Fredericksburg, VA | NDIA.org/Armaments19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WELCOME TO THE 2019 ARMAMENT SYSTEMS FORUM

Dear Attendees,

Welcome to the NDIA Armament Systems Forum and Technology Demonstration. The annual Armament Forum integrates the full spectrum of armament systems into a single event enabling communication and networking partnership of government with the industrial base. The 2019 Forum theme: "Leveraging Armament Technology Integration to Achieve Modernization, Overmatch, and Operational Readiness" reflects the U.S. and allied nation priorities for modernized capability that address changing threats from near-peer competitors. Achieving these capabilities requires advanced technology, system integration and readiness. The Forum highlights the government and industry partnership and the benefits of this collaboration. The program places emphasis on readiness and enhancement of legacy systems while developing and transitioning advanced capabilities.

The forum features Tutorials, Joint Sessions with Keynote speakers from each service, and concurrent sessions for Small Arms; Guns, Ammunition, Rockets, and Missiles; and Unconventional and Emerging Armament Systems. Our speakers, leaders and experts in relevant requirements, programs, and technology, deliver learning opportunities while networking provides information sharing and exchange among attendees. Participation from Allied partners extends the depth of the networking discussions, and the tutorial sessions offer in-depth group discussion of topics considered relevant to enable evolving capability. Our exhibitors display the scope of their innovative approaches to advanced technology and systems for your examination.

The Technology Demonstration taking place on Thursday afternoon highlights advances in Small Arms System Capability. Sal Fanelli and the demo team have coordinated and planned a detailed and informative event. This year Team Crucible has provided the range resources and support meeting the operational, safety, and observation objectives. Thanks to Team Crucible for their welcoming interest and commitment to the NDIA mission.

I want to acknowledge the Armament Division planning committee for their work toward a successful and forum. The committee chairs; Small Arms - Brian Berger, GTDS America; GARM - Matt Phillips, GD-OTS; and UEA - Alan Kull, General Atomic. Each of these chairs together with the government and industry executive teams have established an agenda that reflects the theme and includes topics relevant to government and industry attendees.

Thank you to the sponsors, supporting government agencies, and the industrial base who together form the partnerships demonstrated by the community. As we attend and participate in the 2019 Forum, we seek to build the network through relevance and collaboration among the Armament community. Your attendance and involvement throughout the week are key as NDIA completes its first 100 years of service to the nation.

Dave Broden
Division Chair
Broden Resource Solutions, LLC

SCHEDULE AT A GLANCE

MONDAY, JUNE 3

Registration
Exhibit Hall A Lobby
11:00 am – 5:00 pm

Tutorial Sessions
Please reference agenda for locations
12:30 – 5:00 pm

TUESDAY, JUNE 4

Registration
Exhibit Hall A Lobby
7:00 am – 6:30 pm

Networking Breakfast
Grand Ballroom Foyer
7:00 – 8:00 am

General Session
Grand Ballroom
8:00 am – 5:10 pm

Exhibit Hall Open
Exhibit Hall A
9:30 am – 6:30 pm

Networking Lunch
Exhibit Hall A
12:00 – 1:00 pm

Networking Reception
Exhibit Hall A
5:00 – 6:30 pm

WEDNESDAY, JUNE 5

Registration
Exhibit Hall A Lobby
7:00 am – 6:00 pm

Networking Breakfast
Grand Ballroom Foyer
7:00 – 7:30 am

Concurrent Technical Sessions
Please reference agenda for locations
7:30 am – 5:00 pm

Networking Lunch
Exhibit Hall A
12:00 – 1:00 pm

Networking Reception
Exhibit Hall A
5:00 – 6:00 pm

THURSDAY, JUNE 6

Registration
Exhibit Hall A Lobby
7:00 am – 12:00 pm

Networking Breakfast
Grand Ballroom Foyer
7:00 – 7:30 am

Concurrent Technical Sessions
Please reference agenda for locations
7:30 am – 12:00 pm

Technology Demonstration
Team Crucible
12:00 – 4:00 pm

ARMAMENTS DIVISION

WHO WE ARE

The Armaments Division traces its heritage through 100 years of history to the founding of the Army Ordnance Association in 1919. The Armaments Division provides a forum for industry, military, government and academic personnel to address the issues necessary to ensure a superior armament systems capability today and in the future. The division addresses armament operational needs and requirements, approaches and concepts, system integration, weapons, munitions, fire control, other ancillary Equipment, and logistic support.

LEADERSHIP

Dave Broden
Division Chair

Brian Berger
Chair, Small Arms Committee

Sal Fanelli
Chair, Technology Demonstration

Alan Kull
Chair, UEA Committee

Matt Phillips
Chair, GARM Committee

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. NDIA is proud to celebrate 100 years in support of our warfighters and national security. The technology used by today's modern warfighter was unimaginable 100 years ago. In 1919, BG Benedict Crowell's vision of a collaborative team working at the intersection of science, industry, government and defense began what was to become the National Defense Industrial Association. For the past century, 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**

EVENT INFORMATION

EVENT THEME

Leveraging Armament Technology Integration to Achieve Modernization, Overmatch, and Operational Readiness

The 2019 Armament Forum theme connects the U.S. National Security objectives and those of Allied Nations to the stated priorities for modernization, superior capability and readiness and seeks to communicate the U.S. and Allied response through innovation in technology, integration, and collaboration. Topics address emerging challenges and opportunities and outline roadmaps to maturity and readiness. Attention to the complete armament system (soldier as a system), manned and unmanned autonomous platforms are included in the agenda.

SURVEY AND PARTICIPANT LIST

You'll receive via email a survey and list of attendees (name and organization) after the conference. Please complete the survey, which helps make our event even more successful in the future.

EVENT CONTACT

Meredith Mangas
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Sarah O'Hanley
Manager,
Exhibits & Sponsorships
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sohanley@ndia.org

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.

SESSION TRACKS

SMALL ARMS SYSTEMS

The Next Generation of Small Arms Integrated Systems: Weapons, Ammunition, Enablers, Training

The Small Arms section of the program will include presentations from PM Soldier Weapons, PM MAS, JSSAST, and JSSAP on next generation systems technologies. In addition, the agenda features panel discussions on fire control technology, reduced range ammunition, and lightweight ammunition technology.

GUNS, AMMUNITION, ROCKETS & MISSILES SYSTEMS

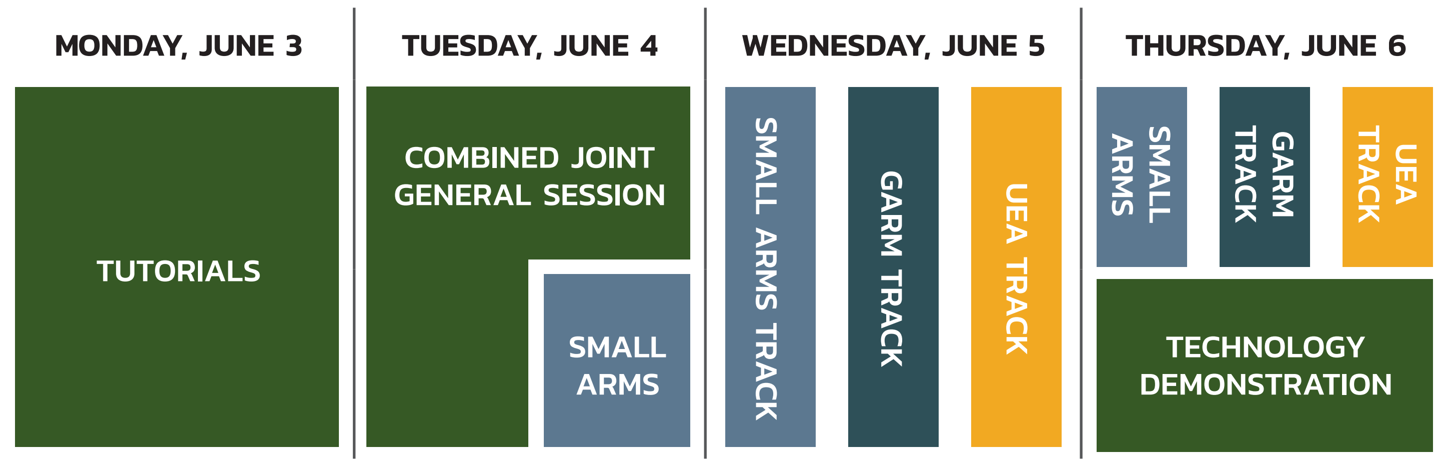
Realizing Future Gun, Ammunition, Rocket, and Missile Systems

The GARM sessions address plans, challenges and modernization approaches for present and future gun systems greater than Cal 0.50. These sessions also address guns, feed systems, ammunition and associated fuzes, fire control, and platform integration.

UNCONVENTIONAL EMERGING TECHNOLOGY ARMAMENT SYSTEMS

Accelerating a Broad Spectrum of Future Target Effects to the Warfighter

The UEA sessions address technologies, systems, capabilities, and applications that encompass a wide range of alternative combat capabilities to include Hypersonics, EM, Directed Energy, Lasers and Integrated Robotic Systems.



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MONDAY, JUNE 3

11:00 am – 5:00 pm **REGISTRATION**
EXHIBIT HALL A LOBBY

TUTORIALS (DISTRIBUTION A)

	Ballroom A	Ballroom B	Ballroom C
12:30 – 2:00 pm	**Tutorial 1: U.S. Export Controls Related to Technology** Johanna Reeves Reeves & Dola, LLP	**Tutorial 2: Intelligence Integration into Capability** Dwayne Hynes USD, Department of Defense	**Tutorial 3: Middle Tier Acquisition – Section 804** Lynne Giordano Defense Acquisition University
2:00 – 3:30 pm	**Tutorial 4: Industrial Base Cyber Risks and Protection** Susan Ebner Stinson, LLP Rolando Sanchez Sanchez PLC	**Tutorial 5: What Gun and Ammunition Designs Need to Know About Case-Chamber Interaction** Jeff Siewert Arrow Tech Associates	**Tutorial 6: Evolving Platform and Armament System Integration** Dave Broden Broden Resource Solutions, LLC *Moderator* Mark Signorelli BAE Systems Platforms and Services Matt Dooley Robotics Division, NDIA John Chadbourne AM General Art O'Donnell Northrop Grumman Innovation Systems
3:30 – 5:00 pm	**Tutorial 7: Artificial Intelligence** Ross Arnold Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command Dr. Jorge Buenfil Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command	**Tutorial 8: DOD Foreign Comparative Testing Overview** Col Doug Creviston, USAF OUSD R&E Randy Everett (GTO) G3/Operations U.S. Army Combat Capabilities Development Command Office	**Tutorial 9: Intellectual Property Objectives, Criteria, and Approach** Col Wesley Hallman, USAF (Ret) NDIA Corbin Evans NDIA

TUESDAY, JUNE 4 – GENERAL SESSION (DISTRIBUTION A)

7:00 am – 6:30 pm **REGISTRATION**
EXHIBIT HALL A LOBBY

7:00 – 8:00 am **NETWORKING BREAKFAST**
GRAND BALLROOM FOYER

8:00 – 8:10 am **WELCOME AND OPENING REMARKS**
GRAND BALLROOM

Dave Broden
NDIA Armament Division Chair

Dave Chesebrough
Vice President, Divisions, NDIA

8:10 – 8:30 am **WELCOME FROM TEAM CRUCIBLE**
GRAND BALLROOM

John Garman
President, Team Crucible

8:30 – 9:00 am **NDIA ENTERPRISE VISION AND POLICY INITIATIVES**
GRAND BALLROOM

MG James Boozer, USA (Ret)
Executive Vice President, NDIA

Col Wesley Hallman, USAF (Ret)
Senior Vice President, Strategic Program & Policy, NDIA

9:00 – 9:30 am **KEYNOTE SPEAKER**
GRAND BALLROOM

BG Alfred Abramson, USA
Program Executive Officer & Senior Commander, Picatinny Arsenal, Joint Program Executive Office Armaments and Ammunition (JEPO A&A)

9:30 – 10:00 am **FEATURED SPEAKER**
GRAND BALLROOM

Anthony Sebasto
Executive Director, Enterprise and Systems Integration Center, Combat Capabilities Development Command Armaments Center

9:30 am – 6:30 pm **EXHIBIT HALL OPEN**
EXHIBIT HALL A

10:00 – 10:30 am

NETWORKING BREAK & POSTER REVIEW
EXHIBIT HALL A

10:30 – 11:15 am

FEATURED SPEAKER
GRAND BALLROOM

Dr. Michael Richman
SSTM, Technical Deputy, Missile Modernization and Development CCDC Aviation and Missile Center

11:15 am – 12:00 pm

LONG RANGE PRECISION FIRE LINES OF EFFORT
GRAND BALLROOM

COL(P) John Rafferty, USA
Director, Long Range Precision Fires Cross Functional Team, U.S. Army Futures Command

12:00 – 1:00 pm

NETWORKING LUNCH
EXHIBIT HALL A

1:00 – 1:30 pm

FEATURED SPEAKER
GRAND BALLROOM

Amy O'Donnell
Deputy Technical Director, NSWC Indianhead Explosive Ordnance Disposal Technology Division

1:30 – 2:00 pm

FEATURED SPEAKER
GRAND BALLROOM

Dr. David Lambert
Chief Scientist, Munitions Directorate, Air Force Research Laboratory

SMALL ARMS TRACK
(DISTRIBUTION A)
ROOM AF

Joint Service Small Arms Synchronization Team (JSSAST) Panel
1:00 – 2:00 PM

MAJ Ian Welch, USA
Combat Capabilities Development Command, Armaments Center, U.S. Army Futures Command
Moderator

Matthew Walker
U.S. Army Futures Command

William Epperson
Capabilities Integration Officer, USMC

Col Enrico Venditti, USAF
U.S. Air Force Security Forces Center

Craig LaMudge
Office of Specialized Capabilities, U.S. Coast Guard

LCDR Peter Downes, USN
DCNO N9

LTC Marcos Cervantes, USA
PEO SOF Warrior

2:00 – 2:30 pm

WEAPONS FOR A DISAGGREGATE BATTLE

GRAND BALLROOM

MG Robert Scales, USA (Ret)
Former Commandant, U.S. Army War College

SMALL ARMS TRACK

ROOM AF

Joint Services Small Arms Program (JSSAP) Introduction

2:00 – 2:05 PM

Augustine Funcasta
Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command

Joint Services Small Arms Requirements Integration (JSSARI)

2:00 – 2:15 PM

MAJ Ian Welch, USA
MILDEP, JSSAP Office

Joint Science And Technology Advisory Council (JSTAC)

2:15 – 2:30 PM

Marc Ritt
Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command

2:30 – 3:00 pm

NETWORKING BREAK & POSTER REVIEW

EXHIBIT HALL A

3:00 – 3:45 pm

USMC CAPABILITY OBJECTIVES AND PROGRAMS

GRAND BALLROOM

Col Michael Manning, USMC
USMC Portfolio Manager Ground Combat Element Systems
Moderator

LtCol Tim Hough, USMC
Program Manager, Infantry Weapons

LtCol Brad Sams, USMC
Program Manager, Fires, USMC

John Knapp
Program Manager, Infantry Combat Equipment, USMC

3:45 – 4:30 pm

DOD NON-LETHAL WEAPONS PROGRAM

GRAND BALLROOM

Col Wendell Leimbach
Director, Joint Non-Lethal Weapons Directorate (JNLWD)

Kevin Swenson
Acquisition Division Chief, Joint Non-Lethal Weapons Directorate (JNLWD)

David Law
Technology Division Chief, Joint Non-Lethal Weapons Directorate (JNLWD)

4:30 – 5:00 pm

FEATURED SPEAKER

GRAND BALLROOM

Charlie Zisette
Executive Director, National Armaments Consortium

5:00 – 5:10 pm

CLOSING REMARKS

GRAND BALLROOM

SMALL ARMS TRACK

ROOM AF

Joint Services Small Arms Program (JSSAP) Portfolio

3:00 – 3:30 PM

Terence Rice
Combat Capabilities Development Command
Armaments Center, U.S. Army Futures Command

JSSAP Special Topics Update

3:30 – 4:00 PM

Matthew Moeller
Combat Capabilities Development Command
Armaments Center U.S. Army Futures Command

Adam Jacob
Combat Capabilities Development Command
Armaments Center, U.S. Army Futures Command

Small Arms Awards Ceremony

4:00 – 5:00 PM

Chinn Award

Thomas Nelson
Presented by Dan Shea

Hathcock Award

Bryan Litz
Presented by Sal Fanelli

Ambrose Award

Arrow Tech Associates, Inc accepted by Jeff Siewert
Presented by Sal Fanelli

Professional Service Award

Mike Tauber, in memoriam
Presented by Brian Berger

5:00 – 6:30pm

NETWORKING RECEPTION

EXHIBIT HALL A

WEDNESDAY, JUNE 5

Time	Small Arms Track: Session 1 Room A, Distribution A	GARM Track: Session 1 Room CD, Distribution A	UEA Track: Session 1 Room BE, Distribution D
7 am	BREAKFAST – GRAND BALLROOM FOYER		
7:30 am	**Small Arms Administrative Announcements** Brian Berger NDIA Small Arms Committee Chair	**GARM Administrative Announcements** Matt Phillips NDIA GARM Committee Chair	**UEA Objectives, Purpose, Challenges, Opportunities** Alan Kull NDIA UEA Committee Chair
7:40 am	**Modern Trends, Threats, and Developments in Global Ordnance** Dan Shea Phoenix Defence	**Discussion of GARM** Dave Broden NDIA Armaments Division Chair *Moderator* Matt Phillips NDIA GARM Committee Chair	**Cost Effective C-UAS Using COTS Components to Improve Exchange Rate** Howard Kent Armor Development Group, LLC
8:00 am	**PM Maneuver Ammunitions Systems (MAS) Panel** COL Hector Gonzalez, USA Maneuver Ammunition Systems *Moderator* LTC Andre Johnson, USA Medium Caliber Ammunition LTC Andrew Lunoff, USA Small Caliber Ammunition	**CCDC Armament Center GARM Related System Technology** Mike George Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command	**Semi-Autonomous Slew and Firing to Defeat Highly Maneuvering Aerial Targetszac** Cliff Chang U.S. Army Futures Command **Reactive Material Technology and Application** Jeb Brough MATSYS, Inc.
8:30 am		**CCDC AvMC GARM Related Technology** Susan Dunbar U.S. Army Futures Command	**Small UAS Gunship** Lucius Taylor NSWC Crane
9:00 am	**PM Soldier Weapons Panel** COL Elliott Caggins, USA Product Manager Soldier Weapons *Moderator* LTC Jason Bohannon, USA Product Manager, Next Generation Weapons LTC Steven Power, USA Product Manager Individual Weapons Peter Errante Product Director, Crew Served Weapons Matthew Walker Capabilities Developer, Solider Lethality Cross Functional Team, U.S. Army Futures Command	**Close Combat Support (CCS) to Army Modernization Priorities** Joe Pelino Close Combat Systems	**How Block Chain and Smart Contracts Will Impact Armament Systems** Ralph Tillinghast Combat Capabilities Development Command Armaments Center U.S. Army Futures Command
9:30 am		**Combat Ammunition Systems (CAS) Support to Army Modernization Priorities** LTC Pat Farrell, USA Ammunition SME Dan Napolitano Ammunition SME's	**Pulsed Power Developments for Directed Energy Systems** Charlie Wiesel VIS, LLC
10 am	NETWORKING BREAK & POSTER REVIEW – EXHIBIT HALL A		

	Small Arms Track: Session 1 Room A, Distribution A	GARM Track: Session 1 Room CD, Distribution A	UEA Track: Session 1 Room BE, Distribution D
10:30 am	**NATO NIAG-228 Study** Yves Roskam NATO Industrial Advisory Group Fabrice Fontanier NATO Industrial Advisory Group	**Next Generation Combat Vehicle (NGCV) Vision** COL Warren Sponsler, USA Next Generation Combat Vehicles Cross Functional Team, U.S. Army	**Reference Architecture for Deep Learning Based Security Systems** Dr. Jorge Buenfil Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command
10:50 am	**Unconventional Emerging Technology Armament Systems** Vincent Battaglia BML Tool Manufacturing	**NGCV System, Technology, and Vision Panel** Dave Broden NDIA Armaments Division Chair *Moderator* LTC Andre Johnson, USA Medium Caliber Ammunition Gary Milcheck Combat Capabilities Development Command Armaments Center U.S. Army Futures Command Jeff Hart Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command Spencer Hudson Combat Capabilities Development Command, Aviation and Missile Center, U.S. Army Futures Command Robert Ruhland Northrop Grumman Innovation Systems Tim Brumfield Northrop Grumman Innovation Systems Matt Phillips General Dynamics Eric Eickstaedt Northrop Grumman Innovation Systems Kyle Patterman Meggitt Defense Systems	**Multicore Considerations for Safety Critical Software Applications** Brian Connell Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command
11:10 am	**Lightweight Small Cal Ammunition Panel** LTC Andrew Lunoff, USA Small Caliber Ammunition *Moderator* Mark Owens True Velocity Lanse Padgett PCP Joe Gibbons MAC Pierre Lemay GD-OTS Canada Gino Spinos Concurrent Technology Corp (CTC)		**Low Cost COTS-Based VTOL UAS for Stealthy Take Downs** Robert Serino Applied Research Associates, Inc.
11:30 am			**Applying Multi-Agent Swarm Artificial Intelligence to Armament Systems** Ross Arnold Combat Capabilities Development Command Armaments Center, U.S. Army Futures Commanderi
12 pm	NETWORKING LUNCH – EXHIBIT HALL A		

	Small Arms Track: Session 2 Room A, Distribution A	Small Arms Track: Session 3 Room F, Distribution A	GARM Track: Session 1 Room CD, Distribution A	UEA Track: Session 1 Room BE, Distribution D
1:00 pm	**Fire Control Technology and System Panel** **Terence Rice** JSSAP *Government Moderator* **Bob Guarasi** Wilcox Industries *Industry Moderator* **Doug Cohen** PM Soldier Weapons **Ross Towers** Fire Control, U.S. Army Futures Command **Dr. Mark Thoreson** NSWC Crane **Tony Bacarella** DRS EOIS **Bryan Bockmon** Aim-Lock, Inc. **Lennart Ljungfelt** Aimpoint	**Propellant Optimization** **Tyler Holland** Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command **Andrew Caldwell** Olin Corp – Winchester Division	**Long Range Precision Fires (LRPF) Panel** **Dave Broden** NDIA Armaments Division Chair *Moderator* **Robert Picht** LRPF CFT **Ole Knudson** Northrop Grumman Innovation Systems **David Musgrave** Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command **Rich Granitzki** Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command **Dr. Michael Richman** Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command **Charles Hayden** General Dymanics	**Distributed, Coordinated, and Cooperative Defeat Technologies** **Dr. David Lambert** Munitions Directorate, Air Force Research Laboratory
1:20 pm		**Contributing Factors in Small Cal Pierced Primers** **Andy Boman** Northrop Grumman Innovation Systems		
1:40 pm		**Environmentally Benign Composition for the M209 Shotshell Primer** **Jim Wedwick** Northrop Grumman Corporation		
2:00 pm		**Incendiary Composition Analytical Study for Small Cal Ammunition** **Daniel Mansfield** Northrop Grumman Corporation, Lake City Army Ammunition Plant	**Long Range Precision Fires CCDC AC** **Mike George** Strategic Technology Investment Office	**Emerging Technology System Perspective – Navy** **Dr. Frank Peterkin** Office of Naval Research
2:30 pm	**NETWORKING BREAK & POSTER REVIEW – EXHIBIT HALL A**			
3:00 pm	**"Gummy" Metals – Why Difficult to Cut and What Can be Done About it** **Jason Davis** NSWC Crane	**7.62mm Case Rupture Failure Analysis** **Zachary Krogstad** Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command **Robert Woolsey** Northrop Grumman Corporation	**Long Range Precision Fires CCDC Aviation and Missile Center** **Dr. Michael Richman** Combat Capabilities Development Command Aviation and Missile Center, U.S. Army Futures Command	**Emerging Technology System Perspective - USAF** **Dr. Don Shiffler** AFRL Directed Energy Directorate, AFMC AFRL/RD

	Small Arms Track: Session 2 Room A, Distribution A	Small Arms Track: Session 3 Room F, Distribution A	GARM Track: Session 1 Room CD, Distribution A	UEA Track: Session 1 Room BE, Distribution D
3:20 pm	**0.50 Cal Ball/Trace Cartridge Match Improvements** David Stubler Northrop Grumman	**Improving Gun Barrel Life and Accuracy** George Kontis Gun IQ International, LLC	**Future Vertical Lift (FVL) and Armament System Panel** Matt Phillips NDIA GARM Committee Chair *Moderator* Michael Colonnello Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command Bradford McHugh Combat Capabilities Development Command Armaments Center, U.S. Army Allan Walker Combat Capabilties Development Command Aviation and Missile Center, U.S. Army Futures Command Jim St. Germain General Dynamics Art O'Donnell Northrop Grumman Innovation Systems Jennifer Zonneveld Northrop Grumman Innovation Systems	**Enhancing Weapons Capabilities through Smart Sensors** Robert Meng Secubit, Inc.
3:40 pm	**AeroShell Armor-Piercing Projectiles** Lucius Taylor IV NSWC Crane			**Speed of Battle** LTC Andre Johnson, USA Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command
4:00 pm	**Sound Testing of Small Arms Weapons** Laura Best NSWC Crane	**Systemic Effects of Cartridge and Weapon Barrel Variation** Thomas Gmyrek Caliber .50 APO		**Quantifying the Accuracy of Wind Estimation Techniques in Direct Fire Ballistics** Tomas Bober Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command
4:20 pm	**High Performance Composite Machine Gun Barrels** David Armstrong NSWC Crane	**Reevaluating Condemnation Criteria for Barrel Erosion/Wear** Anthony Hawthorne Combat Capabilities Development Command, U.S. Army Futures Command		**Protecting Smart Launchers using Advanced Anti-Spoofing** Steve Alexander L3 Technologies
4:40 pm	**Full-Auto Cycle Rate Reducer Transforms M4/M16 in New Full-Automatic Fire Scenario** Terrence Bender High Performance Firearms, LLC	**M14 Short Stroke - Analysis of Ammunition and Weapons System reddInfluencing Factors** Elyse Barone Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command Tim Good Northrop Grumman Corporation		**Virtual Reality Prototyping for Fire Control Platforms** David Musgrave Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command
5 pm	**NETWORKING RECEPTION– EXHIBIT HALL A**			

THURSDAY, JUNE 6

	Small Arms Track: Session 4 Room A, Distribution A	GARM Track: Session 2 Room F, Distribution D	GARM Track: Session 3 Room CD, Distribution A	UEA Track: Session 2 Room BE, Distribution D	
7 am	BREAKFAST – GRAND BALLROOM FOYER				7 am
7:30 am	**Small Arms Administrative Announcements** Brian Berger NDIA Small Arms, Committee Chair	**GARM Administrative Announcements**	**GARM Administrative Announcements**	**UEA Objectives, Purpose, Challenges, Opportunities** Alan Kull NDIA UEA Committee Chair, NDIA Armaments Division	7:30 am
7:40 am	**40mm Low Velocity** Jay Bell MAST Technology, Inc.	**XM913 50mm Chain Gun Technology Development** Tim Brumfield Northrop Grumman Innovation System	**The Joint Packaging, Handling, Storage, and Transportation Center** Robert Rossi Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command Mike Hagn NSWC Indian Head	**Development of High Reliability DPICM Replacement** Kevin Cochran NSWC IHEOOTD Fuze and Initation Systems Branch	7:40 am
8:00 am	**M80A1 Dispersion Reduction** Zachary Krogstad Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command Steve Redd Northrop Grumman Innovation Systems	**Excalibur Shaped Trajectory** Arnaldo Colon Precision Indirect Fires, Land Warfare Systems, Raytheon	**40MM Low Velocity Counter Unmanned Aerial System** Cheng Hok Aw Advanced Material Engineering	**Low-Blast High-Impulse Densified Propellant for Recoilles Gun, Rocket, Missile Systems** Matthew Sanford Naval Surface Warfare Center Indian Head Explosives Ordnance Disposal Technology Division	8:00 am
8:20 am	**Greater Penetration and Lethality for Small Bore Rifle, PDW and Handgun Cartridges** Jonathan Berman Ammo and Bullet Mfg, Inc.	**Reactive Material Technology and Application** Jeb Brough MATSYS, Inc.	**155MM Artillery Platform Projective Fallback Sensor** Kevin Boland Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command	**Services Perspective on Hypersonics** Rob Esslinger Combat Capabilities Development Command Aviation and Missile Center, U.S. Army Futures Command	8:20 am
8:40 am	**Observations and Opportunities in Small Caliber Dispersion** Jeff Siewert Arrow Tech Associates, Inc.	**Armaments Health Monitoring for Autonomous Systems** Anthony Cannone Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command			

Time	Small Arms Track: Session 4 Room A, Distribution A	GARM Track: Session 2 Room F, Distribution D	GARM Track: Session 3 Room CD, Distribution A	UEA Track: Session 2 Room BE, Distribution D
9:00 am	**Reduced Range Ammunition Panel** Evan Poole U.S. Crane *Moderator* Ray Chaplin Combat Capabilities Development Command Armaments Center. U.S. Army Futures Command Kyle Kampo Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command Pierre Lemay GD-OTS Canada Fredrik Erninge Nammo Talley, Inc. Marcelo Moreno Companhia Brasileira de Cartuchos (CBC)	**Technical Challenges Associated with Large Caliber Extended Range Missions: Gun Mounts** Samuel Jacobs Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command	**USN Quad City Rock Island Arsenal Cartridge Case Capability** Mike Hagn NSWC Indian Head	**Industry Perspectives on Hypersonics** Arthur Mabbett Adv High Speed Weapons, Raytheon Missile Systems John Wilcox Advanced Programs & Technology, Northrop Grumman Innovation Systems Dr. Kevin Bowcutt Hypersonics, Boeing
9:20 am		**Burst Test of Composite Mortar Tube Section: Modeling and Experimentation** Andrew Littlefield Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command	**USN Indianhead Trident Plant Revitalization Propulsion Capability/ Technology** Mike Lateulere NSWC Indian Head	
9:40 am		**Fuze and Precision Armaments Test Capabilities and Facilities** Pamela Ferlazzo Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command	**Fire Suppression Round** Joshua Keena Automotive/Weapons Thread Leader, U.S. Military Academy at West Point	
10 am	NETWORKING BREAK – GRAND BALLROOM FOYER			

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VISTA OUTDOOR

WINCHESTER

	Small Arms Track: Session 4 Room A, Distribution A	GARM Track: Session 2 Room F, Distribution D	GARM Track: Session 3 Room CD, Distribution A	UEA Track: Session 2 Room BE, Distribution D	
10:30 am		**Laser-Based Inspection of Weapon Bores and Chambers** James Doyle Laser Techniques Company	**Point of Impact Shift from Muzzle Mounted Chronometer and Combining Ballistics and Differential Equation Modeling** Joshua Keena Automotive/Weapons Thread Leader, U.S. Military Academy at West Point	**Hypersonic Systems Panel Discussion** Dave Broden Broden Resource Solutions, LLC Moderator Rob Esslinger Combat Capabilities Development Command Aviation and Missile Center, U.S. Army Futures Command Arthur Mabbett Adv High Speed Weapons, Raytheon Missile Systems John Wilcox Advanced Programs & Technology, Northrop Grumman Innovation Systems Dr. Kevin Bowcutt Hypersonics, Boeing	10:30 am
10:50 am	**Quantifying Bullet Performance Against Transparent Barriers** Martin Viligiardi QinetiQ	**Interplay of Finite Element Modeling and Experiments in a Weapons Development Project** Jon Yagla Bowhead Technical Services	**20mm Mechanically Fuzed High Explosive Projectile** Chris Idleman General Dynamics OTS		
11:10 am	**Ammunition Production Equipment Diagnosis** Katelyn Riha Northrop Grumman Innovation Systems	**Simplified Instrumentation for Radiometrically Accurate Flash Movements** Dr. David Dye NSWC Crane	**Advanced Shoulder Fired Weapon and Ammunition System** Dr. David Grymonpré Airtronic USA	**Emerging Technology Systems Panel** Alan Kull NDIA UEA Committee Chair Mike George Strategic Technology Investment Office, Combat Capabilities Development Command Armaments Center Dr. Don Shiffler AFATL Directed Energy Rob Esslinger Combat Capabilities Development Command Aviation and Missile Center, U.S. Army Futures Command Dr. Frank Peterkin Office of Naval Research	11:00 am
11:30 am	**Marksmanship Dispersion, Statistical Approach to Dispersion and Recoil** Shawn Spickert-Fulton Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command	**Next Generation Carbine Technologies** Thomas Grego Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command	**Comprehensive Advanced Artillery Solutions** Danny Schirding Elbit Systems Land		
11:50 am	**Wrap Up** Brian Berger NDIA Small Arms Committee Chair			**Wrap up and Vision Forward** Alan Kull UEA Committee Chair	11:45 am
12 pm	**CONFERENCE ADJOURNS**				

TECHNOLOGY DEMONSTRATION

12:00 – 12:20 pm	**BOX LUNCH PICKUP** EXHIBIT HALL A LOBBY
12:30 pm	**BUSES HARD DEPART FOR TECHNOLOGY DEMONSTRATION**
1:15 – 1:45 pm	**ARRIVE AT DEMO SITE, SAFETY BRIEFING**
1:45 – 2:15 pm	**DEMONSTRATING COMPANIES BRIEF TECHNOLOGY INITIATIVES AND FEATURES**
2:15 – 2:45 pm	**TECHNOLOGY DEMONSTRATIONS**
2:45 – 3:50 pm	**ATTENDEE PARTICIPATION**
4:00 pm	**BUSES DEPART**

TECHNOLOGY DEMONSTRATION

Ammo & Bullet Mfg. Inc.
New 9mm Frangible Armor Piercing Ammunition

AMTEC Corporation
40mm Low Velocity (LV) cartridges

B.M.L. Tool & Mfg. Corp.
AMAG Multi-Caliber Rifle

Barrett Firearms
7.62mm version of the SOCOM Advanced Sniper Rifle (ASR)

Extreme Defense, LLC
M4 Carbine / MK 4R Pistol

FN America
MK 20 6.5 Creedmoor, MK 48 6.5 Creedmoor & MK 48 7.62

GLOCK, Inc.
G19X / G45 / G17 MOS / G19 MOS / G43X / G48 Pistols

HIPERFIRE
Full Auto Cyclic Rate Reducer (F.A.C.R.R.)

Knight's Armament Company
SR25 in 6.5 Creedmore & 7.62mm, SR16

LMT Defense
Suppressed MWS 7.62 & 6.5 CM / CSW 300BLK / Suppressed MARSL 5.56

Northrop Grumman
5.56mm and 7.62mm ammunition

Olin Winchester, LLC
New 9mm M1152 and M1153 ammunition designed for use with M17/M18 Pistols

Secubit
Round Counters for Rifles, Carbines and Pistols

Sig Sauer
New U.S. Army M17 and M18 Pistols

ST Engineering
Ultimax 100 MG / SAR 21 Std and MMS

Project Manager Soldier Weapons
40mm M320 Grenade Launcher, M26 12 gauge under-barrel Modular Accessory Shotgun (MASS) and the M110 7.62mm Semi-Automatic Sniper Systems (SASS)

Vista Outdoor
9mm and 12 gauge ammunition

POSTER PRESENTERS

155MM Artillery Platform Projectile Fallback Sensor
BOARD 01
Boland, K.
Combat Capabilities Development Command Armaments Center, **U.S. Army Futures Command**

Improved Ballistic Match and Accuracy for .50 Caliber Reduced Range Ammunition (RRA)
BOARD 02
Bourque, G.
General Dynamics - OTS Canada

Reference Architecture for Deep Learning Based Security Systems with Computer Vision and Human in the Loop
BOARD 03
Buenfil, J.
Combat Capabilities Development Command Armaments Center, **U.S. Army Futures Command**

Kinetic Defeat Modeling and Optimization for Counter-UAS Applications
BOARD 04
Caprara, R.
NSWC Crane

Using Physics Based Explicit FEA Codes to Model and Simulate Ballistic Impact Events
BOARD 05
Cataldi, M.
Combat Capabilities Development Command Armaments Center, **U.S. Army Futures Command**

Effects of Rifling Twist Rate and Geometry on Bullet Engraving During Launch
BOARD 06
Chaplin, R.
Combat Capabilities Development Command Armaments Center, **U.S. Army Futures Command**

Laser-based Inspection of Weapon Bores and Chambers to Improve Manufacturing Quality, Optimize Performance and Sustain Operational Readiness
BOARD 07
Doyle, J.
Laser Techniques Company

Systematic Effects of Cartridge and Weapon Barrel Variation
BOARD 08
Gmyrek, T.
Combat Capabilities Development Command Armaments Center, **U.S. Army Futures Command**

Next Generation Carbine Technologies Advanced Barrel Characterization
BOARD 09
Grego, T.C.
Combat Capabilities Development Command Armaments Center, **U.S. Army Futures Command**

Next Generation Carbine Technologies Signature and Recoil Reduction
BOARD 10
Grego, T.C.
Combat Capabilities Development Command Armaments Center, **U.S. Army Futures Command**

Next Generation Carbine Technologies
BOARD 11
Grego, T.C.
Combat Capabilities Development Command Armaments Center, **U.S. Army Futures Command**

Next Generation Family of Ammunition
BOARD 12
Hawthorne, A.
Combat Capabilities Development Command Armaments Center, **U.S. Army Futures Command**

MATLAB Script to Convert Tetrahedrals to Hexahedrals with Near-Optimal Element Quality
BOARD 13
Hohnecker, K.
Combat Capabilities Development Command Armaments Center, **U.S. Army Futures Command**

Acquisition-Intelligence
BOARD 14
Hynes, D.
USD(I)

Intelligence as Value Added
BOARD 15
Hynes, D.
USD(I)

Design and Implementation of Reduced Range Training Ammunition
BOARD 16
Kampo, K.
Combat Capabilities Development Command Armaments Center, **U.S. Army Futures Command**

Gun Camera Small Arms Applications of The Soldier Worn Network
BOARD 17
Kent, H.
Armor Development Group, LLC

Beating the Heat: Tungsten Ablation Coatings for Firearms
BOARD 18
Kent, H.
Armor Development Group, LLC

How the World Record Sniper Hit Was Made; Meet Charlie TARAC
BOARD 19
Kent, H.
Armor Development Group, LLC

Three Months from Poster to Product; The Frangible AP Story
BOARD 20
Kent, H.
Armor Development Group, LLC

Programmable Dispersion of for Ammunition Production; Using External Ammunition Sealant to Produce Identical or Varying Dispersion on the Production Line
BOARD 21
Kent, H.
Armor Development Group, LLC

Commercial Lightweight Firearms Survey: What's New from the Wide World of the Commercial Firearms Industry
BOARD 22
Kent, H.
Armor Development Group, LLC

Advantages of 21st Century Materials & Manufacturing Processes on Small Caliber Ammunition
BOARD 23
Kent, H.
Armor Development Group, LLC

On- & Off-Cloud Inventory, Training & Qualification Solutions for Government Weapons: Who Knows What About What, What's Condition and Where Everything is for Fleet Management

BOARD 24

Kent, H.
Armor Development Group, LLC

ARDEC Terminal Performance Model - An Unclassified Damage Model for use by Industry

BOARD 25

McFarland, G.
ARDEC

Influencing Factors in Dropped and Leaking Primers

BOARD 26

Meierhofer, D.
Northrop Grumman Corporation

The Great Pacific N-W Silencer Study: How an Aerospace Manufacturer Approaches Sound Suppressor Design

BOARD 27

Morrison, R.
Aero Precision Corp

Exploring Cold Weather Performance of Traditional Asphaltic vs. External Ammunition Sealants

BOARD 28

Poirier, C.
STAC-Tactical

Art-of-the-Possible: Low-Cost COTS-Based VTOL-UAS for Stealthy Take-Downs

BOARD 29

Serino, R.
Applied Research Associates, Inc.

What Gun Gurus Need to Know About Case-Chamber Interaction

BOARD 30

Siewert, J.
Arrow Tech Associates

Predictive Modeling in Small Arms Testing

BOARD 31

Tashjian, N.
Combat Capabilities Development Command Armaments Center, U.S. Army Futures Command

Case Rupture.

BOARD 32

Woolsey, R.
Northrop Grumman Corporation

Longbow HELLFIRE Thermal Testing and Analysis

BOARD 33

Yagla, J.
Bowhead Technical Services

BIOGRAPHIES

BG ALFRED ABRAMSON III, USA

Joint Program Executive Officer Armaments & Ammunition and the Commanding General, Picatinny Arsenal

Brigadier General Alfred F. Abramson III became the Joint Program Executive Officer Armaments & Ammunition and the Commanding General, Picatinny Arsenal on December 29, 2017, leading the mission to develop and procure conventional and leapahead munitions to increase the Warfighter's combat power. Prior to this, BG Abramson served as the Deputy Program Executive Officer Ammunition and Senior Commander Picatinny Arsenal.

Brigadier General Abramson was commissioned a Second Lieutenant in the Chemical Corps after graduating from Virginia State University where he received a Bachelor of Science degree in Chemistry. Brigadier General Abramson served in a variety of positions overseas as well as the contiguous United States to include: Battalion Chemical Officer, 6-37th Field Artillery; Smoke Platoon Leader, 172nd Chemical Company; Company Commander, 266th Quartermaster Battalion; Chemical Staff Officer, Project Manager's Office for NBC Defense; Aide-De-Camp, Soldier Biological Chemical Command; Assistant Product Manager, NBC Point Detection; Program Executive Office Liaison Officer, Coalition Forces Land Component Command; Assistant Product Manager, NBC Reconnaissance Systems; Budget Team Chief, Office of the Assistant Secretary of the Army (Acquisition, Logistics and Technology); Joint Product Manager, Biological Detection Systems; Military Assistant to the Under Secretary of the Army; Joint Project Manager for NBC Contamination Avoidance; Executive Officer for the Principle Military Deputy Assistant Secretary of the Army (Acquisition Logistics, and Technology); and previously served as the Deputy, Joint Program Executive Officer for Chemical and Biological Defense.

His civilian education includes a Master's degree in Chemistry from Johns Hopkins University, a Master's degree in National Security and Strategic Studies from the Naval War College, and a Master's degree in Strategic Studies from the Army War College. His military education includes the Chemical Officer Basic and Advanced Courses, the Combined Arms and Services Staff School, Command and General Staff College, the Advanced Program Management Course, the Senior Service College and Senior Leaders Course.

COL (P) JOHN RAFFERTY, USA

Director, Long Range Precision Fires Cross Functional Team, Army Futures Command

COL John Rafferty, enlisted in the US Army in 1987 and served as an indirect fire infantryman with the 8th Infantry Division in Mainz, Germany for two years. He then attended Longwood University in Farmville, Va where he was commissioned into the regular Army as a Field Artillery officer. His first assignment was in the 18th Field Artillery Brigade at Ft Bragg, NC as a fire direction officer and platoon leader in B Battery, 5th Battalion (AASLT), 8th FA. After two years, COL Rafferty joined the 3d Battalion, 75th Ranger Regiment at Ft Benning, GA where he served as the B Company fire support officer before moving to Marine Corps Base Quantico to attend the USMC Amphibious Warfare School. COL Rafferty then moved to Baumholder, Germany with the 1st Armored Division and served as a Division AFSCOORD and DivArty S4 before assuming command of B Battery 1st Bn, 94th FA (MLRS), and then HHB 1st Armored Division Artillery. In 2002, he returned to the 75th Ranger Regiment to serve as the fire support officer for 1st Ranger Battalion and deployed several times in support of both Operation Enduring Freedom and Operation Iraqi Freedom. COL Rafferty was then selected UK Joint Services Command and Staff College in Shrivenham, England. Following the staff college, COL Rafferty was assigned to the newly formed 4th BCT (Airborne), 25th ID at Ft Richardson, Alaska where he served as the BCT fires and effects coordinator, plans officer, and S3 during operations in Iraq. He then served as the S3 for 2d Bn, 377th PFAR. In 2008, COL Rafferty was assigned to the Office of the Chief of Legislative Liasion (OCLL) in Washington, D.C. where he served as the operations and readiness liaison to the US Congress. From February 2010 until June 2012, COL Rafferty served as the commander of the 1st Bn, 319th AFAR, 3d BCT, 82nd Airborne Division as part of the Global Response Force. He then attended the US Army War College, where he completed the Advanced Strategic Art Program. COL Rafferty returned to OCLL to serve as deputy chief of the House of Representatives liaison division before deploying to Kabul, Afghanistan as the legislative advisor to the Commander, International Security Assistance Force/ US Forces-Afghanistan. COL Rafferty assumed command of the 18th Field Artillery Brigade in June 2015 and deployed with the Brigade headquarters to the CENTCOM area of responsibility to serve as both Joint Fires Cell-Syria and the CFLCC Force Field Artillery Headquarters for a multi-component HIMARS brigade distributed throughout the theater in support of Operations Inherent Resolve and Spartan Shield. After relinquishing command June 2017, he served as the Executive Officer for the Director of the Army Staff, Headquarters Department of the Army in the Pentagon.

His education includes a Bachelor of Arts degree from Longwood University, a Master of Arts degree from King's College London, and a Master of Strategic Studies from the US Army War College.

ANTHONY SEBASTO

Executive Director, Enterprise and Systems Integration Center, RDECOM-ARDEC

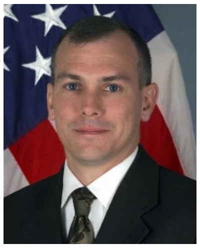
Mr. Sebasto was appointed to the rank of Senior Executive Service (SES) in June 2015 and assigned as the Executive Director of the Enterprise and Systems Integrations Center (ESIC) of the U.S. Army Combat Capabilities Development Command Armaments Center (CCDC AC) headquartered at Picatinny Arsenal, New Jersey with satellite locations at Rock Island and Watervliet Arsenals. In his role, Mr. Sebasto is responsible for leading a large research, development and engineering center responsible for establishing, guiding and measuring the progress of large, complex integrated product development teams and programs executed by CCDC AC in support of the Army, the Joint Services and OSD. He also currently serves as the Chairperson of the Army's Subterranean and Dense Urban Environment Community of Practice. ammunition, mines and countermine, non- lethal weapons and ammunition and special operations gear.

He also served as Associate Technical Director (Systems Concepts and Technology) where he was responsible for the Armament Technology Base Program executed by CCDC Armaments Center.

A career executive, he was appointed to the Senior Executive Service, the highest level of civilian government service, in November 1998.

Mr. Sebasto has over 35 years of experience in the research, development and production of small, medium, and large caliber armament systems for ground/air combat platforms, and for the individual soldier. He has led multiple large complex life-cycle engineering centers with annual budgets exceeding $500M and workforces ranging from 900-1900 civilian and military personnel all in support of life-cycle engineering (research, development, production, demilitarization) for integrated lethal and non-lethal Army and Joint Service armament systems and associated components. He has held numerous leadership assignments and credited with planning over $1B of Science and Technology (S&T) projects in support of Army Modernization.

Mr. Sebasto has served as System Manager leading technical teams for S&T or supporting Project Manager Office managed armor, aviation, and soldier armament system programs to include the Advanced Rifle Program, XM-8 Armored Gun System, 120/140mm Advanced Tank Cannon Armament System, all utility and attack helicopter armaments with primary responsibility for the AH-64 Apache and OH-58D Kiowa Warrior Armed Reconnaissance helicopter armaments.



DR. MICHAEL RICHMAN

SSTM, Technical Deputy, Missile Modernization and Development CCDC Aviation and Missile Center

Dr. Michael Richman is the Technical Deputy, Missile Modernization and Development CCDC Aviation and Missile Center. Dr. Richman's aerospace career began as a project engineer and program manager with the Naval Air Systems Command Propulsion and Power Research and Engineering Department. He also served as staff specialist for Air Platforms the Office of the Secretary of Defense, Defense Research & Engineering (DDR&E) and Special Assistant and Chief of Staff to the Director - Defense Research and Engineering. Dr Richman was responsible for the National Aerospace Initiative and served as a technical liaison between the Director and the components of the DDR&E organization, Congress, and other DoD and federal agencies. As a Commander in the United States Navy (Reserve Component) he is Commanding Officer of the 83 member Norfolk Surge Maintenance Unit. His previous assignments have included tours of duty as the Executive Officer to the Deputy Director, Missile Defense Agency (MDA), Commanding Officer of the MDA Navy Reserve Unit as well as tours with the Norfolk Naval Shipyard as a project superintendent for guided missile cruiser and 688 attack submarine overhaul and repair, special projects officer with the Naval Sea Systems Command Ship Technology Directorate, the theater nuclear warfare program management support unit, Department Head coordinating Amphibious Assault Ship waterfront operations, and as the Disruptive Technology War-game program lead for the Assistant Secretary of Defense (Research and Engineering) Joint Reserve Unit.

CDR Richman deployed, in support of Operation Enduring Freedom, to Afghanistan from December 2011 – December 2012 as the Chief of Operations for the NTM-A/CSTC-A Engineering Directorate.

Dr. Richman received his BSME from Purdue University, MSME from Florida Institute of Technology, and Ph.D. in Mechanical Engineering from Purdue University. Dr. Richman has published and lectured in the areas of, computational fluid dynamics, unsteady aero-mechanics and aero-elastics, multi-variable control system design, gas-turbine and rocket propulsion, high cycle fatigue, hypersonics, long-range strike, rotorcraft, and structures.

ASHLEY JOHNSON

Technical Director, Naval Surface Warfare Center Indian Head Explosive Ordnance Disposal Technology Division

Ashley Johnson is the technical director of the Naval Surface Warfare Center Indian Head Explosive Ordnance Disposal Technology Division (NSWC IHEODTD). Mr. Johnson directs a multi-site workforce of approximately 1,900 employees with annual operations of more than $1 billion.

NSWC IHEODTD is charged with leading the Department of Navy in providing energetics, ordnance and EOD technical capabilities for all DoD interests through research, development, testing, evaluation, engineering, manufacturing and in-service support. During his tenure as technical director, Mr. Johnson has led the development of several major initiatives: a comprehensive strategic plan to revitalize and reinvigorate the facility and workload; a business case analysis to ensure optimal capabilities are maintained and developed; and the implementation of Center for Industrial Technical Excellence partnerships.

Mr. Johnson also serves under the Chief Engineer of the Navy as the Deputy Warrant Officer for Explosive Ordnance Engineering (SEA-O5E).

Mr. Johnson began his career at the former NSWC Indian Head Division in 1987 and spent the next 12 years managing the command's manufacturing operations for missile, torpedo and projectile warhead production. From 1999 – 2001, he managed and directed facilities and personnel within the command's Surface Weapons and Ammunition Program. Mr. Johnson served as the Navy's official spokesperson for the scale-up and production of nitramine gun propellants during the Gulf War.

From 2006 – 2014, Mr. Johnson served as the acting department head and director for the Office of Naval Research's Hybrid Complex Warfare Science Division where he managed and directed the integration of a science and technology (S&T) program consisting of basic and applied research, advanced technology development and other efforts. He also served as the applications director in the Expeditionary Maneuver Warfare and Combating Terrorism S&T Department where he oversaw both the Future Naval Capability and Exploration and Development programs.

Mr. Johnson's other assignments included a tour as the S&T advisor at U.S. Marine Corps Forces Pacific where he served with the U.S. Marine Corps Forces Central Command to include a deployment with the 15th Marine Expeditionary Unit.

Mr. Johnson completed his undergraduate studies in 1987 and has a Bachelor of Science in mechanical engineering from the University of Rochester in Rochester, N.Y. He graduated from the Industrial College of the Armed Forces in 2008 as the Commandant's Distinguished Graduate and has a Master of Science in national resource strategy. He has completed the Defense Acquisition University Senior Acquisition Course, Navy Strategic Thinking Course and the Massachusetts Institute of Technology Seminar XXI.

DR. DAVID LAMBERT

Chief Scientist, Munitions Directorate, Air Force Research Laboratory

Dr. David E. Lambert, a member of the scientific and professional cadre of senior executives, is the Chief Scientist, Munitions Directorate, Air Force Research Laboratory, Eglin Air Force Base, Florida. He serves as the principal scientific and technical adviser to the director and is the primary authority for the technical content of the directorate's science and technology portfolio. The Munitions Directorate leads the discovery, development and integration of affordable warfighting conventional air-launched weapon technologies for the U.S. Air Force. The directorate consists of a staff of more than 500 military, civilian and contracted professionals pursuing a wide variety of research and development efforts in energetic and explosives, fuzes, warheads, missile seekers, guidance, navigation and control, weapon airframes, assessment methodology, and the integration of these into weapon systems.

Dr. Lambert joined the Munitions Directorate in 1987 as a mechanical engineer in the Bombs and Warheads Branch. He has fulfilled a variety of technical positions, ranging from bench level scientist, team leader, technical advisor and core technical competency leader while in AFRL/RW and its predecessor organizations (Air Force Armament Laboratory and then Wright Laboratories). Dr. Lambert is an esteemed Fellow of AFRL (inducted 2011) for his innovative research and strong technical leadership in ordnance and weapons related sciences. He is recognized for his visionary research in detonation physics and explosive-metal systems leading to advanced warhead concepts. His research and wide-spread collaborations in detonation shock dynamics, non-ideal explosives and high rate material response studies has spearheaded the foundations of tomorrow's scalable and selectable effects munitions.

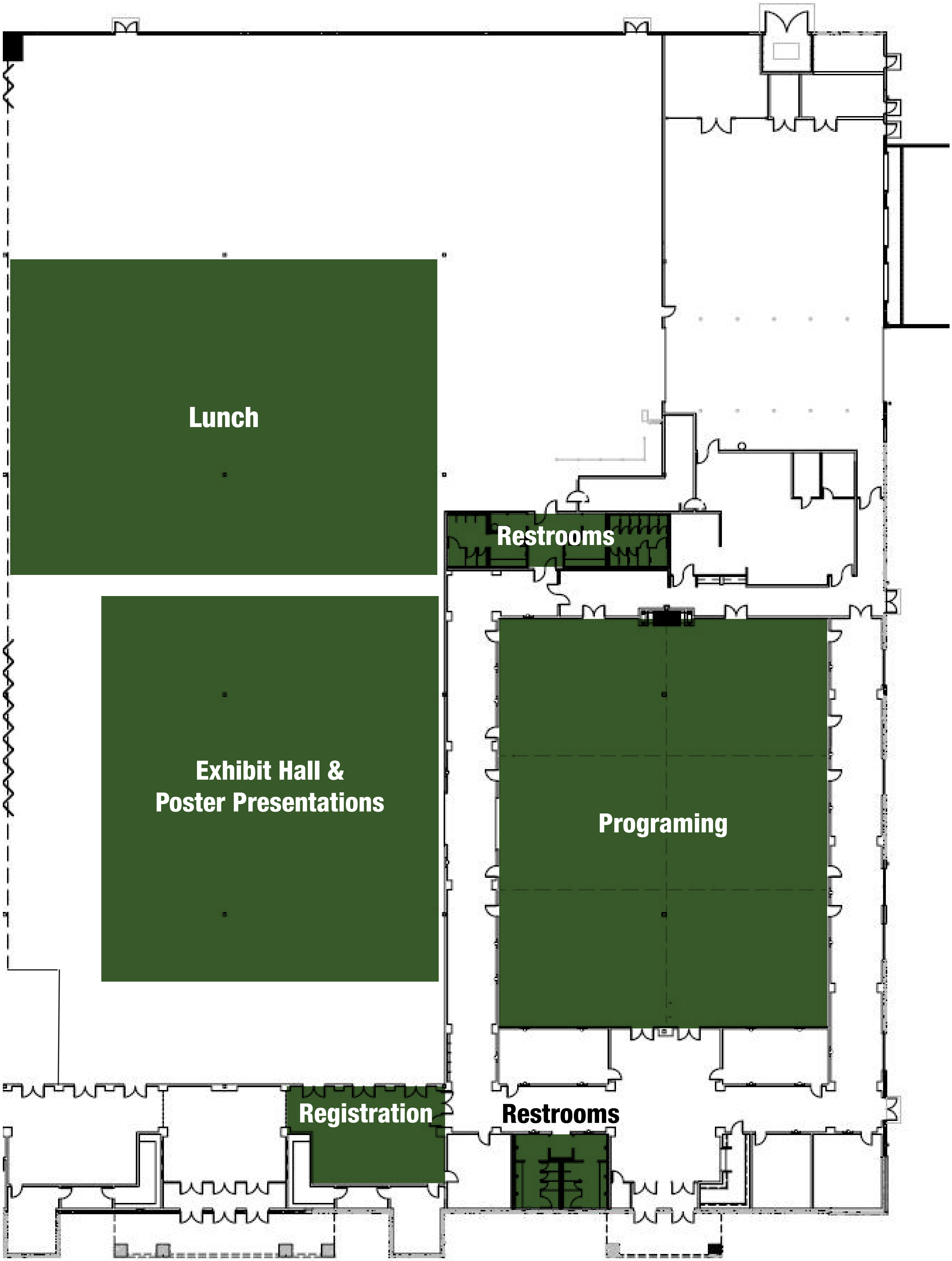
Dr. Lambert has published over 110 technical papers and proceedings in national and international journals and forums. He has an extensive experimental background in areas of fundamental characterization and advancement of detonation physics, focused energy warheads, penetration mechanics and ordnance integration.

MG ROBERT SCALES, USA (RET)

Former Commandant, U.S. Army War College

Retired General (Dr.) Robert Scales is one of America's best known and most respected authorities on land warfare. He is currently President of Colgen, Inc, a consulting firm specializing in issues relating to landpower, wargaming and strategic leadership. Prior to joining the private sector Dr. Scales served over thirty years in the Army, retiring as a Major General. He commanded two units in Vietnam, winning the Silver Star for action during the battles around Dong Ap Bia (Hamburger Hill) during the summer of 1969. Subsequently, he served in command and staff positions in the United States, Germany, and Korea and ended his military career as Commandant of the United States Army War College. In 1995, he created the Army After Next program which was the Army's first attempt to build a strategic game and operational concept for future land warfare. He has written and lectured on warfare to academic, government, military, and business groups in the United States, Australia, Asia, the Middle East, Europe, and South America. He is the author of two books on military history: Certain Victory, the official account of the Army in the Gulf War and Firepower in Limited War, a history of the evolution of firepower doctrine since the end of the Korean War. In addition, he is an authority on contemporary and future warfare. Concepts and ideas contained in his writings and studies have significantly influenced the course of contemporary modernization and reform within the military. He has written two books on the theory of warfare: Future Warfare, a strategic anthology on America's wars to come and Yellow Smoke: the Future of Land Warfare for America's Military. He was the only serving officer to have written books subsequently selected for inclusion in the official reading lists of three services; Certain Victory for the Army, Firepower for the Marine Corps and Yellow Smoke for the Navy. Congressman Ike Skelton has included Yellow Smoke in his National Security Book List sponsored by National Defense University. His latest work, The Iraq War: a Military History, written with Williamson Murray has been reviewed very favorably by the New York Times, Atlantic and Foreign Affairs. He is a frequent consultant with the senior leadership of every service in the Department of Defense as well as Congress and many allied militaries. He is senior military analyst for The BBC, National Public Radio and Fox News Network. He has appeared as a commentator on The History Channel., The Discovery Channel, PBS, TLC, Channel 4 (France), NTK (Japan) and Star Television (China). His commentary is carried frequently on all major television outlets in the Peoples Republic of China. He has written for and been frequently quoted in The New York Post, The Wall Street Journal, The Washington Times, Time Magazine, Newsweek, Roll Call and virtually every service defense periodical and media network on issues relating to military history, future warfare and defense policy. He is a graduate of West Point and earned his PhD in history from Duke University.

VENUE MAP



Lunch
Restrooms
Exhibit Hall &
Poster Presentations
Programing
Registration
Restrooms

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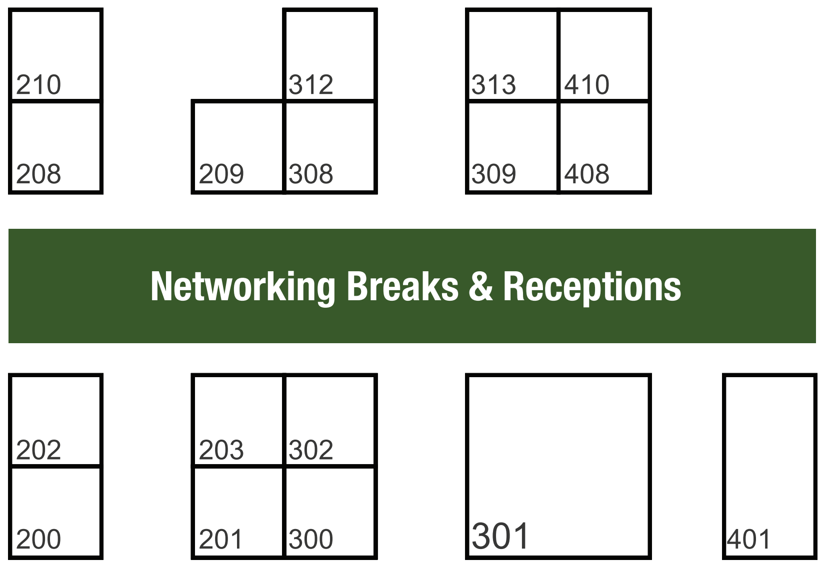
EXHIBIT HALL HOURS

TUESDAY, JUNE 4
9:30 am – 6:30 pm

WEDNESDAY, JUNE 5
9:30 am – 6:00 pm

EXHIBIT HALL MAP



EXHIBITOR DESCRIPTIONS

AIMPOINT, INC. 208

For over 40 years, Aimpoint has been the world leader in design and manufacture of electronic red-dot sighting systems. Soldier tested and combat proven – don't settle for anything less.

ARROW TECH ASSOCIATES 202

Arrow Tech Associates is a small Non traditional contractor located in South Burlington, VT specializing in ammunition design including exterior, interior ballistics, trajectory simulation and reconstruction, test data analysis, structural analysis and design (interior balloting, case chamber interaction, sabot design), Guidance, Navigation and Control, Hardware in the Loop (HIL) Development, Truth Modeling (Firing Tables and Fire Control) along with Technical and Program Management.

BARRETT 209

Headquartered in Tennessee, Barrett is the world leader in large-caliber rifle design and manufacturing. Our products are used by law enforcement agencies, the United States military and more than 73 State Department approved countries in the world. It's one thing to manufacture guns, and another to live and breathe them. Whether we're carefully assembling our latest rifle or increasing the velocity and precision of the ammunition itself - we're always working for absolute perfection.

CBC 408

World leader in ammunition for portable weapons and one of the main suppliers to NATO, CBC is the premier Defense brand in the small caliber segment. CBC products are used globally and contribute to the protection and security of millions of people.

DEFENSE SYSTEMS INFORMATION ANALYSIS CENTER (DSAIC) 200

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.

GENERAL DYNAMICS – OTS 301

General Dynamics Ordnance and Tactical Systems manufactures large-, medium- and small-caliber direct and indirect-fire munitions; and is a leader in the development and production of lightweight tactical vehicles, weapons and armament systems. The company also produces propellants and non-lethal and force-protection products. More information about General Dynamics Ordnance and Tactical Systems is available online at www.gd-ots.com.

HECKLER & KOCH DEFENSE 312

HECKLER & KOCH is the world's premier small arms systems company and a major supplier to the commercial market, global military and federal law enforcement agencies. An innovative leader in design and manufacturing, HECKLER & KOCH provides technologically advanced firearms, logistical support, training and specialized services with the highest standards of innovation and reliability.

HIPERFIRE 203

HIGH PERFORMANCE FIREARMS, LLC dba HIPERFIRE is a firearms technology company, bringing proprietary innovation mainstream. Our solutions are novel, unexpected. Others see problems, we see opportunity. Our products transform the shooter and shooting experience in new ways making elevated skill and excellence more accessible to Everyman, civilian and warfighter. HIPERFIRE is veteran operated. Our products are made in the USA by Americans.

KISTLER INSTRUMENT CORP. 302

Kistler will exhibit its full line of piezoelectric sensors including dynamic ballistic pressure sensors for various ballistics applications, along with high g accelerometers for recoil, high vibration and shock applications. This year, we will showcase the 6239A used in a tangential mounting configuration directly touching the plastic cartridge. This setup eliminates the need for drilling each shot shell prior to the ballistic pressure measurement.

KNIGHT'S ARMAMENT COMPANY 313

Knight's Armament Company is the premier U.S. developer and manufacturer of Small Arms, Signature Reduction Devices, Night Vision Equipment and Accessories for military and law enforcement globally.

LMT DEFENSE 210

Est. in 1980, Lewis Machine & Tool Company 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.

NATIONAL ARMAMENTS CONSORTIUM (NAC) 300

The National Armaments Consortium (NAC) serves as the industry partner for the Department of Defense Ordnance Technology Consortium's (DOTC) and the Aviation and Missile Technology Consortium (AMTC). 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.

RUGER FIREARMS 201

Ruger has a long history of serving the Law Enforcement and Military communities with both handguns and rifles. That tradition continues with a number of firearms designed to meet the continually changing needs of both Law Enforcement and Military professionals. From the Mini-14®, AR-556 SBR and the PC Carbine™ to the Ruger American Pistol® and LCP® II, Ruger has a firearm for individual officer back up and off-duty use, departmental issue or Military use.

SECUBIT 309

Secubit's solution combines three integrated technological components: The revolutionary WeaponLogic Smart Counter, a powerful handheld Reader and a centralized Dashboard and analytics system. Together, they provide a comprehensive new analytical approach for effective weapon management and maintenance. Monitor Weapon AND Operator. Waterproof. Battery life of 10 years. Future integration with NETT Warrior, Real -Time Track weapon performance Rugged MIL-STD-810G compliant mobile reader

SMALL ARMS DEFENSE JOURNAL 410

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.

TEXTRON SYTEMS 308

Textron Systems' innovative approach to lightweight weapons and ammunition significantly reduces the warfighter's burden, while maintaining the same trusted performance of current systems. Visit us at booth #308 to learn more!

TRIJICON 401

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 Marine Corps, United States Army, United States Special Operations Forces, United States Government, and state and local Law Enforcement.

ARROW TECH

If you can't get a bigger target...

Cartridge Cases & Case – Chamber Interactions

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Cartridge Case Analysis

- **Cartridge Cases are:**
  - "Single" use, hi pressure, disposable seal
  - Container for powder & primer
  - Typically stressed above yield for most applications

- Unlike most mechanical structures, stress > yield and "single" use mean that combined stress is not a desirable design criterion, cases would be too heavy

- Percent of ultimate strain is better choice, allows case to be appropriately designed & specified

- What interface parameters concern gun designers?

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Typical Brass Case Development "Philosophy"

- **Engineering "experience" drawn from similar applications/pressures, brass is assumed to yield in operation..**
- **Use "other" cases as baseline, mod geometry**
- **Lots of "cold work" done to base to increase hardness (yield strength)**
- **Abrupt slope changes & sharp corners are avoided**
- **Gradual wall thickness taper from base to neck**

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Cartridge Case Design: Problem Description

1. **Can case structurally survive in selected weapon?**
   - Is case % ultimate strain < 100% under all conditions?
     - Peak Pressure
     - Friction
     - Material
     - Gaps
     - Lock Stiffness
     - Thermal Event
2. **Is case compatible with varying weapon mechanisms?**
   - **A. Case base-bolt face load at unlock**
     - Does weapon mechanism have enough energy to unlock? (influences wpn design)
     - How much bolt movement must happen to remove residual load?
   - **B. Residual case-chamber load at start of extract**
     - Does weapon mechanism have enough energy to extract? (influences wpn design)
     - Case body taper influences distance required to remove residual load
3. **Can we minimize case mass?** (max stowed load & mfg profit, min mat'l cost)
4. **Maximize case internal volume** (max powder, MV & MV margin)

Why is Case-Chamber Analysis so Complex?

- **Multiple computational non-linearities**
  - Case material pushed above yield (typically)
  - Gaps between case & chamber/bolt face: no load until contact is made
  - Case temperature changes rapidly
  - Case-chamber friction varies w/ what's on case exterior
  - Structural forcing function varies (statistically)
  - Case can only expand until shot start is reached, then it accelerates to rear
- **Desired Output:**
  - Case survival (is percent Ultimate Strain < 100%?)
  - Peak bolt load
  - Residual load between case base & bolt face resisting unlock
  - Residual load between case & chamber wall resisting extract

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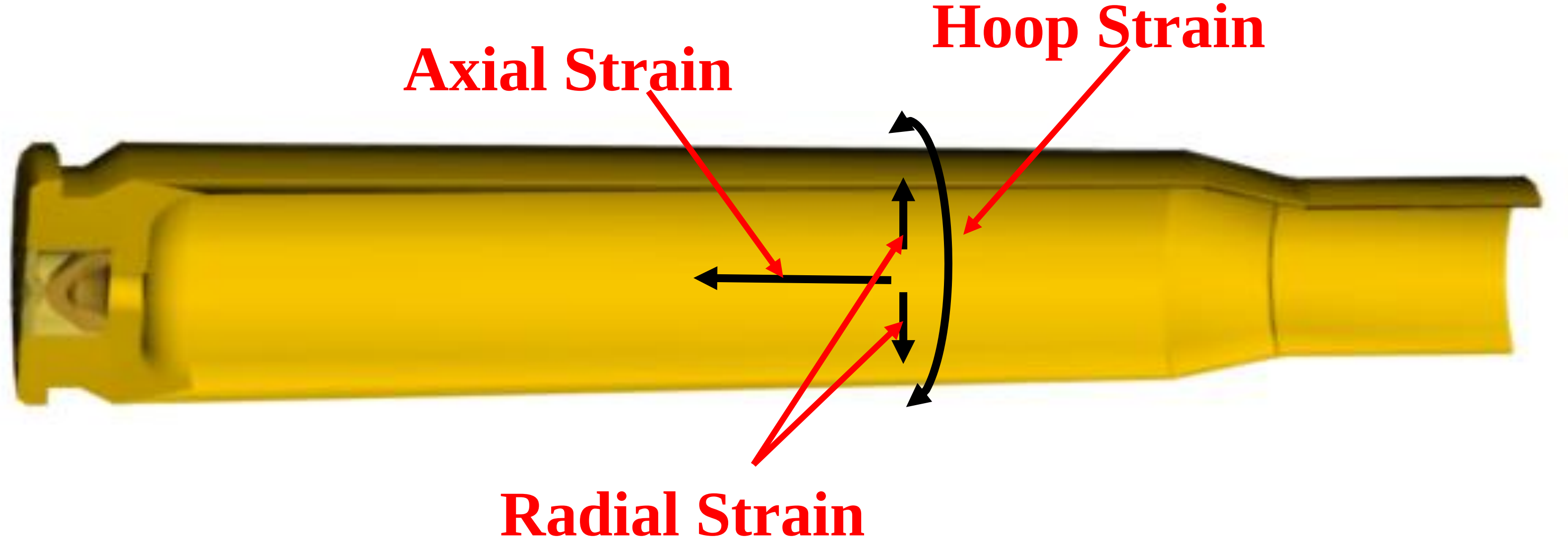
Case Strain Components



- **Total strain is Vector Sum of Axial, Hoop & Radial**
- **Is total strain seen during firing < 100% of Ultimate?**
- **Where is total strain a maximum?**
- **Generally: things that are good for case are bad for gun & vice versa..**

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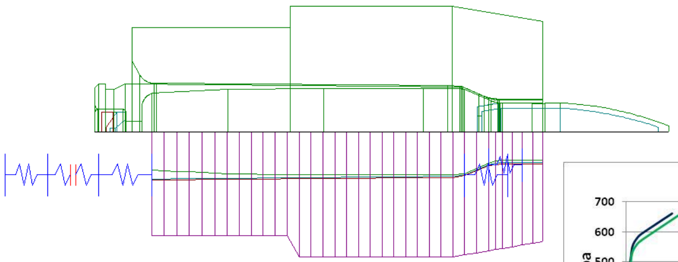
Case-Chamber Analysis History

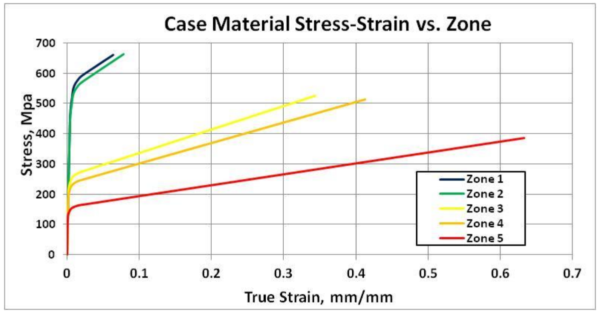
Year	Caliber	Gun	Case Material
1984	30x173mm	GAU-8/A	Lt. Wt. Steel & Aluminum
1985-86	25x137mm	GAU-12/U	Aluminum
1986	20x102mm	M61A1	Aluminum
2001	20x102mm	M61A1	Aluminum
2001	5.56x45mm	M16/M249	Brass/Polymer
2001	40x217mm	Mk44	Steel
2001	155x1059mm	AGS	Steel
2003	5.56x45mm	M16/M249	Aluminum
2005	105x617mm	M68	Steel
2006	25x59mm	XM302	Aluminum
2007	40x51mm	Mk19	Aluminum
2007	5.56x45mm	M16/M249	Steel/Polymer
2008	12.7x99mm	XM806	Brass
2009	40x180mm	ALACV	Steel
2011	5.56x45mm	M16/M249	Brass
2015	300 Win Mag	M2010	Brass
2015	105x615mm	M68	Brass
2017	8.5x63mm	338 MMG	Brass
2019	5.56x45mm	M16/M249	Steel

What Info is Required?

