40th Annual Armament Systems: Guns - Ammunition - Rockets - Missiles
Conference & Exhibition
"Translating Lessons Learned into Systems Requirements"

25 -28 April 2005

Agenda

Tuesday, 26 April 2005

General Session:

- Weapons Systems and Explosives Safety in a Joint Warfighting Environment, Mr. David C. Schulte, Executive Director, Naval Ordance Safety & Security Activity
- The Future of Small Missiles, Dr. James C. Bradas, Associate Director for Missile Technology, AMERDEC

Session: Modeling & Simulation

- Accuracy Modeling of the 120mm M256 Gun as a Function Of Bore Centerline Profile, Mr. David Smith for Dr. Ronald Gast, Benet Laboratories
- Opening New "DOORS" to Managing JSF Gun System Requirements, Ms. Renee I. Bellack, General Dynamics Armament and Technical Products
- Optimized Trajectory Shaping Guidance for an Air-to-Ground Missile Launched from a Gunship, Mr. Shane Sorenson, Naval Surface Warfare Center
- Estimating Ballistic Limits of Skin and Clothing for Projectiles, Mr. Henry E. Hudgins, US Army ARDEC
- A Review of The Insensitive Munitions Design Technology Workshop, Mr. M. Pascal Marchandin, NATO-MSIAC

Luncheon:

- Super Weapons – An Analysis, LTC Simon R. West, British Army, United Kingdom Defence Academy

Session: Medium Caliber System

- Oerlikon Ammunition for New Defense Environment, Mr. Allan N. Buckley, BTECH Oerlikon Contraves Pyrotec AG
- Multi Mission Vehicle Armament & Air Burst Munition for Expeditionary Warfare Force Protection, Mr. Andrew Bradick, Lockheed Martin
- 25mm Gun Systems for theF-35 Joint Strike Fighter (JSF), Mr. Douglass C. Parker, General Dynamics Armament and Technical Products
- Optimized Gun Barrel Targeting Investigation, Mr. Jeff A. Siewart, Arrow Tech Association
- Mk 110 Mod 0 / 57mm Naval Gun & Ammunition Certification Process, LT Timothy J. Hackett, USCG, US Coast Guard Deepwater Sponsors' Representative
- GAU-19/A Barrel Life Study, Mr. James J. St. Germain, General Dynamics Armament & Technology Products
- RNLA IFV Firepower: 30 mm versus 35 mm - 35 mm KETF Firing doctriney, Mr. Eelko van Meerten, TNO Defence, Safety & Security
- OMk44 Gun/Ammo IPT, Maj Kirk D. Mullins, USMC, DRPM AAA
- O30mm Airburst Development - Translating Lessons Learned into System Requirements, Mr. Paul A. Reynolds, General Dynamics - OTS

Wednesday, 27 April 2005

General Session:

- ATEC Update, BG(P) James R. Myles, USA, Commanding General, US Army Test & Evaluation Command
- Raytheon Missile Systems: A Global Perspective, Mr. Robert Salyer, Director, Business Development
  Raytheon Missile Systems
- Acquisition and Sustainment Program, COL Lloyd E. McDaniels, USA, Project Manager, CCWS Project Office

Session: Weapon Systems

- Weapon System Concepts for a Future Gunship, Mr. Michael M. Canaday, Naval Surface Warfare Center
- Royal Navy Small Calibre Gun Research to Defeat the Small Boat Threat, Mr. Johnathan Watkins, Defence Scientific Technology Laboratory
- Mini-Typhoon Remote Operated Small Arms Mount (ROSAM), Mr. Benjamin J. Hardie, General Dynamics Armament and Technical Products
- Update on Picatinny High Speed Turret, Mr. Mr. Richard Ciekurs, US Army RDECOM-ARDEC
- 40mm CTWS Supporting UK and France, Mr. Michael Duckworth, CTA International

Session: Missles & Rockets

Abraham Overview, Mr. Robert Daunfeldt, Bofors Defence
- Summary Overview of an Advanced 2.75 Hypervelocity Weapon, Mr. Larry Bradford, CAT Flight Services, Inc
- APKWS Flight Test Results, Mr. Larry Ingram and Mr. Dean Slocum, General Dynamics Armament & Technology Products
- APKWS Block II Demonstration Program , Mr. Milton E. (Gene) Henderson, Jr., US Army RDECOM-AMRDEC
- Missile Systems Lethality Enhancement Through the Use of a Conducting Aerosol Plasma Warhead, Mr. Allen H. Stults, US Army RDECOM-AMRDEC
- Next Generation Adaptable RF Seekers for Precision Munitions, Dr. Cory Myers, BAE Systems IEWS
- Technology for the Smart Rocket Launcher: The System Enabler For The 21st Century, Mr. Donald E. Davis, US Research, Development & Engineering Command
- Development of a Unique Penetrator Warhead for Rocket or Missile Delivery, Mr. Roger W. Melin, Lockheed Martin Missiles and Fire Control

Session: Large Caliber

- Development of the M1028, 120mm Anti-Personnel Tank Round, Mr. Hugh MacMillan, US Army Armaments Research, Development & Engineering Center and Mr. Neal Hylton, General Dynamics – Ordnance and Tactical Systems
- Metallic Materials & Processes Enabling Lightweight System Initiatives, Mr. Jeff Lehner, Director, Military Programs, Alcoa/Howmet Corporation
- Advanced Modular Gun Demonstrator: Redefining – “Faster Than A Speeding Bullet”, Mr. Steve Coladonato, Applied Ordnance Technology, Inc.
- The Modified Tank Ammunition IMI M152/6 HEAT-AP- T, Mr. Danny Schirding, Chief Systems Engineer
  Tank Ammunition Directorate - IMI Ammunition Group
- A105/120/125 mm PELE Firing Results, Dr. Lutz Börngen, Rheinmetall Wafe Munition
- Line Of Sight/Beyond Line Of Sight (LOS/BLOS) Advanced Technology Demonstrator (ATD), Mr. David C. Smith, P.E., USA Benet Laboratories

Session: Energetics

- Development, Evaluation and Lifetime Prediction of Medium and Large Caliber Ammunition, Mr. Gert Scholtes, TNO
- Concepts and Practices in Finding and Applying Lessons Learned, Mr. David F. Fair, US Army ARDEC
- Propellant Replacement for the 105-mm M67 Propelling Charge, Ms. Adriana L. Eng, US Army ARDEC
- Lead Azide Replacement Program, Mr. John M. Hirlinger, US Army RDECOM-ARDEC
- Modeling Efforts for Autorotation Delivery System Concept Development, Mr. David C. Rutledge, Ph.D., Staff Engineer, United Defense

Thursday, 28 April 2005

General Session:

- Direct Fire Ammunition Lessons Learned: “More Than Just Impacts on Bullets”, COL Mark Rider, USA, Project Manager, Maneuver Ammunition Systems
- U.S. Army ARDEC Overview & Special Weapon Observation Reconnaissance Direct-Action System (SWORDS), Mr. Anthony Sebasto, Associate Director for Technology & Business Development, AETC
- National Defense Industrial Association (NDIA) Armament Division - 2005 Division Status, Mr. Dave Broden, Chairman, Armaments Division, NDIA

Session: Technology & Manufacture

- Automated Ammunition Identification, Mr. David F. Pouliot, United Defense L. P.
- Design for Manufacturing & Assembly (DFMA), Mr. Steve Watts, US Army RD&E Command
- ARDEC Business Development Process, Mr. David L. Burkhardt, Director, Strategic Communications, US Army ARDEC
- MEMS IMU – Common Guidance, Dr. Vicki C. LeFevre, US Army RDECOM-AMRDEC and Mr. David W. Panhorst US Army ARDEC, US Army ARDEC
- Development and Testing of High Explosive (HE) Projectiles for Electro-Magnetic Gun Army Tech Objective (ATO), Mr. Manfredi Luciano, US Army ARDEC
- Metal Injection Molding of Wing/Flaperon, Mr. Jerry C. LaSalle, Director of MIM Operations, Polymer Technologies, Inc (PTI)
- TBX Evaluation Testing in the M151 (2.75") Warhead as Risk Reduction for the APKWS, Mr. Jason C. Gilliam, US Army RDECOM-AMRDEC
- Archer Artillery Program, Mr. Ulf Einefors, Bofors Defence
- Improvements to Airborne Ladar Man-in-the-Loop Operations, Mrs. Sarah J. Hard, RDECOM-AMRDEC

Session: Mortars & Artillery

- M865 TID Improvement Study, Mr. Jason W. Gaines, General Dynamics
- Lessons Learned from the Development of the U.S. Navy 5-Inch Force Protection Projectiles, Mr. Sanford (Luke) Steelman, III, Naval Surface Warfare Center
- Advanced Gun Barrel Technologies, Dr. Amir Chaboki and Mr. Allen Boutz, United Defense
- Defining Homogeneity for Medium Caliber Ammunition and Small Grain Propellant Lots, Mr. Scott Carney, ATK
- Precision Fires for the Field Artillery, Mr. John Halvey, Raytheon, and Stefan Blomgren, Bofors Defence
- Low Cost Course Correction (LCCC) Demonstration Program, Mr. George Barnych and Mr. Daniel Davis, Ordance and Tactical Systems Division
- XM395 Precision Guided Mortar Munition (120mm PGMM): Responsive, Standoff Precision Lethality for Highly Deployable and Mobile Forces, Mr. James Terhune and Mr. Anthony Pezzano, OPM Mortars
- Precision Guided Miniature Munitions, Mr. Mark Carlson, BAE Systems
- The 81mm Non Lethal **Mo**rtar **Ca**rrier **P**rojectile (MoCaP), Mr. Seungeuk Han, Mr. Andrew Ponikowski, and Mr. Raymond Trohanowsky, US Army RDECOM-ARDEC
- Commercial Disposal of Explosive Wastes, Mr. Mark M. Zaugg, EBV Explosives Environmental Company

"Translating Lessons Learned into Systems Requirements"

40th Annual Armament Systems: Guns - Ammunition - Rockets - Missiles Conference & Exhibition

April 25 - 28, 2005

Sheraton New Orleans Hotel
New Orleans, LA

Monday, April 25 2005

10:00 a.m. On-site Registration

Noon Exhibit Move-In

5:00 p.m. - 6:30 p.m. Reception in the Exhibit Hall

6:30 p.m. Adjourn for the Day

Tuesday, April 26, 2005

7:00 a.m. On-site Registration / Continental Breakfast

7:45 a.m. Opening Remarks

8:00 a.m. ***Mr. David C. Schulte***, Executive Director, Naval Ordnance Safety & Security Activity

8:30 a.m. ***Dr. James C. Bradas***, Associate Director for Missile Technology, AMRDEC

9:00 a.m. **Session: Modeling & Simulation**

Accuracy Modeling of the 120mm M256 Gun as a Function of Bore Centerline Profile
Mr. David Smith for Dr. Ronald G. Gast, Benet Laboratories

Opening New DOORS to Managing JSF Gun System Requirements
Ms. Renee I. Bellack, General Dynamics Armament and Technical Products

Optimized Trajectory Shaping Guidance for an Air-to-Ground Missile Launched from a Gunship
Mr. Shane Sorenson, Naval Surface Warfare Center

9:30 a.m. Exhibit Hall Opens

10:00 a.m. Break in the Exhibit Hall

10:30 a.m. Conceptual Weapon System Design for the Defense of Naval Vessels from the Swarming Small Boat Threat
Mr. John E. Bibel, Naval Surface Warfare Center Dahlgren Division

Warhead Penetration Dynamics - Warhead Body, Fuze, and Target Interaction
Mr. Richard Ventura, Talley Defense Systems

Ballistic Limits of Skin and Clothing for Lethality Estimates of Projectiles Wound Ballistics
Mr. Henry E. Hudgins, US Army ARDEC

A Review of the Recent NIMIC IM Design Technology Workshop
Mr. M. Pascal Marchandin, NATO - MSIAC

11:50 a.m. Luncheon: Super Weapons From a Historical and Psycological Basis
LTC Simon R. West, British Army, United Kingdom Defence Academy

1:10 p.m.	**Session: Medium Caliber Systems**
	Ammunition for the New Infantry Battelfield Environment ***Mr. Allan N. Buckley***, BTECH Oerlikon Contraves Pyrotec AG
	Force Protection - Multi Mission Vehicle Armament & Air Burst Munition for Expeditionary Warfare ***Mr. Andrew Bradick***, Lockheed Martin
	F-35 Joint Strike Fighter Gun Overview and System Update ***Mr. David L. Maher*** and ***Mr. Douglass C. Parker,*** General Dynamics, Armament and Technical Products
	Phalanx Targeting Investigation ***Mr. Jeff A. Siewart***, Arrow Tech Association
3:00 p.m.	Break in the Exhibit Hall
3:30 p.m.	**Session: Medium Caliber Systems (Continued)**
	Mk 110 Mod 0 / 57mm Gun Test & Certification Process ***LT Timothy J. Hackett, USCG***, US Coast Guard
	GAU-19/A Barrel Life Study ***Mr. James J. St. Germain***, General Dynamics Armament & Technology Products
	Calibre Choice for the Dutch IFV ***Mr. Eelko van Meerten***, TNO Defence, Safety & Security
	The Expeditionary Fighting Vehicle, How Operational and Combat Lessons Learned Apply to the EFV and the 30MM Mix of Tomorrows Warfighter ***Maj Kirk D. Mullins, USMC***, DRPM AAA
	30x173mm HEAB-T Development and Lessons Learned ***Mr. Paul A. Reynolds***, General Dynamics - OTS
5:30 p.m. - 7:00 p.m.	Reception in the Exhibit Hall
7:00 p.m.	Adjourn for the Day

Wednesday, April 27, 2005

7:00 a.m.	On-site Registration / Continental Breakfast
7:45 a.m.	Opening Remarks
8:00 a.m.	***BG (P) James R. Myles, USA***, Commanding General, US Army Test & Evaluation Command
8:45 a.m.	***Mr. Robert Salyer***, Raytheon
9:10 a.m.	Acquiring and Sustaining US Army Missiles ***COL Lloyd E. McDaniels, USA,*** CCWS Project Office

9:30 a.m. Exhibit Hall Opens

9:45 a.m. **Session: Medium Caliber Systems (Continued)**

Recent Developments of the M230 30MM Chain Gun
Mr. Lawrence A. Mason, ATK Ordnance & Ground Systems

MK44 Automatic Cannon Update
Mr. Mark McMillian, ATK Ordnance Systems

10:30 a.m. Break in the Exhibit Hall

Concurrent Sessions

10:50 a.m. **Session: Weapon Systems**

AC-130U Gun System Production Re-Start
Mr. John G.. Fletcher, General Dynamics Armament and Technical Products

Weapon System Concepts for a Future Gunship
Mr. Michael M. Canaday, Naval Surface Warfare Center

Royal Navy Small Calibre Gun Research to Defeat the Small Boat Threat
Mr. Johnathan Watkins, Defence Scientific Technology Laboratory

11:50 a.m. - Lunch

1:00 p.m. **Session: Weapon Systems (Continued)**

Remote Operated Small Arms Mount (ROSAM)
Mr. Benjamin J. Hardie, General Dynamics Armament and Technical Products

Placing Gunner's Behind the Proctective Armor of Vehicles
LTC Kevin P. Stoddard, USA, PM Soldier Weapons

Picatinny High Speed Turret (PHIST)
Mr. Richard Ciekurs, US Army RDECOM-ARDEC

Session: Missiles & Rockets

Critical Asset Defense - ABRAHAM Rocket Assisted Projectile
Mr. Robert Daunfeldt, Bofors Defence

Hypervelocity Propulsion System Substantially Improves 2.75 Rocket Lethality, Safety, Survivability
Mr. Larry Bradford, CAT Flight Services, Inc.

APKWS Flight Test Results
Mr. Larry S. Ingram, General Dynamics Armament and Technical Products

APKWS Block II Demonstration Program
Mr. Milton E. (Gene) Henderson, Jr., US Army RDECOM-AMRDEC

Lunch

Session: Missiles & Rockets (Continued)

Missile System Lethality Enhancement Through the Use of Pulsed Power and Plasma Conduction
Mr. Allen H. Stults, US Army RDECOM

Next Generation Adaptable RF Seekers for Precision Munitions
Dr. Cory Myers, BAE Systems

The Smart Rocket Launcher as the Key Enabler for the Rocket System of the Future: The Technology Developments Needed for the Next Generation Rocket Laucher to Carry 70mm Rockets into the 21st Century
Mr. Donald E. Davis, US Army Research, Development & Engineering Command

Session: Weapon Systems (Continued)

Recent Activities Involving 40mm CTWS in Support of UK and France
Mr. Michael Duckworth, CTA International

The Marine Corps Expeditionary Fire Support System (EFSS): A Systems Overview
Mr. Jason Burkett, General Dynamics

2:40 p.m. Break in the Exhibit Hall
(Last Opportunity to Visit Exhibits)

3:00 p.m. Exhibit Hall Closed

3:10 p.m. **Session: Large Caliber**

Development of the XM1028, 120mm Anti-Personnel Tank Round
Mr. Hugh MacMillan, Armaments Engineering and Technology Center, ***Mr. Peter Georgantzis***, US Army ARDEC, and ***Mr. Neal Hylton***, General Dynamics-OTS

Titanium Investment Casting Weapon System Application
Mr. Jeff Lehner, Director, Military Programs, Alcoa/Howmet Corporation

Advanced Modular Gun Demonstrator - XLT Test Gun
Mr. Steve Coladonato, Applied Ordnance Technology, Inc.

The Modified Ammunition, Equipped with the “Fuzaman”: The IMI 105-mm Heat-AP-t Cartridge M152/6
Mr. Danny Schirding, Israel Military Industries, Ltd

105/120/125 mm PELE Firing Results
Dr. Lutz Borngen, Rheinmetall Waffe Munition

Lightweight Gun Development and Testing for the Future Combat System
Mr. David C. Smith, P.E., USA Benet Laboratories

5:15 p.m. Adjourn for the Day

Session: Missiles & Rockets (Continued)

Development of a Unique Penetrator Warhead for Rocket or Missile Delivery
Mr. Roger W. Melin, Lockheed Martin Missiles and Fire Control

Determining the Army Aviation Rocket and Missile Mix for the Future Fight
Mr. William M. Mulholland, Whitney, Bradley & Brown

Break in the Exhibit Hall
(Last Opportunity to Visit Exhibits)

Exhibit Hall Closed

Session: Energetics

Advanced Propelling Solutions Complying with Demands (FCS)
Dr. Beat Vogelsanger, NITROCHEMIE Wimmis AG

Development, Evaluation and Lifetime Prediction of Medium and Large Caliber Ammunition
Mr. Gert Scholtes, TNO

Concepts and Practice in the Application of Lessons Learned
Mr. David F. Fair, US Army ARDEC

Propellant Replacement for the 105-mm Artillery Propelling Charge
Ms. Adriana L. Eng, US Army ARDEC

Environmentally Benign Substitute Compounds for Lead Azide
Mr. John M. Hirlinger, US Army RDECOM-ARDEC

Modeling Efforts in Support of PKERS Concept Development
Mr. David C. Rutledge, Ph.D., Staff Engineer, United Defense

Adjourn for the Day

Thursday, April 28, 2005

7:00 a.m. On-site Registration / Continental Breakfast

7:45 a.m. Opening Remarks

8:00 a.m. ***COL Mark Rider, USA***, Project Manager, Maneuver Ammunition Systems

8:30 a.m. ***Mr. Anthony Sebasto***, Associate Director for Technology & Business Development, AETC

9:00 a.m. ***Mr. Dave Broden***, NDIA Armaments Division Status Overview, Chairman, Armaments Division, NDIA

9:20 a.m. Break

Concurrent Sessions

9:40 a.m. **Session: Technology & Manufacture**

Automated Ammunition Identification
Mr. David F. Pouliot, United Defense L. P.

Deep Digger Weapons System Concept
Mr. David W. Burns,US Army ARDEC

Development of Composite Launch Tubes for Shoulder Fired Weapons through Applied Science, Planning and Teamwork
Mr. Thomas P. Jacobson, Talley Defense Systems

Design for Manufacture & Assembly (DFMA)
Mr. Steve Watts, US Army RD&E Command

Technology and Manufacturing Initiatives
Mr. Dave Burkhardt, Enterprise Management Office, US Army ARDEC

Session: Technology & Manufacture (Continued)

Army MEMS Common Guidance Program
Mr. David. W. Panhorst, US Army ARDEC and ***Dr. Vicki C. LeFevre***, AMRDEC

Development and Testing of HE Projectiles for EM Gun - STO
Mr. Manfredi Luciano, US Army ARDEC

Session: Mortars & Artillery

Tank 120mm Training Ammunition: MB65 Target Impact Dispersion Study
Mr. Jason W. Gaines, General Dynamics-OTS

Lessons Learned from the Development of the U.S. Navy 5-inch Ship Self Defense Projectiles
Mr. Sanford L. Steelman, III, Naval Surface Warfare Center

ONR's Advanced Gun Barrel Technology Program
Mr. Allen Boutz, United Defense

Structural Margin Improvement on the M829A3 Projectile
Mr. Scott Carney, ATK

Session: Mortars & Artillery

Excalibur: Turning the Field Artillery into a Long Range Precision Attack Weapon System
Mr. Stefan Blomgren, Bofors Defence

Low Cost Course Correction (LCCC) Demonstration Program
Mr. George B. Barnych, General Dynamics Ordnance and Tactical Systems Division

Session: Technology & Manufacture (Continued)

Advanced Metal Injection Molding Technology Applications to Defense Industry
Mr. Jerry LaSalle, Polymar Technologies

11:40 a.m. Lunch

1:00 p.m. **Session: Technology & Manufacture (Continued)**

TBX Evaluation Testing in the M151 (2.75”) Warhead as Risk Reduction for the APKWS
Mr. Jason C. Gilliam, US Army RDECOM-AMRDEC

Advanced Precision Kill Weapon System
Mr. Ulf Einefors, Bofors Defence

Test Results of an Imaging LADAR Seeker for Small Missiles
Mrs. Sarah J. Hard, RDECOM-AMRDEC

Session: Mortars & Artillery (Continued)

Applying Six Sigma Principles to Implementation of the PGMM Training Concept
Mr. Anthony Pezzano, OPM Mortars

Lunch

Session: Mortars & Artillery (Continued)

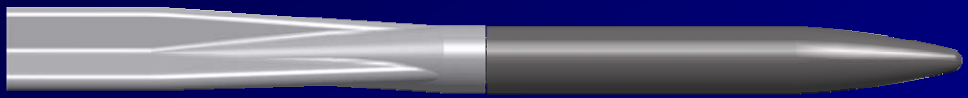
Precision Guided Miniature Munitions
Mr. Mark Carlson, BAE Systems

Development of a Non-Lethal Mortar Delivery System
Mr. Seungeuk Han, US Army RDECOM-ARDEC and ***Mr. Andrew Ponikowski***, US Army, RDECOM-ARDEC

Explosive Waste Recycle and Disposal
Mr. Mark M. Zaugg, EBV Explosives Environmental Company

3:00 p.m. **Conference Adjourns**

Development of a Unique Penetrator Warhead for Rocket or Missile Delivery



Presented to:
National Defense Industrial Association 40th Annual Armament Systems: Guns - Ammunition - Rockets – Missiles (GARM) Conference & Exhibition

25 – 28 April 2005

Roger W. Melin

Lockheed Martin Missiles and Fire Control
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(972) 603-1769

Topics

- I-NAIL™ Penetrator Concept
- I-NAIL™ Penetrator Design
- Recent Testing
  - Penetration Tests
  - Static Expulsion Tests
  - Wind Tunnel Expulsion Tests

I-NAIL™ Project Introduction

Missiles and Fire Control

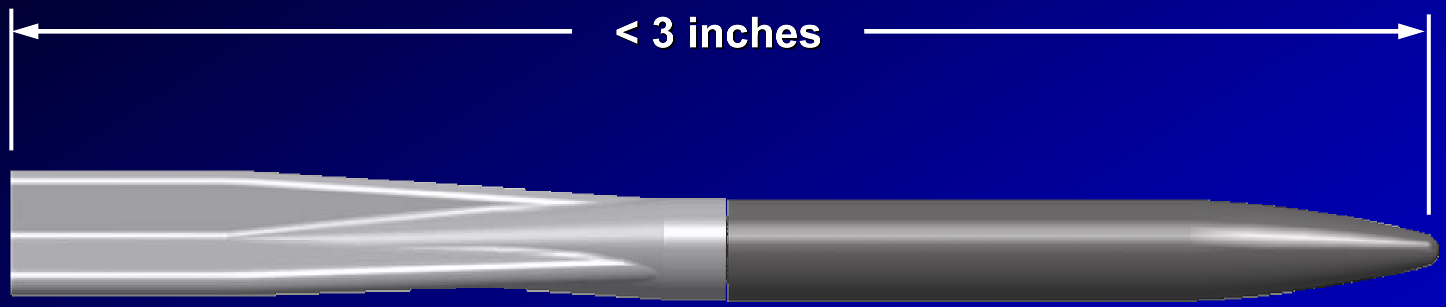
- **Project began as alternate GMLRS/HIMARS payload**
  - ✓ Zero dud rate
  - ✓ Inexpensive
  - ✓ Increased lethality
  - ✓ Limited zone of effects

- **Alternate platforms & applications**
  - ✓ Hydra-70
  - ✓ APKWS
  - ✓ AC –130 Gunship (105 mm cannon)

I-NAIL™ Penetrator

Missiles and Fire Control

Assembled Configuration



Tail
Injected molded plastic

Forebody
Tungsten Alloy

Forebody

I-NAIL™ Penetrator Design Trades

Missiles and Fire Control

Testing

Forebody Materials
- Ceracom 2
- Ceracom 3 hipped
- Ceracom C116
- Ceracom - not hipped
- French Sintered Rod
- French Swaged Bar
- Hawk (Formulas 1 – 3)
- HD17 Tungsten Bar
- HD17D Tungsten Bar
- Liquid Metal
- Sintered Tungsten
- Tungsten Welding Rod

Tail Materials
- Aluminum
- Magnesium
- Plastic
- Mischmetal (cerium & lanthanum)

Penetrator Masses
- 150 – 300 grains

Target Materials
- Al 5083
- Al 6061T6
- A36 Steel
- High Hard Armor
- Cast Iron Engine Manifold
- Concrete block
- Cinderblock Wall Simulant
- Flak Jacket
- Ballistic Gelatin

Impact Velocities
- 750 – 2000 f/s

Analysis

Penetrator Masses
- 150 – 300 grains

Forebody Geometry
- Nose Shape
  - Circular Ogive
  - Von Karman (3:1 - 1:1)
- Shaft Cross Section
  - Circular
  - Hexagonal
- Tip Radii
  - Flat
  - Hemispherical

Impact Velocities
- 750 – 2000 f/s

Penetration Testing

Business Development / Demo Tests

- Performed in conjunction with tungsten evaluations
- Variety of targets, penetrator designs, and impact conditions

Engineering Tests

- Performed to develop structured database
- Design of Experiments techniques used to design test matrix
- Results used to develop regression-based penetration predictors

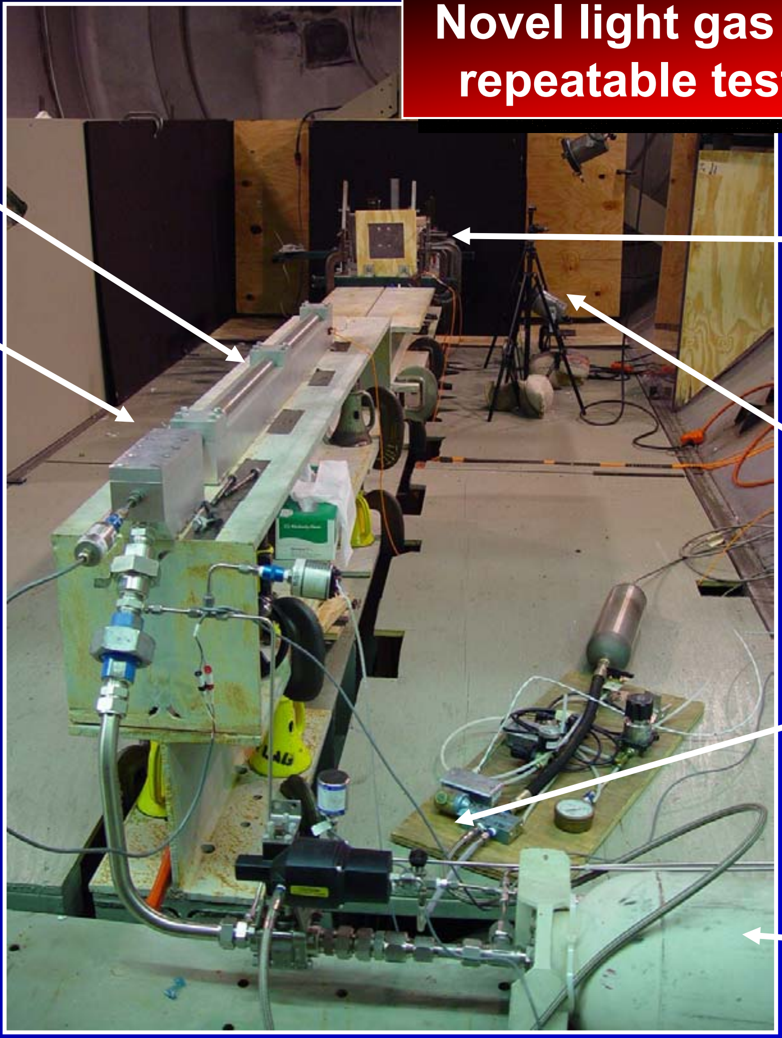
LMMFC Light Gas Gun Facility

Missiles and Fire Control

Novel light gas gun provides repeatable test conditions.

Gas (He) Gun

Breech



Make Screens/ Target

Lighting/High Speed Cameras

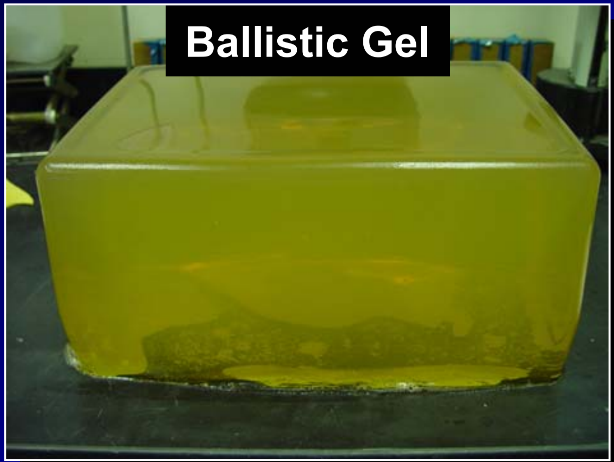
Gas Retention Valve

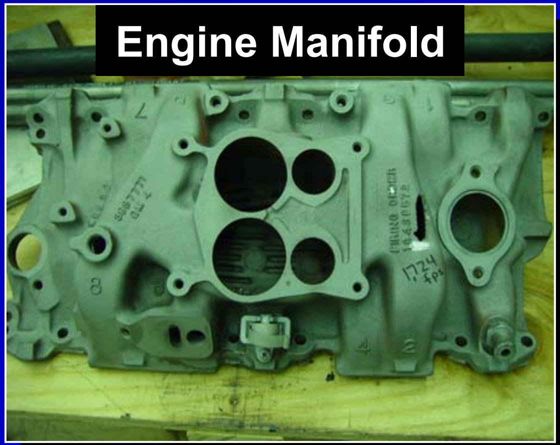
Gas Plenum

Data Acquisition/Data Reduction System

Representative Targets

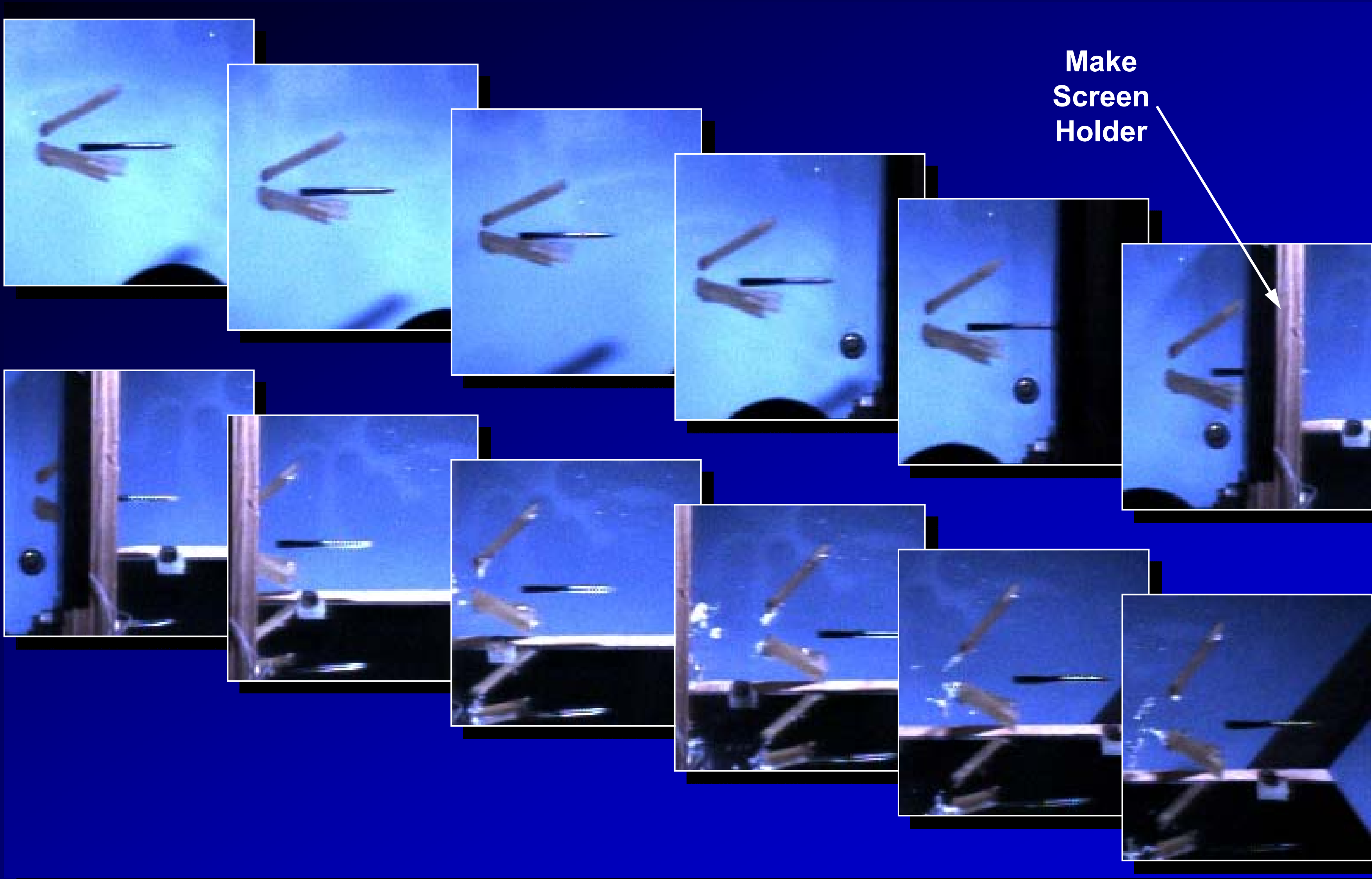
Missiles and Fire Control





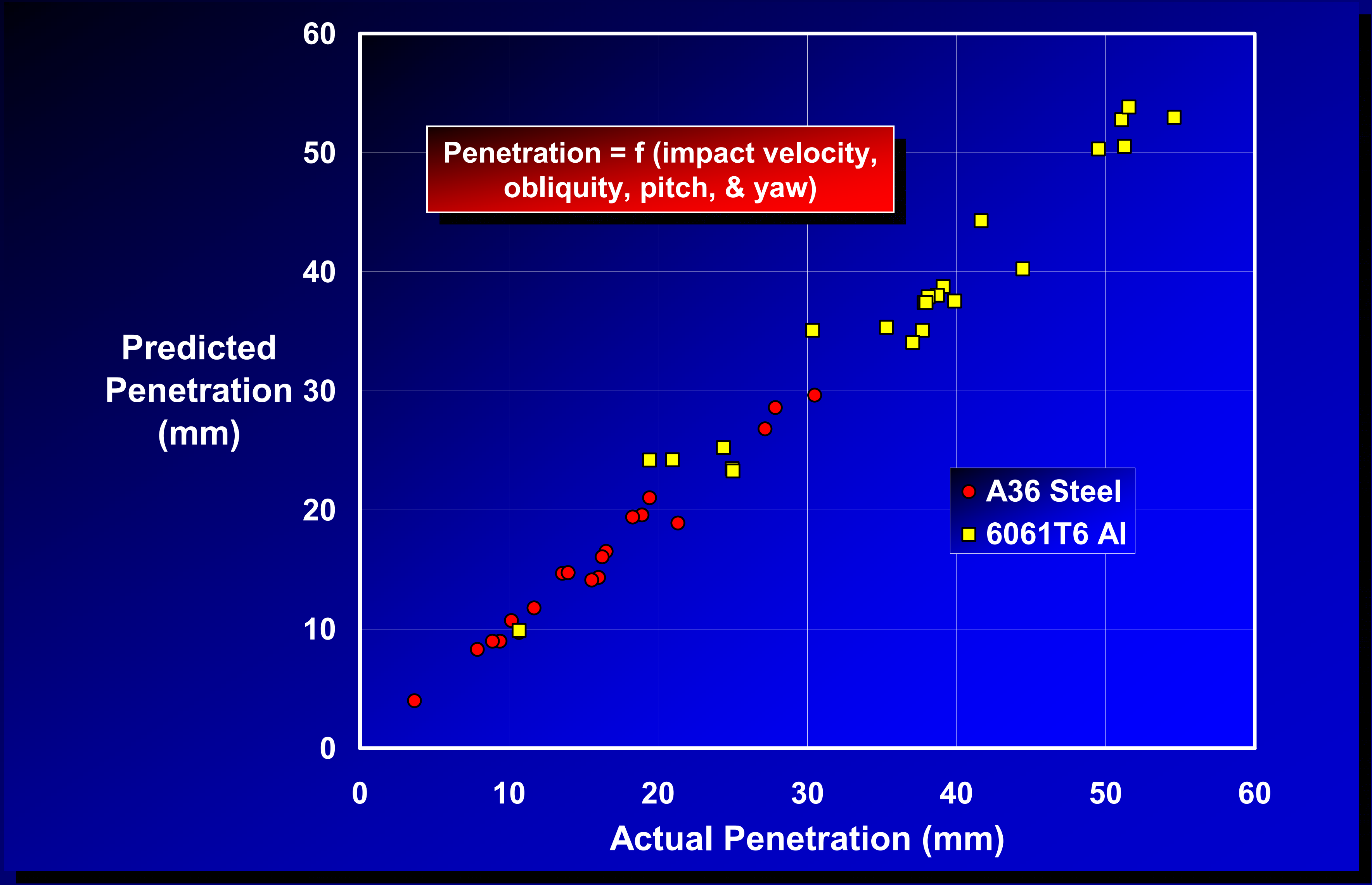
I-NAIL™ Sabot Separation

Missiles and Fire Control



I-NAIL™ Penetration Modeling

Missiles and Fire Control



I-NAIL™ Integration into Hydra

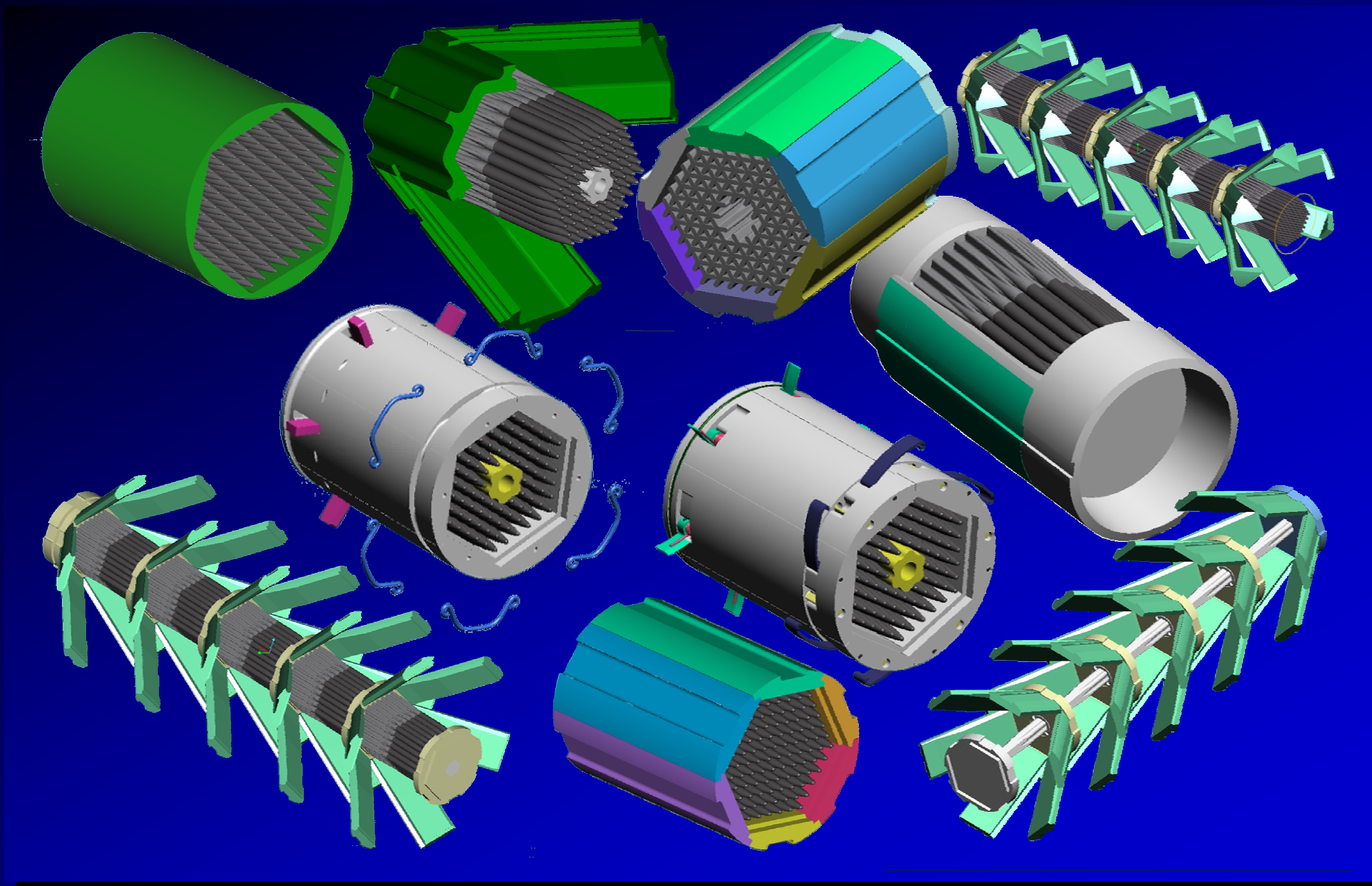
Missiles and Fire Control

Objectives:

- Package maximum loadout of I-NAIL™ penetrators maintaining HYDRA-70 weight / CG requirements
- Design and demonstrate performance of dunnage / penetrator support mechanism
- Demonstrate successful expulsion of I-NAIL™ penetrator payload with Hydra-70 expulsion charge
- Expulsion velocity ~150 f/s

I-NAIL™ Penetrator Dunnage Concepts

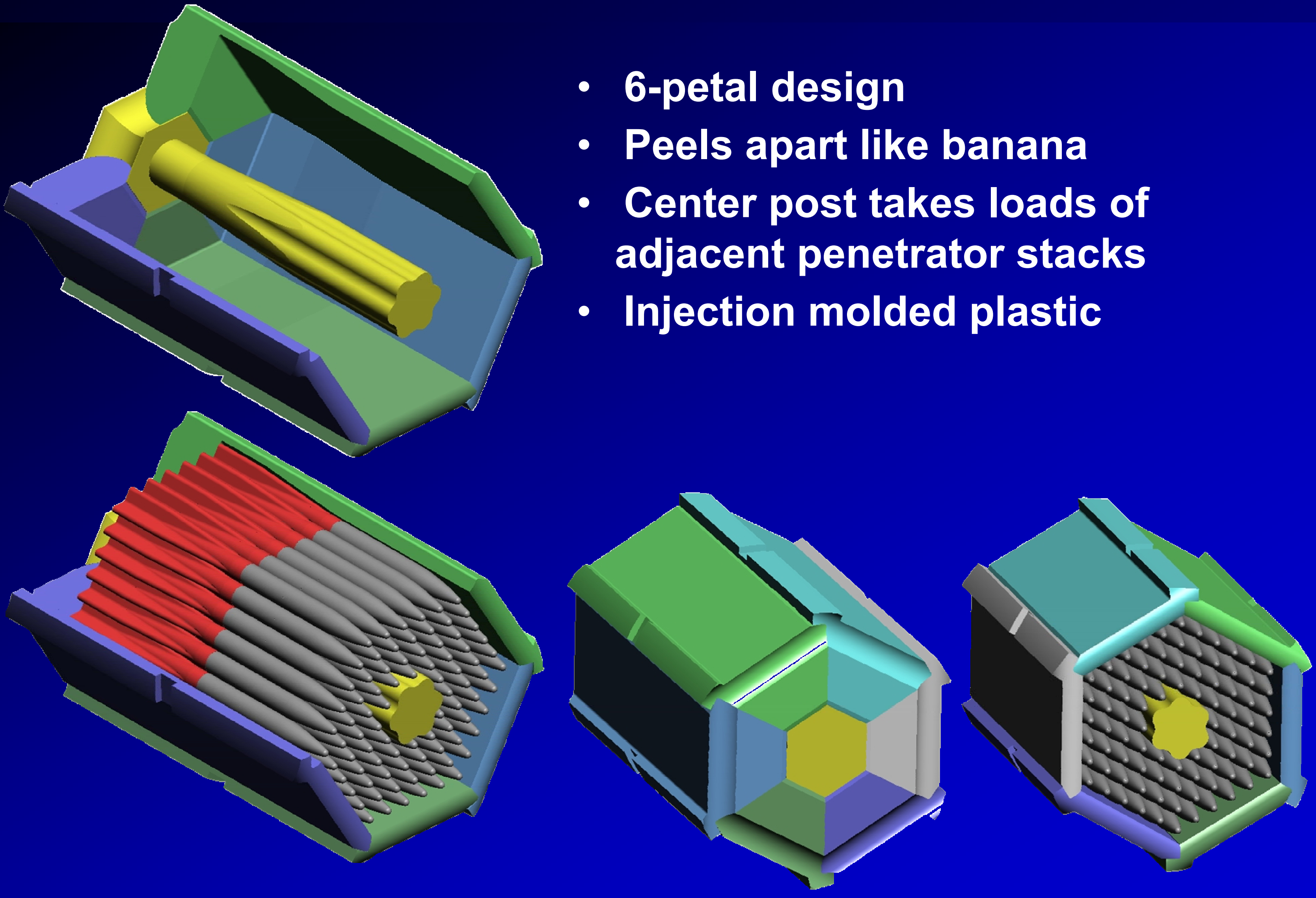
Missiles and Fire Control



Selected Hydra-70 Dunnage Concept

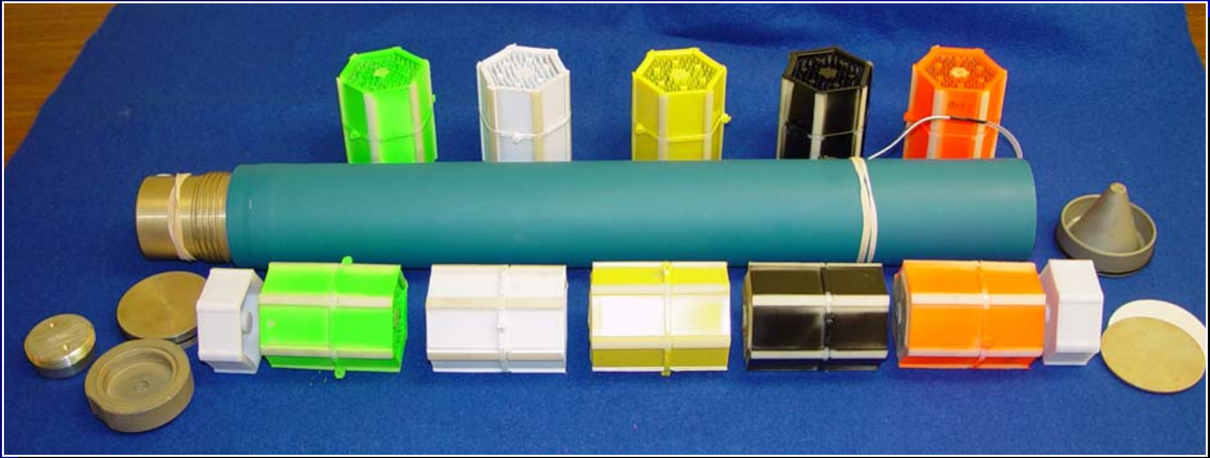
Missiles and Fire Control

- 6-petal design
- Peels apart like banana
- Center post takes loads of adjacent penetrator stacks
- Injection molded plastic