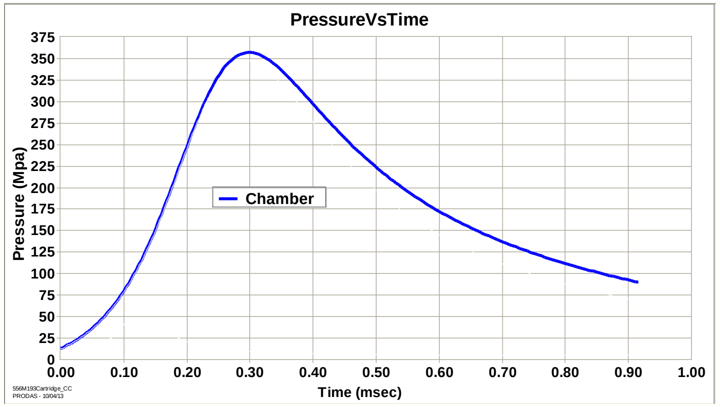
- **Geometry:**
  - Min Case & Max Chamber



- **Material Properties:**
  - Case: Stress-Strain vs Location (& Temp), Density, CTE, Diffusivity, Poisson's Ratio
  - Chamber: Density, Modulus, Diffusivity



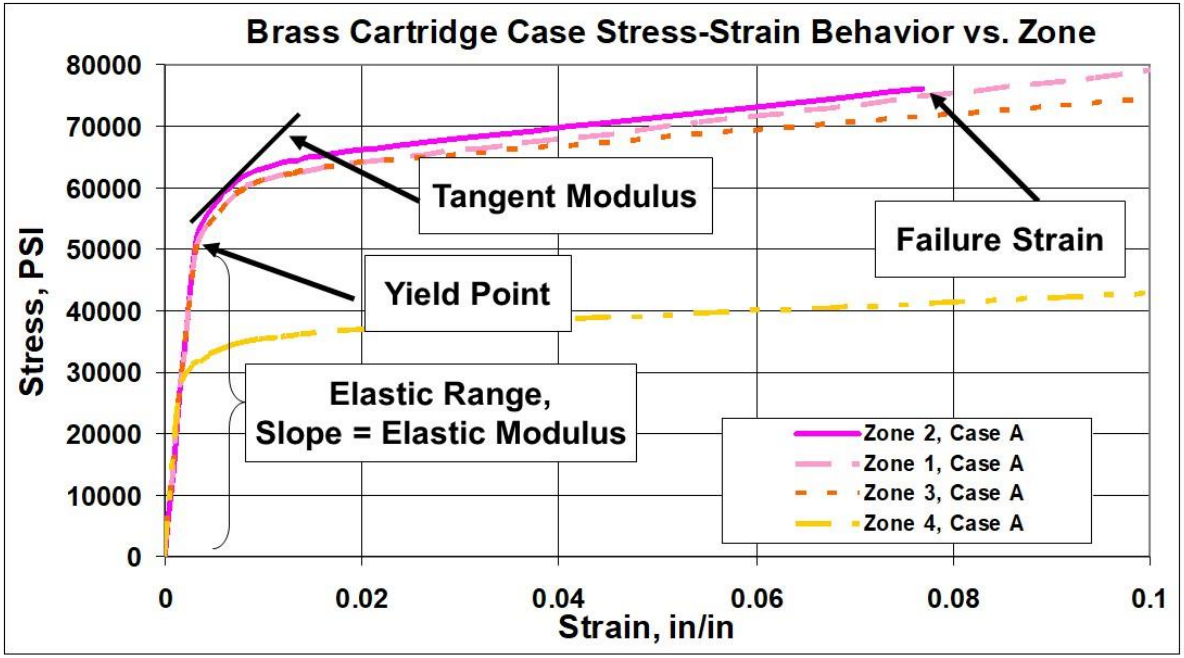
- **Structural Forcing Function:**
  - Pressure vs. Time, Case Temp vs. Time



- **Interface Parameters:**
  - Static & Dynamic Coeff. of Friction, Lock Stiffness, Case Base – Bolt Face Gaps, case base mass, case base stiffness

Info required for any case-chamber interaction analysis

Generalized Material Properties



- **Plot of "True" Stress-Strain**
- **Below yield stress, material is elastic (stress linear w/ strain)**
- **Above yield is "plastic regime"; non-linear material behavior**

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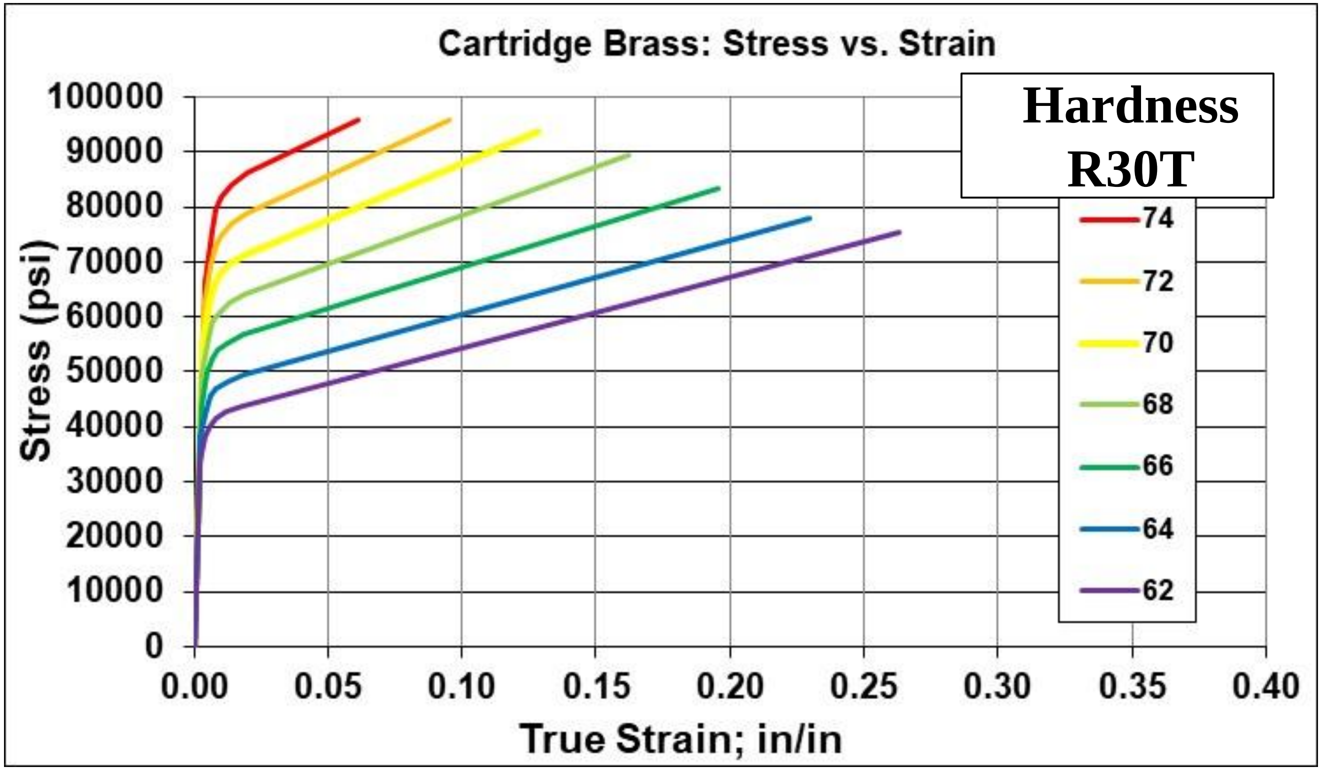
Brass Properties vs. Hardness



- **Hardness (processing) affects yield, failure stress & elongation at failure**
- **Hardness gradient along length of case combined with case wall thickness gradient provides appropriate behavior**

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Phases of Case Function Cycle

1. Initial Conditions
2. Propellant Ignition
3. Pressure Load Increase
4. Elastic Recovery
5. Residual Clearance or Interference
6. Weapon Unlock
7. Case Extraction/Eject

Function – Phase I: Initial Conditions

- **Case and Chamber As-manufactured Dimensions**
- **Case and Chamber Initial Temperatures**
- **Case "Head Space" Approach**
  - **Shoulder**
  - **Rim or Belt**
  - **Case Mouth**

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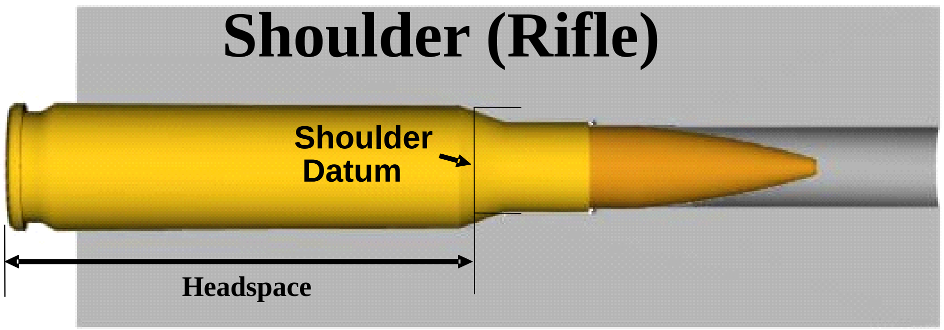
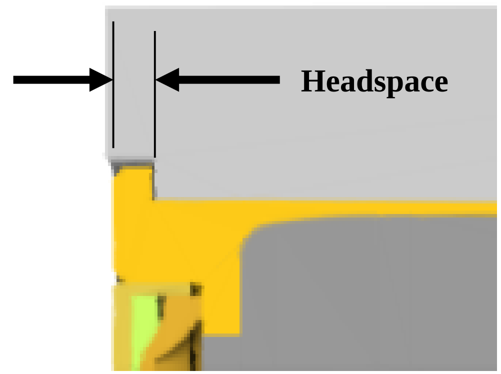
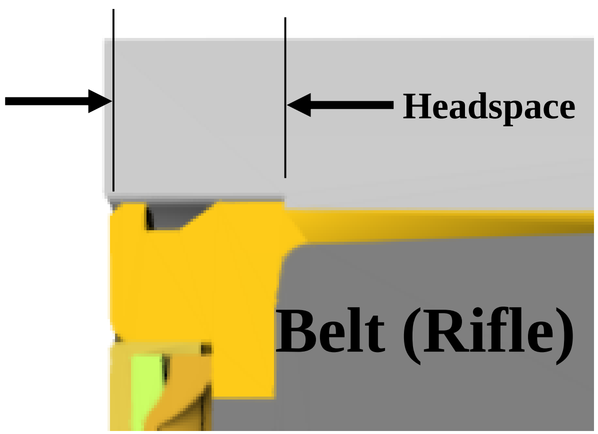
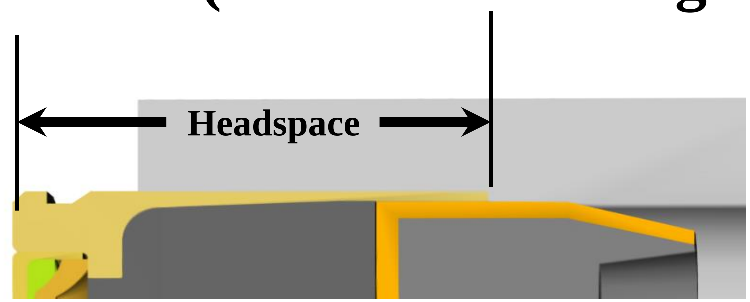
Headspace Details





Rim (Revolver & Shotgun)





Case Mouth (Pistol)

- **Headspace selection based on gun mechanism**
- **Does spring drive case forward in chamber?**

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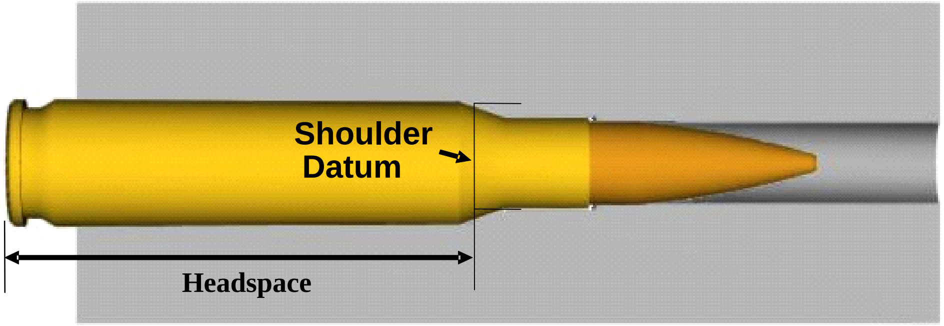
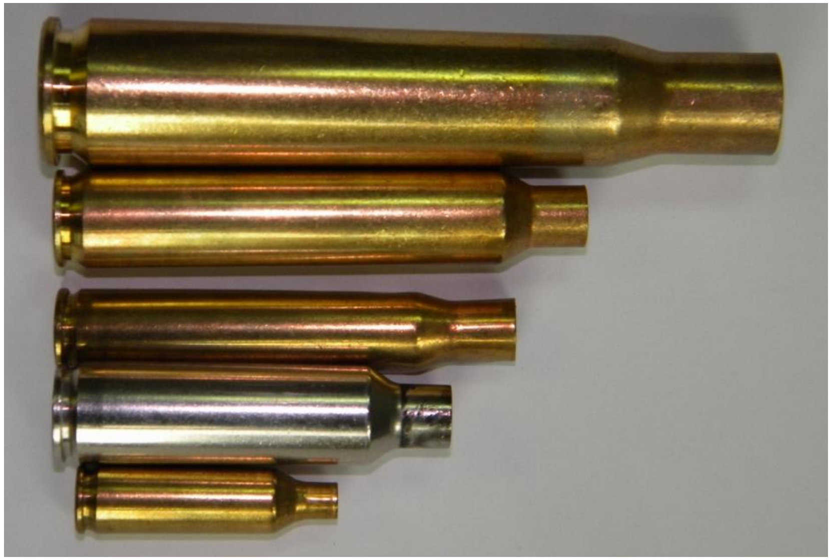
Shoulder Headspace





50 Cal

300 RUM

30.06

300 WSM

17 Mach IV

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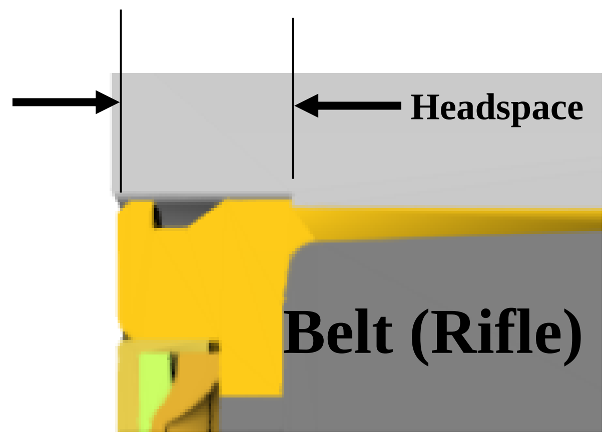
Belt Headspace

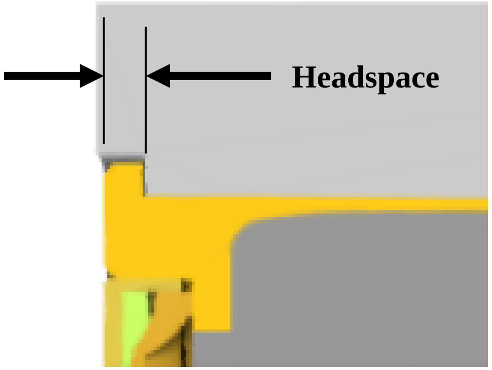
Originally Developed for use in Revolver Cannon



Flange or Rim Headspace

357 Magnum

22 Hornet



Rim (Revolver & Shotgun

Case Mouth Headspace

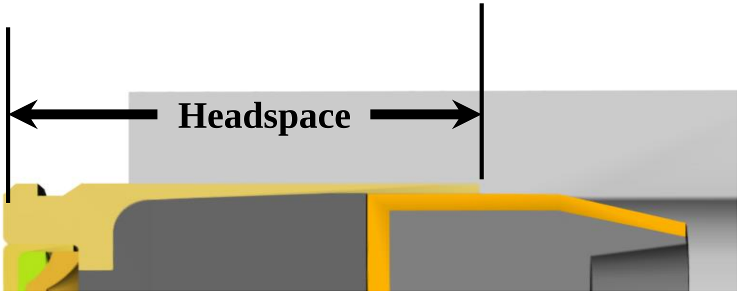
25 ACP

9x19mm

40 S&W

45 ACP

45 ACP



Case Mouth (Pistol)

If you can't get a bigger target...

Function – Phase II: Powder Ignition / Shot Start

- **Case radial expansion to contact chamber**
  - **Speed of action precludes significant temperature rise in case**
  - **Case expansion continues in all directions until shot start is reached**
- **Once bullet moves from case, case accelerates aft, closes aft gap & contacts bolt face**
- **Elastic and/or plastic deformation of the case**
  - **Depends upon case/chamber radial clearance**

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Function – Phase III: Pressure Load Increase

- **After case contact w/ chamber wall, case and chamber deflect radially with stiffness varying due to case plastic behavior**
- **Temperature of the case inside wall surface and internal chamber pressure peak at nearly the same time**
- **The average case temperature is relatively low**
  - **Large thermal gradient through the case wall during this phase**
- **Case avg. temp increase begins to contribute to reducing the load carried by the case**
- **Chamber reaches its maximum radial deflection**

Forcing Functions

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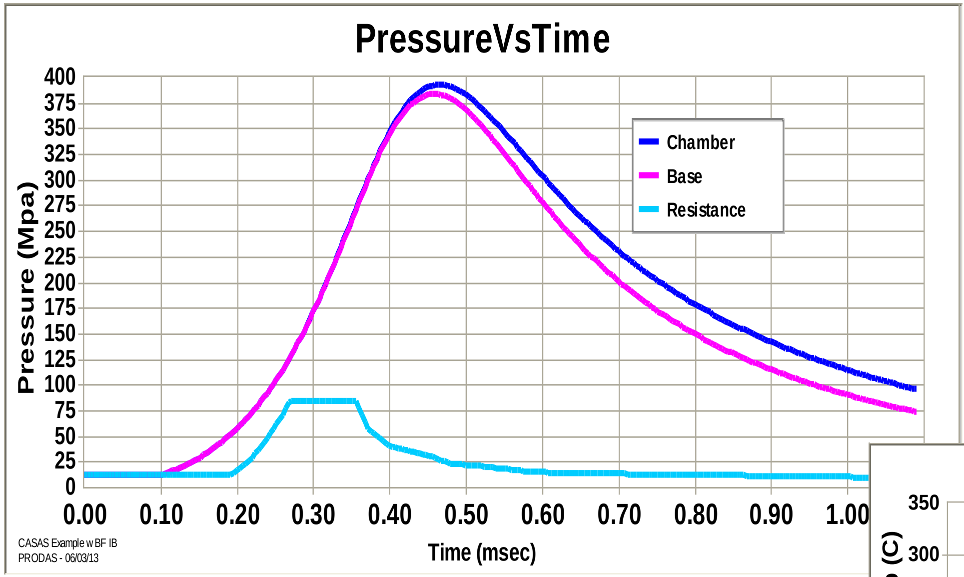
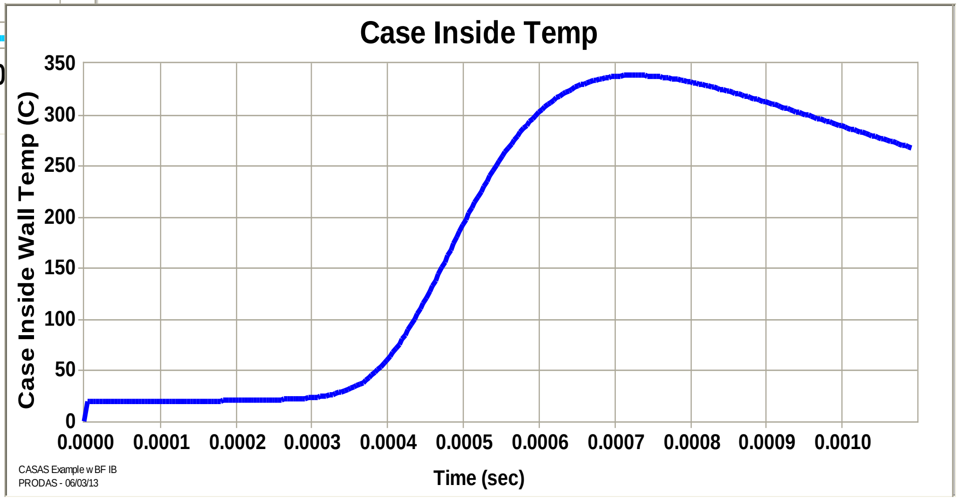
Pressure vs. Time



Inside Case Wall Temp vs. Time



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Function – Phase IV: Elastic Recovery

- **As the case internal pressure decreases, the case and chamber move as a combined unit with each carrying a share of the applied gas pressure (thru case-chamber friction)**
  - **The case-chamber load ratio is determined by the relative loads carried at maximum radial displacement in the previous stage and the thermal expansion of the case**

- **Recovery for both the case and the chamber is elastic**

- **The addition of thermal strain at maximum load produces variable total strain through the case thickness**

- **The case mean temp. continues to increase during the early part of this phase**

If you can't get a bigger target...

Function – Phase V: Residual Clearance/Interference

- The gas pressure is removed completely and the breech is ready to be unlocked
- If the case leaves contact with the chamber, a residual case-chamber clearance will exist
- If the case does not leave contact with the chamber, a residual radial force will be developed between the case and chamber impeding case extraction after the bolt is unlocked
- Any residual load between case base & bolt face will impede unlock (gun mechanism dependent)

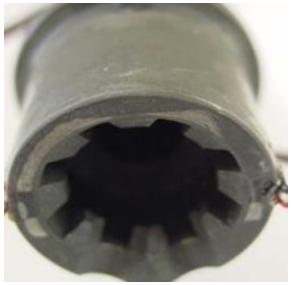
ARROW TECH

If you can't get a bigger target...

Function - Phase VI, Unlock

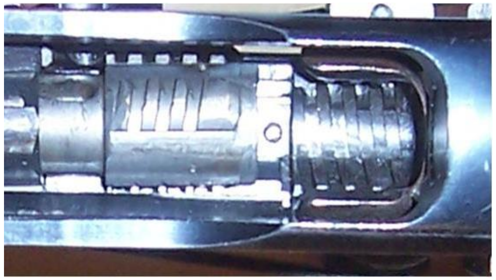
- **Residual load between case base & bolt face may impede unlock of bolt.**
- **Gun mechanism/operator requires sufficient energy to unlock bolt to allow extraction to begin.**
- **Gun mechanism influences bolt motion/energy required to unlock bolt**
- **Bolt lock design influences motion/energy required to unlock**

Bolt



Short Throw Bolt

Drop Block (Tapered?)



Interrupted Helical Lug

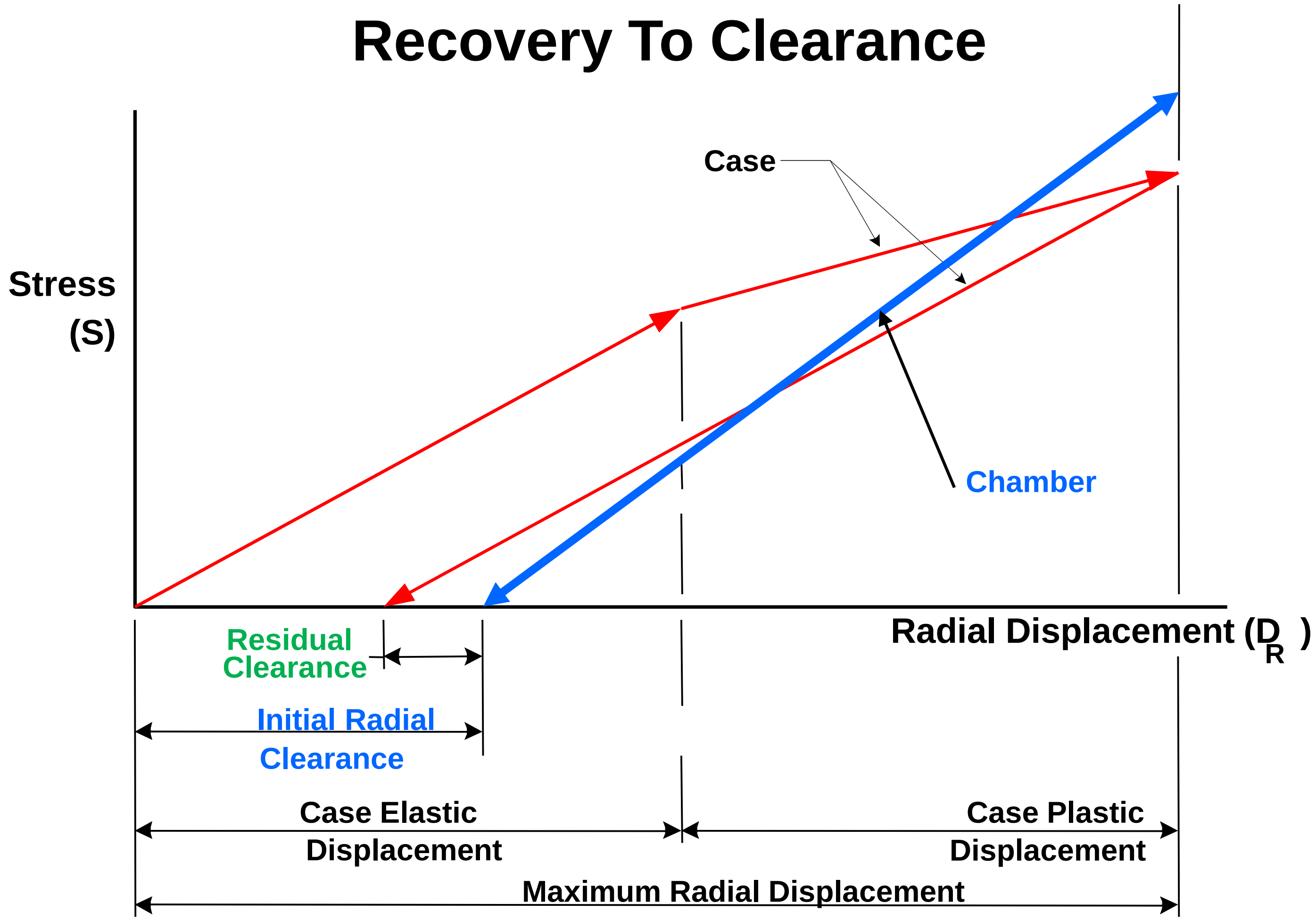
Function – Phase VI: Case Extraction

- **Where the case recovers to an interference condition, the residual load results in a friction load upon extraction**

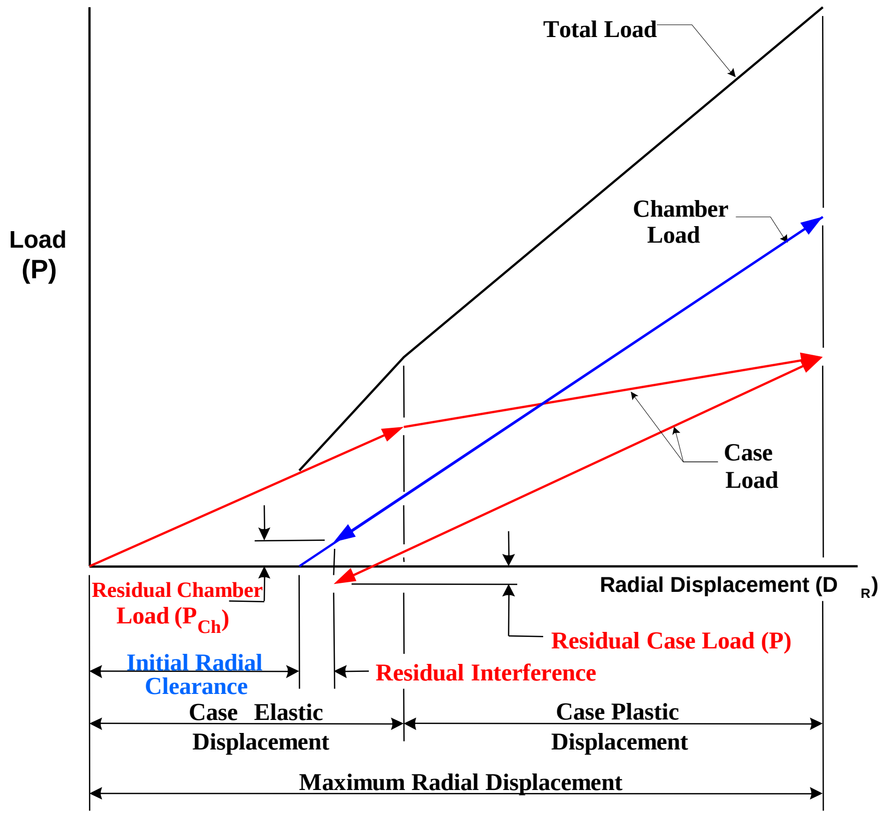
- **The average case temperature variation with time has a considerable influence on the final residual clearance between the case and chamber**

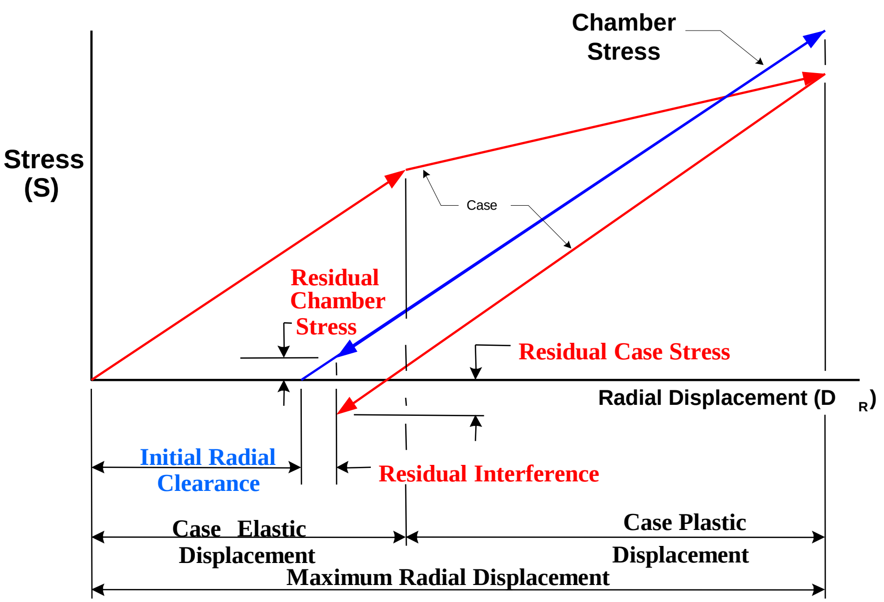
- **Extensive analyses show that case temp at maximum radial displacement (where maximum plastic strain occurs), as well as the final case temperature at time of extraction, is of primary importance to the residual clearance. The temp versus time profile between these points is of lesser importance.**

Case Recovery to Clearance



Case Recovery to Interference





- **Case & Chamber load depends on internal pressure, case-chamber friction**
- **Residual interference dependent on case material properties & initial gaps**

Case-Chamber Interface Factors

- **Initial case / chamber radial gap (Headspace details)**
- **Case material properties (including variation with temperature and load rate)**
- **Case thermal characteristics (specific heat, density, conductivity, and/or diffusivity)**
- **Case and chamber wall thickness**
- **Chamber design stress level**
- **Chamber thermal / mechanical properties**
- **Ambient temperature of case and chamber**
- **Thermal forcing function (especially, the change in temperature at peak radial strain and at unlock & extraction)**
- **Gun axial response (gaps, breech stiffness, unlock loads, etc.)**
- **"Other" Factors (e.g. fluted chambers)**

Case Materials

- Brass (70% copper – 30% Zinc)
- Steel (typically low carbon)
- Aluminum (5000 or 7000 series alloy)
- (Partially) Plastic (various)

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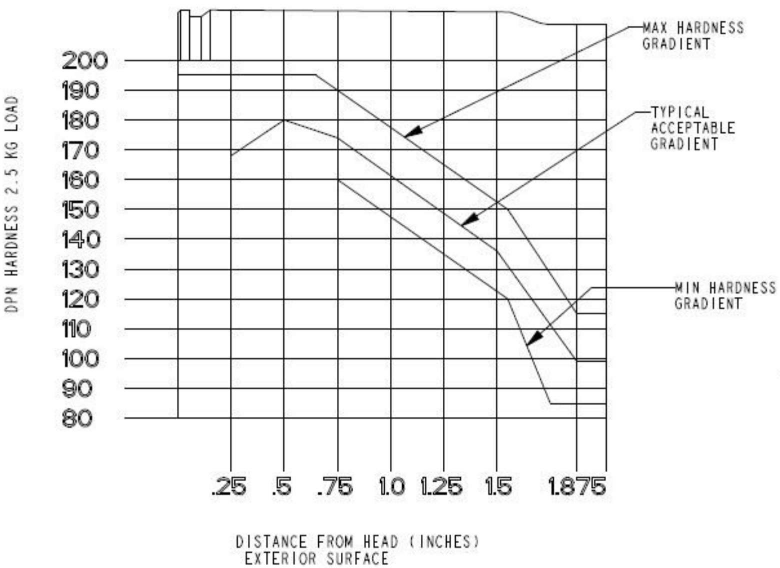
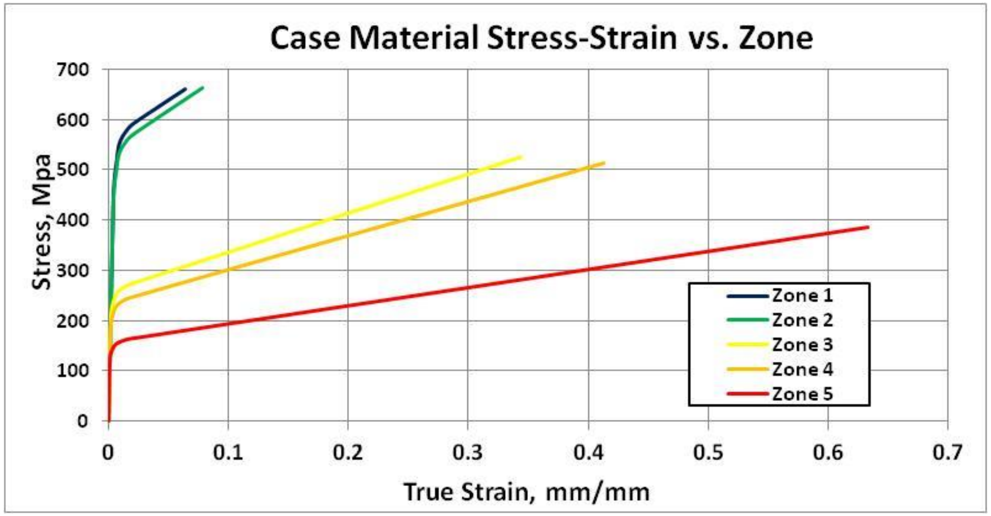
Case Material Properties





- **Hardness profile changes with distance from case base**
- **Hardness must be “translated” to non-linear material properties**
- **Non-Linear properties are a function of case temperature**

If you can't get a bigger target...

Case Material Samples

"Dog-Bone" Samples from Different Case Zones

Micro Hardness Sample from Case Sidewall

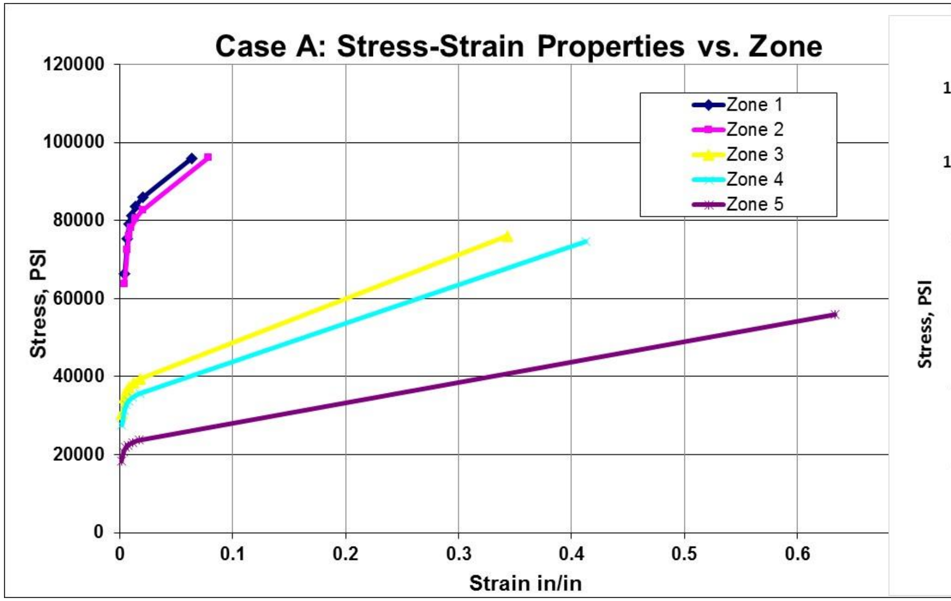
- **"Dog bone" test samples provide stress-strain data**
- **Hardness testing measures hardness along case**
- **Allows correlation between hardness & stress-strain**

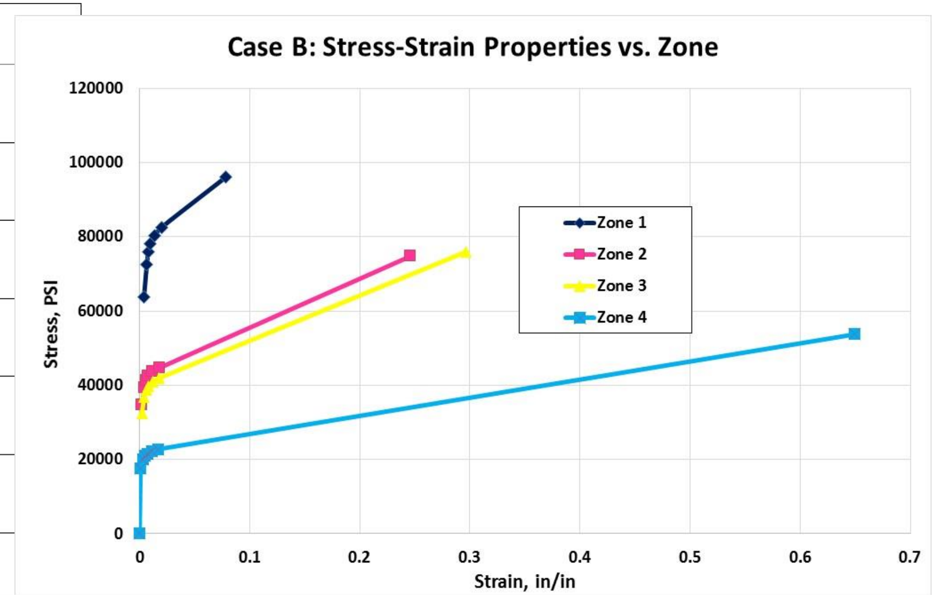
Material Properties Measurement

- **Cut "dog-bone" samples from case in various places**
- **Machine to appropriate geometry**
- **Tensile Test to Failure measuring stress-strain behavior**
- **Requires use of "extensometer" for good data**

Case Material Stress-Strain Behavior

If you can't get a bigger target...





- **Same case, different mfg.**
- **Different unlock/extract performance..**
- **Not a SAAMI / CIP controlled parameter**

ARROW TECH

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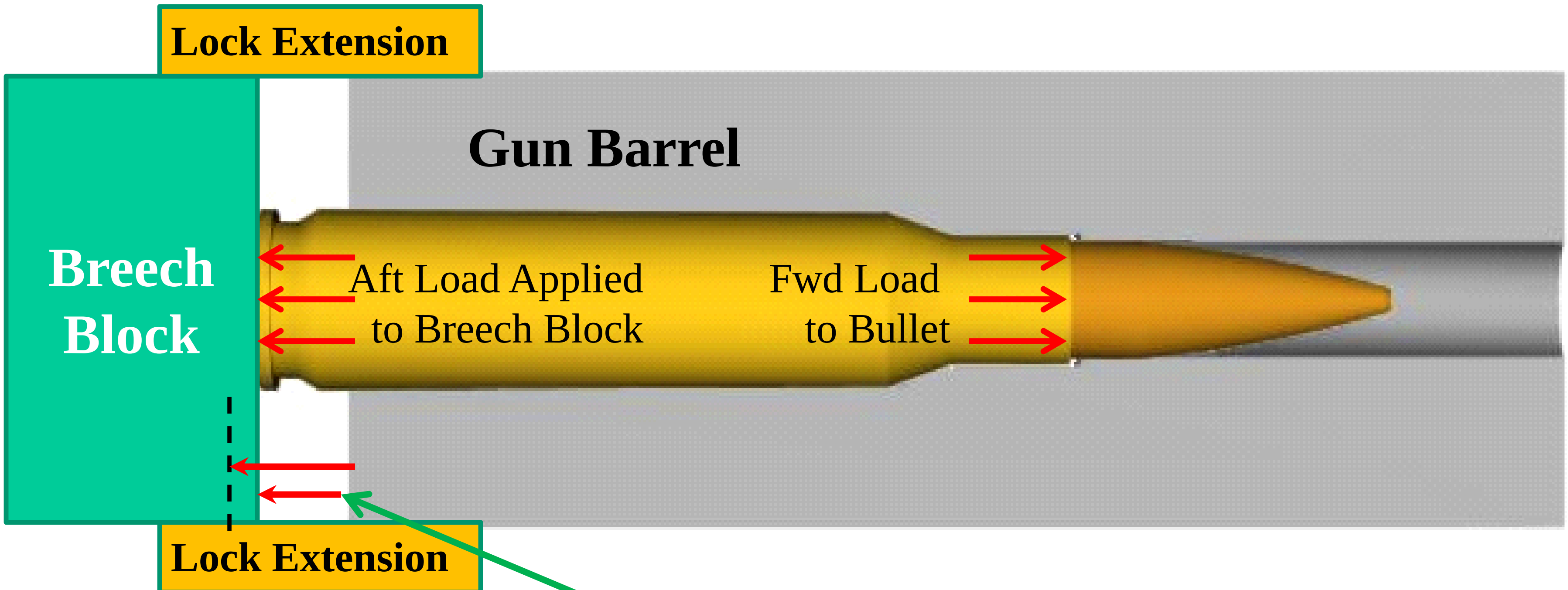
Lock Stiffness Definition

<u>Lock Stiffness:</u>

How Far will breech move relative to barrel face in response to load applied to breech face and reacted at base of bullet? Load/deflection = lock stiffness.



What is elastic movement at peak load?

- **Also Not a parameter controlled by SAAMI / CIP**

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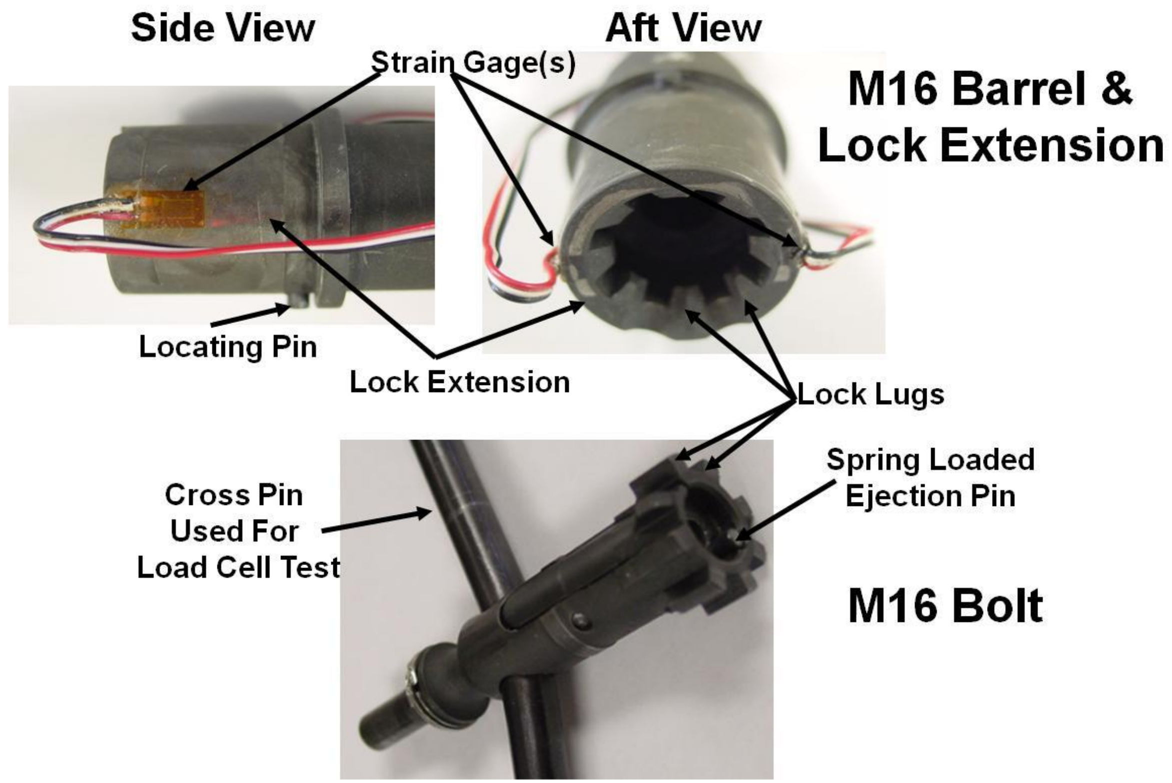
Lock Stiffness Measurement

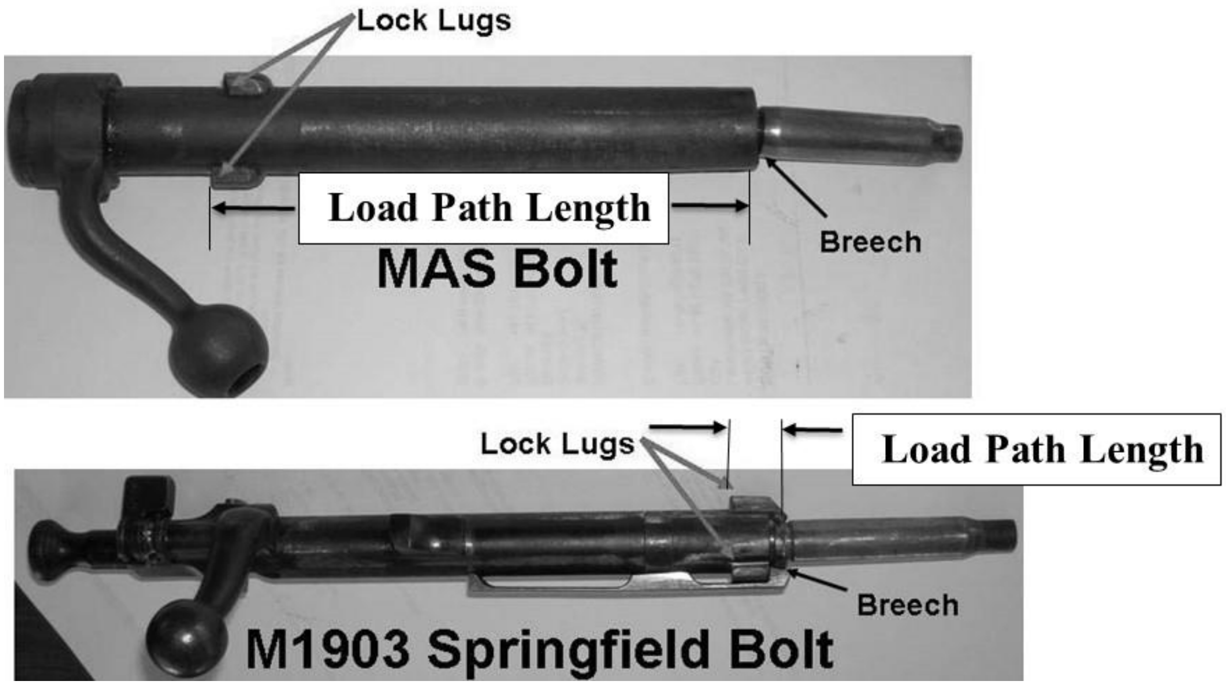


- **Strain gages need to be located in appropriate spot to accurately measure strain**
- **Accurate 3-D linear FEA model is acceptable alternate**

ARROW TECH

If you can't get a bigger target...

Load Path Length Affects Lock Stiffness



- **MAS has long load path & low lock stiffness (return not shown)**
- **Mauser has short load path & high(er) lock stiffness**

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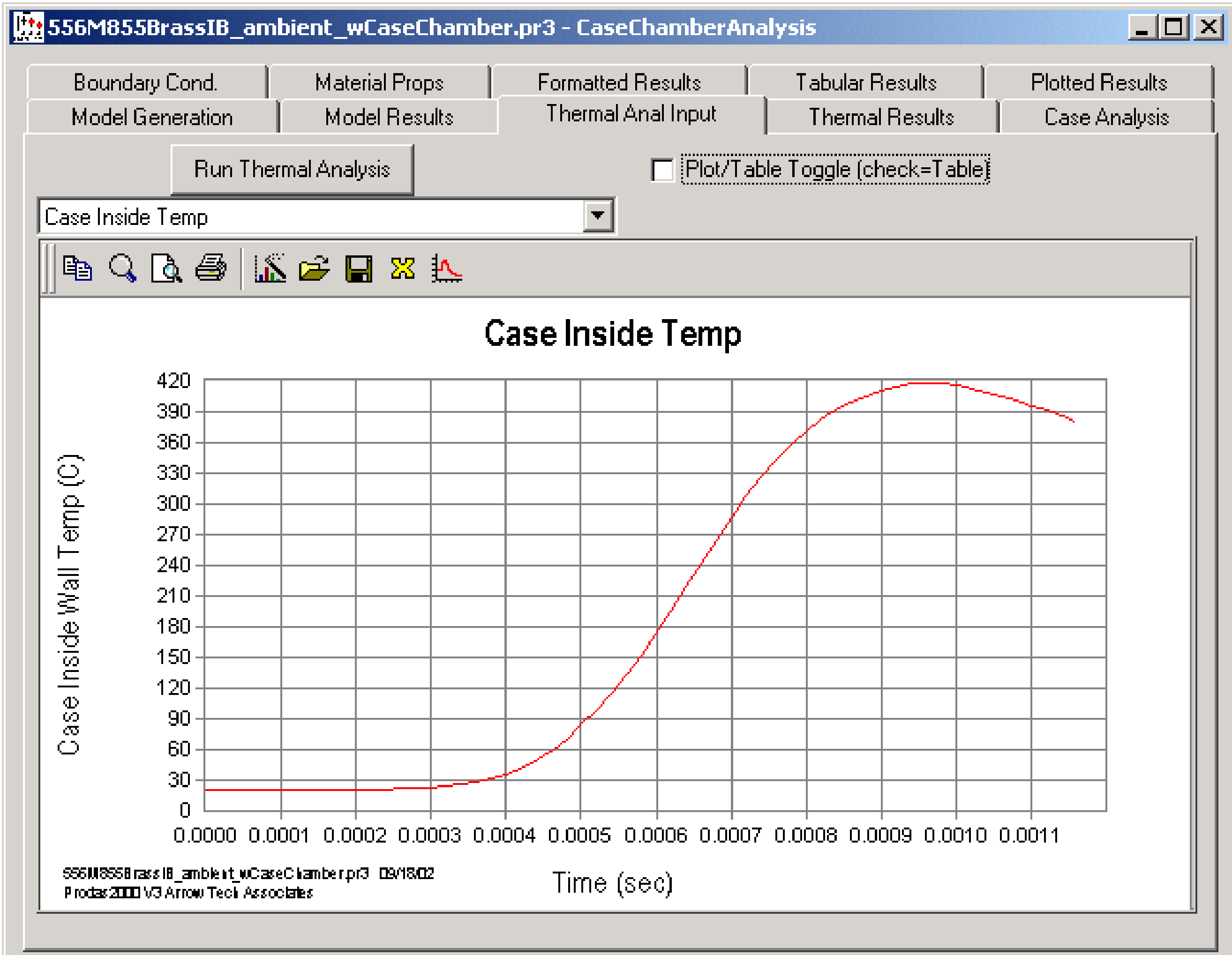
Case Inside Wall Temperature Input

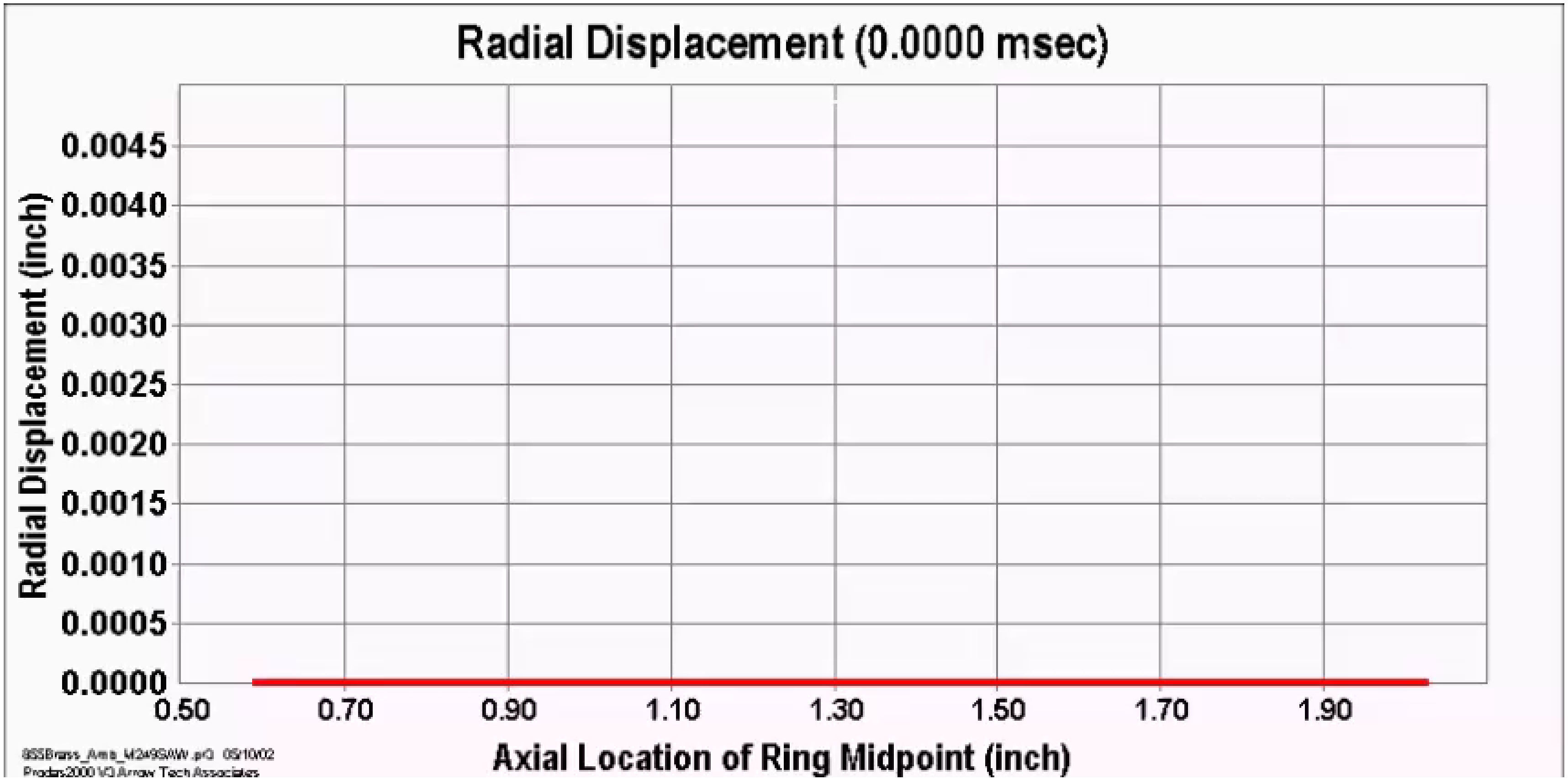


Evaluating Case Designs

- **Look for undesirable conditions**
  - Excessive Axial & Total Strain (<80% "Worst Case" is desirable)
  - Interference at end of cycle indicates potential unlock/extraction problems
  - Long time between fwd and aft case contact with chamber (large strain)
  - Assess case structural robustness WRT deviations in nominal friction, gaps, lock stiffness, etc.
  - Assess residual axial load prior to unlock (hi may impede bolt unlock)
  - Assess peak bolt load & estimated extract load vs. friction/mat'l properties
- **Study the effects of manufacturing tolerances and temperature**
  - "Gap factor" available to quickly evaluate these effects
  - CASAS assumes that dimensions apply at the initial temperatures specified
- **Evaluate bolt loads under various conditions**
  - Peak Bolt Load is Primary Factor in bolt & lock extension fatigue life
  - Large Case Base – Bolt Face Load at unlock may stall gun mechanism
  - Peak Extraction load may stall gun mechanism

If you can't get a bigger target...

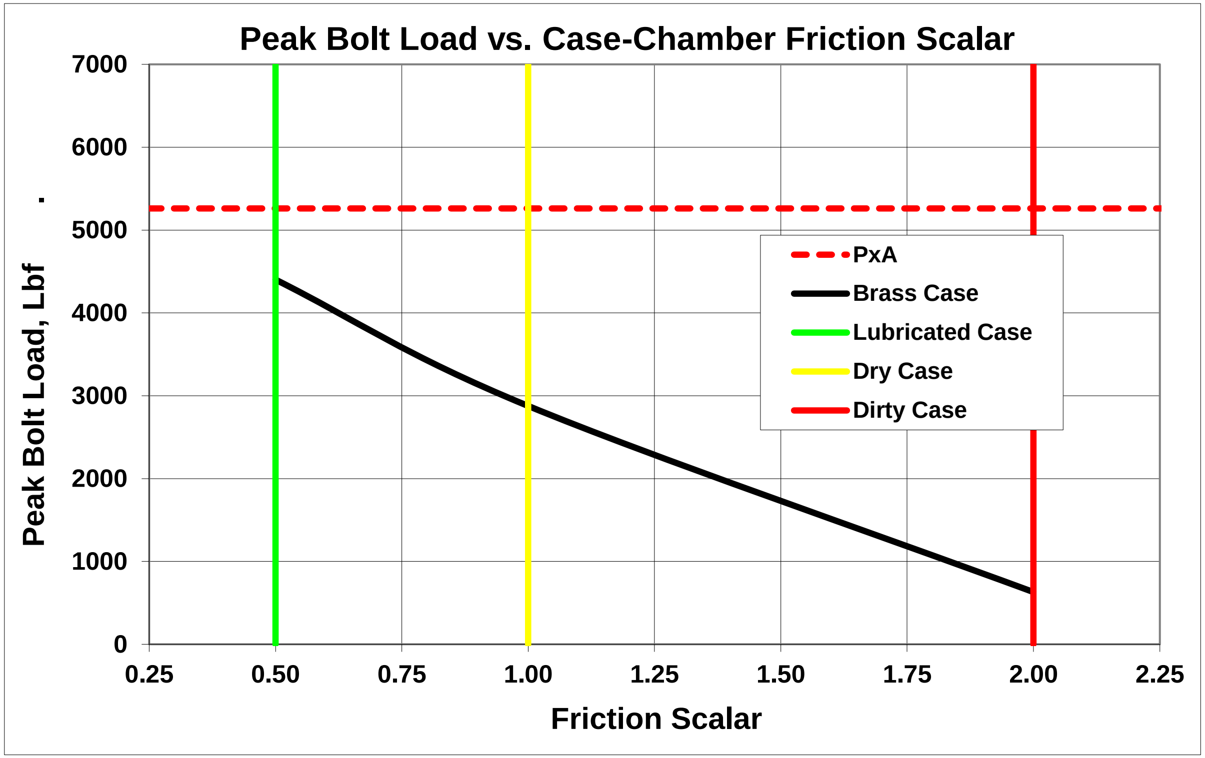
Case-Chamber Movement



ARROW TECH

If you can't get a bigger target...

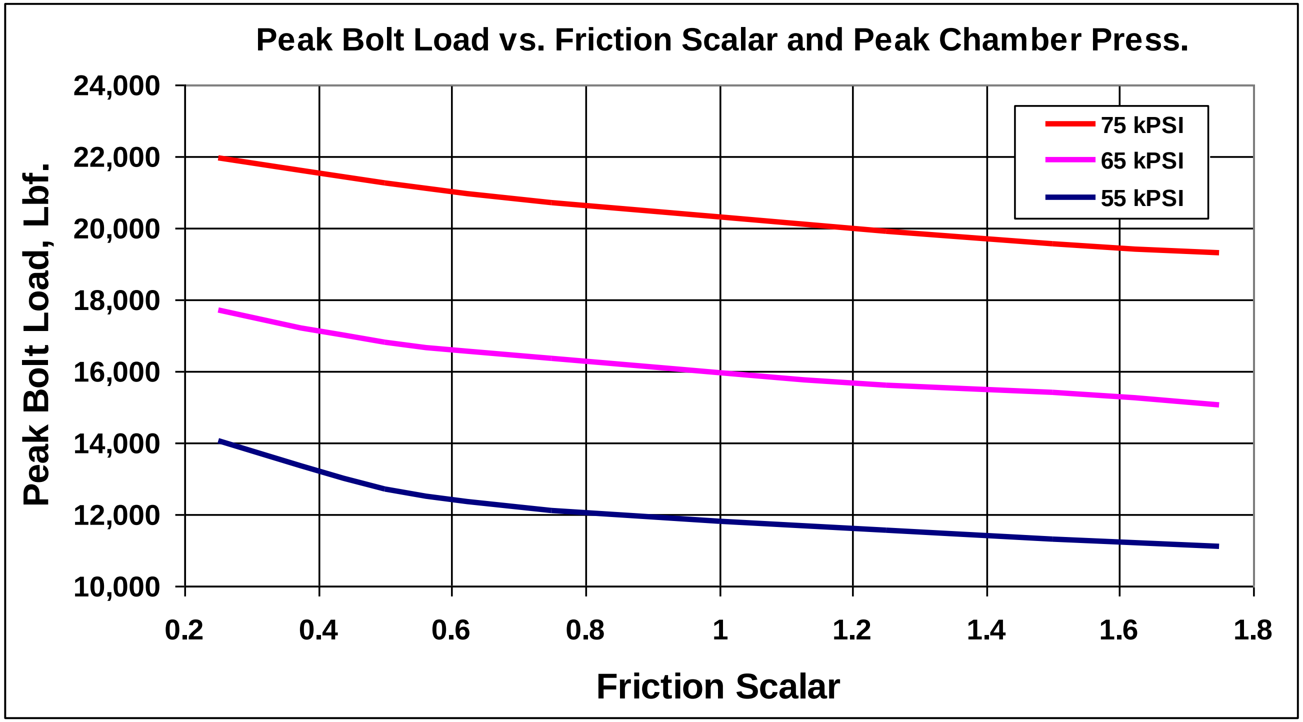
Peak Bolt Load vs. Friction Scalar



- **Simple PxA leaves a lot on the table…**
- **But, it gives you fatigue life margin..**
- **What's good for gun hurts cartridge & vice versa**

If you can't get a bigger target...

Bolt Load vs. Pmax & Friction

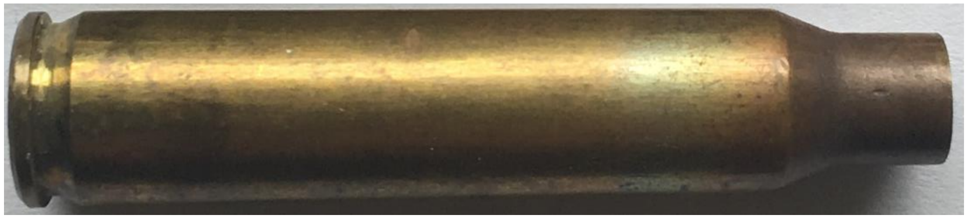


- **Highly non-linear result**
- **Peak load is primary gun fatigue life driver**

ARROW TECH

If you can't get a bigger target...

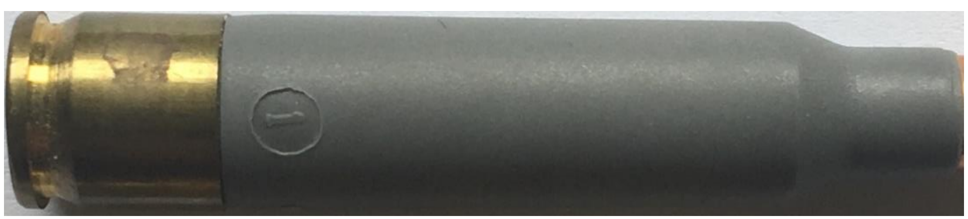
Effect of Case Material on Peak Bolt Load



70/30 Brass (Baseline)

Aluminum Alloy

Steel Alloy



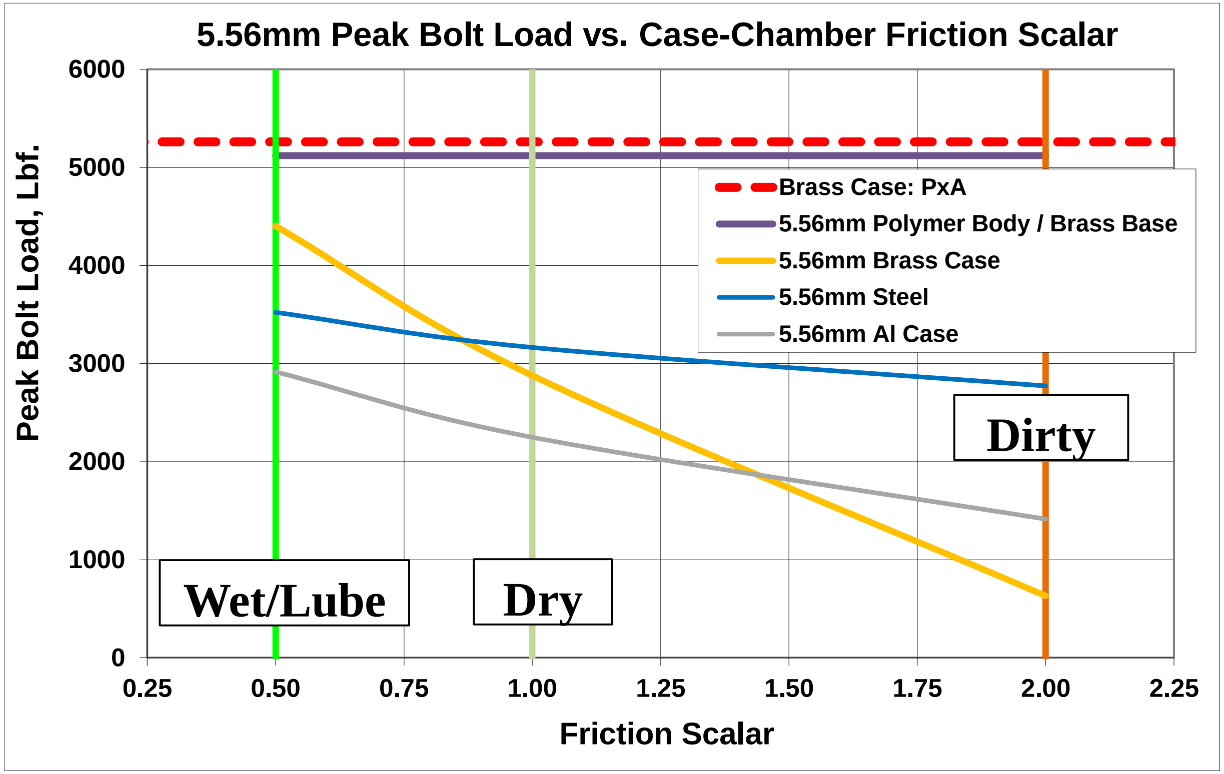
Brass / Polymer Composite

- **Various Mat'l solutions for hi pressure seal**

ARROW TECH

If you can't get a bigger target...

Peak Bolt Load vs. Case Material

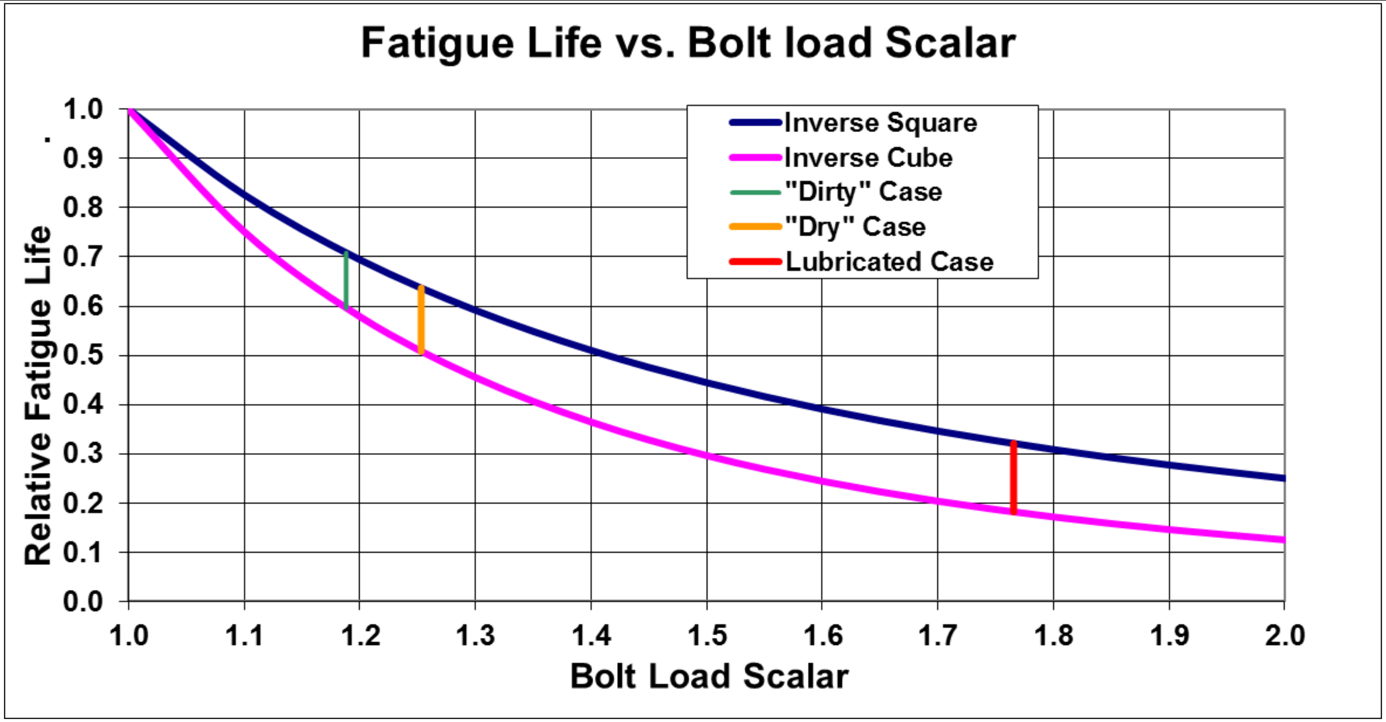


- **P_{max} held constant at 52.5kPSI (362 MPa)**
- **Cases designed to provide % Ultimate Strain < 100%**
- **Peak bolt load is a factor determining fatigue life of gun bolt/lock mechanism**

ARROW TECH

If you can't get a bigger target...