Expulsion Test Hardware

Forward end of Cup



Aft end of Cup

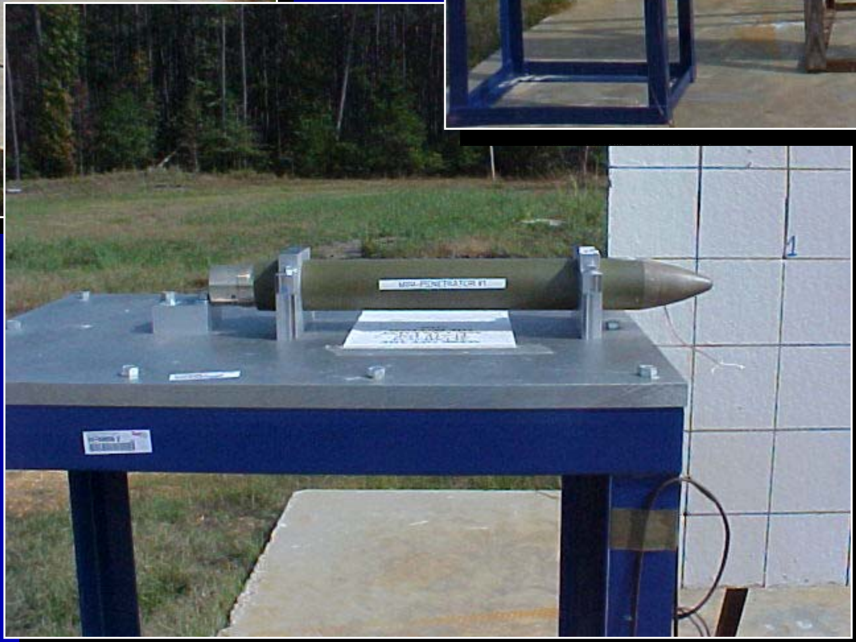
- 390 I-NAIL™ penetrators/warhead + 30 simulants for mass matching
- Fore & aft spacers added for CG match
- 6-Petal dunnage design for support and penetrator release
- GFE Hydra-70 expulsion charge
- Special SAF to allow static function

Expulsion Testing

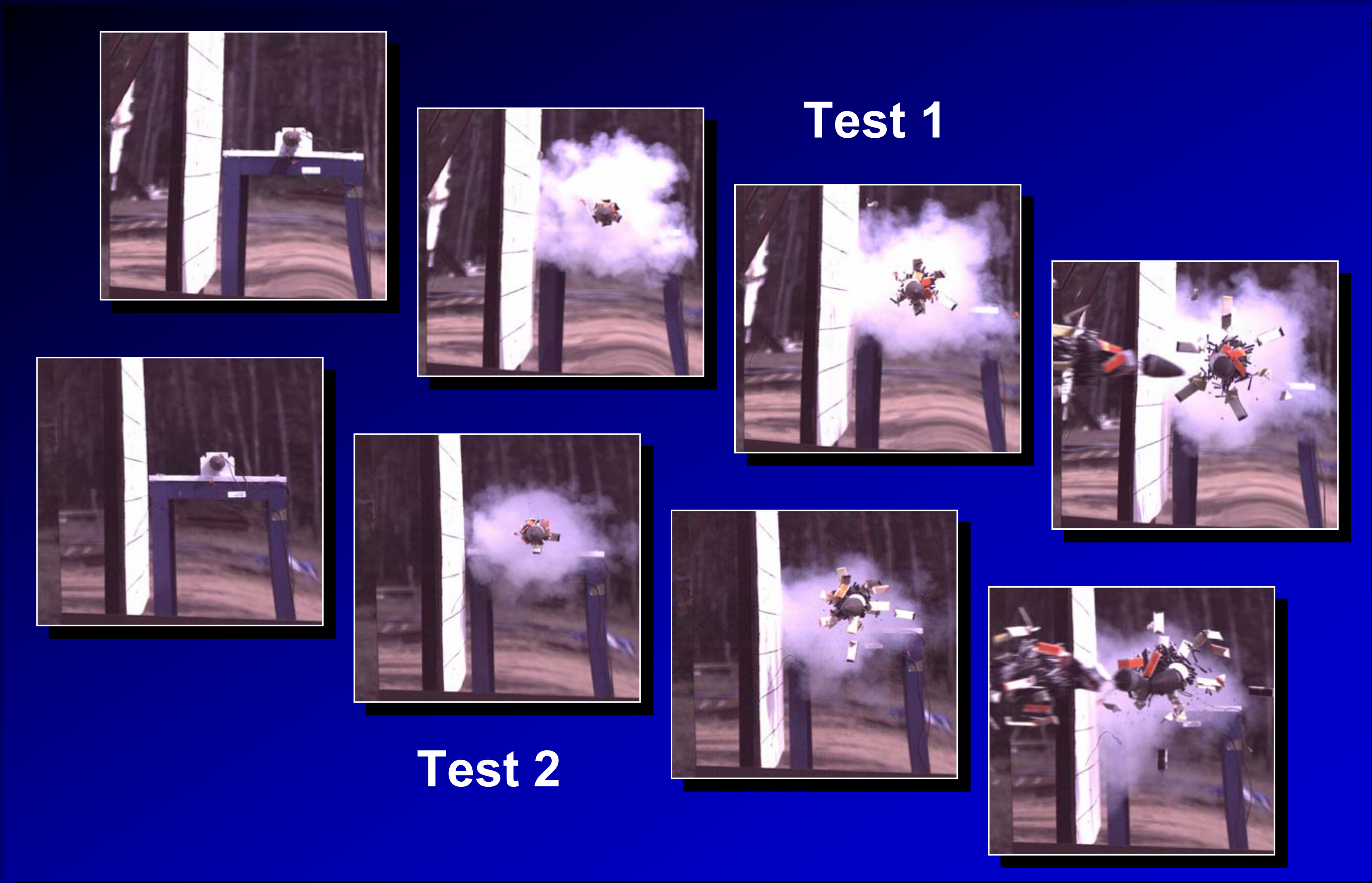
- Two Hydra-70 warhead casings loaded at Camden, AR facility with I-NAIL™ penetrators
- Two warhead tests performed on 20 October 2004 at National Technical Systems site in Camden, AR
- Static fired two warheads
  - No representative rocket airflow
  - No spin
- Three high-speed digital cameras used for data acquisition (2.1K frames/sec)
- Celotex package positioned down range for possible pattern data

Expulsion Test Layout

Missiles and Fire Control

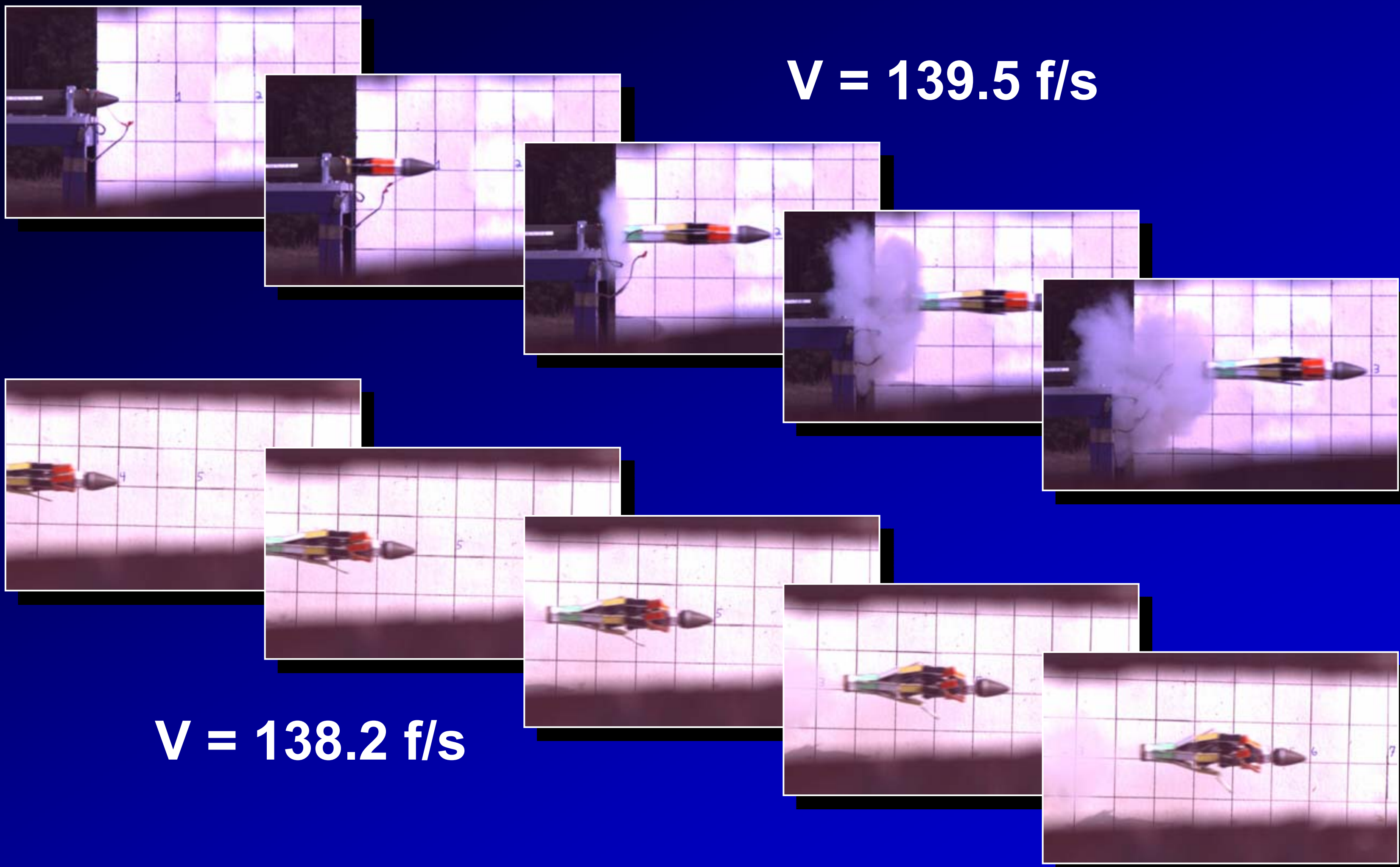


Down-Bore Views



Side View – Test 2

Missiles and Fire Control



V = 139.5 f/s

V = 138.2 f/s

Expulsion Test Results Summary

- Both payloads successfully ejected
- Nominal ejection velocities achieved in both tests

  Test 1: Camera 1 – no data

  Camera 2 – 138.3 f/s

  Test 2: Camera 1 – 139.5 f/s

  Camera 2 – 138.2 f/s
- Most penetrator damage occurred from sideways impacts as opposed to expulsion event
- Actual flight conditions will minimize such effect since penetrators will have time to align correctly
- Penetrator ballistics as expected

Wind Tunnel Tests

Objectives:

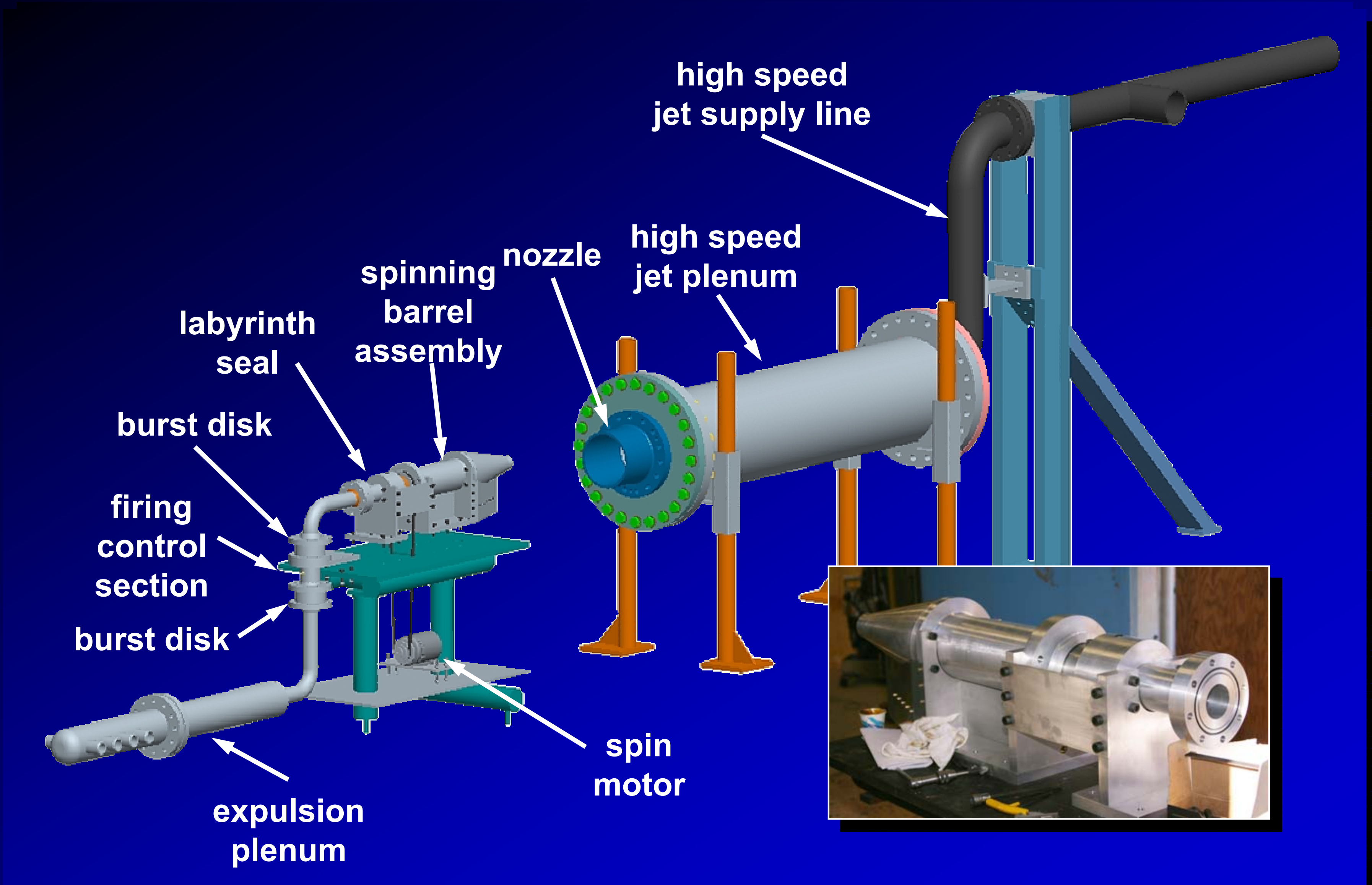
- **Demonstrate separation cleanliness of two potential I-NAIL™ dunnage designs**
  - 6-Petal Design (Hydra-70)
  - 3-Compartment Design (APKWS)
- **Gather initial conditions for possible use in future dispense and pattern simulation studies**

Wind Tunnel Tests

- Testing performed at LMMFC High Speed Wind Tunnel (HSWT) facility in Grand Prairie, TX on 18 December 2004
- “Backyard” Tests – High velocity flow ducted out of high pressure tanks to external test location
- Spinning air gun constructed to expel payload into high mass flow air stream
- Payloads represented two I-NAIL™ penetrator pack concepts
  - 5 packs present in M255-A1 Hydra-70
  - 3 packs present in APKWS

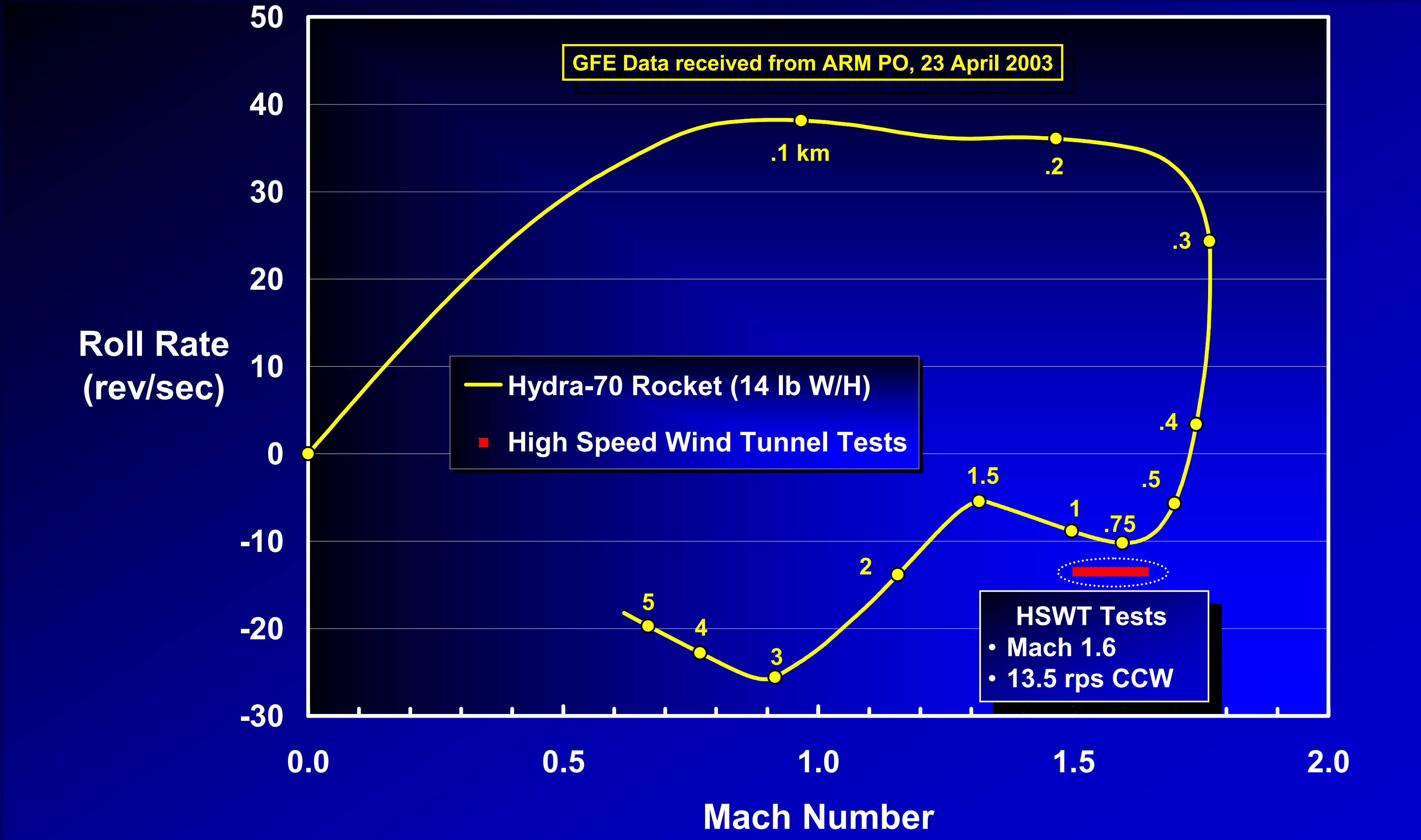
Wind Tunnel Test Setup

Missiles and Fire Control



I-NAIL™ Wind Tunnel Test Conditions

Missiles and Fire Control

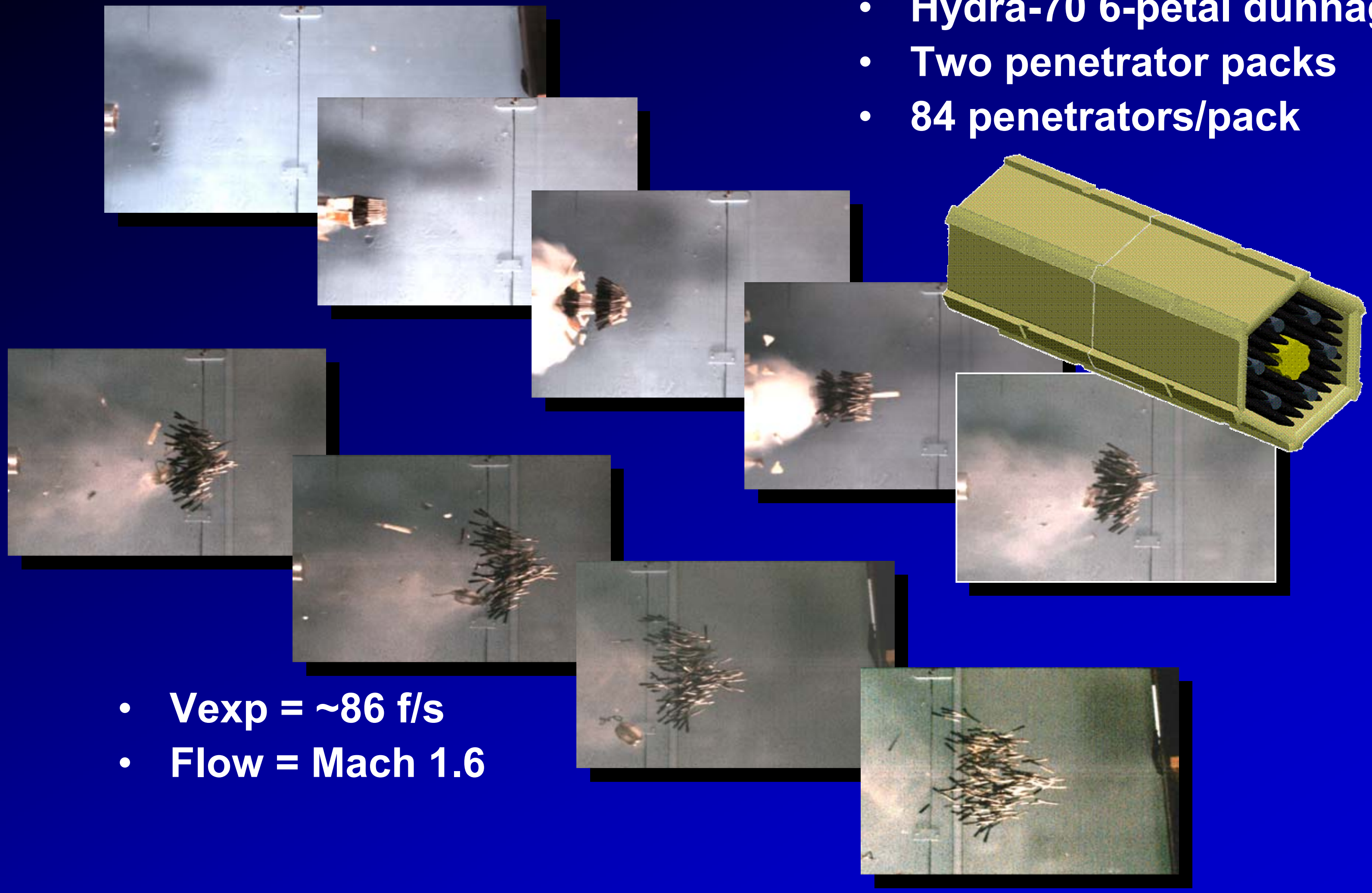


Conditions most representative of 750 – 1000 m Hydra-70 range.

I-NAIL™ Wind Tunnel Test 1

Missiles and Fire Control

- Hydra-70 6-petal dunnage
- Two penetrator packs
- 84 penetrators/pack

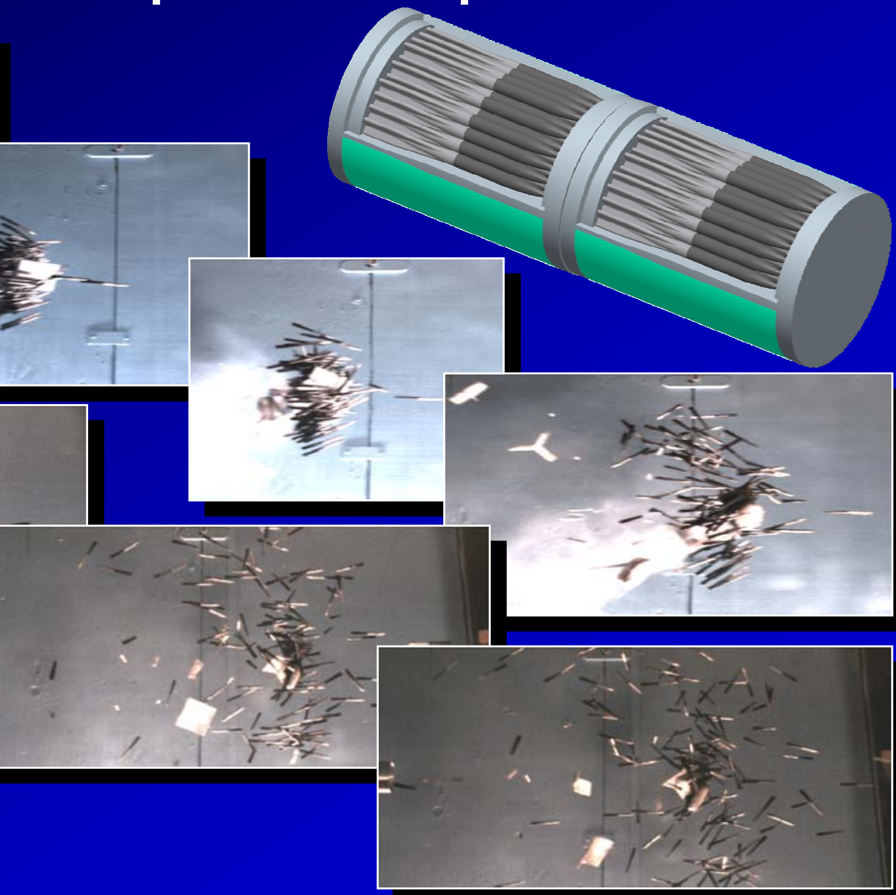


- Vexp = ~86 f/s
- Flow = Mach 1.6

I-NAIL™ Wind Tunnel Test 2

Missiles and Fire Control

- APKWS 3-compartment dunnage
- Two penetrator packs
- 99 penetrators/pack



V_{exp} = ~86 f/s

Flow = Mach 1.6

I-NAIL™ Dunnage Comparison

6-Petal Dunnage Concept

- Good release achieved
- Petals broke in a desired fashion and moved away quickly

3-Compartment Dunnage Concept

- Center structure interferes with radial dispense of penetrators
- Compartment covers and solid forward plate are pushed into penetrator cloud

Both Concepts

- Collisions occurred between two penetrator packs
- Second pack catches up to first mainly due to still being pushed by plenum gas; drafting effects may contribute
- Good penetrator dispersion and aerodynamics

Wind Tunnel Test Conclusions

Missiles and Fire Control

Dunnage

- 6-Petal dunnage design preferred
  - Demonstrated better overall performance
  - Compatible with Hydra-70 and APKWS platforms
  - Utilizes existing M255-A1 components
  - Inexpensive solution for APKWS

Penetrators

- Design has been modified to strengthen weak point in tail attachment section to minimize breakage

Viable dunnage concept has been tested and is ready for integration and flight testing.

I-NAIL™ Summary

- Mini-penetrator design developed
- Design provides significant behind-armor effects
- Highly lethal with no unexploded ordnance left on the battlefield
- System integration approach and implementation demonstrated
- Compatible with a variety of delivery systems

Next Generation Adaptable RF Seekers for Precision Munitions

40th Annual Guns-Ammunition-Rockets-Missiles Conference

Missiles & Rockets Session

April 27, 2005

Dr. Cory Myers
BAE Systems IEWS
cory.s.myers@baesystems.com

Mission Need

- **Provide small unit of operations with organic Precision Strike capability against High Value Targets**
- **Accelerate Enemy Defeat**
- **Reduce Collateral Damage**
- **Improve Deployability & Logistics**
- **RF Guided Munition (RFGM)**
  - **Provide a low cost precision means for ground forces to engage C3 targets, enemy FOs, and some radars**
  - **Completes the sensor-to-shooter chain for IO targets operating from 30MHz to 3GHz**

Current Mortar Munitions generally do not achieve first shot direct hit on target. RFGM guidance system capable of correcting trajectory improves first-shot hit on the target to 50%.

System Concept

BAE SYSTEMS

- **Exploit dismounted, close-in attack scenario with small aperture, RF seeking weapon**
  - If the dismount (SOF) can be cued to the presence of the emitter then the dismount can attack the (soft target) emitter with an organic weapon (e.g. 81 mm mortar)
- **Create a passive, all-weather, and inexpensive precision RF seeker capability for multiple weapon types**
  - Enable a suite of precision and area suppression weapons (ground-to-ground, ground-to-air, and air-to-ground) that home on RF energy all using similar RF seeker and guidance technology
- **Deny enemy use of RF spectrum for military purposes**
  - Counter enemy radar/IR/acoustic signals Camouflage, Concealment and Deception (CCD) efforts

DARPA Hard Technical Challenge: Quick and Precise Geo-location of RF Emitters from a Single, High-Velocity, Small Weapon

Technical Challenges

BAE SYSTEMS

System Requirements:

- *Quick:* Geo-location estimate must be fast enough (5 sec) to guide a mortar which has only 25-30 seconds of flight time
- *Precise:* Geo-location with an objective radius of an 81 mm mortar (20 m)
- *RF Emitters:* Target frequencies from 30 MHz to 3 GHz and multiple waveforms
- *Single:* Emissions received by only a single platform (passive technique)
- *High-Velocity:* Velocity of a mortar varies from 300 m/sec to 100 m/sec
- *Small:* e.g. 81 mm mortar form factor restricts antenna size and distance

Technology Enablers:

- Organic detection (cueing) capability
- Small, lightweight, wideband, and inexpensive RF receivers
- Inexpensive memory and processors
- Proliferation of guided weapons (IR, laser, GPS, etc.)

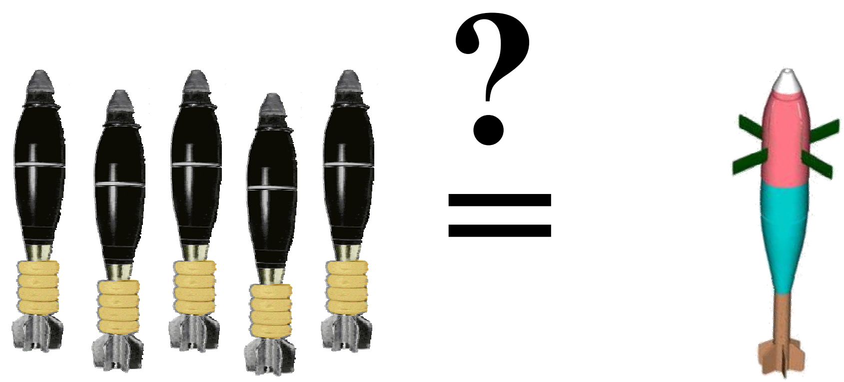
DARPA RFGM Program

BAE SYSTEMS

- Replacement fuze/guidance package that effectively converts current, ballistic 81 mm mortar munitions into precision RF guided munitions
- Screw-on mod-kit
- Affordable, Easy to use
- Frequency range 30MHz to 3GHz
- Accuracy not dependent on visual observation
- Fire and Forget
- Passive, all-weather
- Technology that is scalable to other munitions

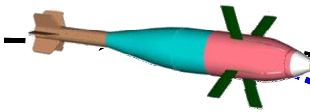
DARPA

Advanced Technology Office



System Operation

BAE SYSTEMS



Launch Cue → **Geo-locate** → **Maneuver toward target** → **Detonation**

Initial detection, discrimination, and Geo-location to <1.5km radius circle

<20m accuracy (CEP) with << 0.3λ aperture

Maneuver capability and stable control

3m Airburst using GOTS proximity fuze

System Integration

- Miniaturize to a 81mm mortar round
- Cost effective
- Match maneuver, target, and munitions capability

Existing technology | Extension of existing technology | Seedling analysis indicates feasible

Design/Trade Space

BAE SYSTEMS

- Cueing:
  - The weapon receives cueing information from an external system such as Wolfpack, ACS, etc.
    - Utilize SIGINT standard emitter descriptors (carrier frequency, bandwidth, modulation, etc.) to future proof weapon versus template matching emitter waveforms
- Geo-location
  - Despite high SNR condition, classic DF techniques alone will not work well enough due to the limited aperture size/spacing and the (low) frequency range of interest
- Maneuver toward target
  - Guidance/control techniques are well known (e.g. ERGM, PGMM, etc.)
- Detonation
  - Utilize existing GOTS fuze technology to avoid re-qualification costs
- System Integration
  - Optimizing the relationship between geo-location accuracy and aerodynamic control authority while minimizing weight, volume, and cost and impact on weapon range and effects
    - Integrating the RF Guided Munition kit with the fuze is preferred
    - Volume/length will need to be added to the weapon (mortar) for antennas, RF electronics, signal processing, and control surfaces in a manner that minimizes range loss
    - Using GPS is possible but an IMU may be sufficiently capable while being cheaper than SASSM modules – both add a precise targeting capability

RF Guided Munitions Program

BAE SYSTEMS

FY05 | **FY06** | **FY07**

Phase 1:

Task 1

Core Geo-location Technologies

Design

- *Antenna*
- *RF Hardware*
- *Geo-location Signal Processing Software*

Demo

- *Captive Carry*

Task 2

Phase 2 Risk Reduction

- *Emitter Discrimination*
- *Miniaturization*
- *Maneuverability*

Phase 2:

Refine Technologies Harden Components

- *Discriminate Target*
- *81 mm Form Factor*
- *GNC*

Demo

- *Soft Launch*

Phase 3:

Refine & Harden All Components for Operational Launch

- *Antennas*
- *Electronics*
- *Control Surfaces*
- *Objective weapon (e.g. 81mm mortar) Form Factor*

Demo

- *Operational Launch*

Alternate weapon platforms to the 81mm mortar will also be considered for funding if a transition sponsor has been identified

Phase 1 Go/No-Go

50% geo-location estimates w/in 20m of actual emitter

Phase 2 Go/No-Go

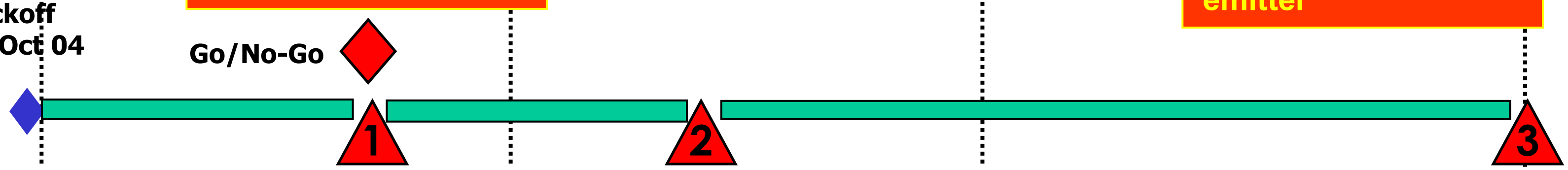
50% rounds impact w/in 20m of target emitter

Phase 3 Go/No-Go

50% Rounds impact w/in 20m of target emitter

Contract Award/ Kickoff Sep/Oct 04

Go/No-Go

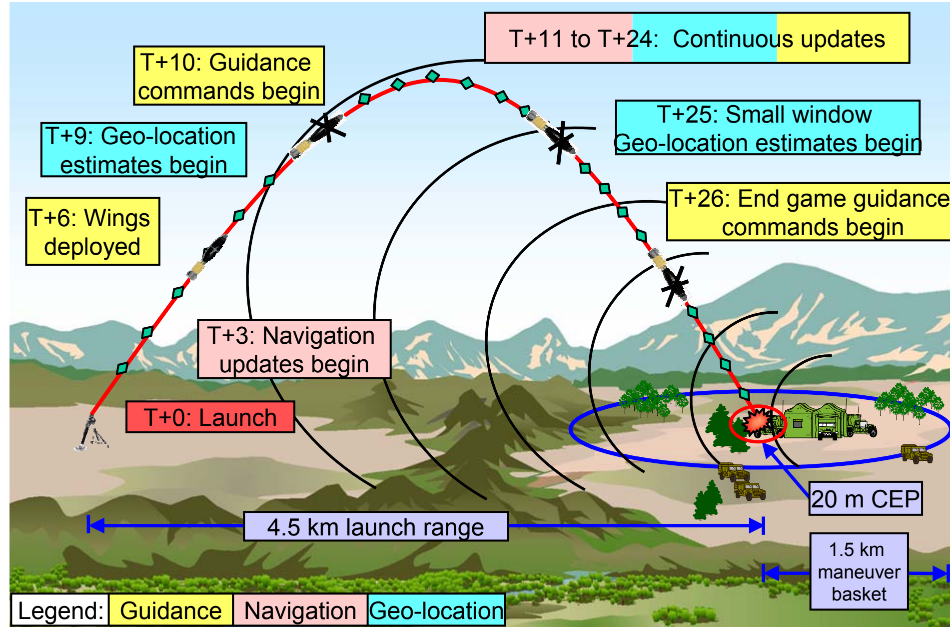


Final Demo and Transition

Geo-location Challenge

BAE SYSTEMS

- **Geo-location Error Sources:**
  - Thermal noise
  - Quantization noise
  - Phase noise
  - Receiver spurs, intermods and harmonics
  - Man-made noise and atmospheric noise at HF
  - Navigation errors from position and roll sensors
  - Channel mismatch errors
  - Calibration errors
  - Multi-path signal corruption
  - Co-channel signal interference
  - Platform motion induced modulation

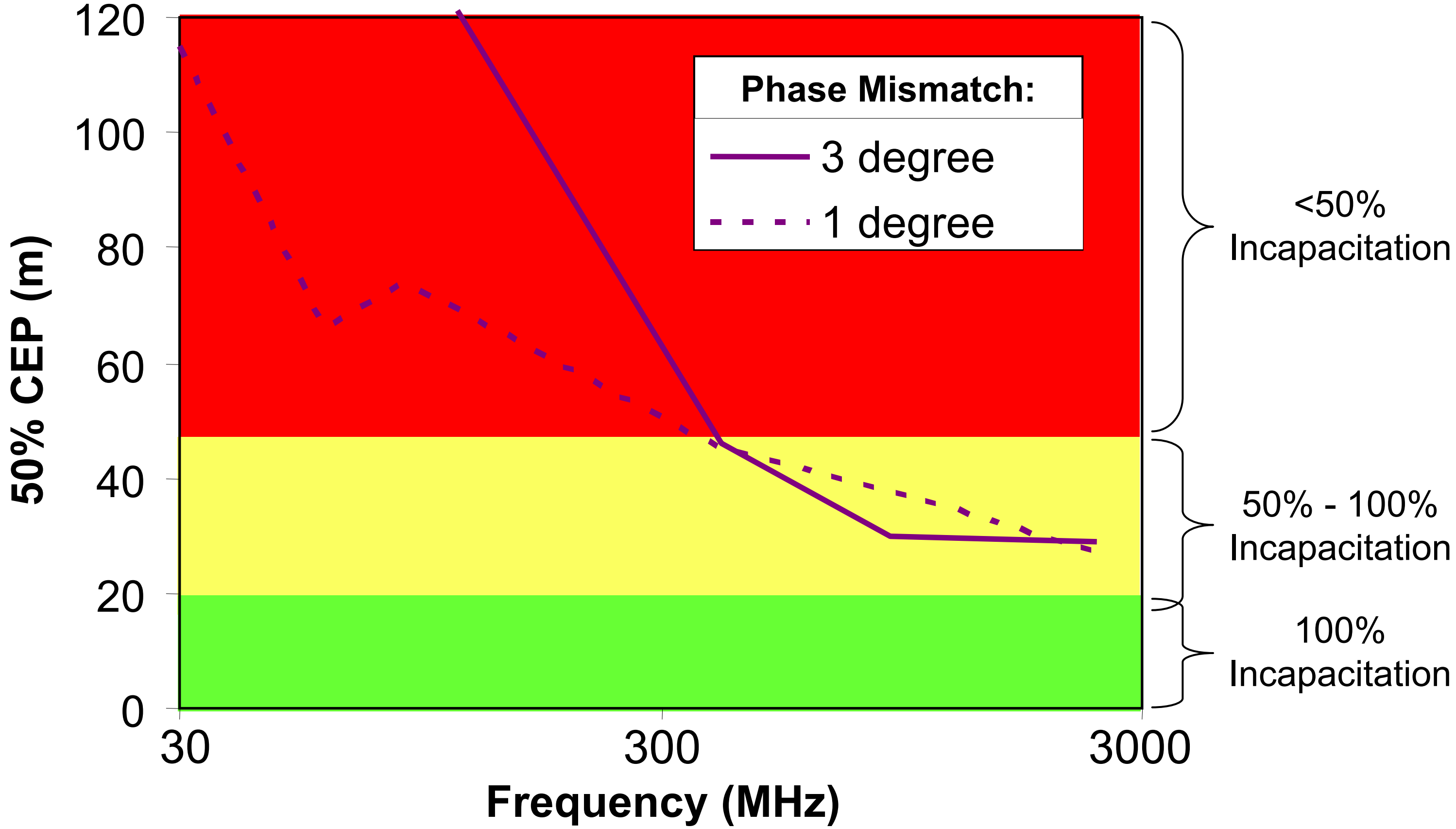


- **Geo-location Requirements:**
  - Provide guidance commands well before apogee to support maneuver basket.
  - Deal with multi-emitter environment. Guide to one emitter, not the centroid of emitters.
  - Provide resiliency to multi-path and polarization.

Geo-location Challenge

BAE SYSTEMS

Angular precision of classic DF techniques is limited by λ/D, SNR, and channel mismatch which is unacceptable for low frequency emitters



Lower Frequency

- **Dominated by channel mismatch which causes a biasing error**

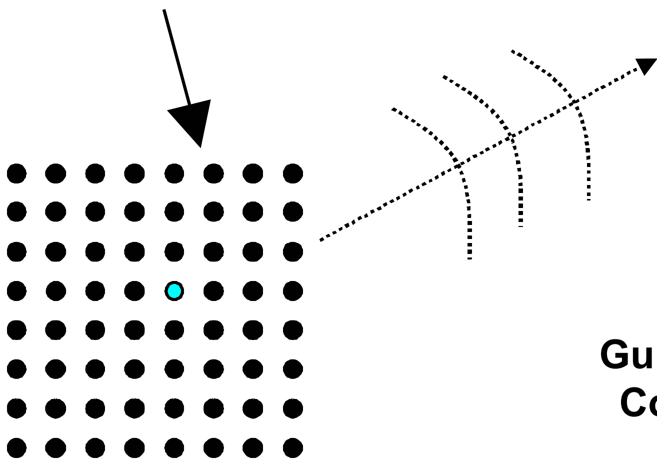
Higher Frequency

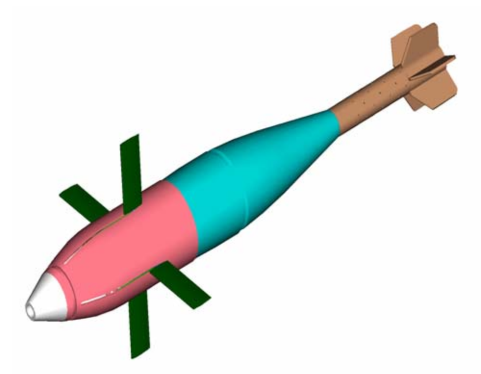
- **Dominated by imprecision in guidance (GPS/IMU error)**

Geo-location Processing

BAE SYSTEMS

Grid of hypothesized target positions on the ground

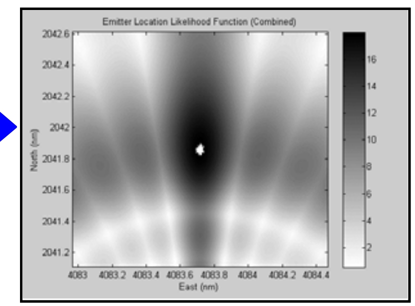




- Collected IQ data and navigation data
- Cued emitter frequency data
- Pre-flight calibration data

Signal Separation and Geo-location

Guidance Control



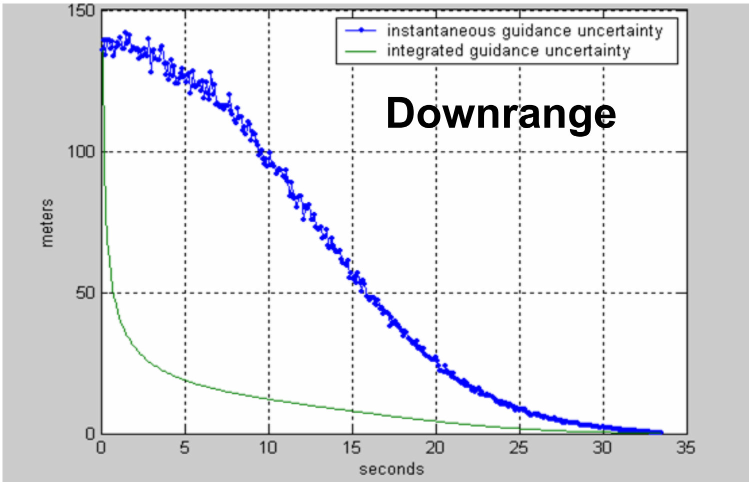
Likelihood function

Geo-location method uses temporal, phase and amplitude information from all the antenna elements, separates signals of interest and then determines emitter geo-location metric by computing the probability likelihood surface of the potential emitter location as a function of its hypothesized location.

BAE SYSTEMS

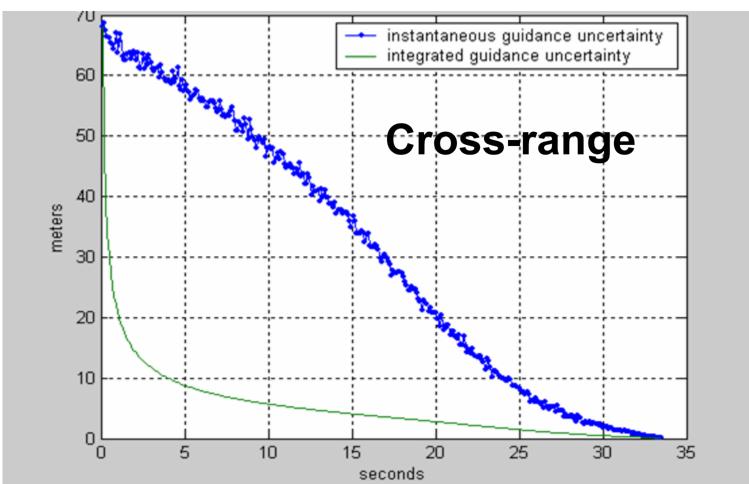
Geo-location and Guidance Performance

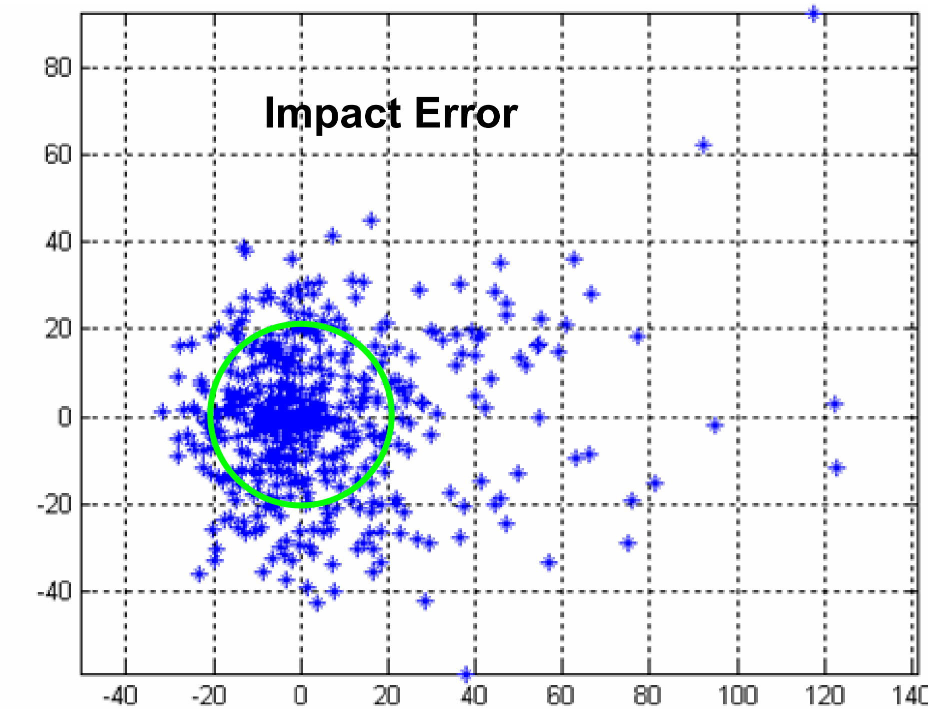
Error



Flight Time

Error





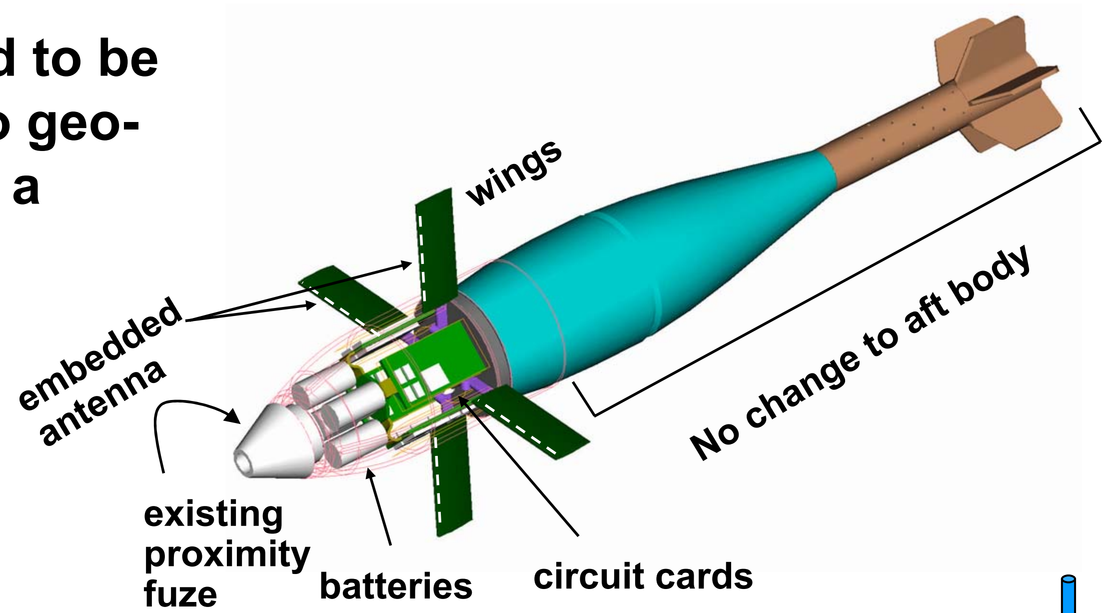
Model of combined geo-location and guidance shows better performance than the specified 20m CEP goal with a maneuver basket of 1.5km in radius.

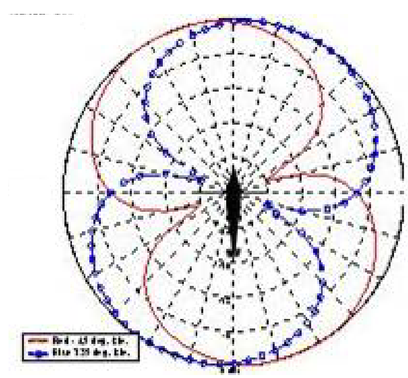
System Integration

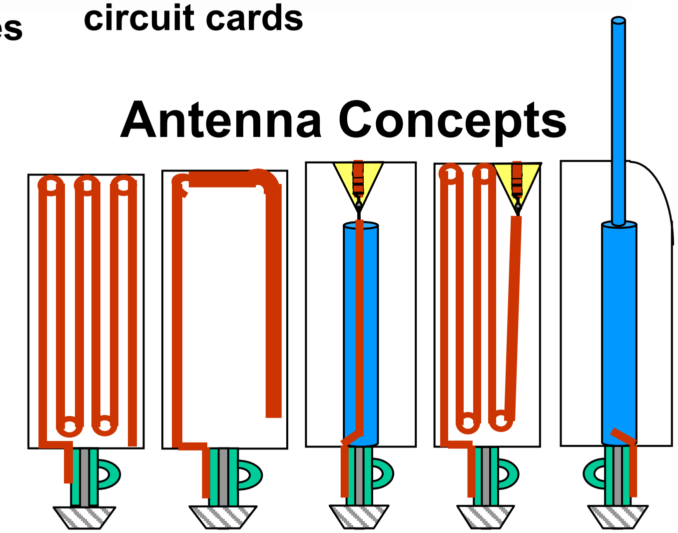
BAE SYSTEMS

Multiple subsystems need to be integrated, in addition to geo-location, to make RFGM a reality:

- Antennas
- Receivers
- Actuators
- Wings
- Navigation
- Guidance
- Control
- Signal Processing
- Power
- Cueing
- Fuze







Questions?

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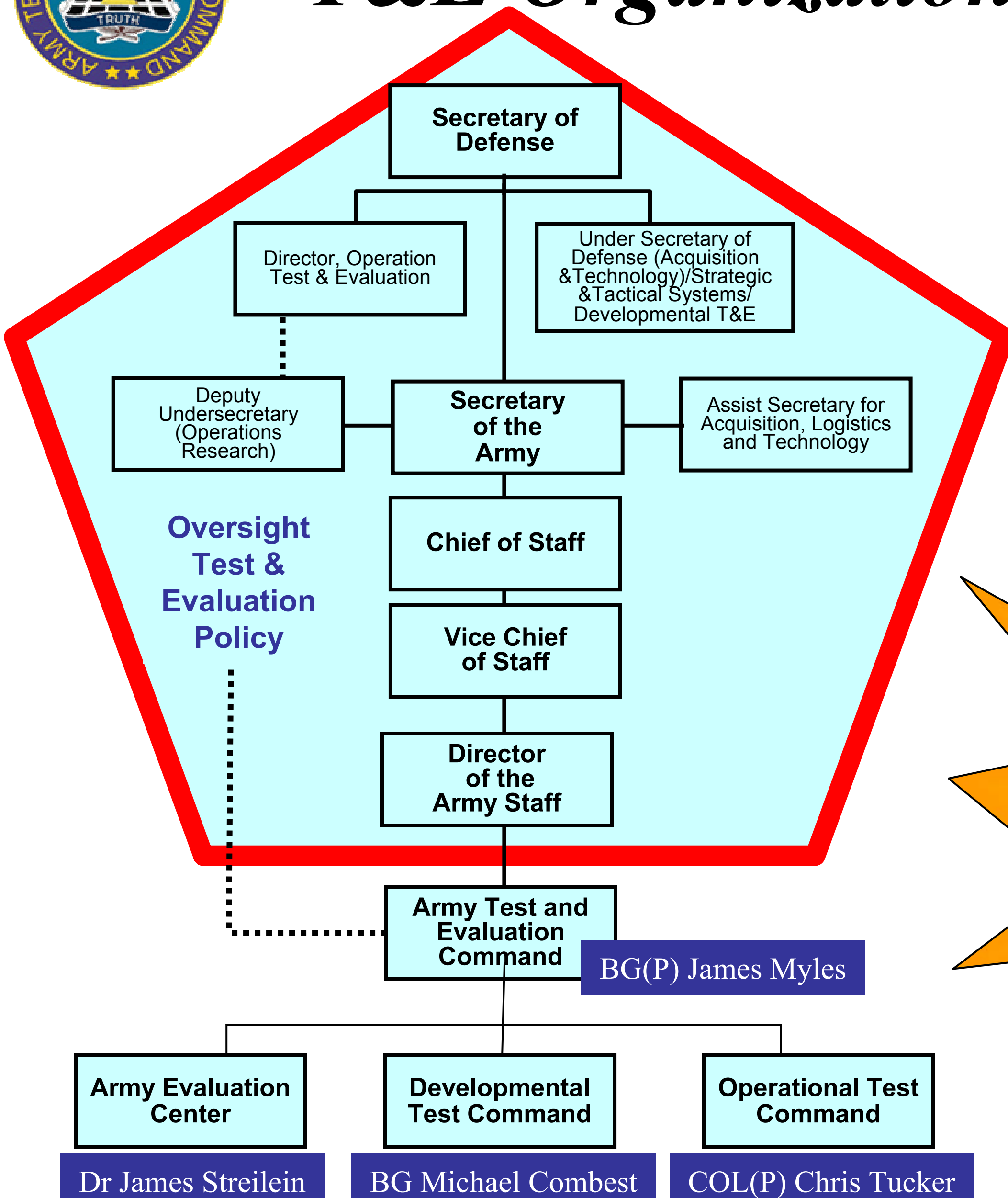
ATEC UPDATE TO NDIA

27 April 2005

Presented by:
BG(P) James R. Myles

T&E Organizational Structure

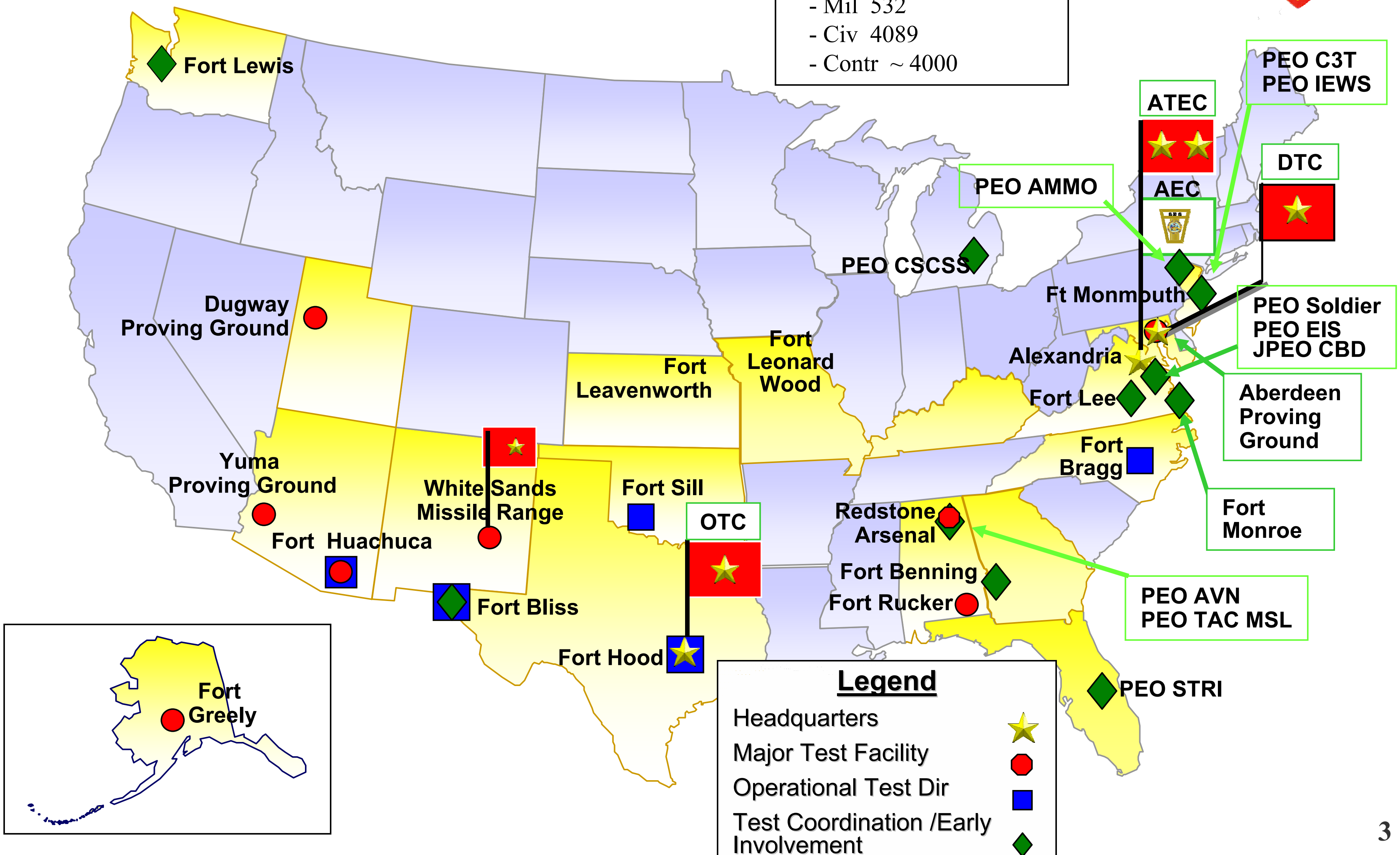


__Mission:__ ATEC plans, conducts and integrates developmental testing, independent operational testing, independent evaluations, assessments and experiments *in order to provide essential information to decision makers*

Required by OMB & OSD to be Independent

Where We Are

Total Strength ~ 8621
- Mil 532
- Civ 4089
- Contr ~ 4000



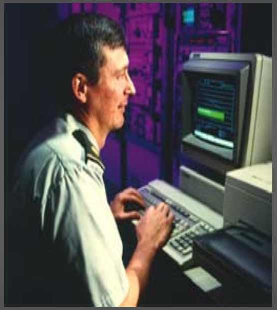
The Army's T&E is Unique

ATEC

DTC

Developmental Testing
engineering type tests conducted under controlled conditions

AEC



Evaluation
independent assessment of all testing and simulation

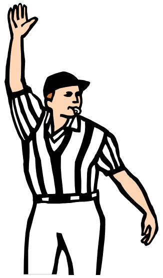
OTC

Operational Testing
testing conducted using real soldiers in simulated combat

ATEC integrates developmental and operational testing

ATEC T&E Philosophy

- Testing is part of acquisition process
- Two Fundamental Missions
  - Make system better (test-fix-test)
  - Provide Info to Decision Makers →



- Does it Work…How do I know?
- Evaluation in Depth:

  Platform → System of Systems → Unit Mission

- No Pass/Fail → Capabilities and Limitations

Good Enough ≠ Anything will do

Where are we headed



- **OTs with fewer troops—tougher and shorter**
- **Rapid Acquisition: Spiral Development, DT/OTs,…**
- **System of systems T&E**
- **Support to War is the norm**
- **OTs During Major Training Events (NTC, JRTC,…)**



GWOT -- What is ATEC Doing About It

- War Support
  - Early Involvement with PMs & REF
  - Focus on performance in the AOR
  - Soldiers in DT / Limited User Testing
  - Respond to Warfighter!
    - -- Up-Armor Vehicles, Slat Armor, Stryker, ECMD, Robotics,..
  - Deploy ATEC Assessment Team in Theater
- Safety Confirmations
- Capabilities and Limitations Report
  - For the Commander
  - What do we know (Cap and Limits)
  - What don't we know
  - Safety, C/L, Training, Supportability and Accountability

Back-up Slides

Additional Thoughts

- NOT YOUR DAD'S ATEC
  - LIKE THE ARMY, ATEC STANCE AND BALANCE HAS CHANGED
  - FOCUS IS GWOT AND SOLDIERS IN HARMS WAY TODAY
  - TIMELINES HAVE SHRUNK TO SUPPORT RAPID ACQUISITION…STANDARDS HAVE NOT!
  - DATA VOIDS ARE FILLED WITH OUR EXPERIENCE AND BEST MILITARY JUDGEMENT
- WE TEST-FIX-TEST AND PROVIDE INFO TO OUR SENIOR LEADERS TO MAKE DECISIONS
- WE ARE NOT SEPARATE FROM THE ACQUISITION COMMUNITY
- GET US INVOLVED EARLY
- WE DO DT/OT
  - UNDERSTAND THE SUBTLETIES…WILL LOOK AT SOMETHING BEFORE IT IS READY…WE KNOW THE DIFFERENCE.
  - BECAUSE WE SEE THAT IT WORKS IN DT DOESN'T MEAN IT WORKS WITH SOLDI
- LOGISITICS, TRAINING, ACCOUNTABILITY OF THE SYSTEMS ARE SHOWSTOPPERS FOR OUR SOLDIERS.
  - LACK OF TRAINING AND LOGISTICS PROVIDES BAD REPUTATION FOR THE SYSTEM…HARD TO REMOVE THE STIGMA
- NDAA 03
- PUT THE SOLDIER FIRST AND YOU ARE NEVER WRONG
- MOMS AND DADS OF AMERICA HAVE EXPECTATIONS
  - THAT THEIR SON AND DAUGHTER RETURN HOME TO THEIR FAMILY
  - THAT THEIR SOLDIER HAS THE BEST EQUIPMENT ON THE FACE OF THIS EARTH
  - AND, THAT WHEN NEEDED, IT WILL WORK…THAT IT WILL WORK

United Defense

Modeling Efforts for Autorotation Delivery System Concept Development

Presented
at the
40th Annual Guns & Ammunition/
Missiles & Rockets
Symposium & Exhibition

April 25-28, 2005 New Orleans, LA

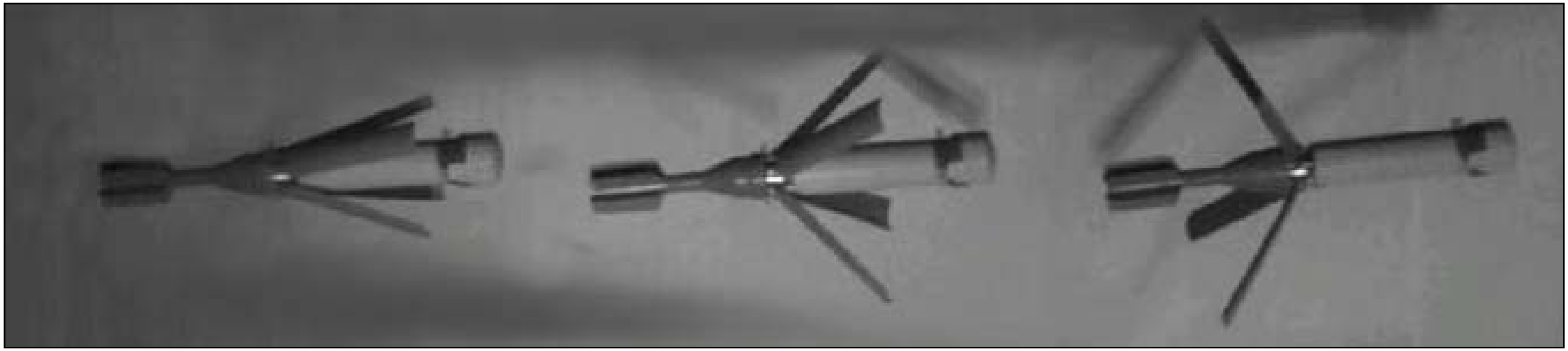
David C. Rutledge, Ph.D., Staff Engineer, United Defense, L.P.
Mark Costello, Ph.D., Oregon State University

***Autorotation Delivery Systems is patent pending**

Presentation

United Defense

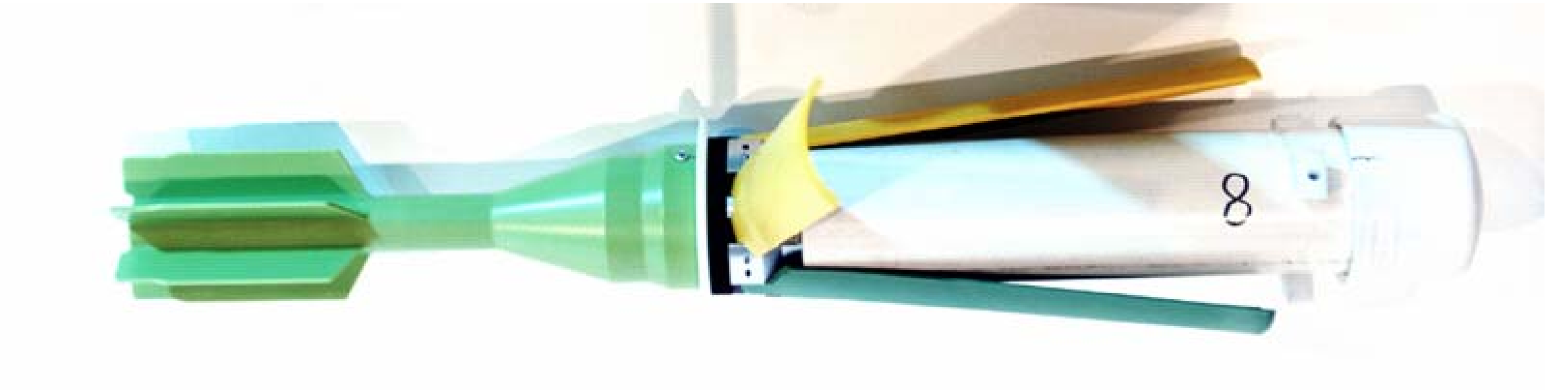
- Overview
- Deployment Sequence
- Applications
- Modeling Performed
- Axisymmetric Model
- BOOM Model
- Summary and Video



Overview

United Defense

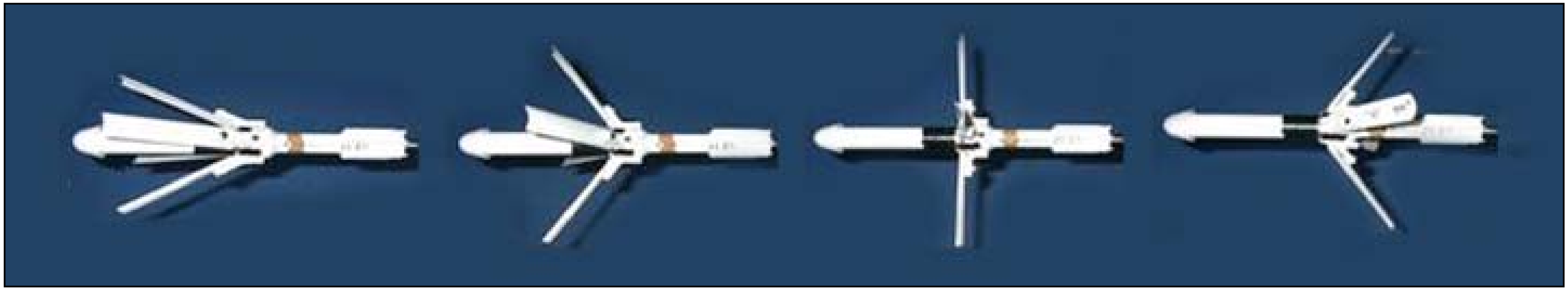
- The Autorotation Delivery System, formerly known as Projectile Kinetic Energy Reduction System (PKERS), is a concept developed by United Defense as an autorotation decelerator for high-value tactical payloads
- Combines a projectile body with a deployable rotor that reduces descent velocity via autorotation
- Modeling and simulation will facilitate the optimal design process during each stage of development



Deployment Sequence

United Defense

- Rotors stowed conformal to the sides of projectile body prior to deployment
- During deployment, rotors rapidly rotate outward due to projectile spin and aerodynamic drag
- Transition to autorotation occurs as the rotor blades become aerodynamically loaded coupled with an increasing spin rate
- System attains a steady descent velocity when the inertial and aerodynamic forces reach equilibrium



Applications

United Defense

- United Defense is developing the Autorotation Delivery System as an alternative to conventional parachutes for certain applications
- Flight characteristics and descent velocities are tailorable for different missions and payloads *(e.g., land and sea sensors, cargo, battle damage assessment, munitions)*
- Can be gun launched, mortar launched, or air dropped
- Modular design allows accommodation of all the necessary components required for precision guidance

First Generation Autorotation Delivery System integrated with Talley SMAW-D Motor

Modeling Performed

United Defense

- An axisymmetric spreadsheet-based model was developed to estimate the dynamics and loads as the rotors initially open and impact the damper
- A detailed flight mechanics model was developed and integrated into the BOOM smart weapon simulation system to model the flight dynamics from initial rotor deployment to full autorotation

Axisymmetric Model:
Initial Deployment

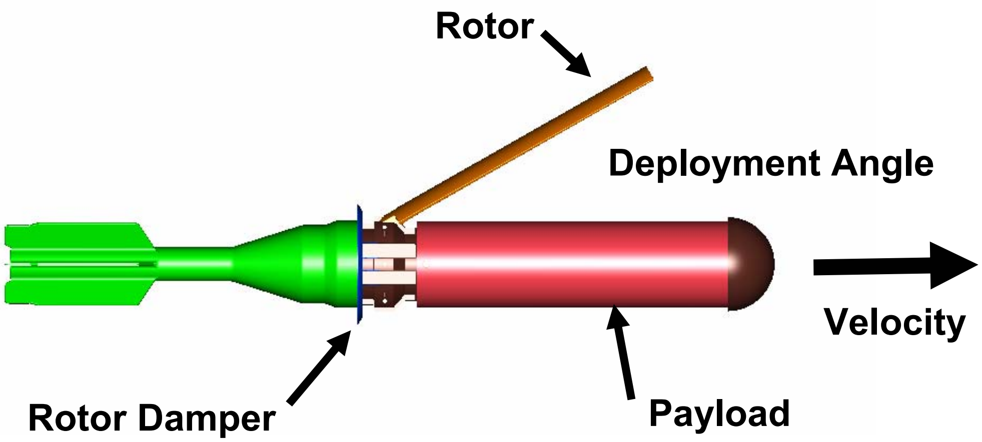
United Defense

- The Axisymmetric Model is a quasistatic spreadsheet-based concept development tool
  - Allows estimates of system performance and parametric studies
  - Assumes symmetry about the longitudinal spin axis, zero spin rate, and conservation of rotor angular momentum
  - Provides 2 Degrees of Freedom (DOF) for the projectile body (forward velocity and spin) and 1 DOF for each rotor blade (deployment angle)

Aerodynamic Load Calculation

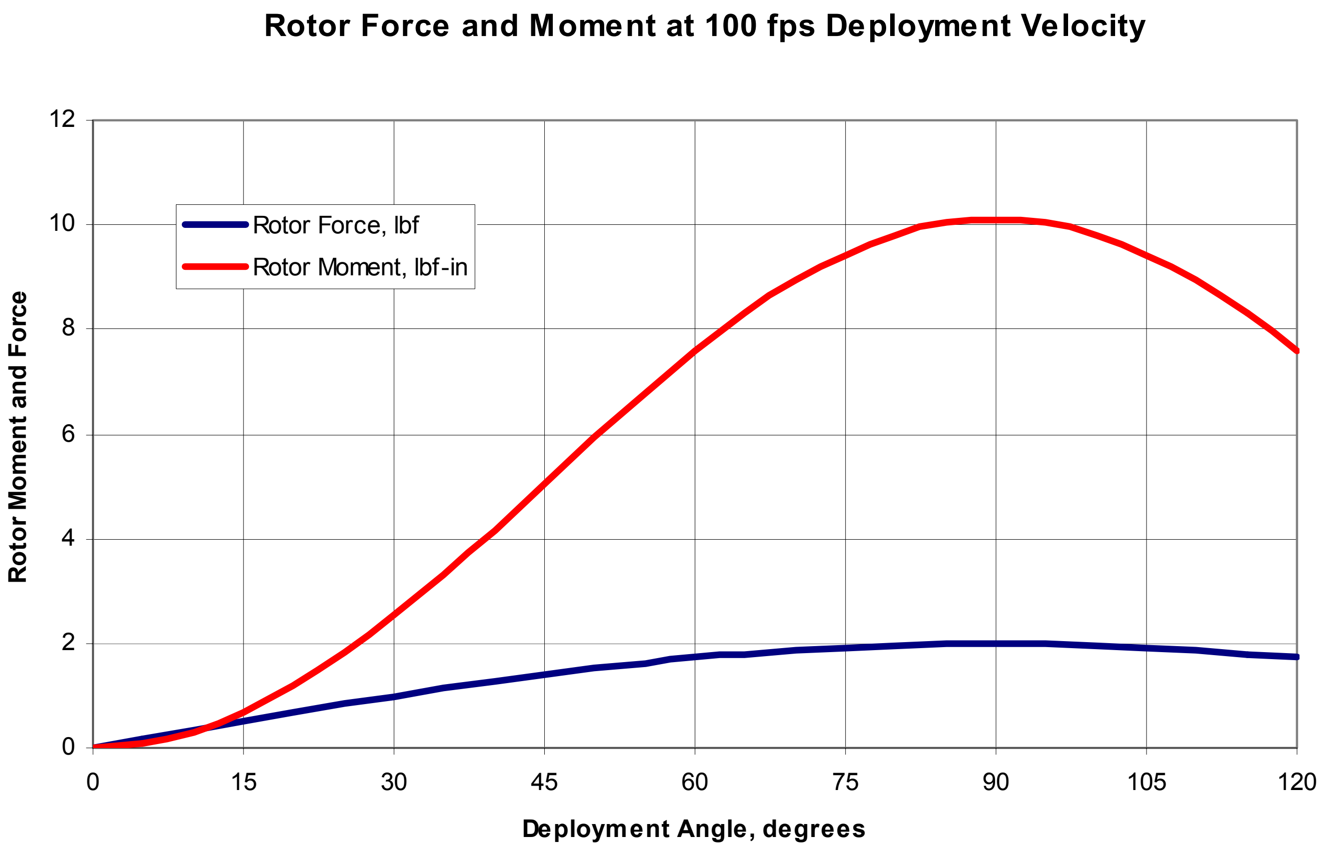
United Defense

- Axisymmetric model assumptions:
  - Centrifugal loads due to flight element spin are a minor contributor during initial rotor opening (zero spin assumed)
  - Flight element velocity constant during initial deployment (worst case)
  - Aerodynamic drag is then a function of deployment angle
- Calculate upper limit on rotor force and moment about rotor hinge as a function of deployment angle



Aerodynamic Loads on Rotor

United Defense

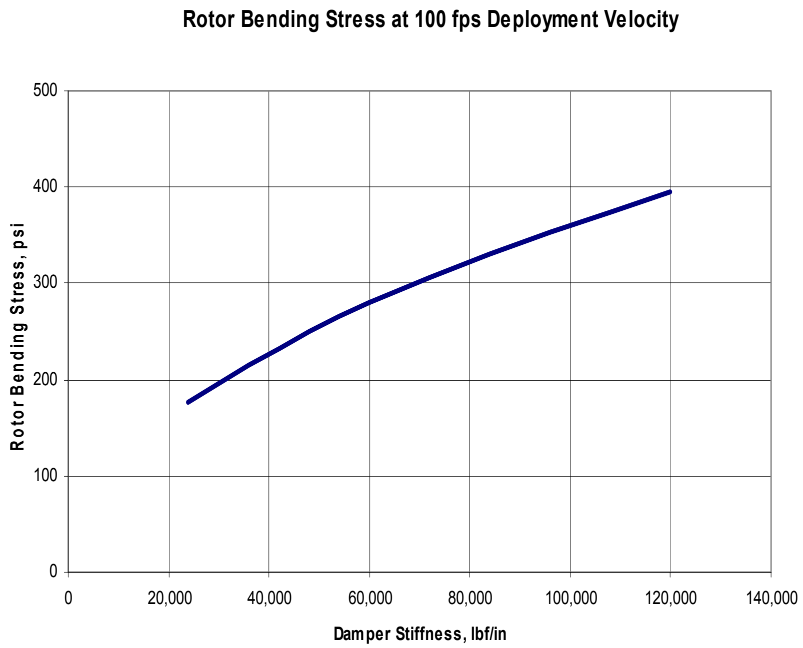


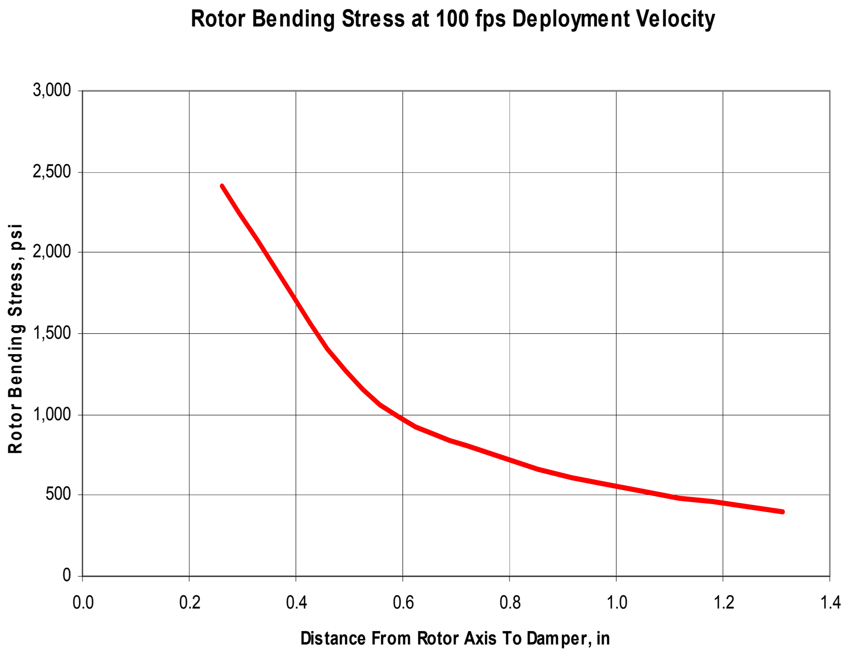
Calculation of Damper Force

United Defense

- Worst case rotor loads accelerate the rotor open until they impact the damper at approximately 120 degrees
- Opening moment is numerically integrated versus deployment angle to get the angular momentum at initial impact with damper
- Corresponding kinetic energy is absorbed by the damper
- Maximum damper force is calculated for multiple damper locations, shapes, and materials to optimize design

Rotor Bending Stress Results



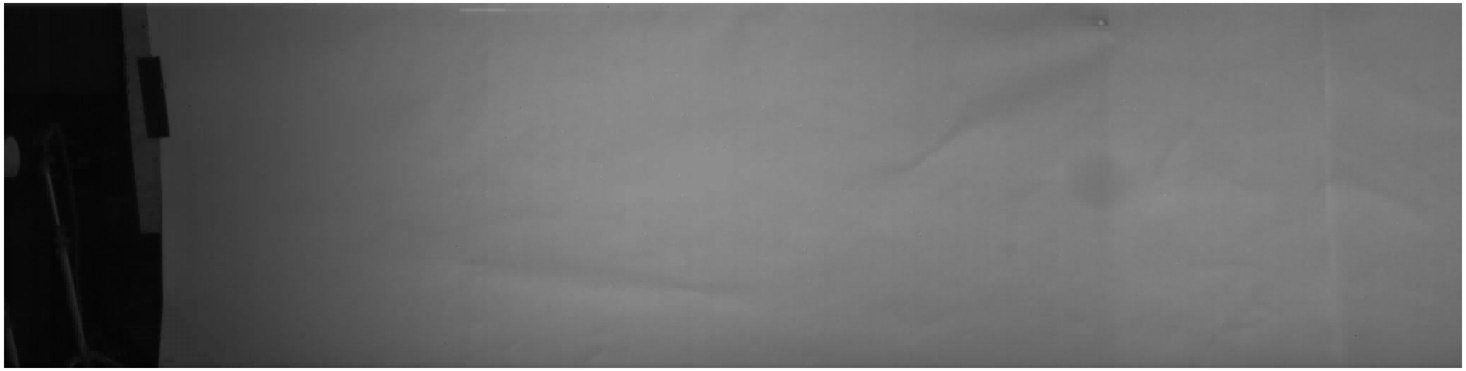


Worst case force is used to design rotors so they can safely survive the bending stress during initial deployment

Rotor Deployment Video

United Defense

Camera 2:
0 – 12'



Camera 3:
12 – 24'

Camera 4:
24 – 36'

BOOM Model:
Detailed Flight Dynamics

United Defense

- The BOOM model is a detailed design and development tool
  - BOOM is a smart weapon simulation system
  - Full model of the delivery system flight mechanics was developed and integrated into BOOM
  - Provides 6 rigid-body DOF for the projectile body (flight element center of gravity position and orientation angles), 1 DOF for each rotor blade (deployment angle), and a 3-state rotor dynamic inflow representation

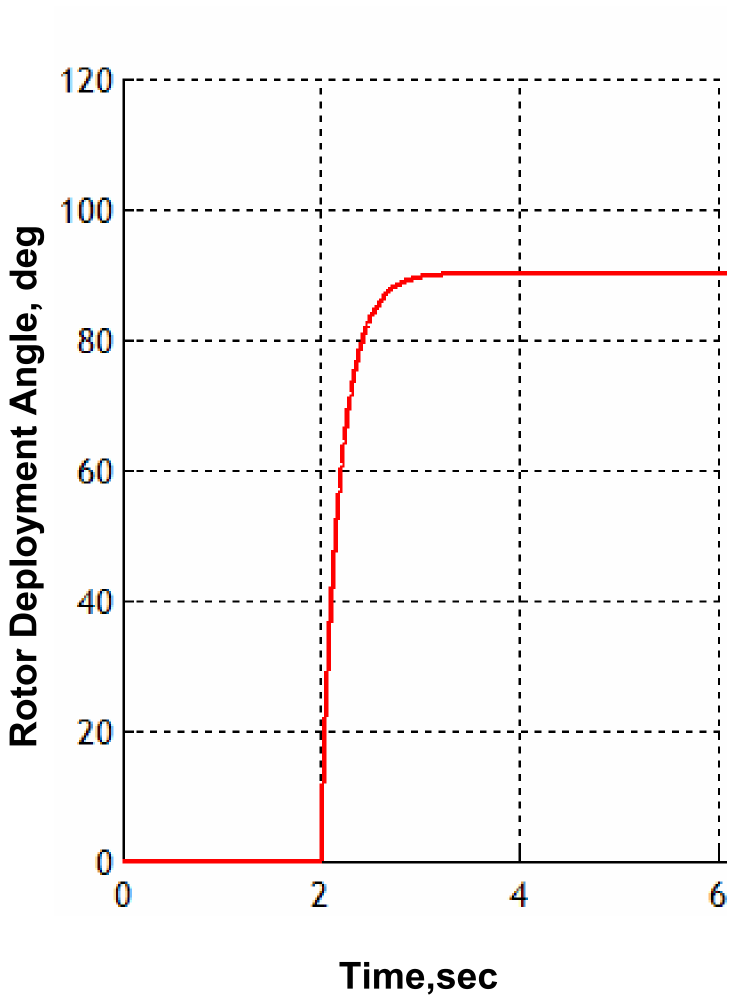
BOOM Model Description

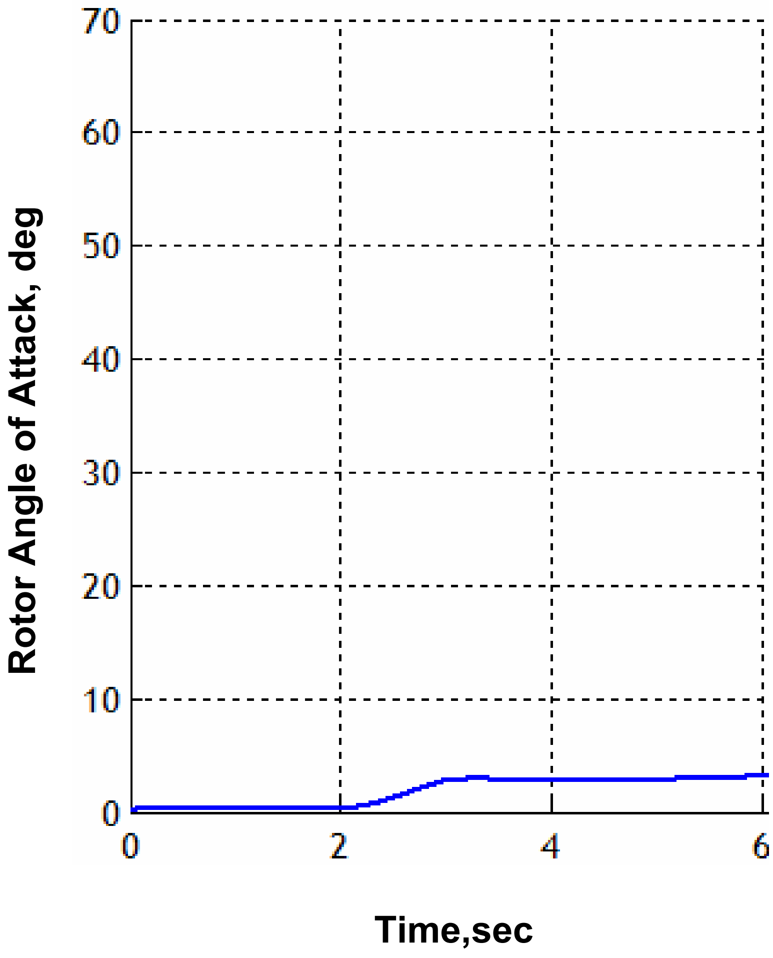
United Defense

- Aerodynamic loads on the projectile body are a function of angle of attack and Mach number
- Aerodynamic forces and moments on the rotors are computed using blade element theory; airfoil lift and drag coefficients are a function of local rotor section angle of attack and Mach number
- BOOM simulations then provide the dynamics of the system as a function of time
- The simulation presented here has the following initial conditions:
  - Linear velocity 43 m/s (141ft/s)
  - Spin (Roll) rate 20 rad/s (3.2 rev/s)
  - Deployment angle fixed at 90 degrees

BOOM Model Rotor Kinematics

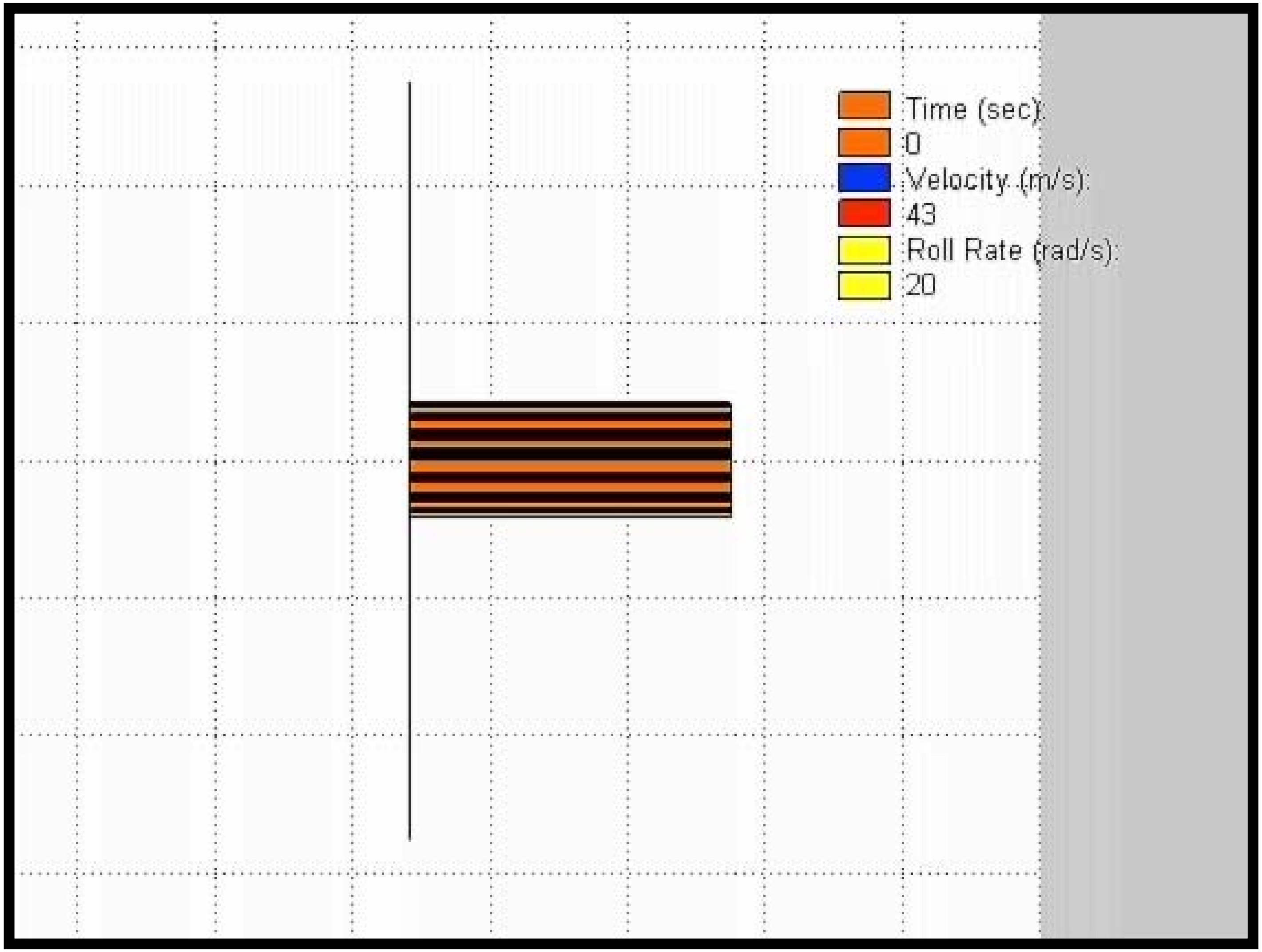
United Defense





BOOM Model Top View Animation

United Defense



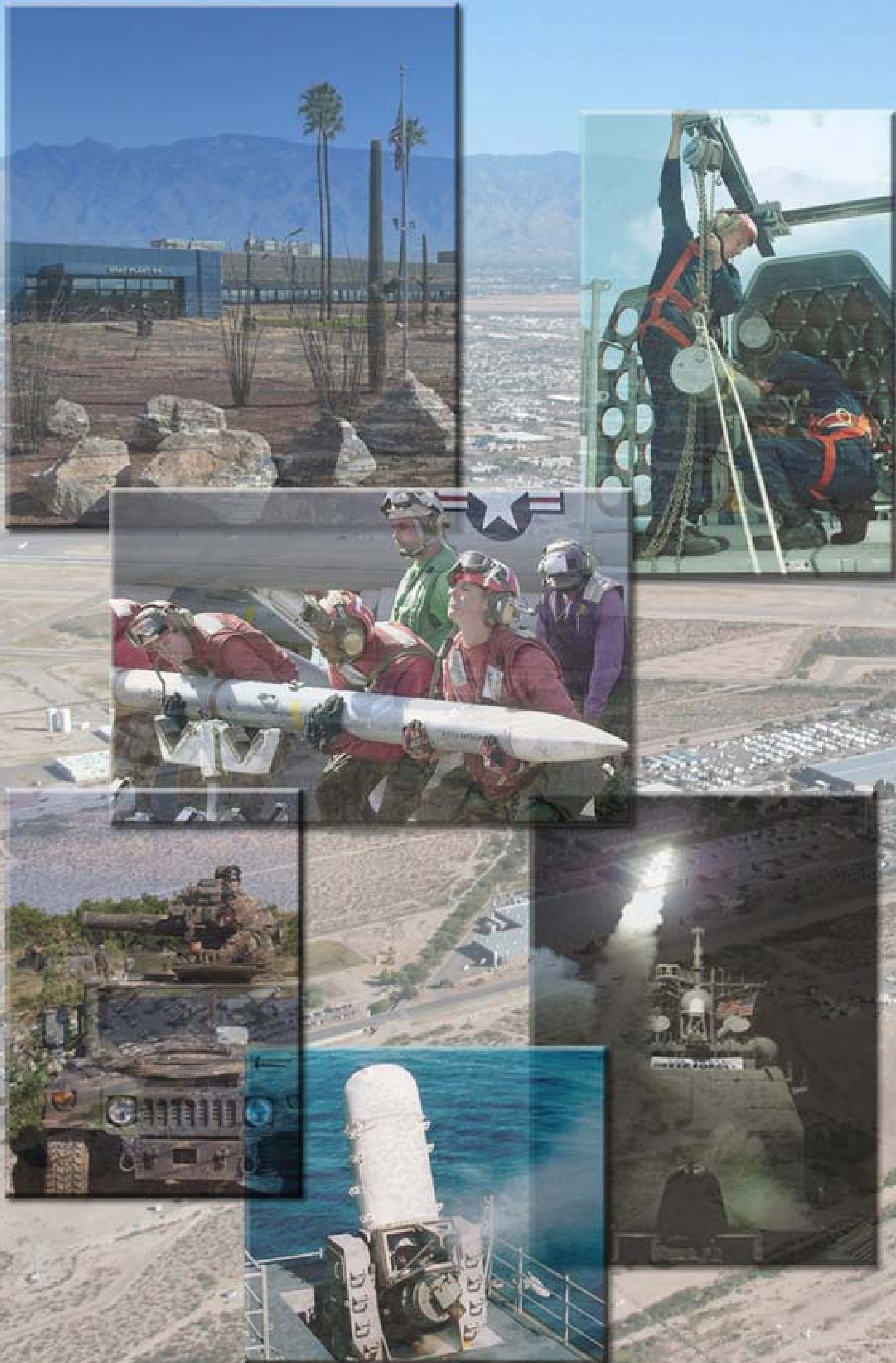
BOOM Model Results

United Defense

- BOOM model results indicate that the concept will deploy in a manner consistent with flight tests
- Model has not been validated yet. Validation with test data is planned for the future, making the model capable of supporting future design, flight control system development, and payload integration
- This simulation assumes that all rotors have the same deployment angle at any time; this causes a short numerical instability that's not present in the actual system
- Model to be modified to allow each rotor to have different deployment angles

Summary and Video

- Test configurations have proven to be robust enough to survive deployment stresses
- Additional development, testing, and demonstration is planned to validate the 6-DOF model and applications
- Exploring a variety of Payloads and Applications
  - Sensors, Cameras, Munitions
  - Reconnaissance, Surveillance, Repeaters