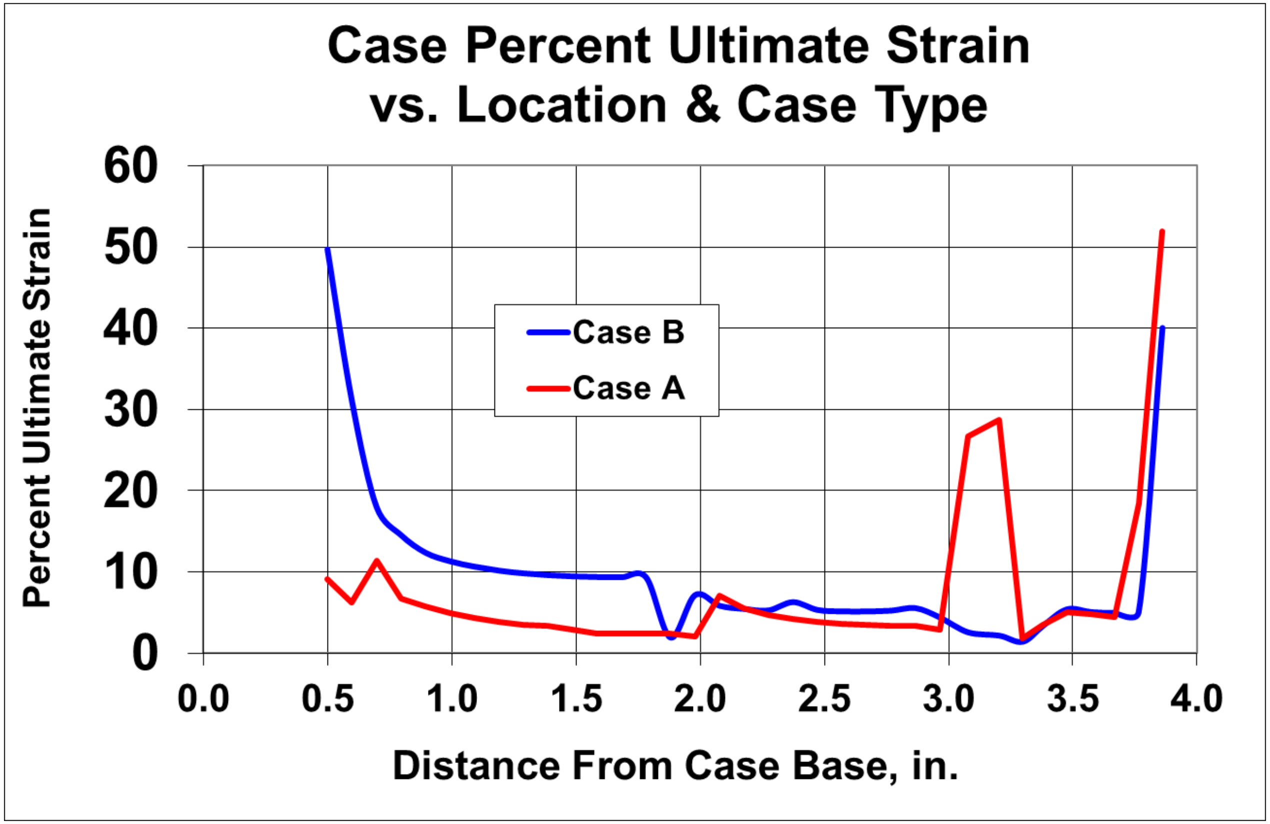
Effect of Bolt Load on Gun Parts Life



- **Increased peak bolt loads are not your gun's friend…**
- **Wet/lubricated case increases bolt loads**
- **So does steel or partially plastic cases…**

If you can't get a bigger target...

Case % Ult. Strain vs. Location

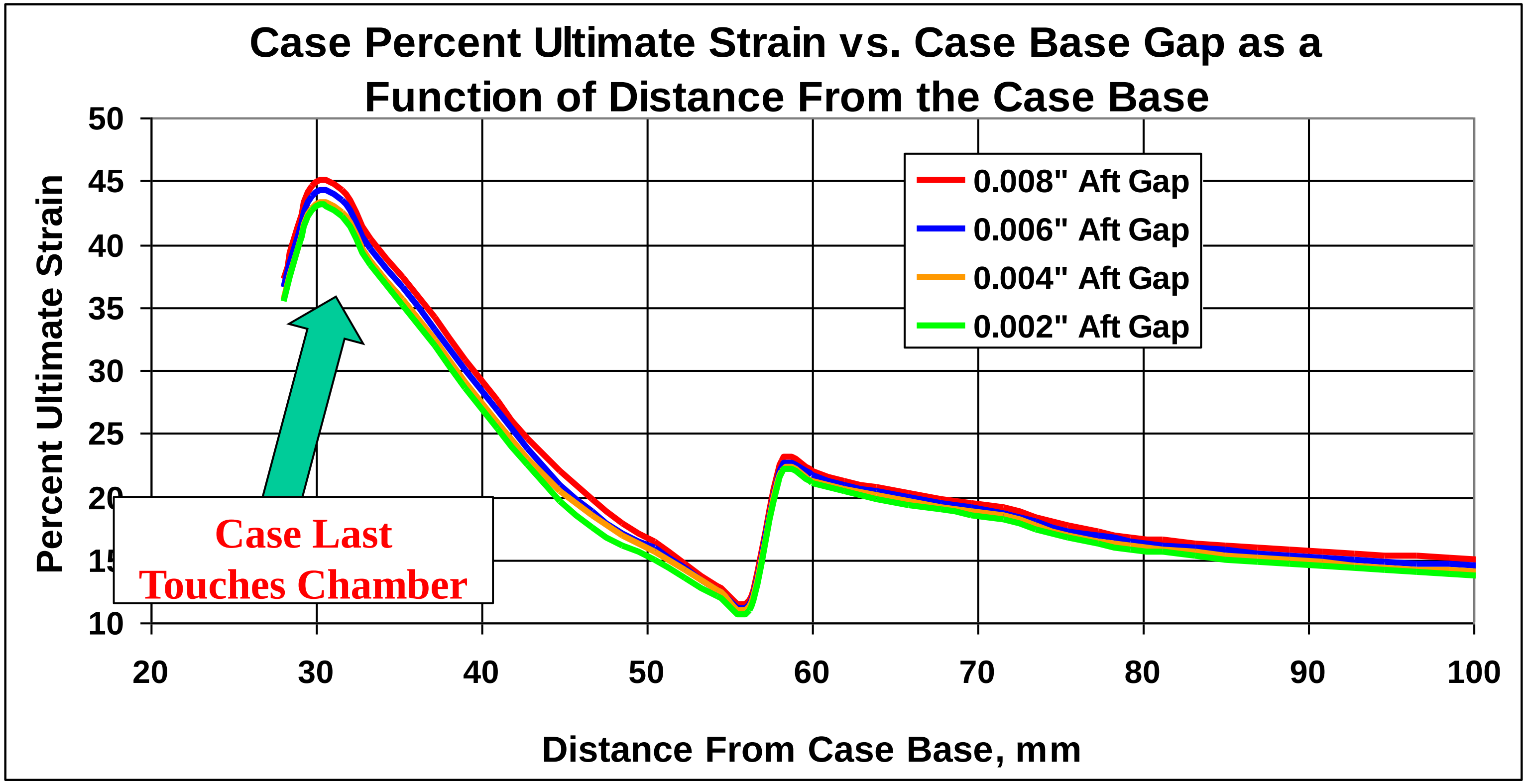


- **Both cases have % Ult. Strain < 100%**
- **Peak % Ult. Strain is in different location (mat't props)**

ARROW TECH

If you can't get a bigger target...

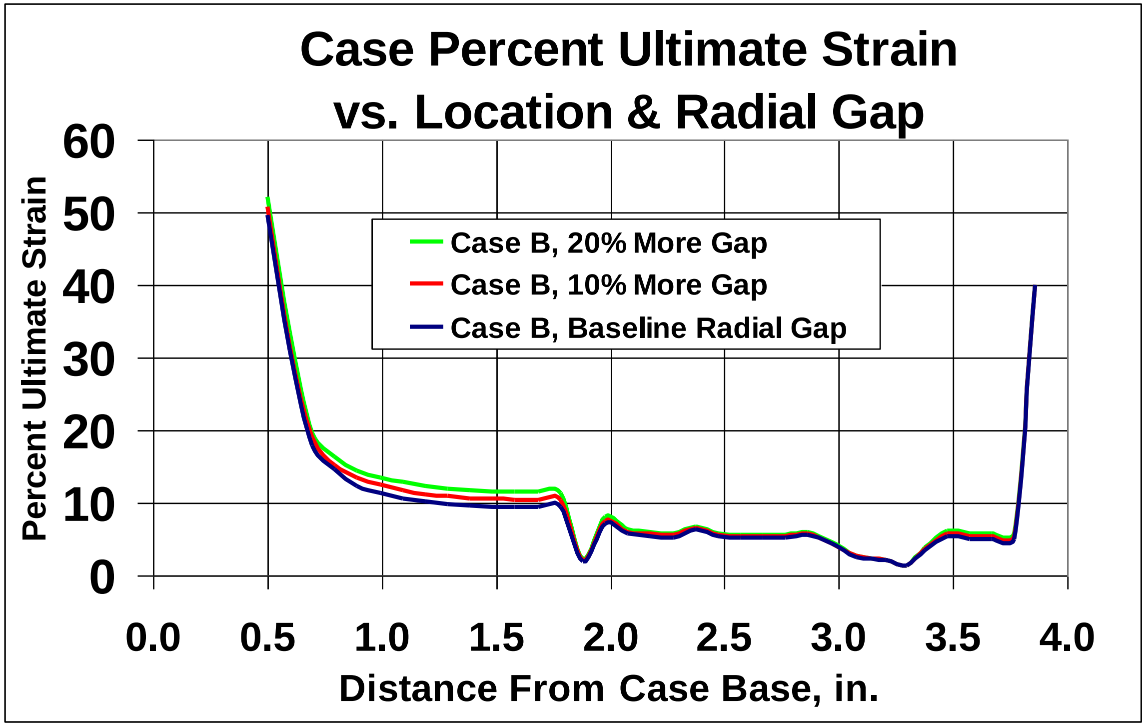
CASAS Results
%US vs Base Gap



- **Non-linear behavior along case length**
- **Not very sensitive to gap magnitude**

If you can't get a bigger target...

CASAS Results
%US vs. Radial Gap

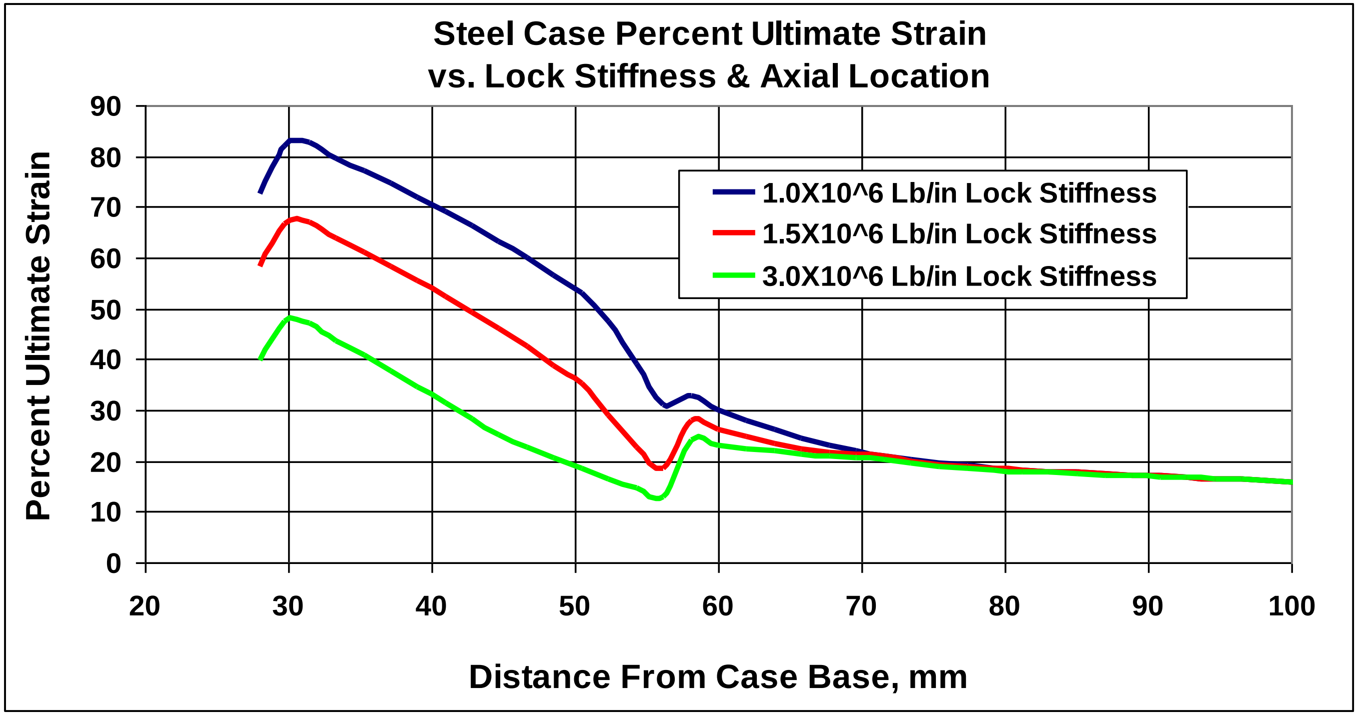


- **Non-linear behavior along case**
- **Not very sensitive to gaps…**

%Ult. Strain vs Lock Stiffness

ARROW TECH

If you can't get a bigger target...

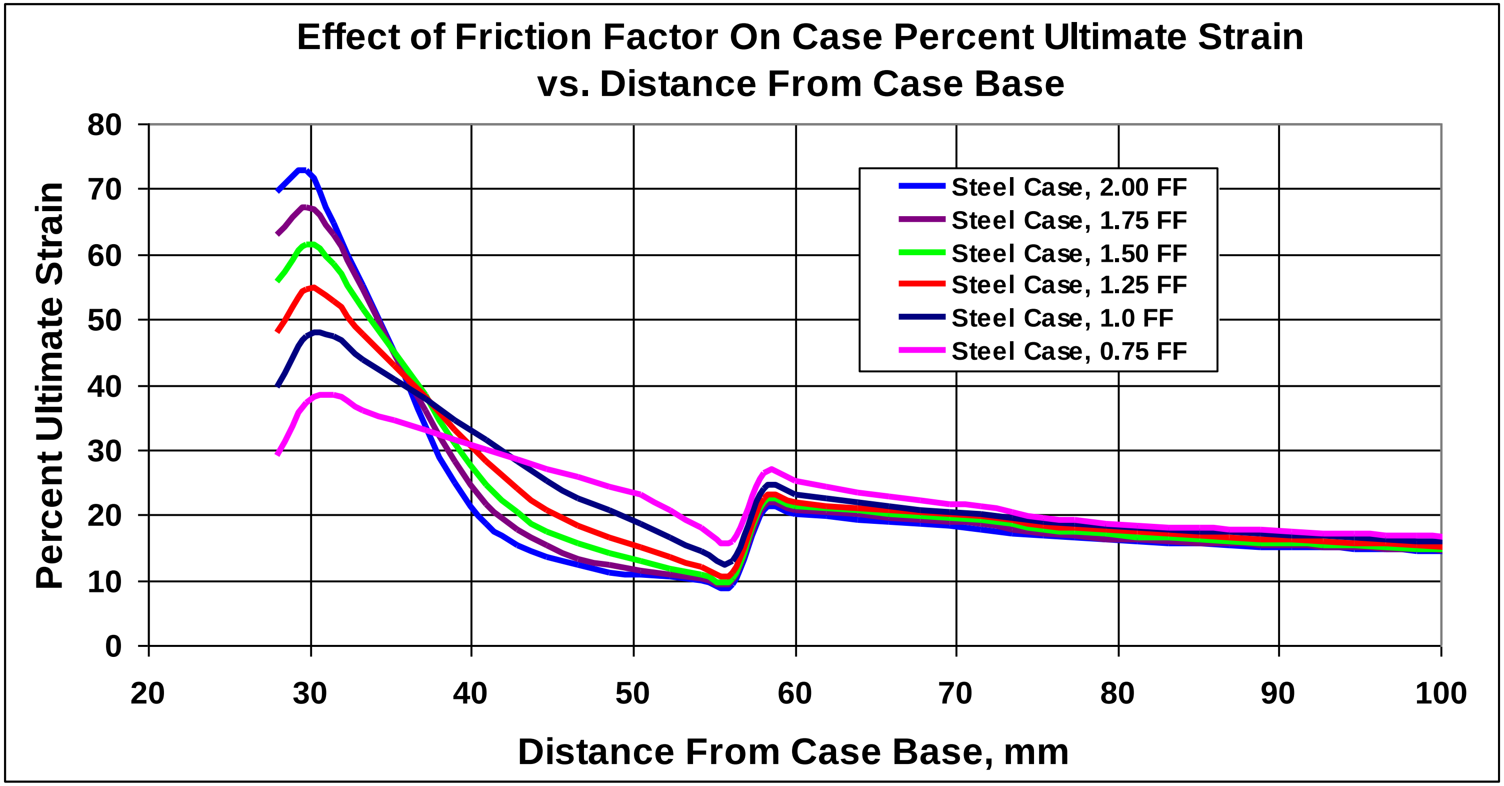


- **Highly non-linear behavior**
- **Lock stiffness is an "Uncontrolled" SAAMI/CIP firearm interface parameter**

ARROW TECH

If you can't get a bigger target...

% Ult. Strain vs Friction Factor

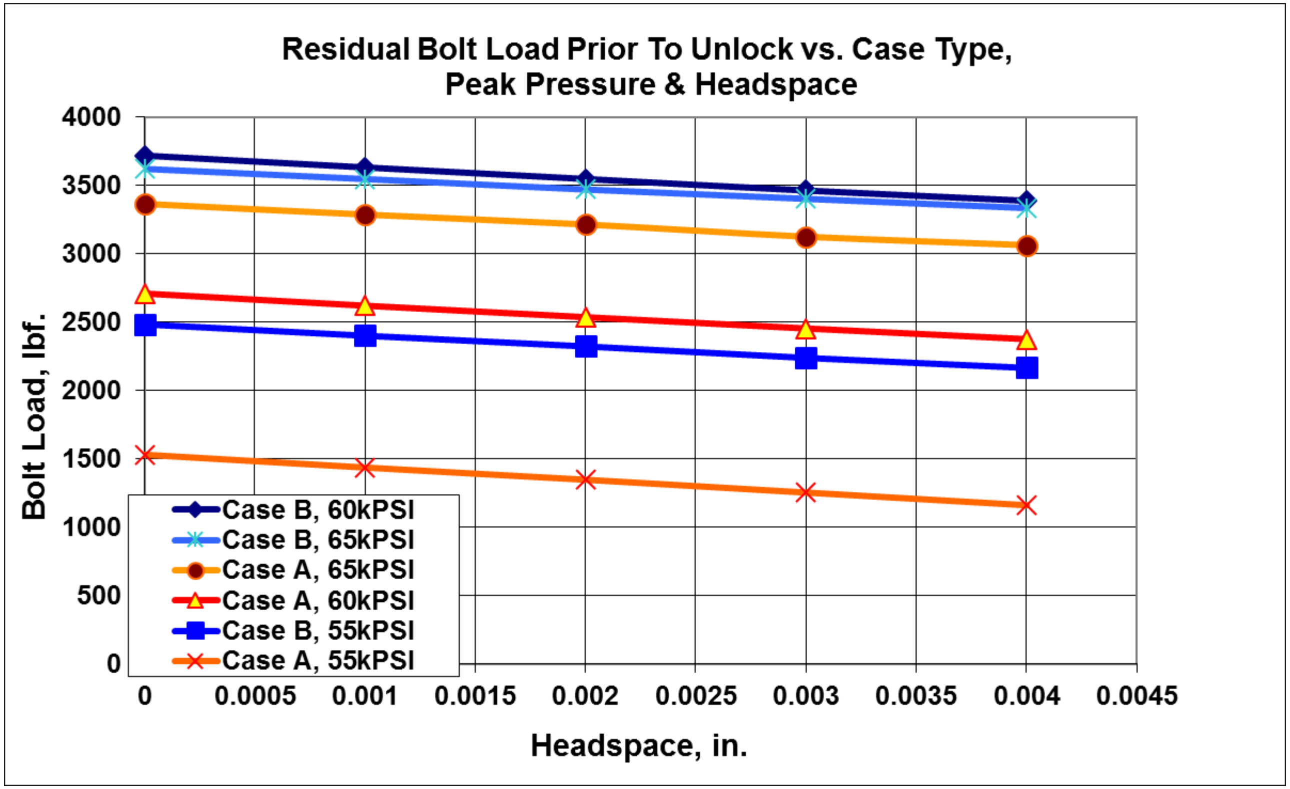


- **Highly non-linear behavior**
- **Friction factor influences % Ult. Strain in aft of case**
- **Evidence suggests friction gradient may exist**

ARROW TECH

If you can't get a bigger target...

Residual Case Base – Bolt Face Load

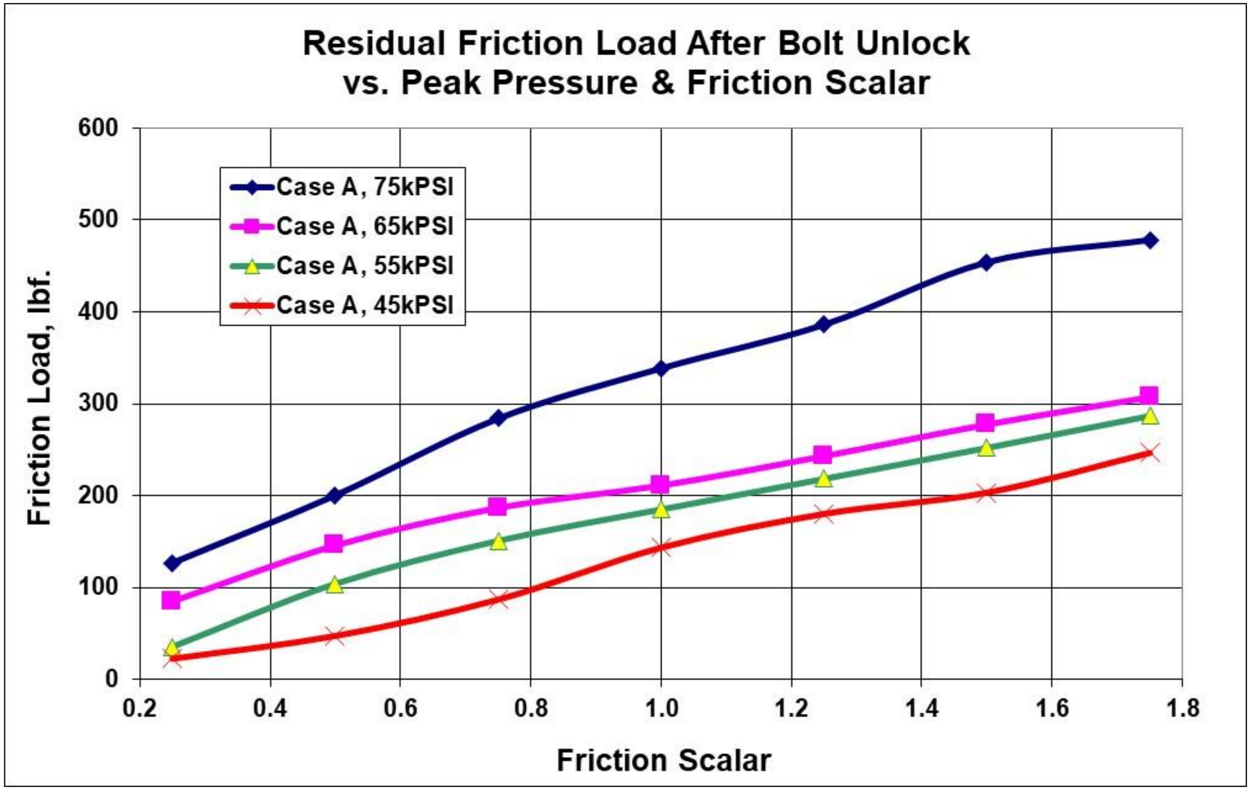


- **Residual Load prior to unlock**
- **Resists unlock…**

Friction Load Resisting Initial Extraction

ARROW TECH

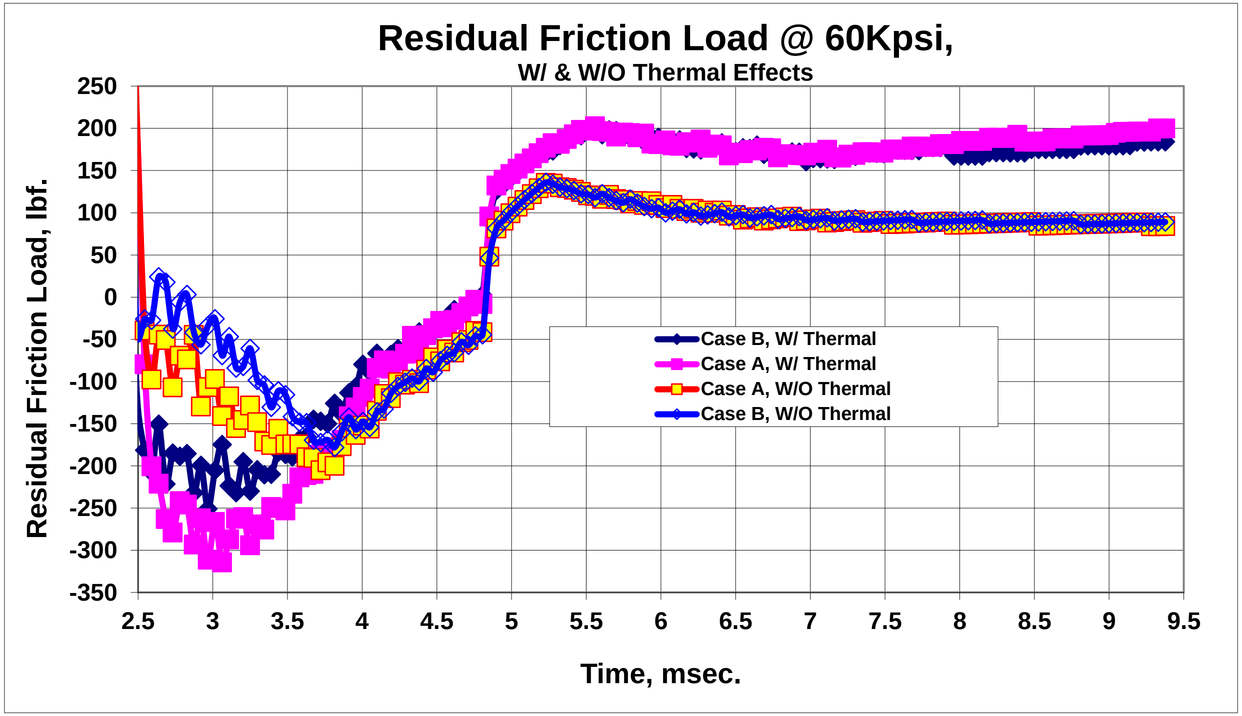
If you can't get a bigger target...



- **Increased pressure & friction = increased extract load (no surprise)**
- **(Somewhat) linear behavior at lower pressures, slope change at higher peak pressures**

Friction Load Resisting Initial Extraction

If you can't get a bigger target...



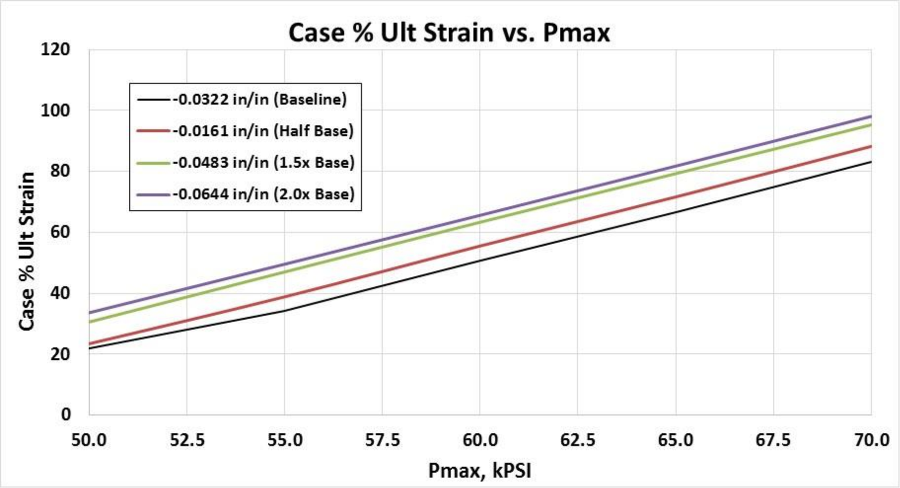
- **Residual Load after unlock**
- **Resists extraction…**
- **Case Taper affects load/distance before clearance develops**

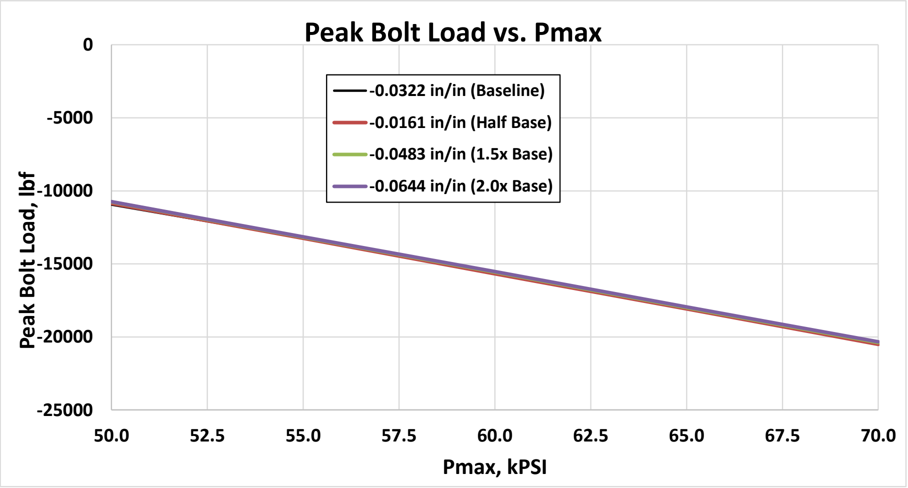
Case Taper Study

- **Compare results to "baseline" case**
- **Tapers of 0.5x, 1.5x & 2.0x baseline**
- **Identical wall thickness & case-chamber gaps**
- **Identical press-time, temp/time & lock stiffness**
- **Identical case material props as f(n) of dist from base**

If you can't get a bigger target...

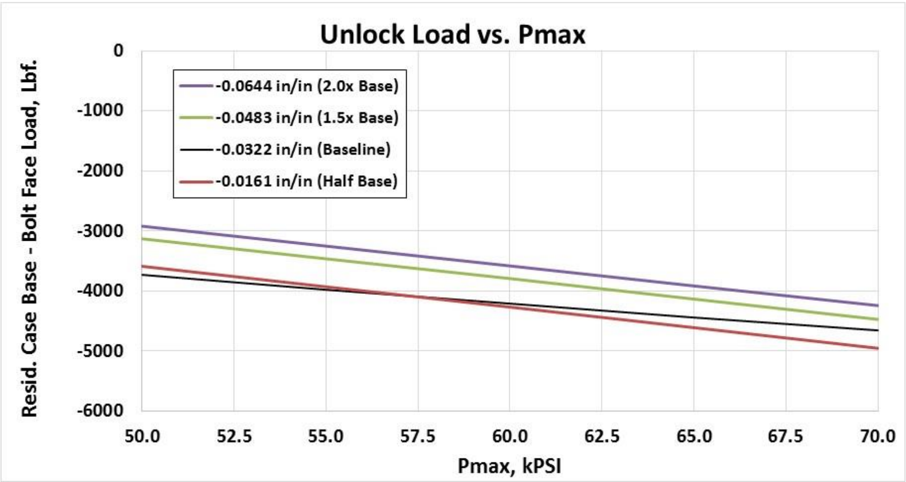
Effect of Case Taper on Case Strain & Bolt Load

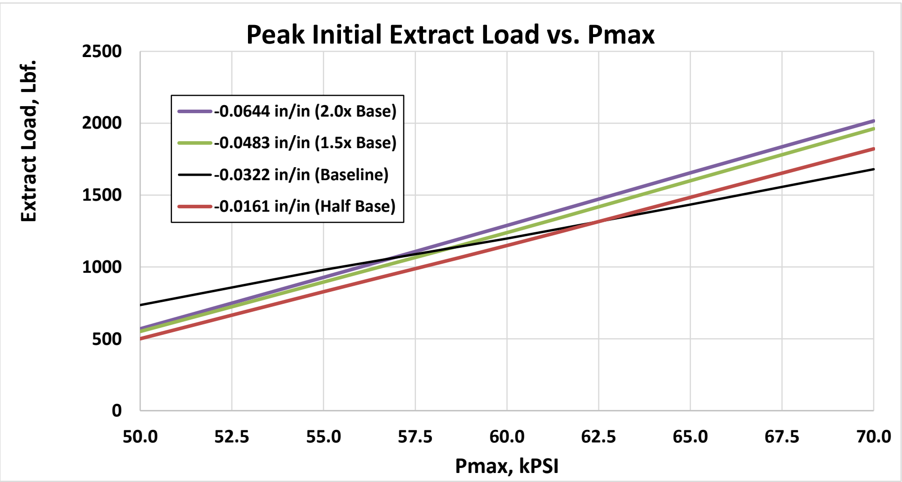




- **Case % Ultimate Strain is structural margin of case.., Baseline taper is lowest (most margin)**
- **Peak Bolt Load is Key factor in gun parts life, Taper has little effect on this parameter**

Effect of Case Taper on Unlock & Extract Load



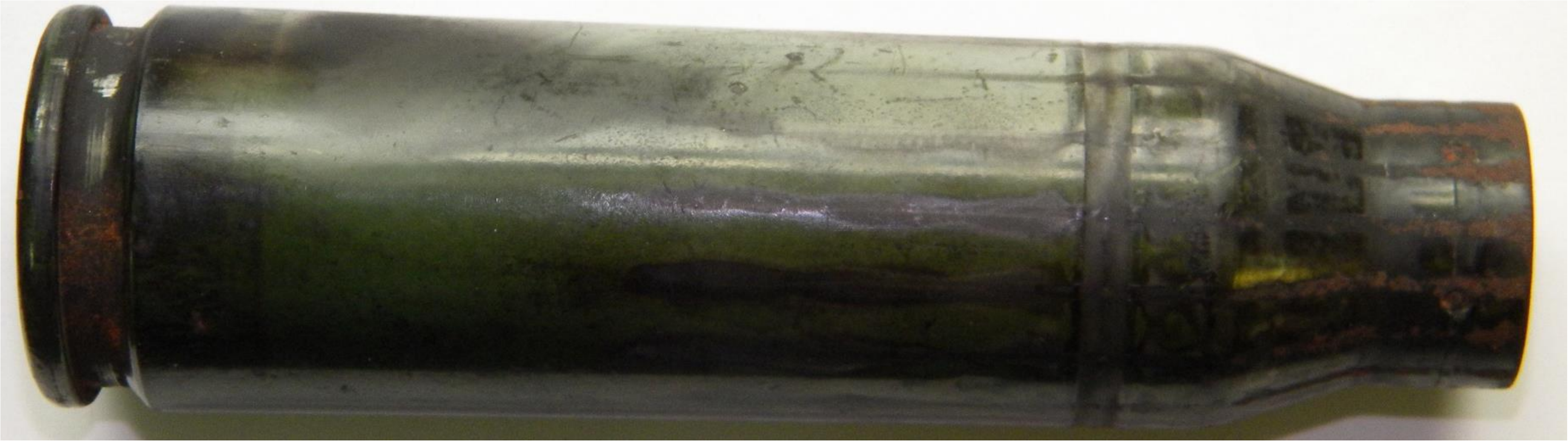


- **Unlock load is residual case base – bolt face load at end of “blow-down”, resists unlock**
  - **Baseline has lowest slope….**
- **Peak initial extract load is residual case-chamber friction resisting extraction**
  - **Baseline has lowest slope..**
- **Expect different behavior based on case matl props, dimension & taper**

Fluted Chamber Effects

ARROW TECH

If you can't get a bigger target...



- **Chamber flutes balance inside-outside pressure at case shoulder & neck**
- **Typically used on hi rate of fire guns to assist w/ early unlock**
- **Reduces case axial stretch & residual case base – bolt face loads**
  - **Particularly advantageous for this case w/ link groove…**
- **Allows case to be extracted under higher residual case pressure**
- **Increases peak bolt load by preventing case-chamber shear transfer at affected zone**

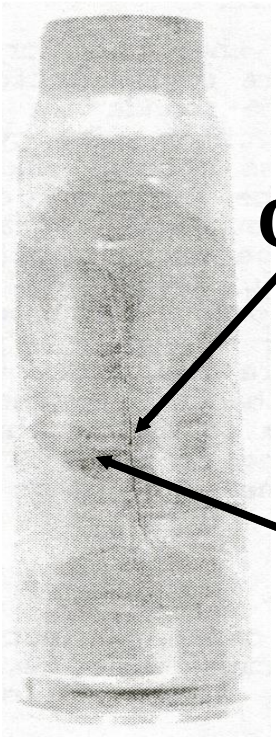
ARROW TECH

If you can't get a bigger target...

Other Issues…

- **Original Case Material: 70% Copper, 30% Zinc (260 Alloy)**
- **Susceptible to Stress Corrosion Cracking (season cracking)**
  - **Originally Observed by British in India on Brass Cartridge Cases Stored in Stables & Exposed to Horse Urine**
  - **Caused by combination of material, residual stress & corrosive atmosphere**
  - **Residual stress caused by forming processes**
  - **Corrosive atmosphere from nitrogen bearing compounds in propellant**
  - **Aggravated by "dezincification" of brass during processing**
  - **Causes internal case wall split that propagates to exterior during firing**
  - **Gas Wash on Exterior of Case**
  - **Gas Cutting of Chamber??**
  - **Case may show no outward signs of problems prior to firing**

Stress Corrosion Cracking: Symptoms

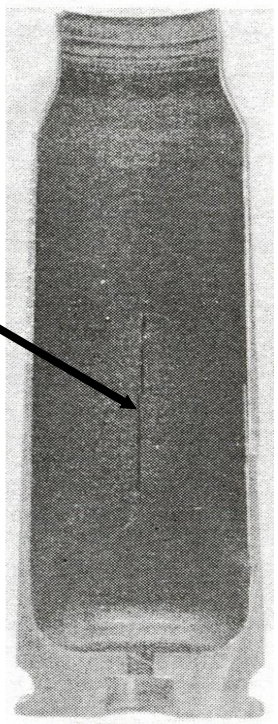


Crack

Gas Wash

Exterior

Photo Thru Wall Section W/ Crack



Crack

Interior

- **Unless crack allows gas to vent aft, little, if any, damage is done to chamber or barrel**

Stress Corrosion Cracking, Small Caliber

- **17 HMR**
- **No preferred crack orientation WRT firing pin strike (not a gun or chamber issue)**
- **No external signs prior to firing, no damage to gun**
- **Effect on dispersion(?)**

Verdigris

- **Toxic green exterior corrosion caused by contact w/ tanned leather (typically)**
- **Sticky surface can cause gun malfunction, case separation**
- **Reason for "plated" cases**

Aft Venting of Al Cases

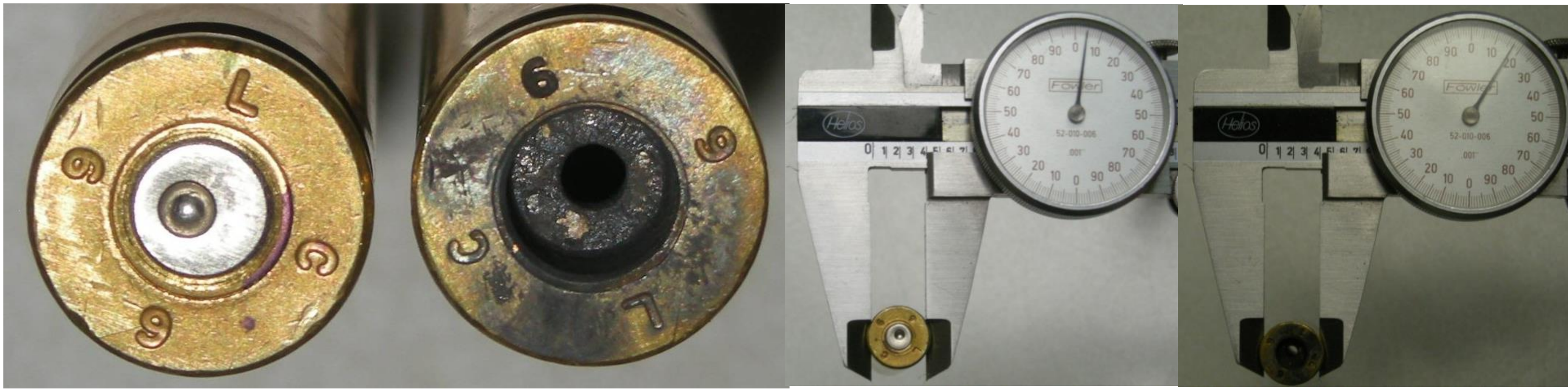
If you can't get a bigger target...

- **Case not properly heat treated**
- **Low strength base allowed large deflections, cracking case anodize**
- **Resulting hi pressure, hi velocity flow cause significant erosion**
- **Significant damage to case, bolt face & barrel**

ARROW TECH

If you can't get a bigger target...

Proof Positive of Over Pressure



- **25.06 case, no primer cup visible upon opening breech**
- **~ 0.012" larger extractor groove diameter**
- **Don't substitute lead core bullet data for solid copper bullets of same caliber & weight.**

Take-Aways

- **Brass** is robust material, long history
  - Hardness & stress-strain properties follow defined profile along case length; hard aft, softer at neck
  - Must be properly processed (neck annealed) to function properly.
  - Stress corrosion cracking is a potential downside
  - Reuse is possible with careful attention to wall thickness (esp. rifle ctgs)
- **Steel** has lower strain at failure than brass of same hardness, somewhat thicker walls, less load transfer in shear to chamber walls = higher bolt loads. Gun should be designed for steel cases.. **Reuse not recommended due to low strain at failure ref brass**
- **Aluminum** has lower strain at failure than brass, somewhat thicker walls compared to brass. Peak bolt loads can be lower than brass depending on case-chamber friction. Gun should be designed for Al cases.. **Reuse not recommended, low strain at failure WRT brass**
- **Plastic** can have much higher strain at failure than brass, but must have thicker walls. Near zero shear load transfer means very high bolt loads. Gun must be designed for plastic cases. **Reuse not recommended, heat checking = cracking = more brittle failure than initial design**
- **If your primers fall out, your pressures are too high.**

THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN

Platform / Armament Systems Integration

Application of Best Practices

NDIA Armament Systems Forum

3 June 2019

Art O'Donnell

Staff Systems Engineer

Northrop Grumman

Mesa, AZ

Art O'Donnell - BIO

- 32 years Aerospace & Defense Mechanical Design and Gun System Integration
  - AH-64D Apache – 30mm M230 Chain Gun, Turret, Ammo Handling System / Sideloader
  - RAH-66 Comanche – Armament Systems Integration Lead
    - 20mm XM301 Turreted Gun System
    - Hydra 70 Rockets
    - Hellfire Missiles
  - 7.62mm M134 Machine Gun (aka "Minigun")
    - 4 Design Improvement Patents
    - Gun System Integration on Rotorcraft and Land Vehicles
- 30mm M230LF Remote Weapon Systems Integration
  - CASA 212 Aircraft
  - Toyota LC79 Pickup
- BS Mechanical Engineering, University of Arizona - 1986
- MBA, University of Phoenix – 2000
- McDonnell Douglas / Boeing / Sikorsky / ATK / Profense / Northrop Grumman

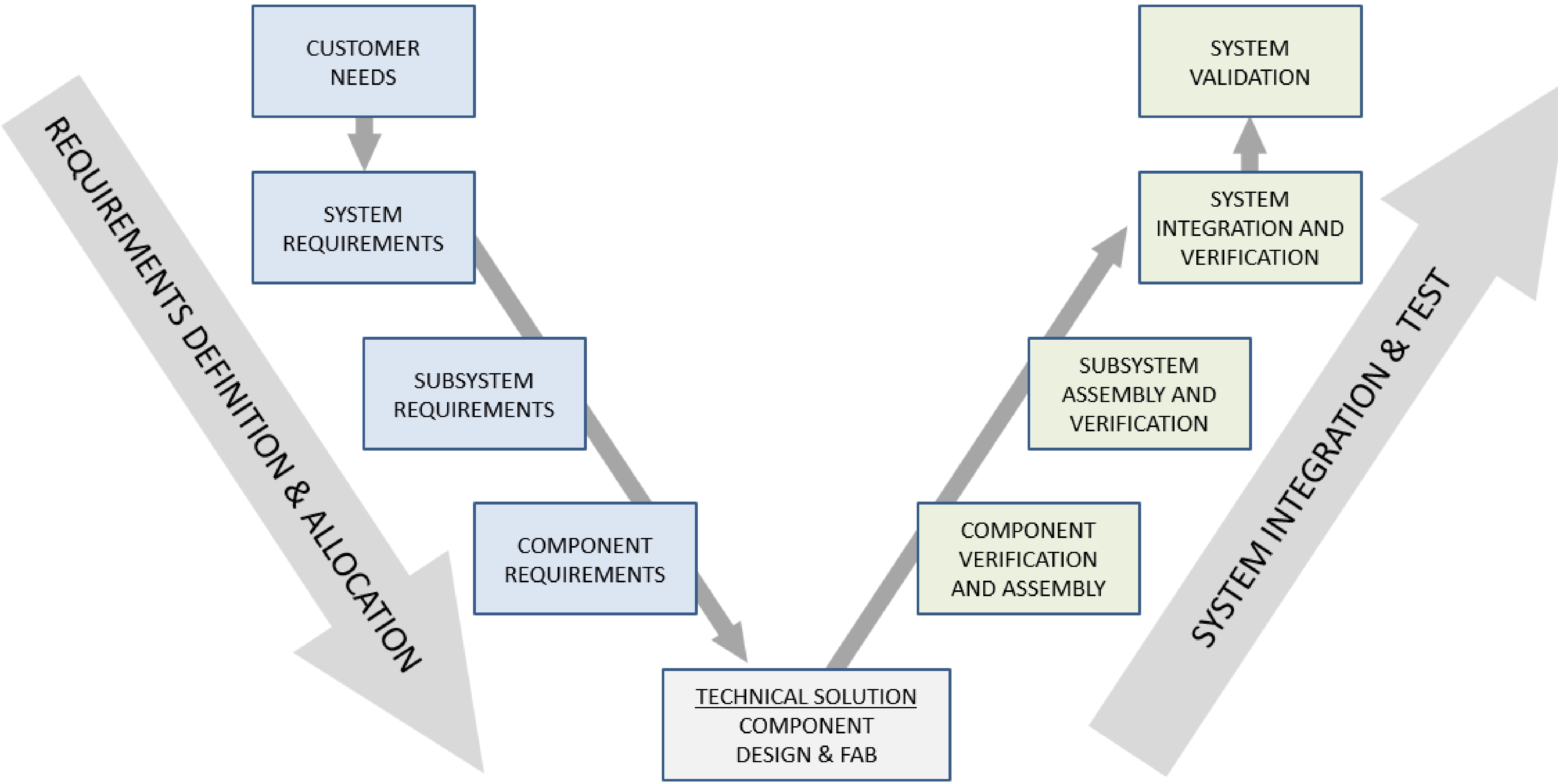
Complexity is a Variable

NORTHROP GRUMMAN

COMPLEXITY DRIVES THE NEED FOR BEST PRACTICES – AND NEW TOOLS

Systems Engineering V-Model

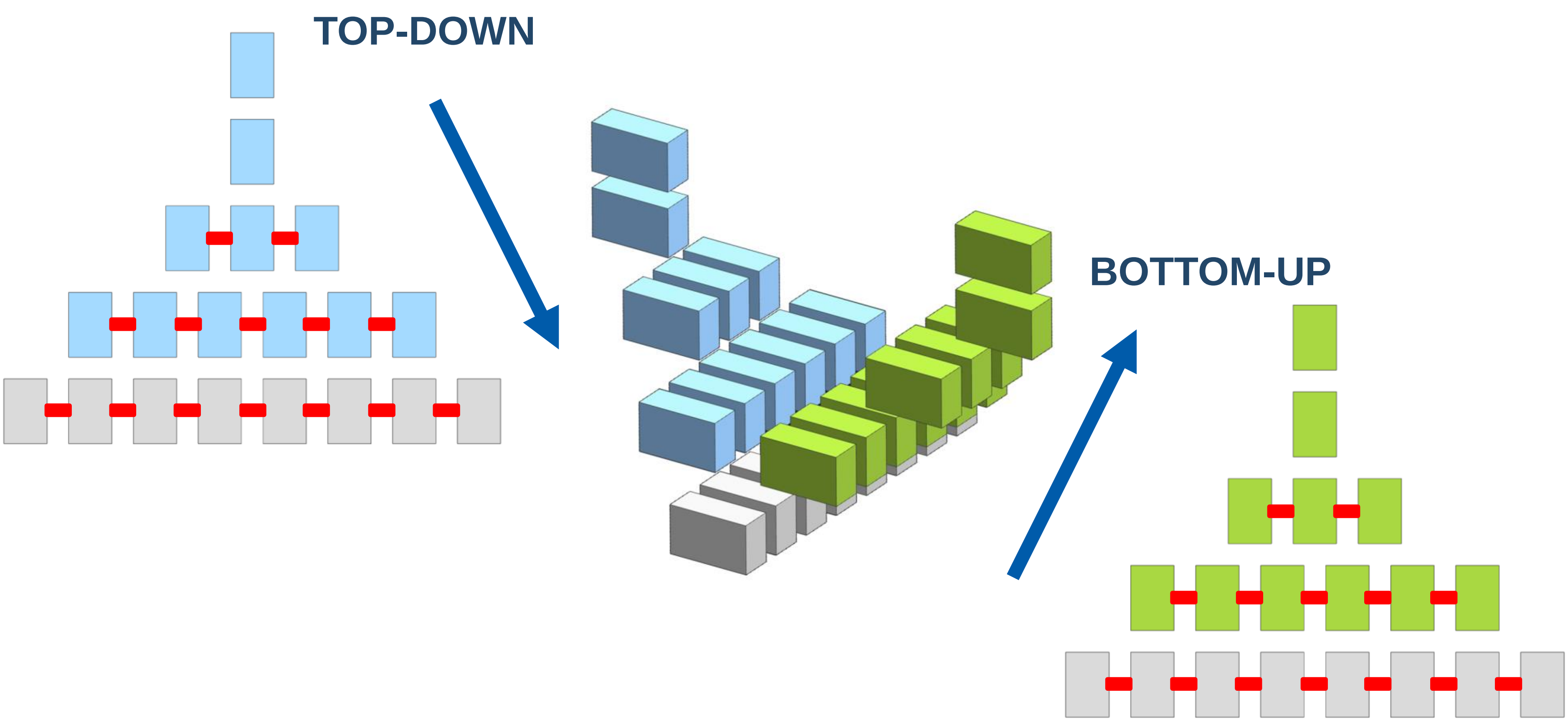
2-Dimensional



CONSIDER THE INTERFACES BETWEEN SYSTEM ELEMENTS

Systems Engineering V-Model

3-Dimensional



UNCOVER THE INTERFACES – AND MANAGE THEM

Best Practices

Plan the Integration Project
SEMP
TEMP
Document Tree
IMP / IMS

Mine the Requirements
Contract Requirements
Derived Requirements
Key Performance Parameters
Technical Performance Measures
Interface Definition

Secure the Resources
Personnel
Modeling & Simulation SW
Labs/Test Equipment: SIL / HILS
Range Time
Ammunition

Manage Change
Press for Commitment
Combat Scope Creep
Early & Loud on Change Impact

START EARLY AND STAY ON TOP OF THESE 4 AREAS

KPPs, TPMs & Other Considerations

NORTHROP GRUMMAN

TYPICAL KPPs / TPMs

- Felt Recoil
- Weight
- Lethality
  - Ph / Pk
  - Accuracy
  - Dispersion
  - ROF
  - Stowed Kills
- Ammo Reload Timeline

OTHER CONSIDERATIONS

- Control System Architecture
- Physical Space Claim
- Gunfire Shock/Vibration Loads
- Muzzle Blast Overpressure
- Platform Mounting / Hard Points
- Airframe / Platform Stiffness
- Ammo Case / Links Eject Path
- Ammo Reload Under Armor
- Ready Rounds
- Power Source / Characteristics
- No-Fire Zones
- Slew Rates / Accelerations
- Control Signal Latency
- Thermal Management

COLLABORATE EARLY WITH END USER, CUSTOMER, AND SUBS

Legacy Tools & Templates

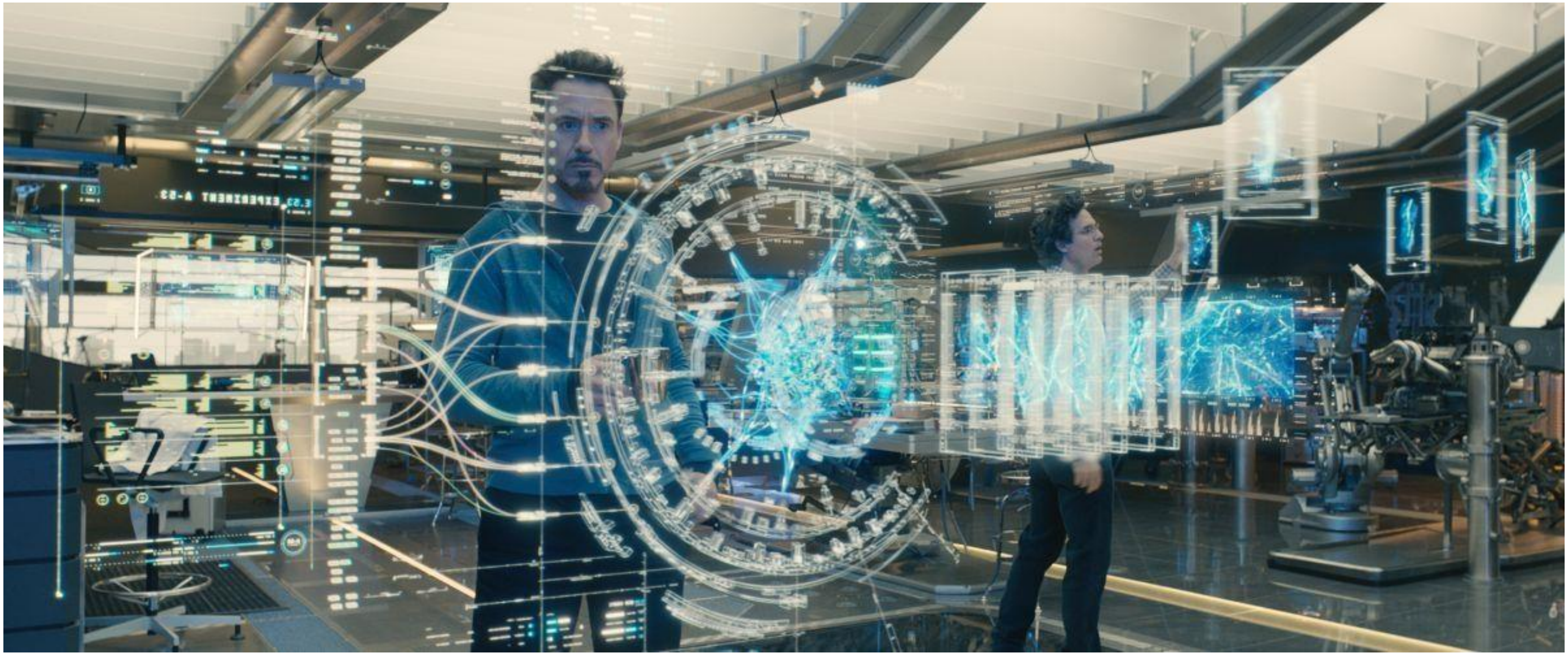
NORTHROP GRUMMAN

- Visit the Customer Workplace
    - End User
    - Maintainer
- Customer Questionnaire
- CONOPS Views
    - OV-1
- System Architecture Representations
    - Block Diagrams
    - Schematics
    - ICDs
    - CAD Views
- Systems Engineering Management Plan
- Test & Evaluation Master Plan
    - Hardware Utilization Matrix
- IMS Milestone Schedule
- Gate Reviews
    - SRR / SFR / PDR / CDR / BRR
- Document Tree
- Requirements Database
- Compliance Matrices
- Modeling & Simulation
- Hardware in the Loop Simulation
- Test Readiness Reviews
- Live Fire Testing

USE WHAT WORKS – ADOPT NEW TOOLS AS NEEDED

Evolving Tools

- High Fidelity Integrated Modeling and Simulation
- Team-Based Collaboration in Model-Based Design and Integration
- Artificial Intelligence / Machine Learning / Deep Learning / Hyperparameter Tuning



COMPLEXITY DRIVES THE NEED FOR BEST PRACTICES – AND NEW TOOLS

THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN





Joint Program Executive Office Armaments & Ammunition

Presented at the:

Armaments Systems Forum

Presented By:

BG Alfred F. Abramson III

Joint Program Executive Officer

Armaments and Ammunition

3 June 2019





….Be comfortable being uncomfortable…..

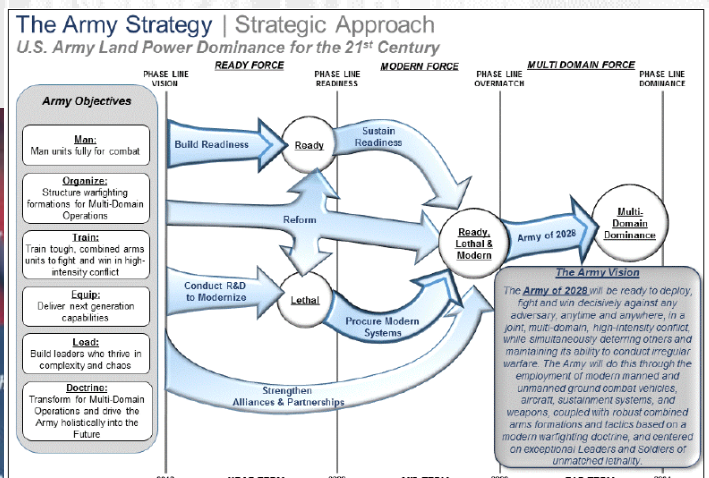
We Changed Our Name…..

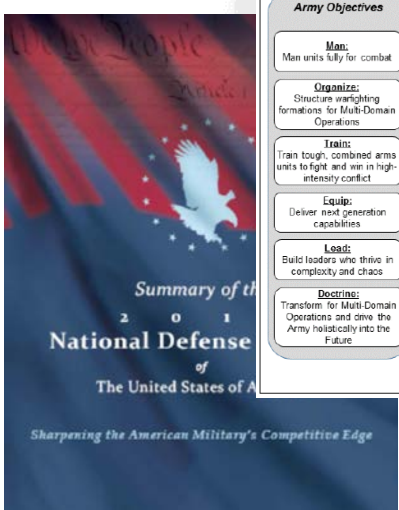
JOINT PROGRAM EXECUTIVE OFFICE

ARMAMENTS & AMMUNITION

Context – The Focus Has Shifted

- **Build Readiness**
- **Modernization**
- **Reform**
- **Strengthen Alliances and Partnerships**





- **Close Critical Capability Gaps…**
- **Achieve Overmatch and Begin Fielding Next Generation…**
- **Strengthen overmatch….**
- **Modernization Priorities**
- **Operational Readiness**

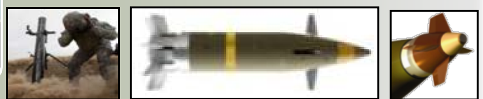
Joint Program Executive Office
Armaments & Ammunition

JPEO A&A
BG Alfred F. Abramson III

DJPEO A&A
Mr. Andrew DiMarco

MISSION: **Lead the development, procurement, and delivery of lethal armaments and ammunition providing joint warfighters with overmatch capabilities to defeat current and future threats.**

Project Manager
Combat Ammunition Systems



COL William McDonough

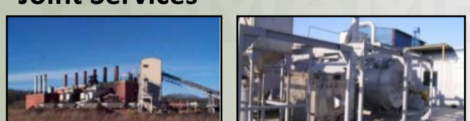
Project Manager
Close Combat Systems

COL Jonathan Slater

Project Manager
Maneuver Ammunition Systems

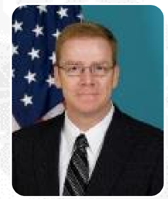
COL Hector Gonzalez

Project Director
Joint Services



COL Justin Highley

CW5
Robert E. Smith, Jr.



JPEO A&A
Chief of Staff
Mr. John Curran

AJPEO
International
Mr. Thomas Coradeschi

Chief Technology Officer
Mr. Paul Manz

Single Manager for Conventional Ammunition (SMCA)

Program Manager
Towed Artillery Systems

Mr. Keith Gooding
USMC

Project Director
Joint Bombs

Col (USAF) Michael Tannehill

OEDCA
Executive Director Conventional Ammunition

SMCA Assessment

CAPT Brian Schorn USN

US Army | US Air Force | US Navy | US Marine Corps

Supporting Army Modernization Priorities

Priority	Support
Long Range Precision Fires	**Supported by 11 Projects** ***Includes: Enhanced Lethality Cannon Munitions, 155mm HE Rocket Assist, Extended Range and Cannon Delivered Area Effects Munitions***
Next Generation Combat Vehicle	**Supported by 8 Projects** ***Includes: Enhanced Lethality Medium Cal Ammo, Advanced Multipurpose 120mm Tank Round and 50mm***
Future Vertical Lift	**Supported by 1 Project** ***Aviation Expendable Countermeasures***
Network / C3I	**Supported by 1 Project** ***Assured Precision Weapons and Munitions***
Air and Missile Defense	**Supported by 1 Project** ***30x113mm CUAS Munitions***
Soldier Lethality	**Supported by 11 Projects** ***Includes: Advanced Armor Piercing (ADVAP) for Small Cal, 40mm Low Velocity HE Air Burst and Next Generation 6.8mm Ammunition***

JPEO Armaments & Ammunition is enabling increased Lethality and ensuring future battlefield success against peer/near-peer adversaries.

JPEO A&A has four additional programs which are enablers to all six CFTs

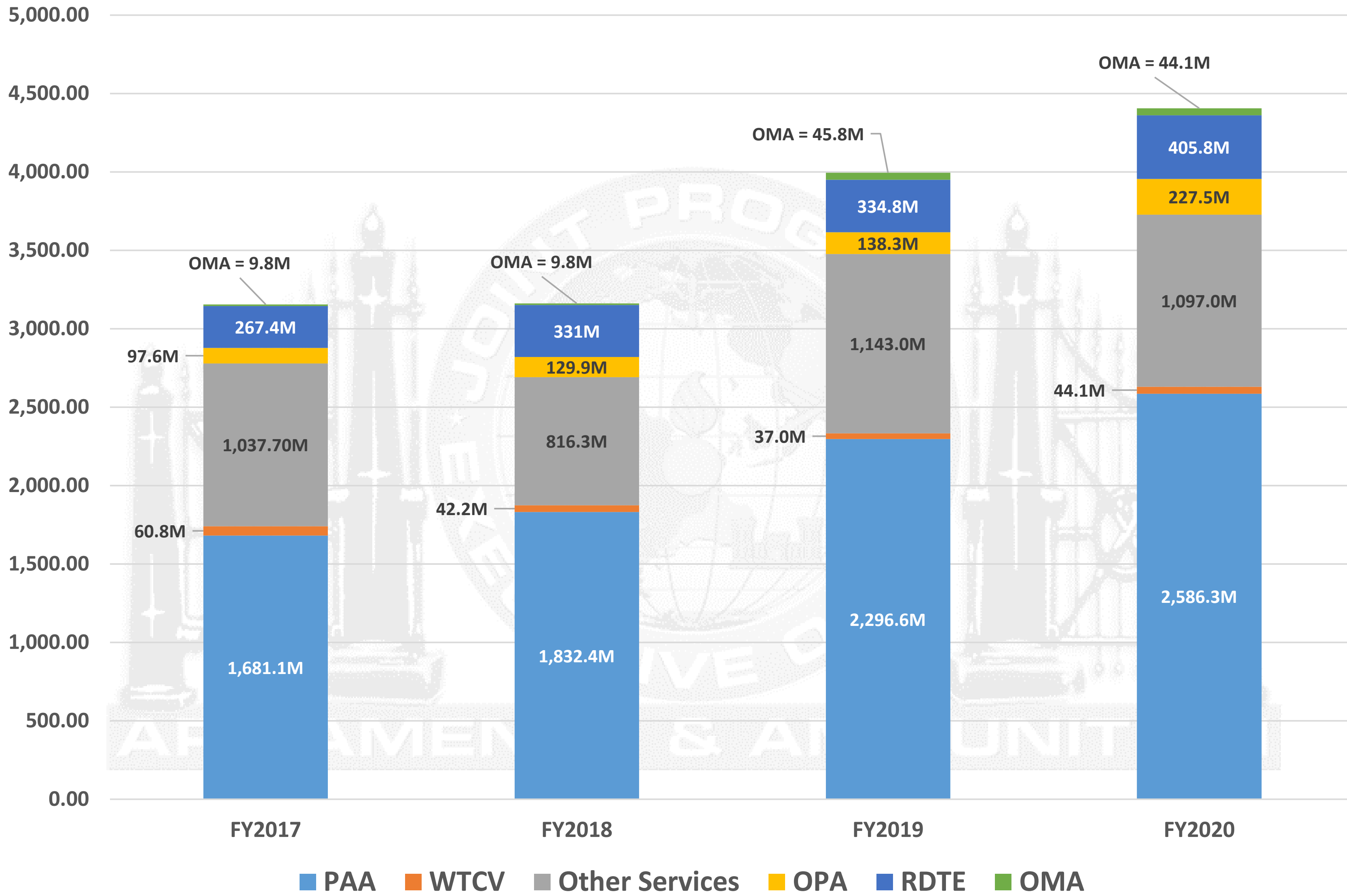
Key Development Thrusts

- Critical armaments proactively “pulling” lethal technologies and system-of-systems capabilities from Army S&T developers like CCDC-AC, including …
  - **Extended Range Cannon Artillery** (Munitions, Weapons, Super Charge, Extended Range alternatives, Precision)
  - **PGK Modernization, Anti-Jam/Anti-Spoof**
  - **Mobile Wheeled Howitzer**
  - **Cannon-Delivered Area Effect** and Sensor Fuzed Munitions
  - **Terrain Shaping Obstacle**
  - **Advanced Armor Piercing** (ADVAP) and **One Way Luminescence (OWL)** for Small Cal Ammo

- Precision Munitions - Leading effort to ensure Assured Position, Navigation, and Timing (A-PNT) Precision and Conventional Fires in GPS Degraded/Denied environments
  - **Assured Precision Weapons and Munitions** (including A-PNT, M-Code GPS, Network Assisted A-PNT (NA2), AltNav and non-GPS solutions)

JPEO A&A is fully engaged to develop, deliver, and ensure Combat Overmatch

FY2017 - FY2020 Budget Comparisons



Source PBs

Single Manager Conventional Ammunition (SMCA)

Sec Def → Sec Army → ASA(ALT) → JPEO A&A (est. 2002)

SMCA Mission: Manage DoD conventional ammunition, and personnel and training functions (DoDD 5160.65)

Objectives: Achieve the highest possible degree of efficiency and effectiveness in the DoD operations required to acquire top quality conventional ammunition for U.S. Forces

Providing all Services with the Highest Quality and Cost Effective Ammunition

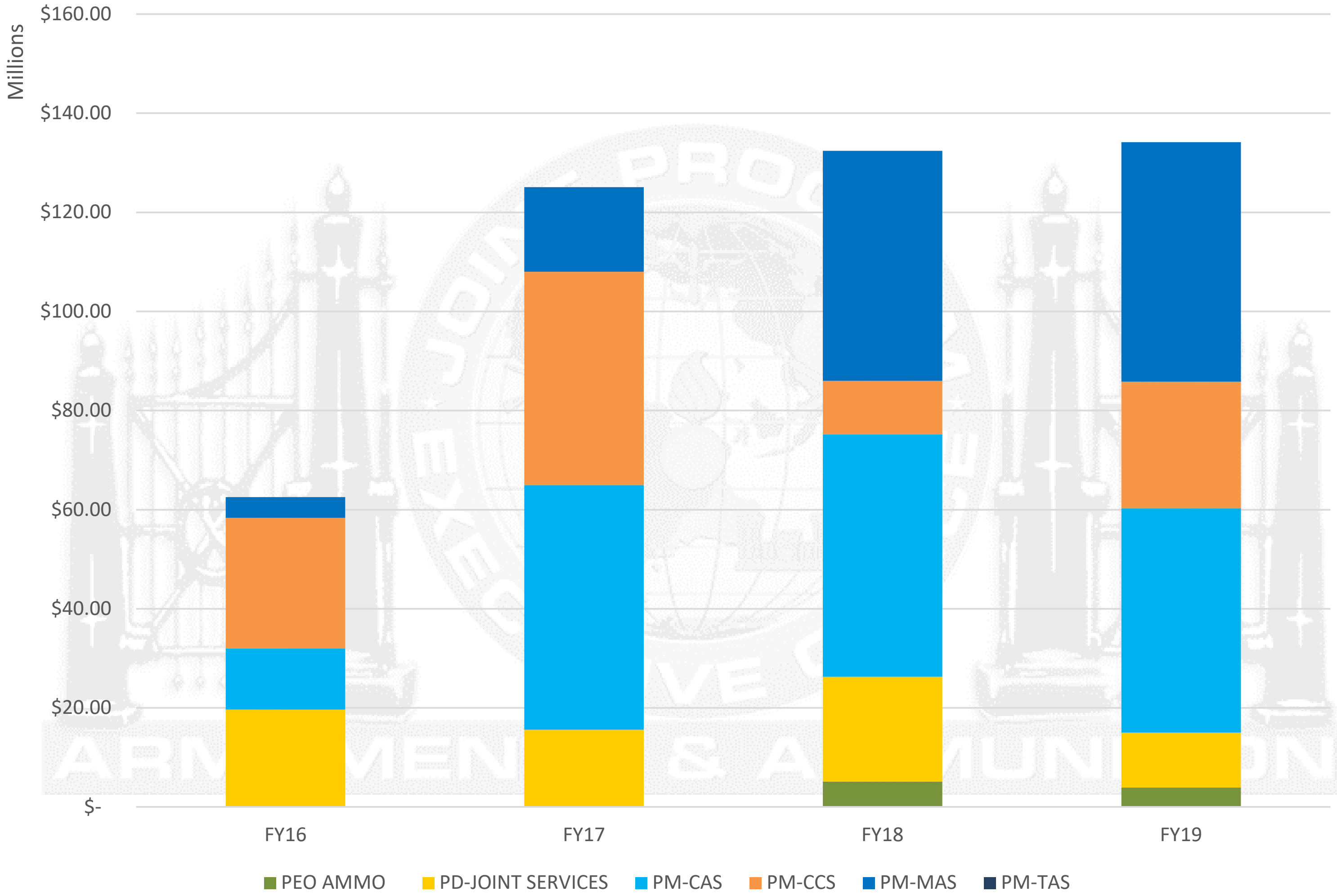
JPEO A&A
GOCO Support to Army Priorities

- **Nearly all DOD weapon systems use products produced by the GOCO Ammo industrial base**
- **JPEO A&A is the Single Manager for Conventional Ammo (SMCA) and responsible for modernization, sustainment, and production at the GOCOs**
- ***The success of the Army's Modernization Plan depends on a vibrant, modernized Industrial Base***
- ***JPEO A&A continues investment to enhance GOCO manufacturing capabilities:***
  - ✓ ***FY2019 = $458M***
  - ✓ ***FY2020 = $475M***

Plant	Mission	CFTs Supported
Holston AAP (HSAAP)	Manufacture Explosives: RDX (USAF Bombs), HMX (Missiles), IMX (Mortars/Artillery)	Soldier Lethality LRPF
Radford AAP (RFAAP)	Manufacture Large Volumes Of Propellants And Propellant Ingredients	Soldier Lethality LRPF AMD NSCV FVL
Lake City AAP (LCAAP)	Provider of DoD Small Caliber Ammunition 5.56mm, 7,62mm, .50 Cal	Soldier Lethality
Iowa AAP (IAAAP)	Load, Assemble, and Pack (LAP) Ammunition Items	LRPF
Scranton AAP (SCAAP)	Manufacture Metal Parts for artillery, mortar, and 5" Navy projectiles	LRPF

DOTC Financials

JPEO A&A's Use of DOTC (FY16-FY19) – Total Funding



FY16-FY18 actuals; FY19 projected

Meeting Joint Warfighter's Needs!