Raytheon

Customer Success Is Our Mission

Raytheon Missile Systems: A Global Perspective

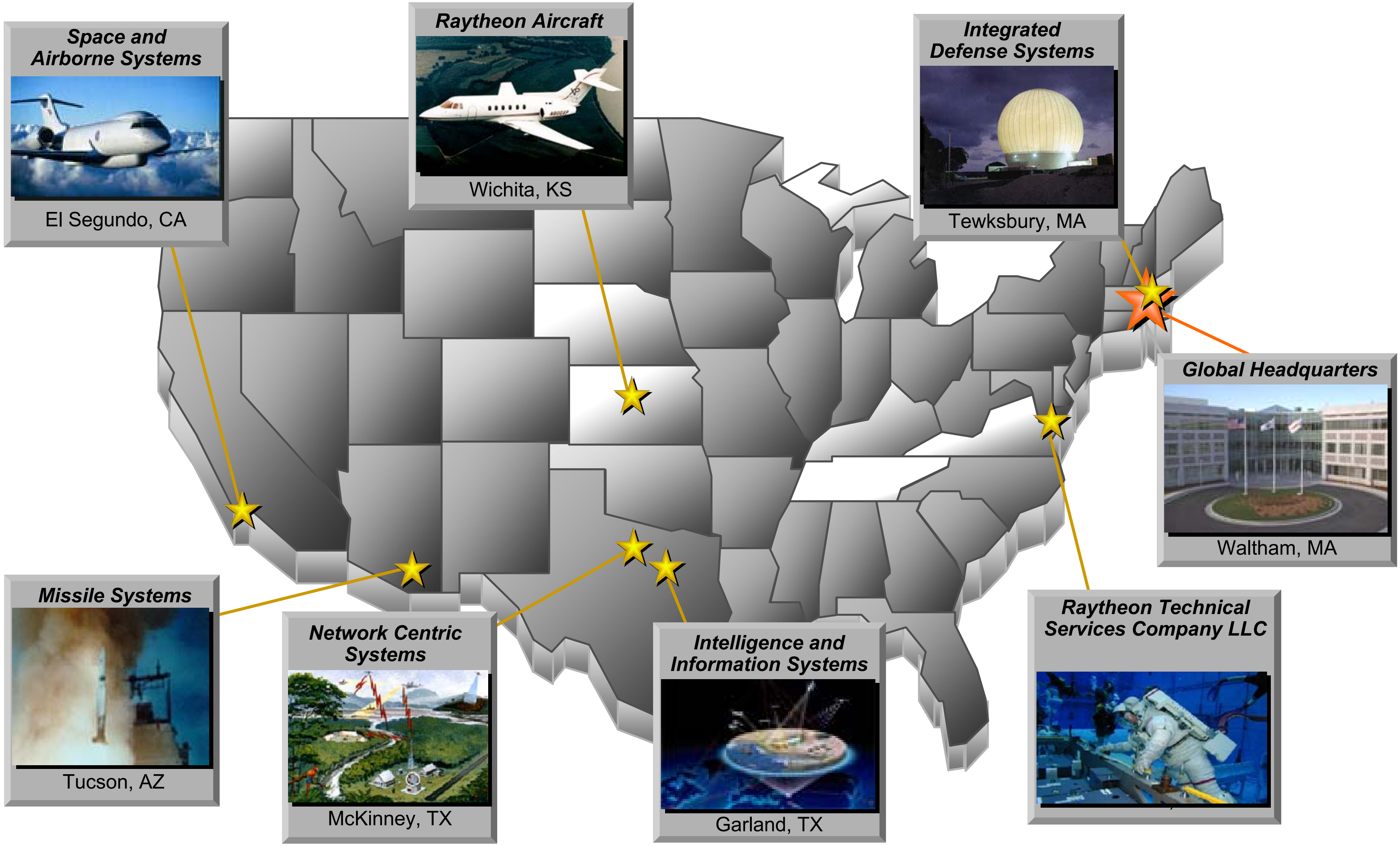
Robert D. Salyer
Director, Business Development
Raytheon Missile Systems

NDIA Symposium
April 27, 2005

50345A-1

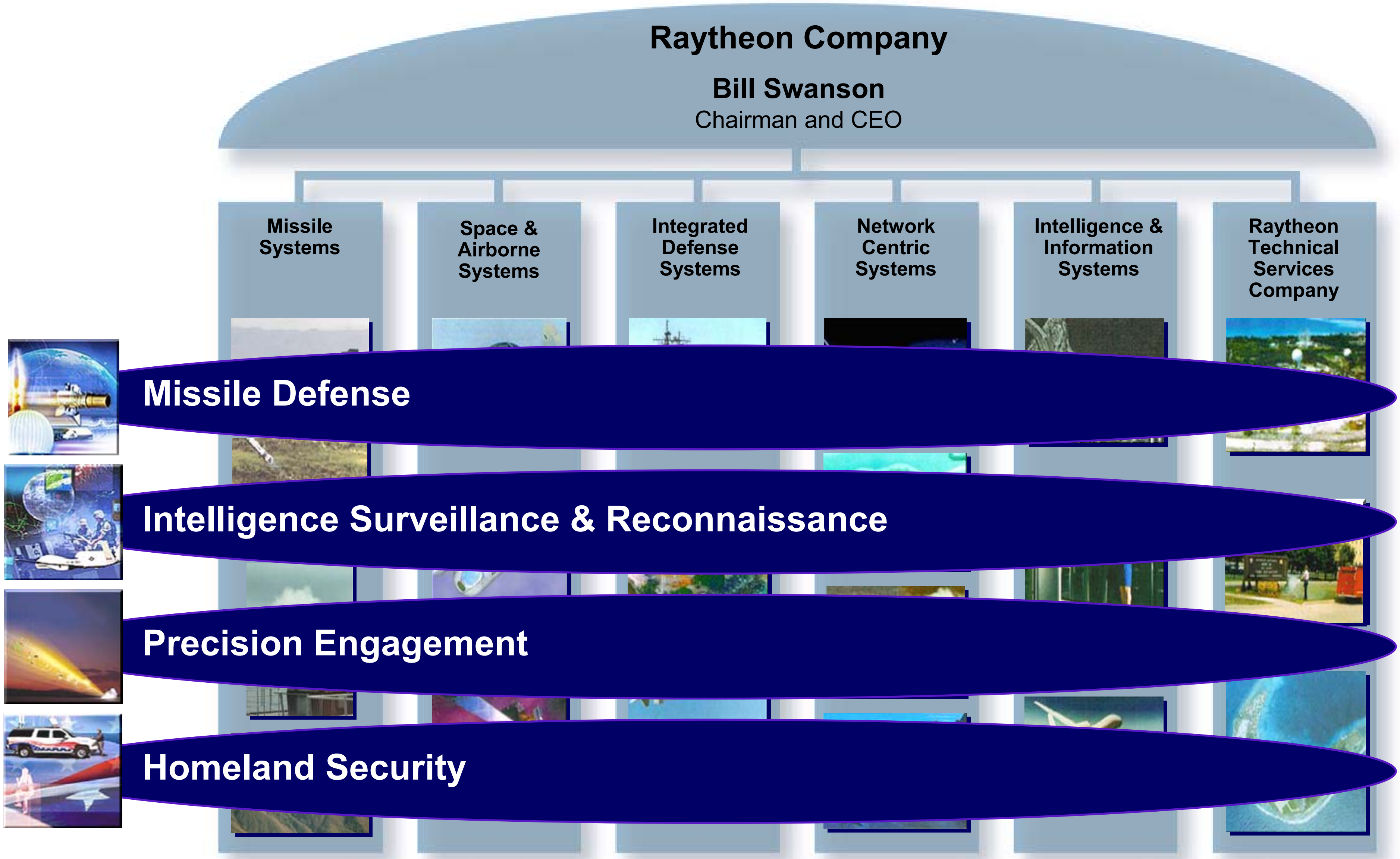
Raytheon

Raytheon Company



80,000 Employees; 2004 Revenue: $20.2B

Business / SBA Intersection



Raytheon

Customer-Focused Marketing

- Meet our commitments
- Actively seek every opportunity to proactively work with our customers to define their needs
- Develop and provide the best solutions
- Earn the customer's confidence

Customer Must View Us As a Valued "Partner of Choice"

Raytheon Missile Systems – Who We Are

- 2004 sales: $3.8 billion
- 11,000 employees
- Headquartered in Tucson, Arizona
- World's largest developer, producer and integrator of weapon systems
  - More than 1 million missiles produced since 1954
  - 70% domestic; 30% international
- Broad weapons portfolio
  - Missiles
  - Smart munitions
  - Projectiles
  - Kinetic intercept vehicle
  - Directed energy weapons
- Customers: all U.S. military services; Allied Forces of more than 40 countries

Raytheon

Our Vision

Raytheon

Missile Systems

Air-to-Air	Strike	Land Combat	Naval Weapon Systems	EKV	Advanced Missile Defense & Directed Energy Weapons	Kinetic Energy Interceptor	Advanced Programs
AIM-9X	ACM	Javelin	ESSM	EKV	DST	Kinetic Energy Interceptor	AT3
AMRAAM	HARM	Stinger	Phalanx 1B		Advanced KV Technology		Silent Eyes™
ASRAAM	JSOW	TOW	RAM		NFIRE		UAVs
HARM Targeting System	Maverick	NLOS-LS	STANDARD Missile-2 (Block IIIA / IIIB / IV)		HEL		Loitering Weapons
Sidewinder	Paveway™	Excalibur (XM982)	SeaRAM		HPM		Long Endurance Vehicles
AMRAAM P^3I Phase 3/4	Tomahawk		SM-3		Navy HELWS		Advanced Cruise Missiles
	MALD		SM-6				
	Precision Guided Bomb		Sparrow				
	Tactical Tomahawk		ERGM				

Comparative Defense Budgets -- 2005

- **US: $401B**
- **Germany: $31B**
- **UK: $53B**
- **Australia: $13B**
- **Japan: $46B**
- **South Korea: $20B**

Note: All Budget Figures above in $US

How Defense Sells Into International Market

Raytheon

- Foreign Military Sales
- Direct Commercial Sales
- International Traffic in Arms Regulations
- Congressional notification

Highly Regulated Industry

Raytheon

International Challenges

- Buy European/Buy America
- Lack of integration into U.S. markets
- Technology transfer
- Offsets – desire for “noble” work
- Fluctuating exchange rates

International Marketplace Complex, Unpredictable

Raytheon

Enablers

- Desire for U.S. products/technology
- Workshare opportunities
- Innovative contract structures
- Co-development opportunities
- Economies of scale reduce cost of U.S. production

Win-win Solutions Attractive to Buyers

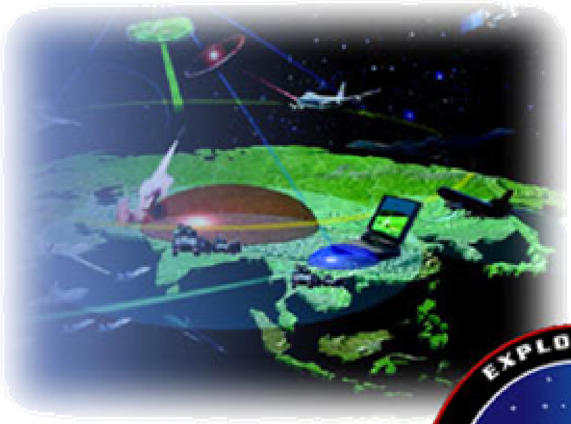
Industry Response

- Grow international presence
  - Raytheon International Inc.
  - Regional in-country expertise
  - Business development/program teams on the road
  - Visibility at international trade shows/events
- Joint ventures
  - Diehl Raytheon Missile Systeme
  - Thales Raytheon
- Joint development opportunities
  - ESSM
  - Excalibur
  - RAM
- Co-production agreements

Relationships are Key

Looking into the Future

- Future "netted" battlespace
  - "Missile as a Node in the Net"
- Expanding into new markets
  - Directed energy
  - NASA space exploration
  - Guided Projectiles
  - Total life cycle logistics support
- Requires system engineers/ system architects

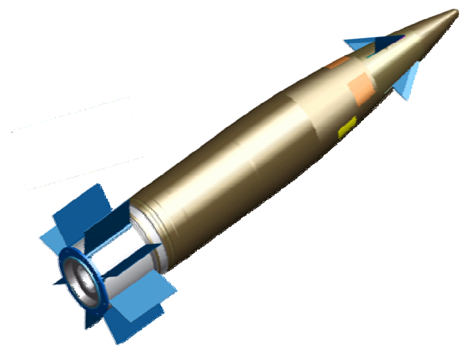


Expanding the Core Beyond the Missile Market

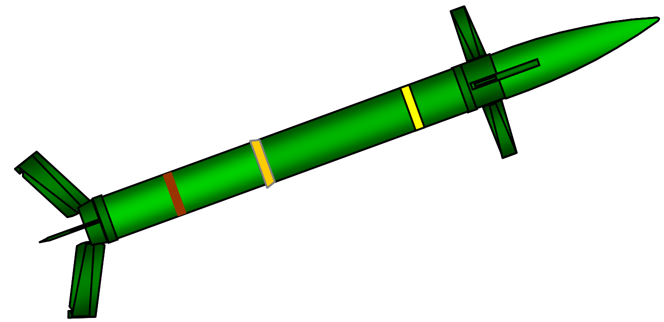
Raytheon

RMS Guided Projectile Family

Excalibur



Extended Range Guided Munition



Mission

- **Indirect fires for legacy, interim and objective force**
- **Paladin, XM777 and NLOS Cannon**
- **Extended range munition**
  - 39 Cal >37 Km
  - 52 Cal > 47 Km
- **Precision guided, <20m CEP**

Mission

- **Naval Surface Fire Support**
- **DDG81 MK45 MOD4 (5”) Gun**
  - Cruiser Conversion
- **Extended Range Munition**
  - >41 Nmi
- **Precision Guided, <20m CEP**

Phalanx Overview

Primary Mission:

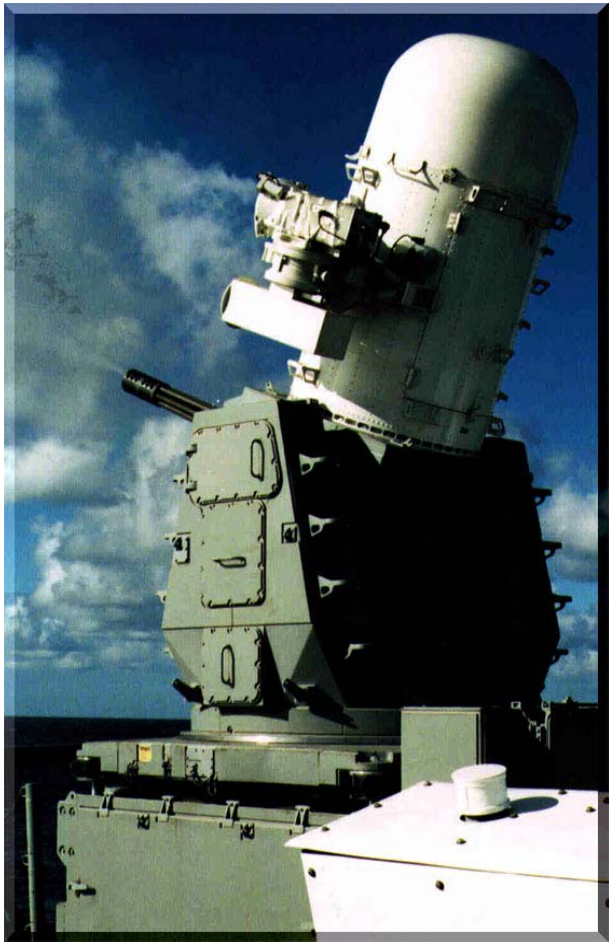
Terminal Defense Against ASCMS and High Speed Aircraft Penetrating Other Fleet Defensive Envelopes

Added Missions:

- Surface Mode
  - Counter Small, Fast Surface Craft and Slow Flying Helicopters and Aircraft
- Sensor Support For Close-in Missile Engagements

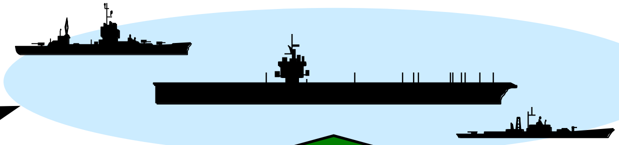
Benefits:

- Supports Multiple Roles In Ships Self Defense
- Man-in-the-Loop, Autonomous or Integrated Operation
- Fast Reaction

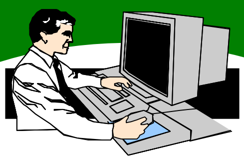


Full Service Contractor
Phalanx Life Cycle Support

Raytheon



Phalanx Communications System



Phalanx
Fleet Service Center

- Coordinates All Support
- Accessible 24 x 7 x 365

Supply Support

- Commercial Inventory Management and Distribution
- Battle Group Sparing
- Total Asset Visibility
- In-Transit Tracking
- Retrograde Recovery

Phalanx Training

- Formal Schools
- FSR On-Job-Training
- Distance Learning

Phalanx Website

- Parts ID and Ordering
- Technical Documents
- Shipment Tracking
- Training

Program Management

- Centralized Management
- Continuous Fleet Assessment

Fleet Support

- Pierside and On Board Tech. Assistance
- Installation/Checkout
- Corrective Maintenance
- Depot and Pierside Maintenance

Engineering

- Fleet Technical Support
- Life Cycle Support
- Core Engineering Services

Technical Documentation

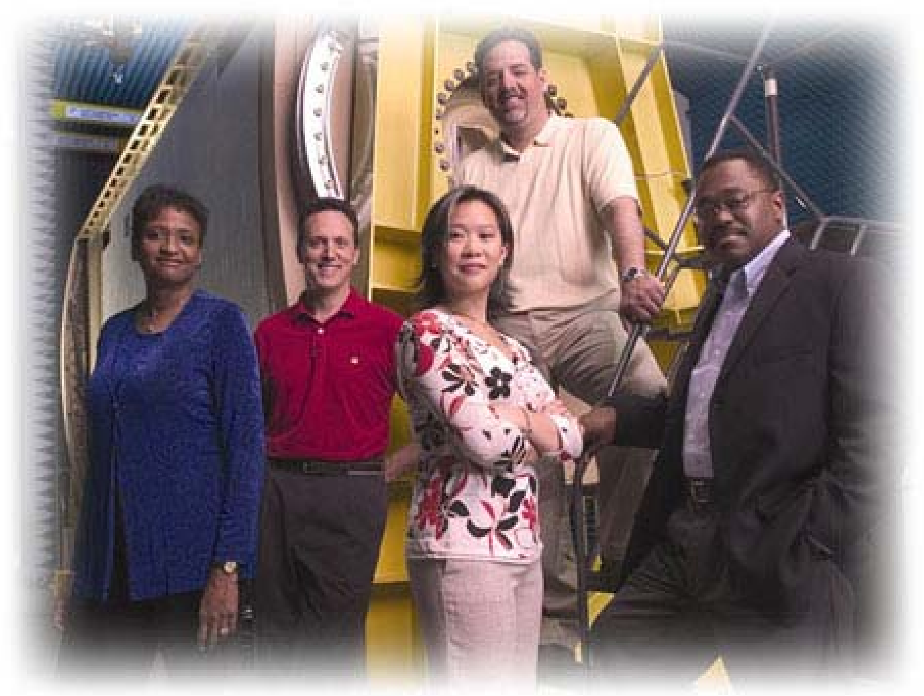
- Real-time Access
- Continuous Updates

Raytheon Phalanx Life Cycle Support Provides Continuous, Worldwide, Support for Deployed and Non-Deployed Phalanx Systems

Raytheon

Engineering Challenges

- Global competition for talent intensifying as innovation drives job growth in engineering, science fields
- In the U.S., fewer young people earning math & science degrees
- Generational challenges
  - Aging workforce
  - Must appeal to younger workforce



Demand Increasing, Supply Decreasing

Feeding The Pipeline

- Must attract, engage diverse workforce
- Industry support/involvement in K-16 math, science education
- Partnerships with colleges, universities
  - Outstanding graduates
  - High-technology research
  - Post-graduate education
  - Creative continuing education programs
  - Outreach to the next generation

Industry/Education Partnerships Critical to Success


Raytheon
Customer Success Is Our Mission

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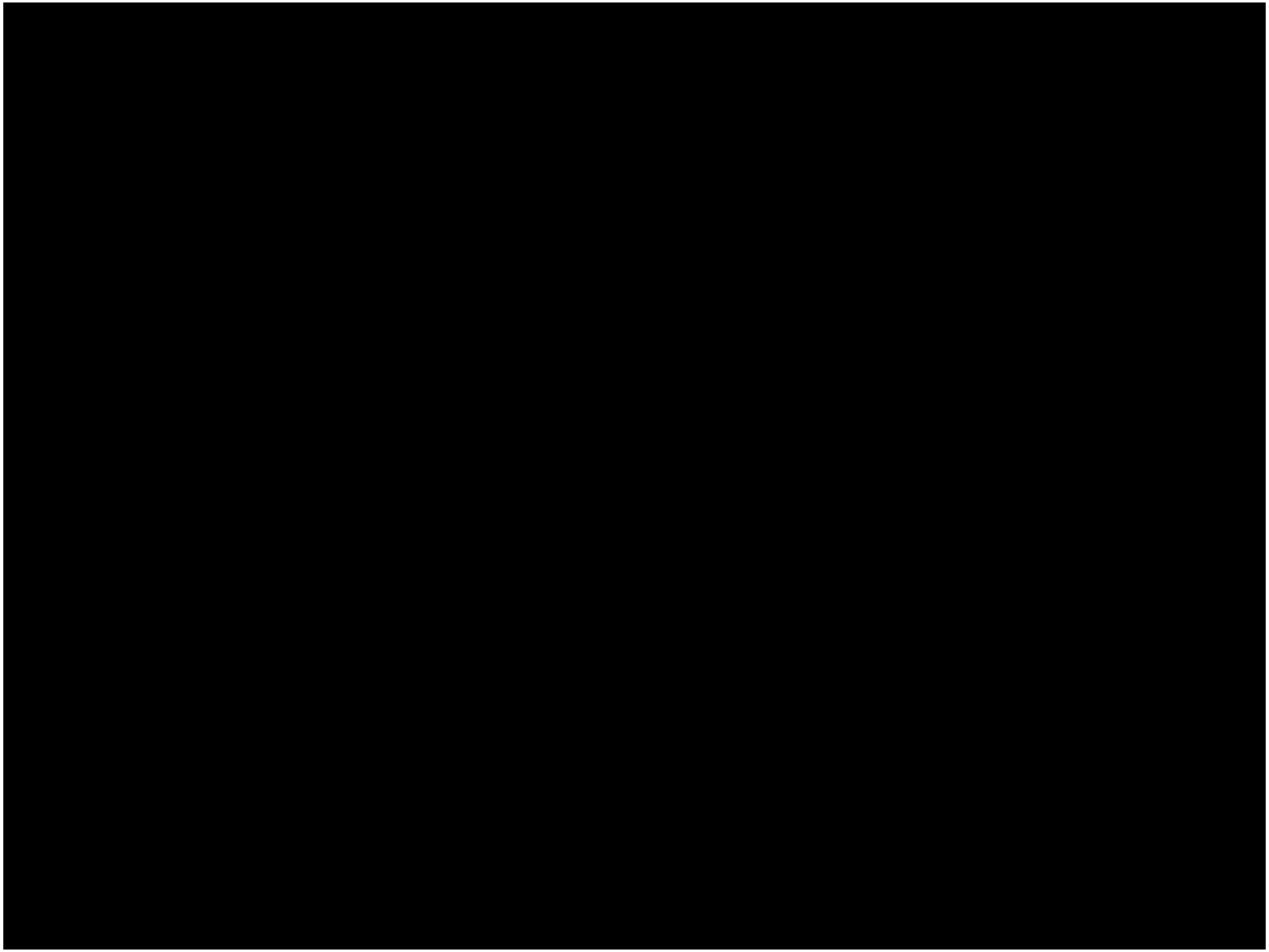
Customer Success Is Our Mission



Raytheon
Customer Success Is Our Mission

Customer Success Is Our Mission

The Modified Tank Ammunition

IMI M152/6 HEAT - AP - T

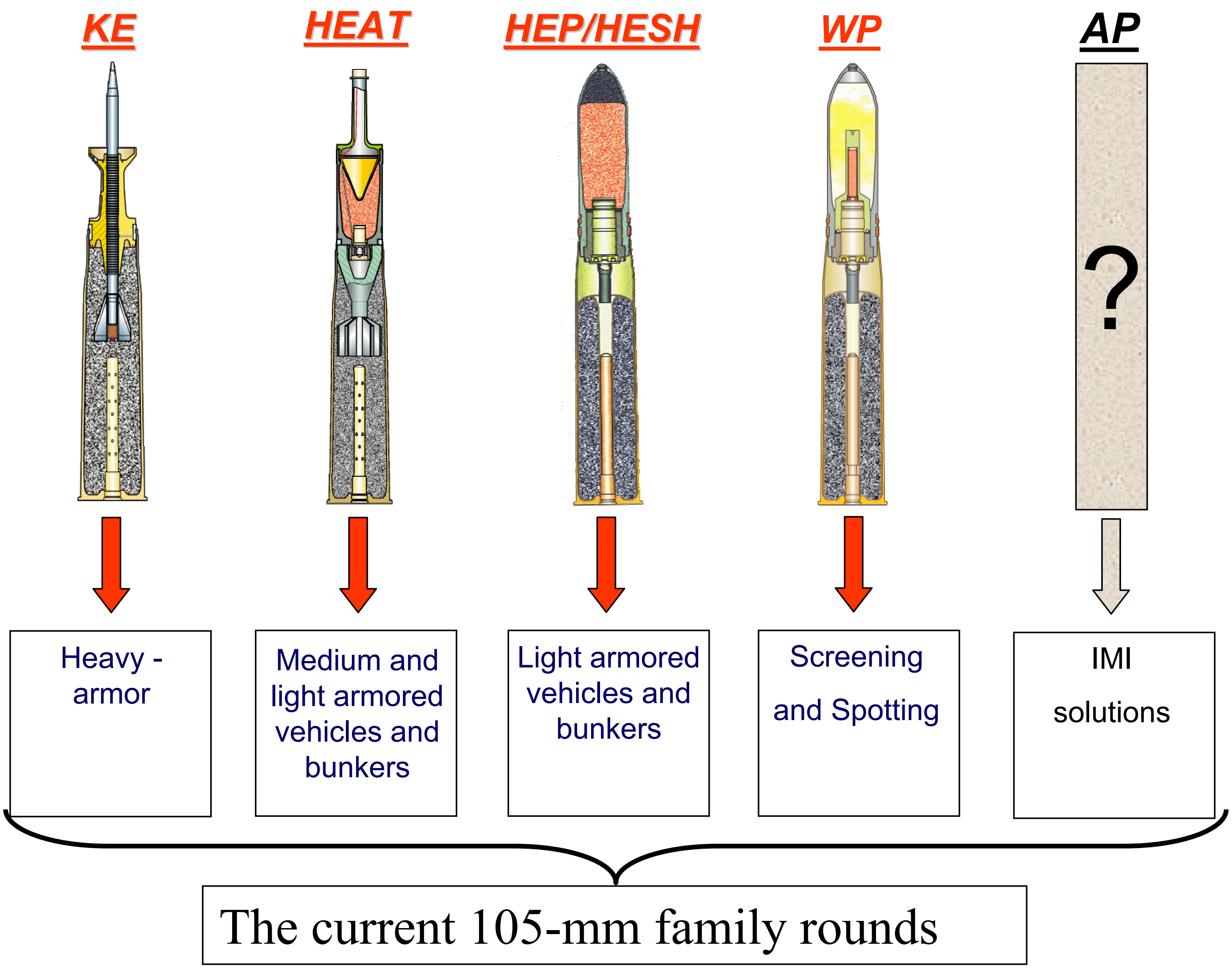
National Defense Industrial Association
40th Annual Armament Systems: GARM
New Orleans, LA
April 25-28, 2005

Danny Schirding
Chief Systems Engineer
Tank Ammunition Directorate - IMI Ammunition Group

Israel Military Industries Ltd. (IMI)
P.O. Box 1044
Ramat Hasharon 47100, ISRAEL
dschirding@imi-israel.com

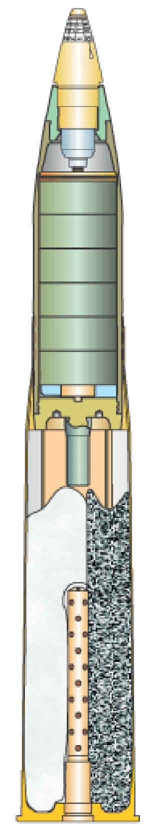
The Main Operational Needs of Armor Corps

- ❖ To destroy Tanks and LAV's
- ❖ To breach and penetrate bunkers and buildings with maximum resulting damage
- ❖ To incapacitate infantry, especially AT squads.

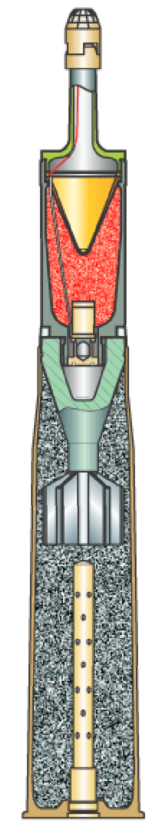

KE
HEAT
HEP/HESH
WP
AP
?
Heavy - armor
Medium and light armored vehicles and bunkers
Light armored vehicles and bunkers
Screening and Spotting
IMI solutions
The current 105-mm family rounds

STUN

APAM



M152/6



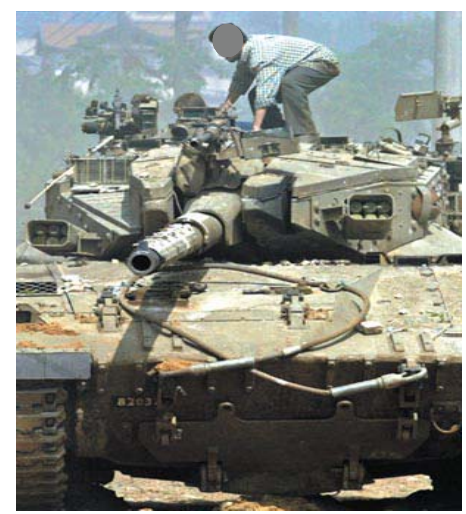
The IMI AP rounds

Tank Stun Rounds - *Mission Statement*

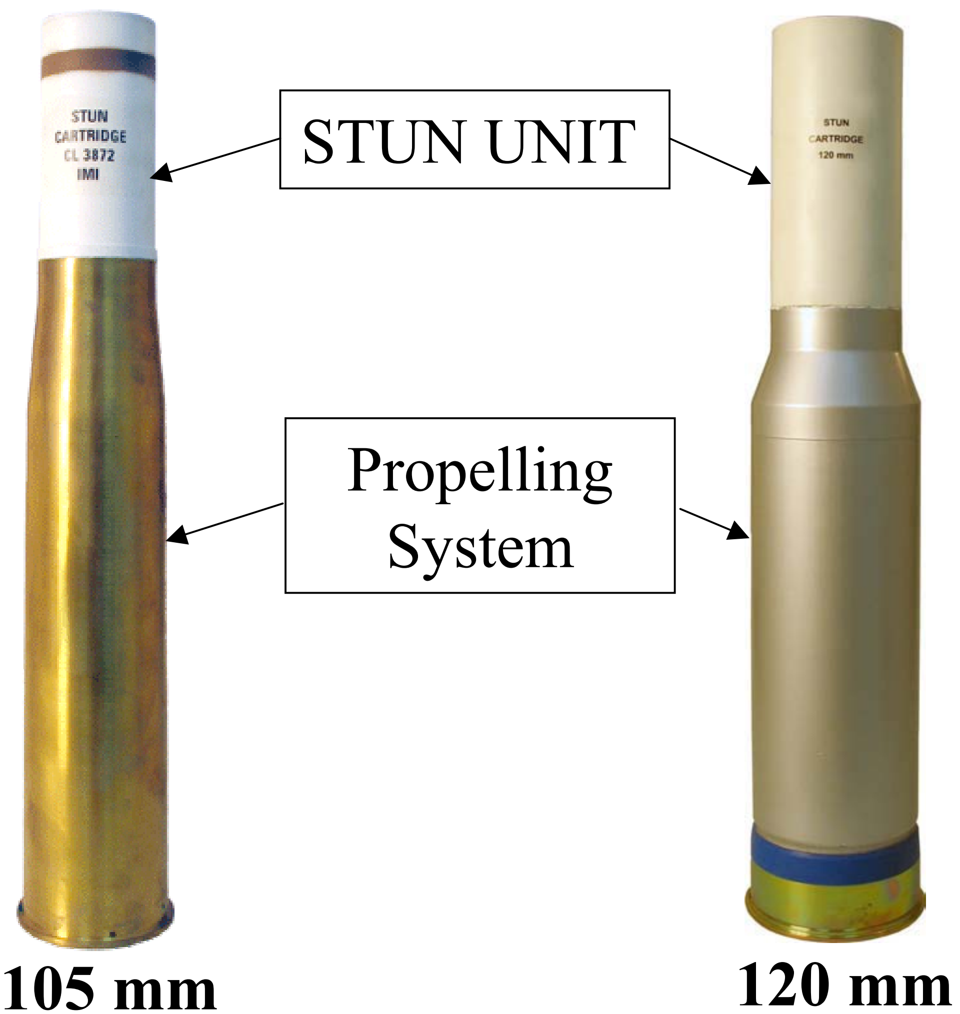
- A less than lethal tank round for use in low intensity conflicts.
- The round is designed to deter by creating a flash, bang and blast effect similar to service ammunition.

❖ **The stun round gives the tank's crew the ability to be effective in situations such as:**

- **Incidents involving non-combatants**
- **Armed terrorists hiding behind a crowd**
- **Hostile civilians (mob) trying to approach/climb on the tank**



105 mm & 120 mm STUN rounds (Less-Than-Lethal tank round)



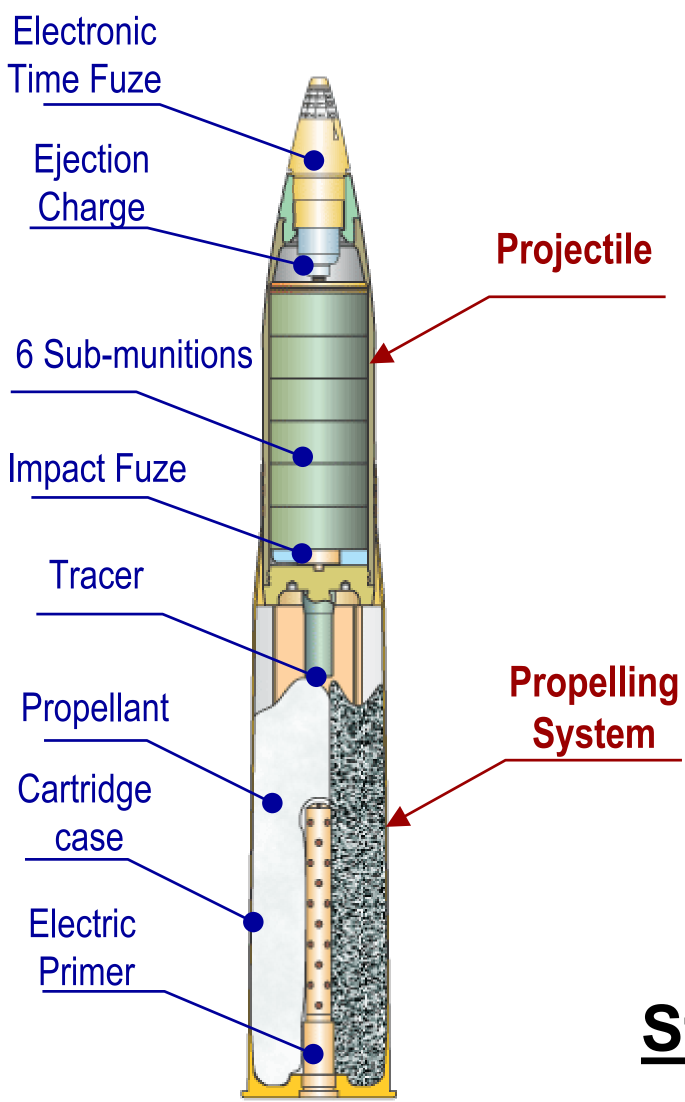
Video film of the firing test – 105 mm

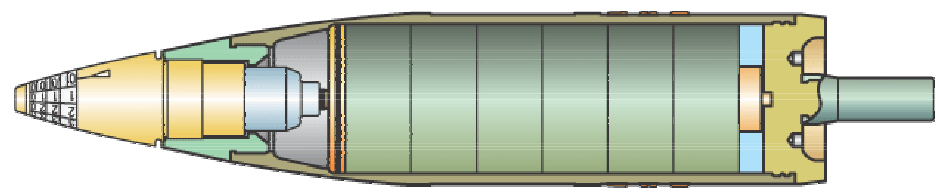

120-mm

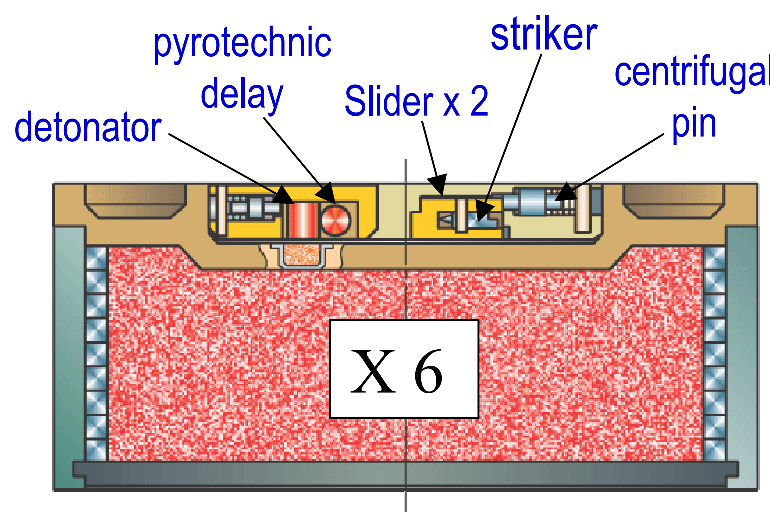
APAM

Anti-Personnel/ Anti-Materiel 105-mmTank Round

APAM – Anti-Personnel/Anti-Materiel







<u>Status</u>: 105 mm in operational use.

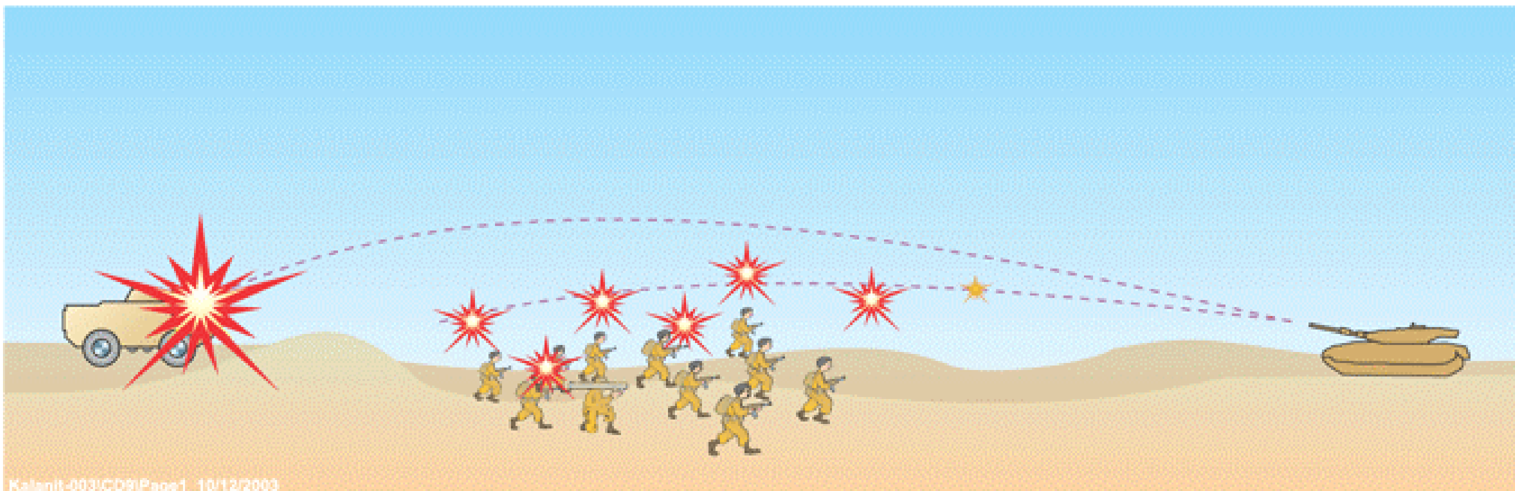
Fuze Setting

Manual fuze setting

Semi-automatic fuze setter

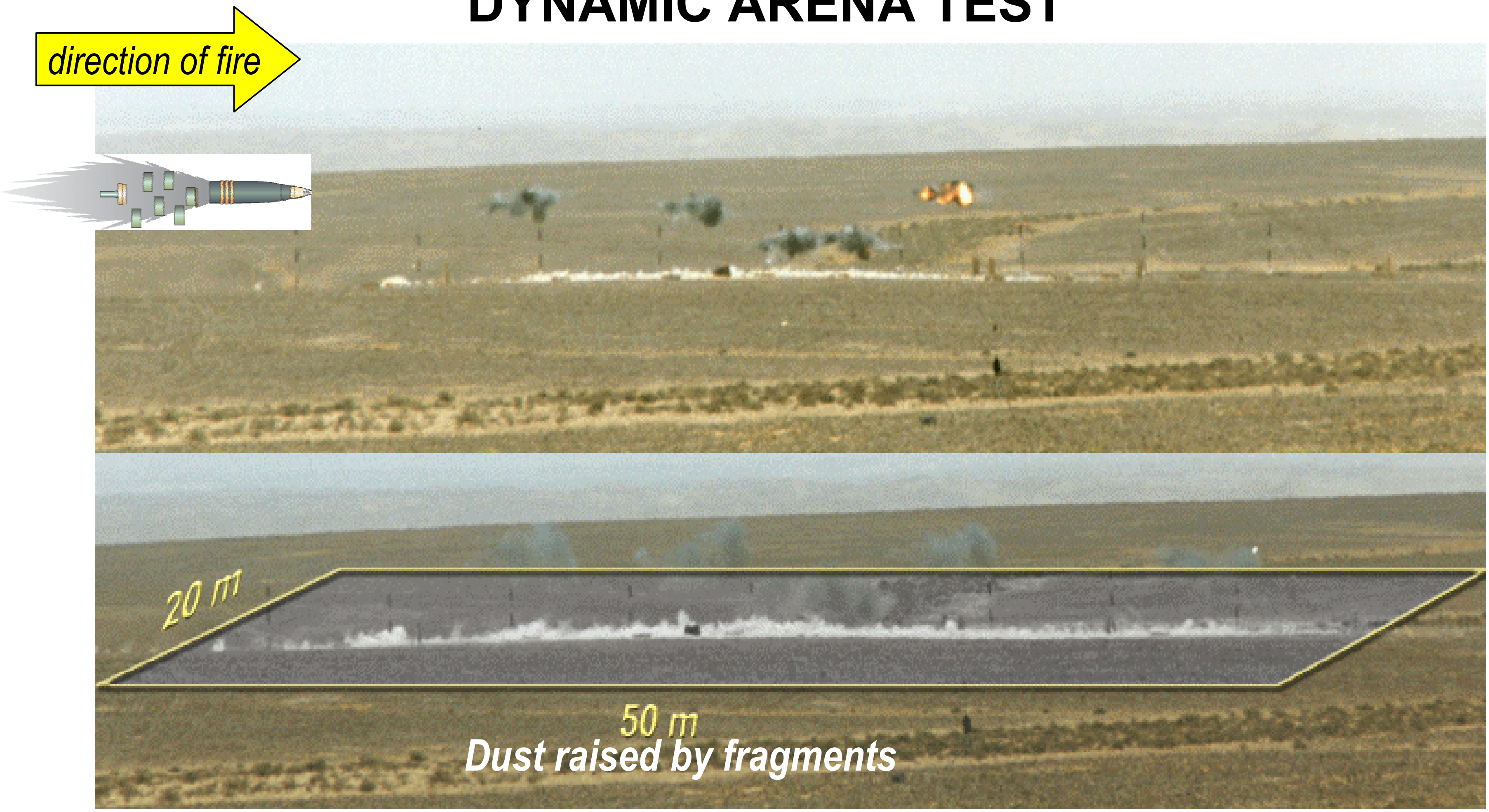
Inductive Fuze Setter (IFS)

APAM – Basic Modes of Operation



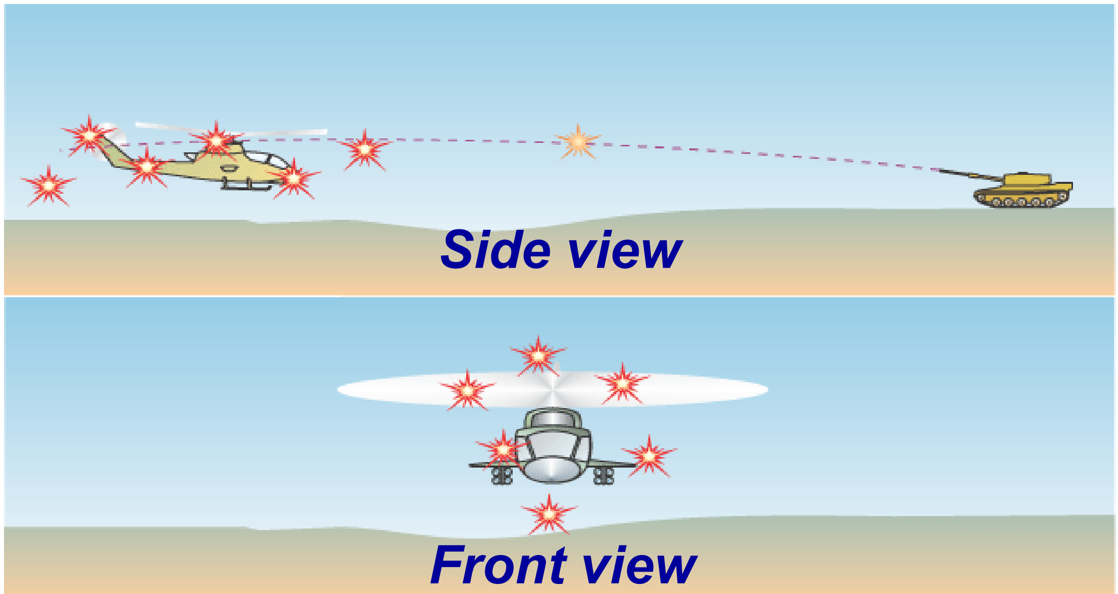
- **Ejection Mode -** Ejected sub-munitions explode sequentially in the air after separation.
  - **Anti-Personnel**
  - **Anti-Helicopter**
- **Impact Mode –** Entire projectile explodes as a unitary warhead upon impact.
  - **LAV's**
  - **Bunkers & Buildings**

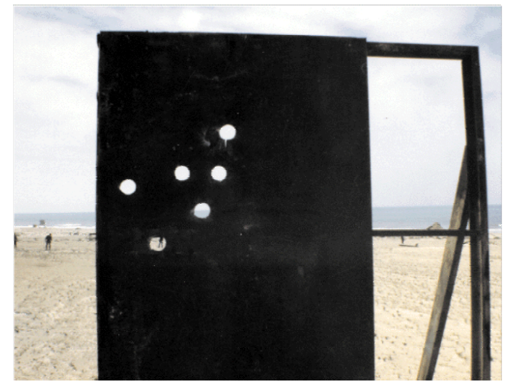
AP MODE (EJECTION)
DYNAMIC ARENA TEST



❖ **High effectiveness against hidden and prone targets**

ANTI-HELICOPTER MODE

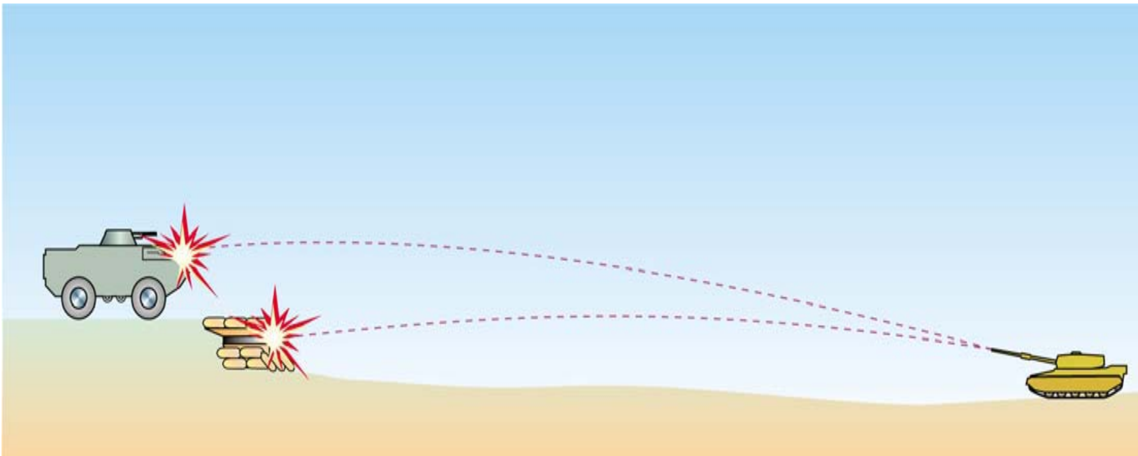




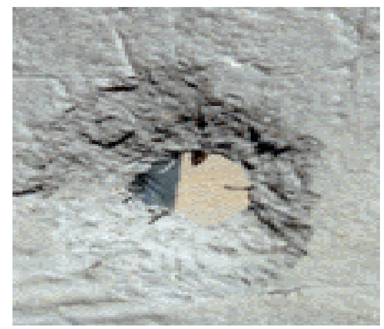
PENETRATION OF 10 mm
RHA TARGET
BY SUBMUNITIONS

- Six submunitions (and the projectile body & base) fly towards the target. One hit is good enough.
- Even in a near miss, the helicopter pilot will see and/or feel the detonations, causing mission abort.

AM MODE (IMPACT)



Light armor



Double reinforced concrete wall

Hits on witness plate

- ❖ Projectile will penetrate LAV's and Bunkers.
- ❖ High density of lethal fragments inside.

APAM 105 - Damage to Sand & Timber Bunker

1 ROUND

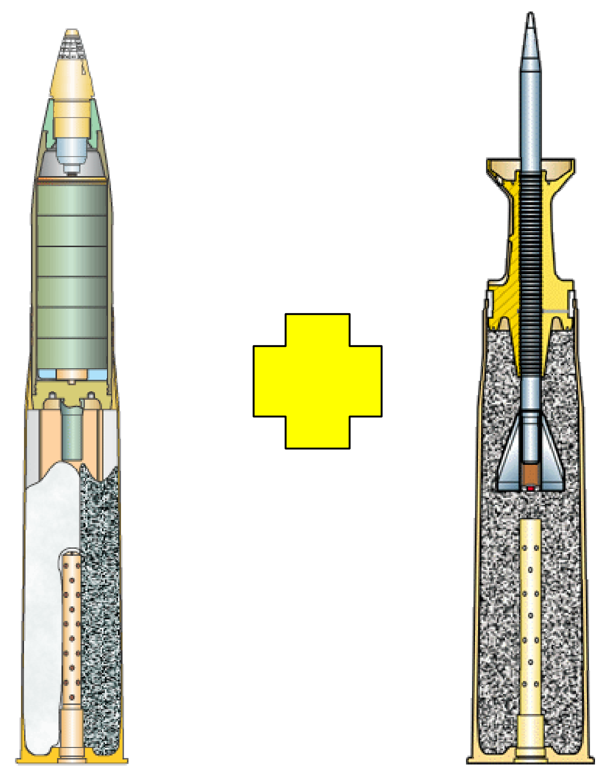
The Optimal Solution !

Infantry,

LAVs,

Bunkers & Buildings,

Helicopters.



Armor

- Maximum capability with minimum rounds.
- Reduced logistic load.

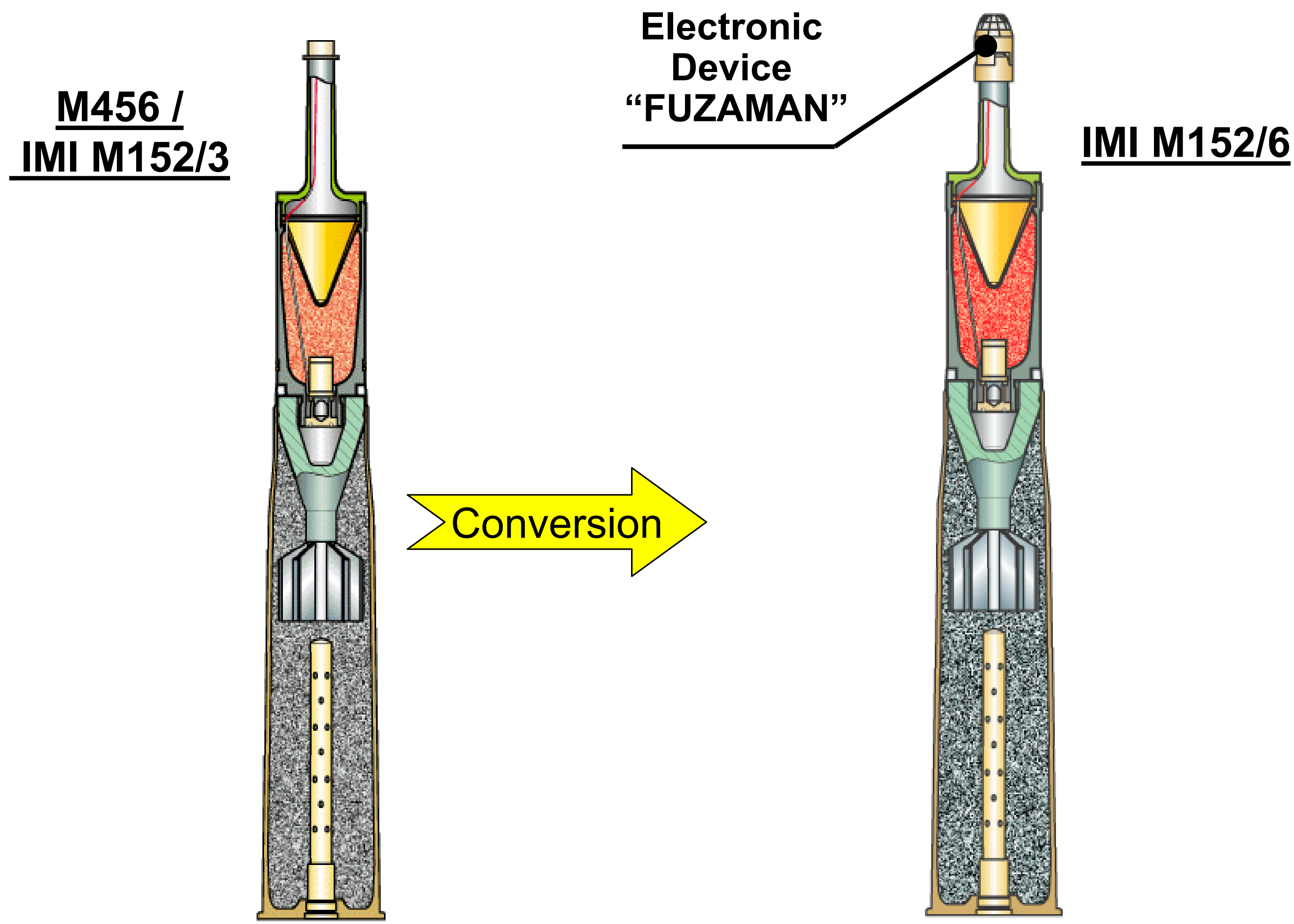
The alternative… !

Armies around the world have large stocks of 105-mm HEAT rounds (M456 / IMI M152/3)

- IMI's alternative solution -

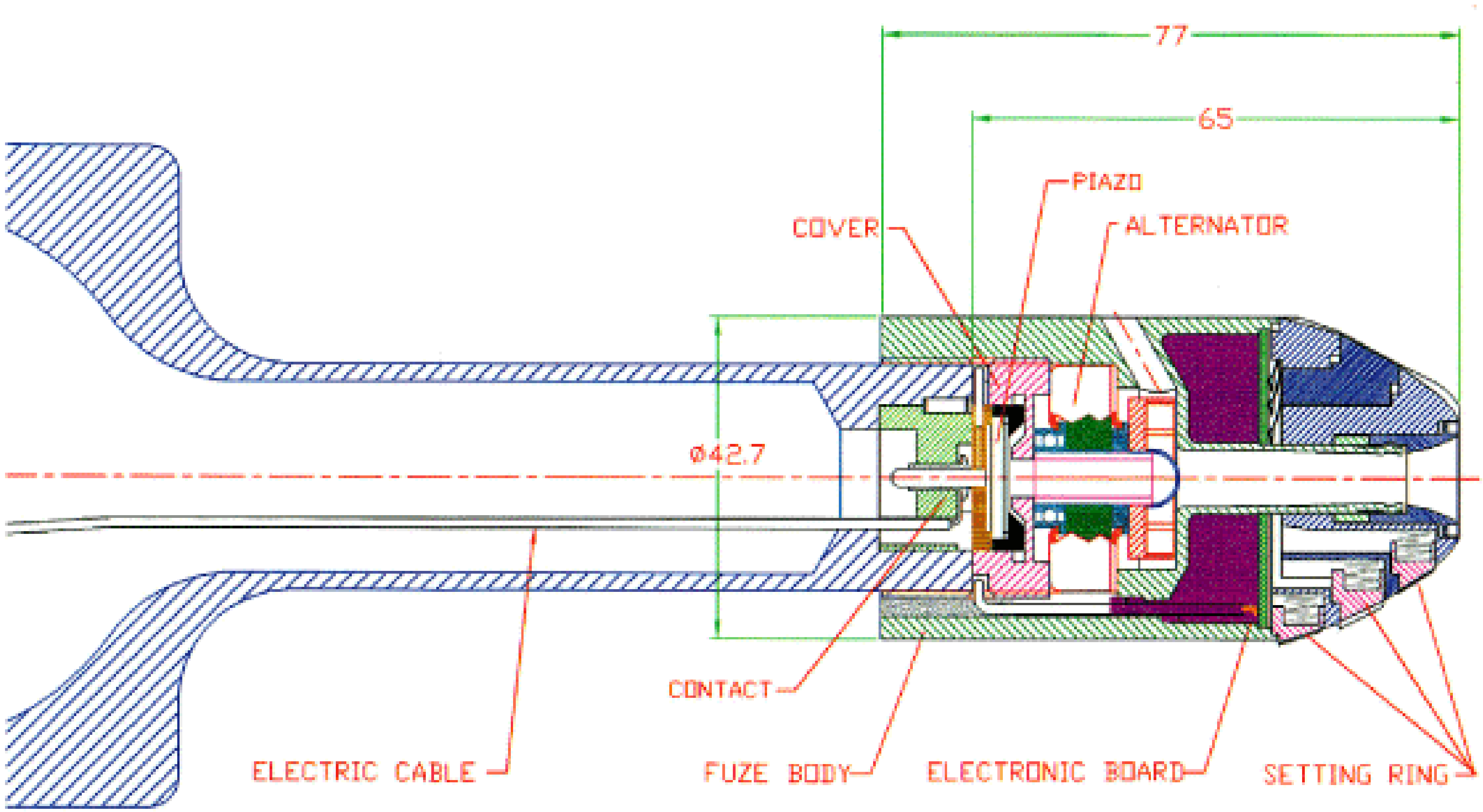
Upgrading HEAT rounds

- Using the old and well known type of ammunition
- Enhance capabilities
- Improve reliability
- Improve safety
- Cost – effective (high kill probability)
- Providing Armor Corps needs

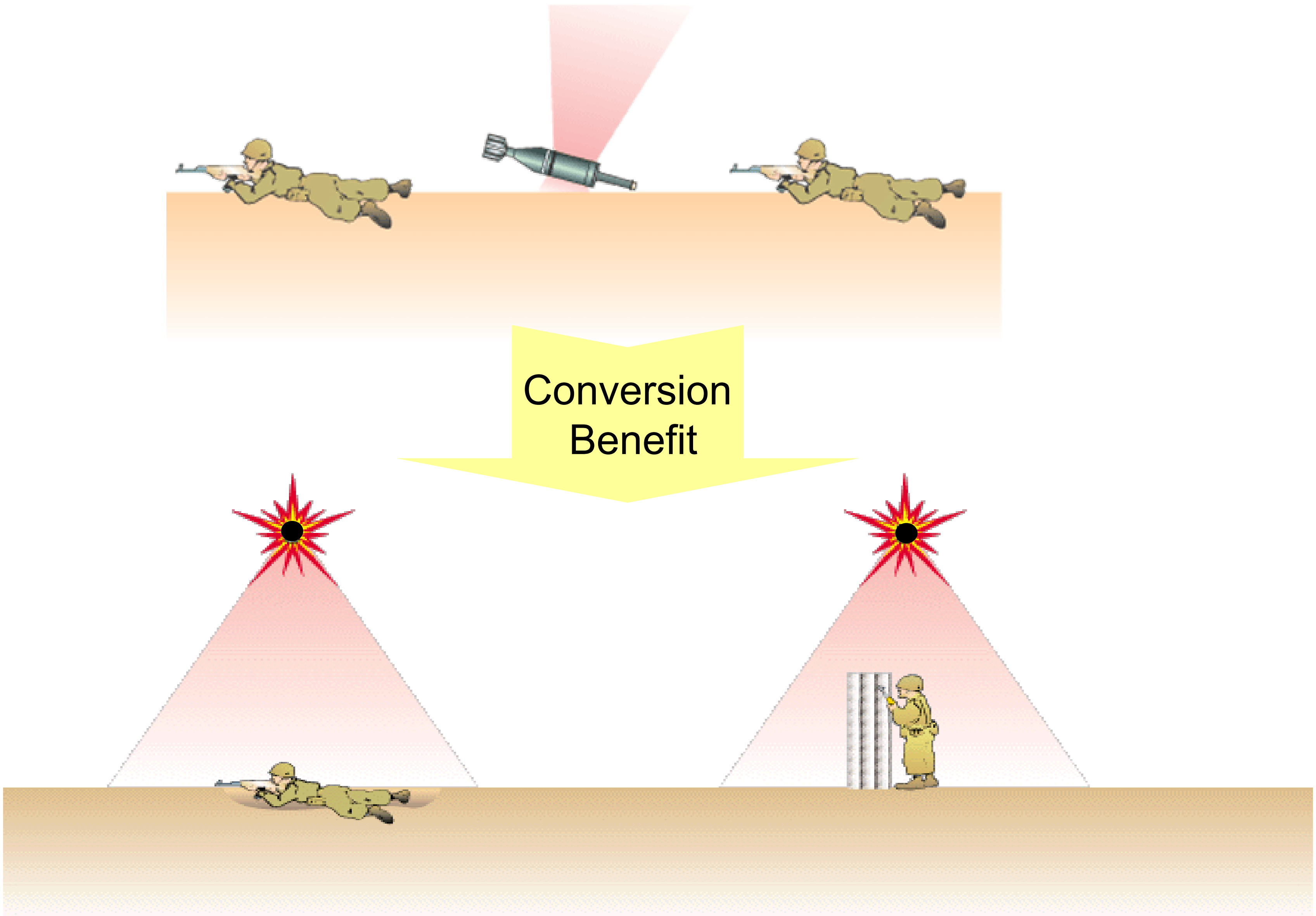

M456 /
IMI M152/3
Conversion
Electronic
Device
“FUZAMAN”
IMI M152/6

"FUZAMAN"

High – Reliability Electronic Time Device



RESHEF TECHNOLOGIES, LTD.
AN ARYT COMPANY


Conversion
Benefit

- **Influence on the aeroballistics performance:**
  - Drag Force
  - Lift Force
  - Static and Dynamic Stability
  - Jump

Trajectory Dispersion (Accuracy)

- **Influence on the final ballistic**

Penetration

Is it that simple?

- **The operational benefits:**
  - Warhead detonation above the ground – AP mode
  - Warhead detonation upon impact and grazing (reliability and safety)
  - Multi-purpose capability

Improvements

Research and Development Activities

Preliminary analysis and wind tunnel tests for the "FUZAMAN"

The max. frequency of the alternator?

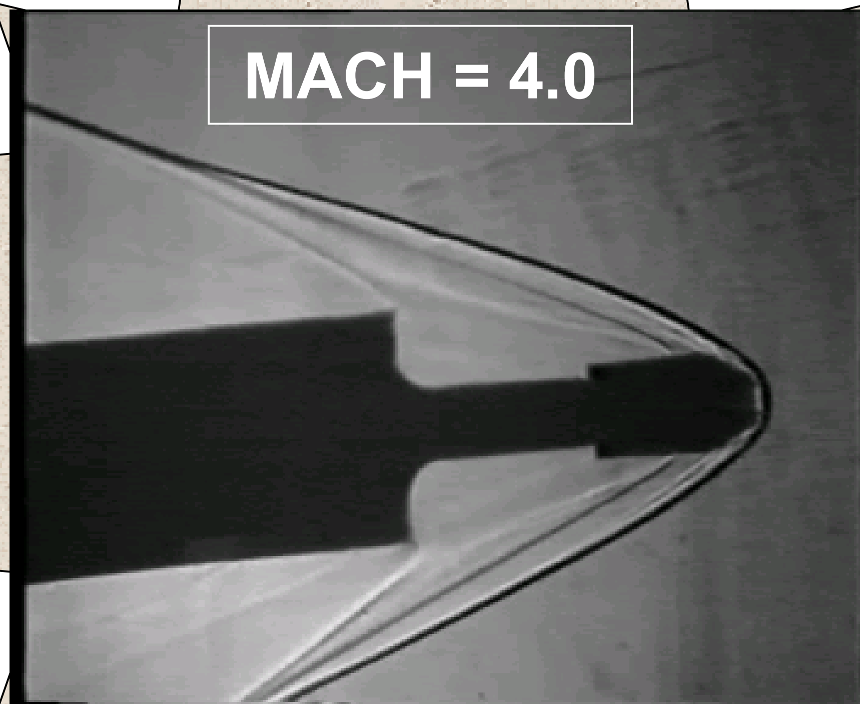
Number of Output nozzle holes?

Output nozzle dia.? [mm]

Input nozzle dia.? [mm]

Height of the impeller wings? [mm]

2 parallel energy sources?



The axle of the Impeller (bar, tube)?

Stress on the impeller?

Material of impeller?

Time to Stability?

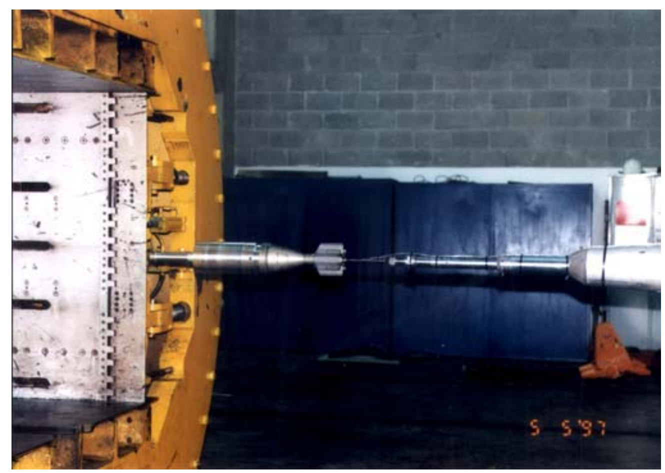
Energy at Stability point?

Mach and spin influence?

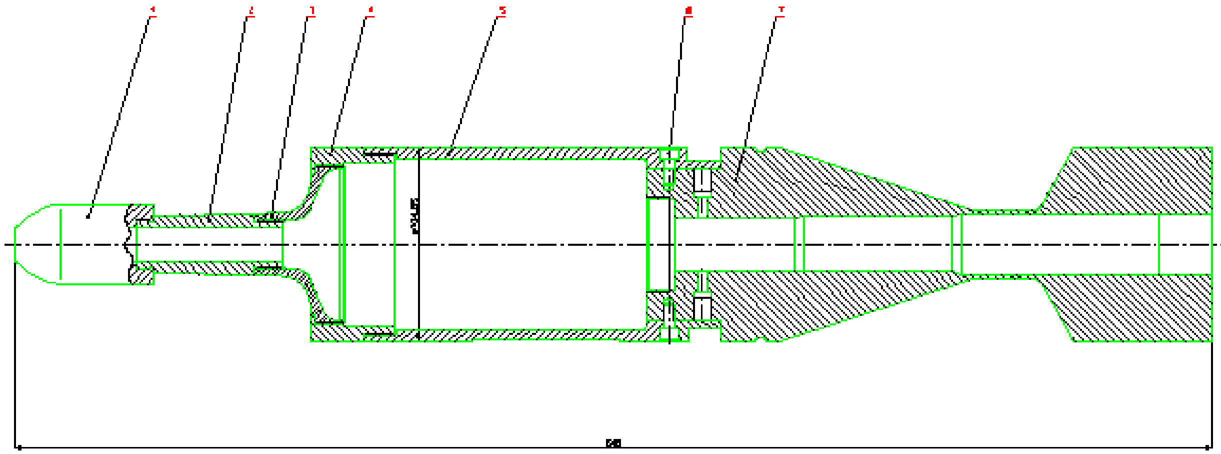
Aeroballistics analysis and wind tunnel tests for the Projectile of IMI M152/6

❖ Wind tunnel tests

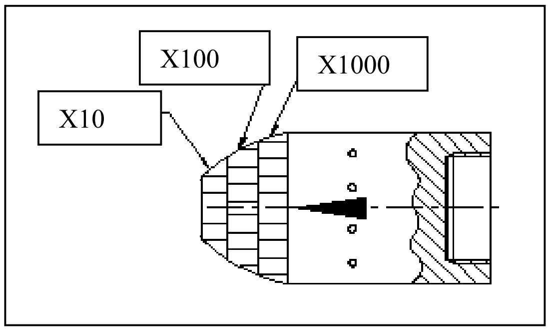
- Mach numbers: 1.2, 1.6, 2.0, 2.2, 2.6, 2.8
- Angle of attack: $-7^{\circ} \leq \alpha \geq +7^{\circ}$
- Cd vs Mach
- Aerodynamic coefficients ($C_{m\alpha}$, $C_{n\alpha}$, C_{roll}, $C_{l\alpha}$ etc.)
- Xcp – Xcg (static stability)



Prototypes for Wind tunnel:



Type No. 1



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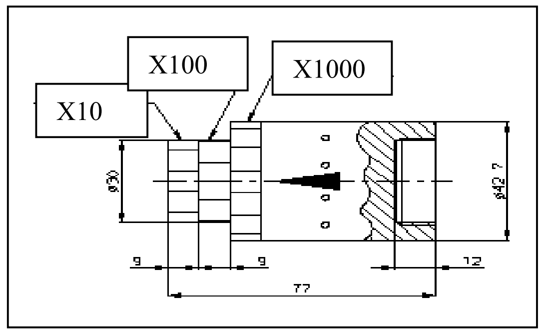
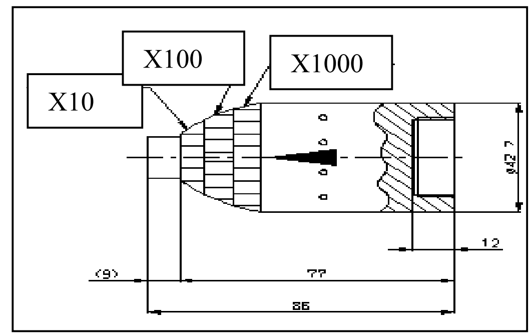
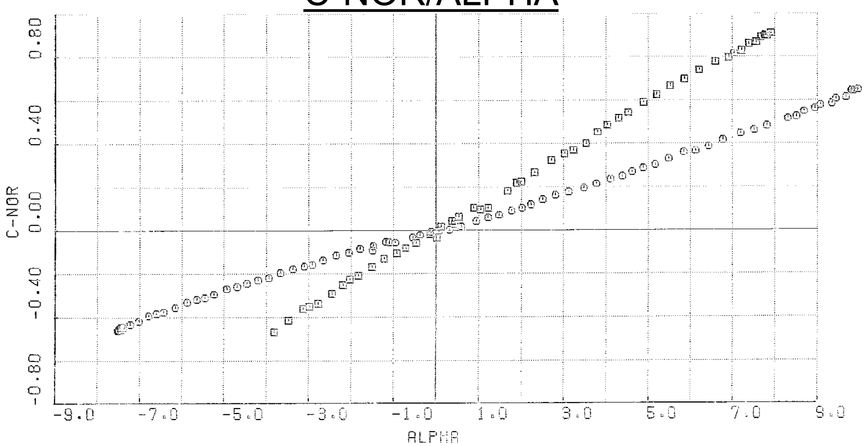


Type No. 3

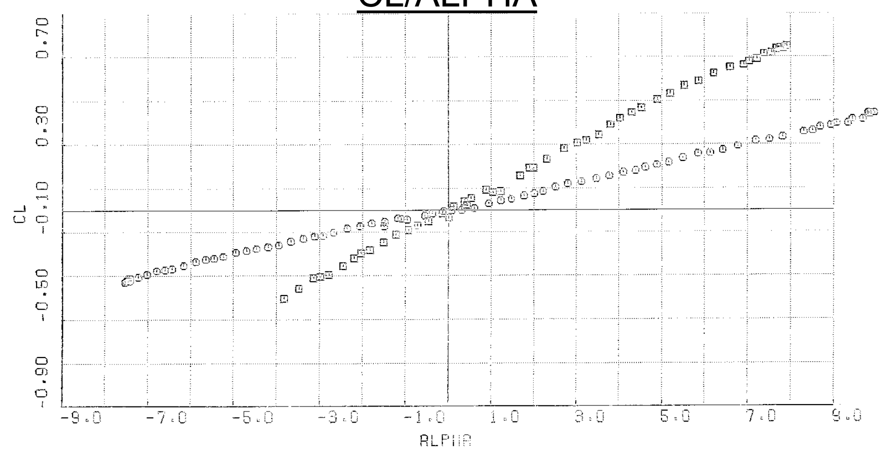



MACH = 2.8
SWEEP ALPHA

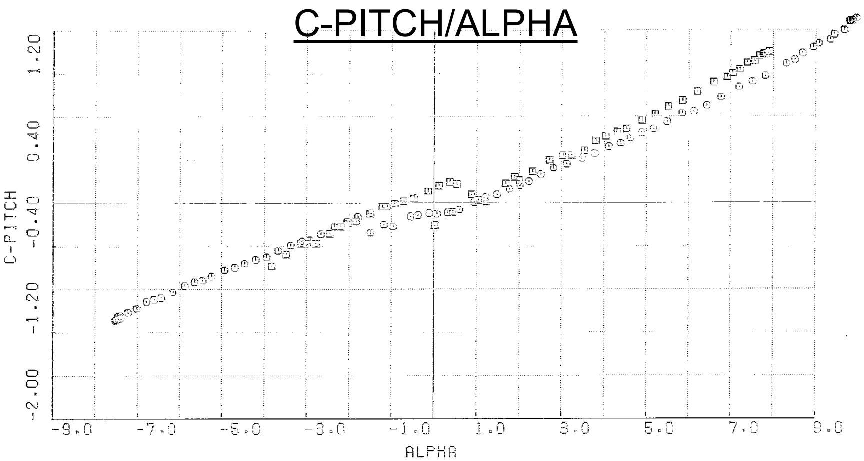
C-NOR/ALPHA



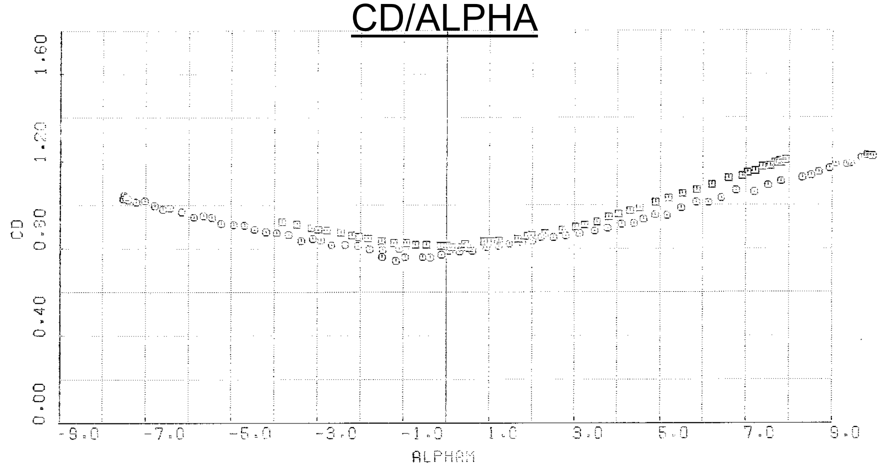
CL/ALPHA



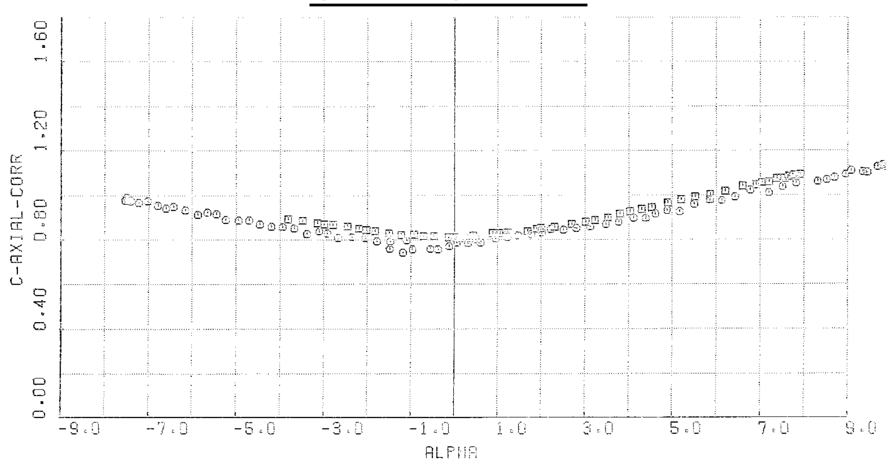
C-PITCH/ALPHA



CD/ALPHA



C-AXIAL/ALPHA



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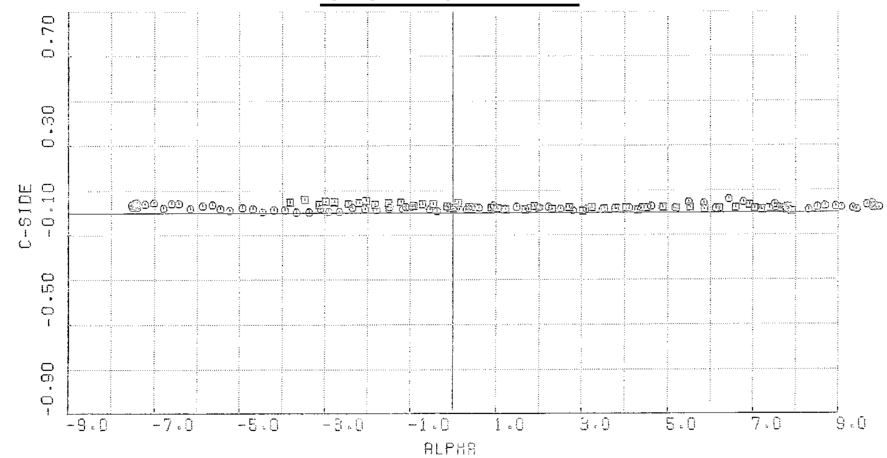
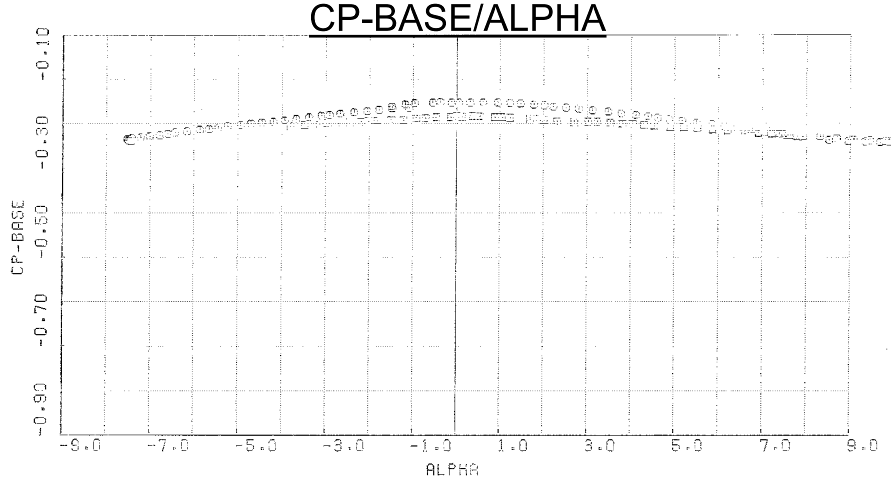
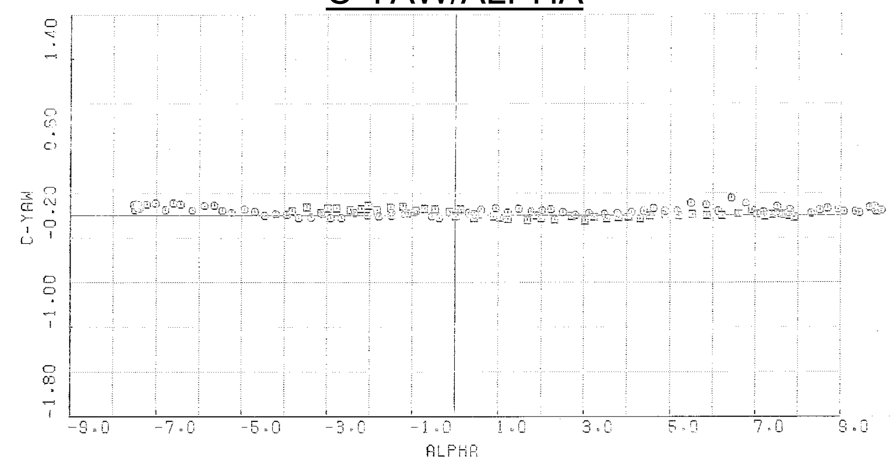


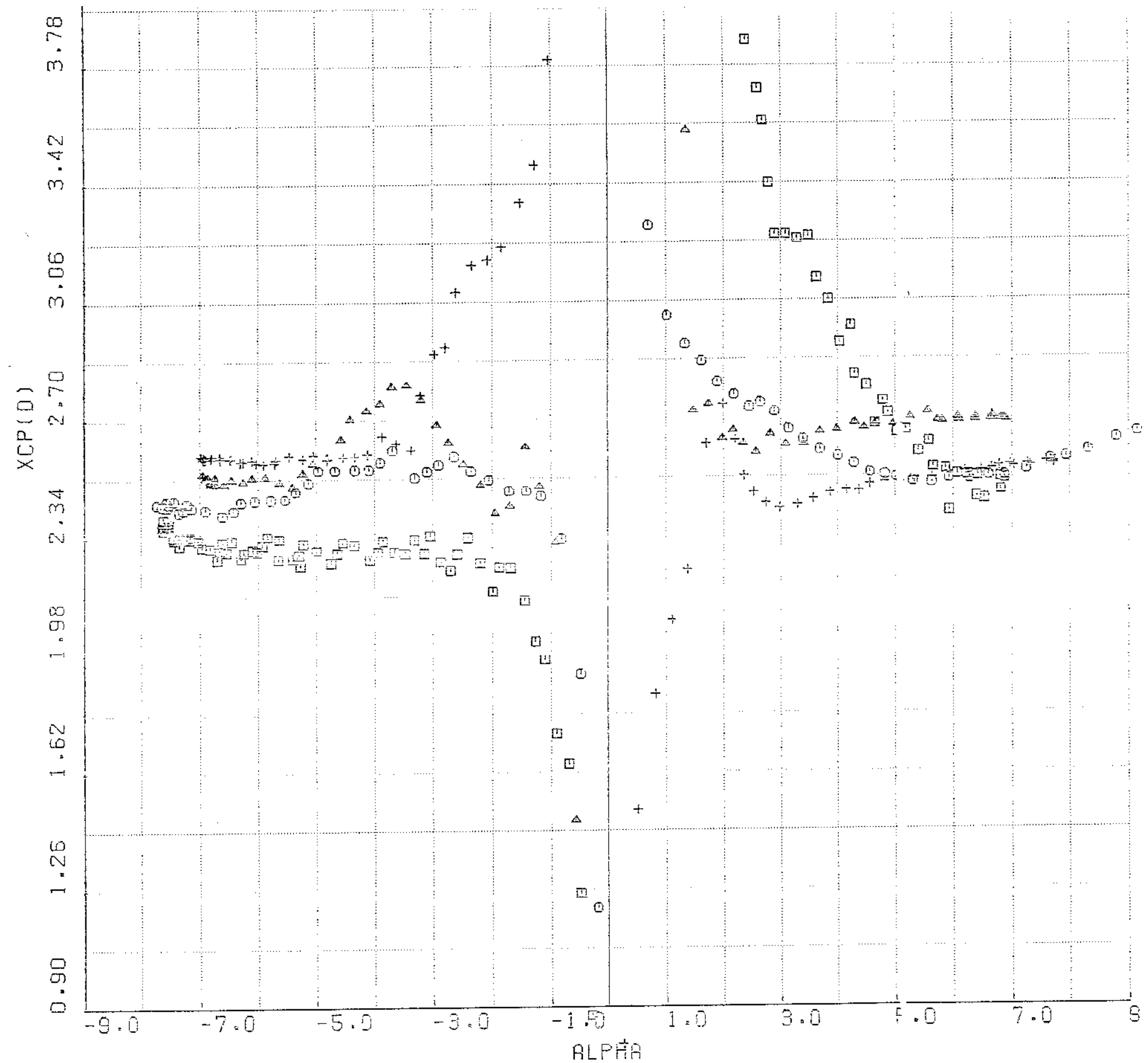
CP-BASE/ALPHA



C-YAW/ALPHA

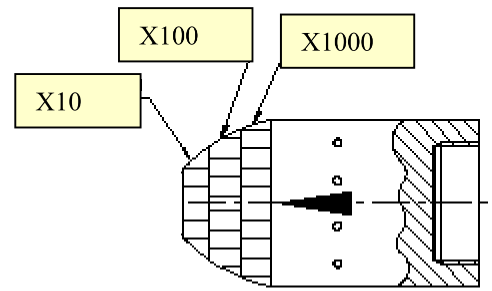


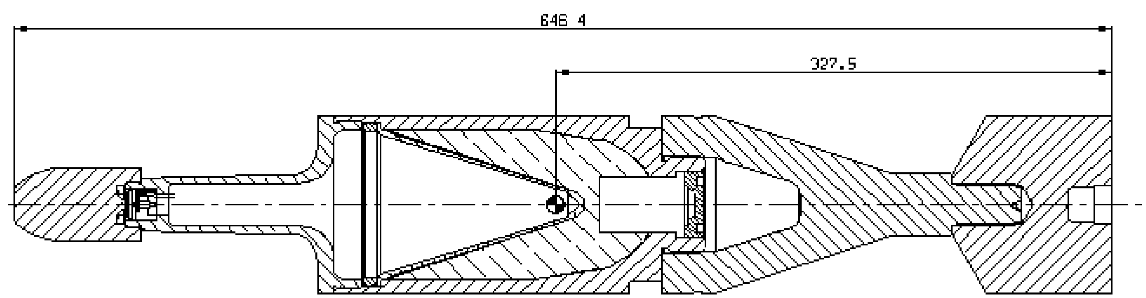
XCP(D)/ALPHA

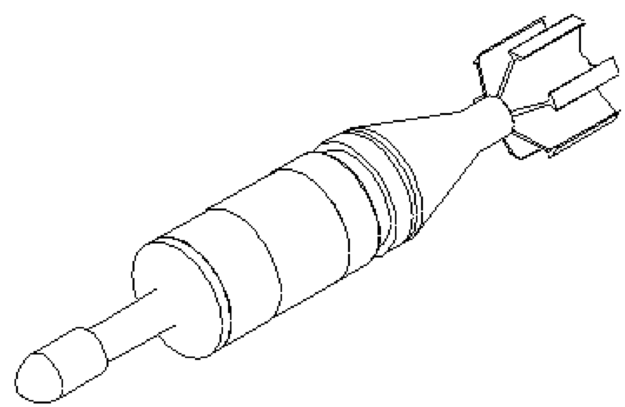

XCP(D)
3.78
3.42
3.06
2.70
2.34
1.98
1.62
1.26
0.90
-9.0
-7.0
-5.0
-3.0
-1.0
1.0
3.0
5.0
7.0
9
ALPHA

External Ballistics test - IMI M152/6

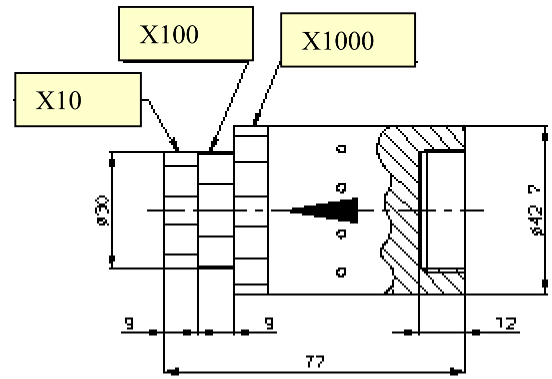
Prototype No. 1

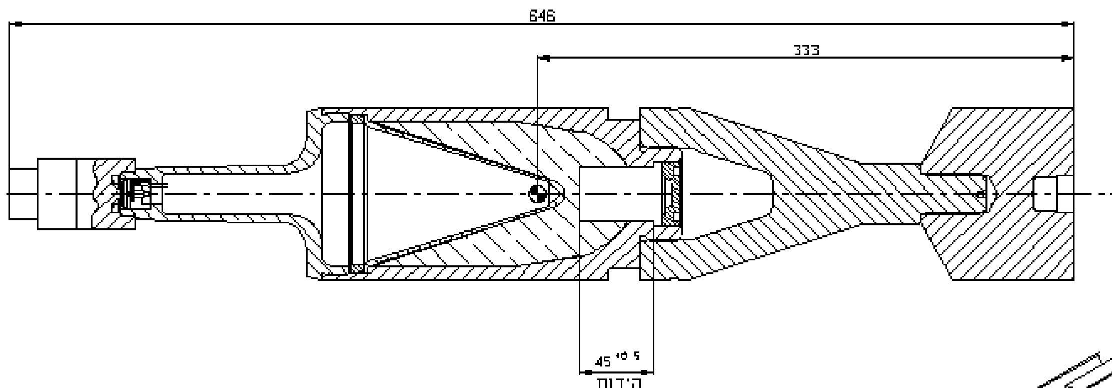


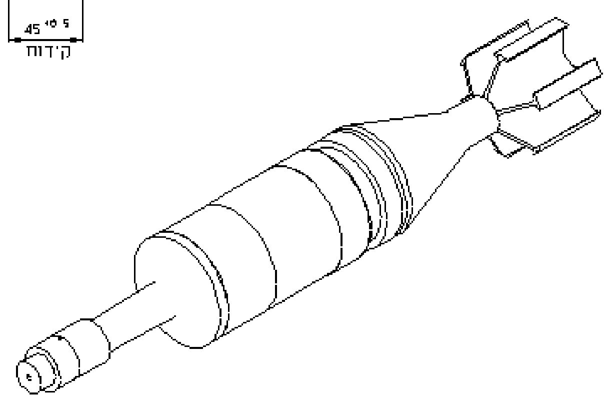




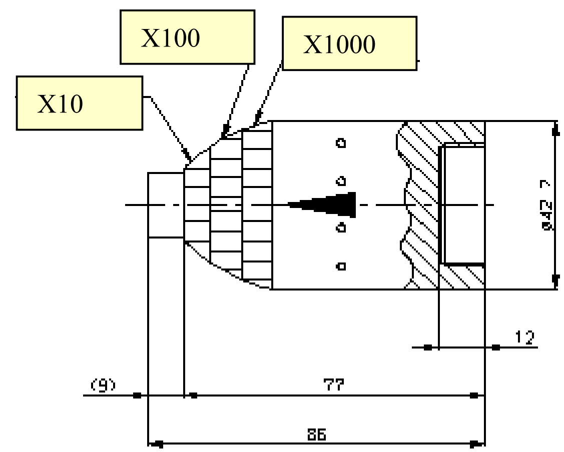
Prototype No. 2

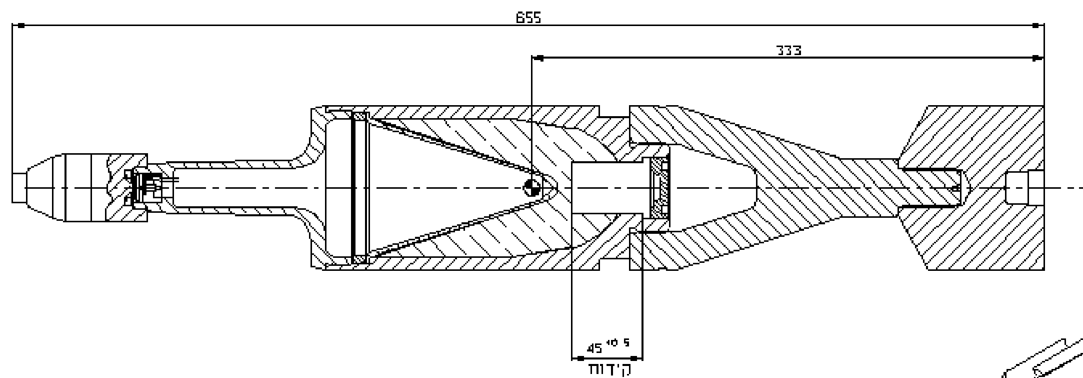


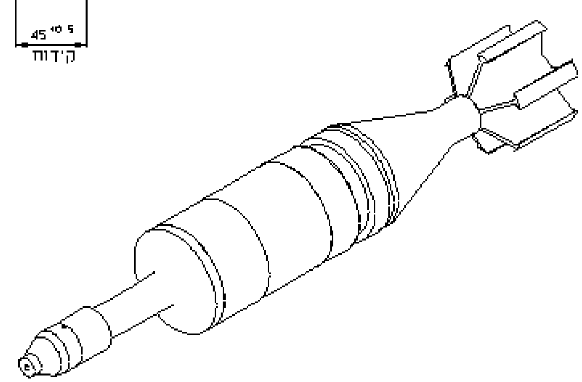




Prototype No. 3

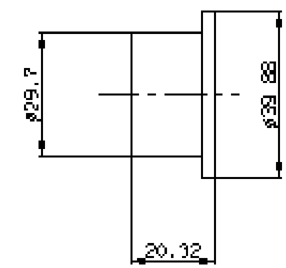


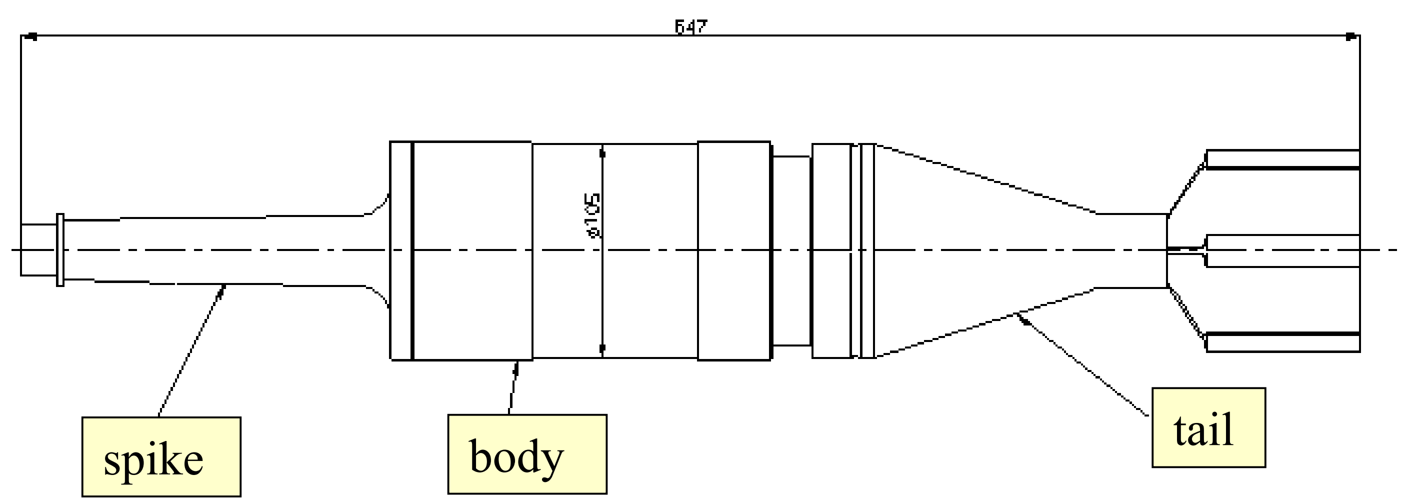




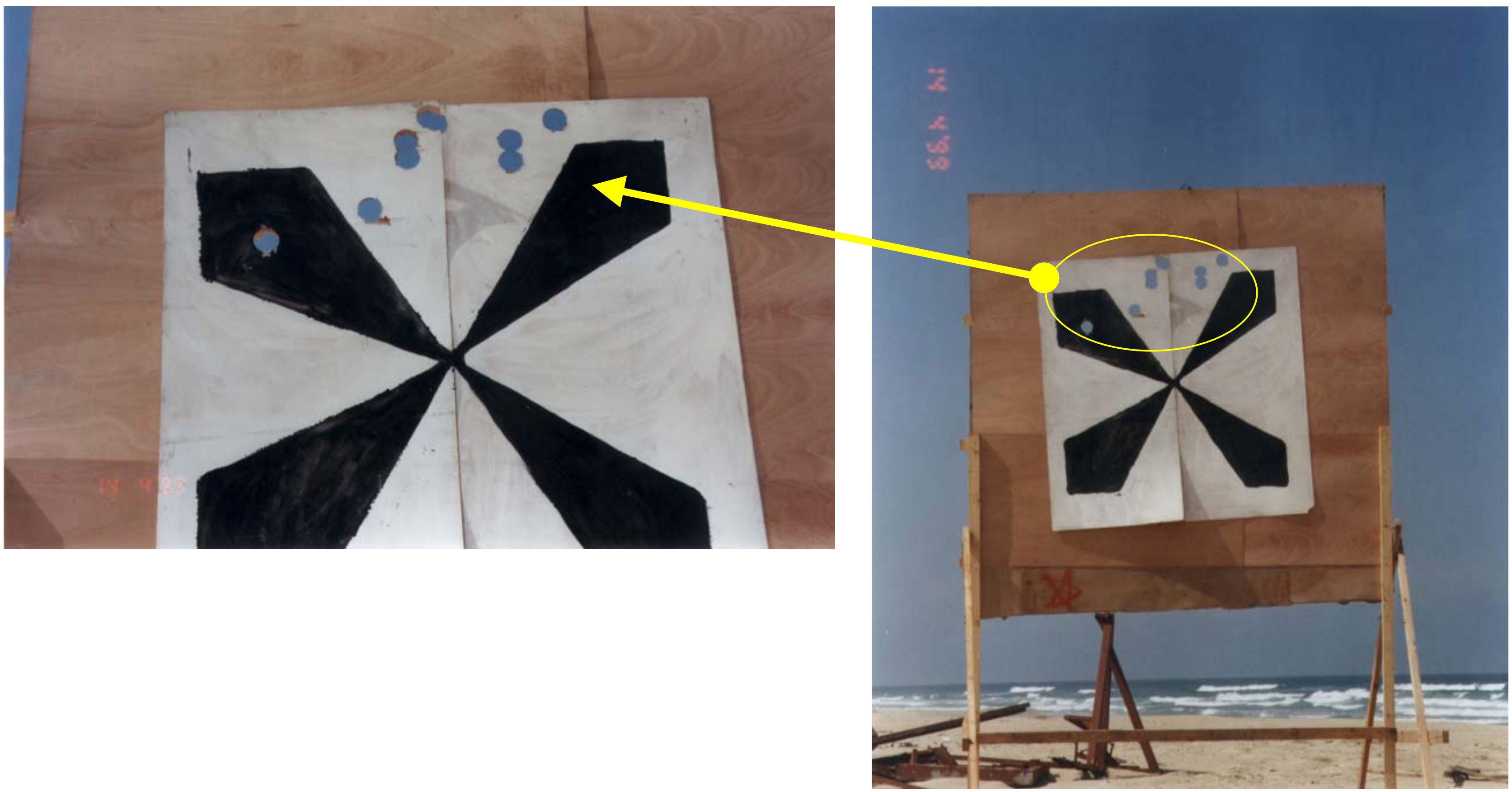
M456 / IMI M152/3

(Reference)