FY2018 Snapshot

- **Direct Fire Ammunition = 908M rds.**
- **Indirect Fire Ammunition = 1.95M rds.**
- **AF and USN Bombs = 250,000+**
- **Misc. Ammo/Munitions (ex. Grenades, Pyro, Less than Lethal Rds.) = 3.24M**
- **Demil = 49k tons of conventional ammo & ~14k tons of missiles & missile components**


THE HIGHEST
CALIBER

THE AIR FORCE RESEARCH LABORATORY
LEAD | DISCOVER | DEVELOP | DELIVER

AFRL Munitions Directorate Overview

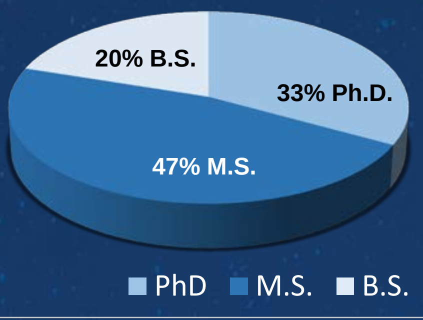
DR. DAVID LAMBERT, CHIEF SCIENTIST
MUNITIONS DIRECTORATE, 4 JUNE 2019

AFRL

A World-Wide Enterprise of Researchers

	Employees	Civilian	Military
Total	5,827	79%	21%
S&Es	3,455	80%	20%

S&E Education



Core Technical Competencies (CTC)

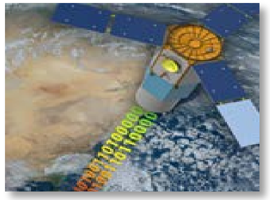
MATERIALS & MANUFACTURING

Structural Materials, Functional Materials, Manufacturing Technologies, Support for Operations

HUMAN PERFORMANCE

Training,
Decision-making,
Bioeffects,
Human Centered ISR

SPACE VEHICLES



Advanced Space Resilience Technologies, Space Communication & Navigation Technologies, Space Awareness and Command & Control, Space Environment

INFORMATION

Autonomy, Command & Control, and Decision Support, Processing & Exploitation, Cyber Science Technology, Connectivity & Dissemination

BASIC RESEARCH

Engineering & Information Sciences, Physical & Biological Sciences

SENSORS

Spectrum Warfare, Trusted & Resilient Mission Systems, Multi-domain Sensing Autonomy, Enabling Devices & Components, Radio Frequency (RF) Sensing, Electronic Optic (EO) Sensing

AEROSPACE SYSTEMS

Aerospace Vehicles, Control, Power & Thermal Management,
High Speed Systems, Rocket Propulsion, Turbine Engines

DIRECTED ENERGY

High Power Electromagnetics, Laser Systems, Ground-based Electro-optical /Infrared Space Situational Awareness

MUNITIONS

Ordnance Sciences, Terminal Seeker Sciences, Munitions, Airframe, Guidance, Navigation & Control, Modeling & Simulation, Evaluation Sciences

EXPERIMENTATION

Capability & Technology Prototyping

Future Technologies - Big Bets

QUANTUM INFORMATION SCIENCE
Harnesses certain laws of particle physics to dramatically improve the acquisition, transmission and processing of information.

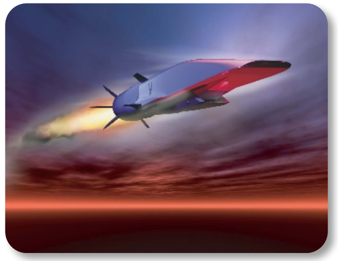
Applications include computing, communication and sensing. Quantum can be used to teleport information, create secure communication networks, gather location data in GPS-denied environments and enhance supercomputing capabilities.

ARTIFICIAL INTELLIGENCE / AUTONOMY
Facilitates the use of machine generated information by creating knowledge from observations gathered.

AI can provide expertly-planned courses of action, streamline business processes, enhance situational awareness and increase mission effectiveness.
It could save time, money, manpower and lives.

DIRECTED ENERGY WEAPONS
Strike critical targets at the speed of light and defeat attacks in an effective, affordable and expedient manner.

DEWs precisely engage targets with little to no collateral impacts or detectable disturbance. They can be integrated with aircraft, munitions or used on the ground.



HYPERSONICS
Flying at five times the speed of sound, also known as Mach 5 or higher.

Hypersonic flight could enable the U.S. to conduct longer range military operations with shorter response times and enhanced effectiveness.

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AFRL Munitions Directorate

Mission

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

Air Force 2030 S&T Strategy

Three Objectives

1

Develop and Deliver Transformational Strategic Capabilities

- Global Persistent Awareness
- Resilient Information Sharing
- Rapid, Effective Decision Making
- Complexity, Unpredictability & Mass
- Speed and Reach of Disruption and Lethality

2

Reform the Way Science & Technology is Led and Managed

3

Deepen and Expand the Scientific and Technical Enterprise

- Engage and Support a Technical and Driven Workforce
- Drive Innovation Through Partnerships

Tech Opportunities to Align to AF 2030 S&T Strategic Capabilities

Speed & Reach of Disruption and Lethality	Complexity, Unpredictability, & Mass	Global Persistent Awareness	Resilient Information Sharing	Rapid, Effective Decision-Making
• Hypersonic Weapons • Low-cost, networked cruise missiles AND Smart munitions • Increased energy coupli / efficiency • Agility on the edge	• Collaborative autonomy and swarming • Low-cost air and space platforms • Agile digital and AM • Cooperative lethality • Non-traditional effects • Multi-functional / adaptiv endgame	• Microelectronics, photonics, and materials • Distributed multi-modal sensing • New sensing modalities • Service-based functionality	• Alternative navigation methods • Mesh networking and topology management • Software defined, agile systems with real-time spectrum awareness • BDA / BDI	• Artificial Intelligence: machine learning and machine-based reasoning • Data fusion and visualization • Digital twin • Software Defined Radios

Not All Inclusive - Other Technologies Should be Considered

Networked / Autonomy Technologies

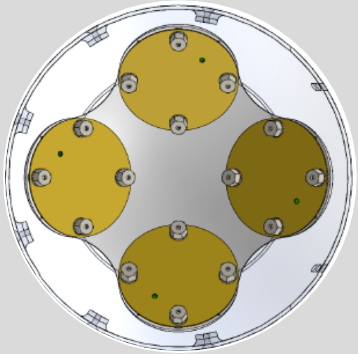
Complexity, Unpredictability, & Mass

- Overwhelm & Confuse
- Low Cost / Cost-Imposing
- Survivable
- Responsive / Flexible Attack
- Stand-Off Capability
- Cooperative

Tech Enablers

Low-Cost Engine Tech

Cooperative Algorithms & Autonomy Modules



Low-Cost DF Sensors, Nav, & Comms

Weapons Open Systems Architectures

Mission Planning Playbooks

Hypersonic Weapons Technologies

Speed & Reach of Disruption and Lethality

Engage Time Sensitive Targets	Provides Flexibility & Precision
Survivable	Enhanced Effectiveness
Stand-Off Capable	Sustain Technology Superiority

Tech Enablers


Solid-rocket-motor technologies


Ordnance technologies for smaller warheads


Advanced materials


Hydrocarbon scramjet-powered propulsion


Guidance, navigation, and control technologies


Affordable system designs and manufacturing approaches

Air-to-Air Weapons Technologies

Speed & Reach of Disruption and Lethality

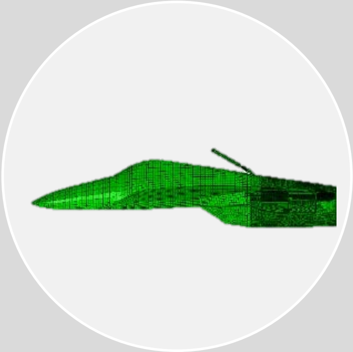
- Increase Load Out
- Lower-Costs
- Platform Persistence in Highly Contested Environments
- Enhance Platform Survivability
- Increase Weapon Lethality

Tech Enablers

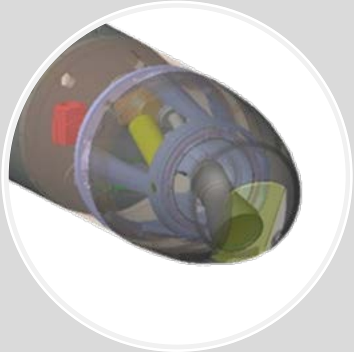
Highly Agile Airframes

Highly Efficient Solid Rocket Motors

Reduced Size, Highly-Lethal Warheads



Modeling & Simulation Tools to Evaluate Performance



Low-Cost Passive Seeker (MSDM)

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Precision Effects Technologies

Speed & Reach of Disruption and Lethality

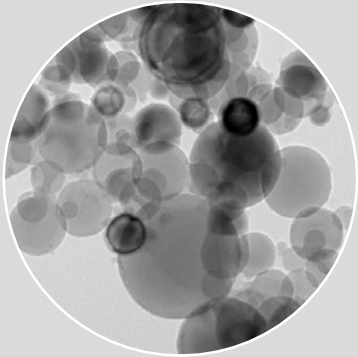
Complexity, Unpredictability, & Mass

- Reduce Collateral Damage
- Optimizes Effect on Target
- Control of Lethal Footprint
- Improves Sortie Flexibility
- Many Target Sets
- Increase load outs

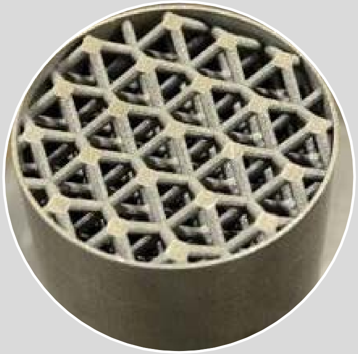
Tech Enablers

Precision Height of Burst Sensor

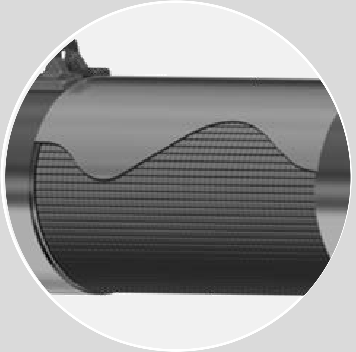
Distributed Embedded Fuze System



Advanced Energetics & Additive Manufacturing



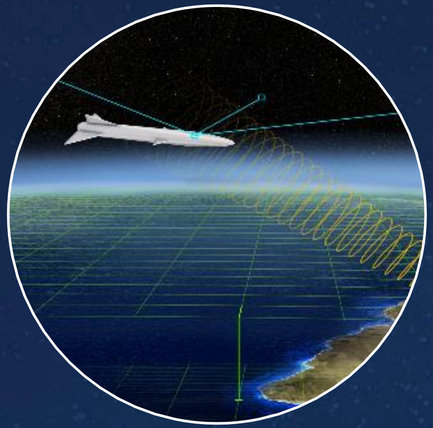
Reactive Materials



Fragmenting Warhead Cases

Pervasive Technology Investments


3D Printing


Alternative Navigation Methods

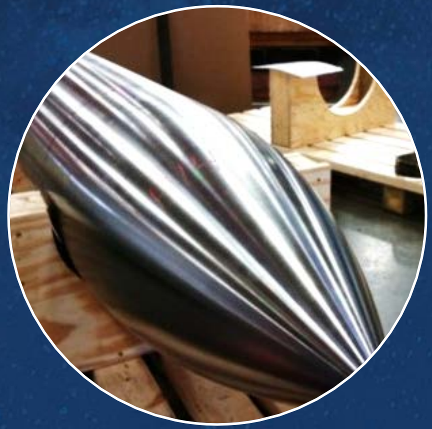

Autonomy / Networked Systems


Selectable / Dialable Effects Tech


Modeling & Simulation


Advanced Seeker Technologies


Advanced Energetics


High Performance Weapon Materials

System Modularity & Software Defined Capability

Cyber Assurance

How We’ve Changed Our Business

Increasing Use of Defense Ordnance Technology Consortium-OTAs (17+)

Selectable Effects Munition (SEM)

Agility

Access to Necessary Materials

Faster Timelines

Hypersonic Weapon Tech Maturation

Synergy of hypersonics S&T

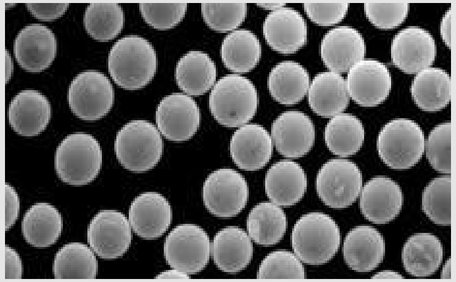
Rapid access to expertise

Counter Air Science & Technology (CAST)

Expedited Contract Award

Obligate + Expenditure Rates

Enhanced AFRL/RW Budget Reviews



Advanced Energetics

High-Temp Energetics for Hypersonics

3D Printing of Explosives

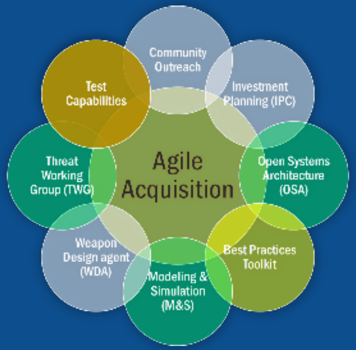
Nanoenergetics

Increasing R&D Reviews and Information Exchange with Industry

OTA to TDI to reduce cost of manufacturing Gray Wolf engine by half

Increasing Use of PIAs for Tech Sprints and Idea Harvesting

Consortium with Team Eglin



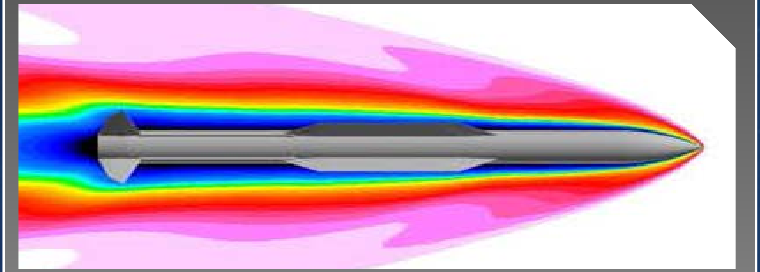
Lots of Ways to Work With Us

Open BAA

FY17 – FY22
Not to Exceed
$500M
Cumulative

White Papers Welcome

Check FedBizOpps
FA8651-17-S-0003



SBIR / STTR

177 Active
SBIR/STTR
$126M

30 Active
STMP
$30M

New Topics as of Nov '18

Check FedBizOpps
https://sbir.defensebusiness.org/

DOTC

18 Active
Initiatives
>$33M

New Topics as of Mar '19

http://www.nac-dotc.org/
DOTC-18-01

AFRL

Questions?

U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND

JSSAP Portfolio
NDIA Update
04 June 2019

Terence Rice

Project Management Engineer

Joint Service Small Arms Program

JSSAP FY19 PORTFOLIO (PROPOSED)

Soldier Lethality - CFT
- Next Gen Family of Ammunition
- Next Gen Squad Weapon Technology
- Next Gen Carbine Tech
- SCOPE (Squad Common Optic Performance Enhancement)

Small Arms Enablers
- Multi Spectral Characterization of Small Arms
- ARES Improved Machine Gun Barrel
- Small Cal Suppressor Blowback Measurement and Quantification
- Multi-Spectral Targeting Sight Dual Channel Crosstalk Reduction
- Prototype Targeting Automated System for RWS
- First Shot Signature Red (Phase II)
- Molten Metal Motion and Deposition
- Plasma Enhanced Chemical Vapor Deposition

Volume
- Optical Material Demonstrator
- External Pressure Rifling
- Novel Recoil Mitigation

Ammunition
- .50 cal All-Purpose Tactical Cartridge (APTC)
- Precision Munitions
- .50 cal One-Way Luminescence (OWL)
- Aeroshell Armor Piercing Projectiles
- Kinetic Energy Pyrotechnic Timed

JSSAP 6.3 Congressional Plus Up
- L2R2
- Active Stabilization
- Small Arms Signature Reduction (SASR) – Crew Served (M240 B/L)

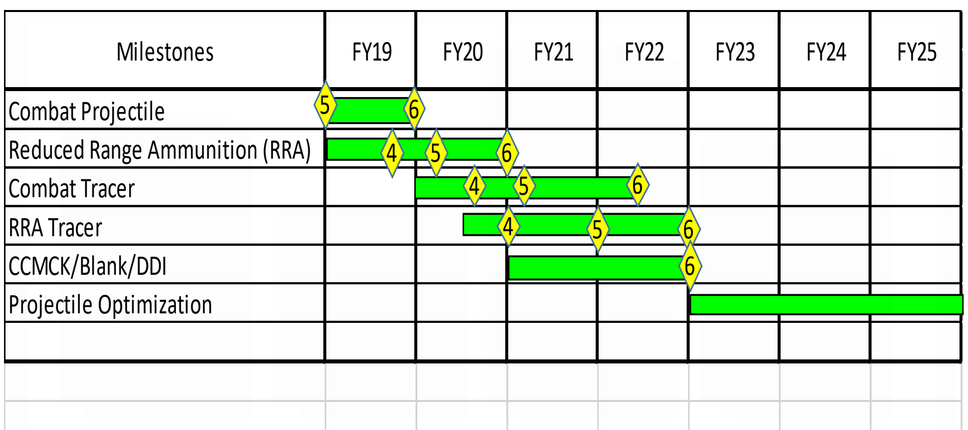
NEXT GENERATION FAMILY OF AMMUNITION

Projectile pictures are examples not actual representations

Combat Round

Reduced Range Ammo (RRA)

Schedule



<u>Purpose:</u>

- Design and development of family of 6.8mm projectiles
- Projectiles directly transitioning to Next Generation Squad Weapon (NGSW) system for cartridge development and fielding

<u>Products:</u>

- Combat round for soft and hard targets
- Training Projectile with trajectory match and reduced Surface Danger Zone (SDZ).
- Tracer rounds not visible by threat targets down range
- Force on Force training cartridge (Close Combat Marking Capability Kit - CCMCK)

<u>Payoffs:</u>

- Provide improved capability vs. a broad spectrum of targets
- Increase soldier survivability (current tracers are seen from all directions)

<u>Partners:</u>

- CCDC Army Research Lab
- Program Manager Soldier Weapons
- Program Manager Maneuver Ammunition Systems
- Maneuver Center of Excellence
- Soldier Lethality Cross Functional Team

<u>Upcoming Events:</u>

- TRL 4 Assessment of Reduced Range – 3QFY19

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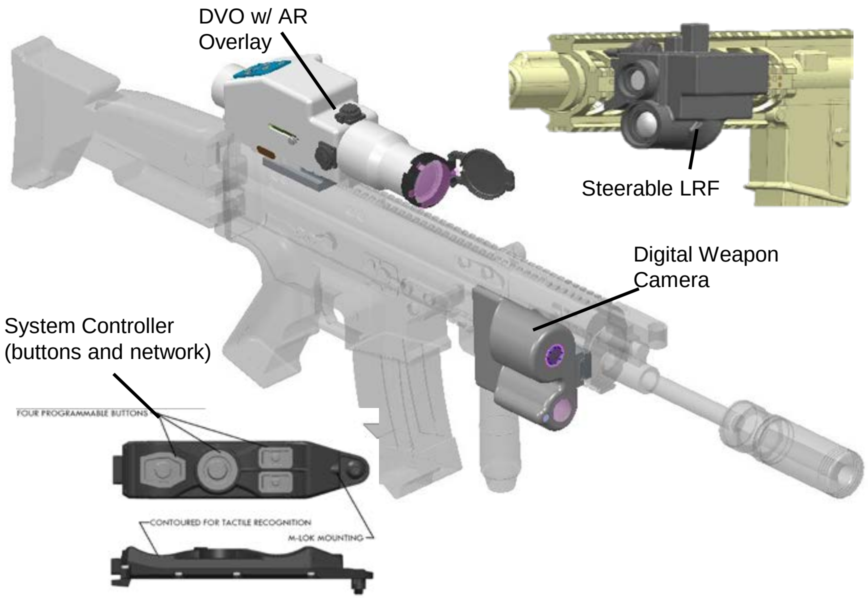
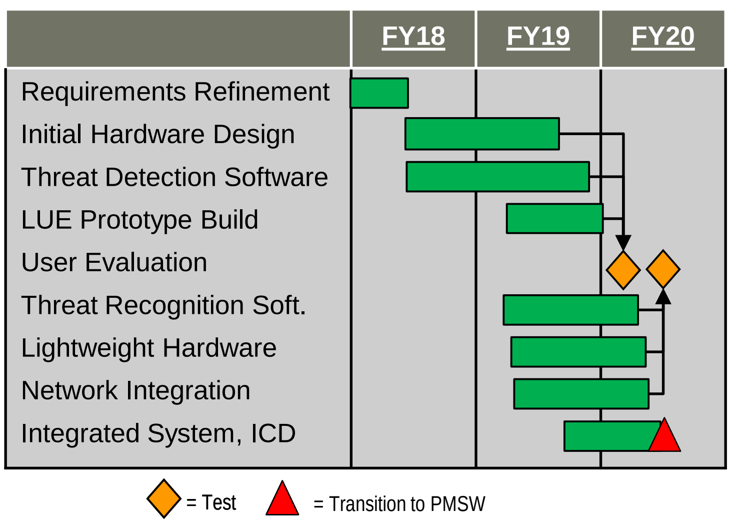
SQUAD COMBAT OPTIC PERFORMANCE ENHANCEMENT (SCOPE)



Schedule



Purpose:

- Pair with the Next Generation Squad Weapons Technology (NGSWT) to mitigate the dismounted combatant threat, as described in Small Arms Ammunition Configuration (SAAC) Study. Develop Fire Control Technologies which meet Next Generation Squad Weapon Fire Control tech insertion timelines and drive down risk on emerging aim augmentation technology for rapid integration/fielding.

Product:

- Full System Interface Control Documentation, including hardware/software/firmware for platform upgradability/maintainability
- Rapid Integration of Digital Fire Control Elements for TRL 6 Rifle-Mounted Advanced Fire Control Optic, including:
  - Digitally Enhanced Aiming when paired with aim augmentation capable weapon platform (steerable barrel, electronic trigger, etc.)
  - Automated Target Recognition/Tracking Algorithms
  - Direct View Primary Optic with Augmented Reality Overlay
  - Steerable Rangefinder which accommodates for aim error
- Integrated Design leveraging Emerging Technologies
  - Artificial Intelligence (AI) for threat recognition and prioritization
  - AI Framework for integration with higher order data systems
  - Advanced Optical Materials for order of magnitude weight savings

Payoff:

- TRL 6 demonstrator of fire control technologies, including hardware for Soldier touch points and feedback
- Initial increment AI capability, appropriate for dismounted use
- System Design to Improve P(I) at max effective range of the weapon in order to mitigate threat (per SAAC modeling)
- Drive advancement of bleeding edge technologies required to achieve objective capabilities outlined in Next Generation Squad Weapon Fire Control requirement and support Soldier Lethality CFT vision

POC: Ross W. Towers, FCDD-ACW-FN
ross.w.towers.civ@mail.mil

NEXT GENERATION SQUAD WEAPONS TECHNOLOGY (NGSWT)

CT Polymer Cartridge

Mid-Cal Projectiles

Purpose:

- Provide weapon integrated technologies leveraging Lightweight Small Arms Technologies (LSAT), Future Advanced Squad Technologies (FAST), 6.5mm Cased Telescoped (CT) Carbine, and Small Arms Ammunition Configuration (SAAC) study results
- Provide for fire control integration - Squad Combat Optic Performance Enhancement (SCOPE) program

Product:

- Demonstration of Weapon/Cartridge for Automatic Rifle (TRL 6)
- Optimized Cartridge Configuration - weight/size vs lethality
- Case Telescoped (CT) Cartridge
- Mid-Caliber Projectiles (TRL 5/6)
- Lightweight Materials
- New Barrel Manufacturing Processes
- Muzzle Device
- Integrated Electromechanical (E/M) Trigger and Data/Power Transfer Rail - interfaces for SCOPE
- TDP for Weapon, Ammunition, and Fire Control Interface

Payoff:

- Provides a TRL 6 platform and growth for future squad weapons by providing the next generation cartridge (carbine, SDMR, etc.)

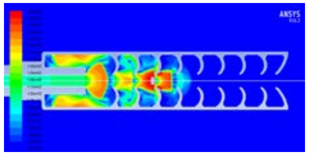
Partners:

- AAI Corp. (Textron Systems)

(U) Schedule

	FY17	FY18	FY19
Program Planning			
Weapon and Cartridge Technology Tradeoffs		4	
Fab. Mann Barrel & Cartridge to critical threshold		4	
Test & Refine Firing Fixture & Function Cartridge		5	
Integrate chamber, barrel, muzzle device		4	
Fab, Test & Refine Integrated Weapon & Cartridge			6
Fire Control Integration Development			6
Projectile Development			6

NEXT GENERATION CARBINE TECHNOLOGY



Signature/Recoil Reduction

Advanced Barrel Wear

Evaluation Fixture

Schedule

	FY18	FY19	FY20
Program Planning			
S&T Stakeholder Analysis			
Evaluation Fixture			5
Signature and Recoil Reduction	4		5
Advanced Barrel Wear		4	5

Purpose:

Development and demonstration of critical component level technologies that provide light weight, reduced signature (visual, acoustic), lower-recoil rifle development to enable increased system performance

Product:

- Develop evaluation and demonstration fixtures
  - Allow for part interchange within single platform
- Characterization of advanced barrel technologies
  - Bore erosion, velocity and dispersion degradation
  - Various technologies
- Characterize visual and acoustic signature and recoil technologies
  - Various technologies targeting signature and recoil

Payoff:

- Enable component development and evaluation
- Knowledge transition of advanced component technologies

Partners:

- ARL

Transition:

- Knowledge transition to PMSW FY20

Capability Gap / Opportunity Area(s) Focus:

- *NGSW - Barrel erosion, signature, and recoil mitigation*

Key Upcoming Events:

- *Obtain fixture and ammunition hardware*
- *Obtain advanced barrels and signature/recoil devices*
- *Characterization Testing*

POC: Thomas C. Grego
Thomas.c.grego.civ@mail.mil; 973-724-9059

US ARMY SUPPORT OF USCG LETHAL REDUCED RANGE AMMUNITION

M80 SC18 LW3 P6?

Schedule

Tasks FY(19)	2QTR	3QTR	4QTR
Current RRTA design review; analysis, selection			
Engineering Support			
Ballistic Testing			
Ballistic Analysis			
Program Reviews			
		TRL5	TRL6

Purpose:

- Provide program support and comprehensive ballistic testing with analysis for the USCG Lethal Reduced Range Ammunition

Product:

- Lethal Reduced Range meeting USCG needs
- Approximate TRL 6 TDP & Demonstration

Payoff:

- Provide support and analysis to USCG that will provide understanding of their product, leveraging Army experience and techniques being applied to the US Army RRTA programs
- Flight and terminal ballistic performance characterized as a function of range.
- Evaluation of JSSAP provided contractor M240 test data

Partners:

US ARMY CCDC-AC; USCG

Transition:

JSSAP-to-USCG

Capability Gap / Opportunity Area(s) Focus:

Lethal Limited Range ammunition to limit collateral damage

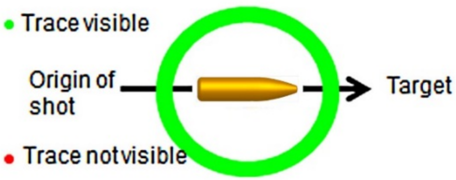
Key Upcoming Events:

- Requirements review with CCDC-AC / USCG
- RRTA design Review
- Contractor Support Kickoff

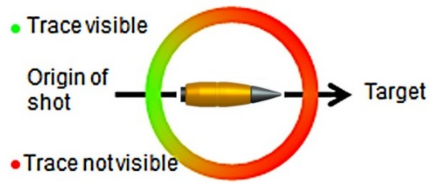
POC: Mark Minisi (x4326)
Shawn Spickert-Fulton (x6088)

ONE-WAY LUMINESCENCE (OWL) 0.50”

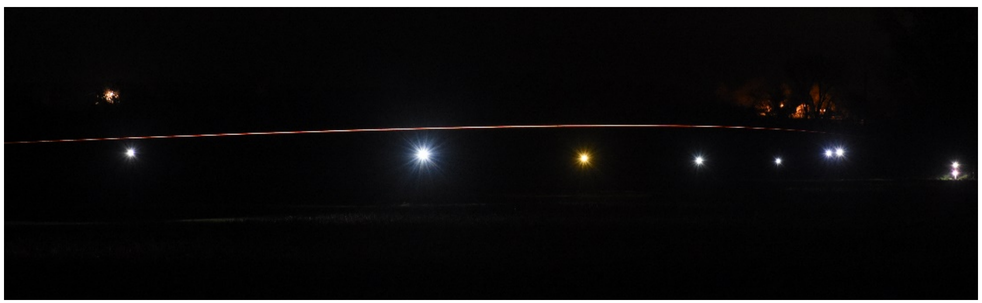
Approximate Visual Signature with Current Tracers



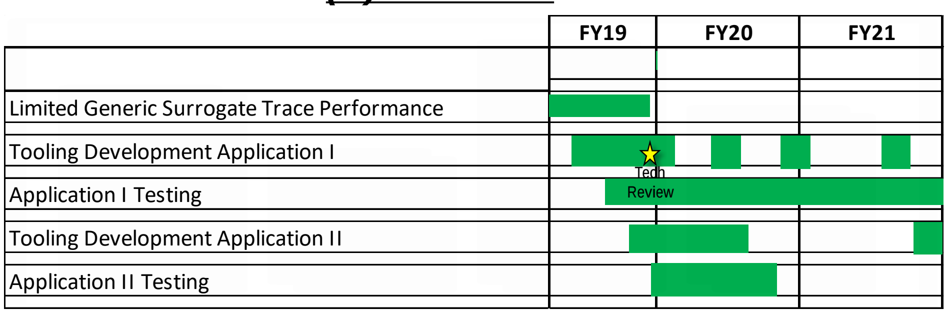
Approximate Visual Signature with One Way Luminescence



.50 Cal Tracer Example



(U) Schedule



Purpose:

- Develop 0.50” tracers not visible from locations down-range of projectile (enemy locations) during flight
- Will utilize 5.56mm & 7.62mm OWL government technology toward 0.50” type projectiles

Product:

- Cal 0.50” small scale one-way tracer manufacturing and testing capability
- Begin gathering test data QTR2 FY19
- Incorporate 5.56mm/7.62mm OWL lessons learned

Payoff:

- Increase soldier survivability (current tracers are 2-way)
- Decrease ball-trace mismatch
- Decrease tracer muzzle signature
- Decrease tracer caused range-fires
- Potential cost savings

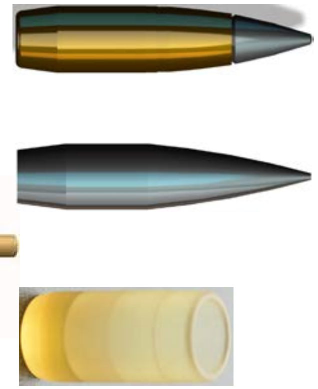
Partners:

- Project Manager – Maneuver Ammunition systems

Key Upcoming Events:

- June-Sept continued charging and trace performance testing
- Updated formulation and projectile design iterations

PRECISION MUNITIONS



Purpose:

- Develop scalable precision munition technologies to increase Warfighter capability in anti-materiel, anti-personnel and other specialized missions.

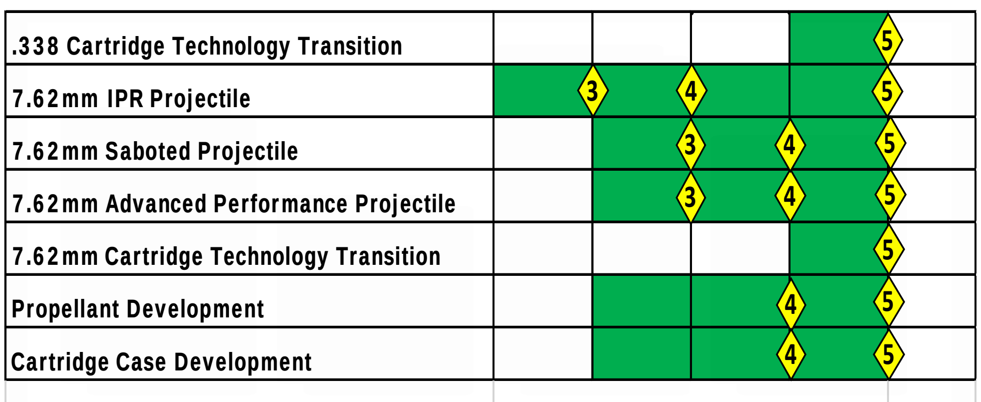
Product:

- .338 caliber Anti-Material Cartridge
- .300 caliber Improved Performance Round
- 7.62mm Improved Performance Round

Payoff:

- Increase in Probability of Hit and Probability of Incapacitation due to increased projectile velocity, flatter shot trajectory and reduced projectile wind/environmental sensitivity
- Increased effective system range
- Increased capability in hard-target penetration

Schedule



Partners:

- Polymer Technologies Inc.
- Concurrent Technologies Corporation

Transition:

- The CDD is currently being revised
- Working with PM-MAS on the TTA

Key Upcoming Events:

- New .338 caliber penetrator concepts
- 7.62mm projectile down-select
- Sabot design enhancements

POC: Pablo Vasquez
pablo.vasquez.civ@mail.mil
973-724-4778

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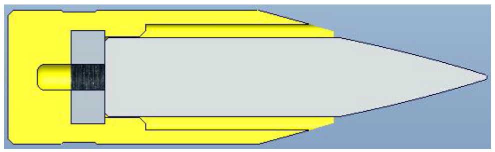
.50 CAL ALL PURPOSE TACTICAL CARTRIDGE



Current M903 SLAP

Purpose:

- Develop a single .50 caliber All Purpose Tactical Cartridge (APTC) capable of performing the mission tasks of M8 API and M903 SLAP.
- Incorporate small caliber munitions developmental efforts, including One Way Luminescence (OWL) and Green Primer

Product:

- Prototype .50 caliber APTC ammunition
- Scalable, caliber-agnostic munition technology which can be leveraged by future efforts

Payoff:

- Addresses capability gaps in .50 Caliber Munitions CDD
- Increased probability of hit due to increased effective range

Partners:

- JSSAP, PM MAS, MCoE, ARL

Transition:

- PM MAS Endorsement – new start program begins FY20

Key Upcoming Events:

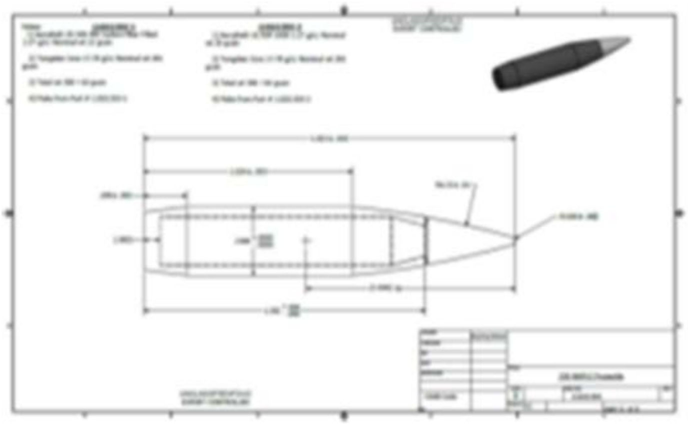
- Propellant optimization via CRADA with SMP, 3Q FY19
- Hard target testing at ARL, 4Q FY19
- EPVAT/Dispersion testing at ATF, 4Q FY20

Schedule

Program Activities	FY18	FY19	FY20	FY21	FY22
Capability Assessment of DODICs					
R&D/AoA on Cartridge Designs		4			
Design Downselect and T&E		5	6		
EMD					

POC: Gavin McFarland, FCDD-ACM-MI
gavin.j.mcfarland.civ@mail.mil

AEROSHELL ARMOR PIERCING PROJECTILES



Purpose:

- Provide Snipers and Advanced Marksmen with the capability of shooting **low-cost** armor-piercing projectiles that will safely pass through suppressors, muzzle brakes, and flash-hiders. Greatly reduce sniper-barrel wear. Provide all Warfighters with new ammunition that will extend barrel life and be environmentally-friendly.

Product(s):

1. RFI for Market Survey – market Survey Report
2. 120 prototype rounds in (a.) 6.5 Creedmore, (b) .300 Norma Magnum, and (c.) .338 Norma Magnum.
3. Developmental Test Plan.
4. Developmental Test and Report.
5. Technology Transfer to Industry via CRADA

Payoffs:

- An understanding of the art of the possible low-cost sniper-grade armor-piercing ammunition.
- Provide snipers and advanced marksmen an affordable sniper-grade ammunition set in relevant future calibers.

Transition:

- Transition 1: USG studies, prototyping and test fires to inform the future requirement.
- Transition 2: Competitive industrial Technology Transition.

Opportunity Area Focus:

- Advanced Ammunition Development

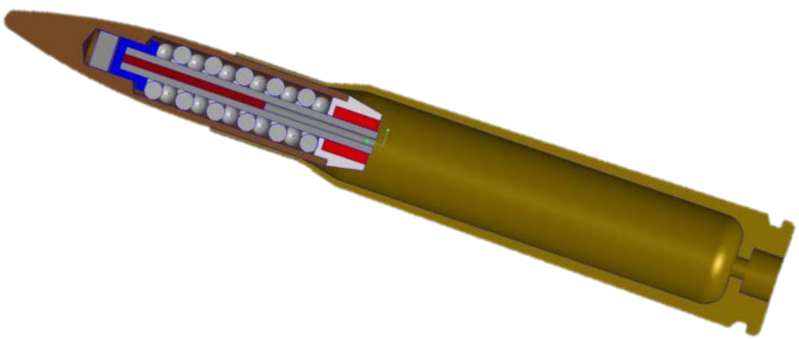
(U) POC: Mr. Gus Taylor, NSWC Crane
(812) 296-1393, Lucius.taylor@navy.mil

PATENT APPLICATION NUMBER 62/779,234

Schedule

	FY19	FY20	FY21
Program Planning			
Market Survey	3		
Market Survey Report	4		
Prototyping		3	
Prototype Live Fires		4	2
Test Report			1
Technology Transfer			3

KINETIC ENERGY PYROTECHNIC TIMED PROJECTILE

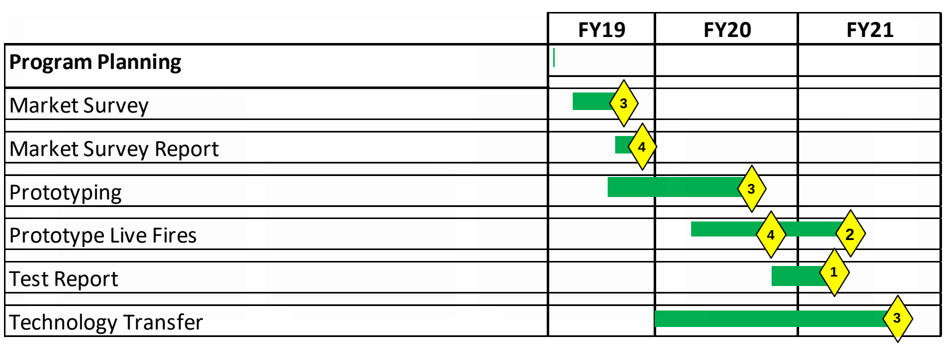


Purpose:
• Provide increased hit probability while maintaining sufficient kinetic energy to neutralize targets.

Product(s):
1. RFI for Market Survey – Market Survey Report
2. 500 Prototype rounds with various delay times.
3. Developmental Test Plan.
4. Developmental Test and Report.
5. Technology Transfer to Industry via CRADA

Payoffs:
• An understanding of the art of the possible on increasing incapacitation of Unmanned Aerial Systems
• Provide user with "shotgun" capability at extended ranges utilizing existing, fielded weapon systems.
• Potential for Lower Collateral Damage Projectile for use in CONUS situations.

Schedule



Transition:
- Transition 1: USG studies, prototyping and test fires to inform the future requirement.
- Transition 2: Competitive Industrial Technology Transition.

Opportunity Area Focus:
- Advanced Ammunition Development

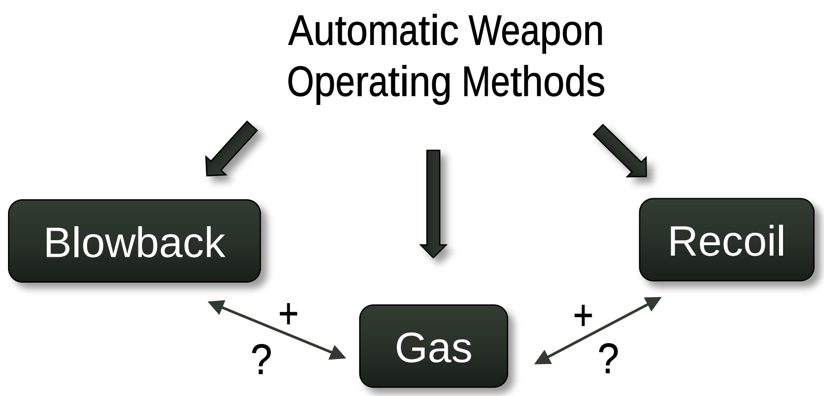
Key Upcoming Events:
- None Schedule at This Time

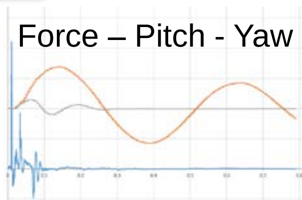
POC: Mr. Lucas Allison, NSWC Crane
(812) 854-5300, Lucas.Allison@navy.mil

PATENT APPLICATION NUMBER 62/779,234

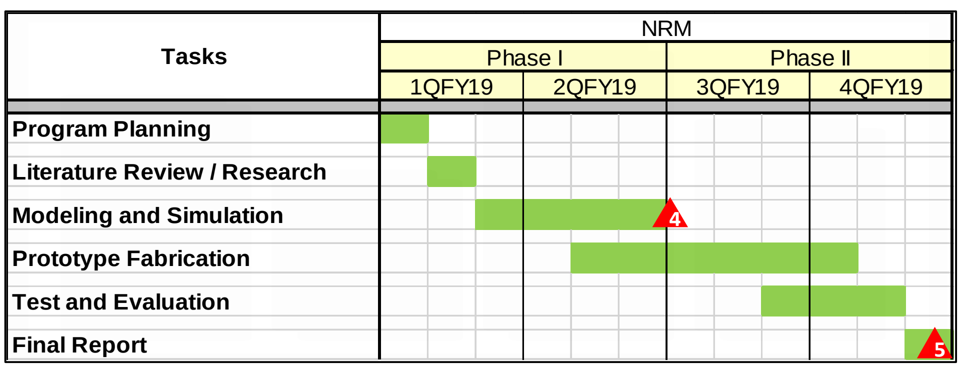
DISTRIBUTION A. Approved for public release: distribution unlimited

NOVEL RECOIL MITIGATION





(U) Schedule



Purpose:
- Development of advanced recoil mitigation automatic weapon operating mechanism for NGSWT / NGCT
  - Unique combination of automatic operating methods

Product(s):
- Phase I
  - Literature Review
  - Modeling and Simulation
- Phase II
  - Prototype Fabrication
  - Test and Evaluation using WRSS
  - Final report documenting all findings

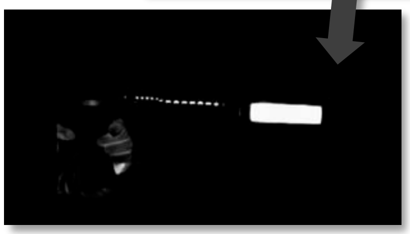
Payoffs:
- Reduced felt recoil
- Improved accuracy and controllability
- Improved Probability of hit P(h)

Partners:
- PM-SW

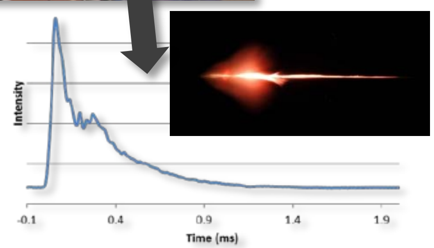
Key Upcoming Events:
- Program Planning

POC: Adam L. Foltz, P.E.
adam.l.foltz.civ@mail.mil, **973-724-7096**

MULTI-SPECTRAL SIGNATURE CHARACTERIZATION OF SMALL ARMS



Thermal Signature



Flash Signature

Schedule

	FY17	FY18	FY19
Program Planning			
Draft NATO AEP for flash signature measurement			
Flash method validation testing			
Draft NATO AEP for thermal signature measurement			
Thermal signature method validation testing			
Conduct baseline signature measurements			

Purpose:

- Develop, validate, & document quantitative, multi-spectral flash & thermal weapon signature measurement methods

Product:

- NATO test standards
- Baseline weapon & suppressor signature measurements

Payoff:

- Improved signature data: quantitative vs. qualitative
- Objective performance evaluation:
    - Quantitative vs. qualitative data
    - Objective programmatic decision making

Partners:

- DSTL (UK), FFI (Norway), DRDC (Canada), SOCOM

Transition:

- Government & private test centers
- Multiple test center customers including SOCOM (SURG)

Capability Gap / Opportunity Area(s) Focus:

- Small arms weapon signatures

Key Upcoming Events:

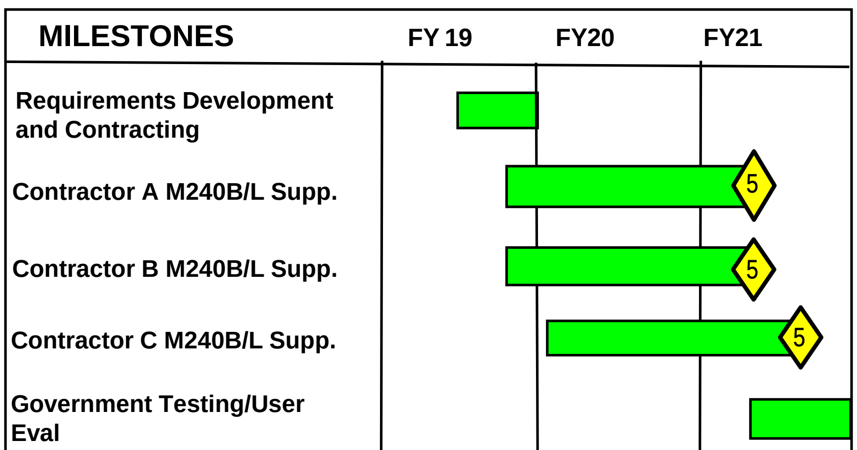
- Thermal signature validation testing at NSWC Crane
- 7.62 mm machine gun suppressor signature measurements

POC: Dr. David F. Dye,
david.f.dye@navy.mil, +1-812-854-6616

M240B/L SUPPRESSOR

DEVCOM ARMAMENTS CENTER

(U) Schedule & Cost



***Purpose*:**

- The purpose of the project is to develop an M240B/L signature suppressor that meets Joint Service requirements for flash, sound, durability, dispersion and point of impact, ease of use, weight, and size.

***Product*:**

- Joint Service developed M240B/L Signature Suppressor requirements.
- Minimum three (3) signature suppressor designs for M240B/L.
- Tech Data Package(s) as appropriate.
- Final design reports, test results, analysis results.
- Minimum three (3) and up to fifty (50) prototype suppressors of each design.

***Payoff*:**

- Provides signature suppression capabilities for the M240B/L that meet military suppression standards while providing a durable platform that withstands rigors of military use.
- Develops technologies that can be transitioned to other signature suppression systems.

***Partners*:**

- Currently working with three(3) different industry partners.

Transition:

- No formal Technology transition Agreement (TTA) in place.
- Will transfer to PM SW M240B/L Signature Suppressor program or other Joint Service M240B/L Signature Suppressor program.

Opportunity Area Focus:

Opportunity Area 1 – Signature Reduction.

POC: Adam M. Jacob,
adam.m.jacob.civ@mail.mil
(973) 724-0535

FIRST SHOT SIGNATURE REDUCTION PHASE-2 PROTOTYPE ADVANCEMENT

Purpose:

- Reduce 1st-shot weapon signature in low light to conduct operations without detection. First shots produces a brighter flash.

Product:

- Continue development of a convenient gas purge system to remove oxygen from the barrel to reduce the weapon flash from the first shot.

Payoff:

- At the completion of the program we will receive oxygen purging devices.

(U) Schedule

MILESTONES	FY19 Q4	FY20 Q1/2	FY20 Q3/4	FY21 Q1
	J/A/S	O/N/D/J/F/M	A/M/J/J/A/S	O/N/D
Finalize Contract / Kickoff Meeting	4			
User Assessment of Ph-1 Device & Design Ph-2 Prototypes				
Design Review PH-2				
Bench Test Design				
Build Prototypes				
Conduct Flash & Pressure Tests				
On-Site Review				
Submit Phase 2 Report				

Milestone Indicators: TRL or SRL: Significant Activities:

Partners:

- Knight's Armament Company (KAC)

Transition:

- *Transition to PM Soldier Weapons for further advancement.*

Capability Gap / Opportunity Area(s) Focus:

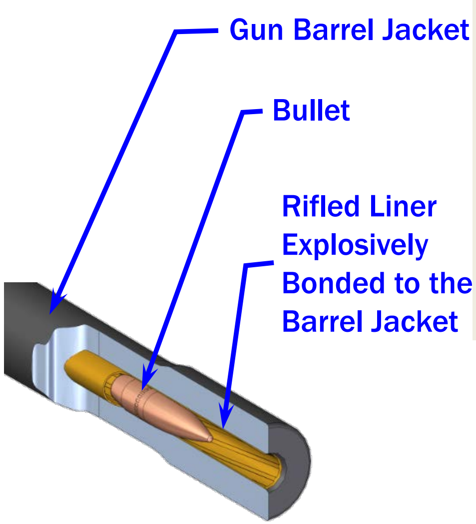
- *Reduce or close the gap for position detection*

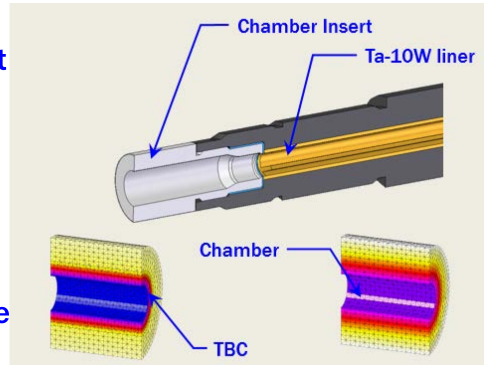
Key Upcoming Events:

- *Demo firing of Phase 1 prototype at APG - Completed*
- *Finalize Phase 2 SOW*
- *Execute contract with KAC*

POC: John T. Brennan – Engineer FCDD-ACW-WF
john.t.brennan28.civ@mail.mil
973-724-6494

ARES IMPROVED MACHINE GUN BARREL





Tasks	2QFY18	3QFY18	4QFY18	1QFY19	2QFY19	3QFY19	4QFY19
	ARES Improved Machine Gun Barrel						
Cook-off Reduction Analysis/Test	3						
Integrated Imp.Bbl Analysis							
Integrated Imp.Bbl Fab.							
Integrated Imp. Bbl Testing							
Fab of Final Prototype							4

Principle Investigators
Ryan Berg, ARES, Inc., Port Clinton, OH
Alex Smith, CCDC-AC Project Officer, CCDC-AC

\# **TRL**
Contract Award

Purpose:

- Develop, fabricate, and test a superalloy lined, jacketed barrel with an isolated chamber.

Product:

- Development and analysis of cook-off reduction through thermal isolation of chamber.
- Development and analysis of superalloy lined barrels for improved wear.
- Results of modeling and simulation, testing.
- Barrel prototype.

Payoff:

- Demonstration of chamber isolation technology and improved cook-off potential. Potential for hotter barrel with reduced cook-off.
- Demonstration of rifling technologies for superalloy liners. Superalloy liners have a variety of advantages but traditionally suffer from difficulty to rifle.
- Feeds PM SW barrel improvement product improvements.
- Demonstration of wear performance in various superalloy liners. Potential to meet wear requirements for advanced projectiles in support of Next Gen. Squad Weapons (NGSW).

Transition:

- PM-CSW

Capability Gap / Opportunity Area(s) Focus:

- Potential elimination of spare barrel – soldier load
- Extending barrel life – lifecycle cost savings

POC: Alexander Smith,
973-724-9642,
Alexander.p.smith28.civ@mail.mil

EXTERNAL PRESSURE RIFLING

7.62 mm barrel for external pressure rifling with electric opening pressure chamber

Purpose:

- Develop new rifling technology, forming rifling grooves under extreme external pressures, where the entire outer surface of the barrel is subjected to high external pressure and the inside is supported by a hard full length mandrel with the rifling geometry machined into the mandrel.

Product(s):

- Three prototype barrels with rifling profiles to be determined through discussions with Army

Payoffs:

- This rifling process will allows the gun designer to choose barrel materials that would be impossible by any conventional manufacturing method.

Partners:

- PM-SW

Key Upcoming Events:

- Program Planning

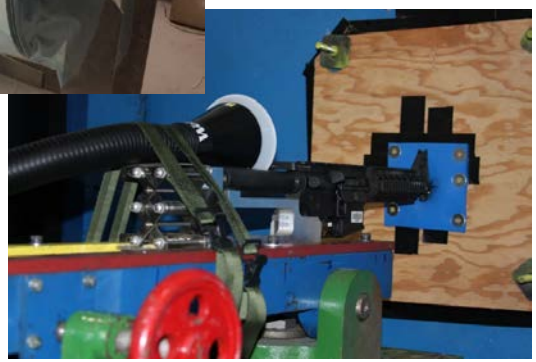
POC: David Ng. david.ng@us.army.mil , 973-724-6981

Schedule

External Pressure Rifling

		2019								2010			
		May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Task 1.	Determine Army Requirements												
Task 2.	Make barrel blanks and mandrels												
Task 3.	External Pressure rifle grooves												
Task 4.	Characterize the rifle geometry												
Task 5.	Finish Machine the barrels												
Task 6.	Government verification												
Task 7.	Prototype Barrel Delivery												

SMALL CALIBER SUPPRESSOR BLOWBACK MEASUREMENT AND QUANTIFICATION



(U) Schedule

	FY17	FY18	FY19
Blowback Measurement			
Planning, Prelim Experiments, Equip. Acquisition			
Test and Data Analysis			
Test Operations Procedure (TOP) Generation			
NATO AEP Generation			
Validation Testing and Document Revision			
Document Review and Approval			

Purpose:

- Currently there is no standard for measuring blowback in a way that is repeatable, and thus blowback is not accurately quantified when assessing small arms suppressors.
- The purpose of this project is to develop a standard method and conceptual system to accurately measure and quantify blowback produced by small caliber suppressors.

Product:

- Initial research, assessment, and concept formulation.
- Concept development, fabrication, testing and validation of a system and method to measure and quantify blowback effects.
- Final Test Procedure documents (Test Operations Procedure (TOP), NATO Allied Engineering Publication (AEP) Volume.

Payoff:

- Method developed will standardize the way to measure and quantify blowback, and be used in Army, SOCOM, NATO and possibly industry, as well as other services.

Partners:

- Naval Surface Warfare Center (NSWC) Crane, CCDC ARL, Army Test and Evaluation Center (ATEC), NATO Land Capabilities Group – Dismounted Soldier Systems (LCG-DSS) Weapons and Sensors Sub Group

Transition:

- Proposed method to be transitioned to Army in form of Army TOP, and to NATO in the form of a NATO Standard Recommendation (STANREC) AEP/Volume.

Capability Gap / Opportunity Area(s) Focus:

- Opportunity Area 1: Signature Suppression.

Key Upcoming Events:

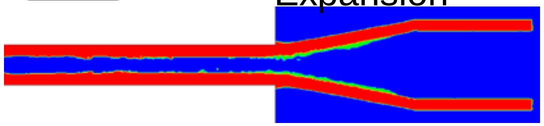
- Completion of final test methods and formal approval – Spring/Summer 2019.

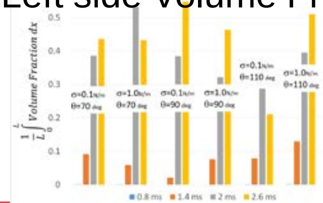
POC: Adam Jacob, adam.m.Jacob.civ@mail.mil, 973-724-0535

MOLTEN METAL MOTION AND DEPOSITION

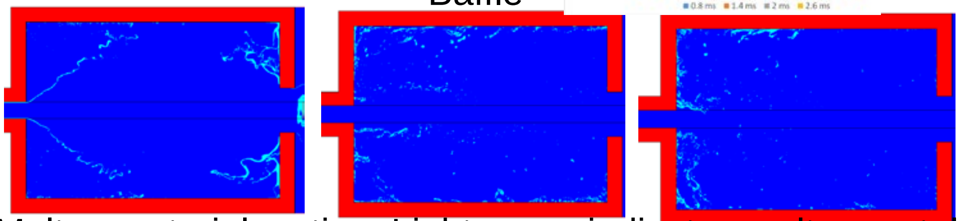
Left side Volume Fraction

Expansion

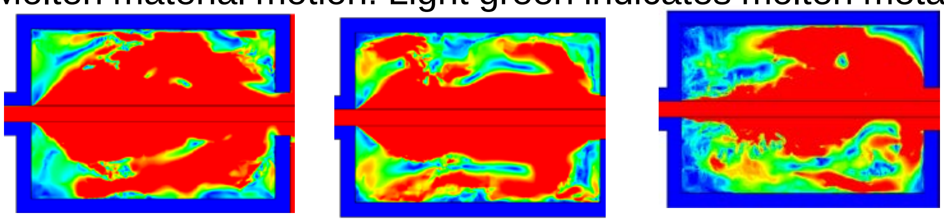




Baffle



Molten material motion: Light green indicates molten metal



Velocity contours showing low velocity to rear of chamber

(U) Schedule & Cost

MILESTONES	Q1	Q2	Q3	Q4
1. Geometry/surface properties, literature review				
2.Develop models/test				
3.Surface tension/contact angle studies				
4. Effect of changes in the system geometry				
5. Carbon/grain particles				
6. Report/Documentation				2

(U) Purpose:

•To enhance the capabilities to predict the areas most prone to erosion and fouling caused by the deposition of molten metal along the internal flow paths of small arms weapon systems

(U) Products:

•Tools to perform simulations of the metallic material motion and deposition along flow path surfaces.

•Analysis of the effects of system parameters on the metal deposition characteristics

•Report documenting the results

(U)Payoffs:

- Improved insight into potential issues with metallic build-up
- Ability to test the effects of different design geometries
- Ability to test the effects of different surface conditions
- Visualization of the molten material motion and deposition

(U) Partners:

- Leveraging test data from the A. Foltz study.

(U) Key Upcoming Events:

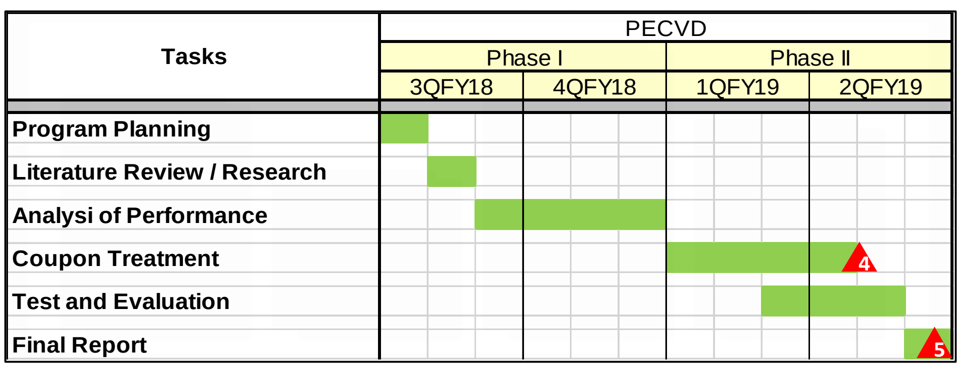
- Study of drop/surface interaction properties.
- Study of longer term flow conditions
- Study of system geometric changes
- Study with particles

POC: Laurie A. Florio, Ph.D.

APPLICATION OF PLASMA ENHANCED CHEMICAL VAPOR DEPOSITION (PECVD) TO PREVENT PLATING OF METALLIC MATERIALS

Significant buildup of material on suppressor baffles from endurance firing

(U) Schedule



Purpose:

- The proposed work aims to study the adhesion mechanisms of copper to Plasma Enhanced Chemical Vapor Deposition applied coatings
  - Leverage current Durable Solid Lubricant (DSL) development efforts by exploring alternative formulations capable of withstanding high temperature environment applications
  - Identify and define critical material property characteristics directly associated performance requirements
  - Develop bench scale test methods to verify performance parameters

Product(s):

- **Phase I**: Literature review, Analysis of performance requirements and operating conditions, Development of bench scale testing methods

- **Phase II**: Bench scale coupon sample treatment, Bench scale testing of applied coating options, Analysis of results

Payoffs:

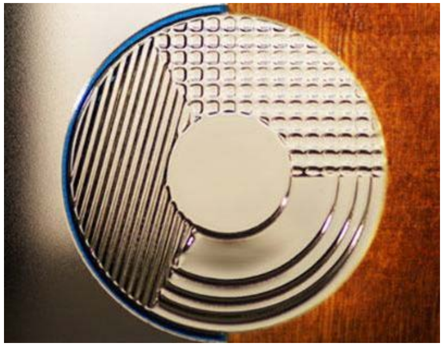
- Enhanced performance coating resistant to plating of metallic materials
- War fighting operation benefits**:** Improved Weapon System Performance, Improved maintainability, Reduced weight

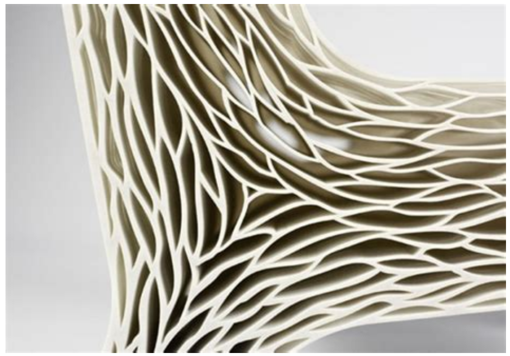
Partners:

- PM-SW

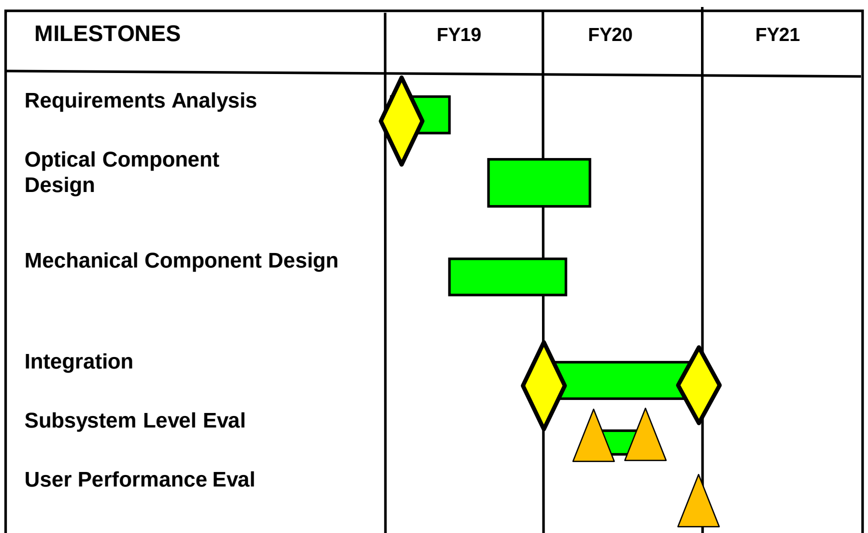
POC: Adam L. Foltz, P.E.
adam.l.foltz.civ@mail.mil, **973-724-7096**

OPTICAL MATERIAL DEMONSTRATOR (OMD)





Schedule



Purpose:
- Leverage advances in manufacturing technology to demonstrate a 3-D printed optic.
- Provide optical performance commensurate with fielded optics, at significantly reduced weight and cost

Product(s):
- TRL 6 printed optical system, using low-weight housing material and printed gradiated index (GRIN) optical system
- Multiple optical designs built around GRIN technology, facilitating tailoring of performance to other capability gaps
- Multiple high strength, ultra-low weight mechanical design structures which can withstand weapon pyroshock

Payoffs:
- Significantly reduced weight of optical systems
- Reduces weight limitation induced by conventional optics; greater sighting capability at the same or lower weight
- Decrease manufacturing time and overall optic cost.
- Improved Government and industry capability to leverage advanced optical structures

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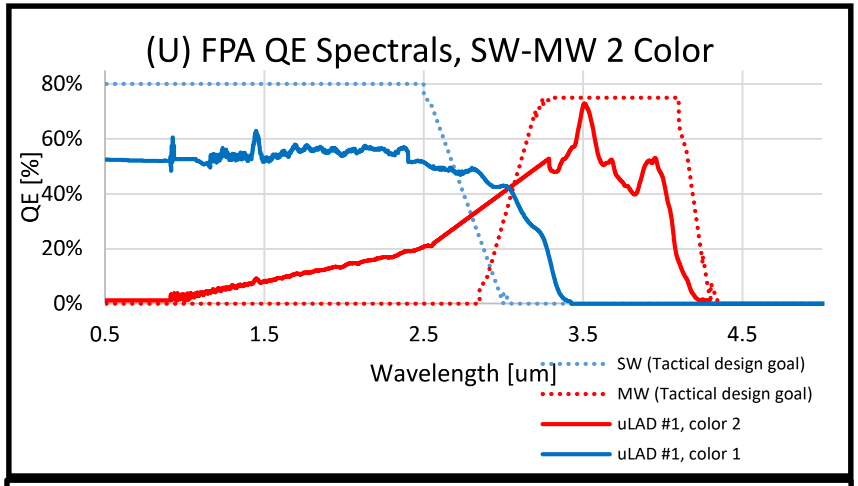
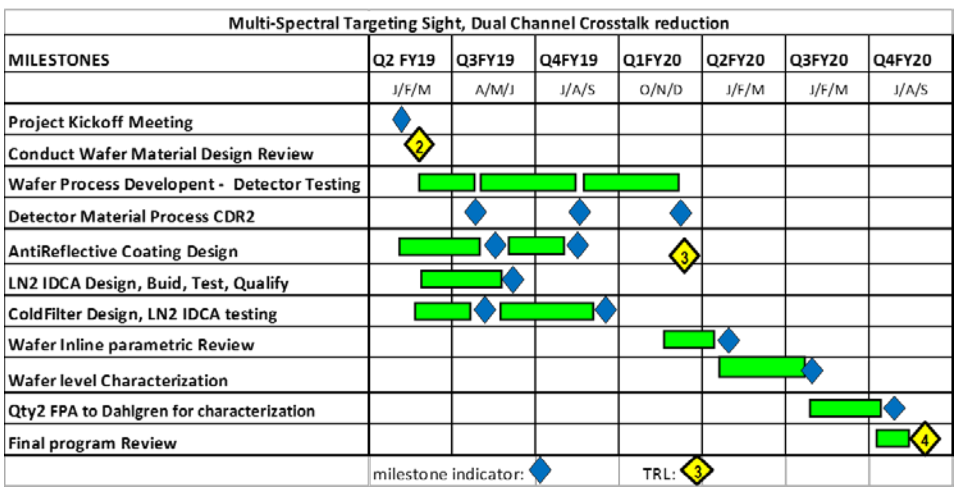
MULTI-SPECTRAL TARGETING SIGHT DUAL CHANNEL CROSSTALK REDUCTION



(U) Dual Channel SW/MW Quantum Efficiency (QE) Plot
SWIR (Blue) and MWIR (Red) Channel response - current and design (tactical)

Schedule



Purpose:

- Reduce spectral crosstalk in 2 band SWIR/MWIR imager
- Detector material spectral absorber development
- Cold-filter spectral notch development
- Anti-Reflective Coating development

Product:

- Research and simulation of spectral absorbance tuning of III-V wafer process material absorbers.
- Established reduced crosstalk wafer process flow.
- In-line test results of wafer test structure parametrics.
- Wafer growth/processing to optimize spectral absorbance
- FPA build and characterization report- TRL 4.

Payoff:

- Development of a multi-spectral SA-FC targeting FPA
- Potential to inform requirements for future SA-FC solutions

Partners: Lockheed Martin-Santa Barbara Focalplane

Transition: ONR/USMC Integrated Clip-on Advanced Targeting Sight (ICATS)

Capability Gap / Opportunity Area(s) Focus:

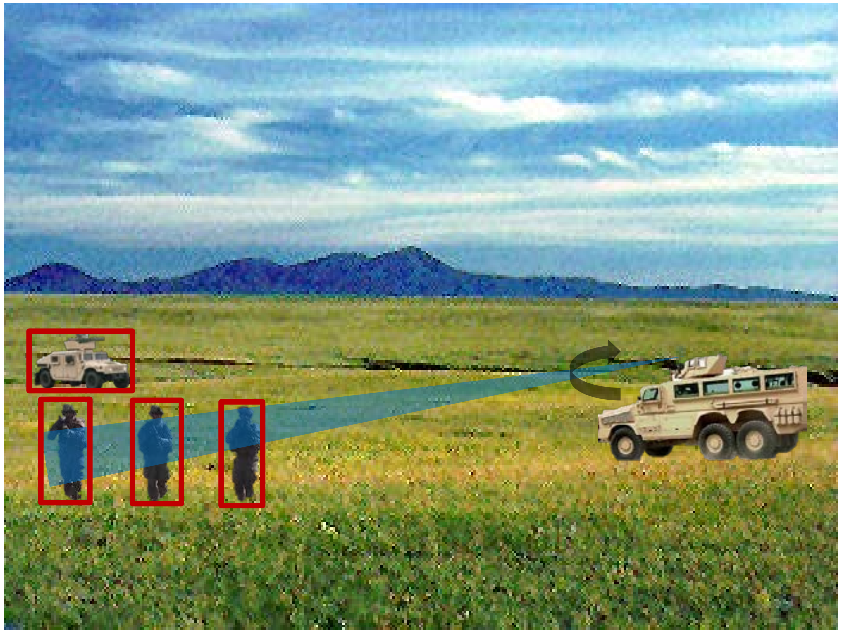
Six of The (ICDT) Soldier Capabilities-Based Assessment (CBA) Functional Solution Analysis (FSA) Gaps- Including:

Key Upcoming Events:

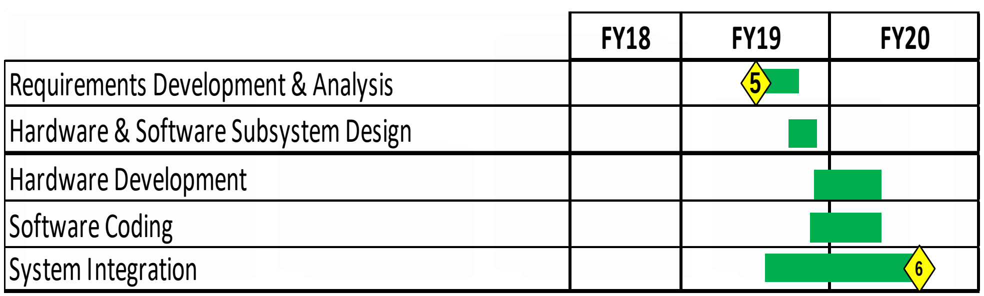
LM-SBF Kickoff Meeting Jan19
Round 1 Detector Material CDR Apr19
Coldfilter Requirements Down select Apr19
ARC CDR Aug19

AUTOMATED TARGETING SYSTEM FOR REMOTE WEAPONS STATIONS

DEVCOM ARMAMENTS CENTER



Schedule



Purpose:

- Enhance the mission effectiveness of existing Remote Weapons Stations (RWS) with an Automated Targeting System (ATS).

Product:

- Prototype to perform real-time target detection, identification, and tracking.

Payoff:

- Enables RWS automation for remote/unmanned applications
- Provides Aided Target Recognition (AiTR) for transition to programs of record
- ***Partners:***
- JSSAP, NSWCDD

Transition:

- Transition through integration with multiple Army and Marine Corps programs/projects

Capability Gap / Opportunity Area(s) Focus:

- Remote Weapons Stations (RWS)/Externally Powered Weapons (EPW)

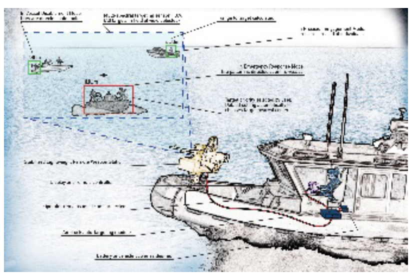
Key Upcoming Events:

- Contract Award & Kickoff Meeting – 3rd Q FY19

POC: Lee Beale, richard.beale@navy.mil, 540-653-3019

ACTIVE STABILIZATION TECHNOLOGIES

(U) Auto-Targeting Remote Operated Weapons



(U) Schedule & Funding

MILESTONES	FY16	FY17	FY18	FY19	FY20
Remote Weapon Status					
Requirements	3				
Sytem Development					
Test1 - Crane					
Test2 - Aimlock					
Live-Fire Test & Evaluation					6
Foundational Development					

Transition to Joint Services

(U) Purpose:

- (U) Develop and demonstrate applicability of active stabilized concepts for mounted operations (Vehicle, Boat, Airborne).

(U) Products:

- (U) Full Auto Analysis – Observe and measure unique environmental factors in full automatic fire conditions
- (U) Sensor Analysis – Perform market survey of single spectrum and multi-spectrum weapon sights; culminates in a target detection experiment in realistic environments
- (U) Fabricate Surrogate Systems - Design and fabricate a technology demonstrator
- (U) Development of machine gun mounted prototype solution
- (U) Target detector integration for boat/engine and other non-standard high-value targets
- (U) High Precision Long Range Application Modification

(U) Payoff

Foundational Development

- (U) Automatic Target Recognition
- (U) Active Stabilization Techniques

Technologies/Techniques for improvements in Aim Error

- (U) Reduce engagement time for increased lethality and improved survivability.
- (U) Fire Control ==> 4th Gen/Level 5+
- (U) Can Active Stabilization techniques be applied to FVL concepts?

(U) Future Events

- (U) CY19 – Maritime Testing, USCG,/USN, Location: TBD
- (U) CY19 – Test Readiness Review (TRR) – Final Life Fire Test prior to project transition.

POC: Terence F. Rice, terence.f.rice.civ@mail.mil

INNOVATION
THROUGH
COLLABORATION

Aviation & Missile Technology Consortium ™

Cornerstone

Charlie Zisette
NAC Executive Director
NACConsortium.org

4 June 2019

OUR VALUE PROPOSITION

Collaboration/Power of the Network to Innovate

- Link traditional and Nontraditional Contractors and government customers
- Collaborate with DOD and Industrial Base during requirements generation
- Collaborate during proposal stage with all technology providers and DOD
- Collaborative Working Groups (DOD and NAC) in specific technology areas

Increase Speed, Enhance Flexibility, Enable Joint Service Requirements/Projects, Streamline Development-to-Acquisition

- Process designed to minimize cost-to-compete and speed-to-deliver
- Encourage cooperative and joint funded requirements
- Provide visibility across DOD of what other DOD organizations are pursuing

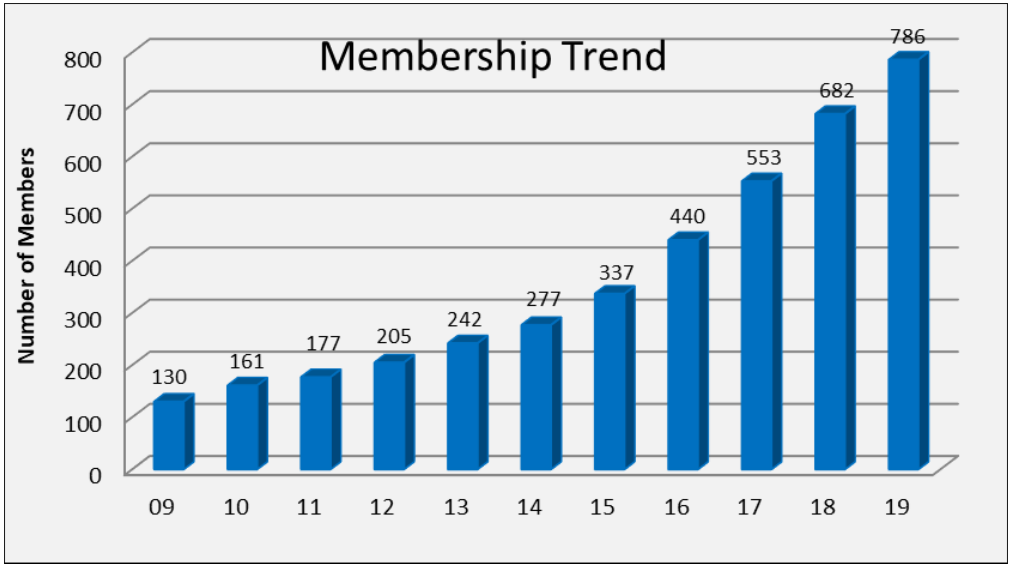
Onboard Nontraditionals and Remove Barriers to Innovation

- Provide training, education and mentoring for doing business with the Government
- Link Nontraditionals with experienced defense contractors to develop technology and optimize for production
- Provide a "bridge" between capital and risk: Traditional Defense Contractors partnering with more agile, less risk averse, or under-capitalized Nontraditionals
- Co-sponsor events to focus on technology/engineering/ programmatic threats, challenges, and opportunities.

NATIONAL ARMAMENTS CONSORTIUM

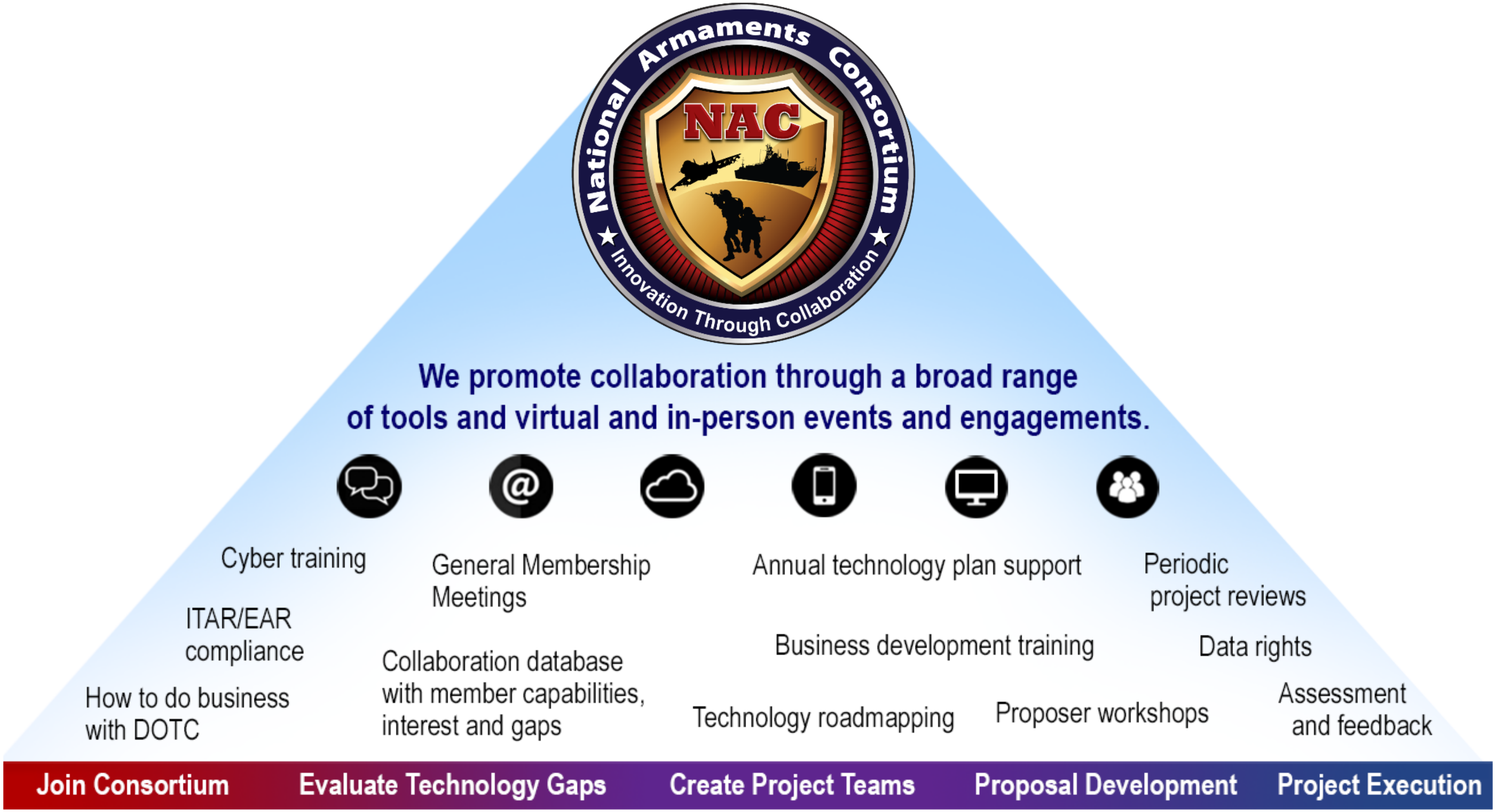
- <u>What We Do</u>: Form industry **partnerships** to collaborate with Government **customers** to **innovate** technology/ engineering **solutions** and rapidly **deliver combat capabilities** for the Nation's Warriors

- <u>Network</u>:
  786 (T-151, NT-635)
    Large - 180
    Small - 560
    Academic - 29
    Not for Profit - 17
  ~4,500 active DoD and NAC participants



- <u>Since 2009</u>:
  Delivered 525 Prototype Projects
  579 Active Prototype Projects

Collaboration Is Disciplined and Intentional



Develop and Deliver Armament Critical Technologies

"**Armaments**" is the ordnance, ammunition, munitions, weapon and sensor systems, and related military materiel, equipment, and components that enable the military to achieve combat and mission effectiveness in all warfare environments: air, land, sea, undersea and space. We cover a diverse range of technology focus areas:

- Ammunition
- Demilitarization
- Directed Energy Warfare
- Enabling Technologies
- Energetic Materials
- Fuzes
- Hypersonics and Hypervelocity
- Information Operations, Cyber Operations and Electronic Warfare
- ISR, Sensors and Sensor Systems
- Joint Enhanced Munitions
- Manufacturing and Process Technology
- Multi-domain Battlespace Management
- Protection, Survivability, and Defense
- Rockets, Missiles and Bombs
- Warheads/Lethal Mechanisms
- Warrior as a System
- Weapon Systems

…Everything in the "Kill Chain"

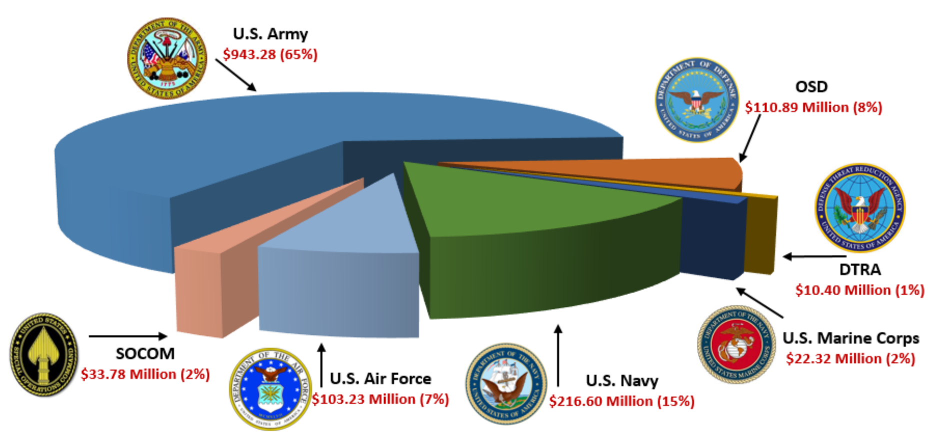
DOTC and AMTC FY19 Participation

- **574 active prototype** projects with funded value of $3.6B
- 19-04 Solicitation included **294 requirements** with an expected value of $2.65B
- 19-05 Requirements submission began June 3!

- **5 active projects** with funded value of $30M
- 19-01 – 19-04 Solicitations included **94 requirements** with an expected value of $3.7B

$1,440.50 Million Provided in FY19 by the Services …

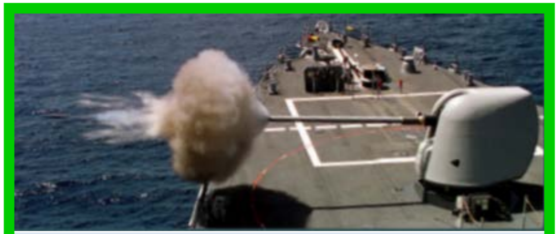
As of EOM April 2019



DOTC Active Initiatives

DOTC TECH OBJECTIVE	# OF INITS	TOTAL FUNDING
Warheads/Lethal Mechanisms	40	$283,107,294
Enabling Technology	131	$878,299,913
Fuzes & Sensors	65	$167,901,828
Energetic Materials	66	$149,173,208
Ammunition	58	$285,155,278
Demilitarization	10	$28,214,569
Joint Insensitive Munitions	4	$4,375,776
Weapon Systems	85	$582,648,047
Protection & Survivability	59	$387,498,303
Rockets, Missiles & Bombs	53	$848,913,772
Directed Energy Warfare	3	$1,721,909
Total Active Funding:	**574**	**$3,617,009,896**

DOTC Estimates $2B Total for FY19



UEA Systems Focus

Small Arms Systems Focus

GARM Systems Focus

SINGLE POINT CONTRACTING

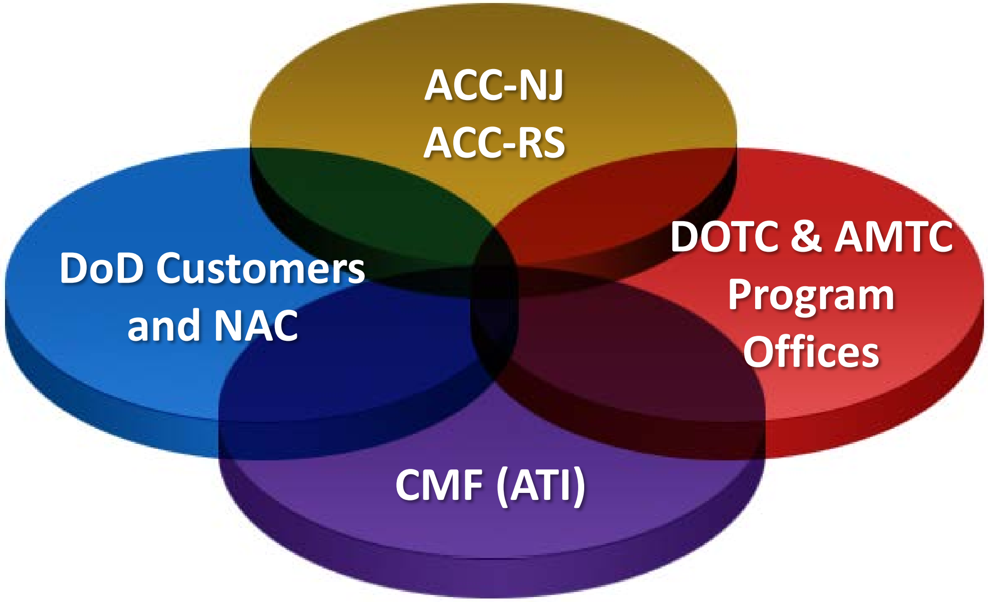
Single Point Contracting is the use of a Consortium Management Firm to facilitate high volume transactions in the solicitation, award, and execution of Government contracted efforts

EFFICIENCY:
Improved process, better communications, and lower costs

SPEED:
Faster transition of acquisition process and closer communication with technical community

CAPACITY:
Ability to execute thousands of transactions per year

FLEXIBILITY:
Ability to tailor resources to meet the requirements and guidance of the Government customer (e.g. surge, schedule adjustments, ect.)



Consortium Management Firm

Advanced Technology International ®

In support of DOTC in GFY18	In support of NAC in GFY18
• Awarded 200 new projects	• Processed 181 applications
• Issued 1,800 contract mods	• Hosted 11 collaboration events
• Screened 1,400 submissions	• Issued 2,100 invoices
• Paid 4,400 project invoices	• Vetted 681 site access requests
• Processed 110 close outs	• Monitored 678 memberships

Rapid, Effective, and Affordable Management

OTA CONSORTIUM GROWTH

The number of active **OTA collaborations** is **growing** and that growth is **accelerating**.

In 2000, there was 1 Prototype OTA Consortium

Today there are ~ 30

NAWCAD Consortium NAWC AD
S2MARTS Consortium NSWC Crane

AF Life Cycle Management Center Consortium Initiative (ACI) AFLCMC
Aviation & Missile Technology Consortium (AMTC) AMRDEC
Information Warfare Research Project (IWRP) SPAWAR
Undersea Technology Innovation Consortium (UTIC) NUWC
Sensors, Communications, and Electronics Consortium CERDEC
Cornerstone OSD MIBP

Space Enterprise Consortium (SpEC) SMC
NGA Enterprise Innovation NGA
Propulsion Consortium Initiative (PCI) AFLCMC
Countering Weapons of Mass Destruction Consortium (CWMD) JPEO-CBD
Training and Readiness Accelerator (TReX) PEO STRI

Medical CBRN Defense Consortium (MCDC) JPEO-CBD
Open Systems Architecture Initiative (OSAI) AFRL
Defense Automotive Technologies Consortium (DATC) TARDEC

National Technology Security Accelerator NSTXL DoD
Medical Technology Enterprise Consortium (MTEC) AMRMC

National Spectrum Consortium (NSC) OSD
Consortium for Command, Control, and Communications in Cyberspace (C5) ARDEC

Consortium for Energy, Environment, and Demilitarization (CEED) ARDEC

Border Security Technology Consortium (BSTC) DHS

Vertical Lift Consortium (VLC) OSD

System of Systems Security Consortium (SOSSEC)

National Advanced Mobility Consortium (NAMC) TARDEC

National Armaments Consortium (NAC)/DoD Ordnance Technology Consortium (DOTC) - OSD

Warheads and Energetics Technology Consortium (WETC) ARDEC – Later renamed DOTC under OSD

2000 2002 2019

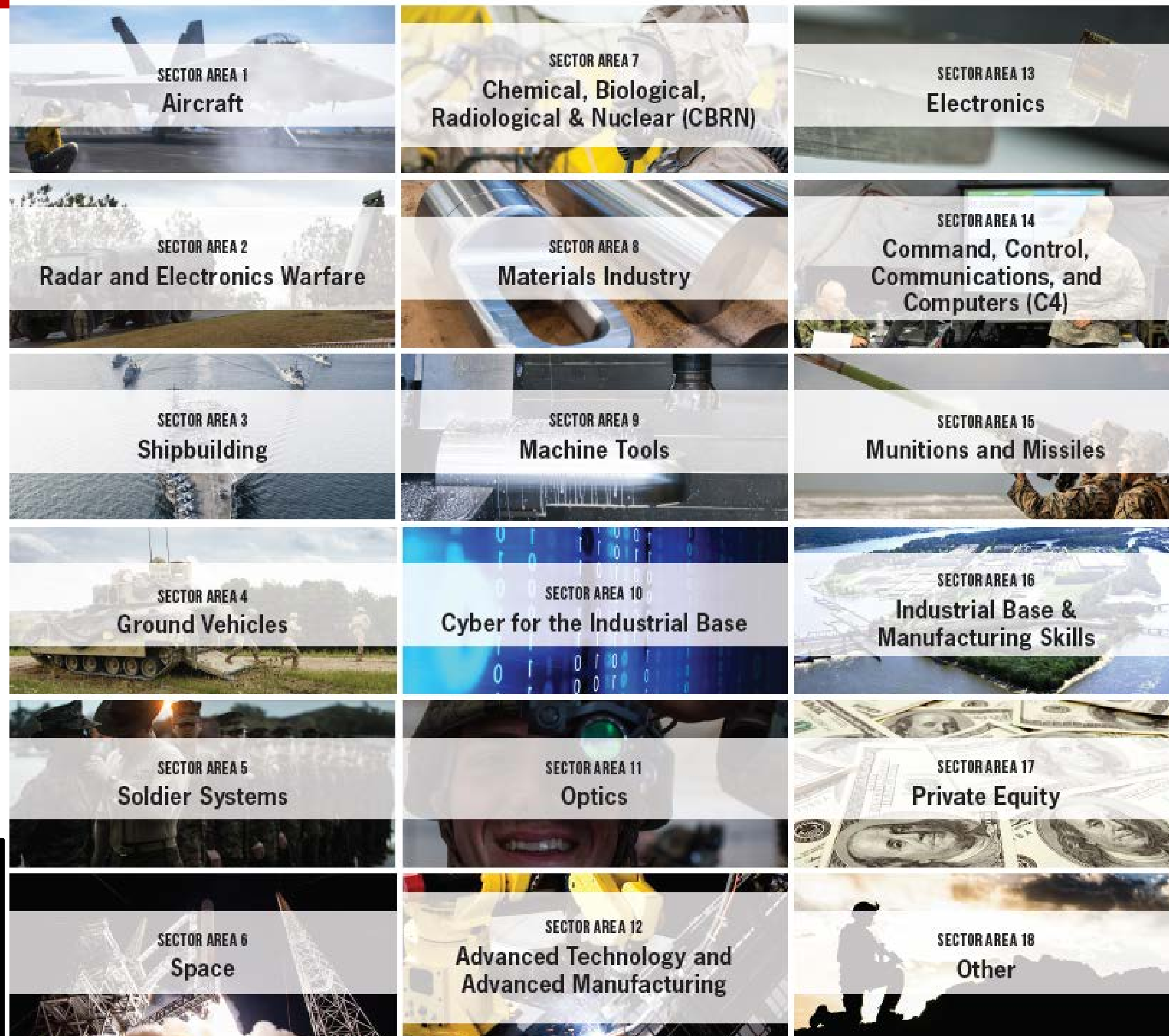
NAC Joined Cornerstone to support IBASp

Industrial Base Analysis and Sustainment (IBAS) Program

Accelerate research, development, prototyping, demonstration, qualification and integration of manufacturing capabilities and capacities into the US Industrial Base and supply chains.

- Monitor and assessment of the industrial base
- Address critical issues in the industrial base related to urgent operational needs
- Support efforts to expand the industrial base
- Address supply chain vulnerabilities

For more information, visit the Cornerstone website: **http://ibasp-public.ria.army.mil/**



TAKE-AWAY

- You have options available and choices to make:
  - ✓ OTA vs. FAR
  - ✓ Consortium vs. individual project
  - ✓ DOTC/AMTC/Cornerstone/other…
- Value Proposition: Collaboration, Speed, Innovation, Streamlining, Power of the Network, Single Point Contracting.
- NAC is your “Gold Standard” for accessing and using all of the above.
- Contact George Solhan or Charlie Zisette for assistance.

BACKUP

CMF ROLE

CMF supports both government and industry activities.

- Solicitation Preparation/Webinars
- Submission Portals
- Whitepaper & Proposal – Receipt/Compliance Review
- Award Processing/Cost Analyses
- Agreement Negotiation/Award/ Admin/Closeout
- Milestone/Deliverable Tracking and Government Approvals
- Invoice Receipt/Payment
- Technical and Financial Reporting
- Nontraditional Tracking/Reporting

- Consortium Leadership Support
- Member Training and Mentoring
- Collaboration Portal and Website
- Meeting Facility
- Member Application Processing
- Member Database (DD-2345, "good standing" tracking, etc.)
- Dues/Assessment Invoicing and Collection
- Program Status & Financial Reporting
- Conferences/Booth
- Other Support Services

NDIA

GENERAL DYNAMICS
Ordnance and Tactical Systems–Canada

Lightweight Small Caliber Ammunition Presentation + Panel Discussion

General Dynamics – OTS Canada

Repentigny, Québec, Canada

Presenter: Pierre Lemay, Product Manager

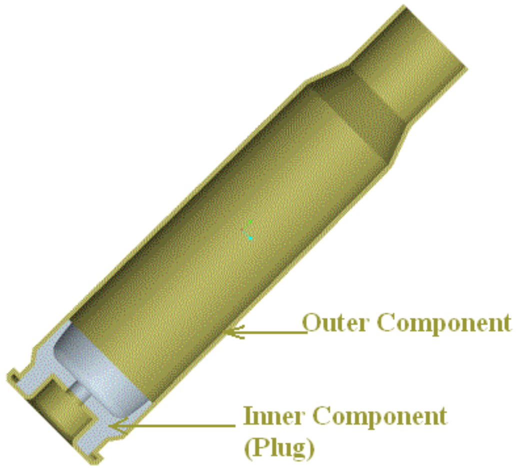
06 Jun 2019

NDIA Armament Conference / Small Arms Division Themes

“”

Metal Lightweight Case Evolution

- 2005-2012: Initial cartridge case design used a thin Stainless Steel outer shell along with an **internal** aluminium plug in the head for reinforcement:
- 2017-   : New cartridge case design uses a thin Stainless Steel outer shell along with an **external** aluminium plug as the cartridge case head:



Weight Advantages

- Stainless Steel/Aluminium LW case weighs about 45% less than brass case
- 20% reduction in overall cartridge weight

.338 Norma LW Machine Gun Cartridges

NDIA

GENERAL DYNAMICS
Ordnance and Tactical Systems–Canada

Weapon Interactions

- Stainless Steel/Aluminium LW case is a direct, drop-in substitute for brass cases
- Cartridge case as robust as brass case
- Links like standard brass cases
- Machined aluminium extractor groove does not wear out extractor
- Two-part .338 case assembly will resist a 500 pound average disassembly force

Ballistic Advantages

- Internal case volume of LW Stainless Steel/Aluminium case is equivalent or higher than brass case (from 2% to 7% more, depending on caliber)
- Firing with .338 Norma LWMMG weapon provided up to 30 m/s higher muzzle velocity
- New LW cartridge cases have been tested up to 500 Mpa in .338 caliber with no issues
- Cartridges have been successfully fired from -54°C to +71°C.

Future Developments

- More than 1,000 LW cartridges fired in .338 LWMMG
- Many more .338 trials scheduled in coming months
- Testing with new LW External Plug case design will soon begin with 7.62mm and .50 caliber
- Due to multiple customer requests, design of a 5.56mm cartridge is now getting underway
- Patent Pending

Point of Contact

- For additional information, please contact:

Pierre Lemay,

Product Manager Small/Medium Caliber

Email: pierre.Lemay@can.gd-ots.com
Phone: (450) 582-6361

Target Acquisition Fire Control Technologies for Next Generation Systems

PM Soldier Weapons / US Army

Picatinny Arsenal NJ

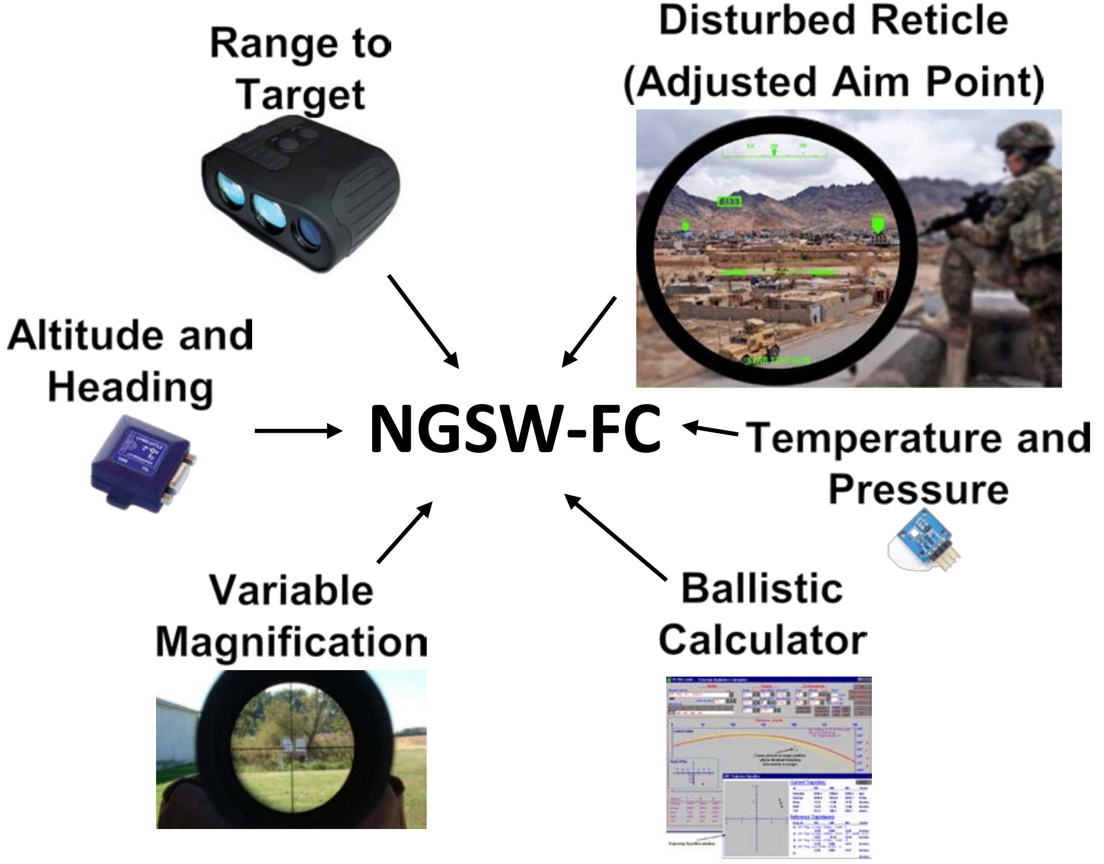
Doug Cohen & Paul Koerner

05 Jun 2019

NDIA Armament Conference / Small Arms Division Themes

PM SW NGSW-FC Overview

- **Integrated Technologies to reduce soldier load**
- **Increase ability to accurately engage targets**
- **Direct View Optic for Degraded/Powerless Operation**
- **Magnification**
  - Variable Magnification to 6x or greater to identify and engage targets beyond 600 meters
- **Disturbed Reticle**
  - Ballistics calculated in near real time using sensor suite information
- **Sensor Suite:**
  - Temperature
  - Pressure
  - Range Finder
- **Close Quarters Battle (CQB)**
  - True 1X magnification for two eye open shooting

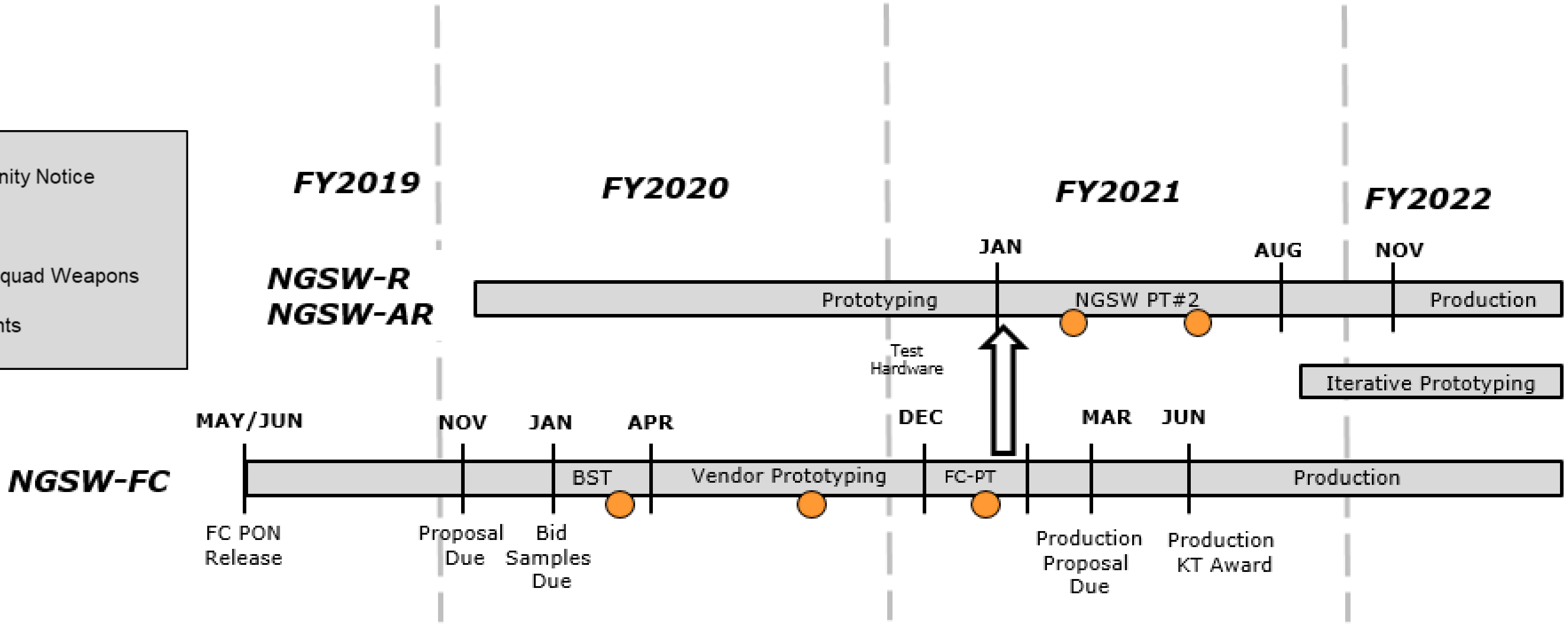


Modernizing Fire Control Capabilities for the Dismounted Soldier

NDIA

Overarching Schedule/Roadmap

Legend	
PON	Prototype Opportunity Notice
BST	Bid Sample Test
PT	Prototype Test
FC	Fire Control
NGSW	Next Generation Squad Weapons
KT	Contract
●	Soldier Touch Points



GROWTH TECHNOLOGIES

Increasing Capability with Iterative Prototyping

- Automatic target recognition
- Target tracking
- Facial recognition
- Optical augmentation
- Aim Augmentation
- Wind sensing
- Soldier Load Optimization
- Advanced Network Lethality
- Ruggedization Improvements
- Augmented Reality
- Improved Power Efficiency
- Integrated Night Sensing

S&T Integration

- DEVCOM S&T Projects (SCOPE, AFCT, LSS)
- PMSW Internal 6.4 RDTE Projects
- SBIRS & MANTECH Efforts

Technologies apply to Fire Controls across the PEO Soldier Portfolio along with partner agencies

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

Evolution in Small Arms Fire Control Technologies: Present to FY25

Ross W. Towers

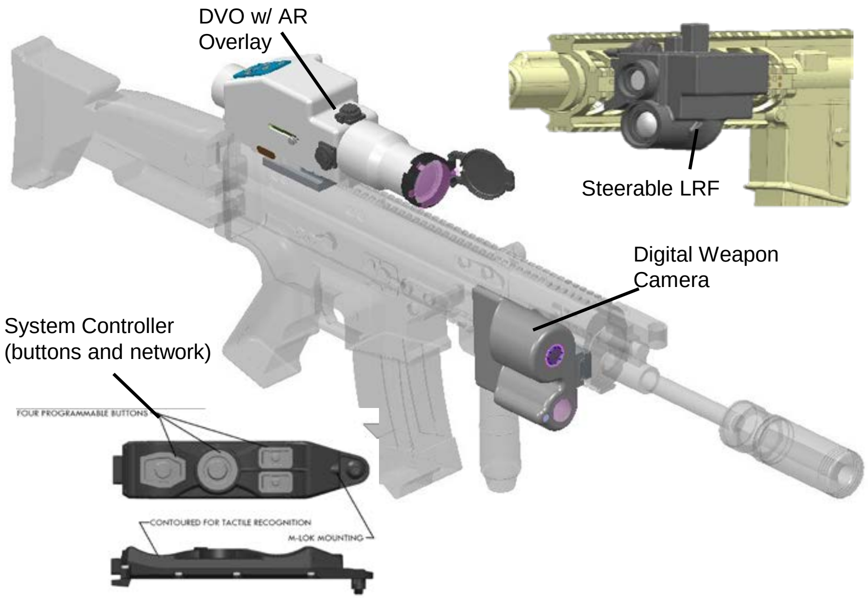
Future Technology Team Lead

FCDD-ACW-FN

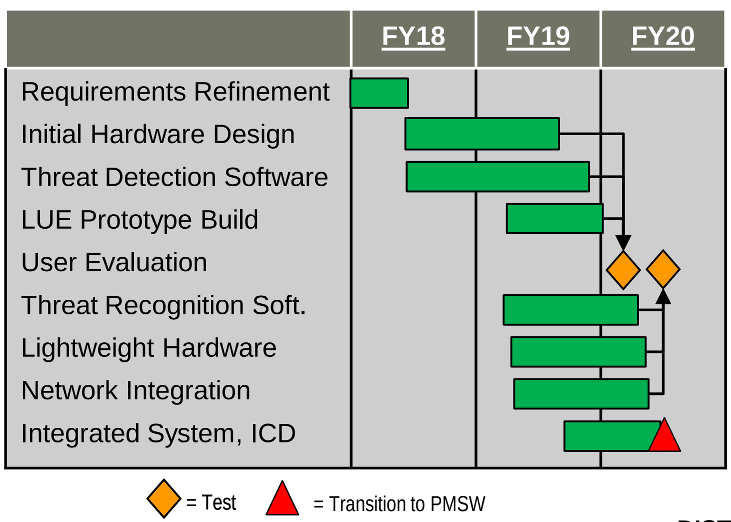
JUNE 2019

Current Efforts (through FY20)

SQUAD COMBAT OPTIC PERFORMANCE ENHANCEMENT (SCOPE)



Schedule



Purpose:

- Pair with the Next Generation Squad Weapons Technology (NGSWT) to mitigate the dismounted combatant threat, as described in Small Arms Ammunition Configuration (SAAC) Study. Develop Fire Control Technologies which meet Next Generation Squad Weapon Fire Control tech insertion timelines and drive down risk on emerging aim augmentation technology for rapid integration/fielding.

Product:

- Full System Interface Control Documentation, including hardware/software/firmware for platform upgradability/maintainability
- Rapid Integration of Digital Fire Control Elements for TRL 6 Rifle-Mounted Advanced Fire Control Optic, including:
  - Digitally Enhanced Aiming when paired with aim augmentation capable weapon platform (steerable barrel, electronic trigger, etc.)
  - Automated Target Recognition/Tracking Algorithms
  - Direct View Primary Optic with Augmented Reality Overlay
  - Steerable Rangefinder which accommodates for aim error
- Integrated Design leveraging Emerging Technologies
  - Artificial Intelligence (AI) for threat recognition and prioritization
  - AI Framework for integration with higher order data systems
  - Advanced Optical Materials for order of magnitude weight savings

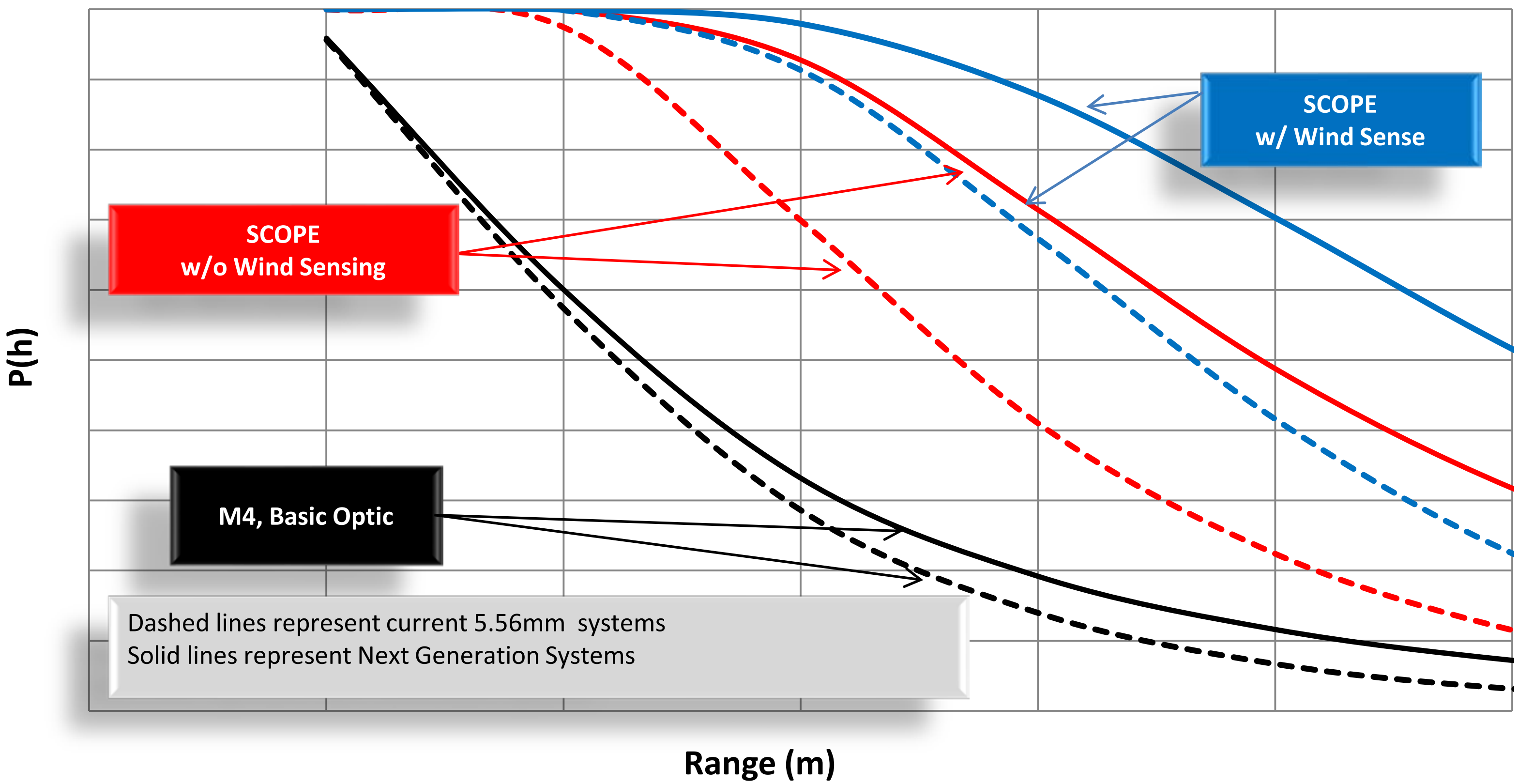
Payoff:

- TRL 6 demonstrator of fire control technologies, including hardware for Soldier touch points and feedback
- Initial increment AI capability, appropriate for dismounted use
- System Design to Improve P(I) at max effective range of the weapon in order to mitigate threat (per SAAC modeling)
- Drive advancement of bleeding edge technologies required to achieve objective capabilities outlined in Next Generation Squad Weapon Fire Control requirement and support Soldier Lethality CFT vision

DISTRIBUTION STATEMENT: A

POC: Ross W. Towers, FCDD-ACW-FN
ross.w.towers.civ@mail.mil

PROBABILITY OF HIT



Black is what is currently fielded

Red is the capability provided by SCOPE

Blue is the capability provided by SCOPE and POWS

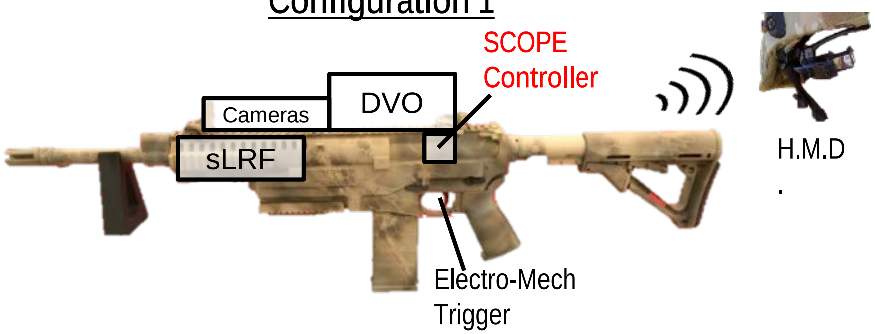
ONE FIRE CONTROL

Fire Control combines technologies in order to enable the shooter to get rounds on target

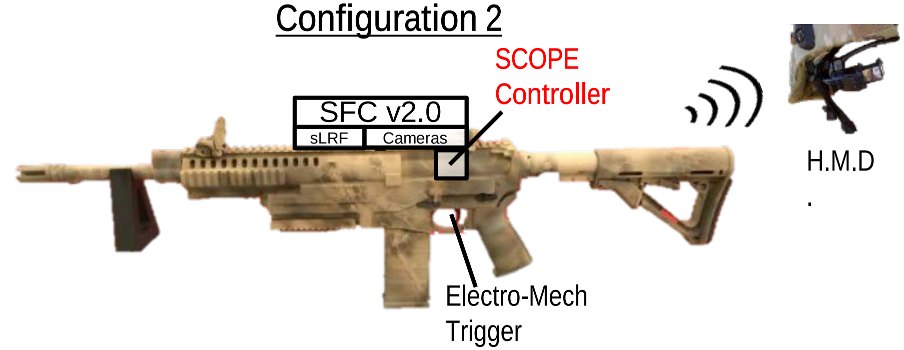
- SCOPE Architecture builds on existing hardware, and allows for infinite configurations
- Current designs leverage direct view optic (DVO), but capability to accommodate future digital technology is *intended* from inception (day and night, visible and IR systems)
    - Interface definitions allow for "plug and play" with digital optics and imagers
    - Legacy devices can be readily modified to interface with the architecture (STANAG 4740)

Sample SCOPE Configurations

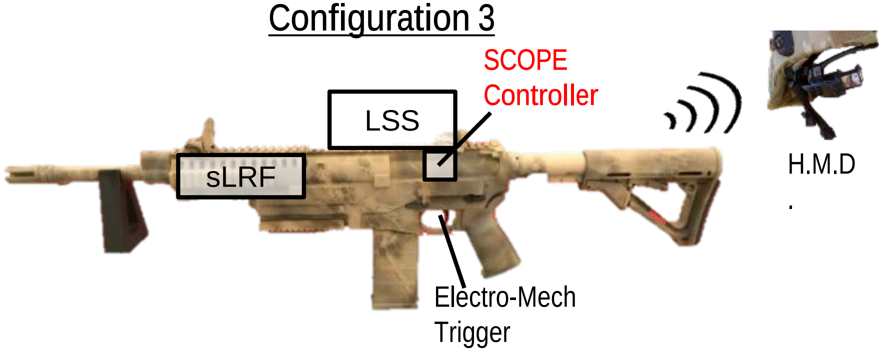
Configuration 1



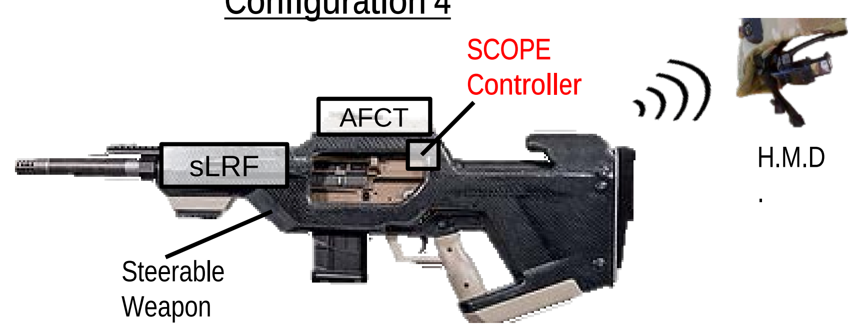
Configuration 2



Configuration 3



Configuration 4



"FIRE CONTROL ARCHITECTURE" OVERVIEW

System Specific ICD

- References Fire Control Architecture ICD, selected Fire Control Transport ICD, and selected Fire Control Service ICDs
- Defines Subsystem messaging flows

Fire Control Architecture

Fire Control Architecture ICD

- Defines rules of the architecture – independent of transport (Ethernet, serial, etc.)
- Defines architecture management functions such as unique interface identification, service discovery, etc.

Fire Control Transport ICDs

- Defines how the architecture works in specific transport environments (Ethernet, serial, USB, bluetooth)

Fire Control Architecture Service ICDs

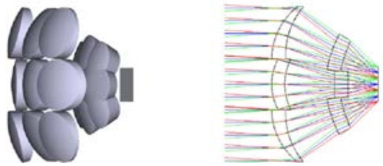
- Defines various uniquely identified functional services / enabler capabilities
- e.g. SLRF, LRF, ATD, ATD/ATR, DVO, Ballistic Solver, Flashlight,

DISTRIBUTION STATEMENT: A

Planned Efforts (through FY25)

ADVANCED FIRE CONTROL TECHNOLOGY (AFCT)

Shooter AID

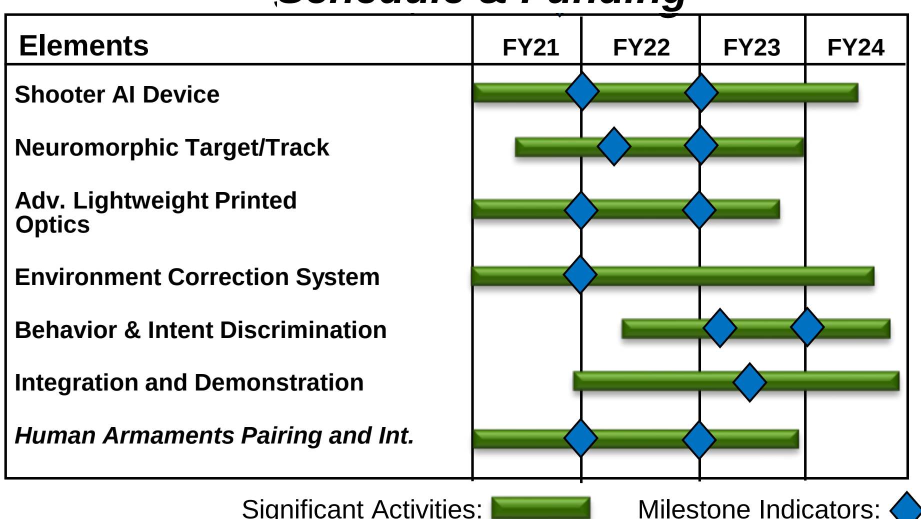


Alternative Lightweight Printed Optics

Environment Correction System

Neuromorphic Targeting and Tracking

Schedule & Funding



Purpose:

Design and demonstrate next generation fire control technologies which exploit the rapid technology advancements of Squad Combat Optic Performance Enhancement (SCOPE) and Integrated Visual Augmentation System (IVAS). Integrate solutions which are lighter weight, provide better targeting and prioritization performance, and a definitive increase in target probability of hit (P(h)).

Products:

- **Shooter Artificial Intelligence Device (Shooter AID):** embedded artificial intelligence to integrate network and platform level control to provide target allocation and prioritization between the battlefield network, helmet mounted display, and weapon.
- **Neuromorphic Targeting and Tracking (NTT)**: neuromorphic processing system for automated threat recognition, prioritization, tracking, firing solution automation, and moving target lead generation; coupled with shot tracking to maximize accuracy
- **Advanced Lightweight Printed Optics (ALPO)**: development of optical design solutions extensible to multiple roles (magnifications) which leverage advances in polymer manufacturing (3D printing) to improve probability of detect/ID while reducing cost, weight
- **Environment Correction System (ECS)**: address real environmental shooting condition measurement deficiencies (including cross- and head-wind) for carbine and automatic rifle applications, focused on short range, high speed readings
- **Behavior & Intent Discrimination (BID)**: Target recognition algorithms which include ability to distinguish intent based on threat (motion, posture, etc.) and feed prioritization
- **Human Armaments Pairing and Integration (HAPI)**: exploit ARL research to address system level operational concerns for fire control system operation, including display configuration, physical configuration, and hardware interfacing

Payoff:

- Improved dismounted Soldier lethality:
  - Greater probability of hit, P(h)
  - Enhanced threat detection
  - Enhanced Soldier-System digitally, augmented interface
- Integration with dismounted sensors available to Soldier/Squad
  - Supports Army Decide Faster/Asymmetric Vision
  - Increased Soldier performance from multiple sensors

DISTRIBUTION STATEMENT: A

POC: Ross W. Towers, RDAR-WSF-N
ross.w.towers.civ@mail.mil

Advanced Fire Control Technologies TECHNICAL APPROACH

- Pursuing parallel, interrelated product thrusts:
  - **Soldier Weapon-borne Artificial Intelligence**:
    - Weapon embedded artificial intelligence
    - Integrates network and platform level control
    - Provides target allocation and prioritization between the battlefield network, helmet mounted display, and weapon
  - **Neuromorphic Based Threat Discrimination**:
    - Neuromorphic based image processing system for automated threat recognition, prioritization, tracking
    - Automated firing solution, including prediction for moving targets
    - Bullet tracking to maximize follow-on accuracy
  - **Advanced Lightweight Printed Optics**:
    - Development of 3D printed optical design solutions
    - Extensible to multiple weapon platforms
    - Leverage advances in polymer manufacturing (3D printing) to improve probability of detect/ID while reducing cost, weight

Develop AI and Advanced Optics to Improve Soldier Lethality

Advanced Fire Control Technologies EXPECTED PERFORMANCE/TRADE-OFFS

- Success will be measured by
  - Probability of correct target recognition
  - Time to effectively engage target(s)
  - Follow-on hit accuracy
  - Weight Reduction
  - Power Management
- Processing Performance Trade-Offs:
  - Expected Performance: Advanced GPU based processors reduce board weight, reduce electrical power consumption relative to conventional solutions (ASIC/FPGA)
  - Trade-Off: System weight and electrical power inversely correlated to processing speed and target recognition reliability; trade-off curve must be developed (inherent part of this effort)
- Optical Performance Trade-Offs:
  - Expected Performance: Gradient Index 3D printed lenses coupled with honey-comb style opto-mechanical 3D printed housings reduce optical system weight
  - Trade-off: Optical quality relative to currently fielded optics may suffer; loss of transmission / hazing is possible

Advancing State of the Science in Fire Control Technologies while Managing Size, Weight, and Power

Questions

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

Propellant Optimization

Tyler Holland

CCDC AC – Production Engineer

Andrew Caldwell

Olin Winchester – Ballistics Engineer

DISTRIBUTION A

22 MAY 2019

Propellant Optimization

Fouling Reduction

PROJECT BACKGROUND

BLUF: Direct impingement weapon systems are susceptible to bolt fouling due to unburnt propellant and other propellant additives cycling through the system during a firing event

- **Constituent quantities blended in the propellant will effect the amount of fouling imparted on the weapon system**
  - Inorganic constituents account for most fouling
- **Phase 1 - six (6) propellant formulations were conceptualized, produced, and loaded into M855A1 cartridges for testing.**
  - M4A1 weapon fouling tests conducted at Olin-Winchester
  - Chemical analyses conducted at ARL
  - Muzzle Flash testing conducted at BSO
- **Phase 2 – two (2) formulations were down-selected and further evaluated vs. the control propellant.**
  - Fouling and LAT testing at Olin-Winchester
  - Chemical analyses at ARL
  - Muzzle flash testing at ARDEC and ATC

PROPELLANT FORMULATIONS

Sample #	1	2	3	4	5	6	7 (Control)
De-coppering agent %	-	-	-	-	-	-	0.22
Standard Flash Suppressant (Surface) %	0.7	0.2	0.2	0.2	0.2	0.2	0.5
Alternate Flash Suppressant (Surface) %	-	0.4	-	0.6	-	-	-
Alternate Flash Suppressant (Pellet) %	-	-	0.4	-	0.6	-	-
Total Flash Suppressant %	0.7	1.0	1.0	1.4	1.4	0.2	0.5
Nitroglycerine %	12.88	12.97	12.8	12.87	12.73	10.21	13.32
Bulk Density (g/cc)	1.003	0.972	1.008	0.982	1.007	0.991	1.006

M4A1 FOULING TEST DOE

- **Phase 1**
  - Seven (7) M4A1 weapons were used to fire a total of 1,200 rounds of each propellant formulation (6 experimental and 1 control)
    - Each gun was broken in with 3600 rounds prior to DOE commencement
    - (7 Samples) x (7 Guns) x (1200 Rounds) = 58,800 rounds tested in DOE
    - Bolt assembly and bolt weights were measured at 600 round increments. Guns were cleaned after 1200 rounds before moving to the next sample.
    - Each gun started with a different sample number and indexed to account for gun history.
- **Phase 2**
  - Three (3) M4A1 weapons were used to fire a total of 2,400 rounds of each down-selected formulation (2 experimental and 1 control)
    - (3 Samples) x (3 guns) x (2400 Rounds) = 21,600 rounds tested
    - Tested and measured as above

BOLT FOULING DATA- PHASE 1

Phase 1 Fouling Data

	Propellant Formulation						
	1	2	3	4	5	6	7
Average Bolt Fouling Mass (g)	0.1471	0.2102	0.1458	0.1945	0.1635	0.1305	0.1726
Percent of Control	85%	122%	84%	113%	95%	76%	100%
Average Bolt Carrier Assembly Fouling Mass (g)	0.5631	0.7834	0.5559	0.7871	0.6985	0.4228	0.6079
Percent of Control	93%	129%	91%	129%	115%	70%	100%

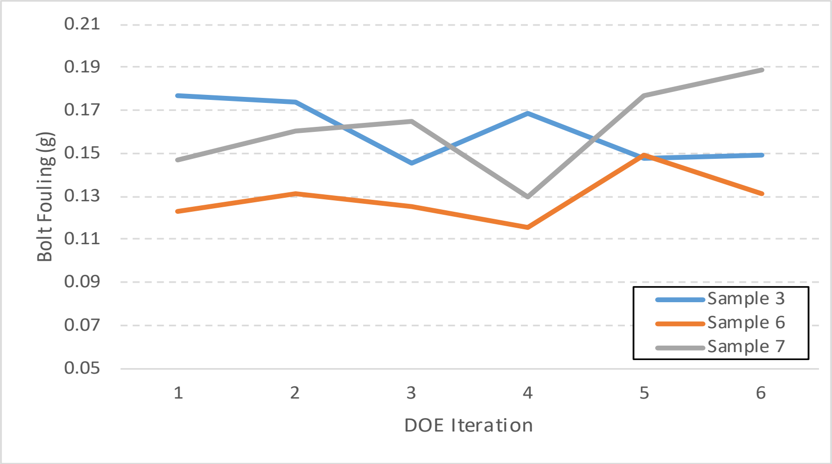
Phase 1 Down-Select Analysis

	Fouling Mass (Olin)		Fouling Composition (ARL)		Muzzle Flash Intensity (BSO)		
Sample	Bolt	Assembly	M4A1	Mann Barrel	Peak (cd)	Integrated (cd*s) $x10^{-4}$	Average Rank
1	3rd	3rd	5th	4th	5th	5th	4.2
2	7th	6th	4th	5th	7th	6th	5.8
3	2nd	2nd	2nd	2nd	3rd	4th	2.5
4	6th	7th	6th	3rd	6th	7th	5.8
5	4th	5th	7th	6th	1st	3rd	4.3
6	1st	1st	1st	1st	4th	1st	1.5
7 (Control)	5th	4th	3rd	7th	2nd	2nd	3.8

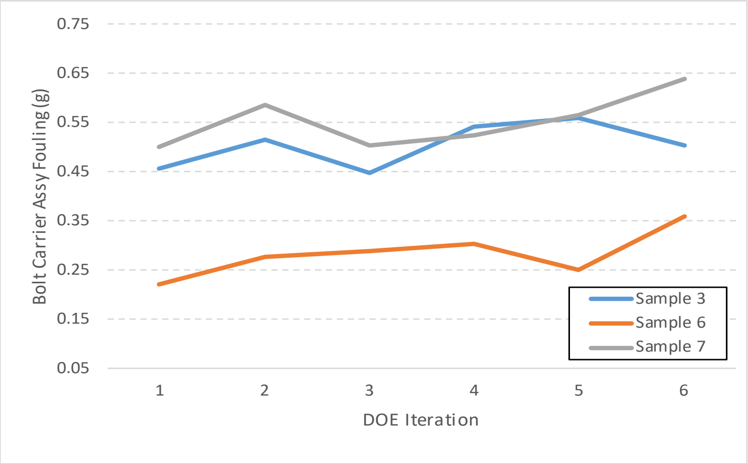
Phase 1 testing showed compelling results for improved fouling formulations, down selected to continue investigation of samples 3 and 6

BOLT FOULING DATA – PHASE 2

Bolt Fouling



Bolt Carrier Assembly Fouling



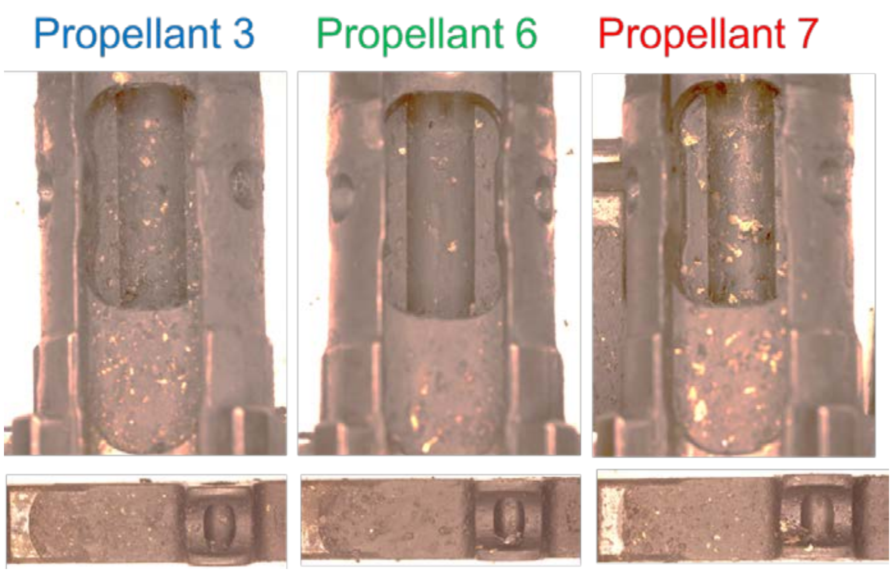
Phase 2 Fouling Data

	Propellant Formulation		
	3	**6**	**7**
Average Bolt Fouling Mass (g)	0.1605	0.1294	0.1614
Percent of Control	99%	80%	100%
Average Bolt Carrier Assembly Fouling Mass (g)	0.5044	0.2839	0.5531
Percent of Control	91%	51%	100%

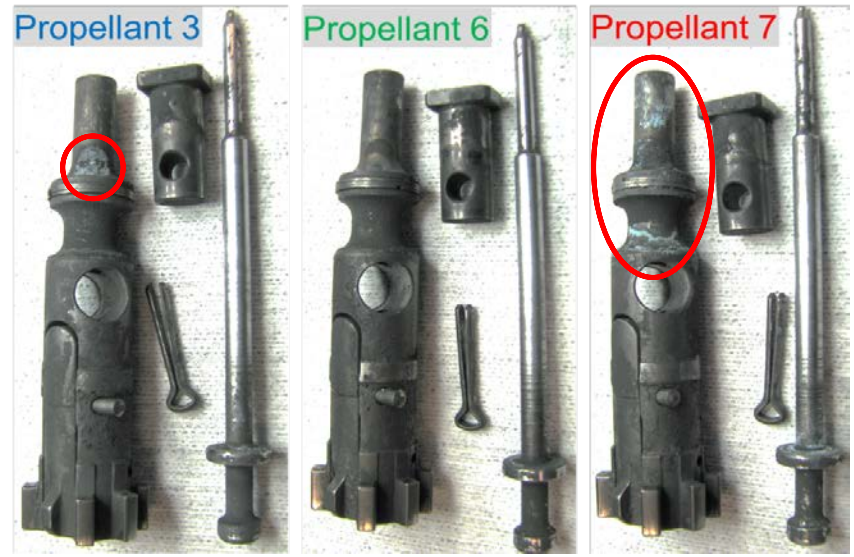
Sample 6 reduced bolt assembly fouling by 51% compared to the control

ARL – VISUAL OBSERVATIONS

- **Dirty bolts observed under magnification, and under ambient lighting conditions**



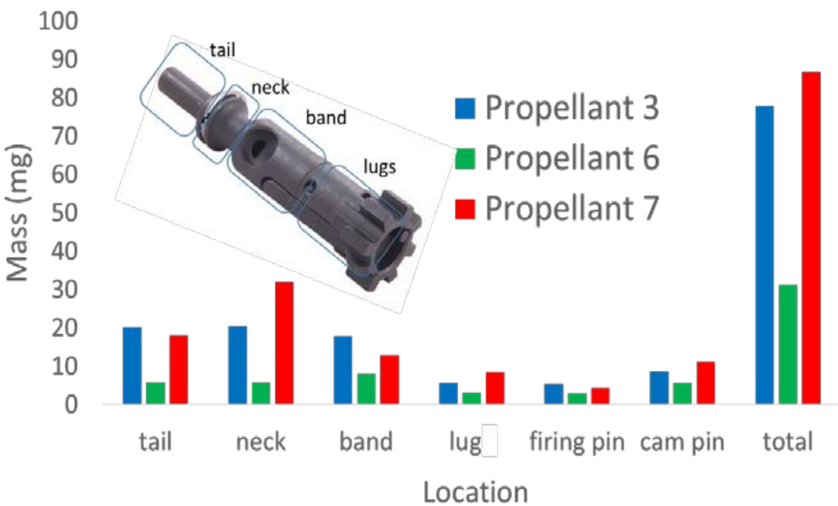
Extractor shows very few brass shavings from sample 6. Less risk of failure to extract or eject.

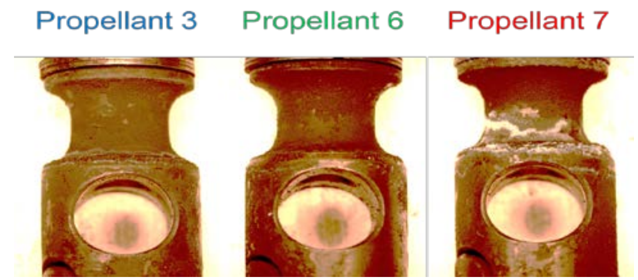


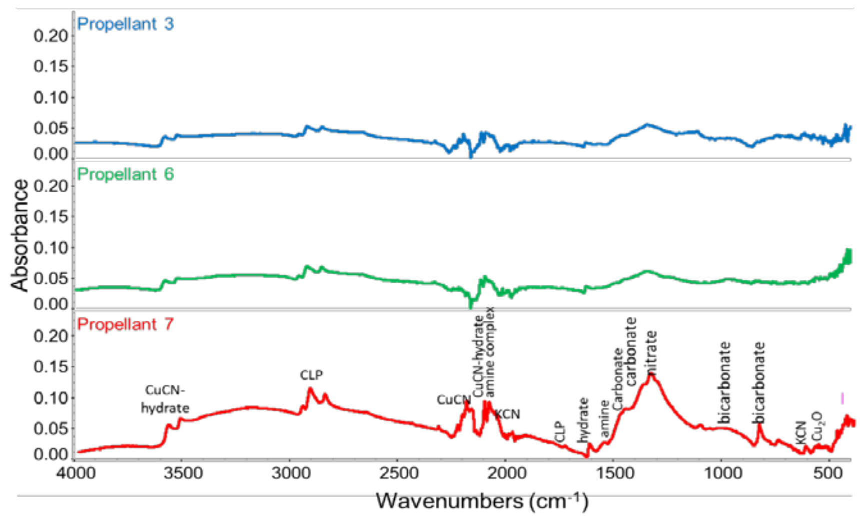
Basic Copper Carbonate (BCC) shown in excess on bolt tail for Sample 3 and 7. Most difficult residue to clean from bolts.

ARL ANALYSIS – BOLT AND ASSEMBLY

- **Quantitative and qualitative analyses were performed on dirty bolts which further confirmed conclusions from bolt weight analysis performed at Olin**
  - Residue was scraped from the dirty bolts and weighed by region
  - IR spectroscopy was performed on the residue to determine the chemical composition







Sample 6 is clearly superior in terms of fouling mass

Spectra of Sample 3 and 6 suggest "cleaner" residue compared to Control. Much less cyanide and carbonate/bicarbonate products.