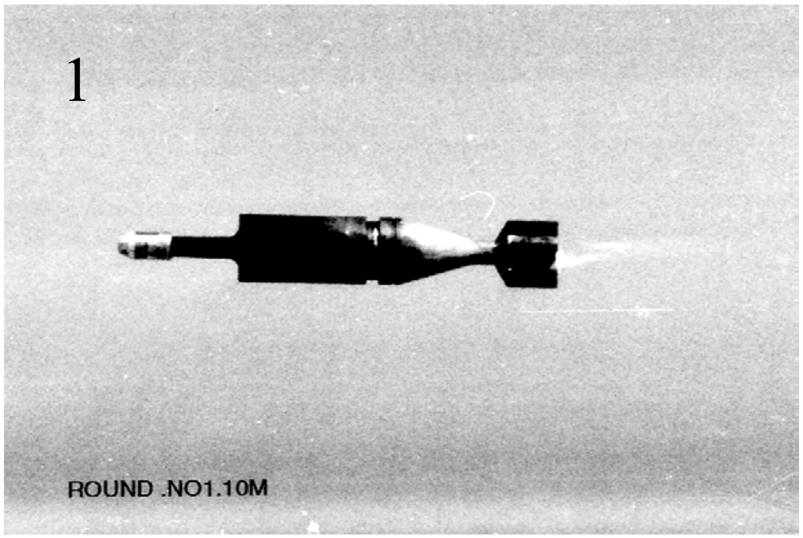


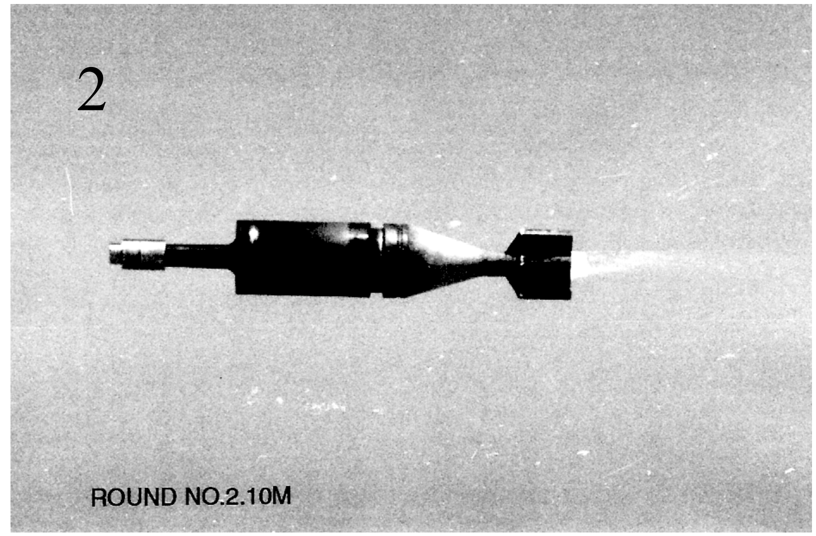


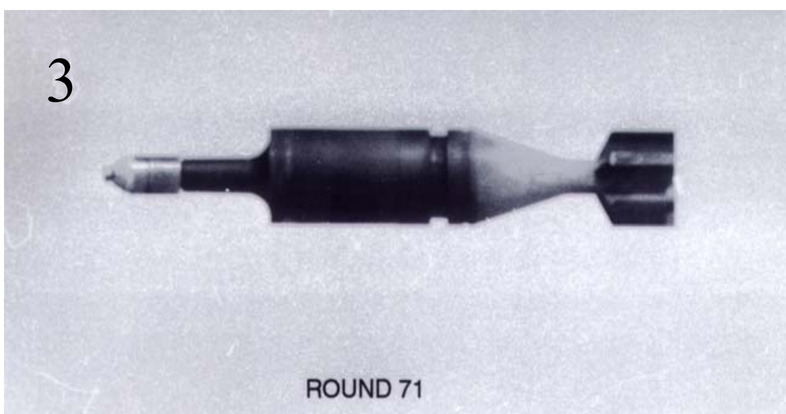
❖ Dispersion / accuracy (2,000 m)

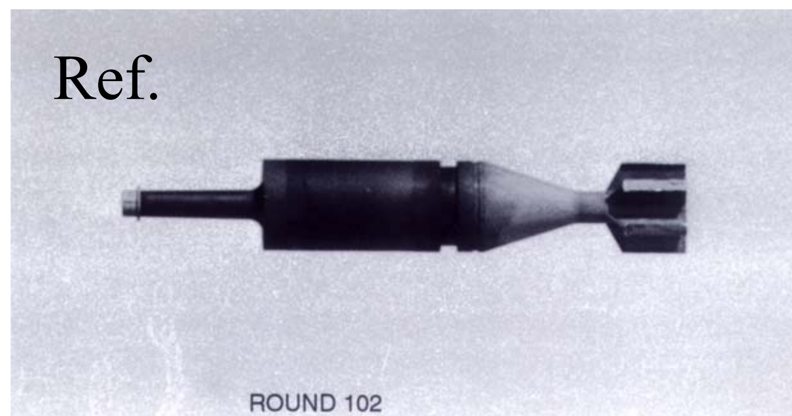


❖ Ballistically matched trajectory

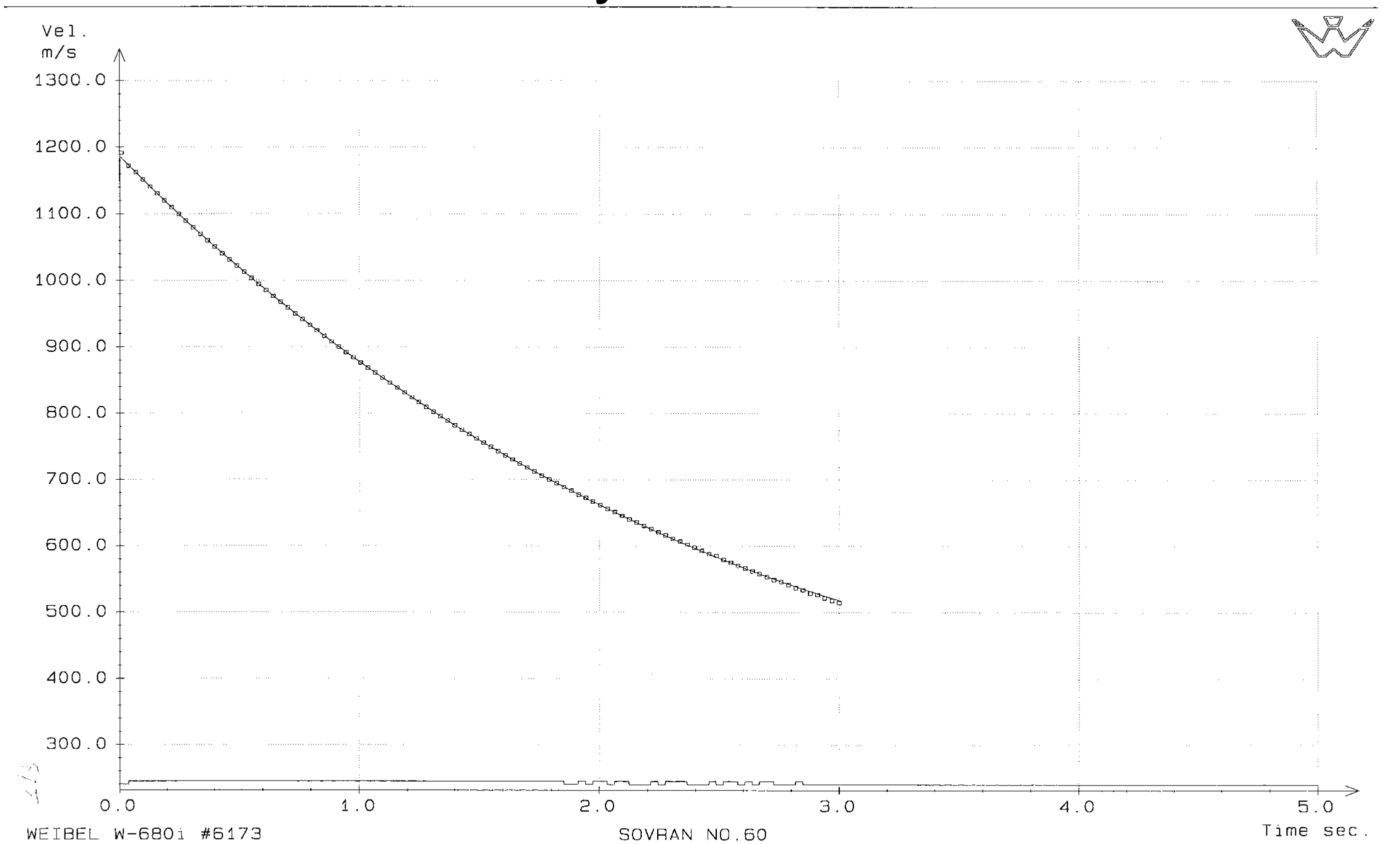








Velocity vs. Time



Final Ballistics test - IMI M152/6

- **Safety Firing Test**
  - Simulated cartridge with pyrotechnic (flash) composition

Firing test – Yaw

- Wave length
- Dynamic stability

Penetration tests

- M152/3 warhead
- RHA target (225 mm plate at 120-m from the muzzle)
- 60º NATO
- Alternator axle in the "FUZAMAN":

bar / tube

$\bar{P}$= **465 mm** | $\bar{P}$= 440 mm

Significantly better then M456

Front Side

Back Side

❖ Dynamic arena test (AP mode)

❖ Reliability - Detonation above the ground (AP mode)

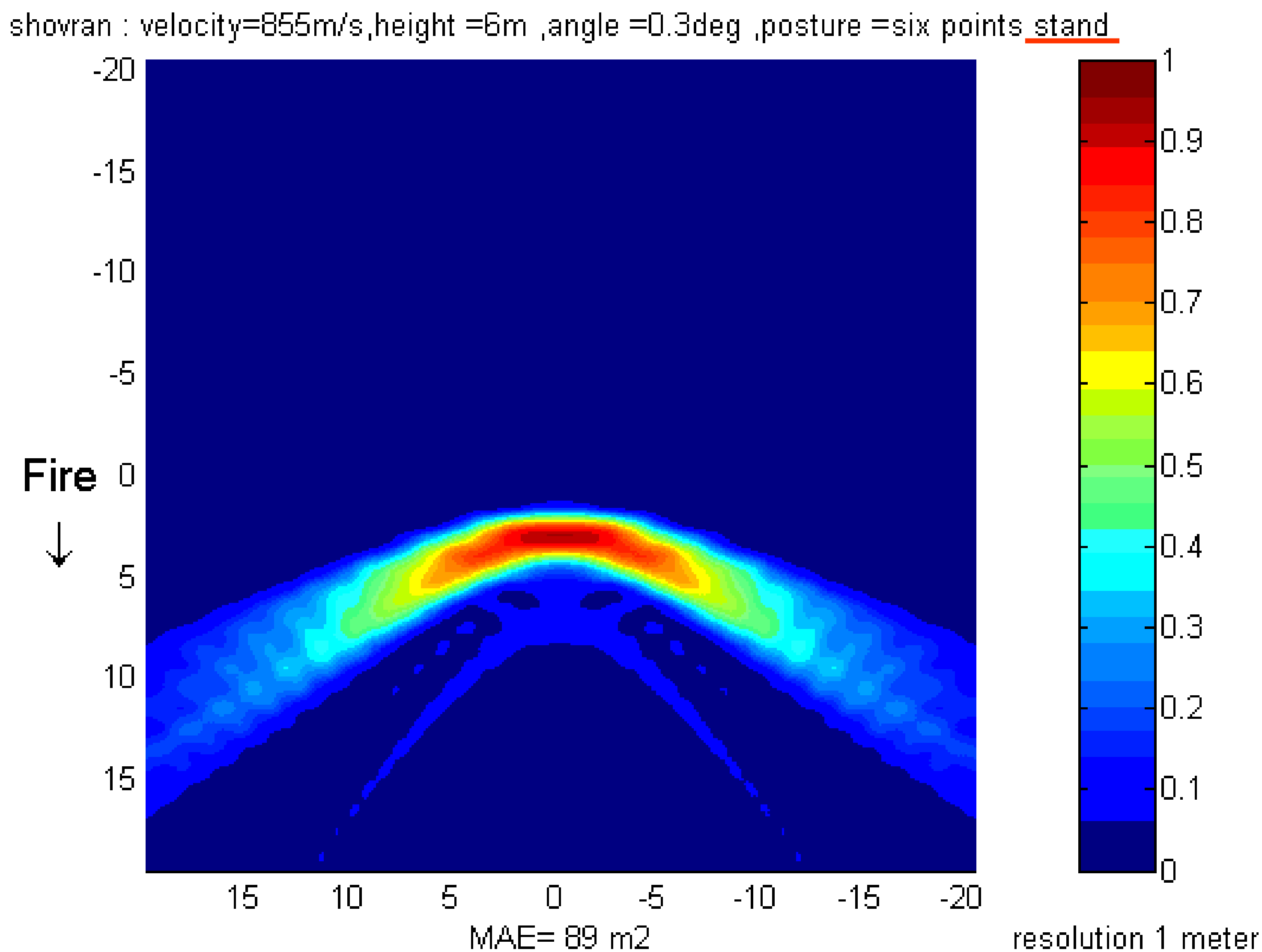
❖ Operational Research -

- *Lethal Area - 20x50 m*
- *Criteria: Personnel Enemy*
  Standing / Prone 30" assault
- *Firing: 1 round / series of 3 rounds*
- *Remaining velocity - 855 m/sec (2,000 m)*
- *Angle of fall - 0.3 deg.*

❖ Results -

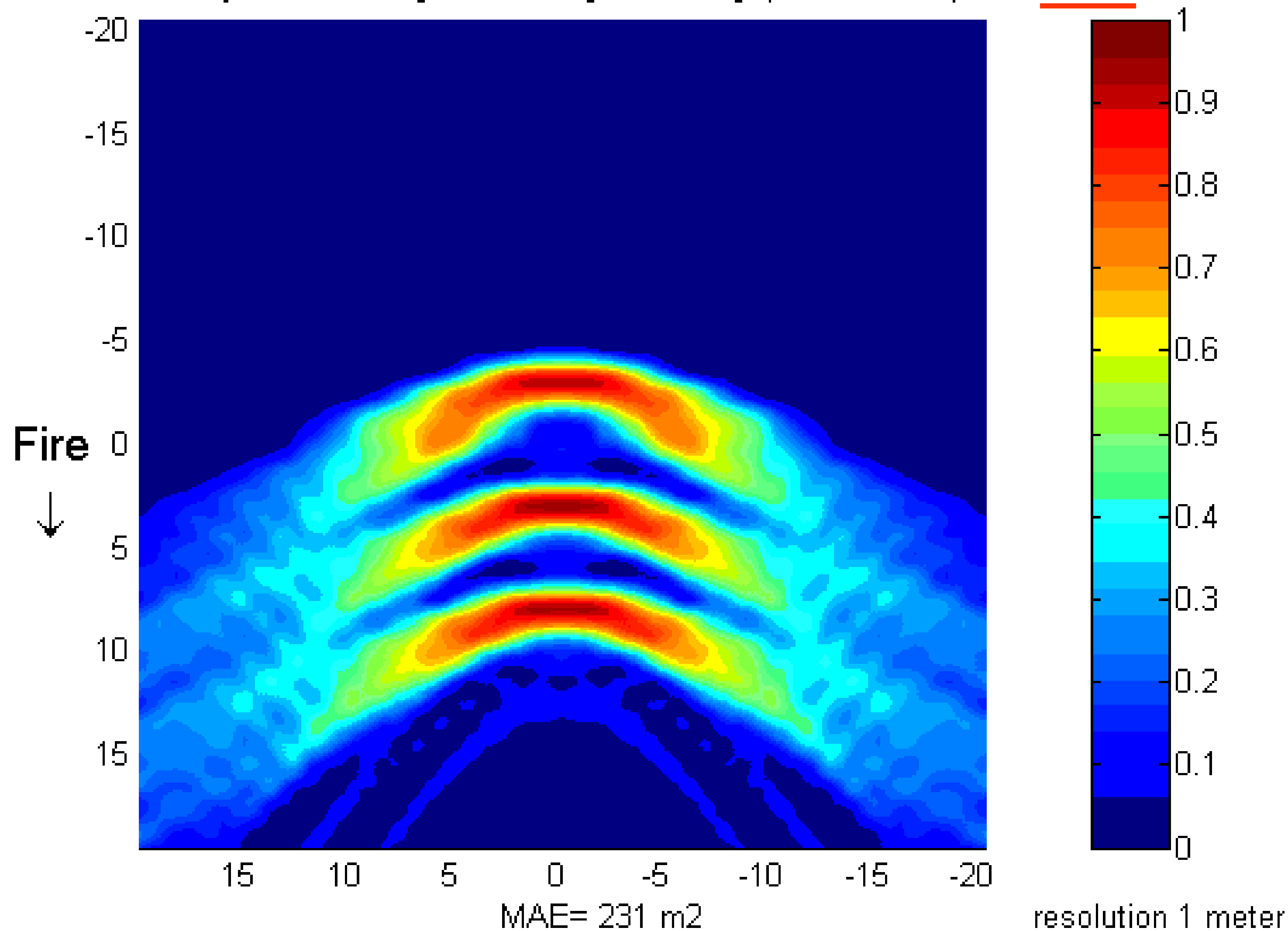
- ✓ The optimal height of detonation (above ground) - 6 m
- ✓ Mean Area of Effectiveness (MAE) / Lethal Area and Incapacitation Probability Maps

Incapacitation Probability (ρ_k) Map

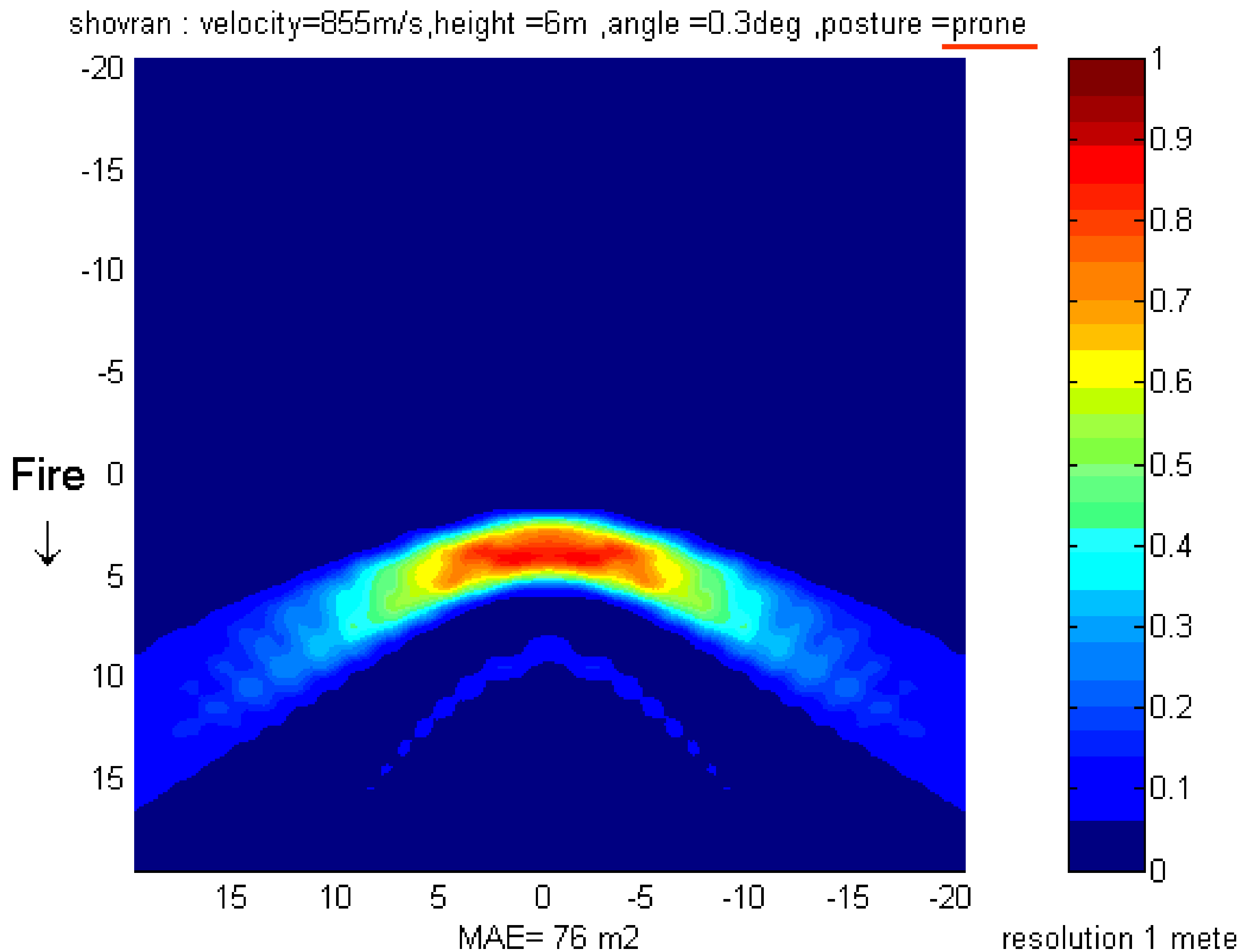


Incapacitation Probability (ρ_k) Map

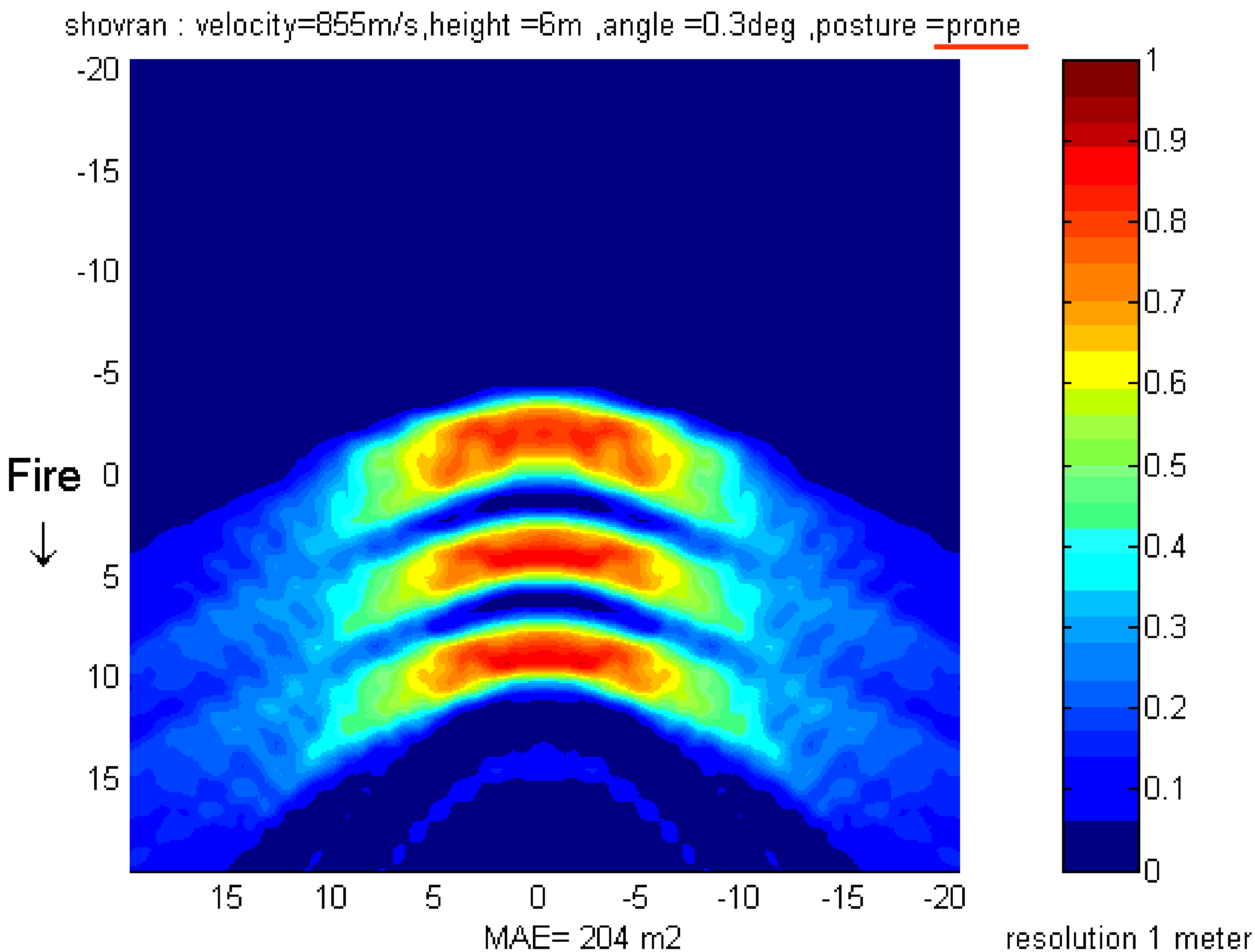
shovran : velocity=855m/s,height =6m ,angle =0.3deg ,posture =six points stand



Incapacitation Probability (ρ_k) Map

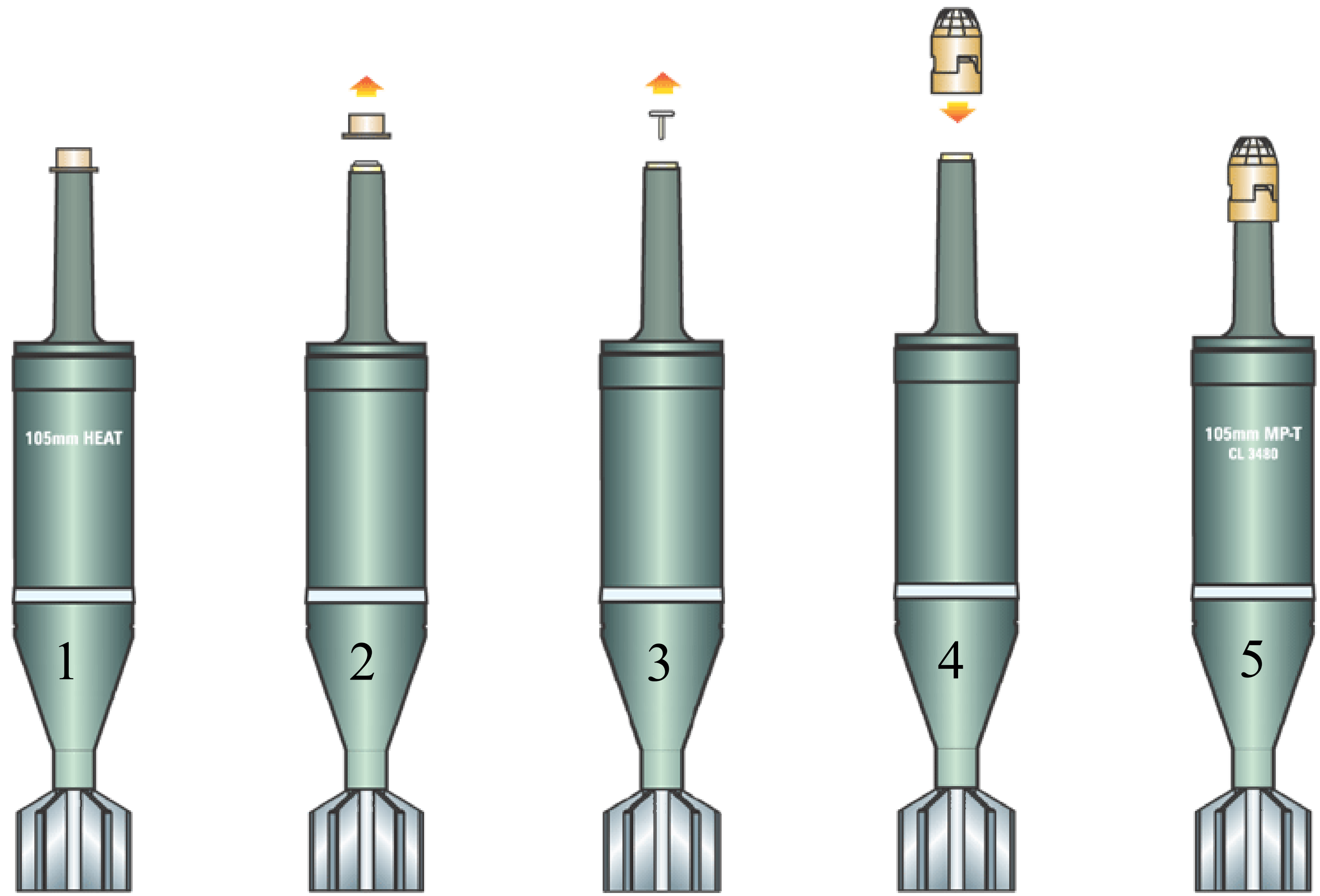


Incapacitation Probability (ρ_k) Map

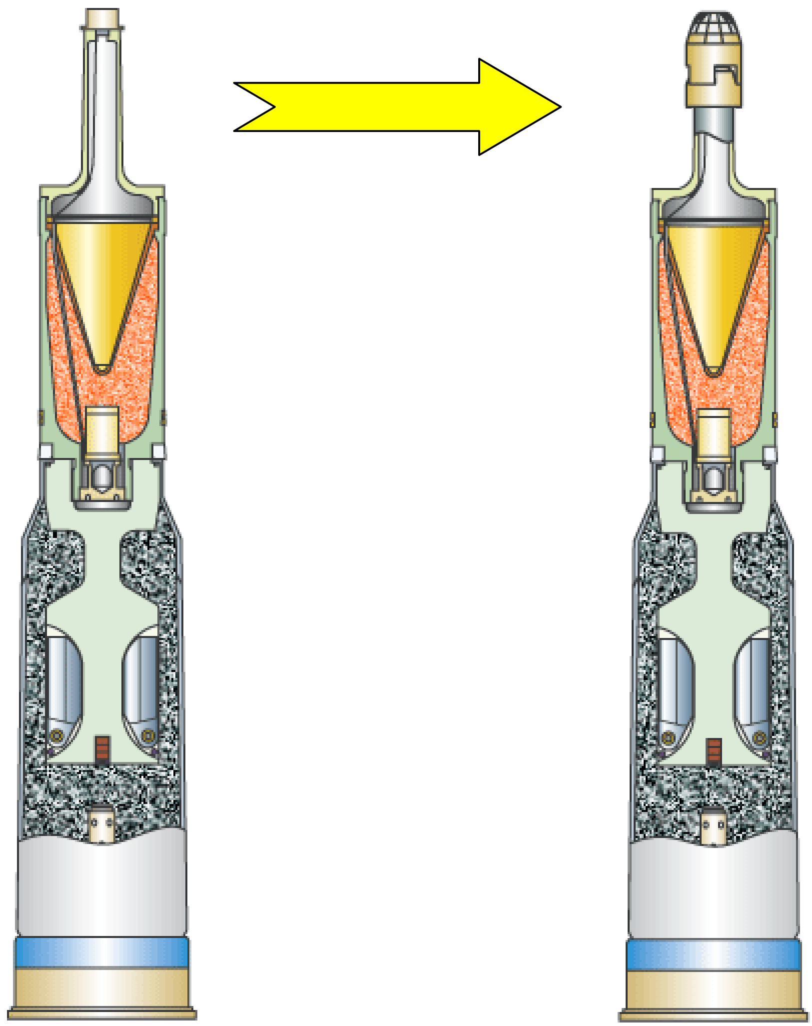


❖ Grazing (impact switch) Functioning test

Conversion of M456 or IMI M152/3 to <u>IMI M152/6 at field level</u>



Growth Potential – 120 mm



CHARACTERISTICS

Cartridge

Weight	25 kg
Length	984 mm

Projectile

Weight	15 kg
Length	726 mm
Body material	steel
Explosive	Comp. B, 1.8 kg

Other Components

Cartridge case	combustible
Propellant	M30, 5.6 kg
Primer	electric, M4513
Fuze	dual mode, electronic time/point initiated base detonation (ET-PIBD)

BALLISTIC PERFORMANCE

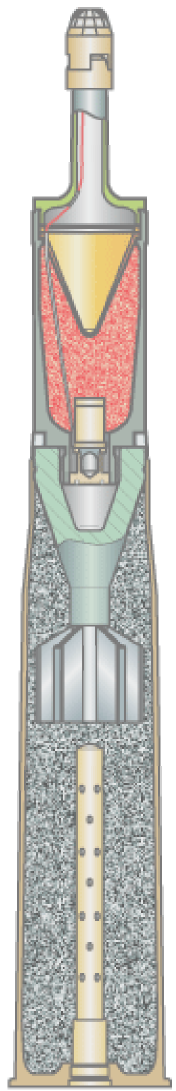
Muzzle velocity	1078 m/s
Accuracy, typical SD	0.25 mil, H and B
Effective range	more than 3000 meters
Set for time (=distance) functioning	projectile detonates 5 m above ground

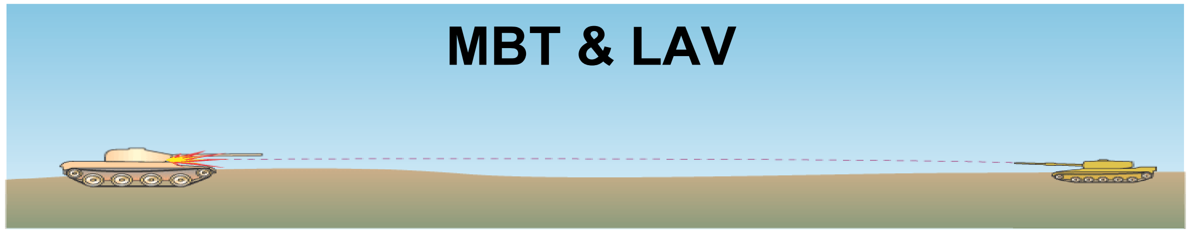
BALLISTIC PERFORMANCE

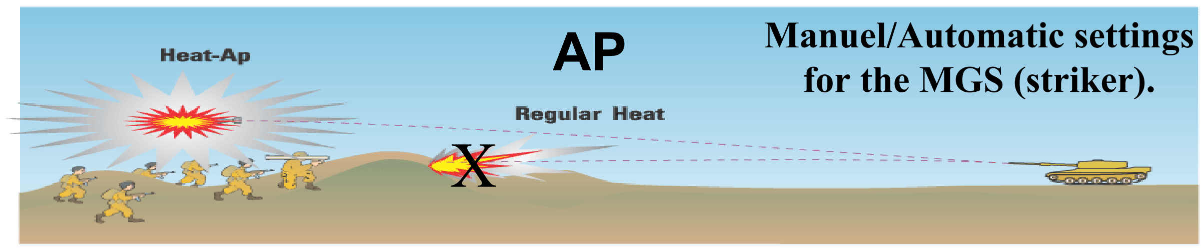
Temp. limits, firing	-40 to +52°C
Temp. limits, storage	-40 to +63°C

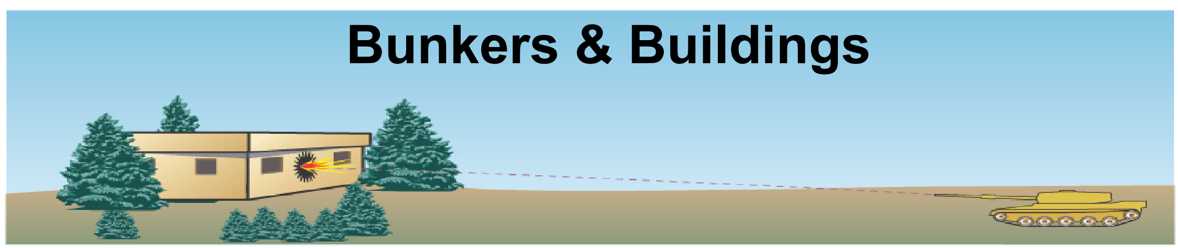
Various tests IAW MIL-STD-810D and NATO standards

Summary - Targets and Operating Modes


M152/6







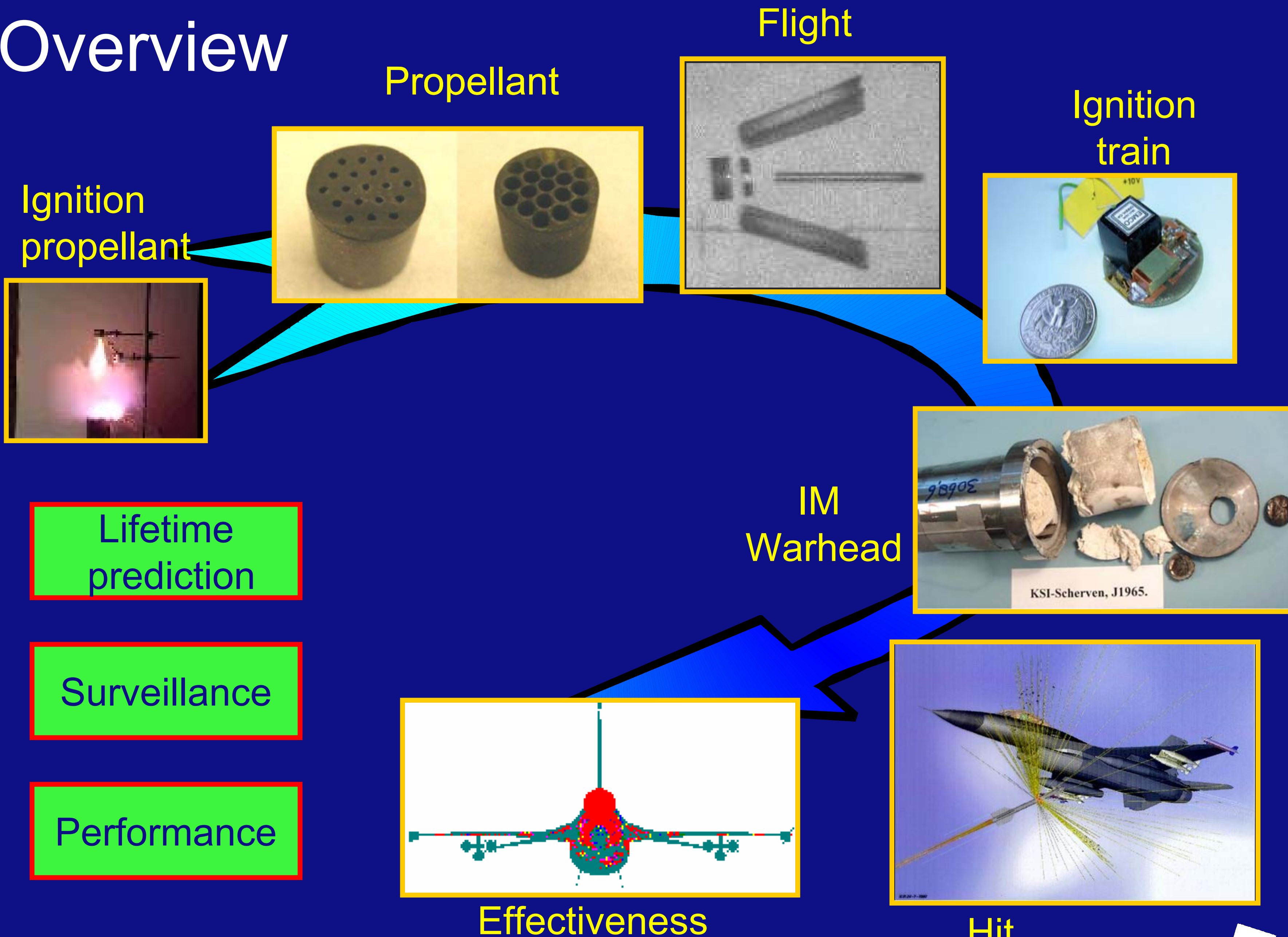
Grazing (safety)

If the projectile grazes the ground, an impact switch functions and detonates the warhead (no duds).