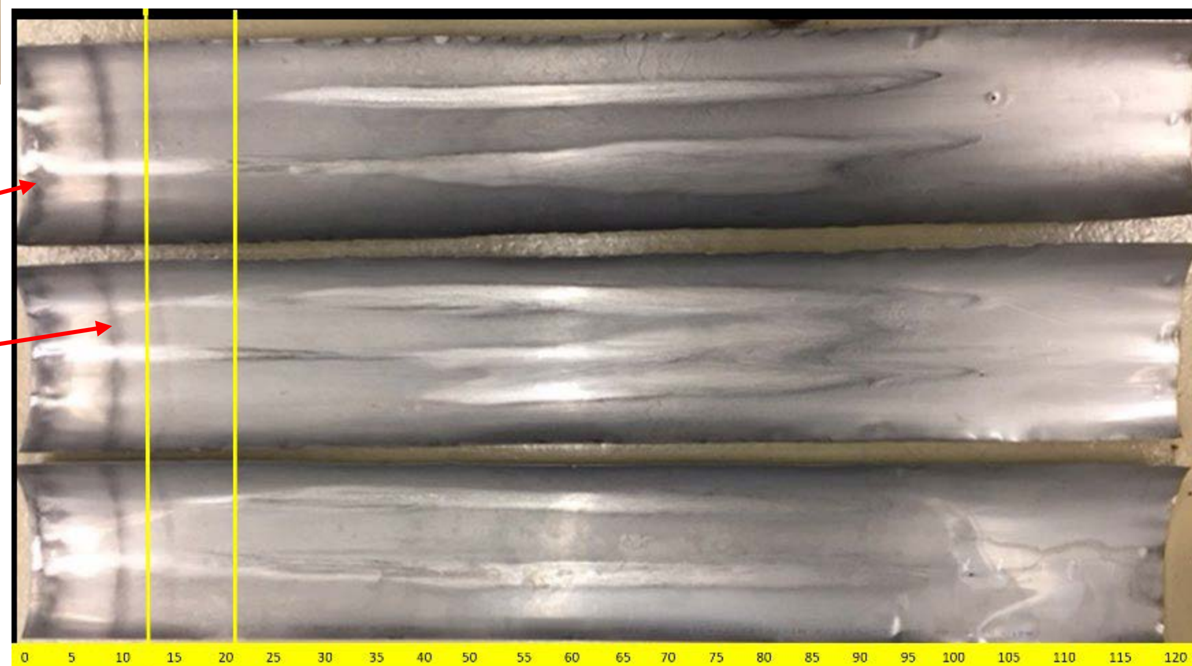
ARL MUZZLE "SHIM" TEST METHOD

- **Roll sheet metal shim into a tube and affix at the muzzle of the M4A1 weapon**
  - Fire 10 rounds of one sample type
  - Repeat with 3 shims for each sample type
- **Sheet metal is unrolled and observed visually both with and without magnification**
  - Impact points were counted at 12cm and 21cm from the muzzle within a random $4cm^2$ area
  - Impacts were measured to estimate particle size
- **pH strips were used to determine alkalinity of the residue**

ARL MUZZLE "SHIM" SETUP

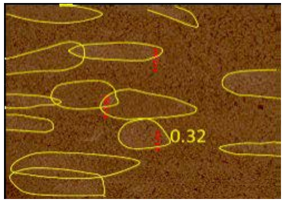
Primary flash signature

Secondary flash signature

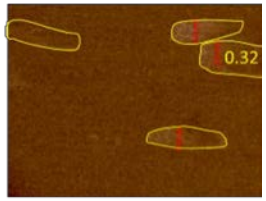


ARL MUZZLE "SHIM" IMPACT RESULTS

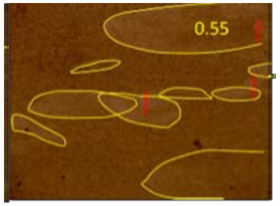
Impacts 12cm from muzzle



Sample 3

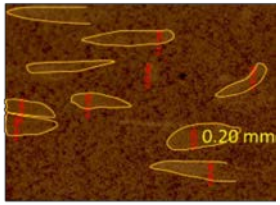


Sample 6

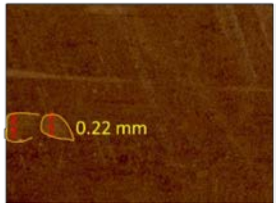


Sample 7

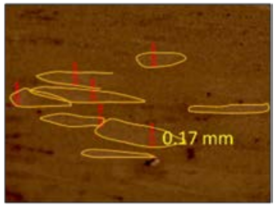
Impacts 21cm from muzzle



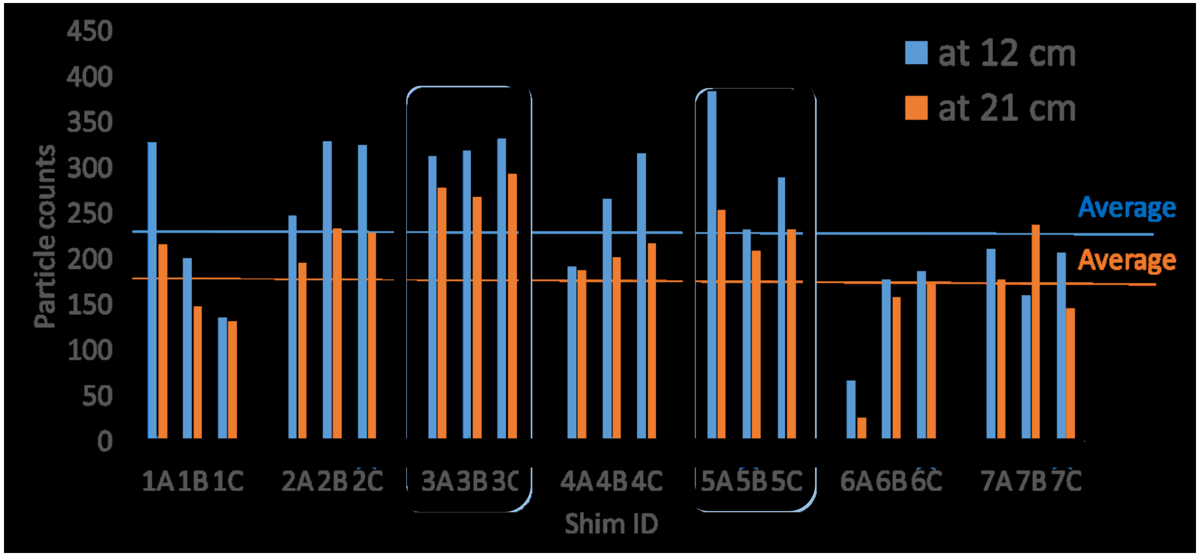
Sample 3



Sample 6



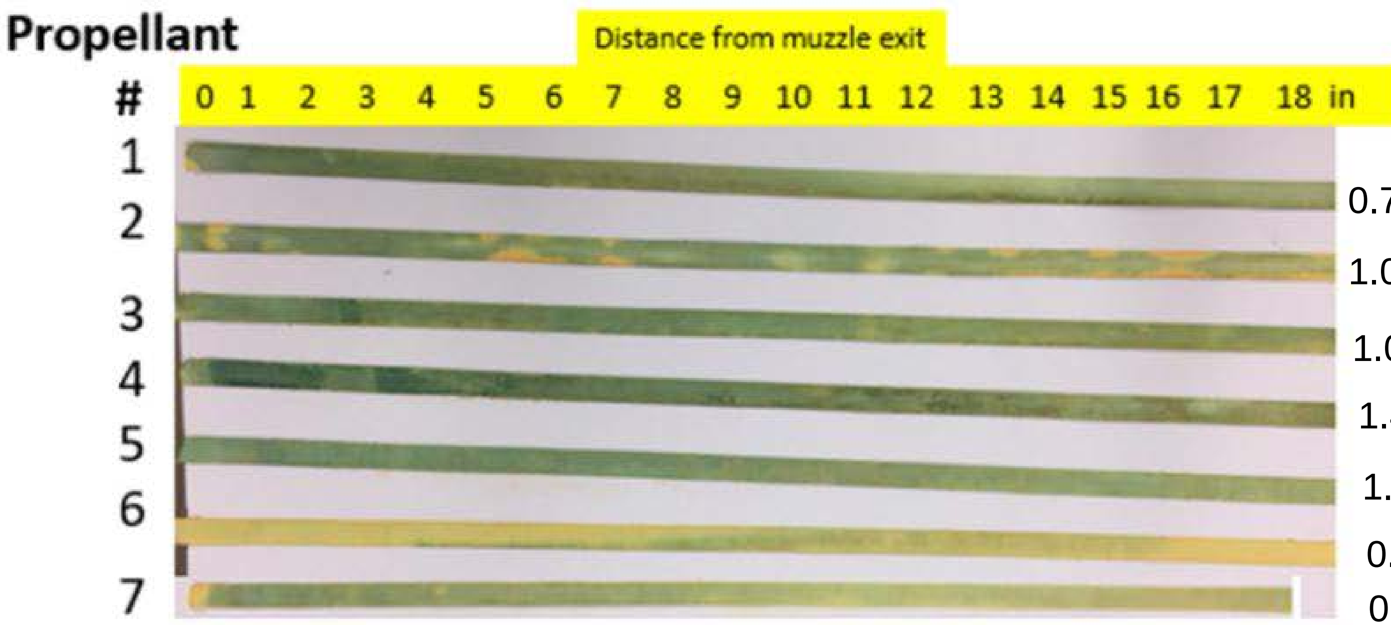
Sample 7



Reduced muzzle fouling would be an added benefit for silenced weapon systems

MUZZLE “SHIM” ALKALINITY TEST

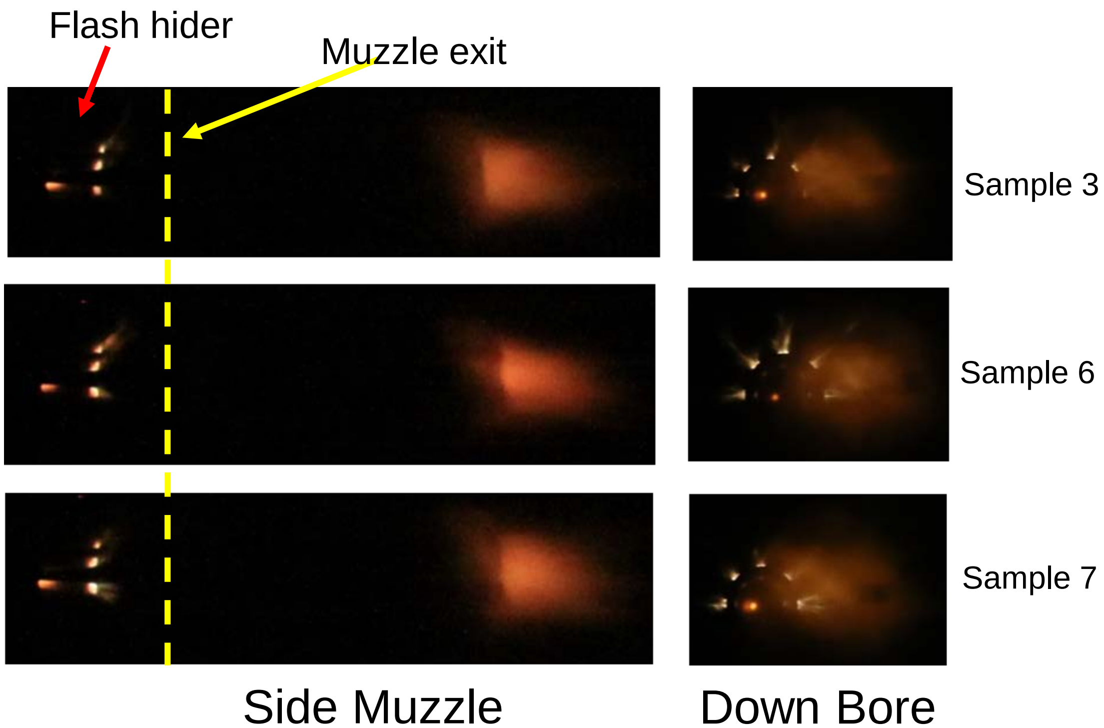
- **pH of ~7 (neutral) turns yellow. More alkaline Ph ~9 turns green**
  - Potassium based flash suppressants are highly alkaline

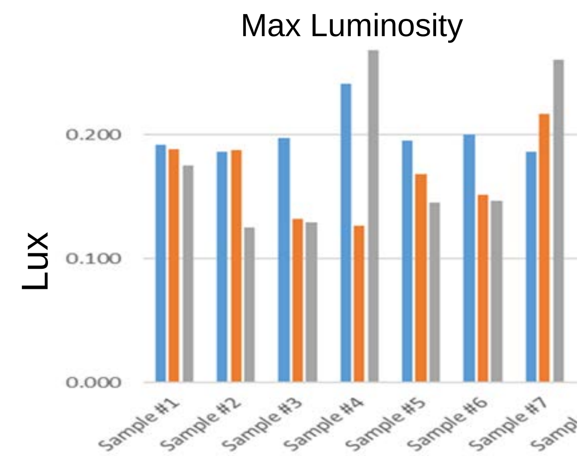


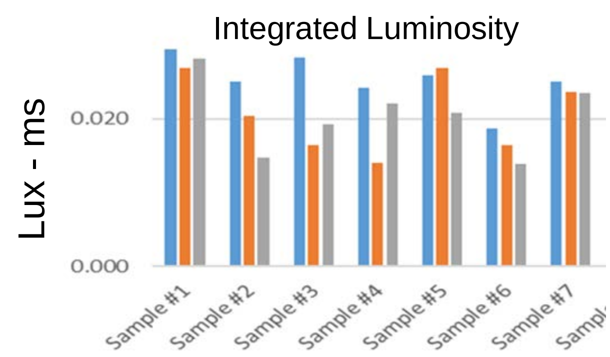
pH strips suggest alkaline products are expelled from all weapons, but less for Sample 6

MUZZLE FLASH TESTING

- **A study was performed to determine if reduction in flash suppressant would significantly impact muzzle flash**
  - Intensity of muzzle flash was observed using a photo optic sensor
  - Open shutter photography was used to compare muzzle flash visually







No significant difference in muzzle flash

CONCLUSIONS

- **Weapon fouling mass and chemical analysis testing demonstrated the effect of propellant formulation of buildup of on M4A1 bolt assemblies.**

- **Inorganic additives to propellant formulations (flash suppressant, de-coppering agent) and bullet jacket metal migrate from the gun barrel to the bolt through the gas port.**
  – De-coppering agent facilitates migration of copper
  – Potassium in flash suppressant forms potassium carbonate and supports basic copper carbonate formation

- **A reduction of inorganic additives to propellant formulations improves fouling characteristics**

- **A reduction of flash suppressant can be offset by reduced flame temperature to yield comparative muzzle flash output.**

- **Sample 6 is superior in terms of bolt/bolt carrier assembly fouling, and is capable of meeting cartridge specifications.**

ACKNOWLEDGEMENTS

- Saint Mark's Powder (SMP)
- Olin-Winchester
- Army Research Laboratory (ARL)
- Aberdeen Test Center (ATC)

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

Demonstration of an Environmentally Benign Composition for the M209 Shotshell Primer

Jared Moretti
Pyrotechnics Technology Division
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James Wedwick
Northrop Grumman Innovation Systems (Small Caliber Systems)
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Independence, MO 64056

AGENDA

Introduction

Initial Development at CCDC

Safety Approval at Manufacturer

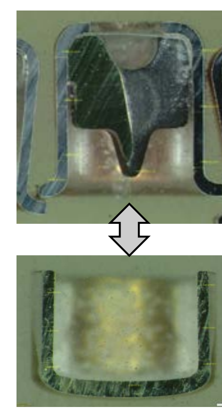
Mixing and Primer Assembly

Conclusions

HAND HELD SIGNALS (HHS)

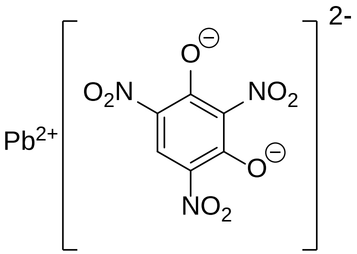
- HHS suite of armaments employ the 209 shotshell primer
  - HHS is used in training and combat for visible smoke and illuminant signatures
  - 209 primer embedded in end of rocket barrel; end cap contains firing pin

Cup in cup design

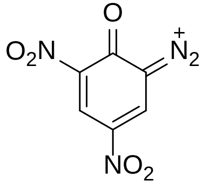


PROBLEMS WITH 209 PRIMERS

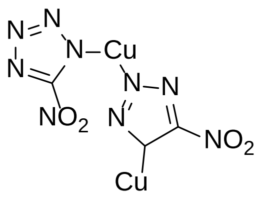
- Most primers use toxic lead styphnate as active explosive ingredient
- Manufacturers have lead-free primer options based on DDNP
  - Inadequate for military, due to vacuum thermal stability and cold performance
- An alternate lead-free explosive is copper (I) 5-nitrotetrazole (DBX-1)
  - Proven out in detonators, CAD/PAD devices and more
  - Relatively unexplored in primers
  - A possible drop-in production replacement; no major capital investment needed



Lead styphnate



Diazodinitrophenol
(DDNP)



DBX-1

ALTERNATE, LEAD-FREE PRIMER MIX

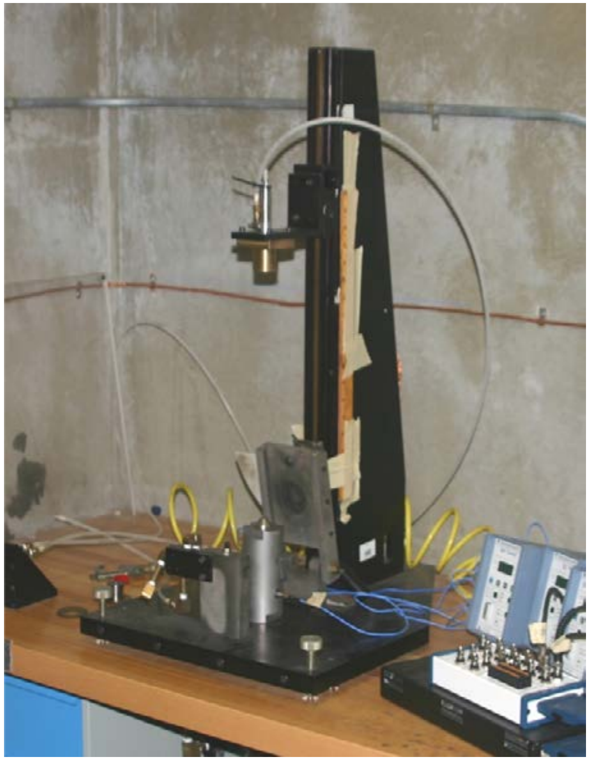
- **Established a new primer mix based on DBX-1 to replace lead**
  – Also replaced:
    •barium nitrate (toxicity problem)
    •antimony sulfide (supply problem)
  – Mixed 10 gram batches at CCDC by hand
  – Loaded into primer bits with custom tooling
    • One at a time!

Ingredient	Function	Wt. %
Potassium nitrate (KNO_3)	Oxidizer	61.4
DBX-1	**Active ingredient**	**17**
Aluminum powder	Fuel, slag generator	10
Tetrazene	Sensitizer, gas generator	5.7
Boron carbide (B_4C)	Abrasive, frictionator	5.7
Celvol 523	Binder	0.2

Csernica, C.; Oyler, K.; Sabatini, J.; Mehta, N. (2016). "Non-Toxic Primer Mix." US Patent no. US9409830B1.

TESTING PRIMERS AT CCDC

- **CCDC primers tested against commercial primers with 3.94 oz ball in 1.8 cc partially vented bomb.**
  - Setup allows output and sensitivity testing simultaneously
  - CCDC and commercial primers have comparable sensitivity profile



Lot	Hbar (in.)	σ (in.)	Hbar + 4σ (in.)	Hbar - 2σ (in.)	P_{peak} (psi)
CCDC	3.32	0.22	4.20	2.88	**3,962**
Commercial	3.05	0.21	3.89	2.63	2,594

TRANSITION TO INDUSTRY

- **Need to scale up primer mix at high volume producer**
- **Improve manufacturability**
  - –Scale up primer assembly process
  - –Transition from one at a time to integrated plate process
- **Transitioned to NGIS out of Lake City Army Ammunition Plant (LCAAP)**
  - –First needed safety approval to handle DBX-1
    - Chemical compatibility testing with common chemicals
    - Wet and dry Impact/Friction/ESD testing on DBX-1
    - 7-day water stability study
  - –Invent plate process
  - –Fabricate and test 209 primers with alternate mix

DBX-1 SENSITIVITY STUDIES

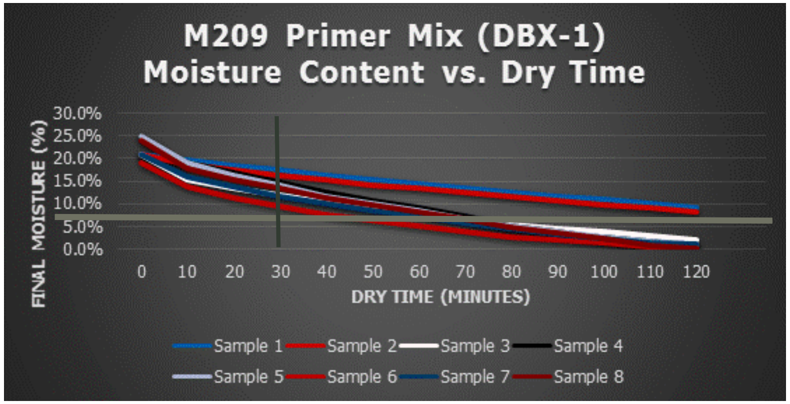
	Test	DBX-1/ water	Lead Styphnate/ water	Color Change	DBX-1/IPA
	Impact, cm	1	11		1
0 Hrs	Friction, N	<4	18	no	<4
	ESD, J	<0.0013	0.0013		<0.0013
	Impact, cm	1	11		
24 Hrs	Friction, N	<4	31	no	
	ESD, J	<0.0013	0.0013		
	Impact, cm	11	7		
48 Hrs	Friction, N	<4	11	no	
	ESD, J	<0.0013	<0.0013		
	Impact, cm	3.5	3.5		
72 Hrs	Friction, N	<4	18	no	
	ESD, J	<0.0013	0.0013		
	Impact, cm	3.5	3.5		
96 Hrs	Friction, N	<4	11	no	
	ESD, J	<0.0013	0.0013		
	Impact, cm	7	>100		
120 Hrs	Friction, N	<4	53	no	
	ESD, J	0.0013	<0.0013		
	Impact, cm	11	>100		
144 Hrs	Friction, N	<4	53	no	
	ESD, J	<0.0013	<0.0013		
	Impact, cm	7	>100		
168 Hrs	Friction, N	<4	53	no	
	ESD, J	<0.0013	<0.0013		

MOISTURE CONTENT AND SENSITIVITY

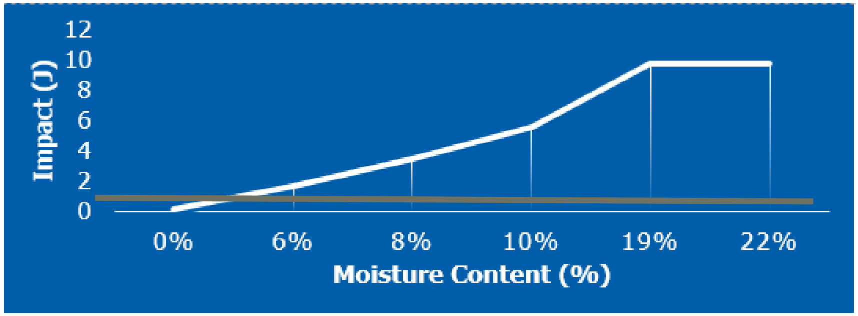
Atmospheric mix drying study and corresponding sensitivity testing to determine safe handling

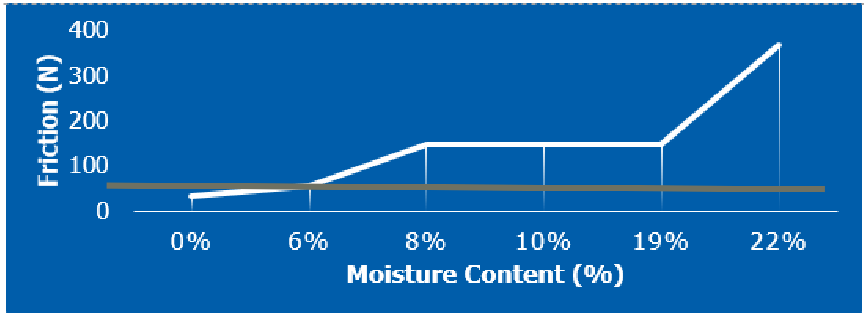
All moisture levels were ESD sensitive and required a departure

Friction drove the processing time



6% moisture





≥ 0.5J Impact lower limit

≥ 75N Friction lower limit

MIXING AT LCAAP

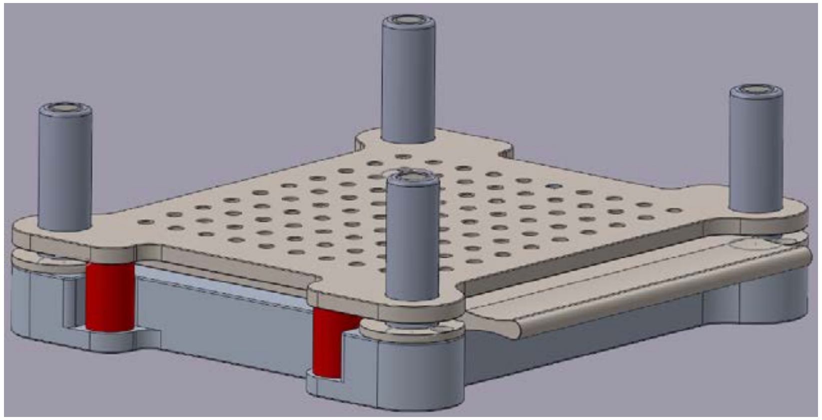
- **Approved for 10-gram mixing operation with DBX-1 primer mix**

- Mixed in a speed mixer at 2,000 rpm
  – All ingredients except fuels added, mixed for two 30-second intervals
  – Fuels added and mixed two additional intervals

PRIMER ASSEMBLY (1)

- Next, we needed to establish a pilot 209 primer assembly process
- Representative of regular LCAAP primer production, amenable to future scale-up
- A few key steps in the process:

1. Cups added to wells in base plate



2. Rub plate added, filled with primer mix

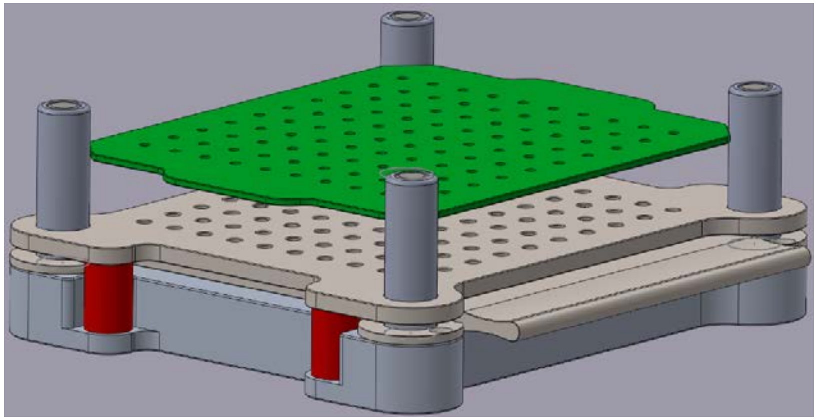
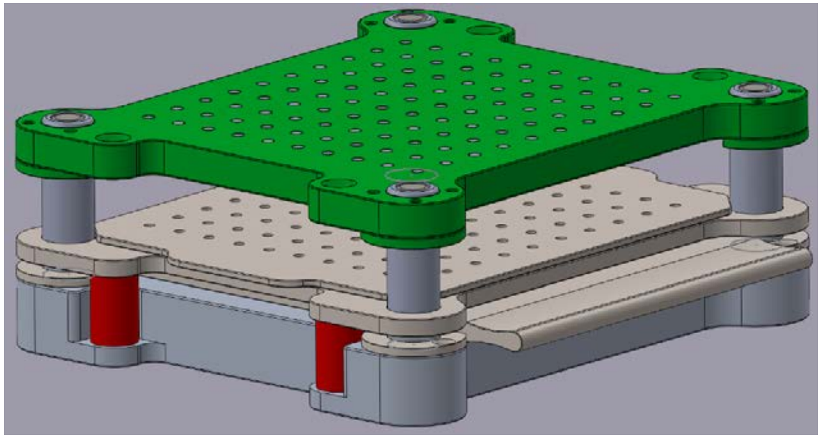


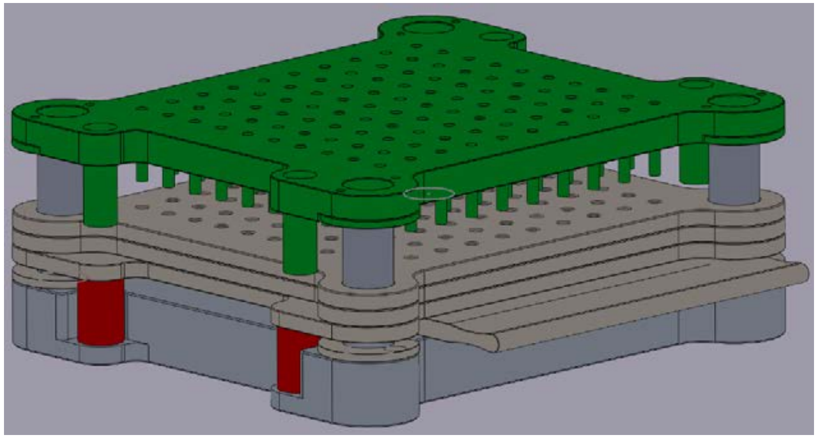
Plate gap controls pellet weight.

PRIMER ASSEMBLY (2)

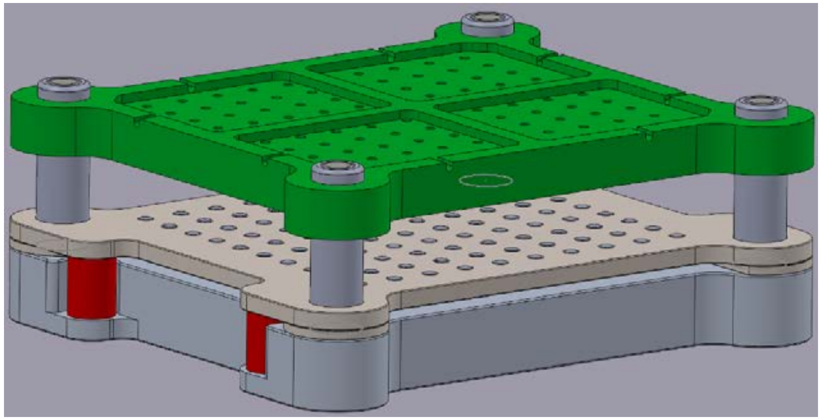
3. Pin pellet plate inserted; pellets shaken into cups



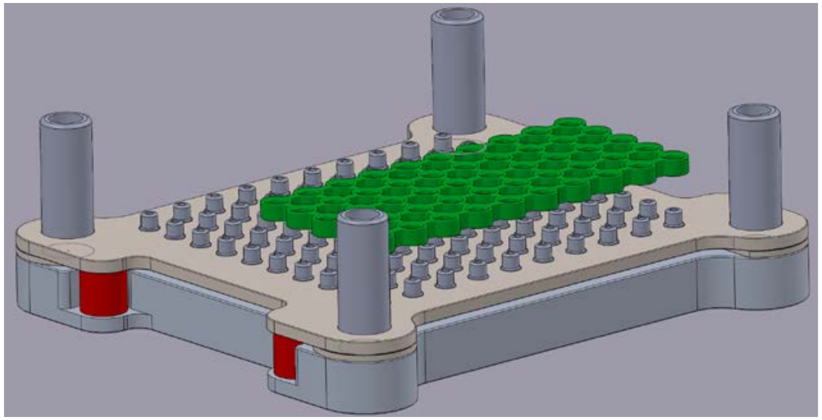
4. Foil punched on top of pellets



5. Battery cups pressed into cups
Plate gap controls anvil-mix distance.



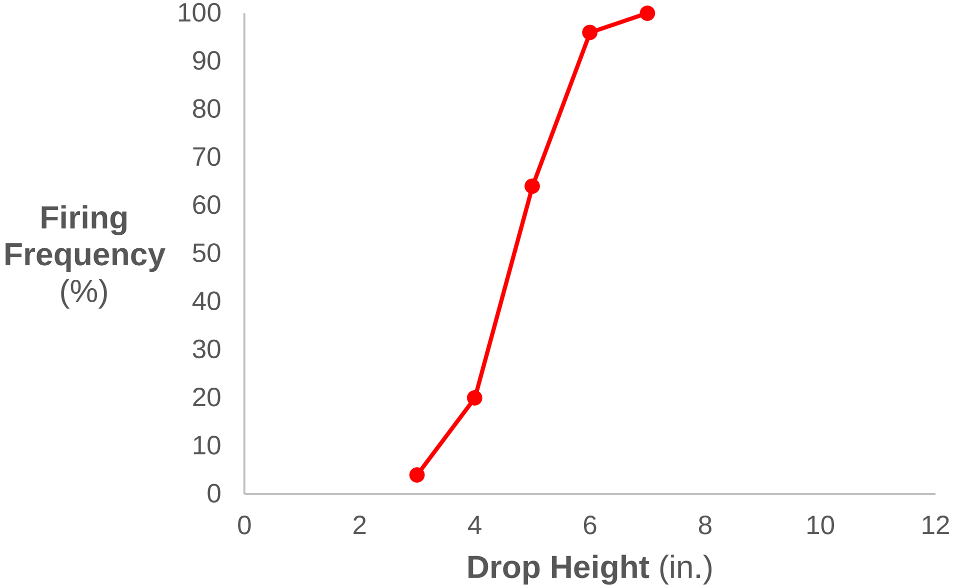
6. Completed primers transferred to packaging sleeve



PRIMER TESTING (1)

- Commercial lot subjected to impact testing to determine firing frequency as a function of impact height

Commercial lot gave virtually linear response to impact

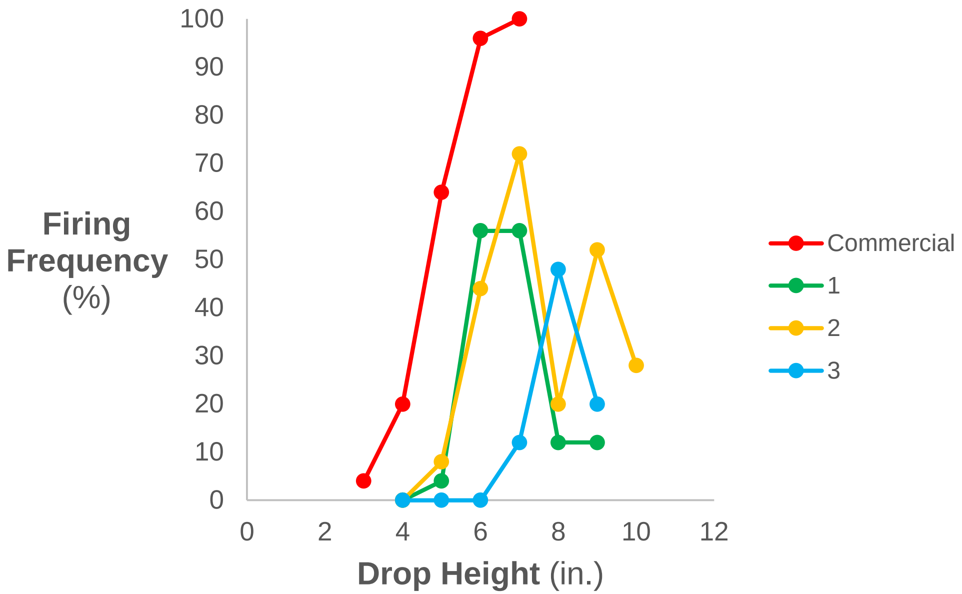


PRIMER TESTING (2)

- Commercial lot tested in parallel with 3 experimental lots that varied assembly parameters

- Initial primer batches gave erratic sensitivity profiles

Lot	Pellet Weight
1	0.0694"
2	0.0652"
3	0.0610"

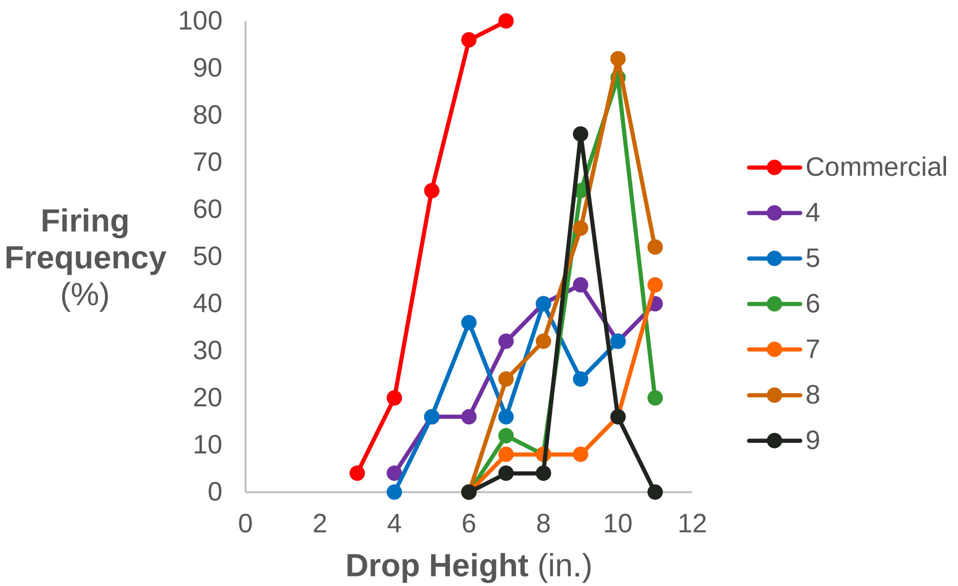


PRIMER TESTING (3)

- Made efforts to improve sensitivity profiles by adjusting assembly parameters
  - Pellet plate gap (pellet weight)
  - Battery cup plate gap (sensitivity)

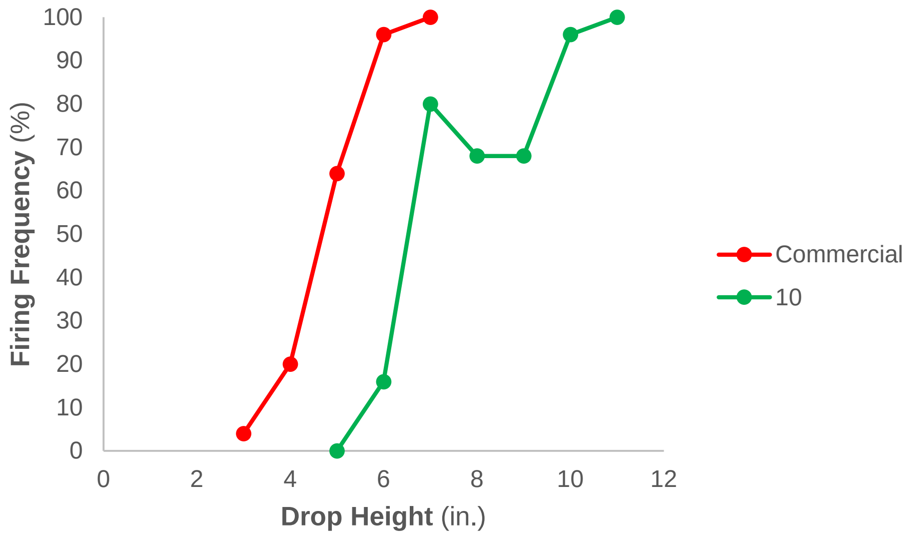
- Tested 6 more lots with alternate manufacturing settings; problems remained

Lot	Pellet Weight	Sensitivity
4	0.0652"	+0.005"
5	0.0610"	+0.005"
6	0.0694"	-0.005"
7	0.0652"	-0.005"
8	0.0610"	-0.005"
9	0.0610"	-0.010"



PRIMER TESTING (4)

- Next hypothesis
  - Erratic behavior due to mix inhomogeneity
  - Pocket formation within mix
- Mix procedure adjusted
  - Screen out coarser KNO_3 particles; remove sub-100 mesh material before mixing, repeat lot 9 assembly parameters
  - Profound improvement
  - Identified all-fire/no-fire energies…
  - …but still no 50/50 point!



Lot	Pellet Weight	Sensitivity
10	0.0610"	-0.010”

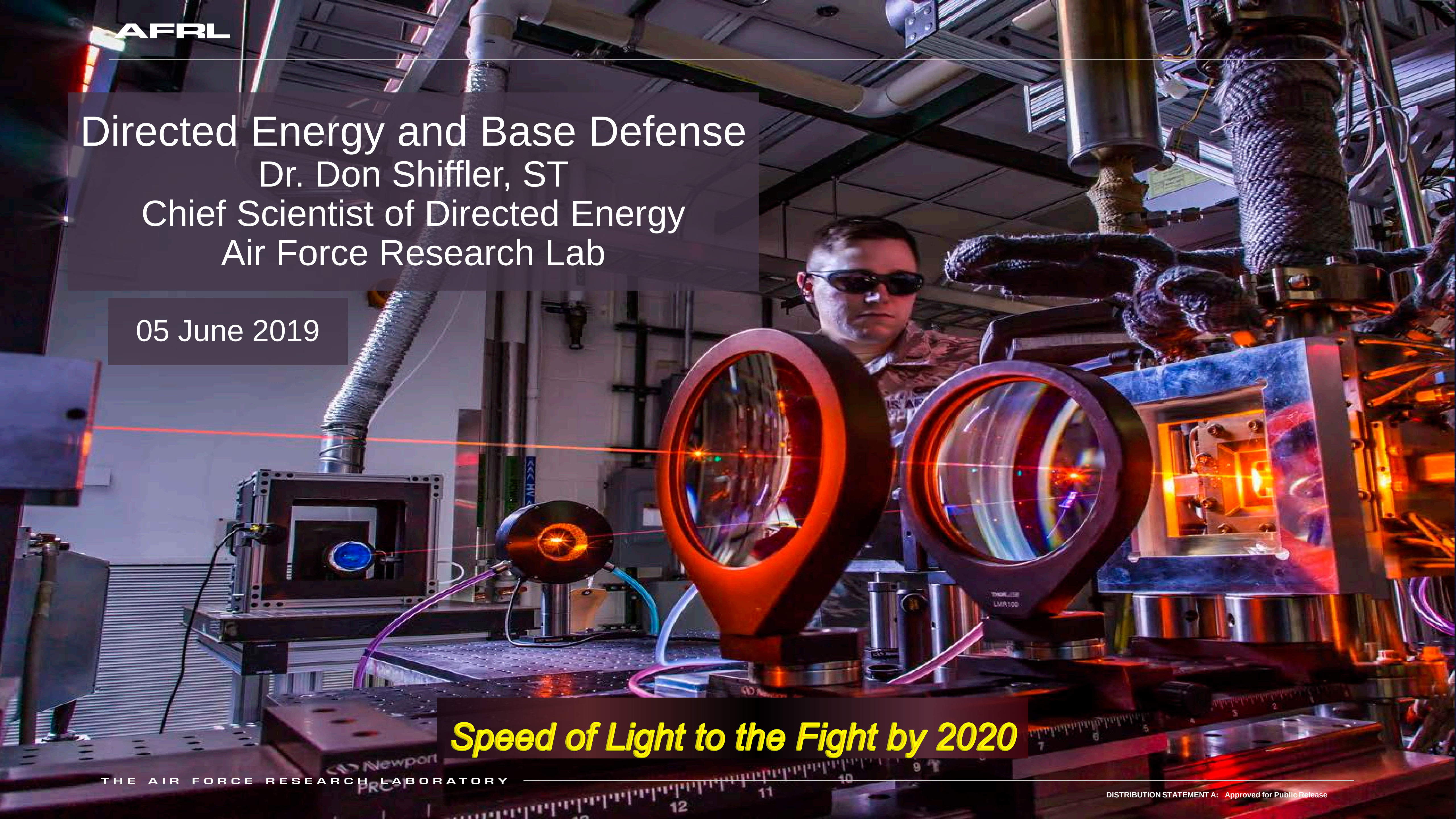
SUMMARY

- DBX-1 composition shows promise
- DBX-1 mix has acceptable sensitivity numbers with the exception of ESD
- Challenges working with DBX-1
  - Very sensitive material
    - Water/alcohol does not desensitize it
  - The mix was processed with IPA which reduces available processing time
  - Breaks down in water to more sensitive material
    - Water cannot be used in the process
  - Requires different waste treatment than current materials at LCAAP
    - Waste treatment of DBX-1 mix requires more work

FUTURE WORK

- Work at flare manufacturer will include function testing of lot 10 primers in:
  - Empty HHS rocket barrels
  - HHS rocket barrels with propellant
  - Fully loaded HHSs with rocket motors and payloads
- Completion of above testing will close out HHS program
- Pending results, can transition to other systems, like shotshell

AFRL



Directed Energy and Base Defense

Dr. Don Shiffler, ST
Chief Scientist of Directed Energy
Air Force Research Lab

05 June 2019

Speed of Light to the Fight by 2020

Outline

- **Why Directed Energy?**
- **What are the Strategic Drivers for our S&T?**
- **Lasers for Aircraft Self-Protect**
- **High Power Microwaves for Base Defense**

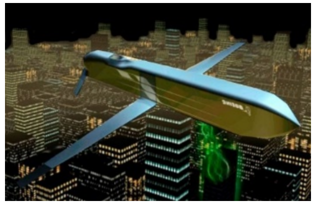
Outline

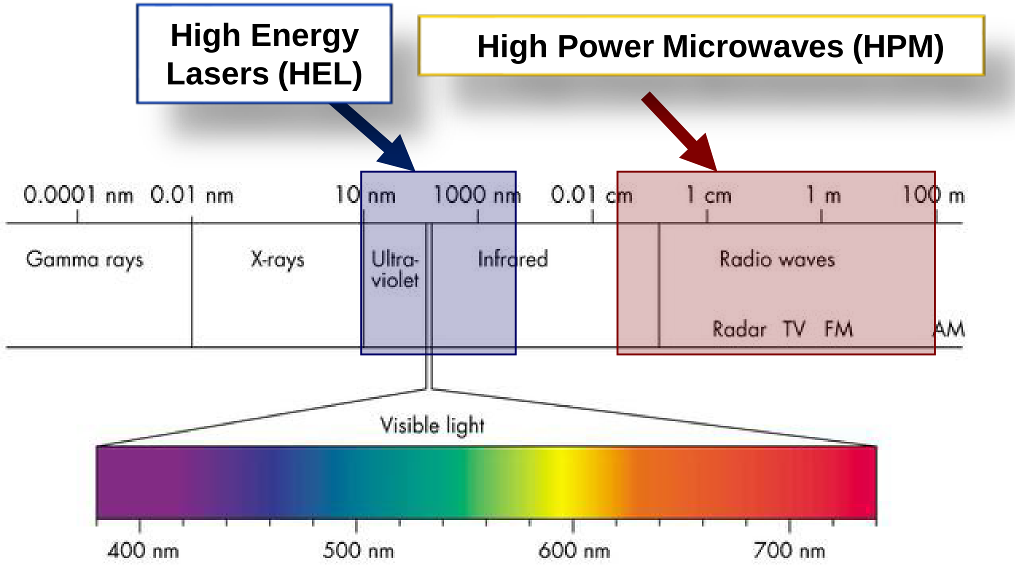
- **Why Directed Energy?**
- What are the Strategic Drivers for our S&T?
- Lasers for Aircraft Self-Protect
- High Power Microwaves for Base Defense

Why Directed Energy (DE)?

DE is a beam of concentrated electromagnetic energy

- Speed-of-Light Delivery
- Precision Engagement
- Controlled/Scalable Effects
- Logistical Advantage
- Low Cost per Shot



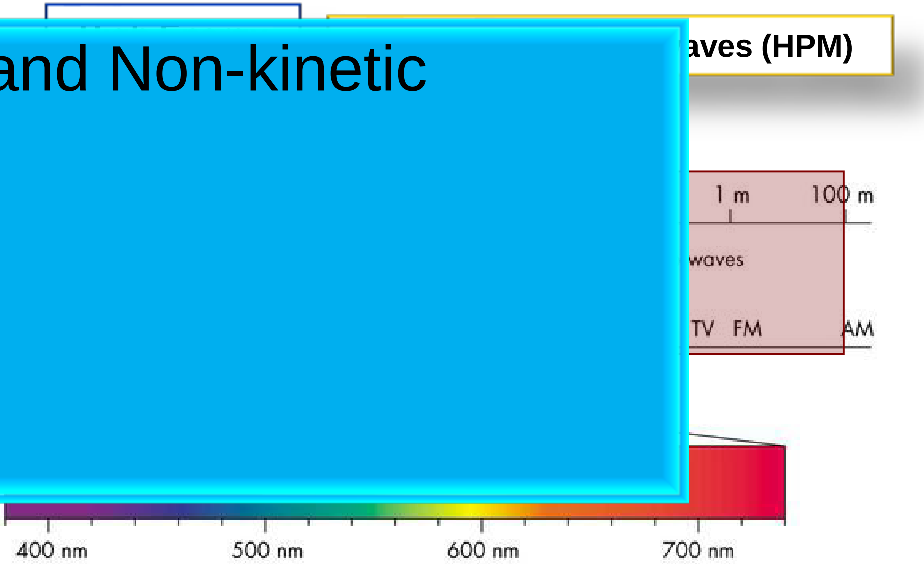


DE offers unique effects & benefits to the Warfighter

Why Directed Energy (DE)?

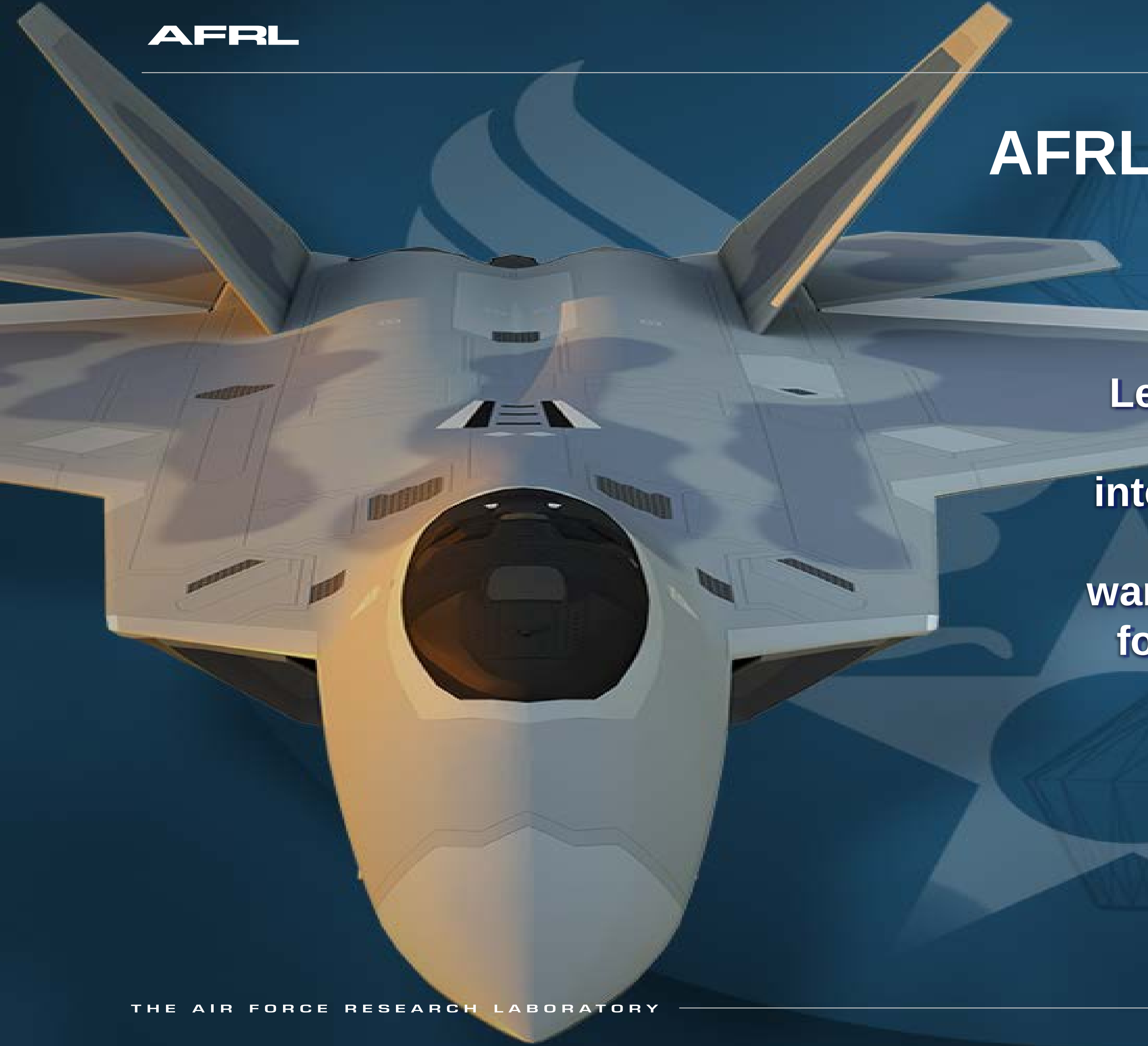
DE is a beam of concentrated electromagnetic energy

- Speed-of-Light Delivery
- Pr
- Co
- Lo
- Lo



- Force multiplier: Kinetic and Non-kinetic synergies are imperative!
- Not a cure for everything
- Not 100% effective

DE offers unique effects & benefits to the Warfighter



AFRL Directed Energy

Mission

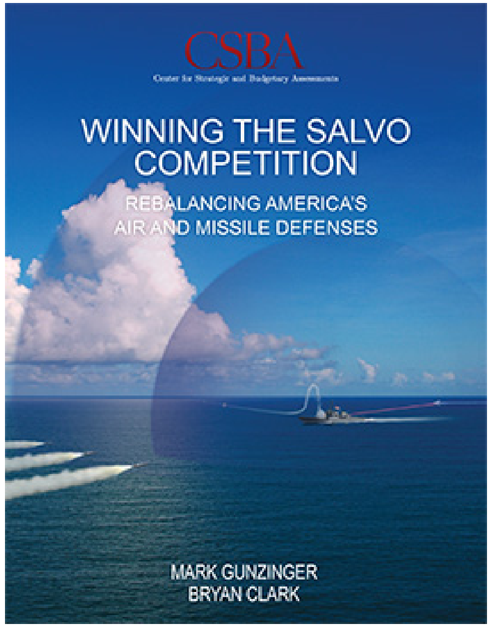
Leading the discovery, development, and integration of affordable *directed energy* warfighting technologies for our air, space, and cyberspace force.

Outline

- Why Directed Energy?
- **What are the Strategic Drivers for our S&T?**
- Lasers for Aircraft Self-Protect
- High Power Microwaves for Base Defense

Great Power Competition

Out-gunned and Out-sticked in the Western Pacific

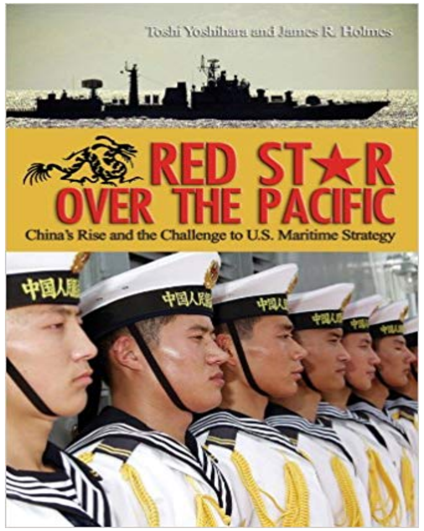


THE DEBATE

China's New Missiles in the Spratlys May be a Turning Point

There is no longer any reason for China to acknowledge the diplomatic fig leaf of Xi Jinping's "militarization" assurance.

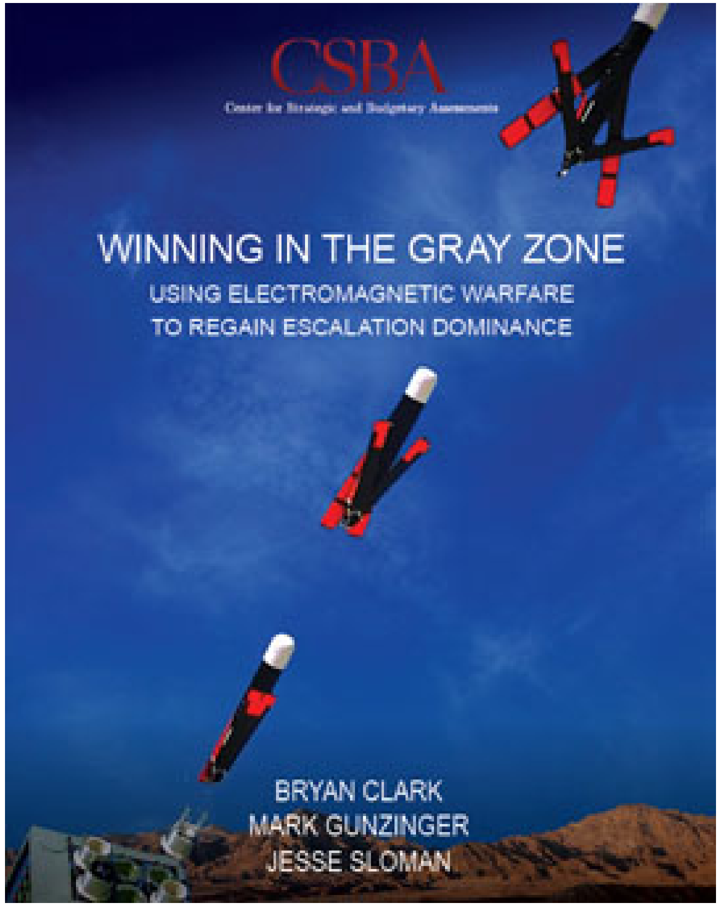
By Steven Stashwick
June 14, 2018



Warfare in the Gray Zone

Incapable of fighting gray zone warfare

- Rise of China and Resurgent Russia



Outlook • Perspective

Russia is advancing on Ukraine again — and Ukraine isn’t going quietly

President Petro Poroshenko tells the Post how he wants the war to end.

Most Re

Study→ Experiment →Prototype

Class 1 & 2 UAS are being used as precision guided munitions to target heavily guarded areas.


DJI Phantom 4

A *single* $1,000 UAV can hold an *entire F-22 squadron* at risk

10JAN2018
Russian Base in Syria

Outline

- Why Directed Energy?
- What are the Strategic Drivers for our S&T?
- **Lasers for Aircraft Self-Protect**
- High Power Microwaves for Base Defense

Self-Protect High Energy Laser Demonstrator (SHiELD) ATD

Description

- SHiELD was commissioned by the Air Combat Command Applied Technology Council as an Advanced Technology Demonstration (ATD) in 2015.
- SHiELD's mission is to integrate a high energy laser and beam control system into a singular pod that will be mounted to a tactical platform in order to shoot down an incoming threat.
- Success of this ATD will indicate a TRL of 6 for High Energy Laser Technology for the Aircraft-Self protect mission

Purpose

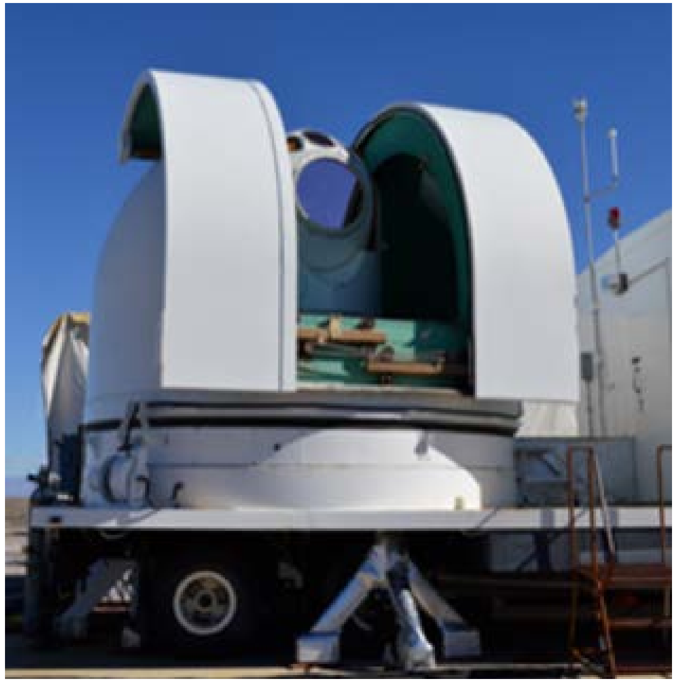
- Improve future aircraft survivability by providing self-protect capability from High Energy Lasers
- Retire Science and Technology risks associated with integrating high energy lasers on tactical platforms
- Demonstrate maturity of integrated laser systems in a complex flight environment

Approach

- Beam Control Testing: Demonstrating aero-effects mitigation
  - Acquisition, tracking, and pointing performance on threats
  - Characterization of aero-effects to develop concepts to expand operational envelop
  - Improved performance through aero-effects mitigation
- High Power Target Testing: High power system demonstrating performance in flight against threats
  - Aircraft & high power laser system compatibility & concept of employment
  - Provides initial data for reliability, maintainability, availability
  - Anchors system models with flight data
  - Informs follow-on science and technology investments

Recent Success – MFC Testing

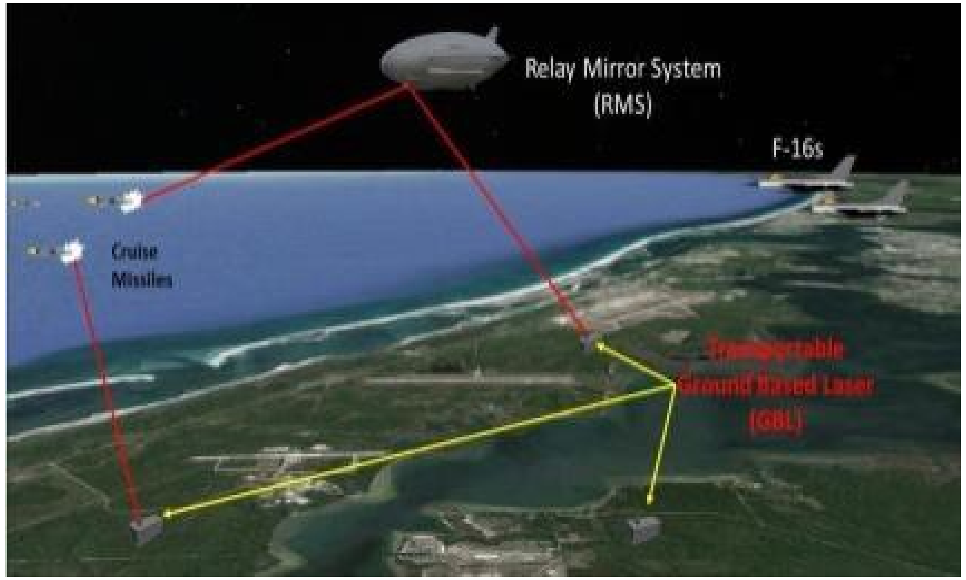
- **Major Test Milestone accomplished April 2019:**
  - **Shoot-down of several in-flight missiles at White Sands Missile Range, NM**
  - **Employed DLWS (Demonstrator Laser Weapons System) to serve as a surrogate High Energy Laser (HEL) System for SHiELD Engagements**
    - Note: SHiELD will be much smaller and lighter, as well as ruggedized for an airborne environment.
  - **Necessary intermediary step for SHiELD System**
    - Demonstrates failure mechanisms of relevant threats



Outline

- Why Directed Energy?
- What are the Strategic Drivers for our S&T?
- Lasers for Aircraft Self-Protect
- **High Power Microwaves for Base Defense**

Hybrid Defense of Restricted Airspace (HyDRA I/II) Addresses Airbase Defense Challenges



- **GOAL:** Perform systems, engagement, and mission-level Military Utility (style) Assessment (MUA) of the HyDRA system of systems.
- **CAPABILITY:** Cost-effectively defend bases, strategic targets, etc. against attacks by UAS, CM & RAM considering weather.
- **STUDY HYPOTHESIS:** Hybrid Kinetic & Directed Energy weapon & sensor solutions maximize system capability

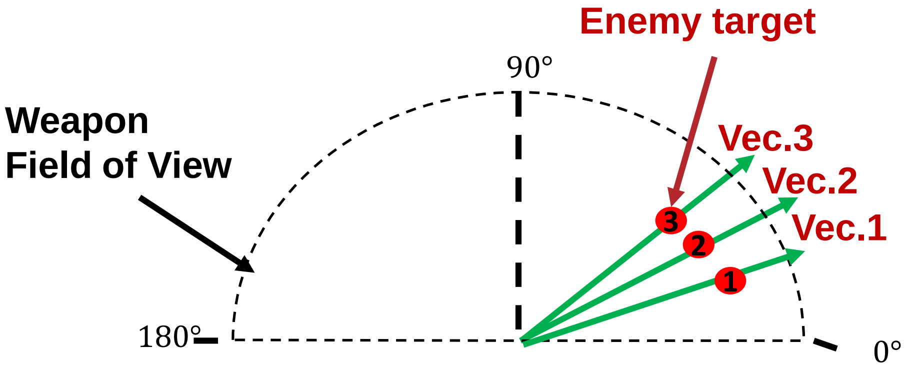
The HyDRA team delivered to AFLCMC/HBU (Force Protection SPO) trade space brief for DE C-sUAS

– Full trade space includes sensors, HEL, and HPM options to address the C-sUAS JUON by early 2019

HyDRA I Resulted in fielding of positive ID prototype in NRC

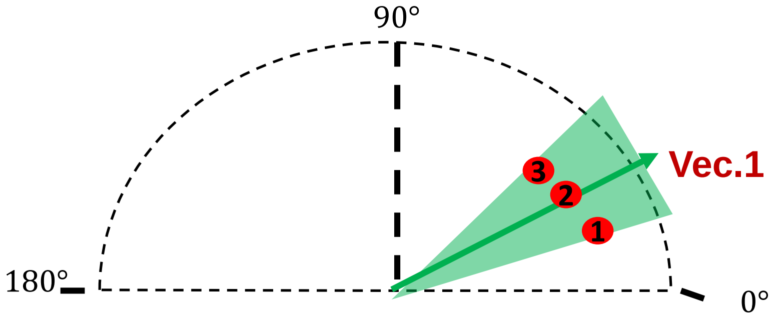
HPM Weapon Characteristics

Kinetic Weapon
(1 shot, 1 kill)



- **Kinetic requires minimally 1 shot per Target**
- **Precise tracking critical to complete fire control solution**
    - Maneuvering target lowers single shot probability of kill
- **Range: 250 - 750m**

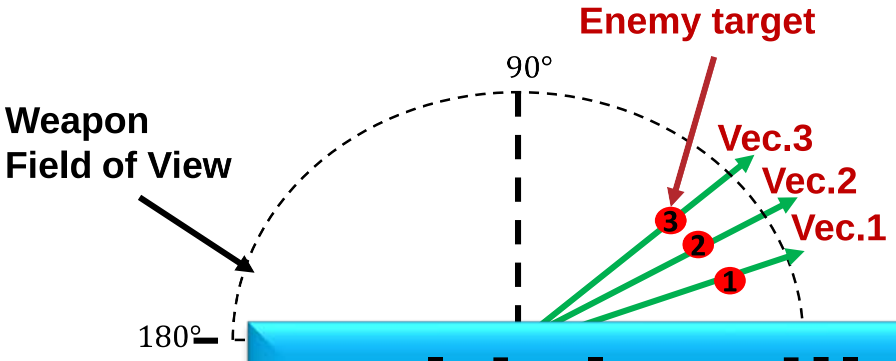
THOR
(1 shot, >1 kill)

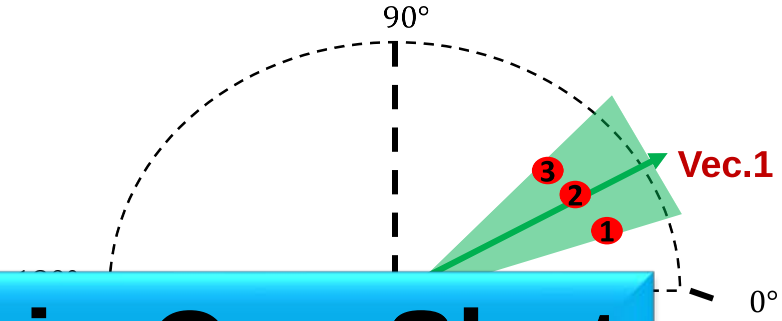


- **HPM can provide One Shot on Many Targets**
    - System rotates 30deg/sec to support many engagement vectors with simultaneous time of arrival
- **Tracking is less critical based on speed of light effects**
- **Range: >750 m**

HPM Weapon Characteristics

Kinetic Weapon (1 shot, 1 kill)	THOR (1 shot, >1 kill)





Multiple Kills in One Shot

- **Kinetic r**
  shot per Target
- **Precise tracking critical to complete fire control solution**
  - Maneuvering target lowers single shot probability of kill
- **Range: 250 - 750m**

- **Shot on Many**
  Targets
  - System rotates 30deg/sec to support many engagement vectors with simultaneous time of arrival
- **Tracking is less critical based on speed of light effects**
- **Range: >750 m**

HPM Effects

- Expanded effects understanding in counter-UAS and counter-missile

Front Door Coupling Paths

- HPM field couples to antennas
- In-band HPM energy at receiver
- Vulnerable components: low noise amplifiers (LNAs), limiters
- Effect is generally ***damage***
- Can achieve EW-like effects with upset

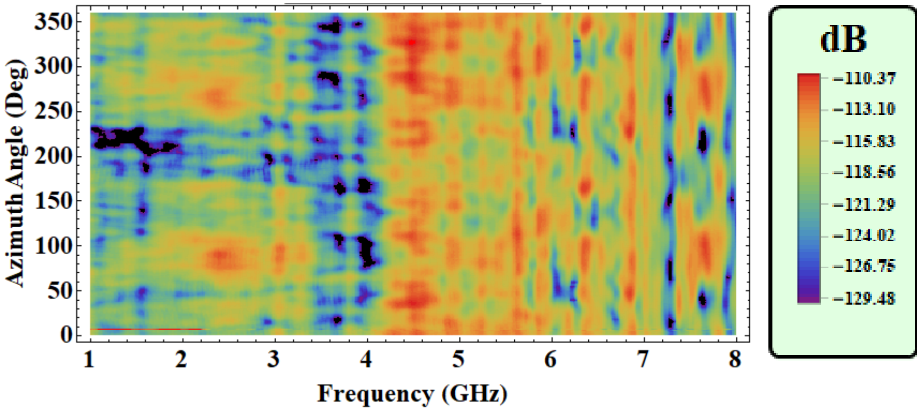
Back Door Coupling Paths

- Control / guidance systems involve digital electronics
- HPM field couples to control wires (e.g. UAS), internal cables (e.g. missile)
- Effect typically ***disruption*** of digital electronics

DJI Phantom 4

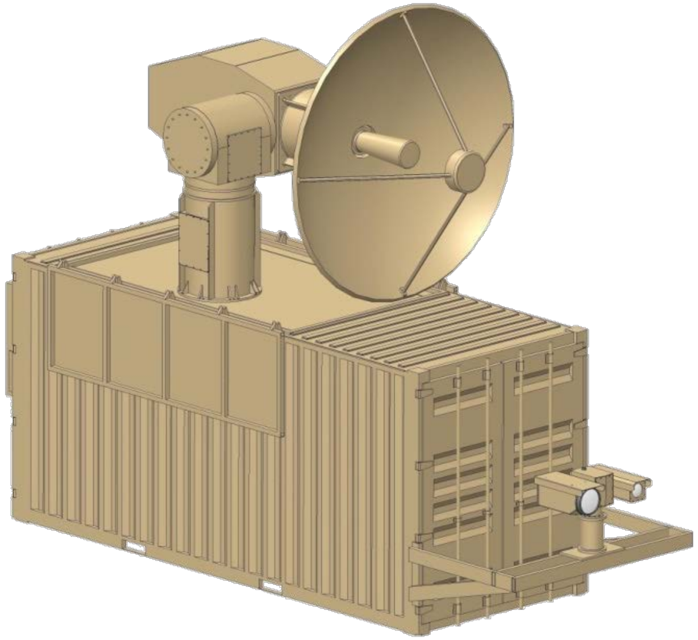
Electronic Speed Controllers

RF absorption by azimuth & frequency

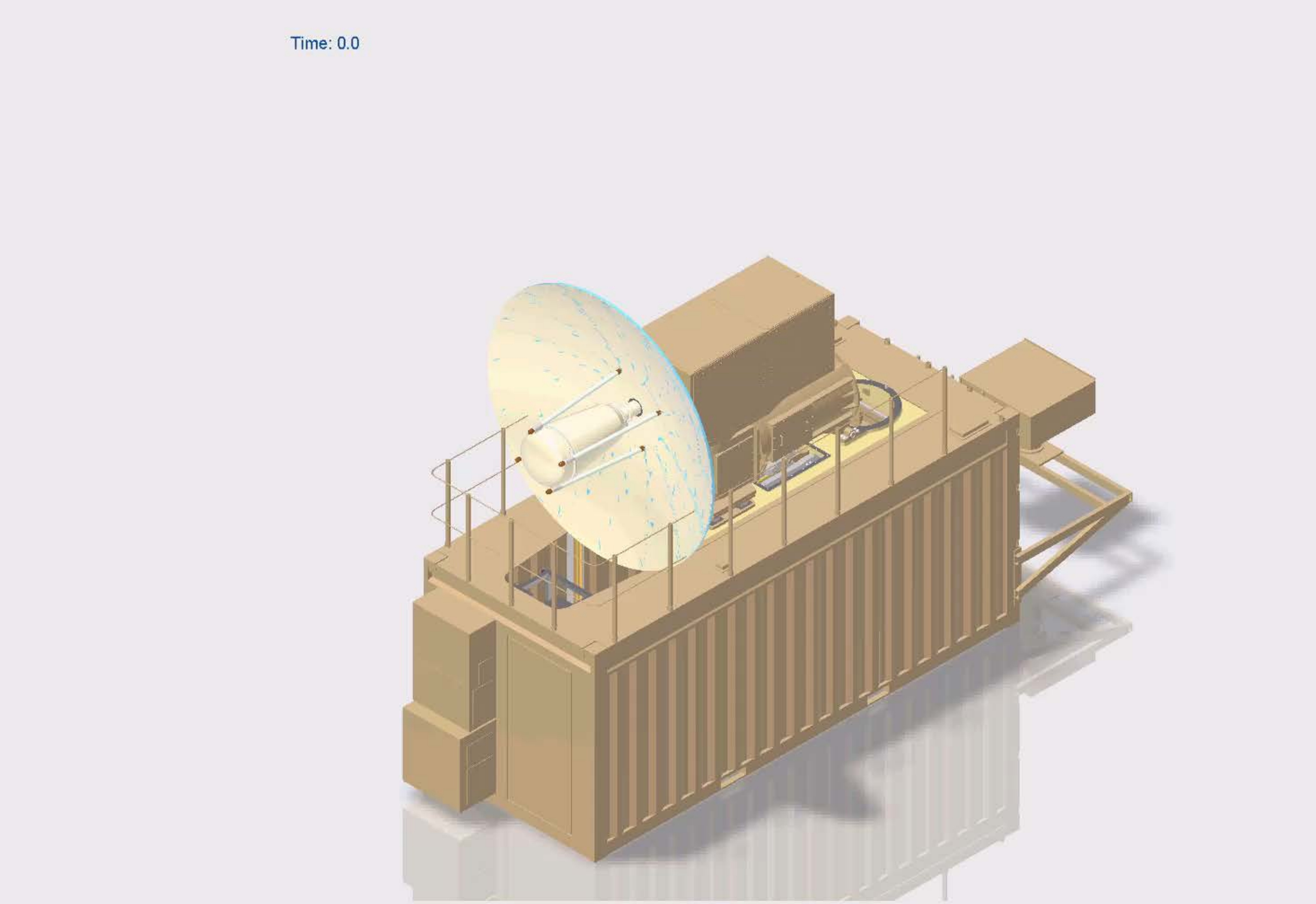


Tactical High-power-microwave Operational Responder (THOR)

- Directed Energy Weapon specified by HyDRA Study
- Demo a non-kinetic kill of autonomous class 1 UAS swarms
  - Rapidly develop Advanced Technology Demonstrator suitable for integration into Air Base defense control
    - Near term: 18mo. to Transition
  - Transportable
  - Engagement of UAS at ranges less than 2km
  - Integration with existing C2 and standalone operation
  - **Demonstration in real-world scenario Summer 2019**



THOR: Operational Focus



- Currently has a stand-alone operations control
- Integration with Maneuver Aviation Fires Integrated Application (MAFIA) and Forward Area Air Defense (FAAD) C2 planned
- Designed for One/Two Person Setup
- No tools required for antenna assembly
- Withstand winds up to 125mph
- Organic EO/IR for dedicated Find/Fix/Track/ID

S&T to Make HPEM Weapons Airman Ready

THEN…

1983

PhD operated,
Bulky,
No environmental hardening,
Not Aerodynamic

NOW!

CHAMP
(Flying HPM)

2012

Warfighter operated,
Smaller,
Ruggedized,
Demonstrated aerodynamics

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

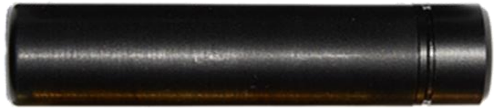
Next Generation Squad Weapons Technology
NDIA Armaments Systems Forum
June 3-6, 2019

Matthew R. Moeller

Project Officer

Combat Capabilities Development Command – Armaments Center

NEXT GENERATION SQUAD WEAPONS TECHNOLOGY



Polymer Cased Telescoped Cartridge

6.8mm Very Low Drag (VLD) Projectile

Cased Telescope 6.8 mm Automatic Rifle

Purpose:
- Provide critical weapon-integrated technologies for Next Generation Squad Weapon - Automatic Rifle (NGSW – M249 SAW replacement), leveraging prior efforts and to inform requirements

Key Features:
- Mid-Caliber (6.8mm) VLD Projectile
- Optimized Cartridge – Weight/Size vs. Lethality
- Integrated Muzzle Device - Recoil and Signature Management
- Power/Data Transfer Rail

Milestones:
- FY19 – Transition of Technical Data Package (TDP) and Design Reference Packet to PM Soldier Weapons
- FY20 – Demonstration of Small Arms Fire Control Integration

Partners:
- Industry (Textron/AAI, ATI Flowform)
- CCDC ARL, CCDC DAC

NGSWT PROTOTYPE SYSTEM CHARACTERISTICS

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- **Characteristics**
  - 6.8 mm cased telescoped cartridge
  - Vertically rising chamber operating group
  - Length: 35" buttstock collapsed, including muzzle device
  - Weight: 11.9 lbs (with sling, bipod, muzzle device)
  - Magazine Feed: 20 round capacity
  - Cyclic rate: 600 rpm
  - Integrated muzzle device to reduce recoil, sound, and flash
  - Integrated Picatinny Smart-Rail compliant powered data rail on four sides of upper receiver
  - High-capacity Li-ion battery
  - M-Lok mounting system

SUMMARY

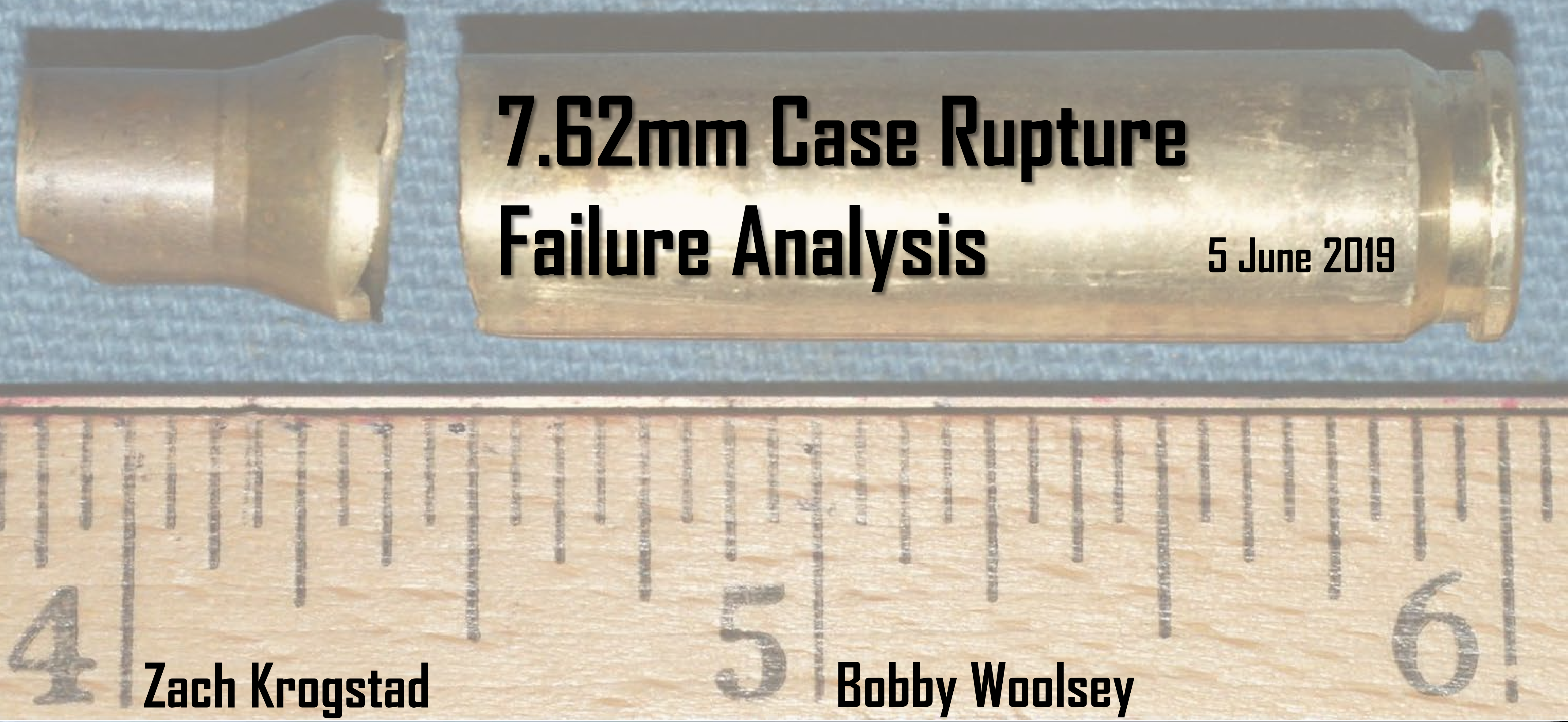
- Meets or exceeds most performance requirements in DRAFT Capabilities Development Document (CDD)
- Technology completed in <u>*15 months*</u>
- Technology transitioned to PM Soldier Weapons in MAY 2019
- Plans are to continue to evaluate technology with limited user assessment in 4QFY19

LIVE FIRE DEMONSTRATION
CCDC-AC – G2 RANGE DEMO – APRIL 15, 2019

LIVE FIRE SEMI-AUTO LONG RANGE
ARMY RESEARCH LAB M-RANGE – MAY 2, 2019

7.62mm Case Rupture Failure Analysis

5 June 2019



Zach Krogstad

Bobby Woolsey

NORTHROP GRUMMAN
Alliant Techsystems Operations LLC

Project Manager PM MAS Reliable, Precise, Lethal Maneuver Ammunition Systems

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Problem Statement

- Multiple lot acceptance tests at the Lake City Army Ammunition Plant (LCAAP) from 2017-2018
  - 10 partial and complete circumferential ruptures
- 7.62mm M80 shot in the M240 weapon system

M80 ruptured case and subsequent cartridge which failed to chamber (middle)

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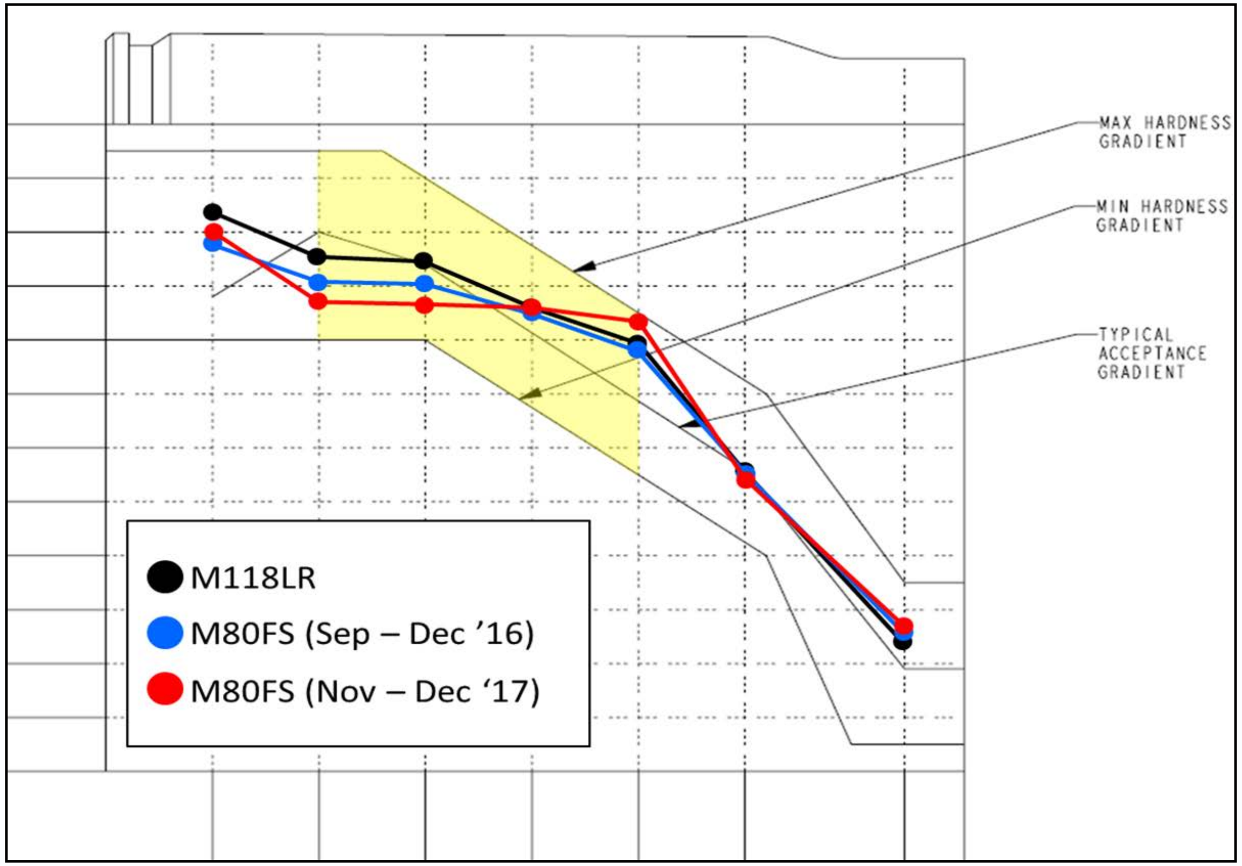
Root Cause Identification

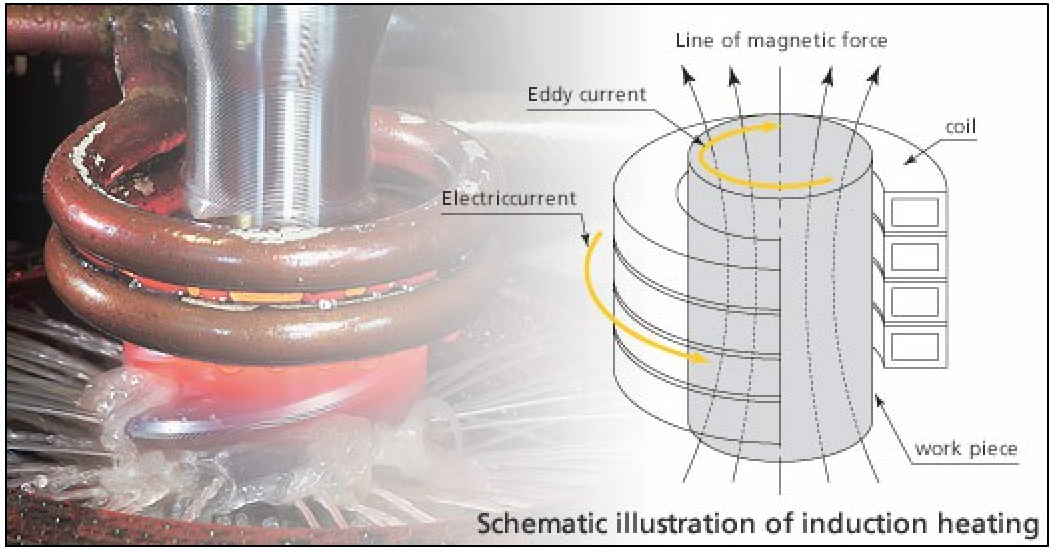
- All cartridge case hardness data were within acceptable limits
- However, the **hardness gradient** appeared significant
- A steep hardness gradient can cause a **localized region of stress**
- The technical team worked to ***improve the hardness gradient***



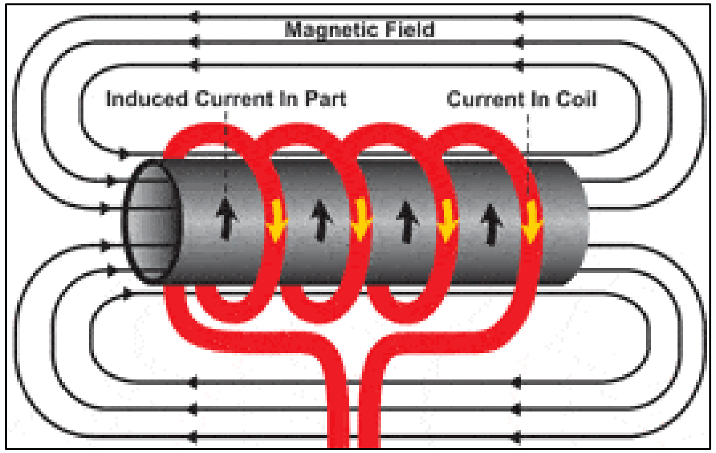
CASE DWG NOTE: "The greatest probability of satisfactory function of cartridges assembled with these cases occurs when the graph of these average readings is ***generally parallel to the limit gradients*** and is ***free from sharp angular departures*** therefrom in the region 0.5" from the head to 1.875" from the head."

INDUCTION ANNEALING

- 7.62mm cases rely on induction heating coils to rapidly anneal the body of the case
- **Precise coil manufacture** and **precise positioning** with respect to the case are required in order to yield consistent anneal results
- Coil geometry and position resulted in cases with a large hardness gradient just below the shoulder

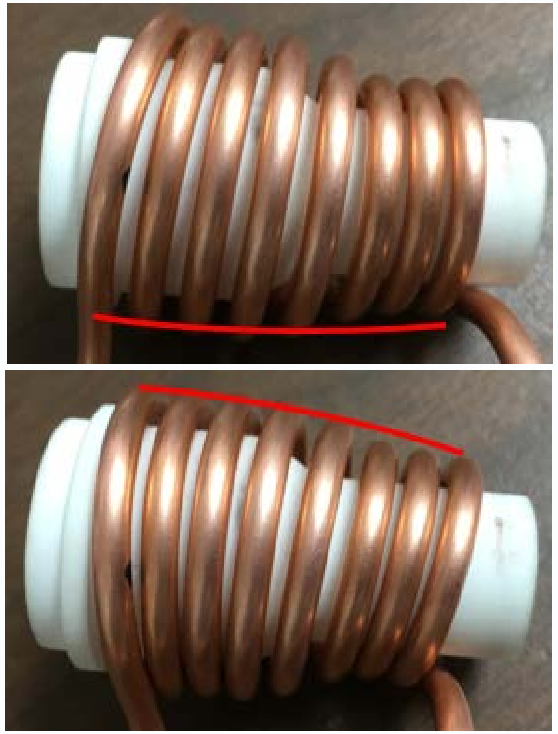


Schematic illustration of induction heating

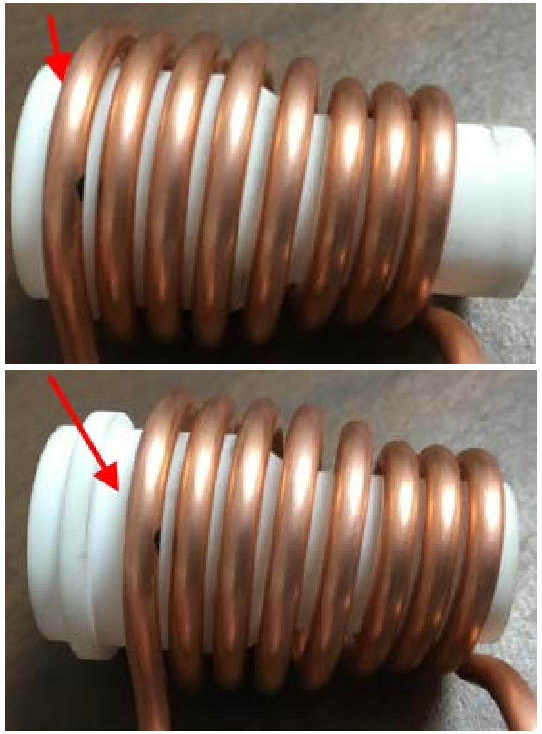


ANNEAL COIL VARIABILITY

- The design of the ceramic insert allowed the copper anneal coil to shift during setup
- Across 16 case manufacturing machines, each coil functioned differently because of variation in setup
- The team worked to reduce the sources of annealing variability across the machines



Coil spacing variation or bent coil axis



Axial position of coil in relation to insert and block

New Anneal Coil Design

Old ceramic insert design

New ceramic insert design

New ceramic insert design with coil

A redesigned anneal coil reduced setup variability among machines

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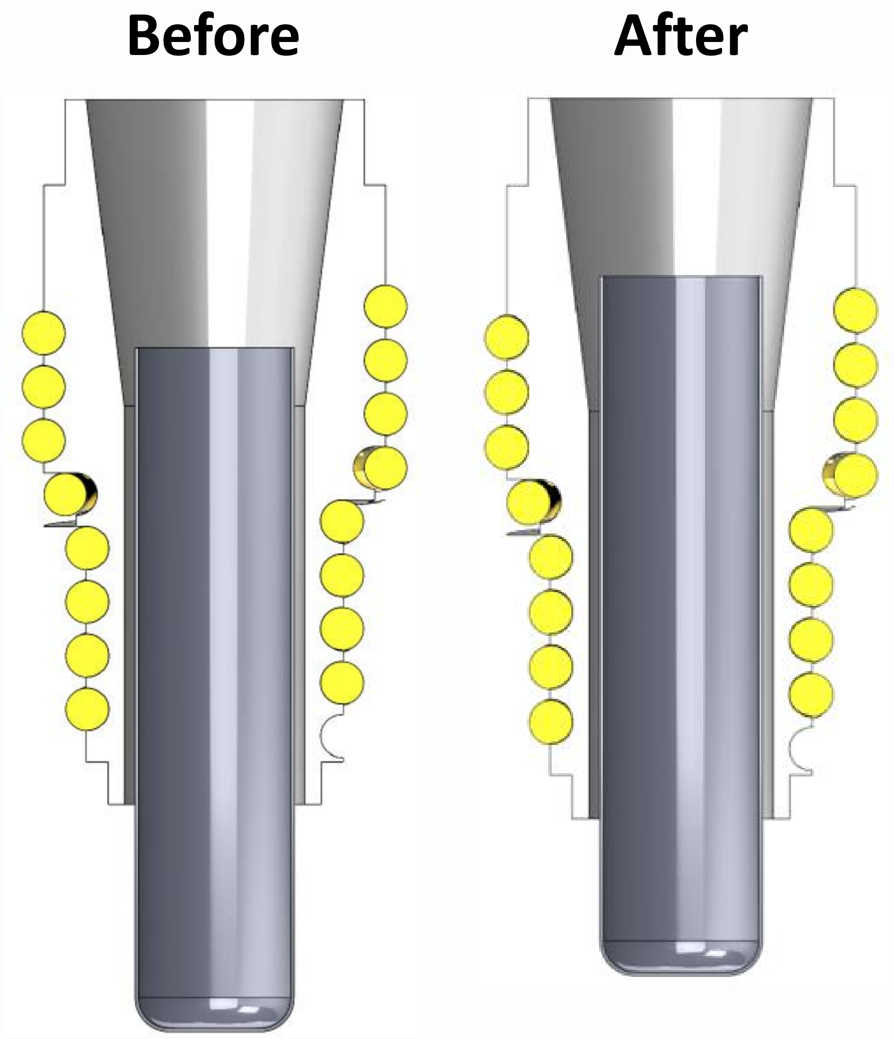
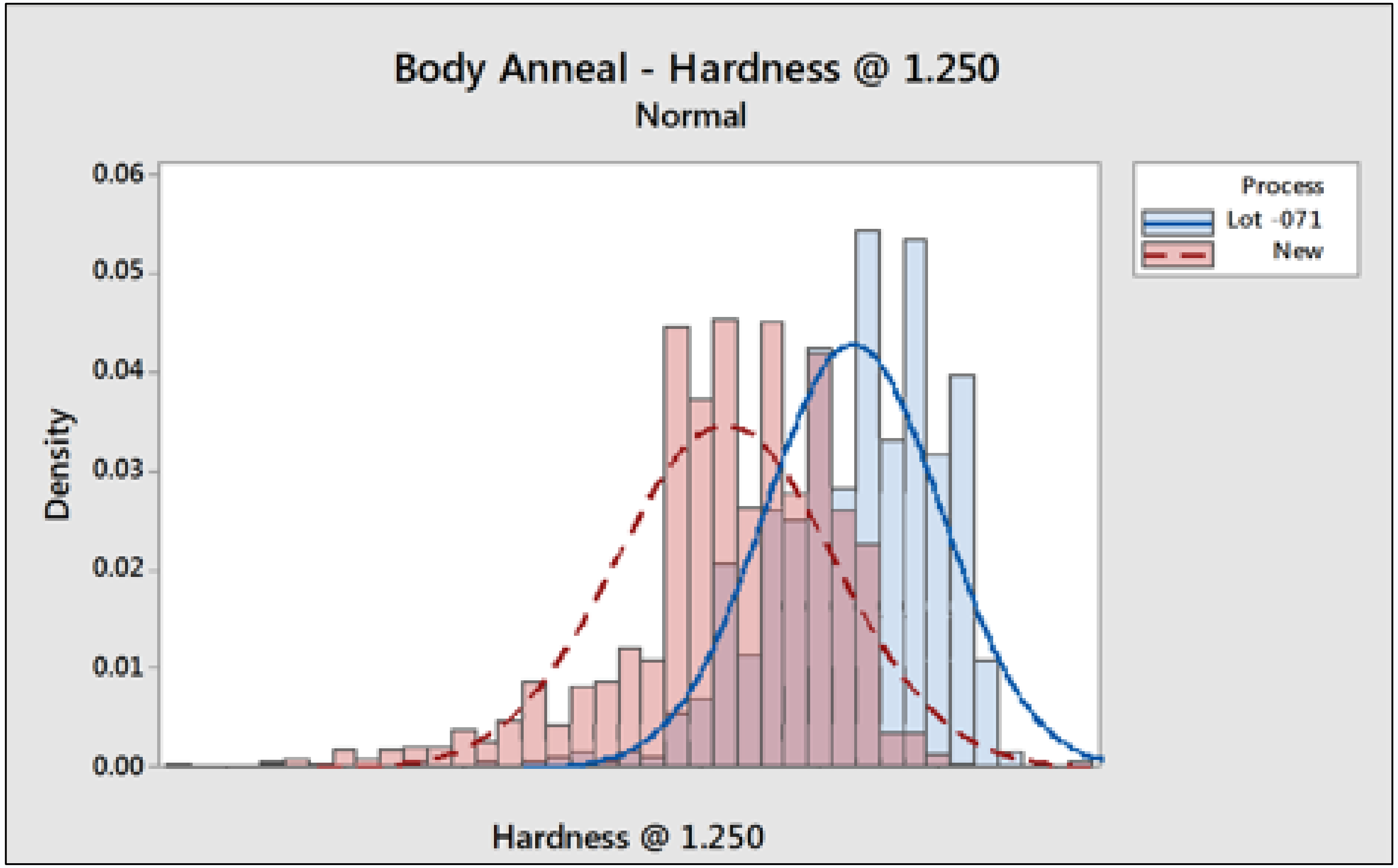
Annealing Location

- Positioning the part further in the coil allows for more **heat applied lower** on the body of the case
- This shift reduced hardness in the 1.25" region which reduced the hardness gradient and resulting localized stress
- Results in case hardness parallel to the drawing limits



RESULTS

- These changes caused a shift at our most critical location on the case
- The improvements have prevented any further case ruptures to date



Conclusion

- An improved 7.62mm case manufacturing process was implemented at LCAAP
- Resulted in a more robust 7.62mm case which is less prone to rupturing in the M240 weapon system
- Zero (0) case ruptures have occurred since new process implementation

- Coauthors:
  - David Redfearn (ATO - LCAAP)
  - Daniel Meierhofer (ATO - LCAAP)
  - John Conway (U.S. Army)
  - Jignesh Patel (U.S. Army)

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

Virtual Reality Prototyping for Fire Control Platforms

NDIA Armament Systems Forum 2019

DISTRIBUTION STATEMENT A. Approved for Public Release. Distribution Unlimited.

- Classification: UNCLASSIFIED, Distribution A: Approved for Public Release. Distribution Unlimited.

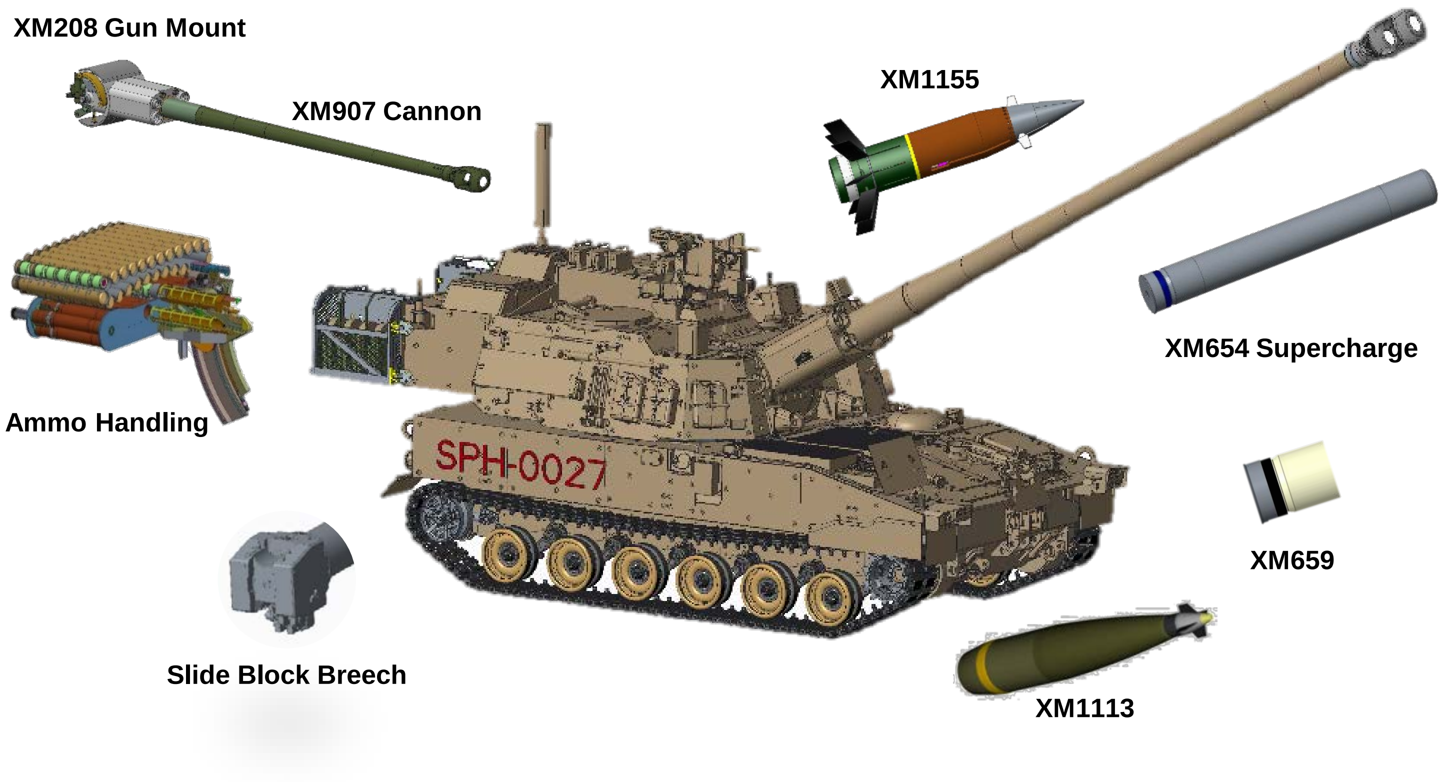
- Type of Briefing: INFORMATIONAL

AGENDA

- ❑ Extended Range Cannon Artillery (ERCA) Overview
- ❑ Autoloader, Optionally Manned and Design Decision Paralysis
- ❑ AR Prototyping
- ❑ Virtual Testing with Human Factors
- ❑ Aggressive, Representative Testing
- ❑ Rapid A/B Analysis
- ❑ Example: RWS Pointing
- ❑ Path Forward

EXTENDED RANGE CANNON ARTILLERY (ERCA) OVERVIEW

- Newly designated the XM1299
- New 155mm Self Propelled Howitzer (SPH) based on the current M109A7
- 58 caliber cannon increases range from 38km to 70km+
- Ammo handling system increases rate of fire from 3 rpm to 10 rpm
- New cannon and slide block breech design for improved reliability



AUTOLOADER, OPTIONALLY MANNED AND DESIGN DECISION PARALYSIS

- XM1299 will be deployed in a few spirals
- First cut is focused on the gun
- Future iterations will incorporate an autoloader and functions to support optionally manning the platform
- Removing the crew from the gun radically opens up the design space
- Can easily run into design decision paralysis
- Need to have a way to quickly address design options and make decisions in order to maintain program schedule

AUGMENTED REALITY PROTOTYPING

- **When designing new hardware a major issue is seeing how it fits in with other components and the rest of the physical word**
  - Computer models on a screen can show how they fit together, but can't as easily show fit (can my hand easily fit to attach a cable?)
  - A 3D printed model can show fit, but takes significant time to print a model and any change requires a new model
- **Augmented Reality allows for taking CAD files and directly injecting them into the physical world**
  - Allows rapid prototyping to check real world fit
  - Reuse of existing CAD files saves time
  - Multiple COTS solutions exist or in development
    - Microsoft Dynamics 365 Layout
    - NASA Jet Propulsion Lab Protospace

VIRTUAL TESTING WITH HUMAN FACTORS

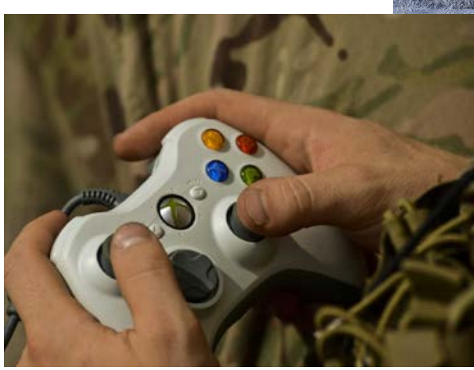
- **Many elements of the howitzer can be automatically modeled to support design decisions**
  - Gunfire shock response, electrical power draw, internal ballistics, etc.
- **Systems that involve human input and use are more difficult to model**
  - 2^{nd} and 3^{rd} order effects are often missed
  - Human testing on real vehicles is often restricted for safety purposes or testing constraints
- **Use a virtual testing environment to try these out**
- **Especially as programs shift to remote operation, the difference between operating tactically and in a virtual environment is reduced**

AGGRESSIVE, REPRESENTATIVE TESTING

- **Much of the testing we do, especially when real people are involved, is highly controlled, limited and expensive**
  - Reduce risk to injure personnel
  - Reduce risk to damage limited test assets
- **In a virtual testing environment we can create realistic and highly stressing scenarios**
  - Nobody gets hurt, nothing is damaged
- **Not used to validate the design but to inform design decisions**
  - Doesn't have to be 100% accurate to conduct conceptual experiments

RAPID A/B ANALYSIS

- Use existing virtual tools to facilitate rapid decision making early in the design process
- Quantitative results from human interaction with the system
- Example: Remote weapon system operation on an optionally manned platform
- Question: “Should I point with a thumb stick or head tracking?”



OR

EXAMPLE: POINTING METHOD

- **Design several virtual testing environments with targets**
- **Settle on quantitative scoring method**

Score = W1 x (# of hits) + W2 x (ammo used) + W3 x (collateral hits)

Weighted values

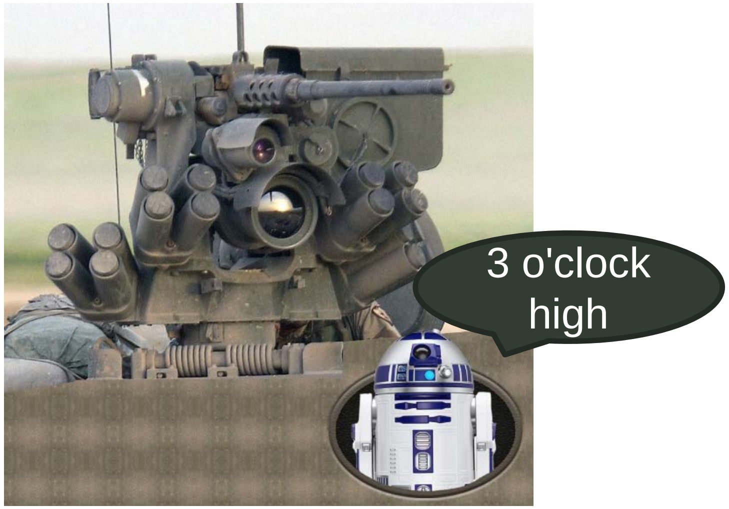
- **Run through test scenarios with a representative group**
- **Testing this 'for real' would be too dangerous, too expensive, or happen too late in the design process**

RESULTS

- **Rapid comparative score**
  - “Head tracking scored 45.8% better than thumb pointing”
- **Deeper data to pull from**
  - “Head tracking provided slower response but greater accuracy”
  - “Thumb pointing worked better in urban environments”
- **As many or as few runs as necessary to help inform a decision**
- **Results can be weighed with other factors**
  - “Sure head tracking is better but it costs 10x as much, it’s not as reliable and it’s only to support a secondary weapon……so we’re sticking with a standard controller.”
  - “Head tracking used half the ammo of thumb pointing and that alone pays for the extra equipment.”
- **<u>Is the juice worth the squeeze?</u>**
- **A reasonably accurate answer today is better than a perfect answer 6 months from now….**

OTHER A/B TESTING OPPORTUNITIES

- **Many other design aspects of a remote weapon station that can be simulated and scored**
  - System latency (how far away can your remote operator be?)
  - System response (how powerful do your motors need to be?)
  - System accuracy (how sophisticated do your optics need to be?)
- **Can also be used for many other human interfaces such as remote driving**
- **Can create simple / 'simulated' models of assisting AI applications to judge effectiveness with operator**
  - Is R2D2 a helpful co-pilot or backseat driver?
  - How much does R2 help?
  - Is it worth the cost to build and add R2?
  - Is BB8 better?



PATH FORWARD

- **Plan to pioneer this virtual prototyping and analysis on the XM1299 program**
- **Working concept in the next few months to demonstrate capability**
- **Assist design decisions over the next several years**
- **Leave behind capability of an accurate trainer**

- **Most of the effort could be rapidly applied to other similar programs by reusing**
  - Test environments and targets
  - Scoring methods and metrics reporting
  - Hardware and lab facilities

QUESTIONS

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M80A1 Dispersion Reduction

6 June 2019

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Steve Redd
Dustin Triebel
Jeff Siewert

NORTHROP GRUMMAN
Alliant Techsystems Operations LLC
ARROW TECH
Project Manager PM MAS Maneuver Ammunition Systems
Reliable, Precise, Lethal
DEVCOM ARMAMENTS CENTER
NDIA 100 1919 2019

BACKGROUND

- Two packing configurations exist for M80A1
    1. Linked (machine guns)
    2. Carton (rifles)

- Ammunition dispersion requirements differ
    – Rifle packing requires smaller dispersion

- In order to increase flexibility in manufacturing, PM-MAS initiated an effort to improve the ammunition dispersion of M80A1

- Armaments Center, Northrop Grumman, and Arrow Tech collaborated to *prioritize the error sources that contribute to ammunition dispersion*

Linked M80A1

Carton-packed M80A1 (in rifle magazine)

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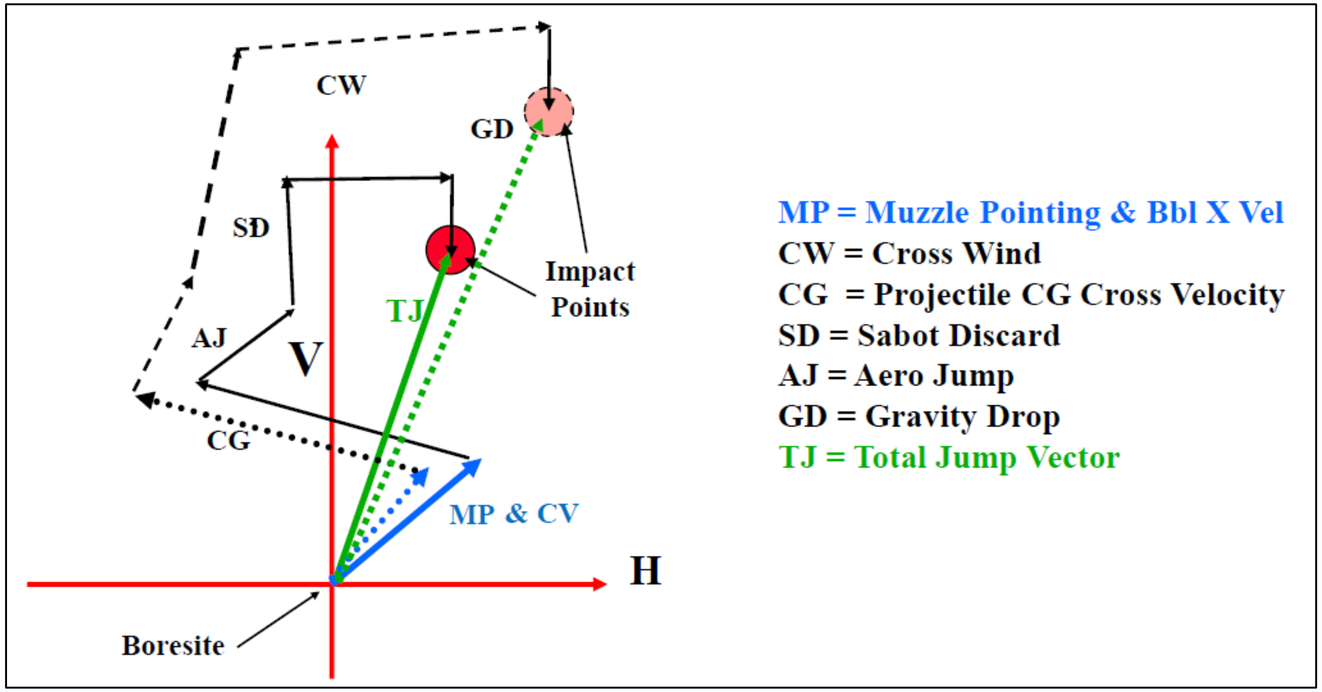
Ammunition Dispersion

NDIA 100

- Ammunition dispersion is composed of various effects
- The unpredictable magnitude and direction and of these effects causes a random "miss distance" from the boresight with each shot
- The project goal was to assign priority to the error sources
    - Efficient approach to improvement



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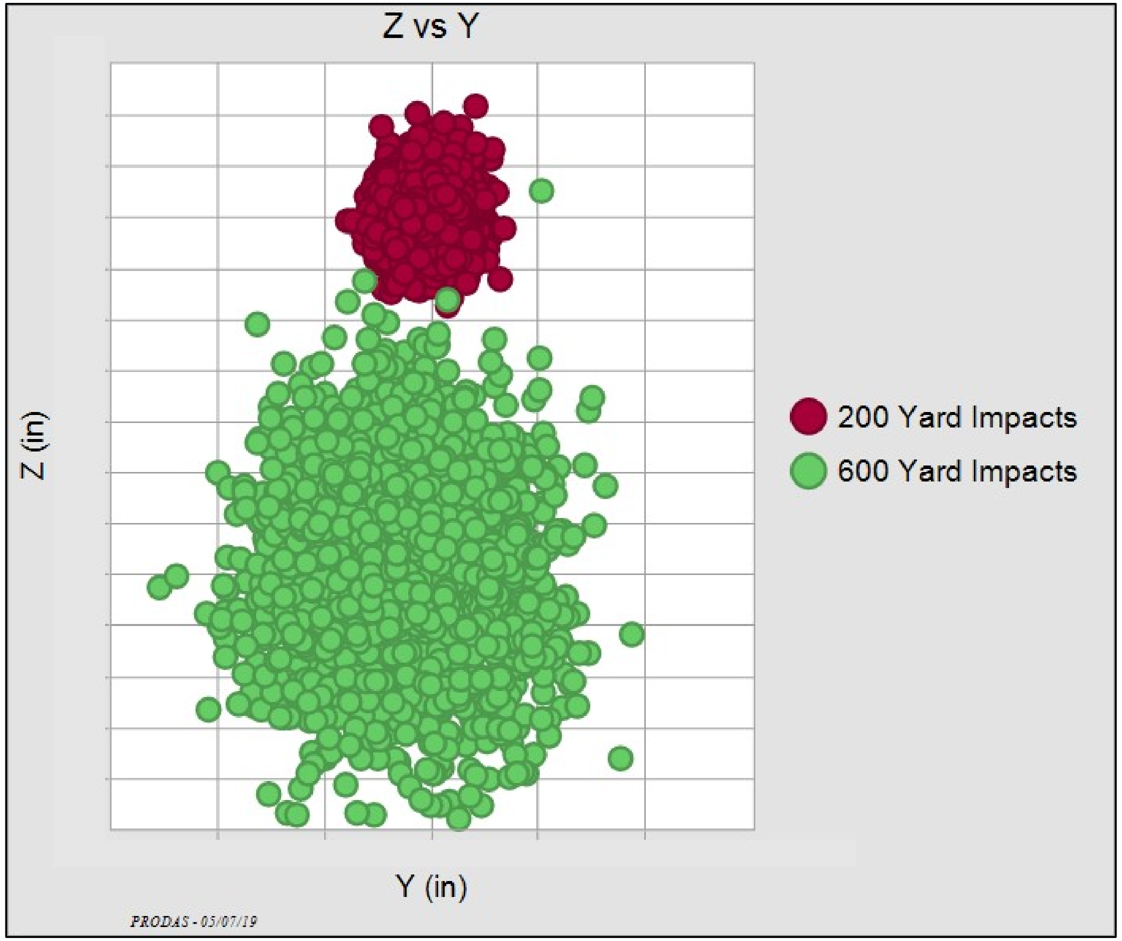
General Approach

PRODAS

1. **6DOF w/ Trades**
   - *Inputs:*
     - Mean and SD of:
       - Drag
       - Muzzle velocity
       - Angular rates
       - Etc.
   - *Outputs:*
     - Group size vs. range
     - Quantify and rank error budget factors

2. **Body Fixed 6DOF**
   - *Inputs:*
     - “Load case” CG offset
     - “Load case” principal axis tilt
   - *Outputs:*
     - Dispersion sensitivity
     - Ranking of typical manufacturing variances



ARROW TECH

Tests Conducted

1. BAM by BAM
2. Radar
3. DOE
4. Dimensional inspection
5. Load case study
6. Spin balancing
7. X-ray with soft catch

All tests listed provided inputs to error budget construction

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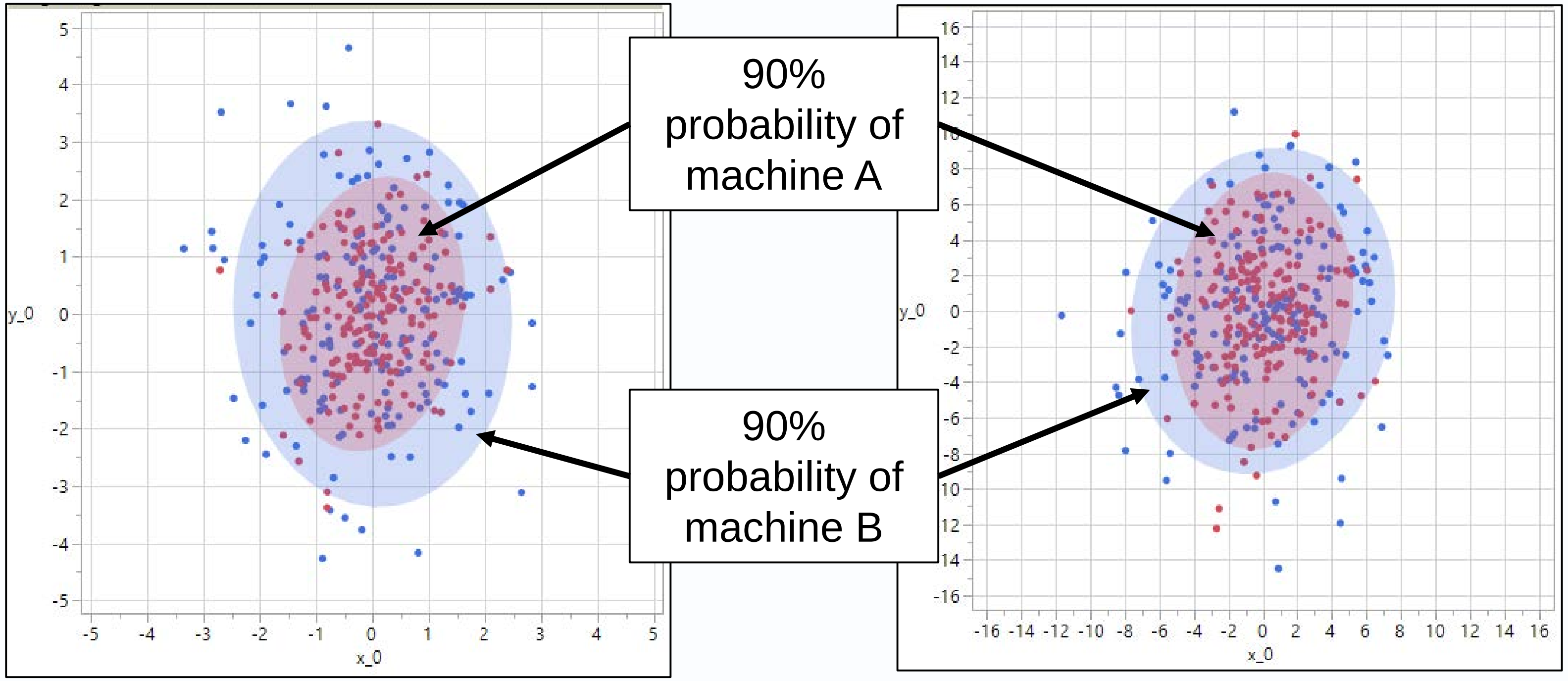
BAM BY BAM

- Compile baseline dispersion data for M80A1
- Identified differences between bullet assembly machines (BAMs)



Noted that the best and worst performing BAMs were generally consistent

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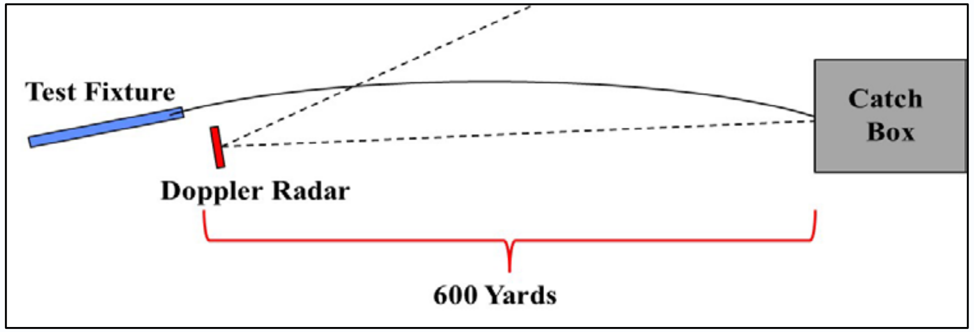
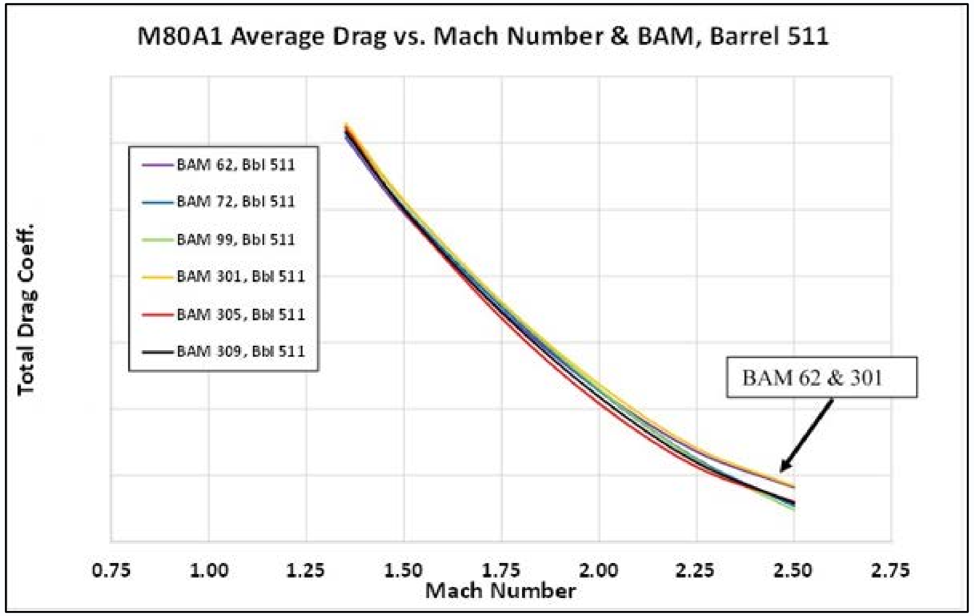
Radar

- Tests conducted using Doppler radar
- Tests samples from multiple bullet assembly machines
- Drag vs. Mach number extracted from Doppler radar data, compared by BAM and barrel





Design of Experiments

Contributing factor	Explanation	Selected Features
Mass asymmetry	Results in CG offset and PA tilt, angular rates at muzzle exit	Cannelure concentricity
Radial stiffness	Resistance to engraving in the rifling, sensitivity to curved barrel	Cannelure diameter Multiple cannelures
Asymmetric engraving	Affected by jump to the rifling	Cartridge overall length
Muzzle blast interaction	Affected by reverse flow of gas around the heel of the bullet at muzzle exit	Heel radius

- 6 factors, 2 or 3 levels each
- Optimized design utilized for this experiment

Factors	Level 1	Level 2	Level 3
Cannelure Diameter	L	H	-
Cannelure Concentricity	L	H	-
Bullet Heel Radius	L	H	-
Double Cannelure	No	Yes	-
Barrel	A	B	-
Cartridge Overall Length	L	M	H

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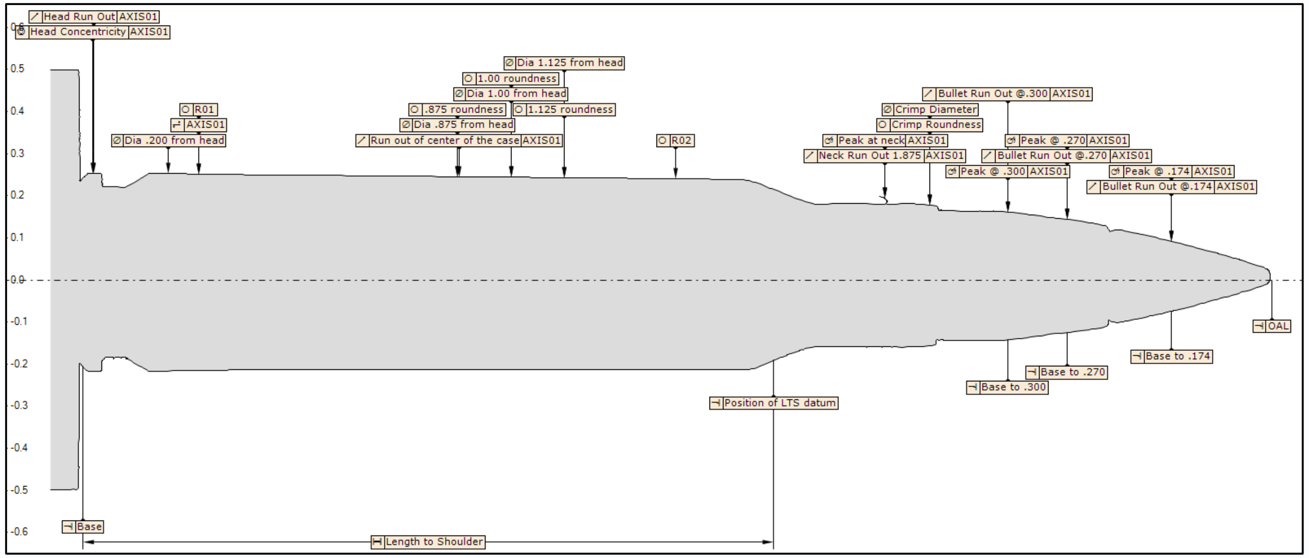
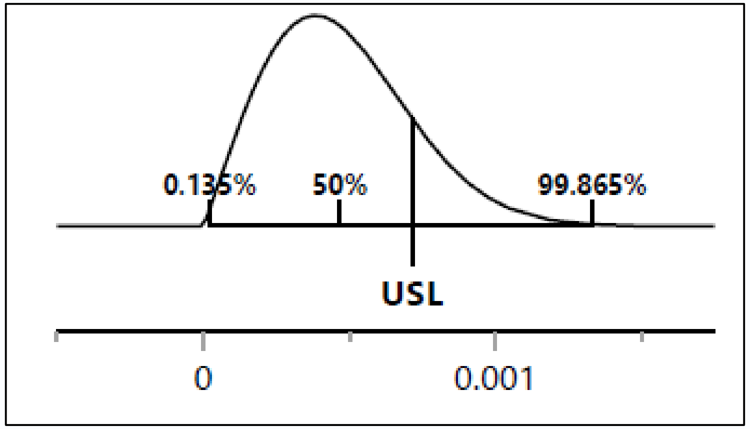
DIMENSIONAL DATA

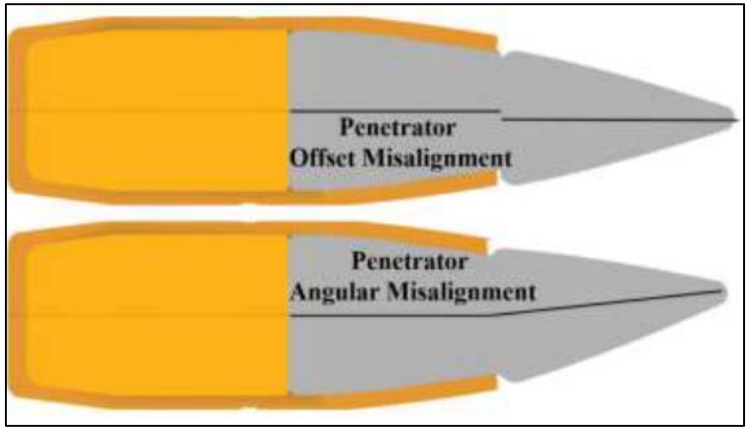
- Optical inspection machine used to capture dimensional data from bullet and cartridge samples

- Used to model physical parameters of M80A1 cartridges



Load Case Study

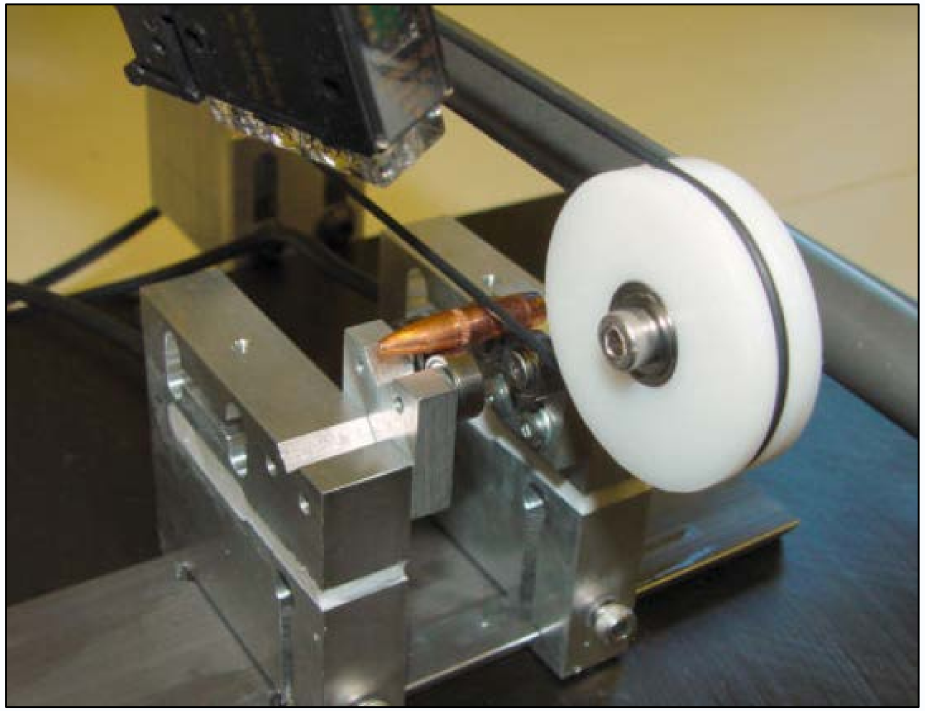




- Various dimensional data were collected to determine the effect of common manufacturing variances
  - Examples: tip runout, boattail runout
- Mean plus 1 standard deviation were determined for each variance
- These values were input into physical models and simulated to determine the sensitivity of the variances
  - Answers the question: “How bad is tip runout relative to other forms of runout?”

Spin Balancing

- Dynamic spin balance machine used to quantify bullet mass imbalance
- Mass imbalance used to derive CG offset and principal axis tilt



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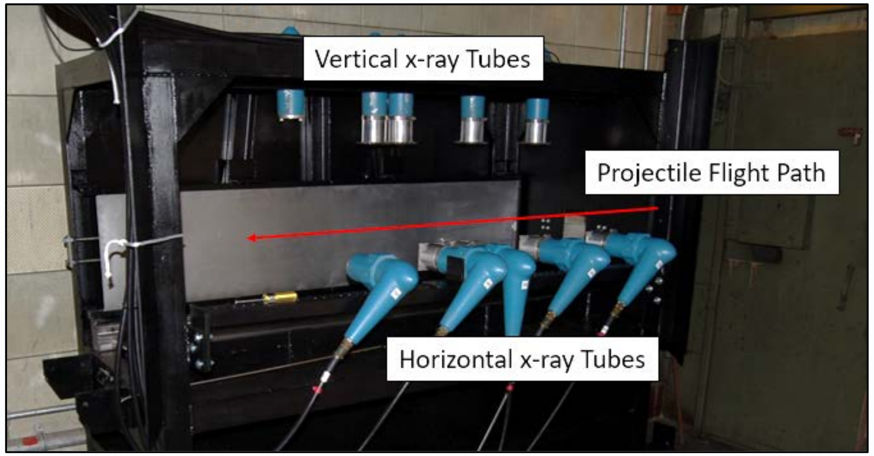
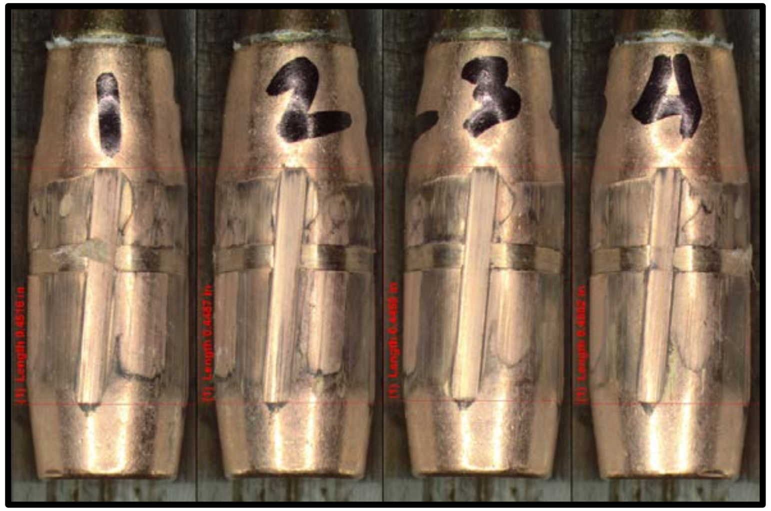
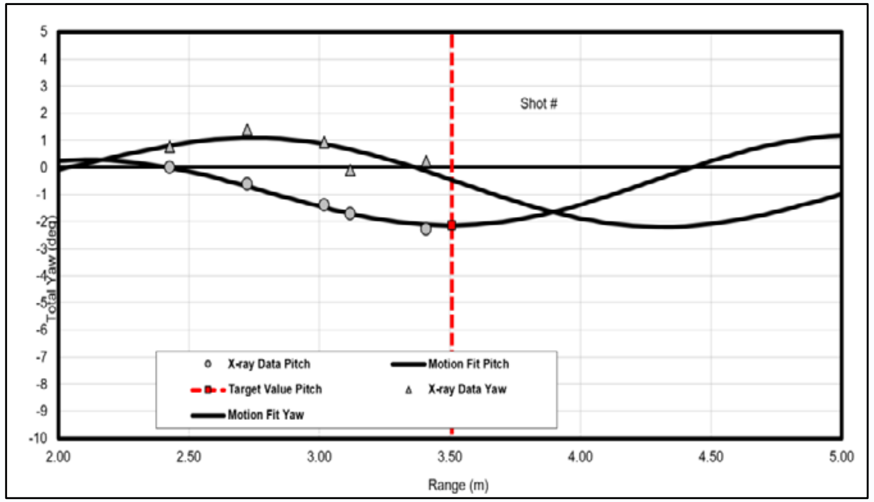
X-Ray and Soft Catch

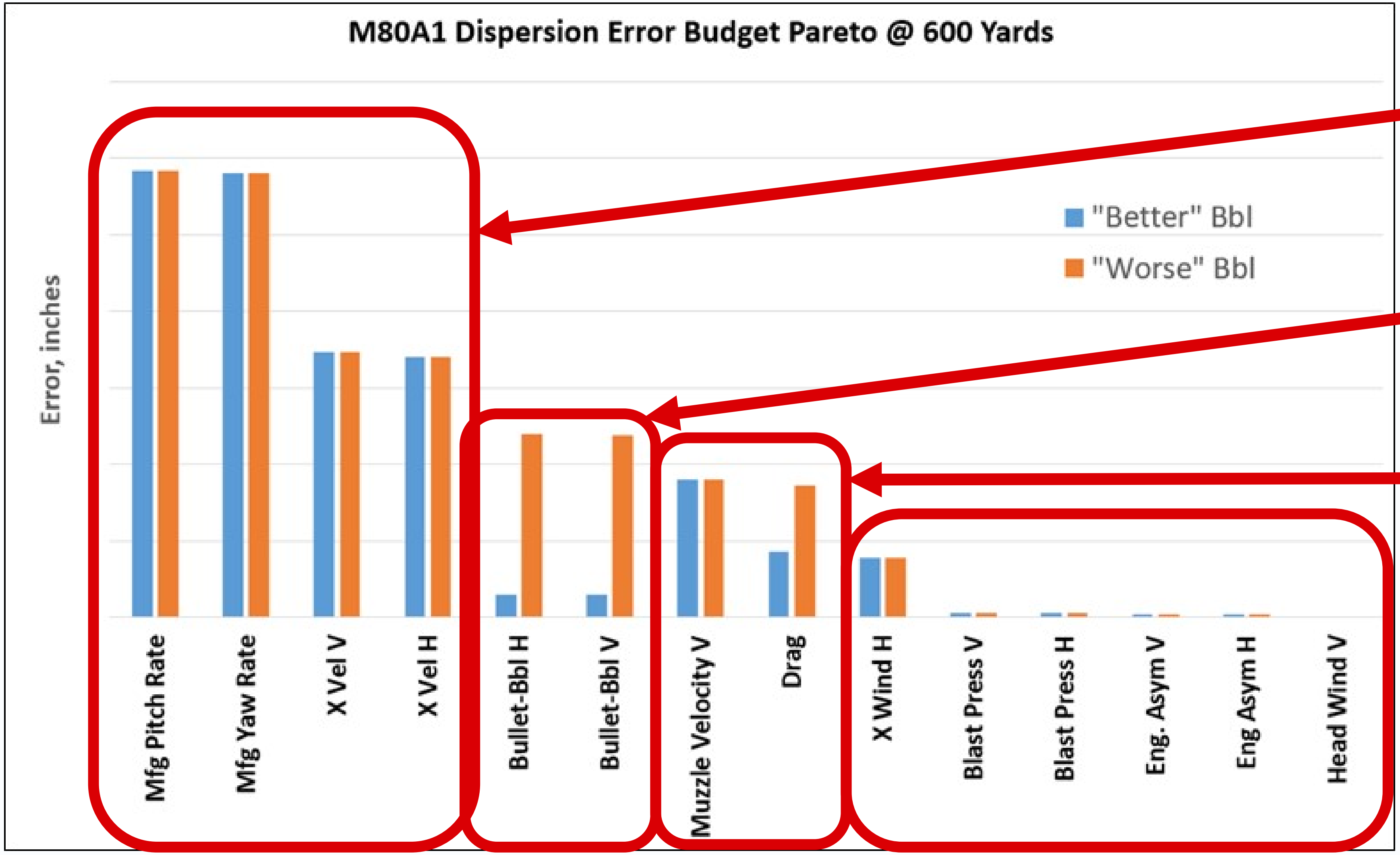
- Shot samples through orthogonal x-ray to determine mean and standard deviation of muzzle exit yaw rates
- Fired projectiles into bullet catcher to assess asymmetric engraving







M80A1 Error Budget



- Bullet quality matters a lot (variability)
- Barrel interaction is significant
- MV variation and drag effects are present but not main drivers
- Everything else is fairly small

CONCLUSION

- M80A1 dispersion is most sensitive to variation in bullet manufacturing
- Future efforts may involve M80A1 bullet manufacturing improvements
- DOE revealed potential gains from minor design changes (deeper cannelure)
  - More testing is required
- Potential paths to improvement:
  - Reduce mass asymmetry (tip runout)
  - Reducing variation in processes (only use best BAM)
  - Minor design changes (cannelure optimization)

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

155MM ARTILLERY PLATFORM PROJECTILE FALLBACK SENSOR

Kevin Boland

M109 Project Engineer

Production and Sustainment Large Caliber

18 APR 2019

CLASSIFICATION

Classification: Unclassified

Distribution A: Approved for Public Release. Distribution Unlimited.