Development, evaluation and lifetime prediction of medium and large caliber ammunition

Gert Scholtes, 40th GARM, April 25-28, 2005

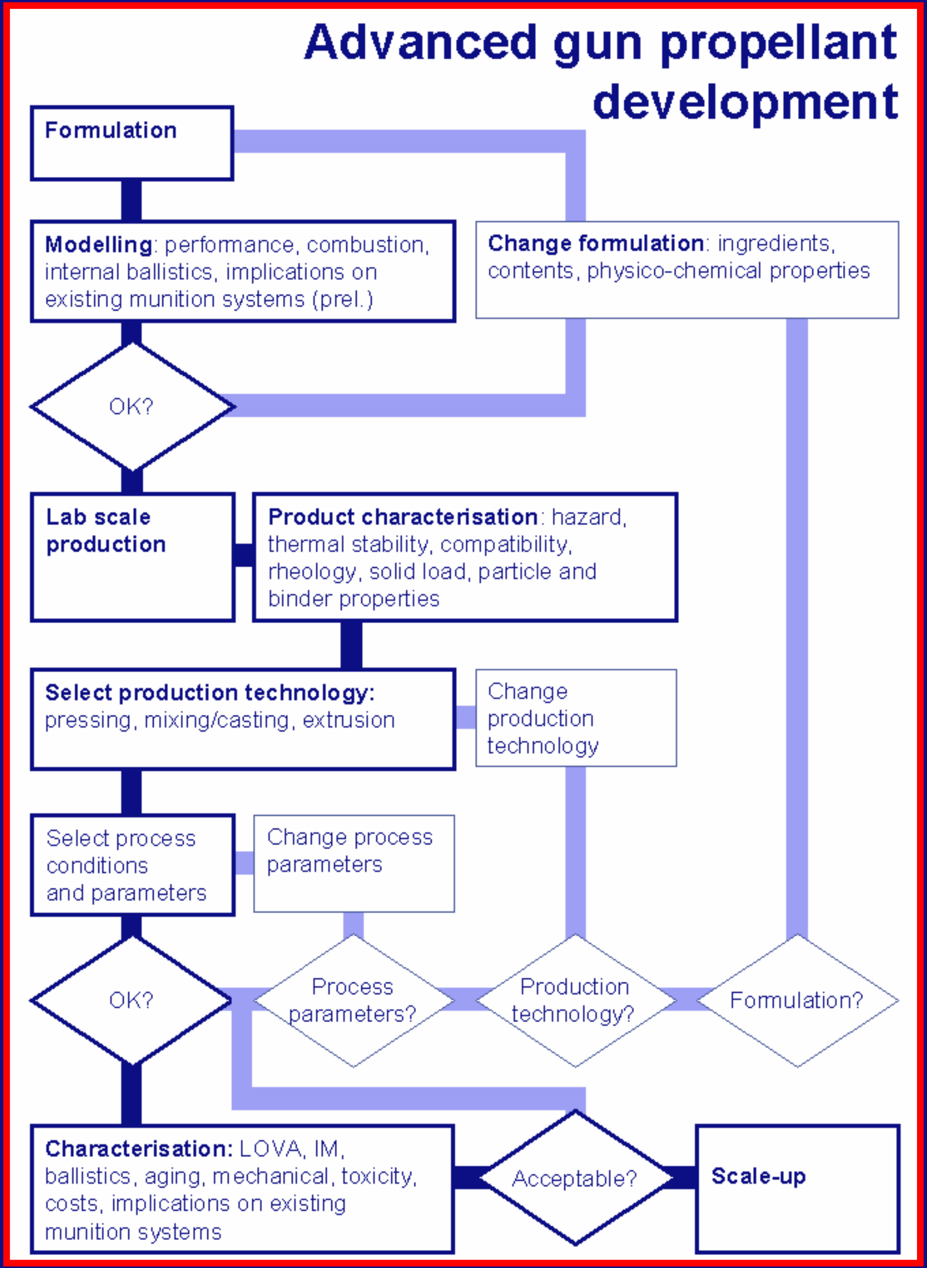
Overview



Lifetime prediction

Surveillance

Performance

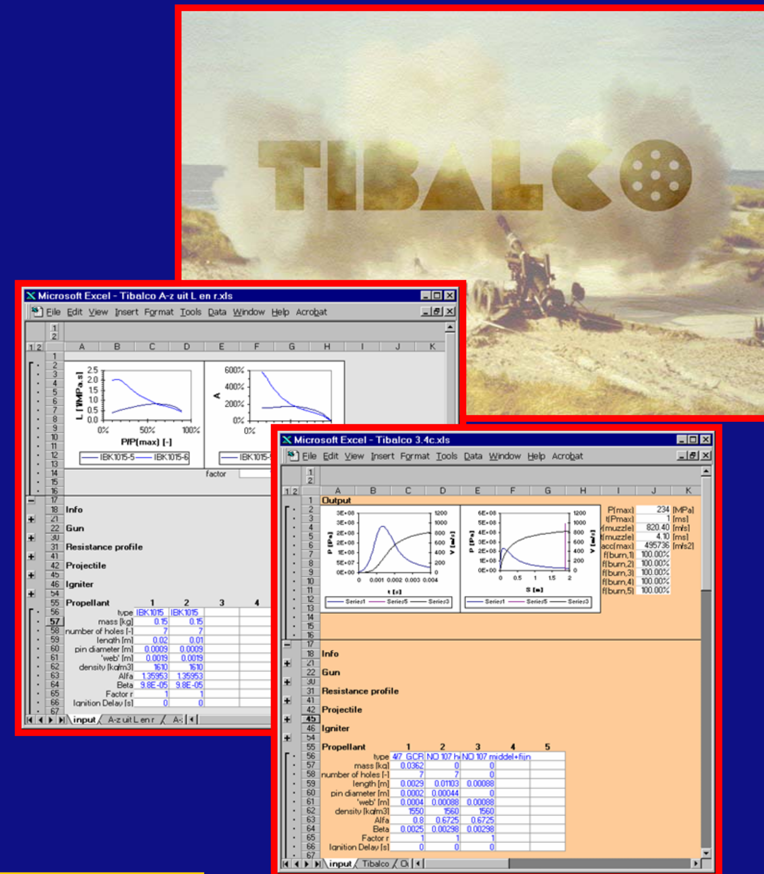


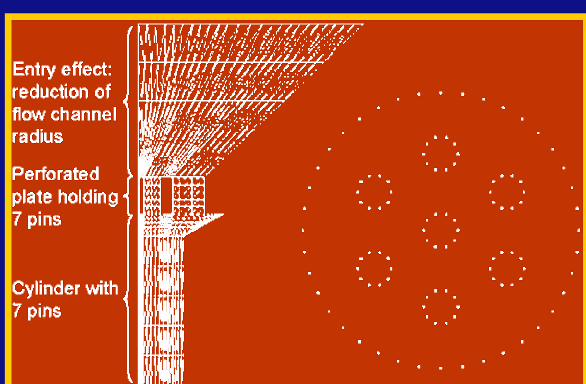
Propellant: Capabilities

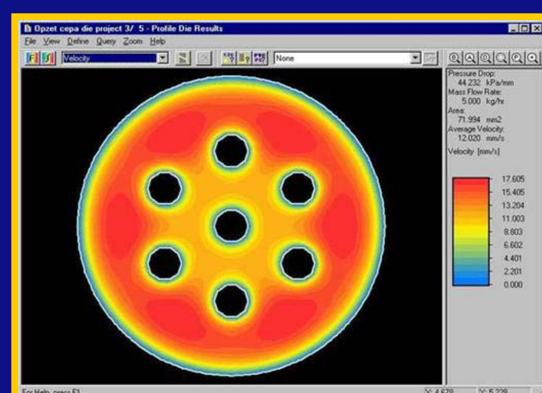
- Modeling & simulation
  - Thermodynamics
  - Processing
  - Internal ballistics
- Lab-scale production
  - Up to ~ 1 kg (analyses)
- 'Small scale' production
  - Up to ~ 300 kg
- Performance testing
  - Closed & vented bombs
  - Test guns
  - Thermal, IM & safety properties

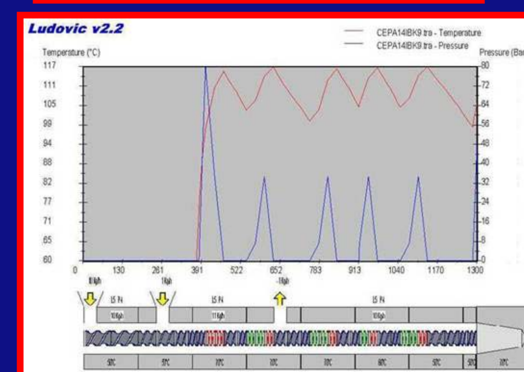
Propellant: Modeling & simulation

- Thermodynamics
  - NASA-Lewis, Blake, ICT-code
- Internal ballistics
  - TIBALCO (TNO Internal BALlistic Code)
- Processing
  - Rheology
  - Extrusion & shaping processes









Propellant: Processing

45 mm twin-screw extruder

Propellant: Test facilities

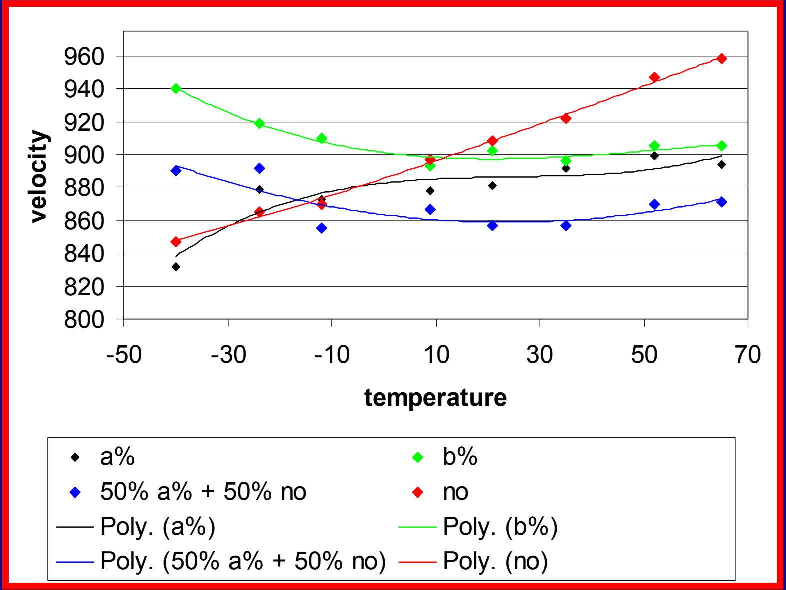
- Closed Vessels
  - 43.5 cc / 130 cc LPCV (20 MPa)
  - 25 - 700 cc CV (150 – 500 MPa)
  - 400 cc HPCV (1000 MPa)
- Erosivity & burning interruption tests
  - 130 cc – 20 MPa
  - 500 cc – 150 MPa
- Plasma ignition
- Instrumented guns
  - .50 gun
  - 29-mm / 50-mm / 78-mm accelerator

CV's (25 – 700cc)

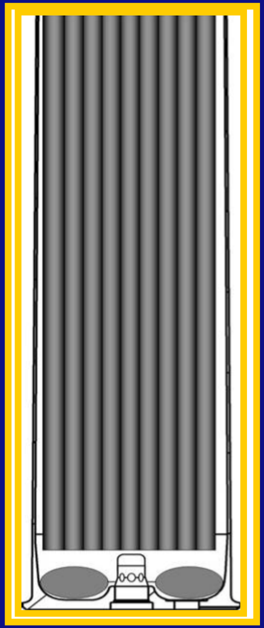
Vented HPCV and catch tank

Propellant:
Examples of R&D projects

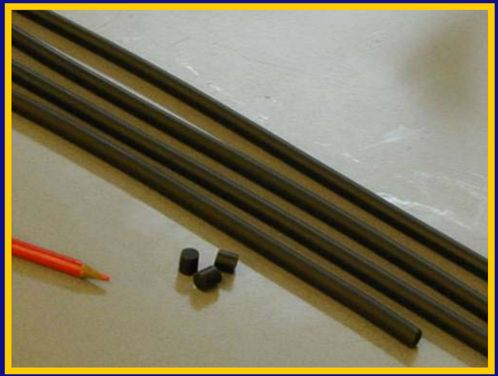
- Propelling charge development
- Temperature independent propellant
- Barrel erosion
- Ageing & lifetime assessment



Proven temperature independency



Stick propelling charges for excellent ignition behaviour



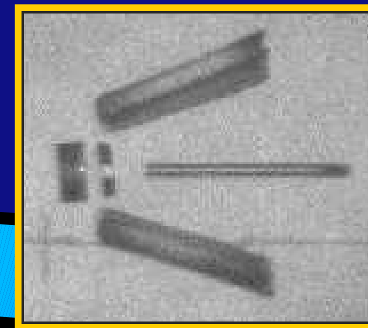
Burning properties and mechanical integrity of aged propellants

Overview

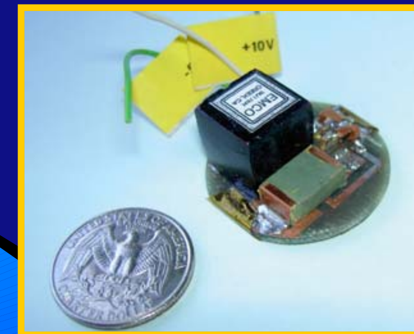
Ignition propellant

Propellant

Flight



Ignition train



IM Warhead

Hit

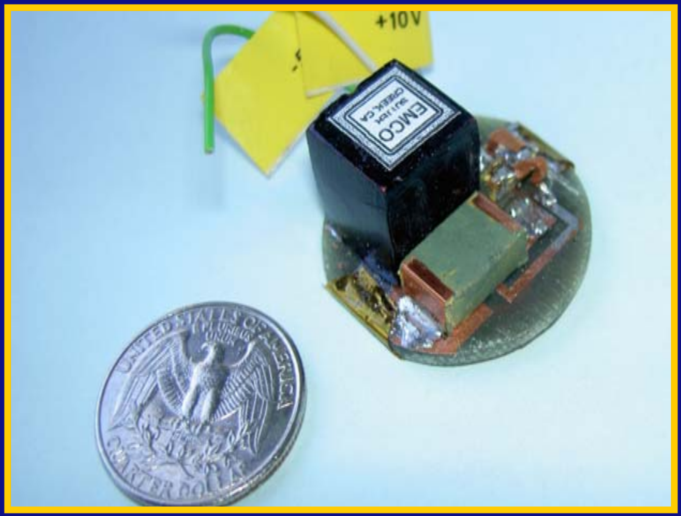
Effectiveness

Lifetime prediction

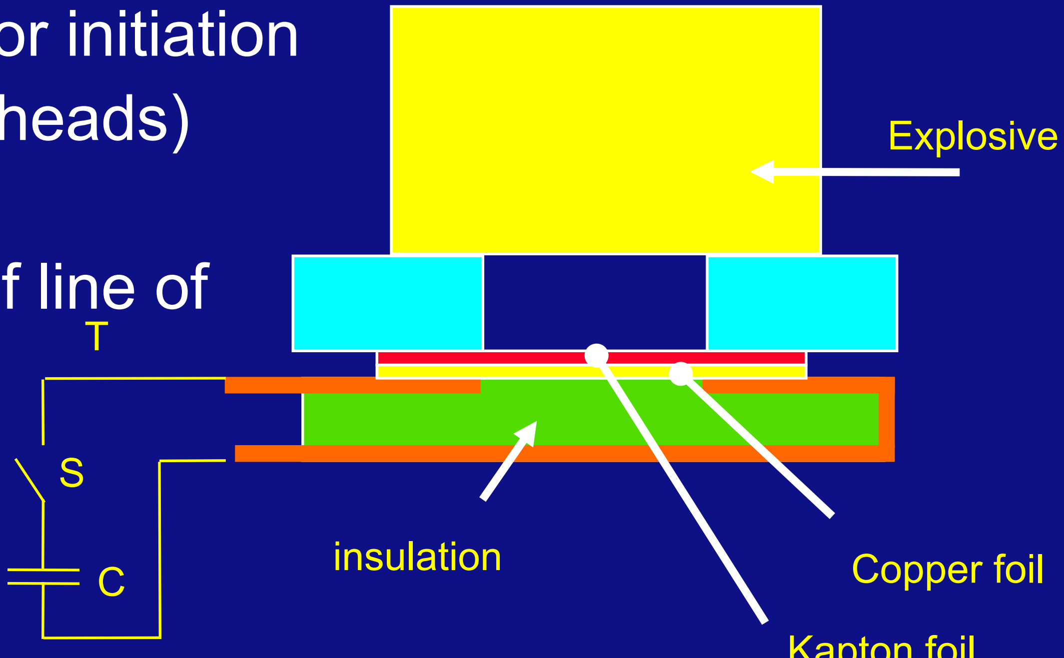
Surveillance

Performance

MEMs Exploding Foil Initiator (EFI)



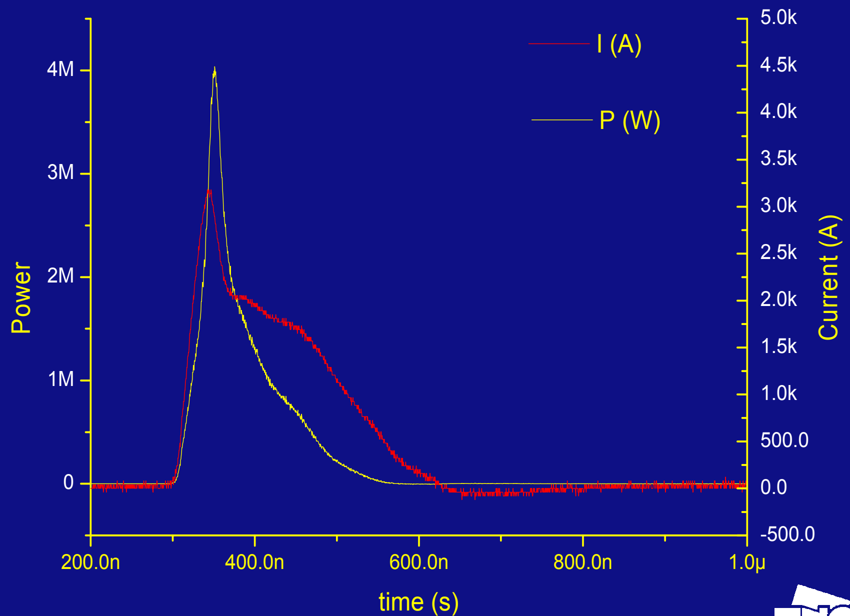
- Intrinsic safe
  - No primary explosives
  - Not sensitive to EM fields
- Precision timing for initiation (e.g. aimable warheads)
- Very reliable
- No need for out-of line of charge



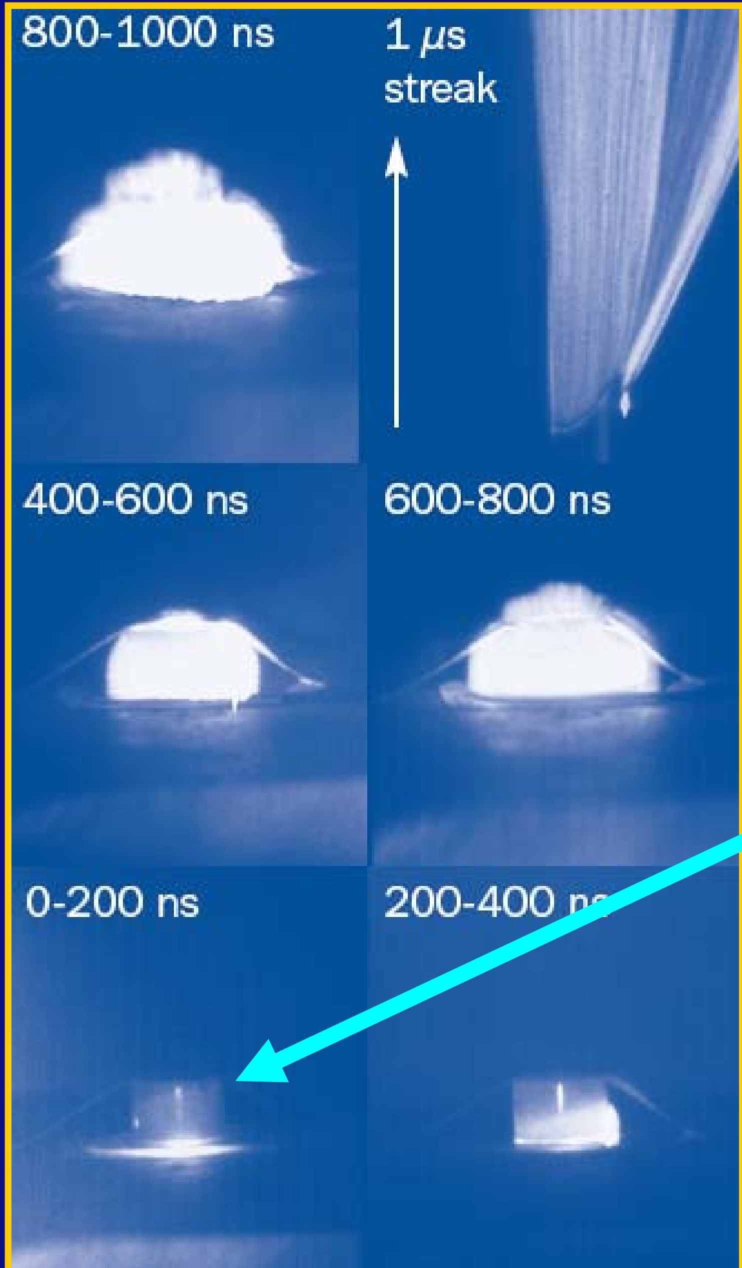
MEMs EFI: What you need

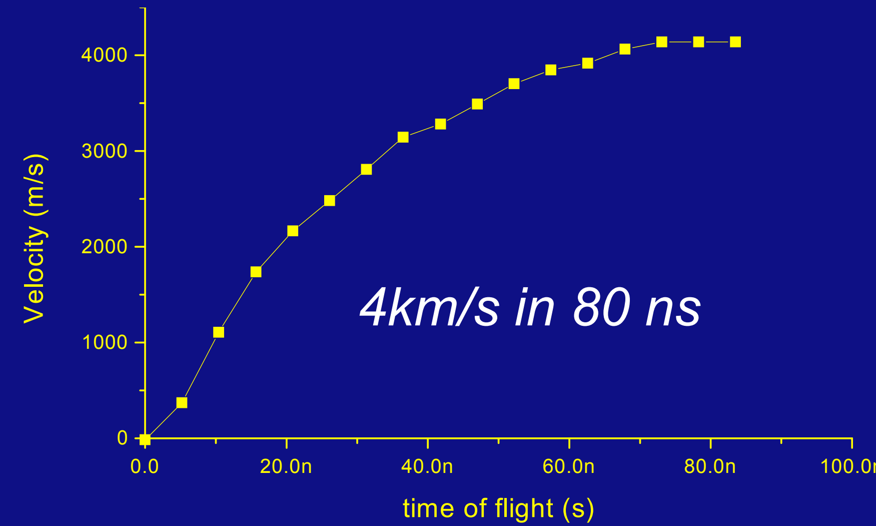
- Proper circuit with COTS components
  - Small high voltage power supply (several kV and kA)
  - Solid state Switching device
- Appropriate dimensions en properties of:
  - Exploding foil
  - Flyer plate
  - Strip-line
  - Barrel
- Pressed HNS-IV crystals at the right density

Performance of an optimised EFI-circuit

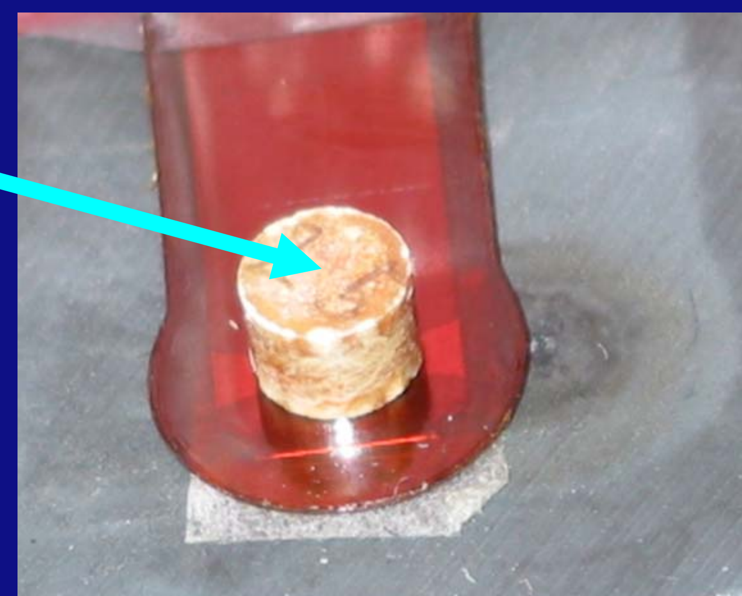


Ignition train: MEMs EFI





HNS-IV

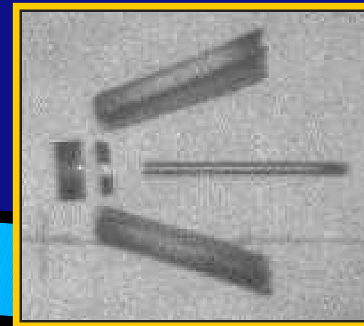


Overview

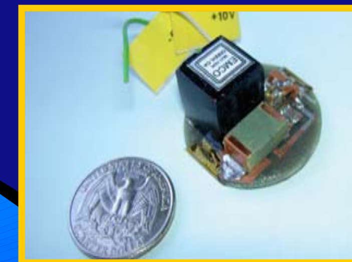
Ignition propellant

Propellant

Flight



Ignition train



IM Warhead

Hit

Effectiveness

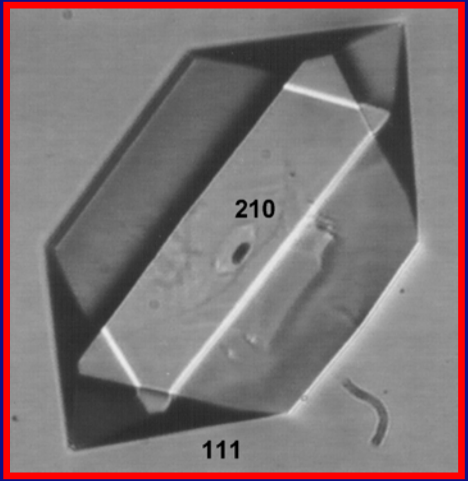
Lifetime prediction

Surveillance

Performance

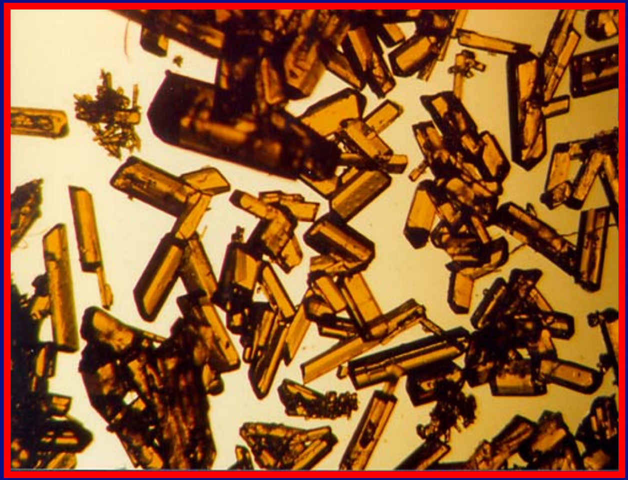
Warhead: recrystallisation to obtain the next generation of explosives

RS-RDX



Insensitive crystals for HE Warheads

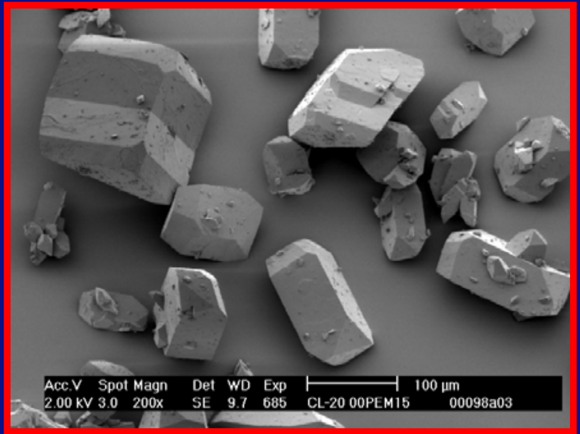
HNF



Insensitive crystals for rocket propellants

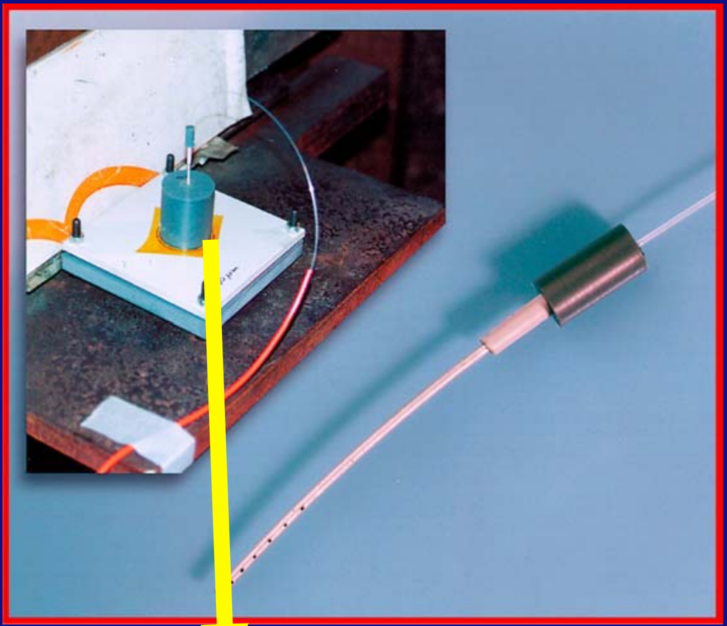
HNS-IV

CL-20

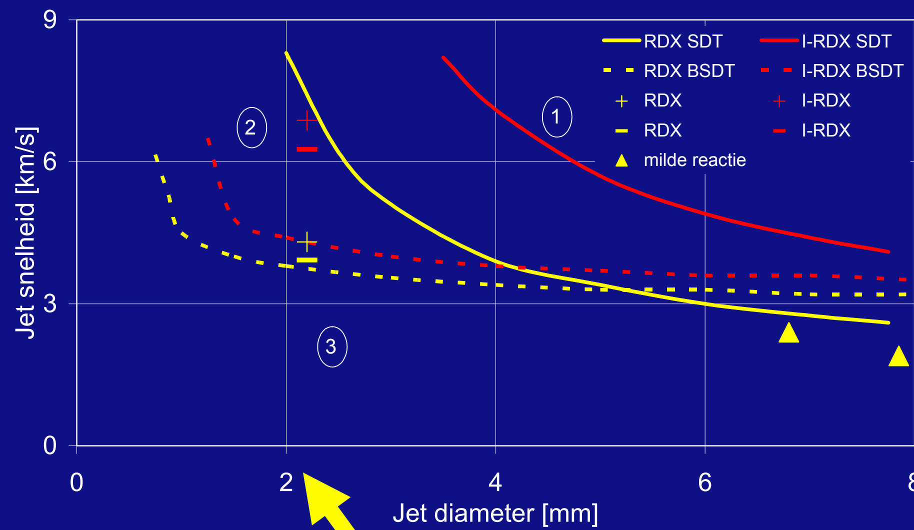


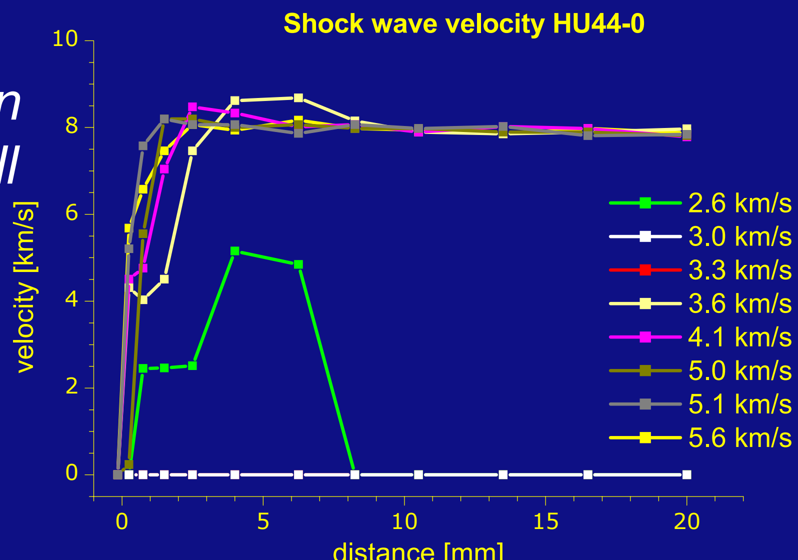
Insensitive crystals for Booster Explosives

Warhead: characterisation of explosives

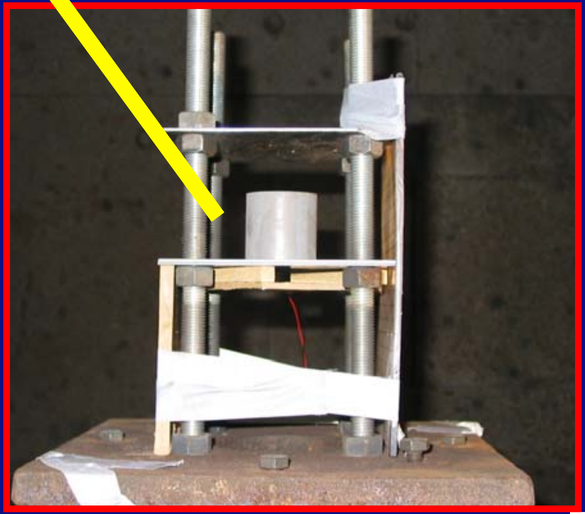


Shock initiation testing of small samples

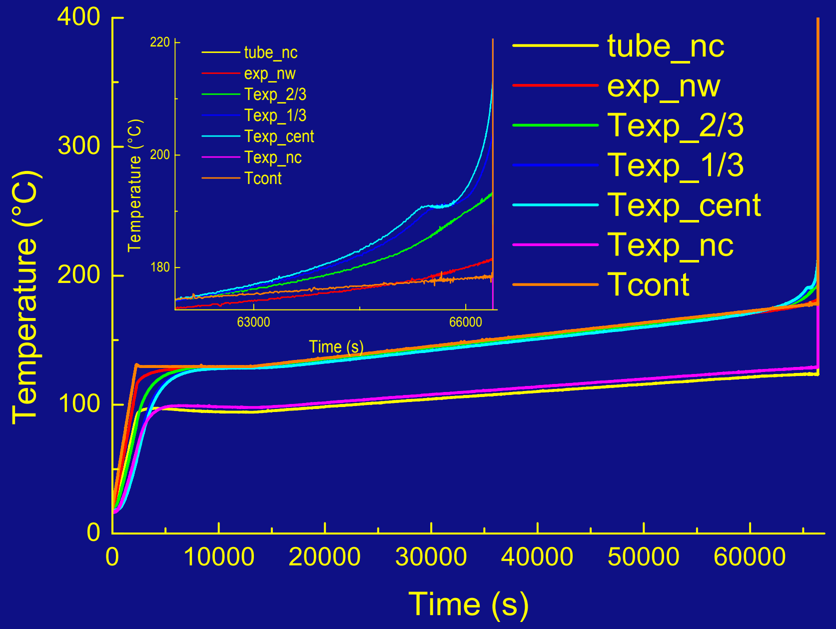


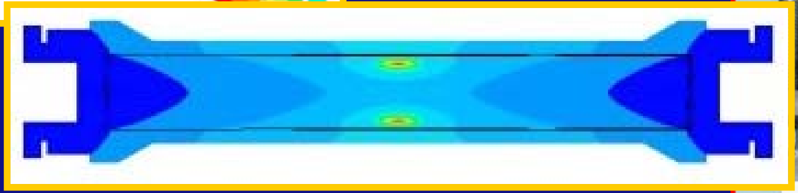


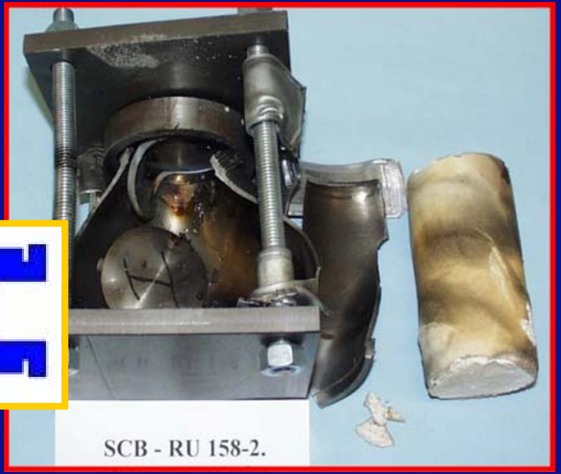
Shaped charge testing and simulation (PBXN109)



Warhead: Understanding the behaviour of explosives and IM

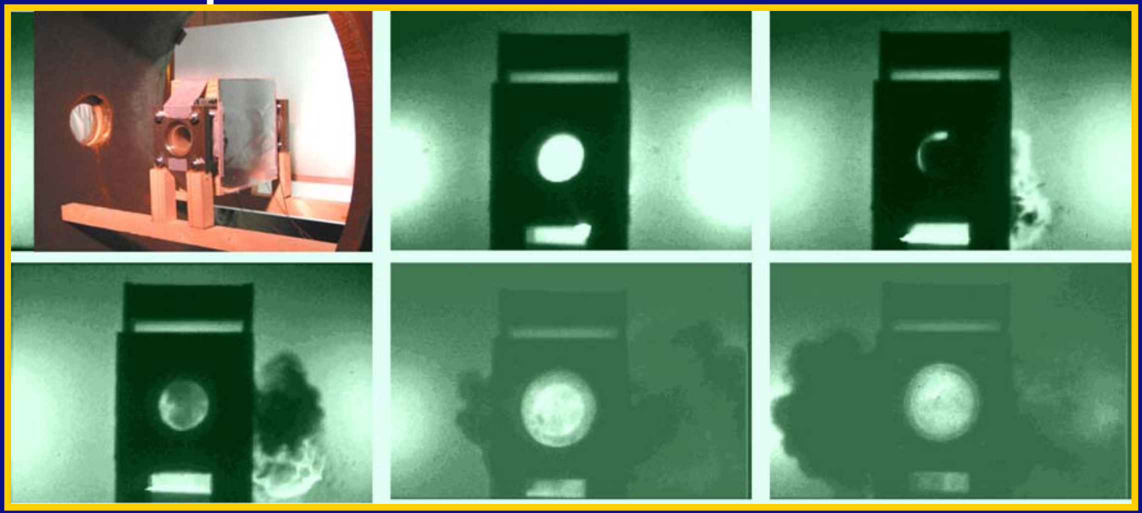




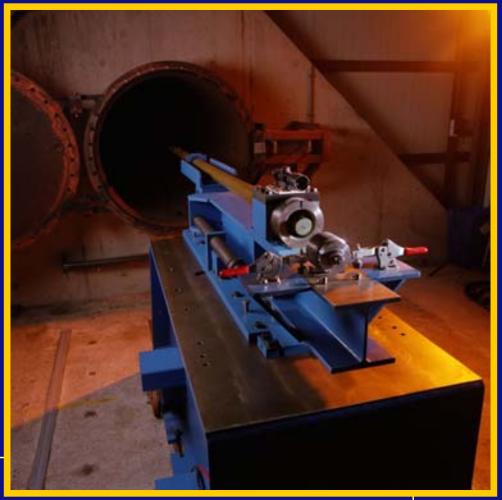


Cook-off testing and Simulation

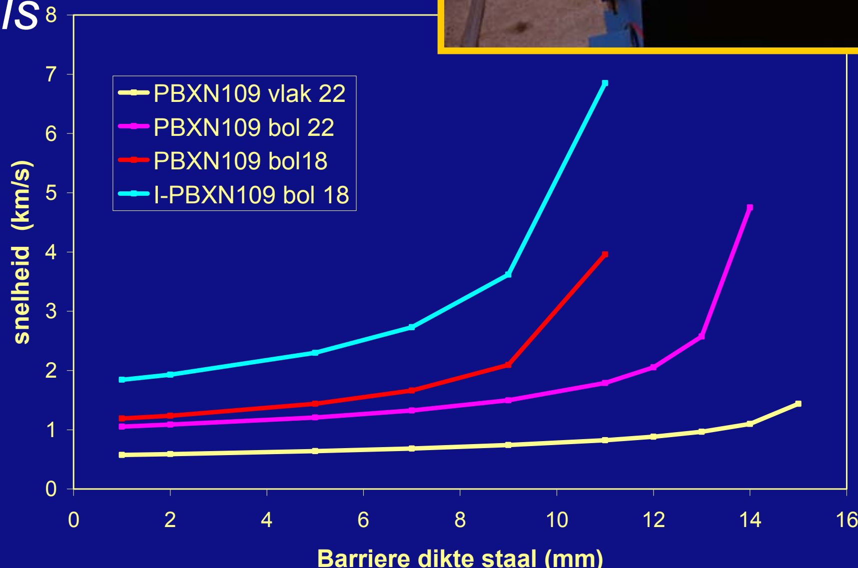
Warhead: Understanding the behaviour of explosives and IM



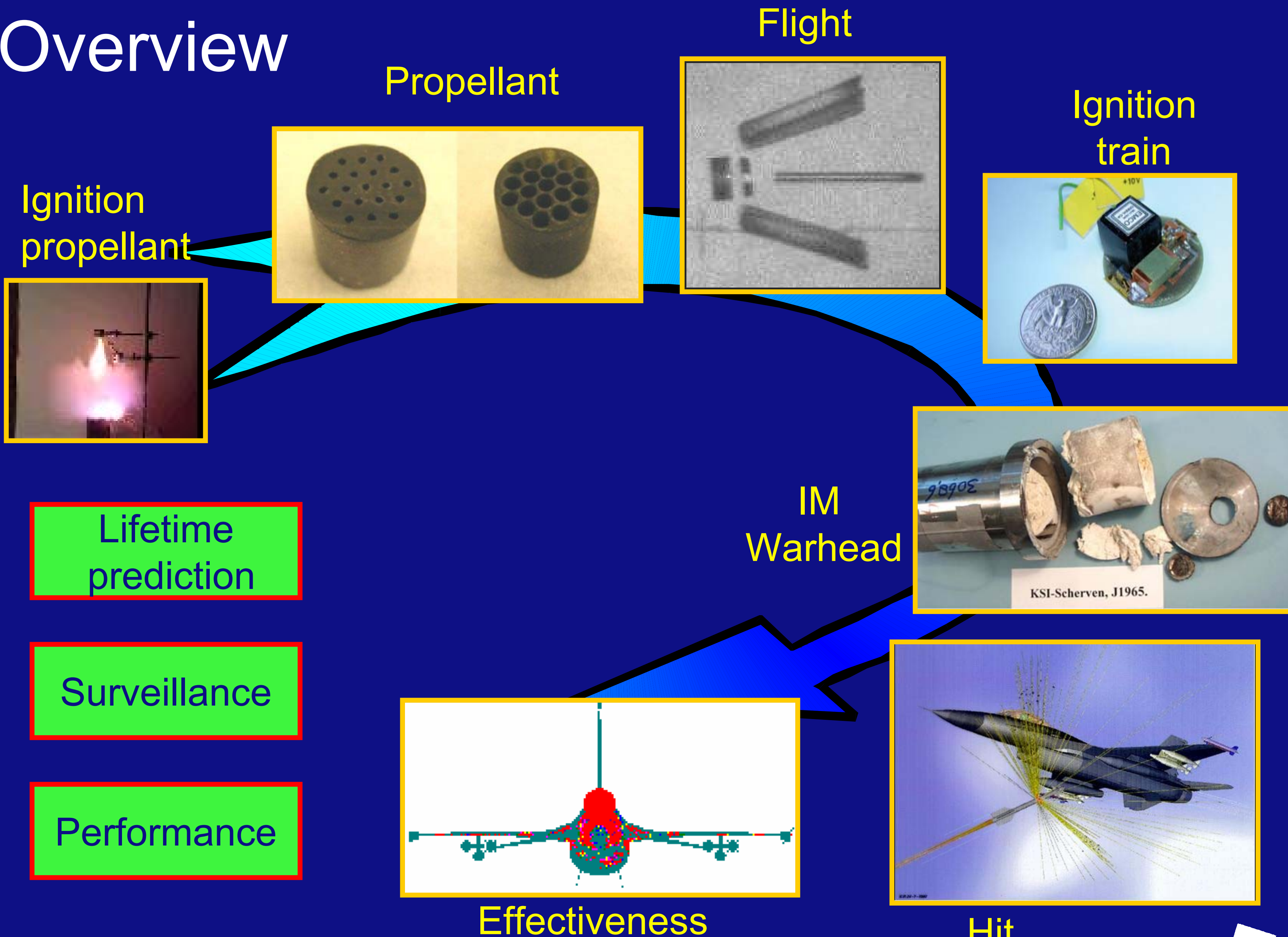
Bullet/Fragment testing and simulation



The responses of a confined materials after the impact of a fragment.



Overview



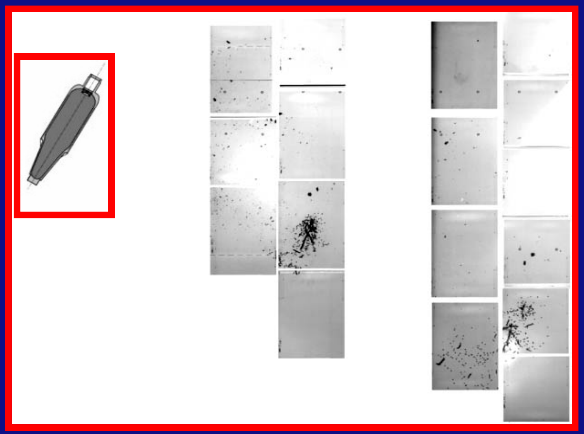
Lifetime prediction

Surveillance

Performance

Effectiveness: Fragmenting ammunition testing

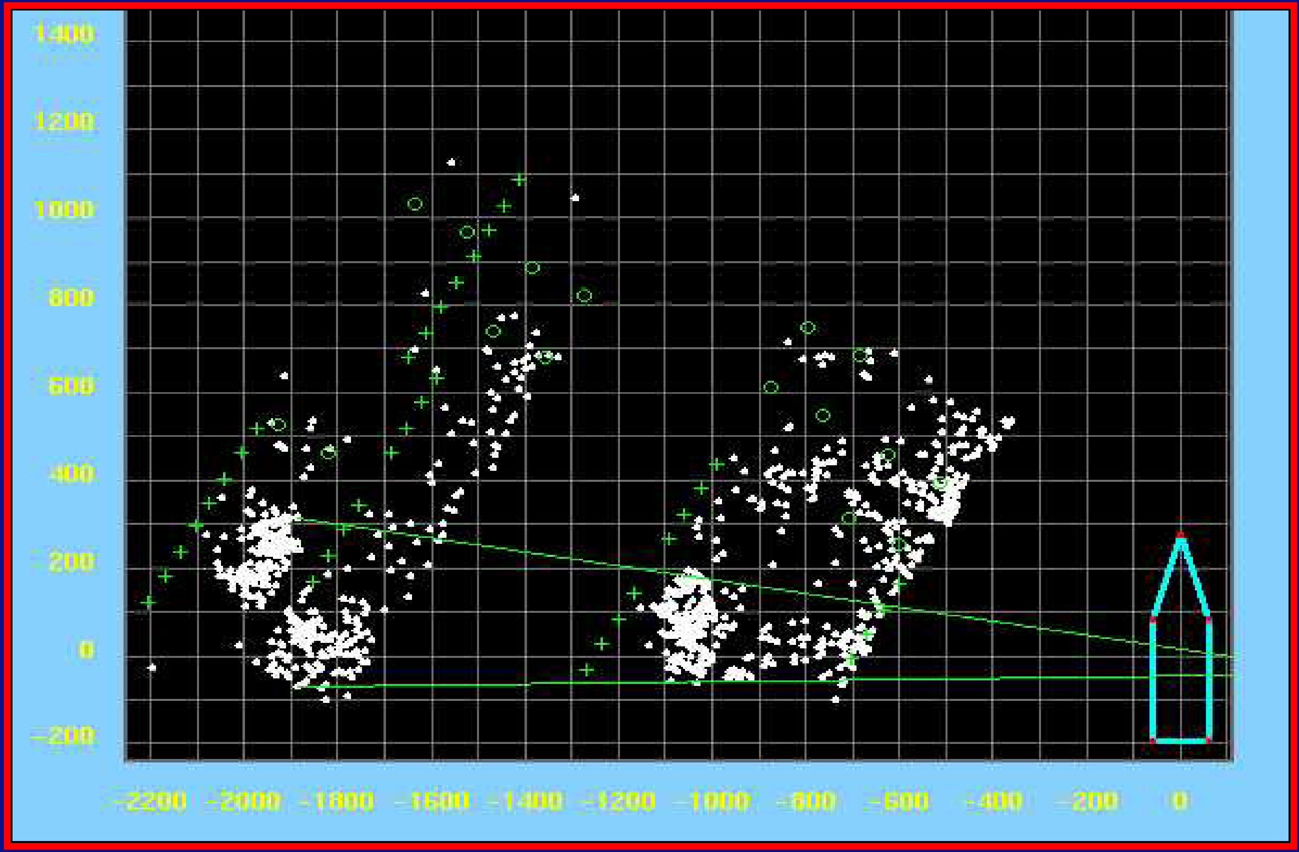
- 60 m range for HE ≤ 76 mm
- 200 m range for KE ≤ 40 mm
- Bunker for ≤ 25 kg TNT



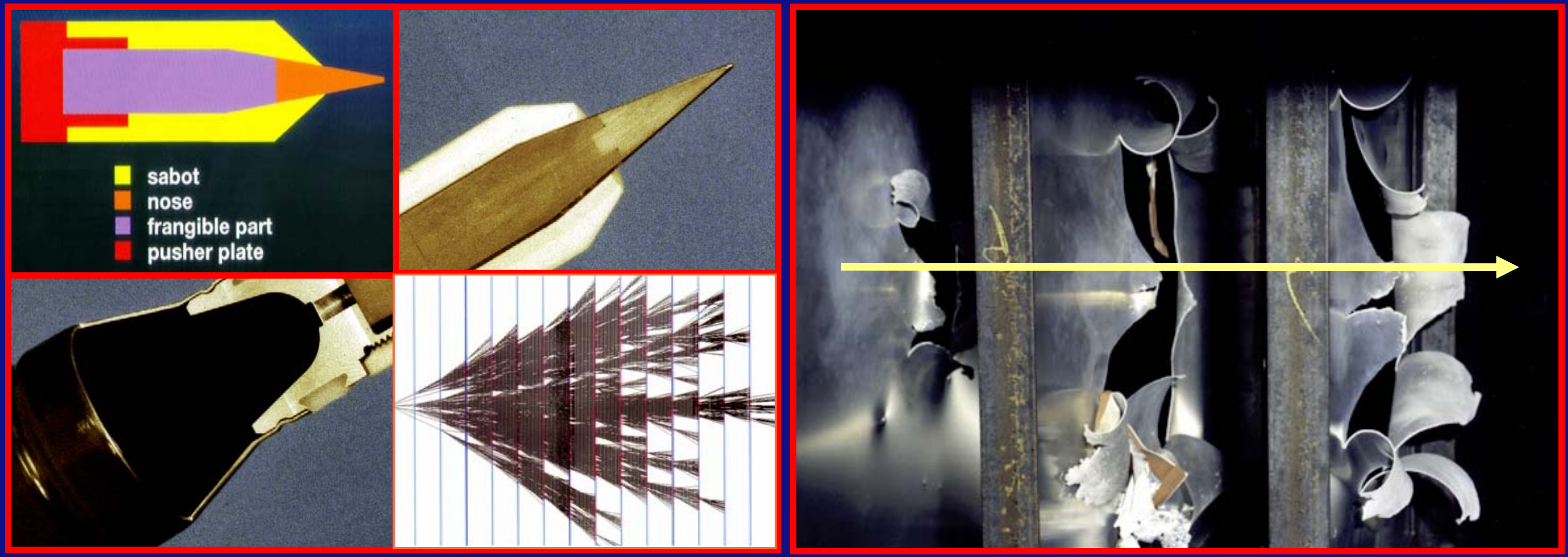
- Fragment cloud analysis method
  - Rotational symmetry
  - Cylinder with windows
  - Cardboard soft recovery
  - X-ray shadowgraphs
  - Image processing

Effectiveness: Fragmenting ammunition testing

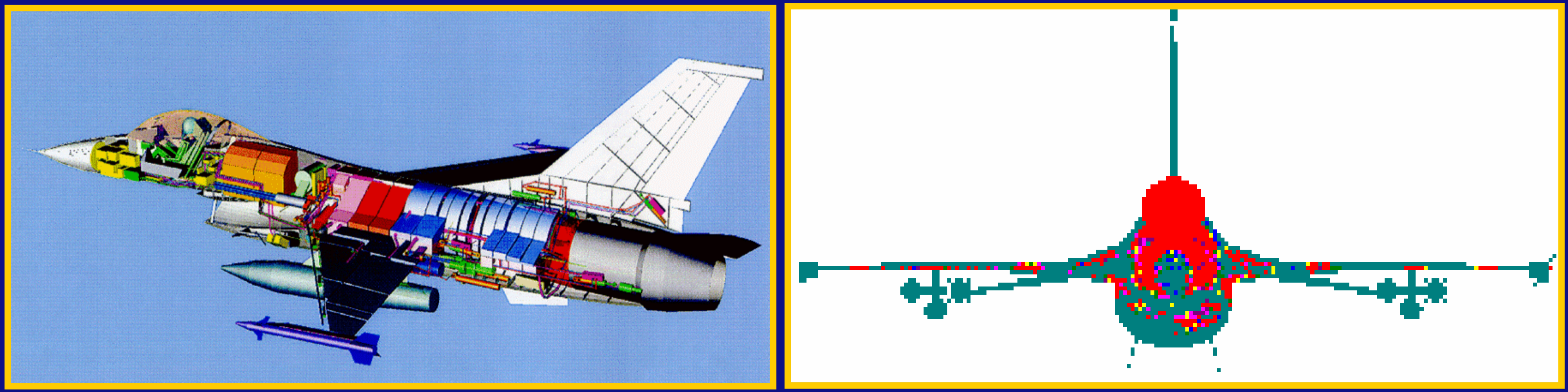
- Fragment distribution
  - Spatial
  - Velocity
  - Mass
  - Energy



Effectiveness: Munition Lethality/Platform Vulnerability



Terminal ballistics experiments & simulations

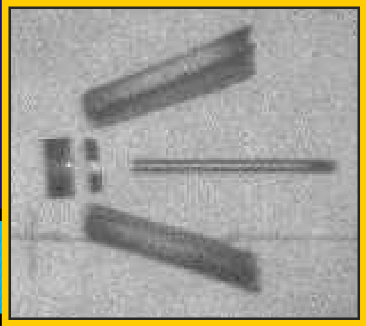


Lethality / vulnerability simulations

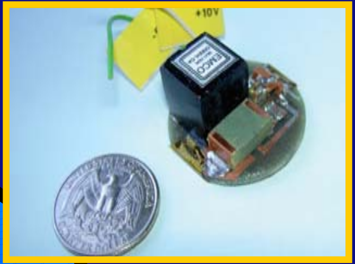
Overview

Propellant

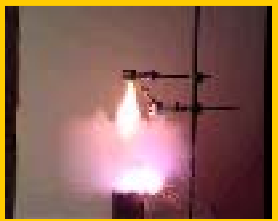
Flight



Ignition train



Ignition propellant

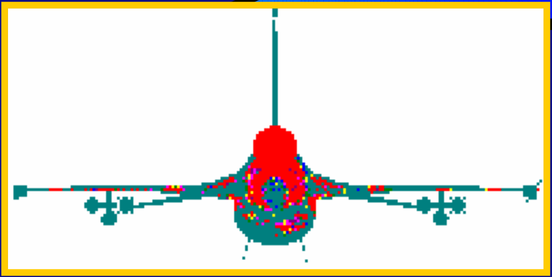


IM Warhead

Lifetime prediction

Surveillance

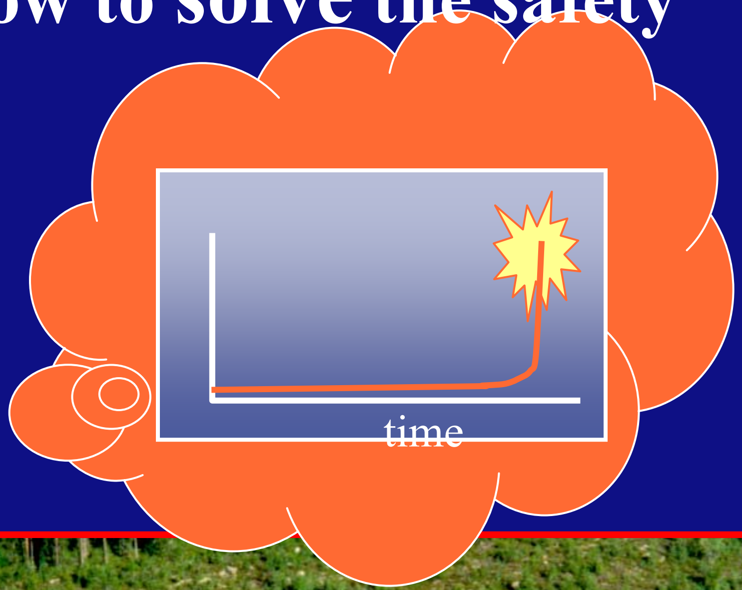
Performance



Effectiveness

Hit

Lifetime prediction: How to solve the safety problem?