Briefing Type: Technology Needs

AGENDA

- NDIA 2019 Theme & Focus
- Modern US 155MM Platforms
- Fallback Definition
- M109 FoV Armament System
- Additional Challenges
- Path Forward
- Questions

NDIA 2019 THEME & FOCUS

"Leveraging Armament Technology Integration to Achieve Modernization, Overmatch, and Operational Readiness"

BLUF: Soldiers have no method of determining whether their round stays loaded after the breech is closed

- **US Government to identify technology that can detect the following:**
  - Poor Projectile Seating after Loading into chamber
  - Projectile Fallback

- **Currently no system requirement exists for fallback sensor**

MODERN US 155MM HOWITZER PLATFORMS

- **M777 Towed Howitzer**
  - 10,000lb, air drop capable
  - Manual crank to elevation
  - Hand-ram to load projectile

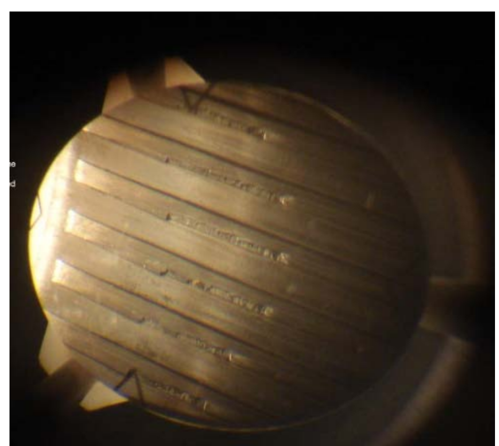
- **M109A7 Self-Propelled Howitzer**
  - 80,000lb armored vehicle
  - High Voltage drive system
  - Vehicle powered ram & hand-ram
  - Legacy Vehicles in the Field

- **Loading 155MM Projectiles**
  - Projectile pushed quickly into chamber
  - Projectile retained via interference with gun tube rifling
  - Propellant loaded separately
  - Screw-block breech is closed and primed to fire

FALLBACK DEFINITION

- **Projectile Fallback:**
  - Projectile is loaded such that seating isn't adequate
  - Propellant is loaded, breech is closed
  - Interference is unable to retain projectile when tube is elevated to fire
  - Projectile falls back onto propellant charges unnoticed
  - Crew fires fallen back round

- **Consequence:**
  - Propellant gasses blow by the rotating band and obturator
    - Exposes projectile aft to higher pressures (potential in-bore detonation)
  - Remaining propellant gasses launch round so it collides with origin of rifling at an angle (potential gun tube damage)
  - Round exits gun and falls short of intended target increasing risk to friendly forces


M109 FOV ARMAMENT SYSTEM

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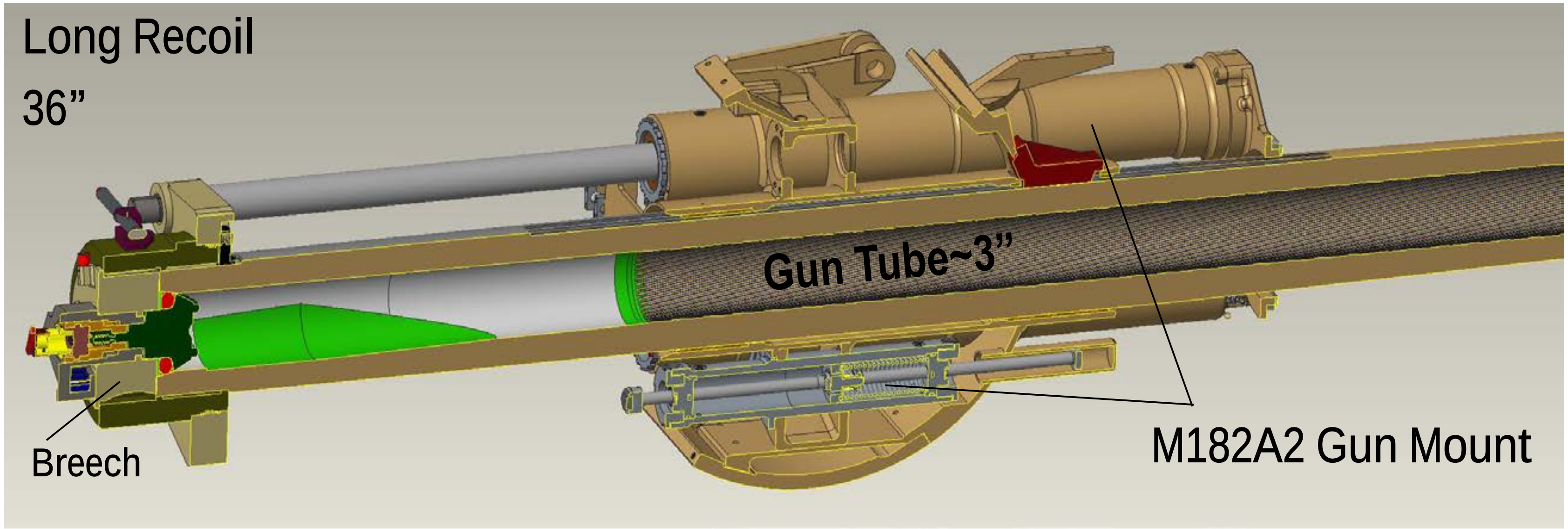
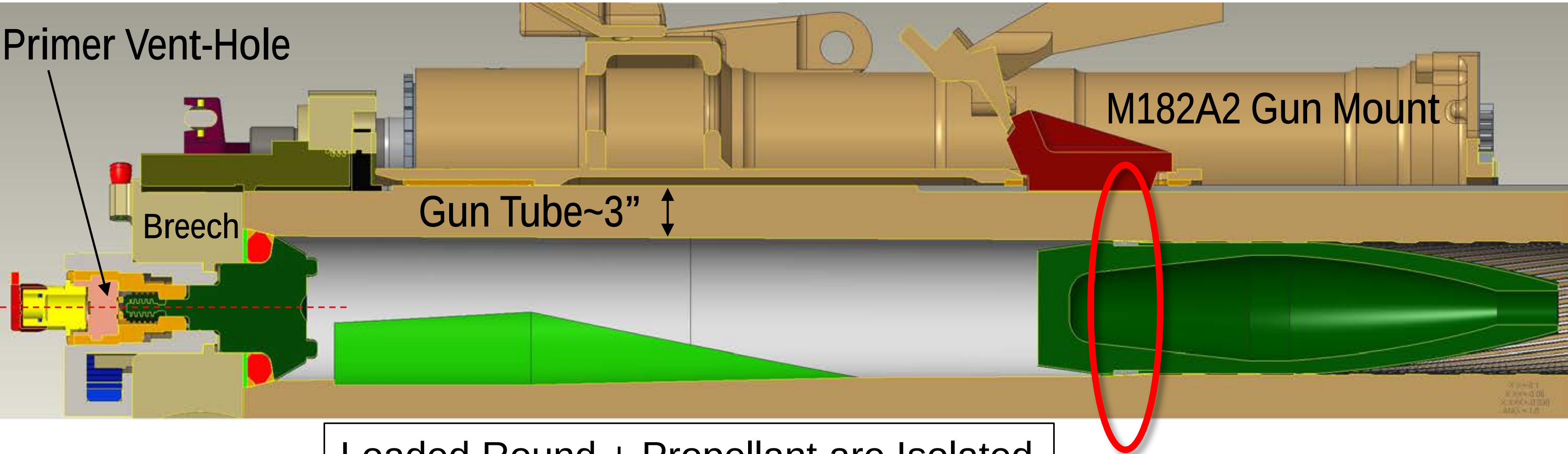


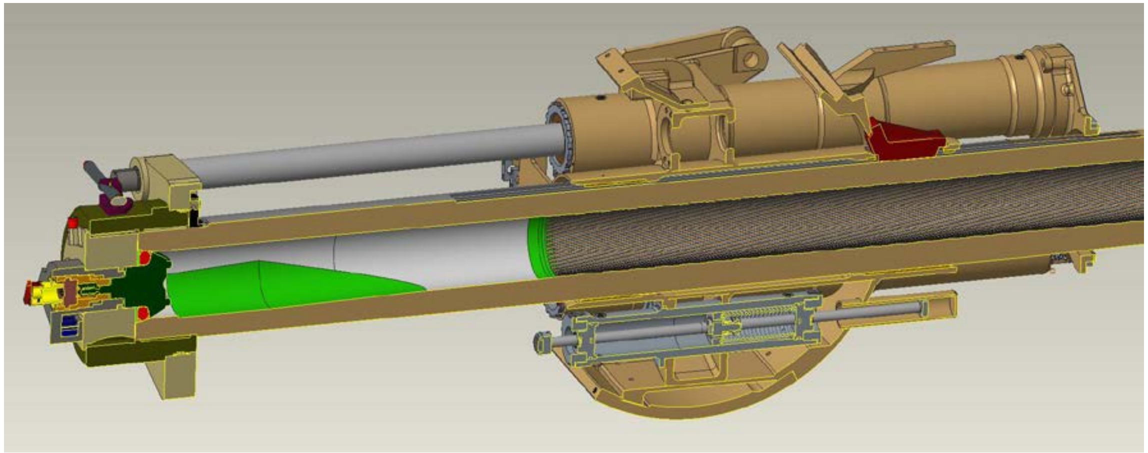


Loaded Round + Propellant are Isolated

ADDITIONAL CHALLENGES

- **In addition to sensing seating/fallback with closed breech, sensor must be:**
  - Compatible with several 155MM systems in their required range of operating environments
  - Compatible with all projectile and propellant types
  - Automated
  - Extremely reliable

- **“Good Seat” not well defined**
  - Soldiers believe they can hear a good seat
  - Fallback difficult to hear, dampened by propellant
  - Additional Vehicle Noise: engine, hydraulic motors, nearby firing howitzers, ect



PATH FORWARD

- **Obtain proposals from Industry (August 2019)**

- **Feasibility Test(s) Complete (December 2019)**
  – Simulate Projectile Fallback
  – Capture Data Live
  – Data reduction and Analysis
  – Present to Government

- **Longer Term Initiative to Integrate Armament Solution**
  – Into Howitzer Systems: Legacy, Current, and Future

QUESTIONS

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NDIA

GENERAL DYNAMICS
Ordnance and Tactical Systems–Canada

Reduced Range Ammunition Presentation + Panel Discussion

General Dynamics – OTS Canada

Repentigny, Québec, Canada

Presenter: Pierre Lemay, Product Manager

06 Jun 2019

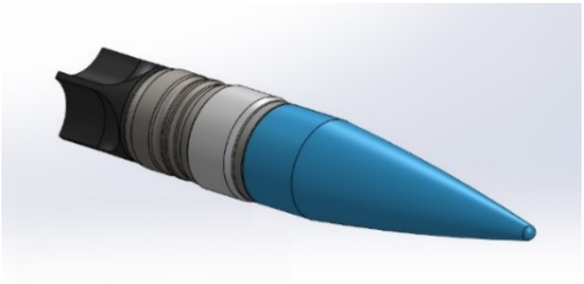
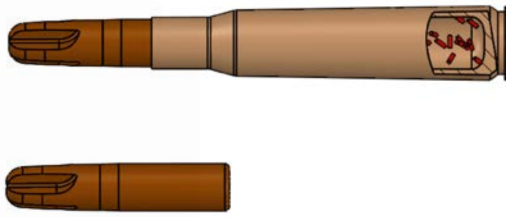
NDIA Armament Conference / Small Arms Division Themes

“”

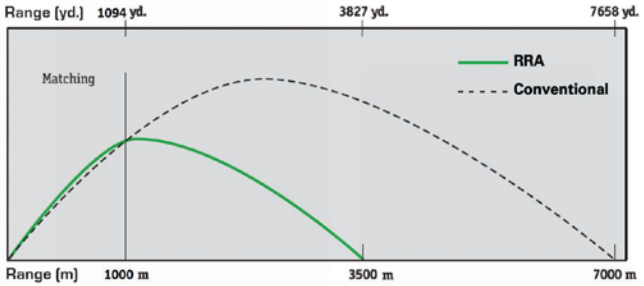
NDIA

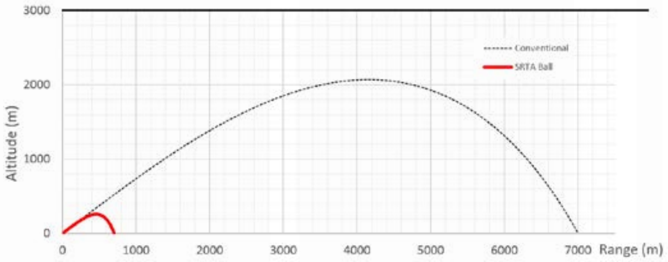
GENERAL DYNAMICS
Ordnance and Tactical Systems–Canada

Two Families of RRA Cartridges

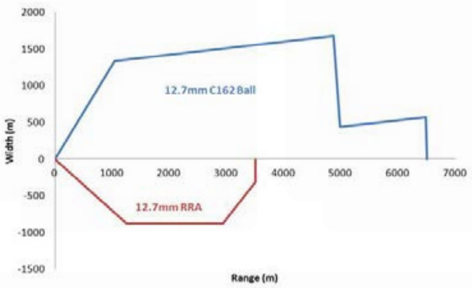
RRA=50% of Max Range	SRTA=10% of Max Range
	

Maximum Range Comparison:





Safety Danger Zone Comparison:

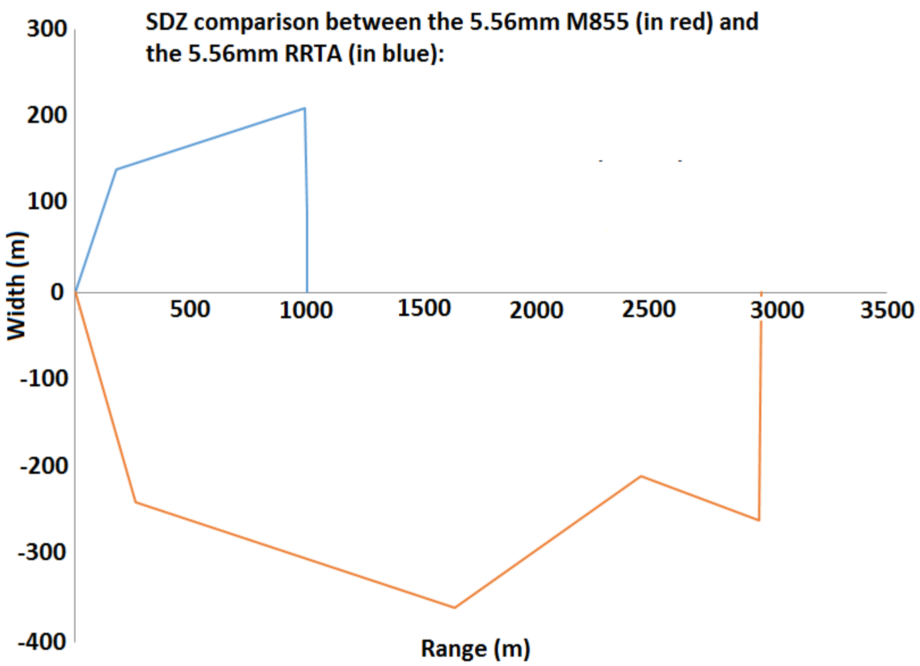


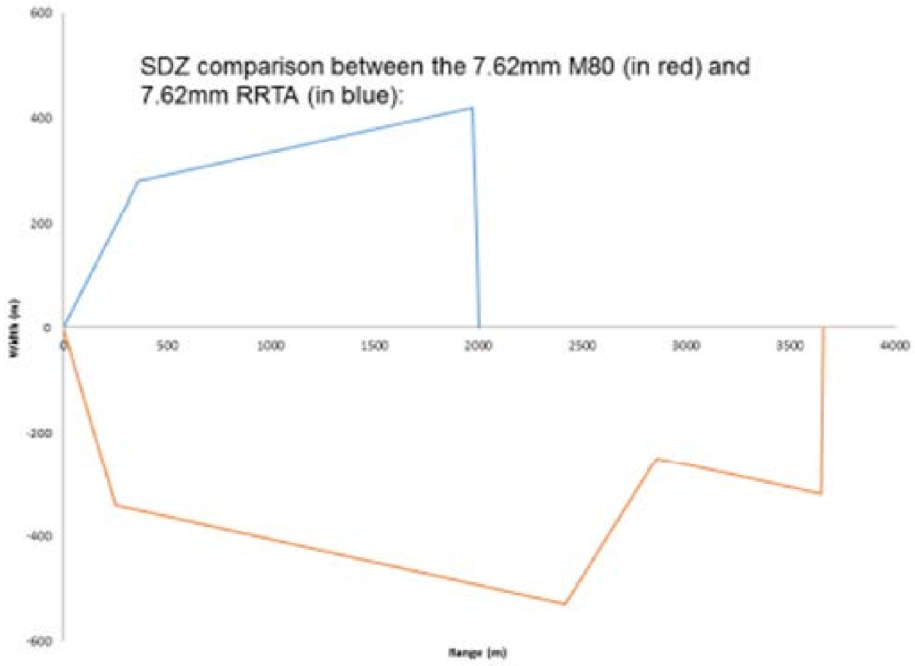
Features:

- Lead-free bullets
- Tracers available
- ToxFree® primers
- REACH Propellant

- Available in:
  - 5.56mm
  - 7.62mm
  - .50 Cal
  - 25mm
  - 30mm

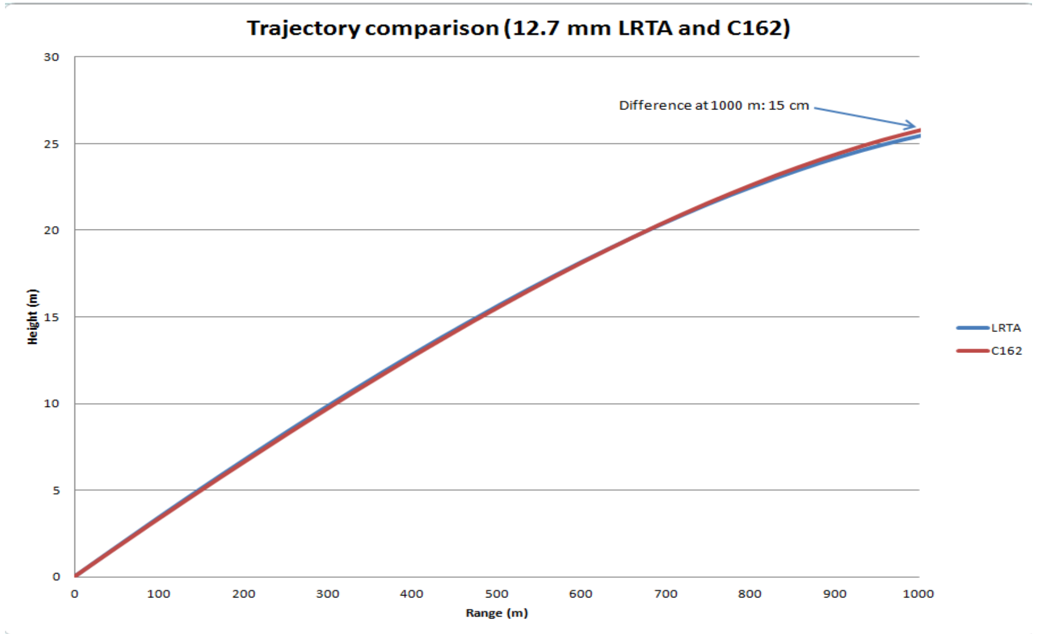
Aim: Shortest Maximum RRA Range and SDZ

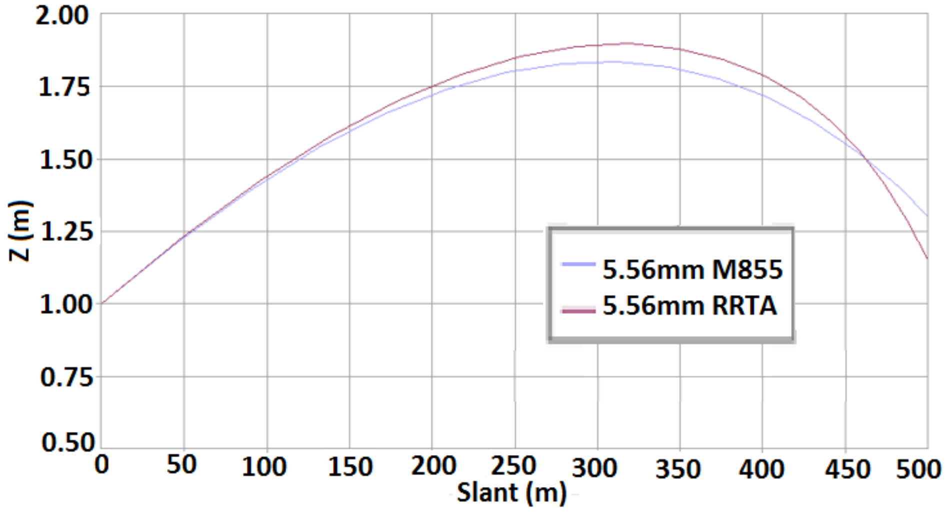




	5.56 mm M855	7.62 mm M80	.50 Cal M33	
			Current RRA	New RRA
Max range of regular rds	3,500 m	4,200 m	6,500 m	6,500 m
Max range of RRA	1,700 m	2,300 m	3,500 m	3,600 m

Aim: Longest RRA Trajectory Match

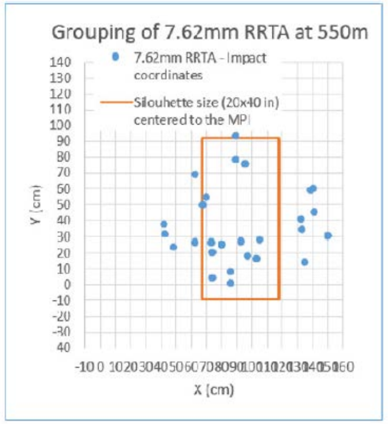




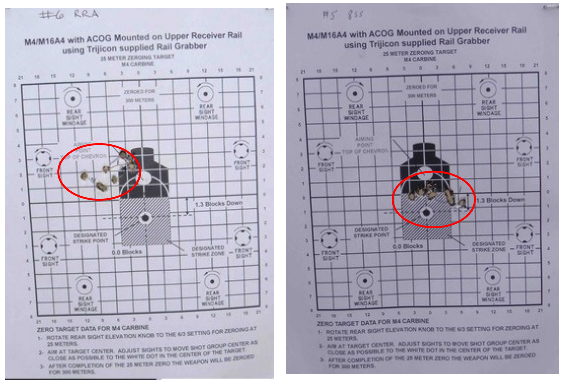
	5.56 mm M855	7.62 mm M80	.50 Cal M33	
			Current RRA	New RRA
Max range of regular rds	3,500 m	4,200 m	6,500 m	6,500 m
Ballistic match of RRA	600 m	800 m	1,000 m	1,500 m

Aim: Tightest Target Dispersions

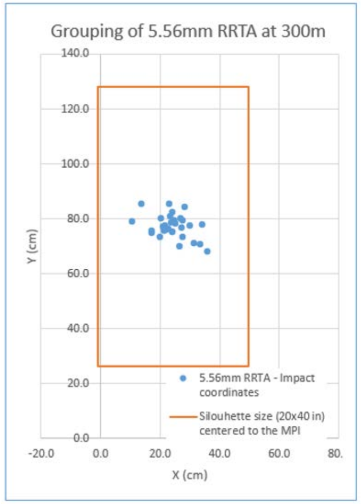
.50 caliber RRA target at 550 meters



7.62mm RRA target at 550m



5.56mm RRA and M855 targets at 25m



5.56mm RRA target at 300m

.50 Caliber RRA

7.62mm RRA Trials at 2017 AEWE in Ft Benning

Point of Contact

- For additional information, please contact:

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Phone: (450) 582-6361

Abstract # 21864

Ammunition Production Equipment Diagnosis

Katie Riha, Northrop Grumman
Zach Krogstad, CCDC-AC

NORTHROP GRUMMAN
Alliant Techsystems Operations LLC

DEVCOM ARMAMENTS CENTER

Outline

Alliant Techsystems Operations LLC

- Introduction
- High Speed Video
- Metallurgical Analysis
- FEA Analysis
- Conclusions

Introduction

Alliant Techsystems Operations LLC

In a high production rate manufacturing environment, dilemmas frequently arise that require diagnosis of equipment, tooling issues and implementation of corrective actions. The degree of difficulty trouble-shooting varies depending on the issue being investigated. In some circumstances unique methods of troubleshooting are used to diagnose a problem.

This presentation will show examples of how the following more advanced trouble-shooting methods have been used at the Lake City Army Ammunition Plant:

- High Speed Video
- Metallurgical Analysis
- Finite Element Analysis

High Speed Video
Missing Cannelure Cut

Northrop Grumman
Alliant Techsystems Operations LLC
DEVCOM Armaments Center

Problem encountered:
- Bullets were being found with missing cannelures.
- A missing cannelure can result in low bullet pull of the completed cartridges.

Challenges with troubleshooting:
- Machine runs at approximately 80 parts per minute in a small enclosure.

From this video, it was determined that:
- Cut part got stuck in the collet and ejected late
- Due to late ejection, the uncut part was pushed out the back side of the transfer unit.
- Uncut part was pushed into good material catch pan and cut part fell into scrap.

Corrective action:
- Underlying cause of failure to eject part was component wear. Implemented a new preventative maintenance program on the worn components.

When diagnosing equipment that runs at a high rate of speed, high speed videography is a very effective way to slow the process down to see what is causing the failure.

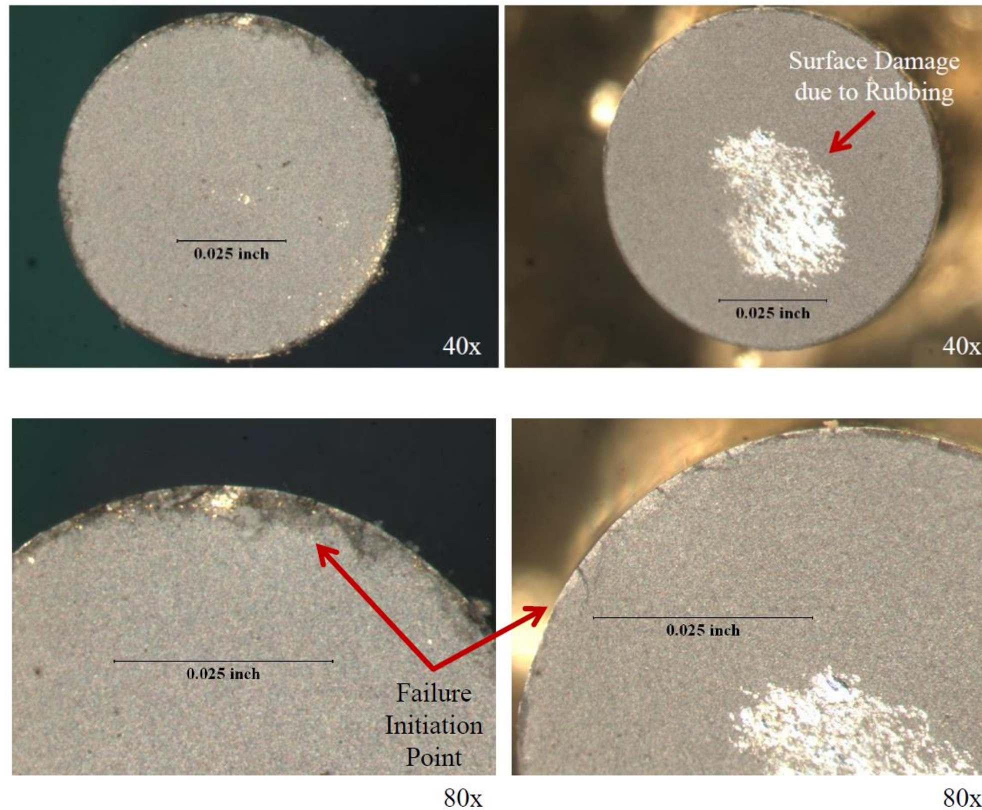
Metallurgical Analysis Broken Vent Punch

NORTHROP GRUMMAN
Alliant Techsystems Operations LLC
DEVCOM ARMAMENTS CENTER

Problem encountered:
- High usage of vent punch tooling due to tool breakage
- High usage of vent punch tooling results in increased tooling cost, increased downtime and an increased risk in no vent cartridge failures.

Challenges with Troubleshooting:
- Machine runs 300 parts per minute. Impossible to see what is occurring during normal operation

Conclusions from this analysis were:
- The material and hardness were correct per the drawing
- Failure initiation points were identified
- A brittle fracture occurred
- Rubbing on the broken surface of the punch suggests crack propagation over multiple punch hits



Metallurgical Analysis
Broken Vent Punch- continued

NORTHROP GRUMMAN
Alliant Techsystems Operations LLC
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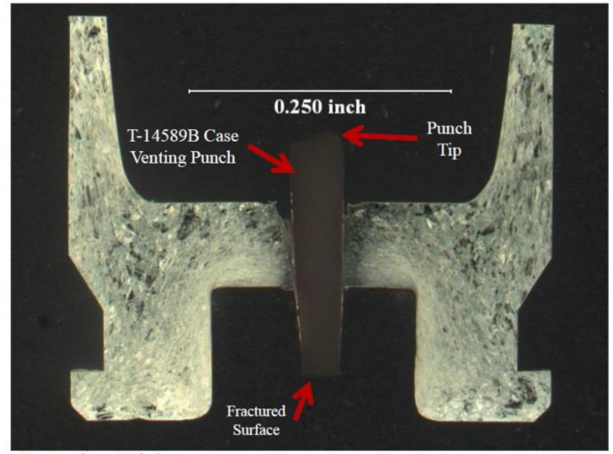
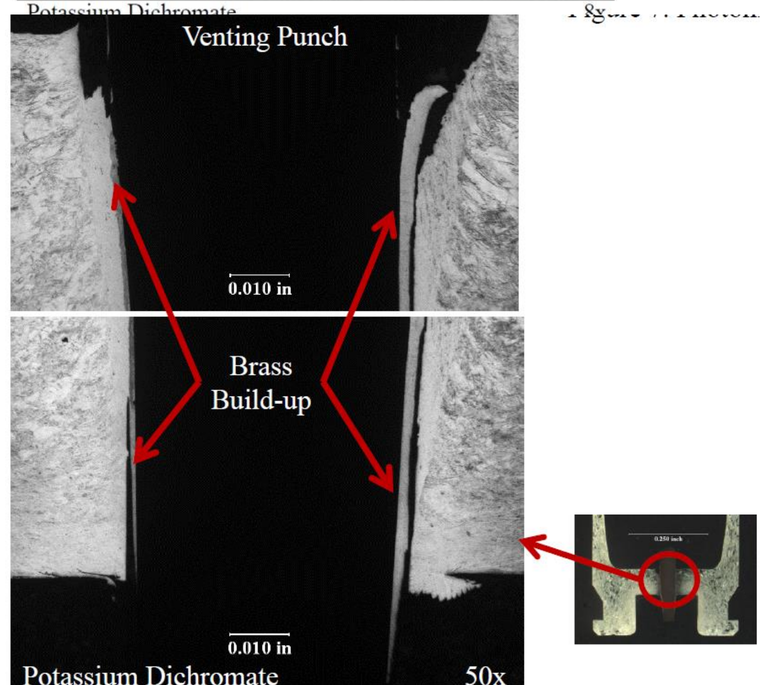
Conclusions continued:
- The microstructure of the case that caused the broken punch was not atypical
- Excess buildup on the punch was asymmetric- adding bending stress to the punch





When troubleshooting tooling issues, metallurgical analysis is very useful in diagnosis. Knowing the material properties and type of failure help guide the troubleshooting process in the proper direction.

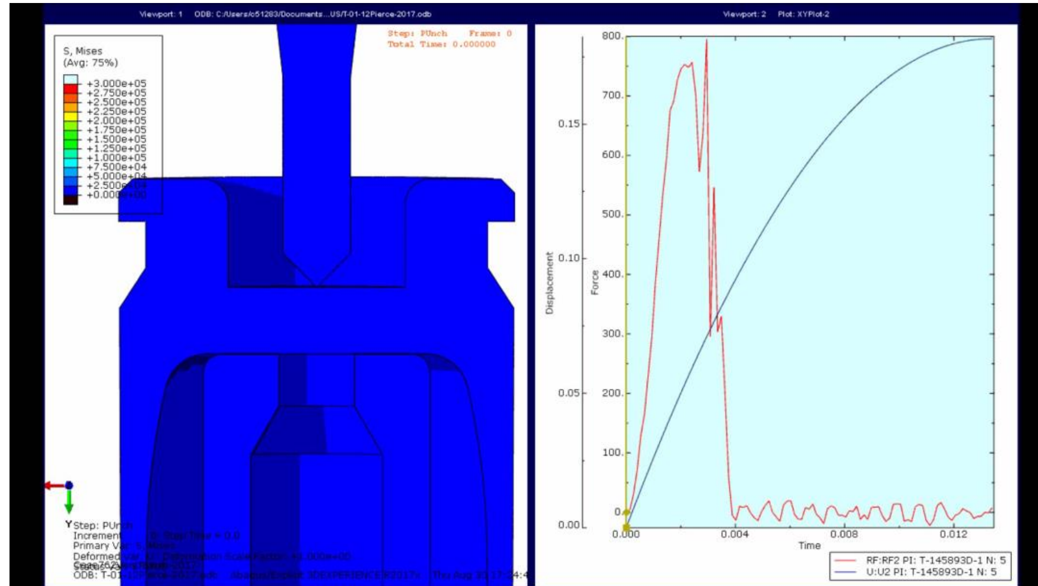
Finite Element Analysis (FEA) Broken Vent Punch

NORTHROP GRUMMAN
Alliant Techsystems Operations LLC
DEVCOM ARMAMENTS CENTER

Problem encountered:
- High usage of vent punch tooling due to tool breakage
- High usage of vent punch tooling results in increased tooling cost, increased downtime and an increased risk in no vent cartridge failures.

Challenges with Troubleshooting:
- Machine runs 300 parts per minute. Impossible to see what is occurring during normal operation

How FEA has been utilized to troubleshoot:
- Current punch design was modeled to identify improvement opportunities.
- Additional scenarios that are seen in production are being modeled to identify likely failure modes
- The results of this FEA model look very similar to the actual broken punches seen in process



Actual broken punches seen in production

How FEA is being used to fix the problem:
- Design concepts are being analyzed using FEA before being prototyped. This allows us to assess improvement of a new design before spending excessive amounts of money to make and test prototype parts.

From diagnosing issues to prototyping solutions, FEA simulations are a great start to finish tool when diagnosing equipment and tooling issues.

Conclusion

Alliant Techsystems Operations LLC

Running a high rate production facility involves troubleshooting equipment that is difficult to diagnose due to machinery speed and complex modes of failure. Innovative troubleshooting and diagnostic tools are needed.

High speed video, metallurgical analysis and finite element analysis are great tools to utilize to determine root cause and corrective actions of more complex equipment and tooling diagnosis challenges.

Alliant Techsystems Operations LLC

Thank you!

Questions?

Elbit Systems, Land

Comprehensive Advanced Artillery Solutions (ID 22047)

Danny Schirding

June 25, 2019

Elbit Systems™ Land

Business AREAS

Maneuverability

Artillery

AMMUNITION

Survivability

Naval Solutions

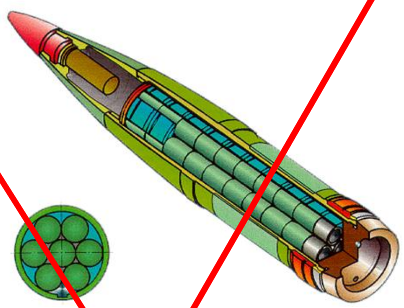
Aerial solutions

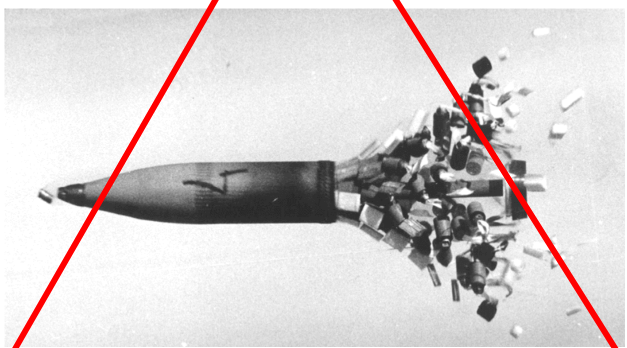
Land and beyond

The Evolution of Artillery ammunition

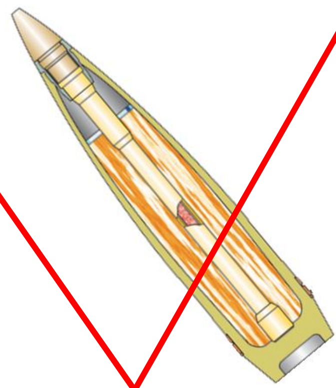
Elbit Systems™ Land

Cargo Ammunition

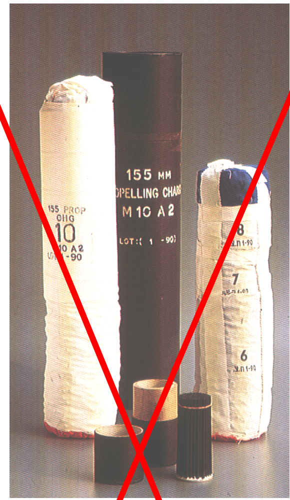


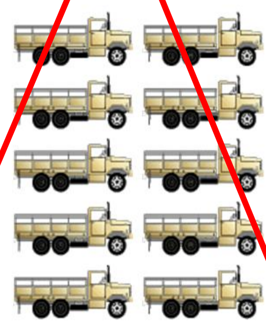


SMOKE (WP) Ammunition



Bags Charges





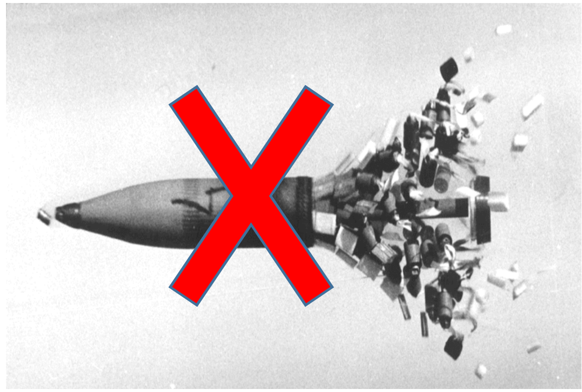
Need New Portfolio to Replace the Restricted Projectiles and Ineffective Charges

New Generation - MISSION STATMENT

Elbit Systems™ Land

New Generation

&

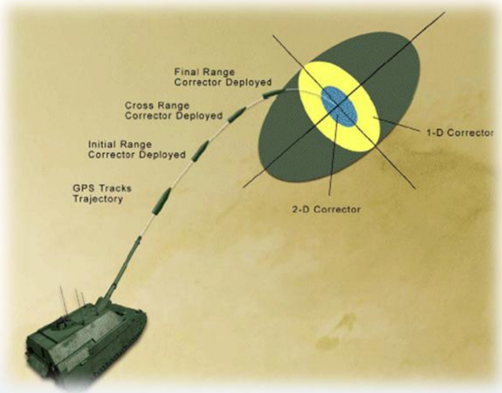


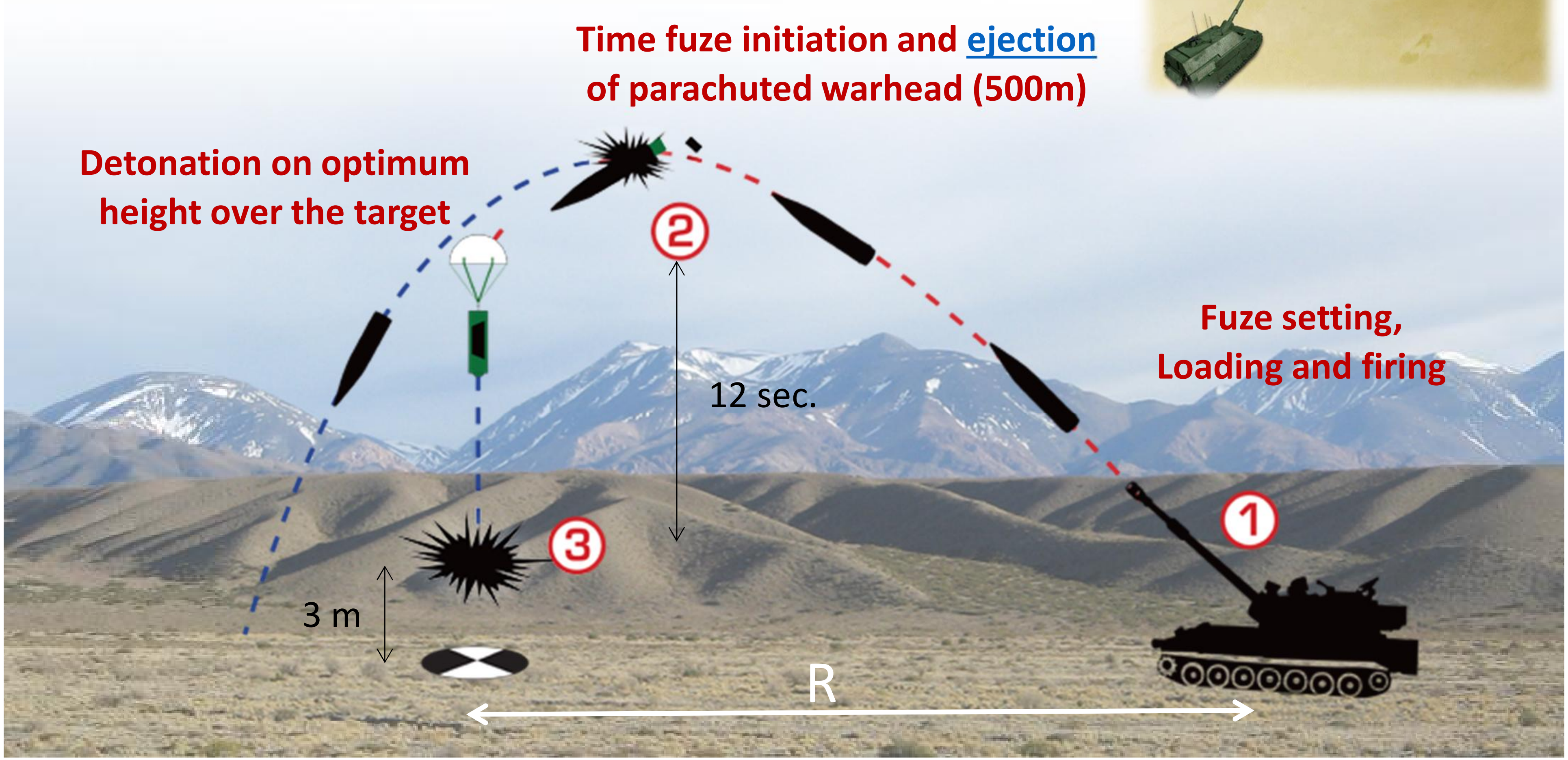
- **Improve efficiency** over any conventional HE projectile and **increase lethality** capability.
- **Incapacitate** and defeat **infantry** troops.
- Improve the **performance** against **variety of targets** in the battle field (tracks, LAV's, Infrastructures etc.).
- **Low collateral damage** by using self-destruct mechanism.
- **Shoot & scoot** ability in order to prevent counter artillery fire.

155mm Super HE – M454

- Advanced 155mm Super - HE projectile designed
- Neutralize infantry and “soft” targets (LAV’s) with **greater effectiveness** by utilizing an **advanced warhead**
- Compatible with all 155mm guns

155mm Super HE – M454





155mm Super HE – Technical characteristics

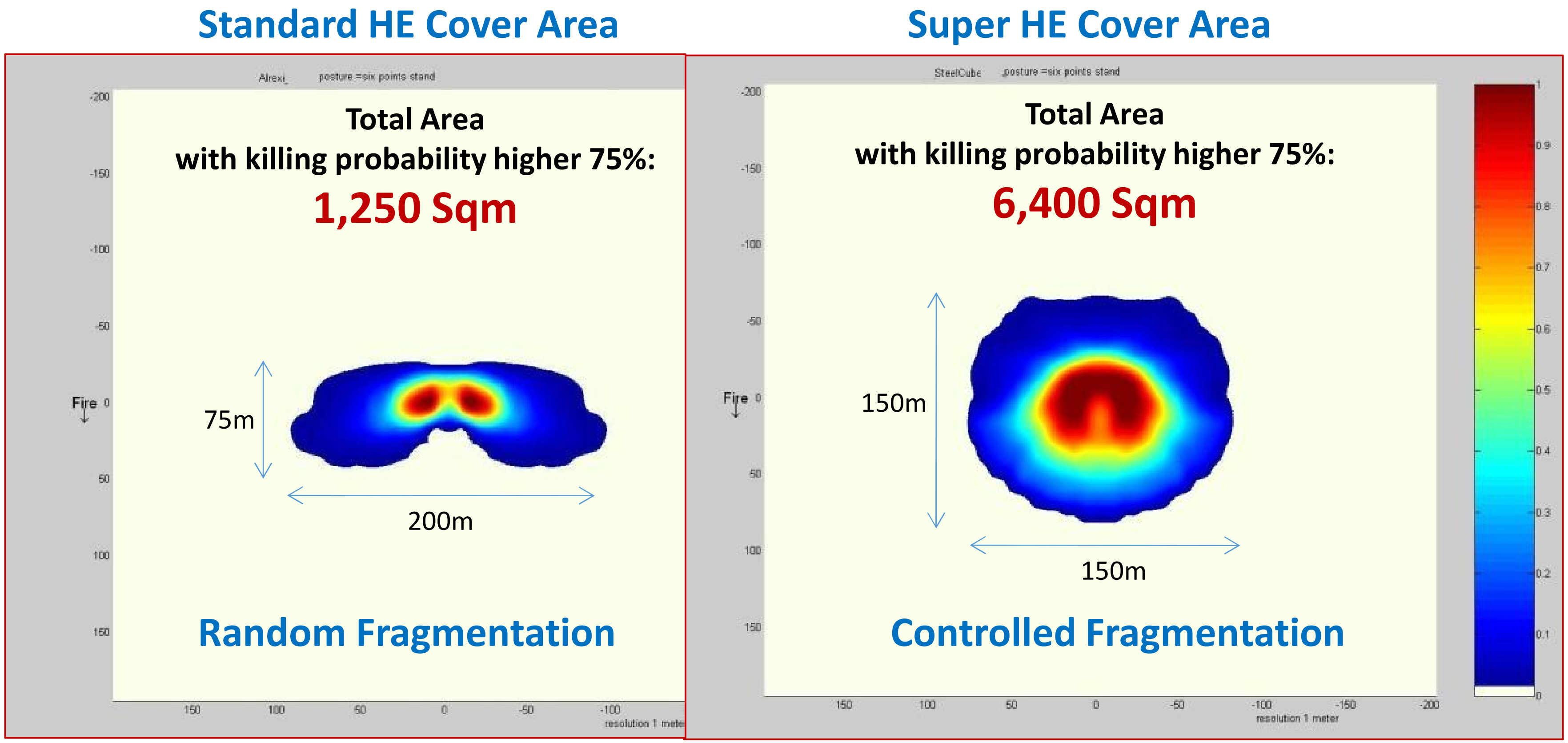
Elbit Systems™ Land

- Weight in flight: 48 Kg
- Length (w/o fuze): 804 mm
- Explosive & control fragmentation weight: 3 Kg CLX663 + ↑7,000 steel balls
- Time fuze type: IMI M910/M762 or similar
- Ranges: (*) 39-cal barrel - 22 Km
  45-cal barrel - 24 Km
  52-cal barrel - 26 Km
- Proximity fuze operation height: 3 m Approx.
- Accuracy with time fuze : 60m CEP

(*) – For HB type

155mm Super HE – M454

Operations Research Results
Kill Probability Chart – Infantry in open terrain



Up to 5 times more effective! than the standard HE

155mm Super HE – M454

155mm Super HE - Logistics Advantages
Minimal Logistic Footprint

S-HE

Regular HE

ADVANTAGES USING S-HE over HE PROJECTILES

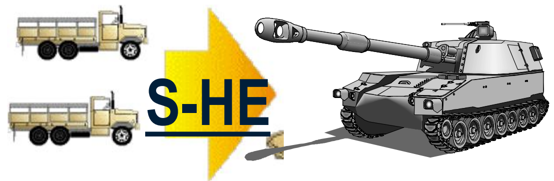
Elbit Systems™ Land

Greater Effect on target &

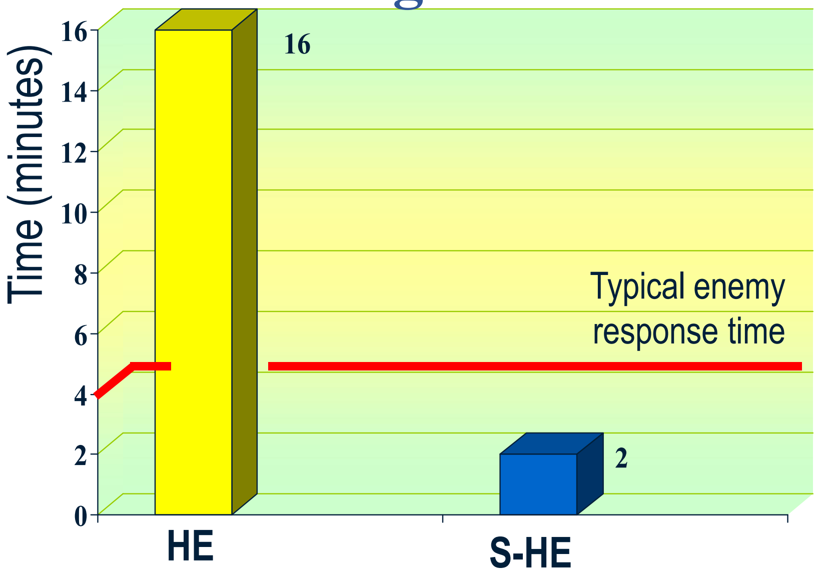
Shoot & Scoot capability

LOGISTICS Benefits

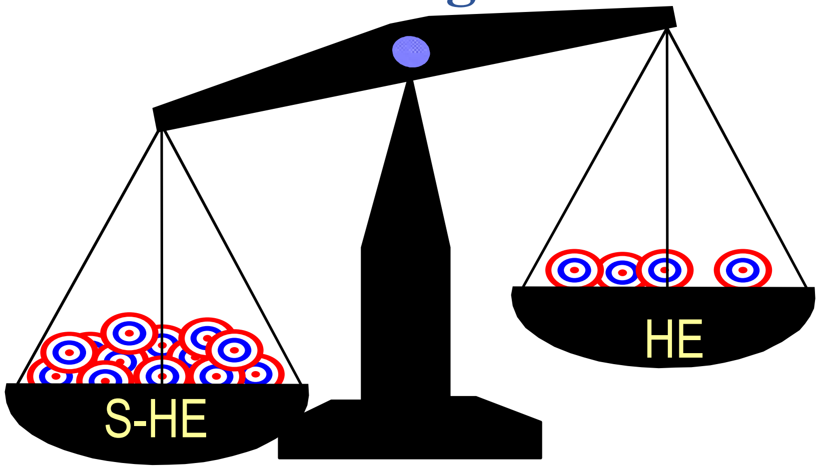
& More projectiles per barrel



TIME for target destruction



More TARGETS per Artillery carrier stowage



Propellant charge Market development

Bags

Five types:
M-4A2;M-8; M-8 ½; M-9; M-10

JBMoU*
BMACS

Two types:

Short-range “green” module

Long-range “white” module

? (Modification)

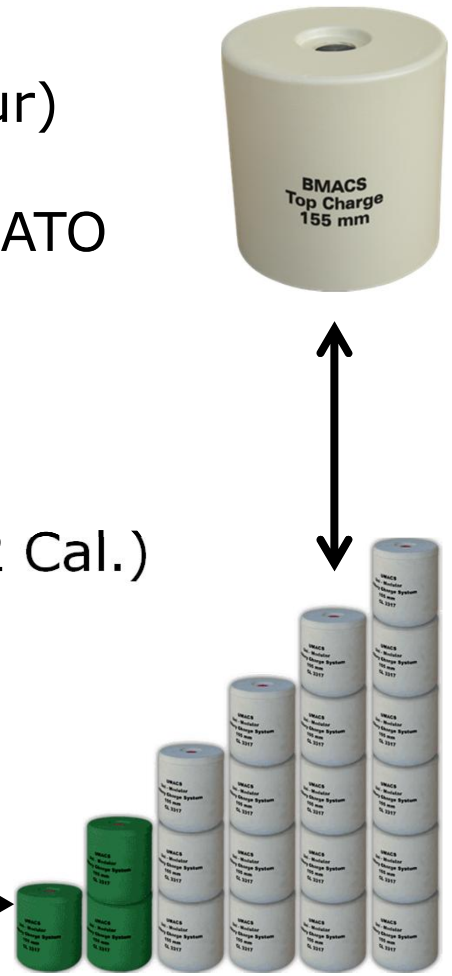
***Joint Ballistic Memorandum Of Understanding**

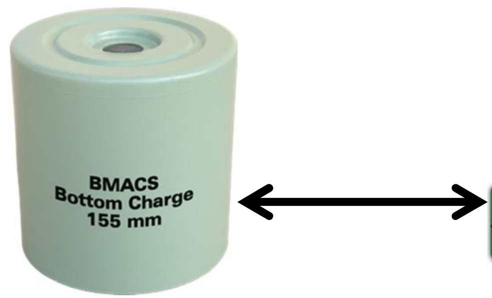
BMACS - Description

- The BMACS consists of two module types:
  - TCM - Top Charge Module (White colour)
  - BCM - Bottom Charge Module (Green colour)

- Developed by IMI according to MIL-STD and NATO standards to replace the existing old charge systems.

- Based on JBMoU principles for firing from all standard 155-mm Howitzer guns (39, 45 & 52 Cal.)

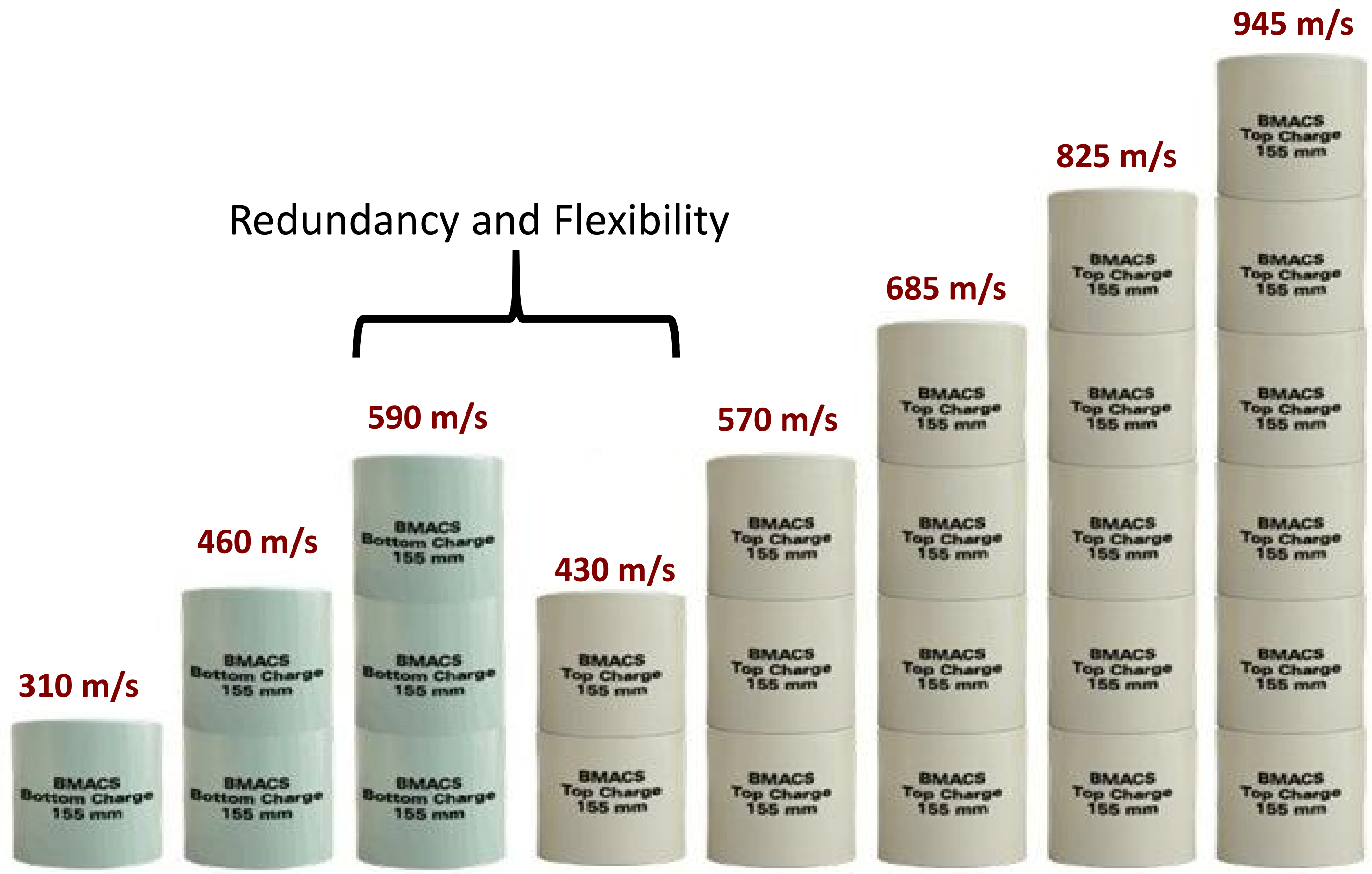




Modified BMACS

Modified BMACS Version (redesign)

Based on JBMoU principles (L15)



JBMoU Compliance

Parameter	Requirement	Compliance
Ignition Delay	≤ 300 ms	≤ 100 ms
Differential Pressure	≤ 725 Bar	≤ 150 Bar
Pressure Limit	≤ 4158 Bar	≤ 4158Bar
Upper Temp Limit	63°c	63°c
Residues	no detrimental residues to operation	no detrimental residues to operation

Parameter	Requirement	Compliance
Module Dimensions	D ≤ 158mm	D ≤ 153 mm
	L ≤ 156mm	L ≤ 155mm
	Ignition hole dia. ≥ 20mm	d ≥ 28 mm
Muzzle Velocity	945m/s	945m/s 6 Modules

Parameter	Requirement	Compliance
Trails for safety	Safety in a New Gun	Comply
	Safety in Worn Barrel	Comply
	Sequential Environmental	Comply
	Safety of Prop. Charge	Comply
	12m Safety Drop	Comply
	Low Charge Trial	Comply
	Cook-Off in Hot Gun	Comply

Propellant charge Market development

Elbit Systems™ Land

Bags

Five types:
M-4A2;M-8; M-8 ½; M-9; M-10

JBMoU*

BMACS &
Modified BMACS

? (NEW GENERATION)

***Joint Ballistic Memorandum Of Understanding**

Propellant charge Market development

Bags

Five types:
M-4A2;M-8; M-8 ½; M-9; M-10

JBMoU*

BMACS & Modified BMACS

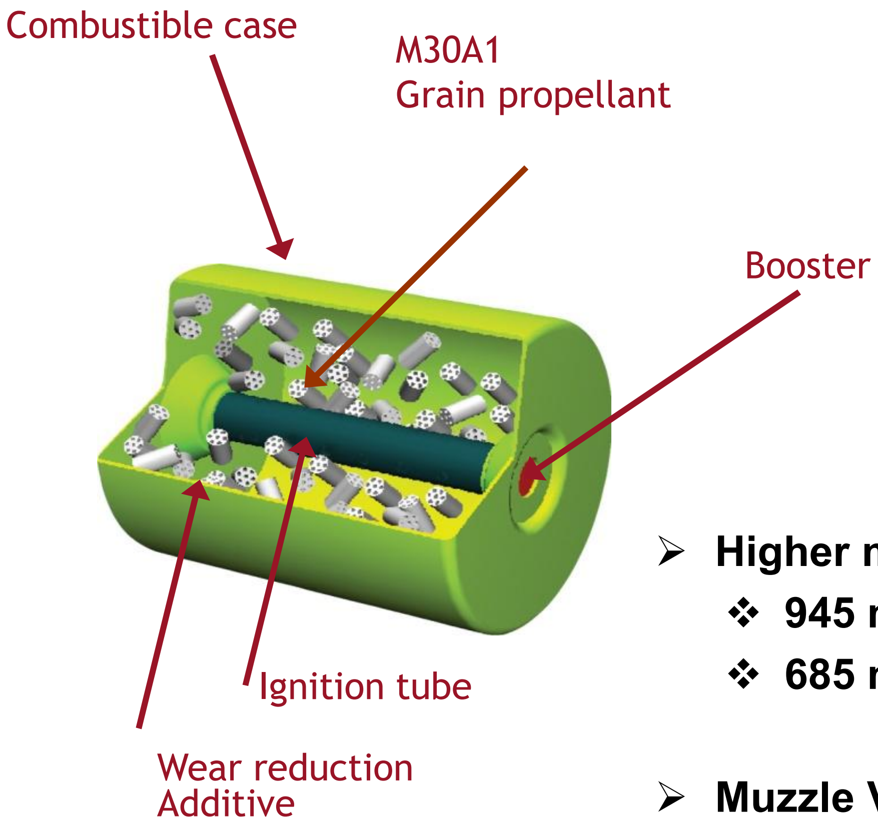
JBMoU*
UCM

One type

***Joint Ballistic Memorandum Of Understanding**

Uni – Charge Module

IMI's UCM is the only Uni-Modular charge propellant system which is based on single module type - one size.



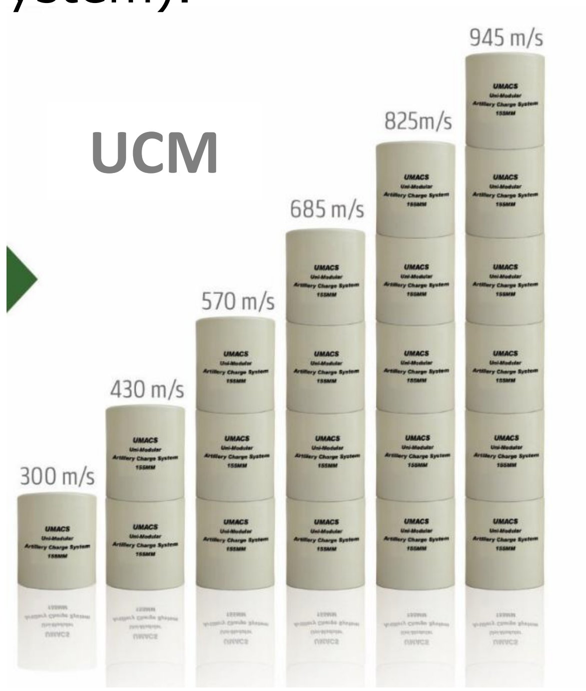
- **Higher muzzle velocities with less modules:**
  - **945 m/s with 6 modules (for 52 cal. gun)**
  - **685 m/s with 4 modules (Optimized 39 cal. gun)**

- **Muzzle Velocity could be tailored to customer requirements**

UCM - Product Advantages

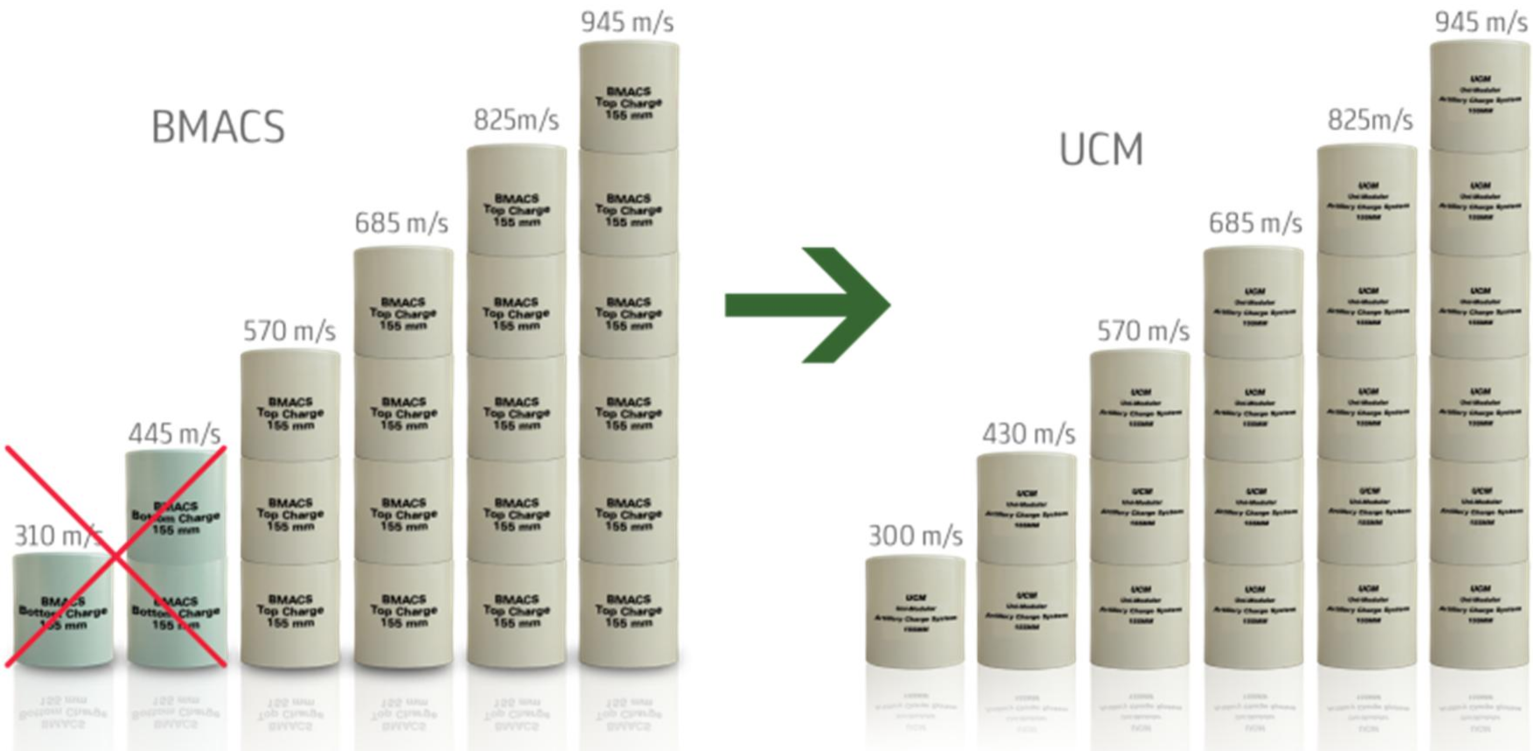
Elbit Systems™ Land

- **Next generation technology** for next generation of cannons.
- Only **one type** of modular artillery charge system in all artillery **logistics chain**, from the artillery gun, company, battalion and above.
- Adjusted to **FALCS** (**F**ull **A**utomatic **L**oad **C**harge **S**ystem).
- Minimum **ignition** delay time.
- Increase **fire rate**.
- **Water proof** protecting surface.
- **No residue** in the barrel.
- Proper **internal ballistics** - pressure and differential Pressure.
- Reducing barrel's wear, **longer barrel life**.
- Identical and symmetric module design **prevents** any chance of **human/loading error** in day or night-operation.



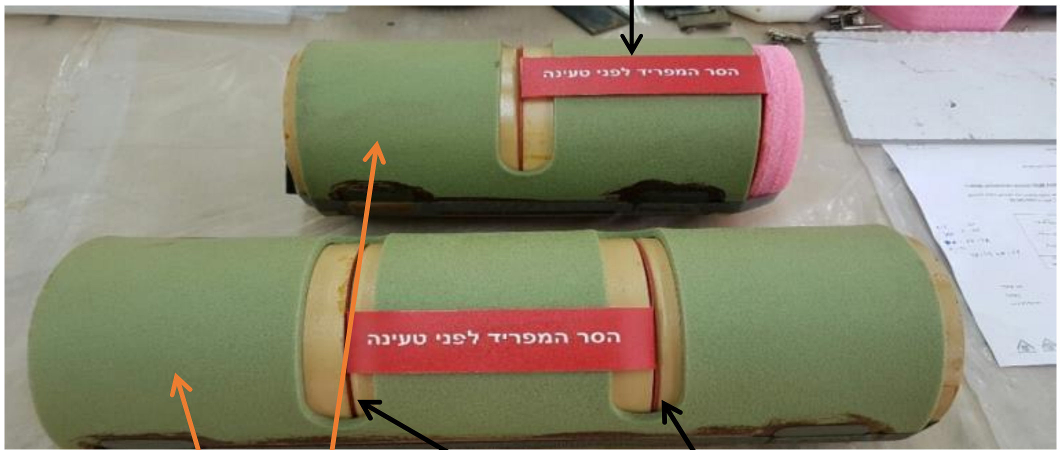
Uni-Modular Artillery Charge System M662

- New and STATE-OF-THE-ART solution
- **Fully Comply with JBMoU**
- Can be used with any 155mm gun
- The most affordable solution with logistic simplicity (FIFO)
- **Qualified by the IDF**
- **In service by the IDF (no risk)**



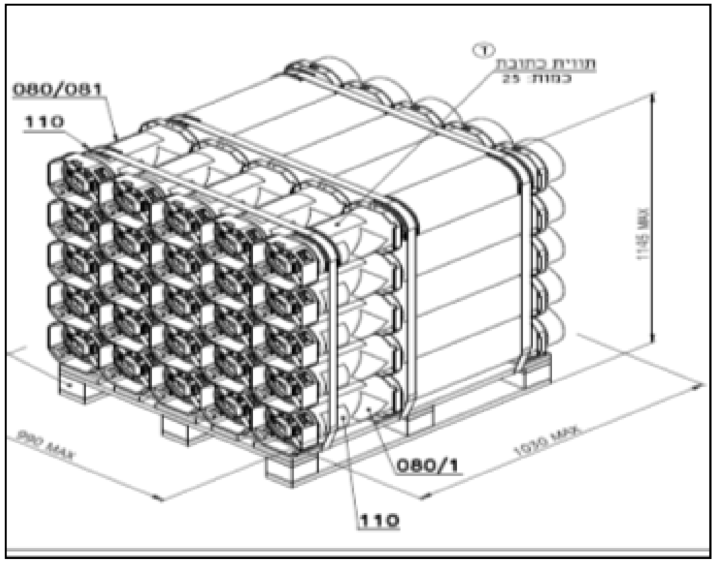
UCM M662 - PACKAGE

Remove before loading



Sponge sleeve for high protection during storage and handling

Absorber to prevent wear between the modules

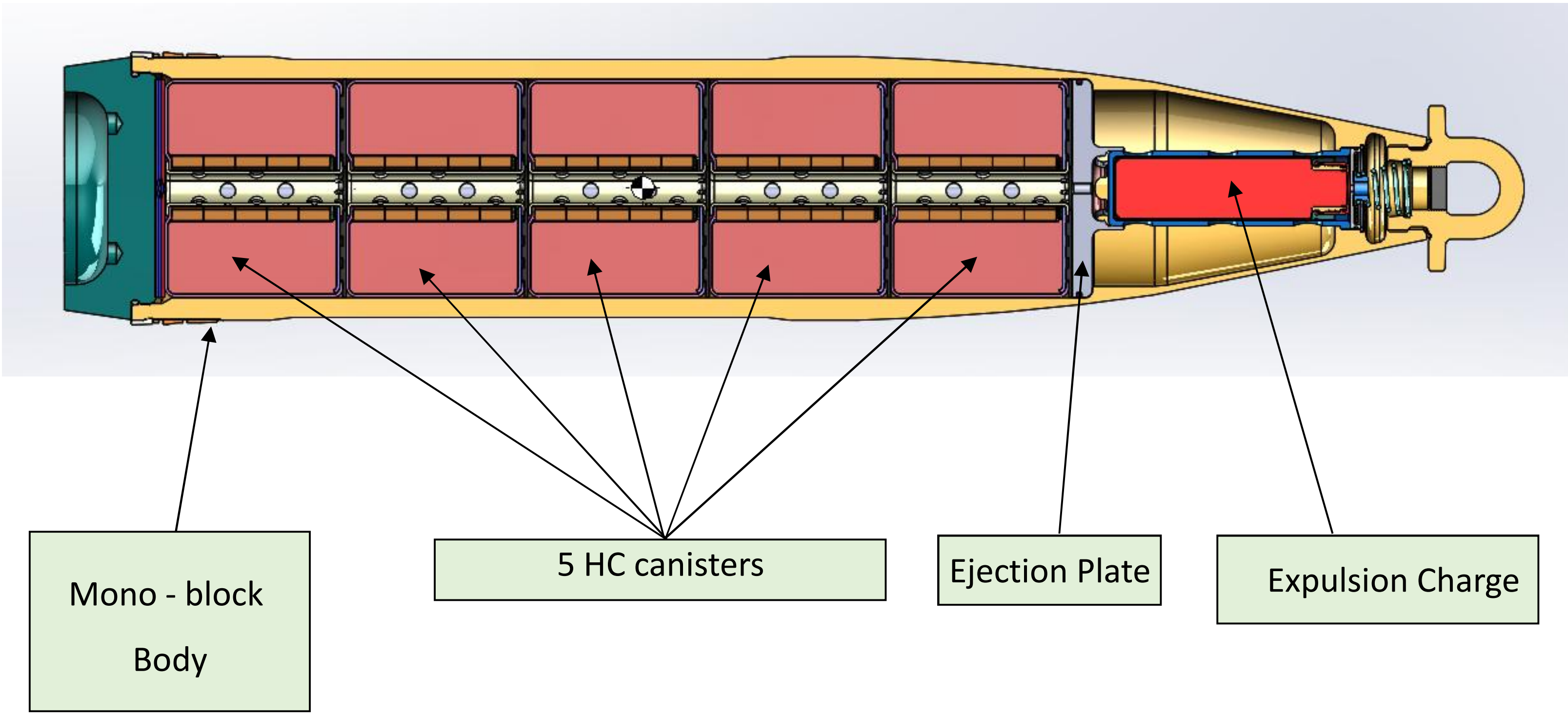


SMOKE Projectile - Background

1. Need Smoke projectile for **screening** and **spotting**
2. **Smoke WP has Phosphor**, which may cause burns when in contact with human skin.
3. Israeli internal committee decided not to use of such projectiles in urban terrain involving civilians.
4. Decision to use improved smoke projectile –> **Elbit's Smoke HC .**

155mm Smoke HC
M150

155 mm SMOKE HC – Description



155 mm SMOKE HC – Comparison with M116

Feature	Elbit's M150 Smoke HC	M116 (WP)
Duration	~ 3 Minutes	~ 2 Minutes
Screen Size	120% (in L&H)	100%
Range (39 Caliber)	22 km	18km
Canisters	5	3
Quantity	HC = 13.5 kg	WP = 8.7 kg
Projectile	Based on M483 family	Based on M107 family
MV (m/sec)	Up to 890 (52 Caliber)	685

155 mm SMOKE HC – Advantages

1. Long lasting smoke – up to 3 minutes
2. Higher screening size
3. Higher density
4. Better spotting at long distances
5. No use of phosphor

M910

Electronic time fuze for 155mm artillery projectiles

- The M910 fuze is suitable for use on all projectiles in accordance with STANAG 9216 (MIL – STD - 333B) for 105mm to 203mm calibers
- The fuze initiates all types of carrier shells at airburst (smoke, illuminating and Super- HE) or Impact
- The fuze can receive the data by using Stand Alone Setter Device or by inductive during automatic projectile loading in compliance with STANAG 4369

UCM /BMACS

M910
Electronic time fuse

M454
(S-HE)
155mm artillery projectile

M401-A1
(HE-ER-BB)
155mm artillery projectile

M107-A3

M150
155mm smoke projectile

M481
(HE-ER-IM)
155mm artillery projectile

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THANK YOU
FOR LISTENING

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