Accident with propelling charges

Lifetime prediction: Ageing of missile

US AIM-7 Sparrow incidents (1997 & 1999)

US MK-58 Mod 2 motor investigation

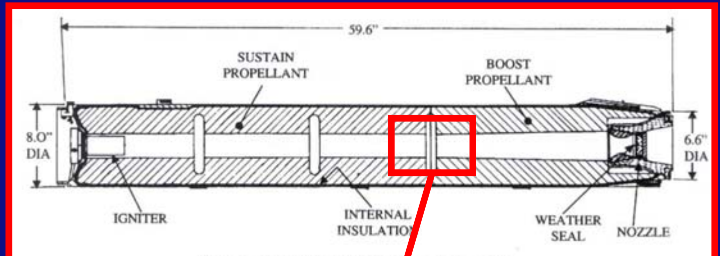
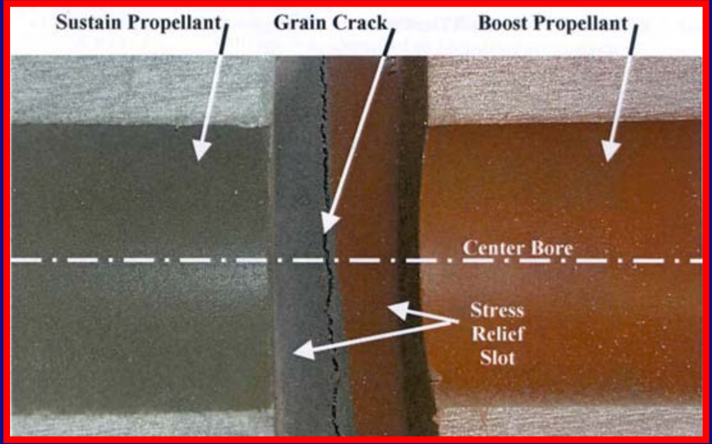
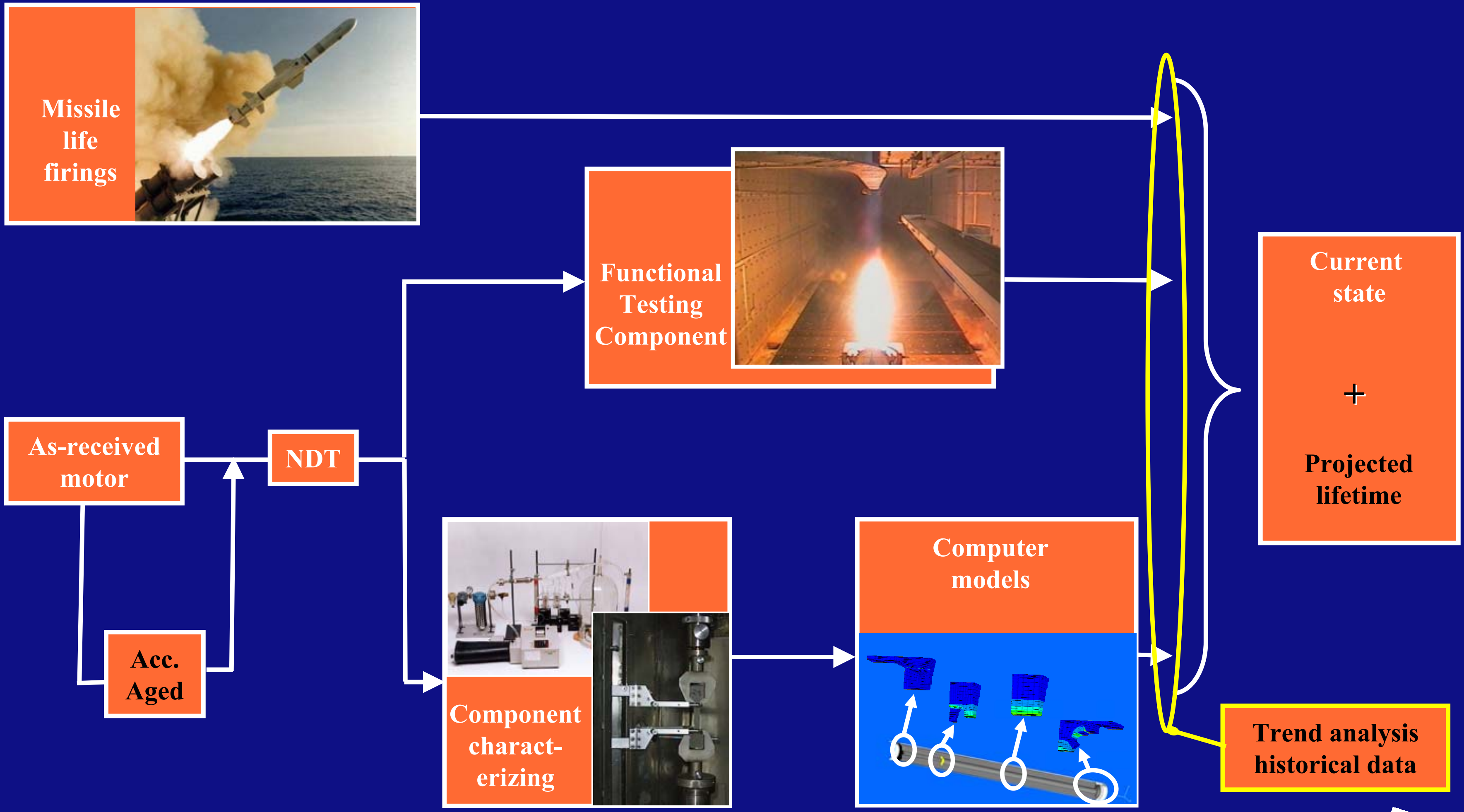


Figure 2, MK-58 Mod 2 rocket motor

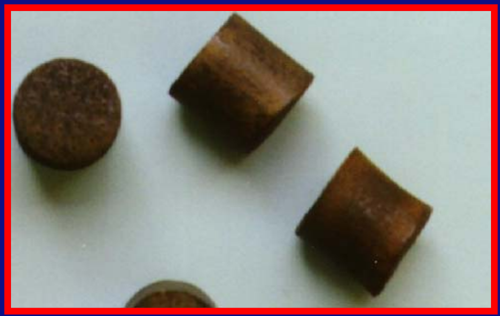


Source: paper P. Huisveld AVT-RTO-089, 2002 Aalborg

Lifetime prediction: Element "toolbox" for missiles



Surveillance of gun propellants

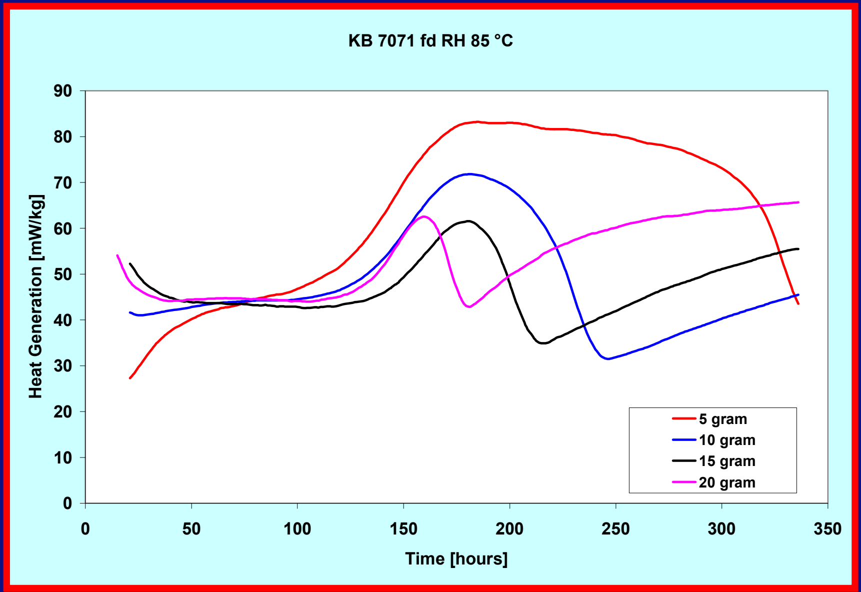


Range of 5 sample vessels covers the whole range of propellant grains

No pre-treatment of grai necessary

Surveillance of gun propellants

- Heat flow Calorimetry (HFC) with full size grains
- Heat generation in time as function of loading density of vessel
- →Munition like testing



Lifetime production and surveillance: Products

- Lifetime studies (Toolbox)
- Surveillance methodology for gun propellants (realistic comparison to ammunition situation, including
  - Equipment
  - Tailor made training programme
  - Tailor made munition management system
  - Guarantee and spare parts

Summary

- TNO Defence, security and safety is an independent organisation and a strategic partner for the Dutch Ministry of defence
- We also use our accumulated expertise for foreign governments and for defence related industries.

- R&D → development → prototyping → pre-production → production → in service, of munition: TNO has the expertise for Effective and Insensitive Munitions development.
- But also the expertise for lifetime predictions and surveillance of propellants.

- Combination of experimental facilities, theoretical knowledge/expertise and model/computer codes makes TNO a qualified partner for your future munitions development.

NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

LINE OF SIGHT/BEYOND LINE OF SIGHT (LOS/BLOS) ADVANCED TECHNOLOGY DEMONSTRATOR (ATD)

BRIEFING FOR THE GUNS, AMMUNITION, ROCKETS & MISSILES SYMPOSIUM - 25-29 APRIL 2005

Providing America Advanced Armaments for Peace and War

Armaments Engineering & Technology Center
AETC
Picatinny, New Jersey

DAVID C. SMITH, P.E.
ANTHONY J. CANNONE
LOS/BLOS ARMAMENT TEAM

Providing America Advanced Armaments for Peace and War

LIGHTWEIGHT 120 MM GUN (LW120) LOS/BLOS ATD

ISO 9001 Certified
FS15149

- OVERVIEW OF LOS/BLOS ATD GUN
  - DESIGN CONCEPT
  - REQUIREMENTS
- OVERVIEW OF TEST STATUS TO DATE
  - TEST RESULTS PHASE 1
  - TEST RESULTS PHASE 2
  - TEST RESULTS PHASE 3 (PRELIMINARY TEST DATA)
  - IN HOUSE TESTING
- PATH FORWARD
- ACCOMPLISHMENTS

LOS/BLOS ATD GUN OVERVIEW

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- GOAL: DEVELOP A LIGHTWEIGHT 120MM GUN FOR USE ON A 20 TON VEHICLE
  - WEIGHT: < 4,400 POUNDS
  - RECOIL IMPULSE: < 5,300 POUND-SECONDS
  - RECOIL LENGTH 25 INCHES
  - SPACE CLAIM LIMITS OF MCS CONCEPT VEHICLE
- STATUS & ONGOING ACTIVITIES
  - VEHICLE DYNAMIC RESPONSE DEMONSTRATOR (VDRD) GUN DEVELOPED AND COMPLETED TESTING IN FEBRUARY 2004
  - LINE OF SIGHT/BEYOND LINE OF SIGHT (LOS/BLOS) ADVANCED TECHNOLOGY DEMONSTRATOR (ATD) PROGRAM BUILT AND TESTED 3 VERSIONS OF THE LIGHTWEIGHT 120MM GUN FROM NOVEMBER - MARCH 2005
  - KEY TECHNOLOGIES CONTINUE MATURING IN NEW PROGRAM

LOS/BLOS ATD GUN DESIGN CONCEPT

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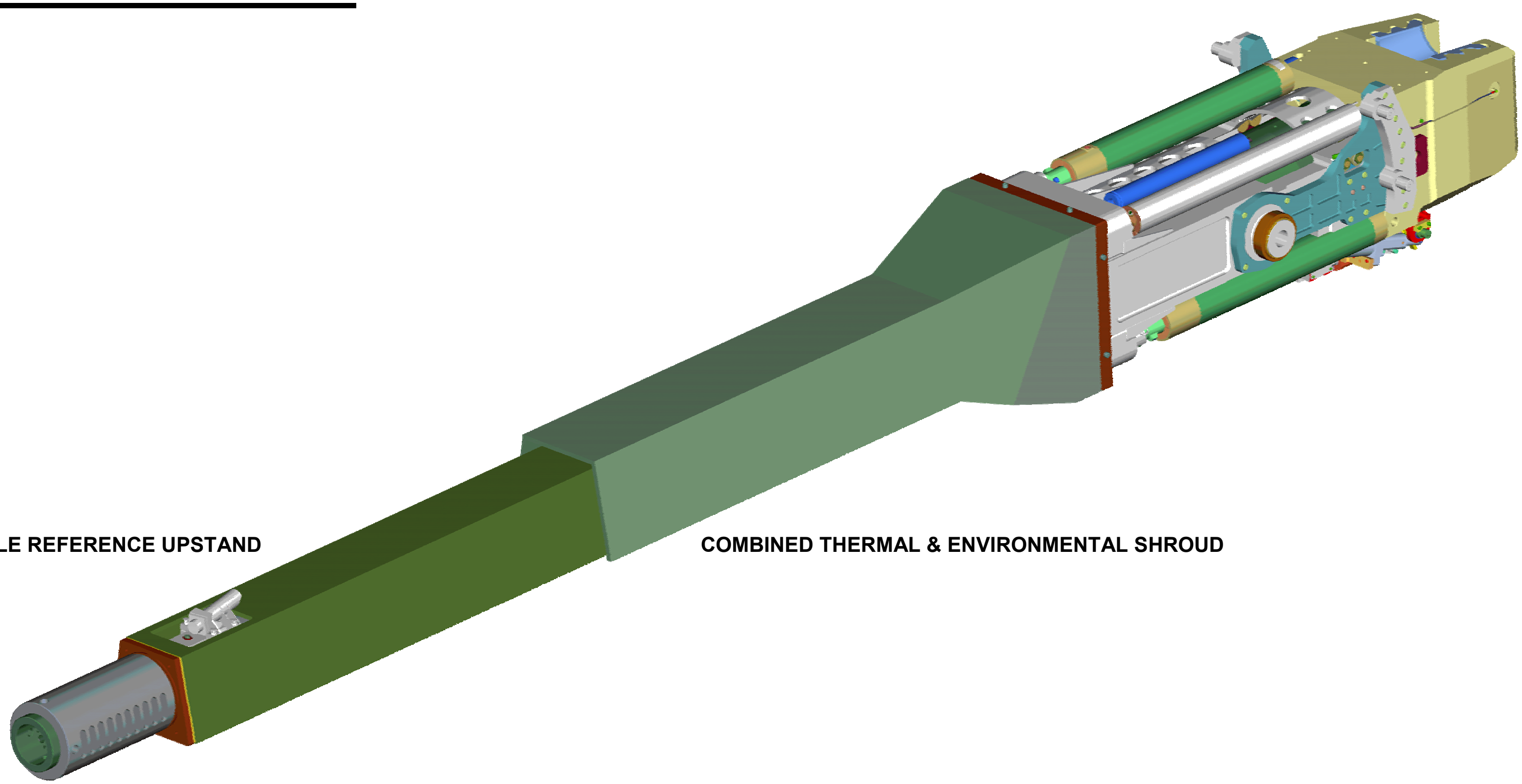
GUN ASSEMBLY



LOS/BLOS ATD GUN DESIGN CONCEPT

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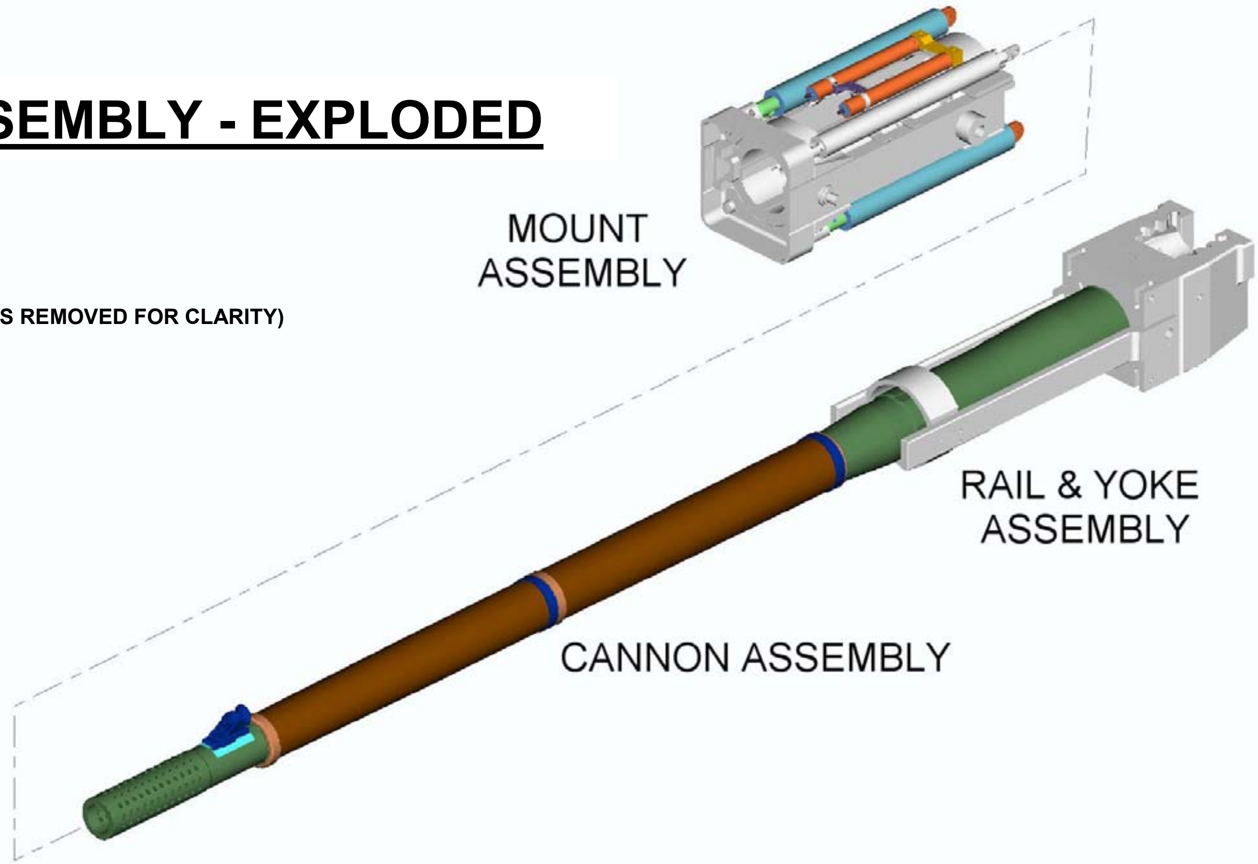
GUN ASSEMBLY - EXPLODED

(SHROUDS REMOVED FOR CLARITY)



LOS/BLOS ATD GUN DESIGN CONCEPT

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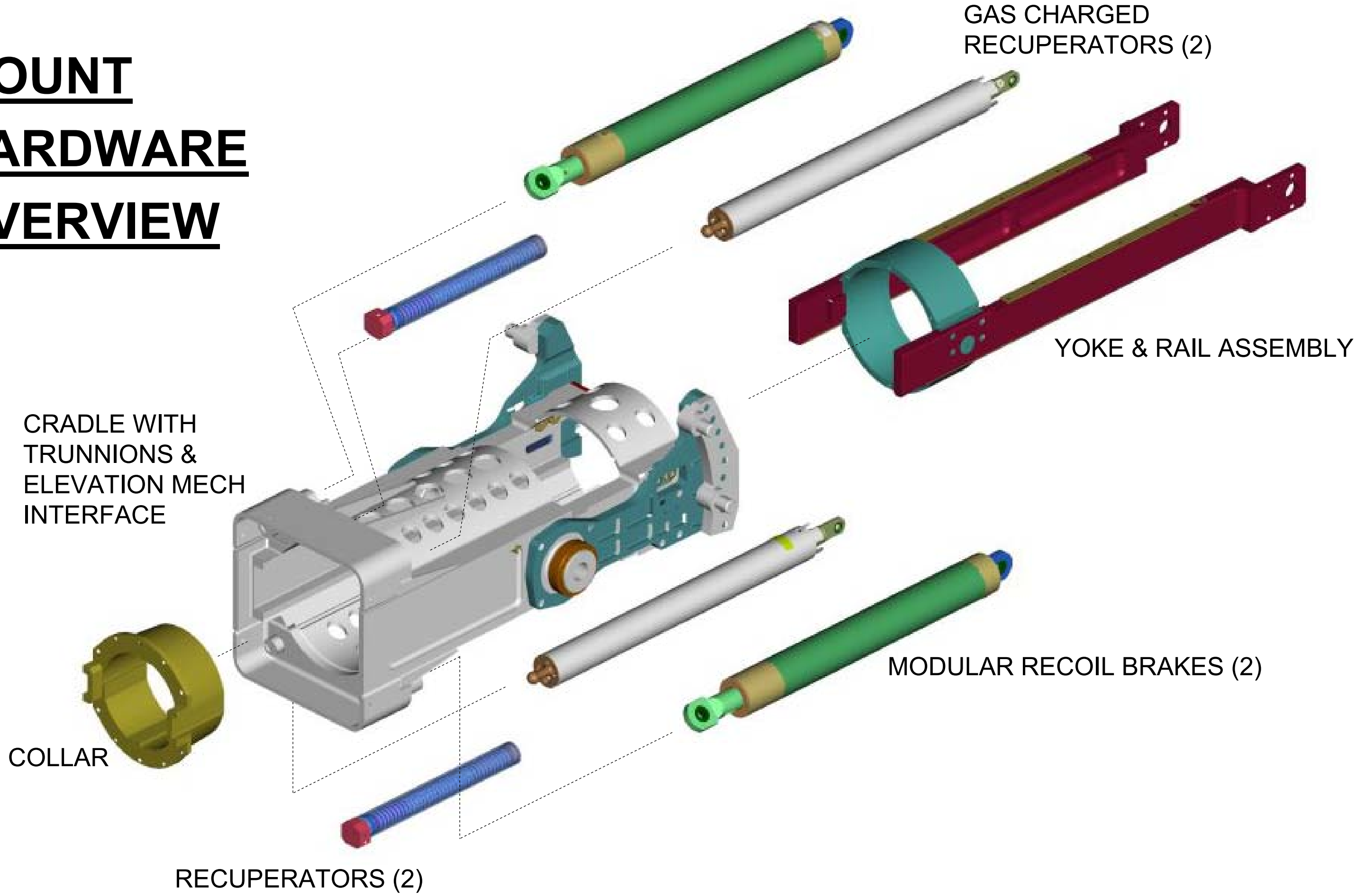
MOUNT HARDWARE OVERVIEW



LOS/BLOS ATD GUN DESIGN CONCEPT

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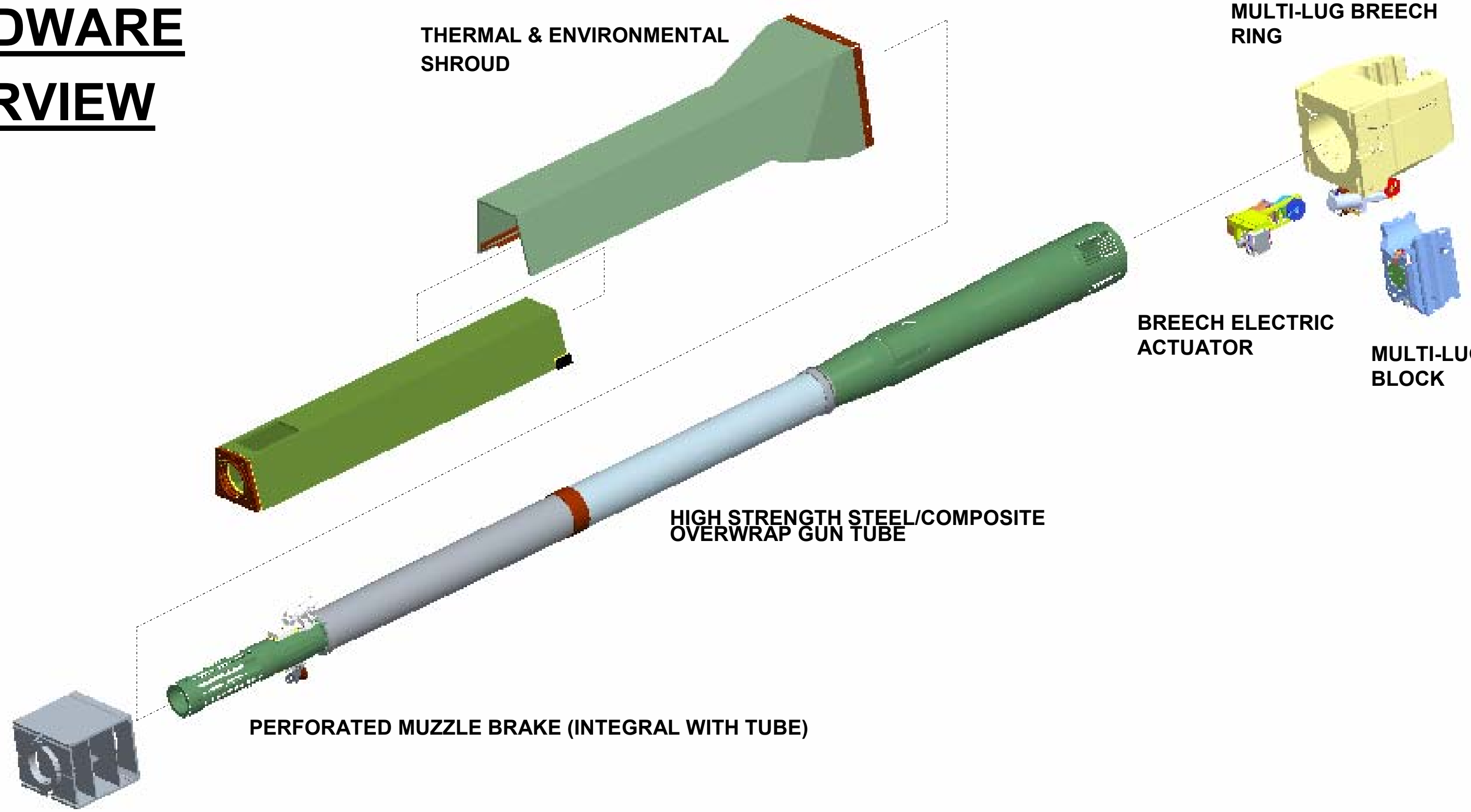
CANNON HARDWARE OVERVIEW



LOS/BLOS ATD GUN DESIGN CONCEPT (ATD # III.WP.2003.01)

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Capability	*Current Capability (Baseline)*	*LOS/BLOS ATD* Minimum	*Goal*
• Armament			
• Gun weight (lbs)	6700 lbs	4,400 Lbs	4000 Lbs
• Gun elevation	20^0	30^0	50^0
• Recoil & Ammo Volume	4.5 m^3 (Abrams)	3.5 m^3	3.5 m^3
• Stowed Rounds	42 (Abrams)	38	43
• Weapon Recoil Force	160,000 Lbf	90,000 Lbf	85,000 Lbf
• Weapon position error (LOS)	.75 mil (El and Az) (M1) dynamic	.5 mil (El and Az) dynamic	.35 mil (El and Az) dynamic
• Ammunition			
• Advanced KE Armor Penetration	M829A2 @ 2km	Advanced Armor Threat @2km	Advanced Armor Threat @4km
• MRM – PSSK	N/A	Pssk (class) 2-12km	Pssk (class) 2-16km
• Warheads:			
Warhead – SC L/D (pen) Capability	1.7 Armor	1.0 (class) Armor	1.0 (class + 30%) Armor, personnel, Bunker, Urban Helicopter
Precision Ignition Demo	T2 s of 3 ms (abrams)	T2 s of 0.5 ms	T2 s of 0.1 ms

Providing America Advanced Armaments for Peace and War

ARDEC

LOS/BLOS ATD GUN
TEST RESULTS/STATUS

- **ATD GUN FIRING TEST PHASE – COMPLETED TO DATE AT APG**
  - **97 ROUNDS FIRED**

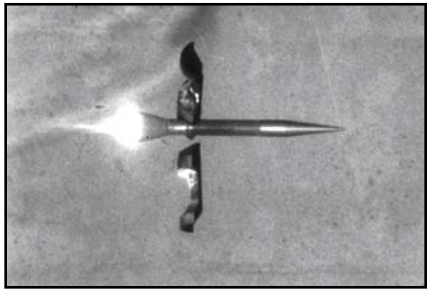
    40 - M829A3   5 – M829A2   25 – M865   40 – M831A1

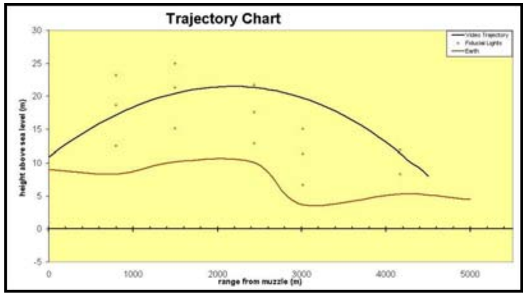
    10 – M829A2 (PRECISION IGNITION MOD)

    3 - MRM-CE SLUG   3 – MRM-KE SLUG   1 MRM-KE FINNED
  - **TEST HARDWARE/PHASES COMPLETED**
    - **GUN TUBE STRUCTURAL INTEGRITY**
    - **TRUNNION FORCE**
    - **MUZZLE BRAKE EFFICIENCY**
    - **MRM ROUNDS**
    - **ACCURACY**
    - **CMS TANTALUM LINER**

LOS/BLOS ATD GUN
TEST RESULTS/STATUS

- TEST SET UP AT ATC TRENCH WARFARE II FIRING RANGE
- MULTIPLE SOFT TARGET RANGE UP TO 5000M LOS, VIDEO SCORING
- 2 SEPARATE LOF ALLOW DU AND HEAT TO BE FIRED
- FIRE CONTROL DATA COLLECTION
- HIGH SPEED PHOTOGRAPHY, MUZZLE EXIT BALLISTICS
- NEAR REAL-TIME PROCESSING USING TEST SITE INTEGRATION
- RANGE ALLOWED MRM FIRING TO 12 KM





LOS/BLOS ATD GUN
TEST RESULTS/STATUS

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- ATD GUN FIRING TEST RESULTS TO DATE –
  - COMPOSITE JACKETED GUN TUBE FIRED & STRAIN MEASURED
  - STRUCTURAL INTEGRITY DEMONSTRATED, PERFORMING WELL.
  - TRUNNION FORCE MEASUREMENTS:
    - PRELIMINARY RESULTS INDICATE GOOD AGREEMENT WITH PREDICTIONS
    - PEAK FORCES FIRING M829A3 WITH MUZZLE BRAKE < 65,000 LBS
    - MUZZLE BRAKE EFFICIENCY GOAL OF > 25% FIRING THE M829A3 ROUND DEMONSTRATED.
  - MRM-KE ROUND FIRED TO MAX RANGE (30° ELEVATION)
    - 12 KM RANGE DEMONSTRATED, ACTUAL RANGE 12.8 KM.
    - PROPER FIN DEPLOYMENT THROUGH MUZZLE BRAKE DEMONSTRATED.

LOS/BLOS ATD GUN
TEST RESULTS/STATUS

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- **RESULTS (cont'd)**
  - INITIAL EROSION TESTING ON CYLINDRICAL MAGNETON SPUTTER (CMS) COATED (TANTULUM) LINER (~2')
  - ACCURACY TESTING - TARGET IMPACT DISPERSION (TID)
    - M829A3 INITIAL TID COMPLETED
    - M865 & M831A1'S GOOD RESULTS – TID WITHIN REQUIREMENTS.
  - BREECH BLOCK WITH AMMO DATA LINK (ADL).
    - FUNCTIONALITY, STRUCTURAL INTEGRITY OF DUAL DATA PIN ADL DEMONSTRATED.
    - SINGLE PIN ADL (GERMAN) SYSTEM DEMONSTRATED.
    - PRECISION IGNITION DEMONSTRATION.
    - BREECH ACTUATOR HARDWARE DEMONSTRATED
  - ULTRA HIGH STRENGTH STEEL TUBE FIRED

LOS/BLOS ATD GUN
TEST RESULTS/STATUS

ified

LIGHTWEIGHT 120 MM GUN ASSEMBLY AT ABERDEEN TEST CENTER – 19 OCT 04. NOTE MICROPHONES TO RECORD BLAST OVERPRESSURE, ADDITIONAL RISERS UNDER GUN 'KNEES' TO OBTAIN MORE ACCURATE GROUND REFLECTION DATA.

PENCIL PROBE AND HULL MOUNT SIMULATOR MICROPHONES WERE CUSTOM DESIGNED AND FABRICATED BY ATC BALLISTICS AT THE REQUEST OF THE BENET LABORATORIES

LOS/BLOS ATD GUN
TEST RESULTS/STATUS

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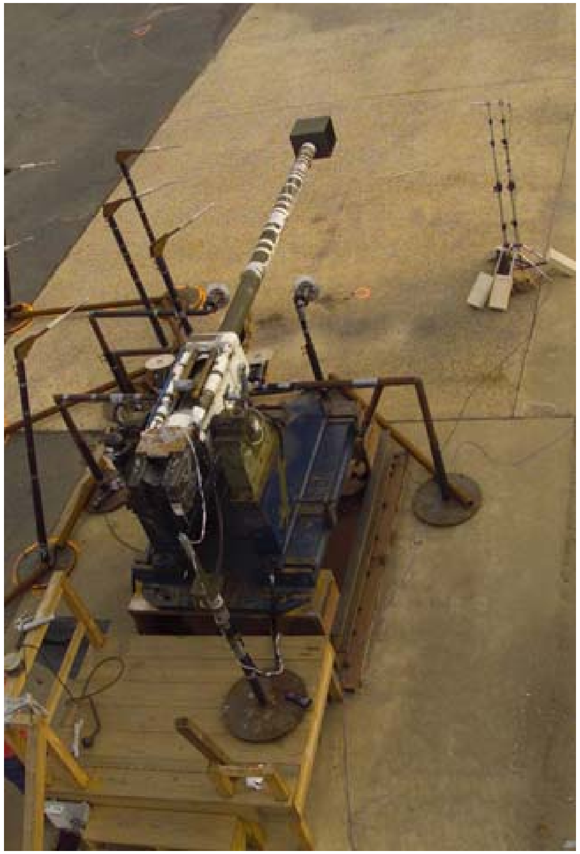

LOS/BLOS ATD GUN TEST DATA

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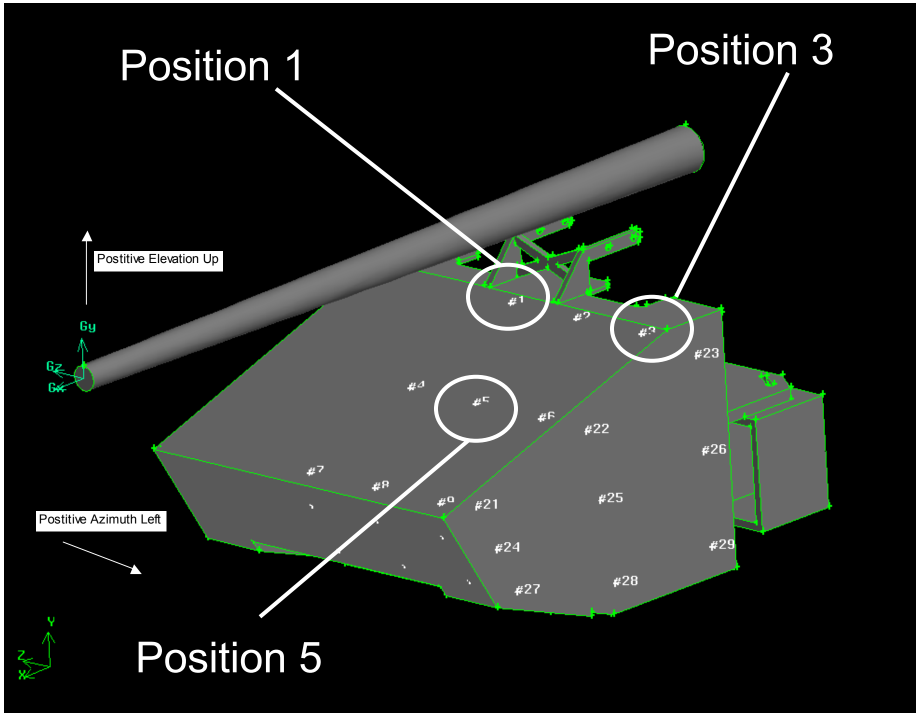
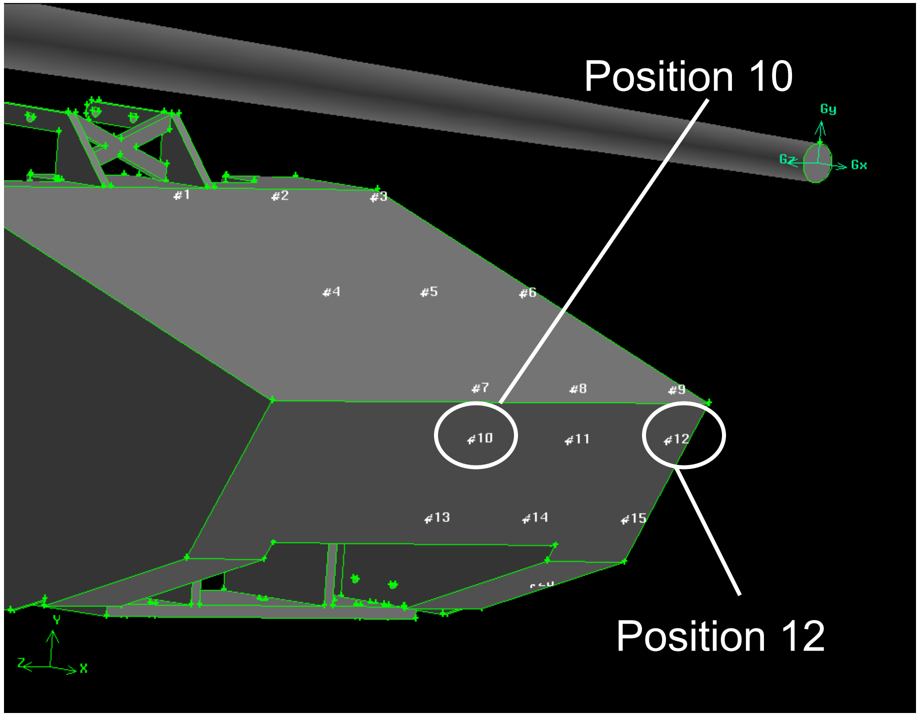
HULL POSITIONS MEASURED WITH CHASSIS SIMULATOR GAGES





LOS/BLOS ATD GUN TEST DATA

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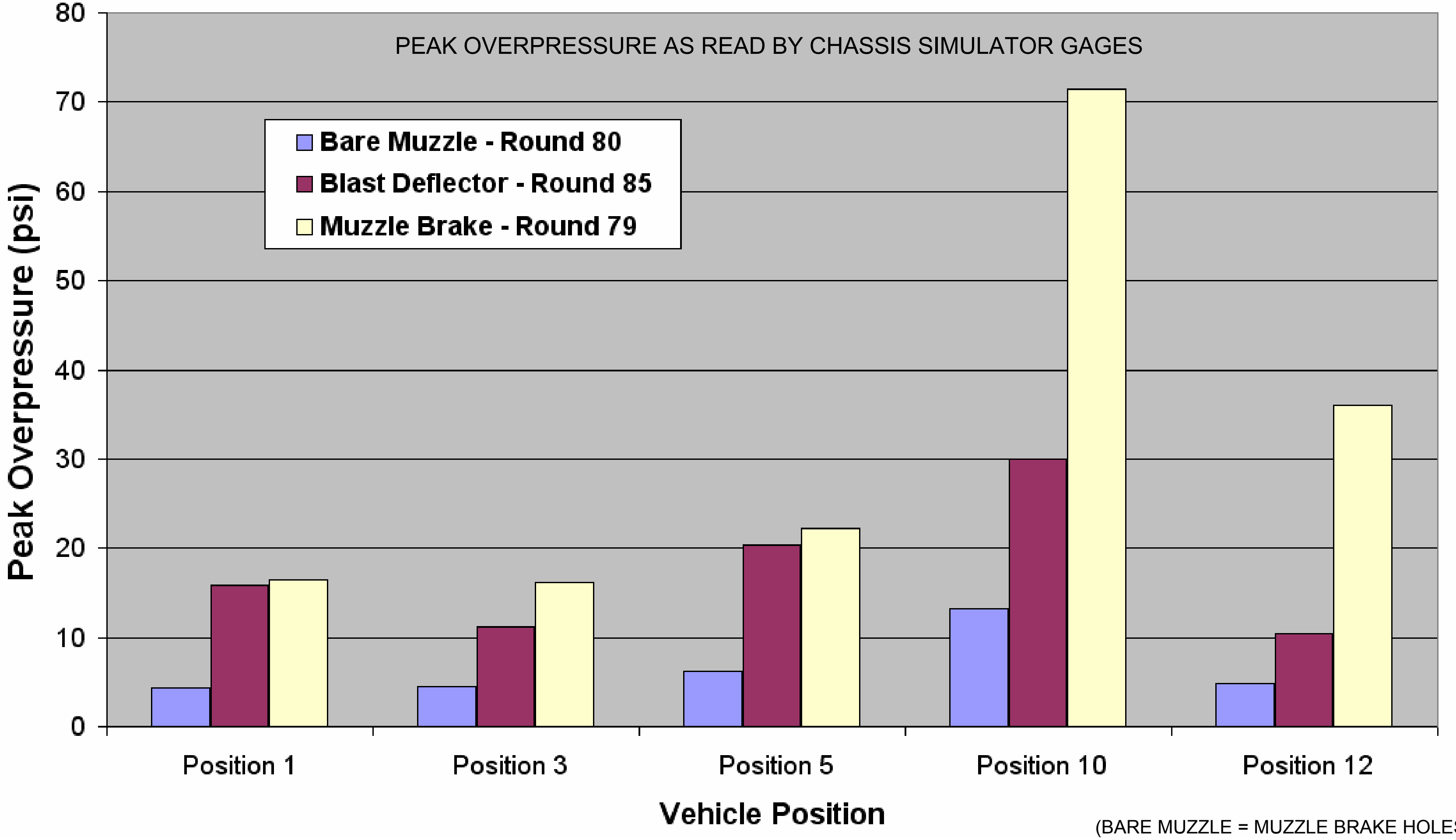

(BARE MUZZLE = MUZZLE BRAKE HOLES COVERED)

LOS/BLOS ATD GUN TEST DATA

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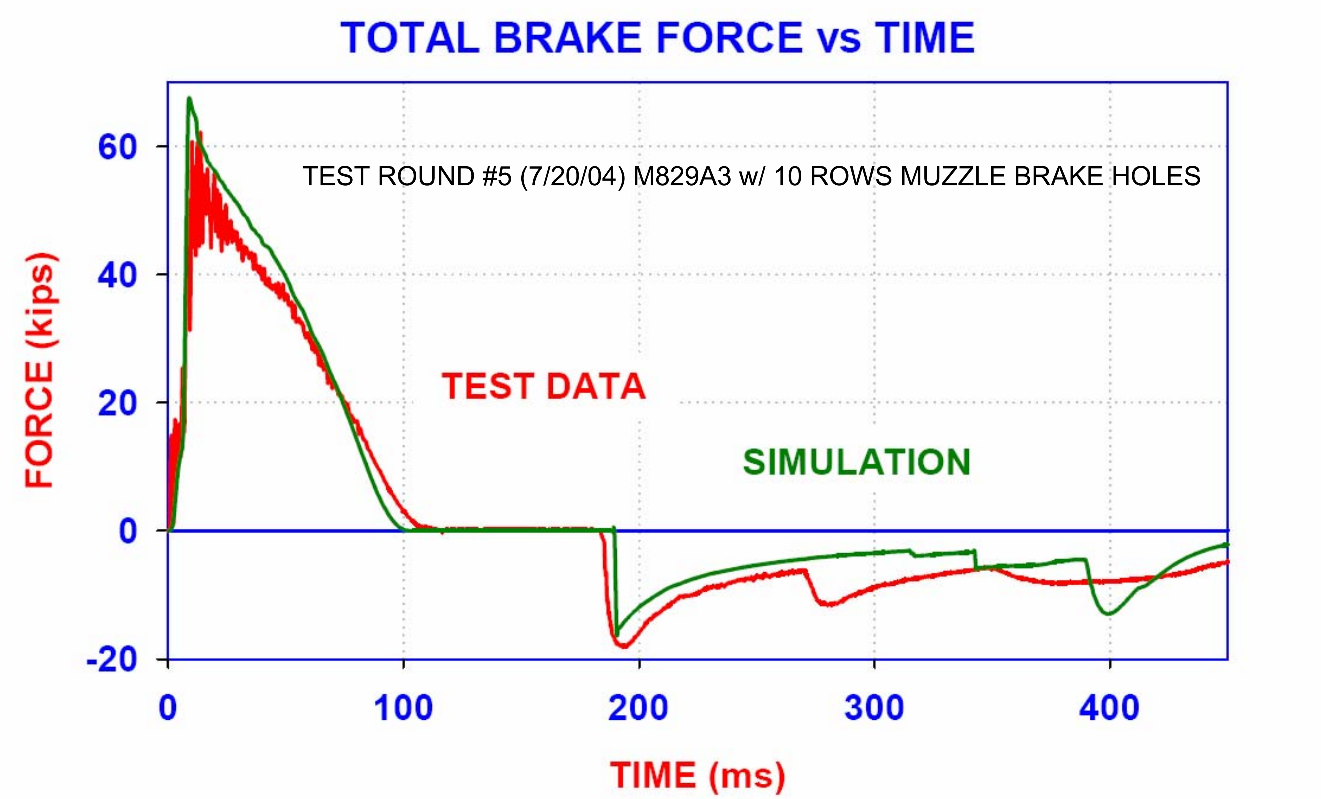

ROUND	CARTRIDGE	IMPULSE (LBSEC)	CONFIGURATION
5	M829A3	5,232	Full Muzzle Brake
6	M829A3	5,315	Full Muzzle Brake
7	M829A3	5,360	Full Muzzle Brake

LOS/BLOS ATD GUN TEST DATA

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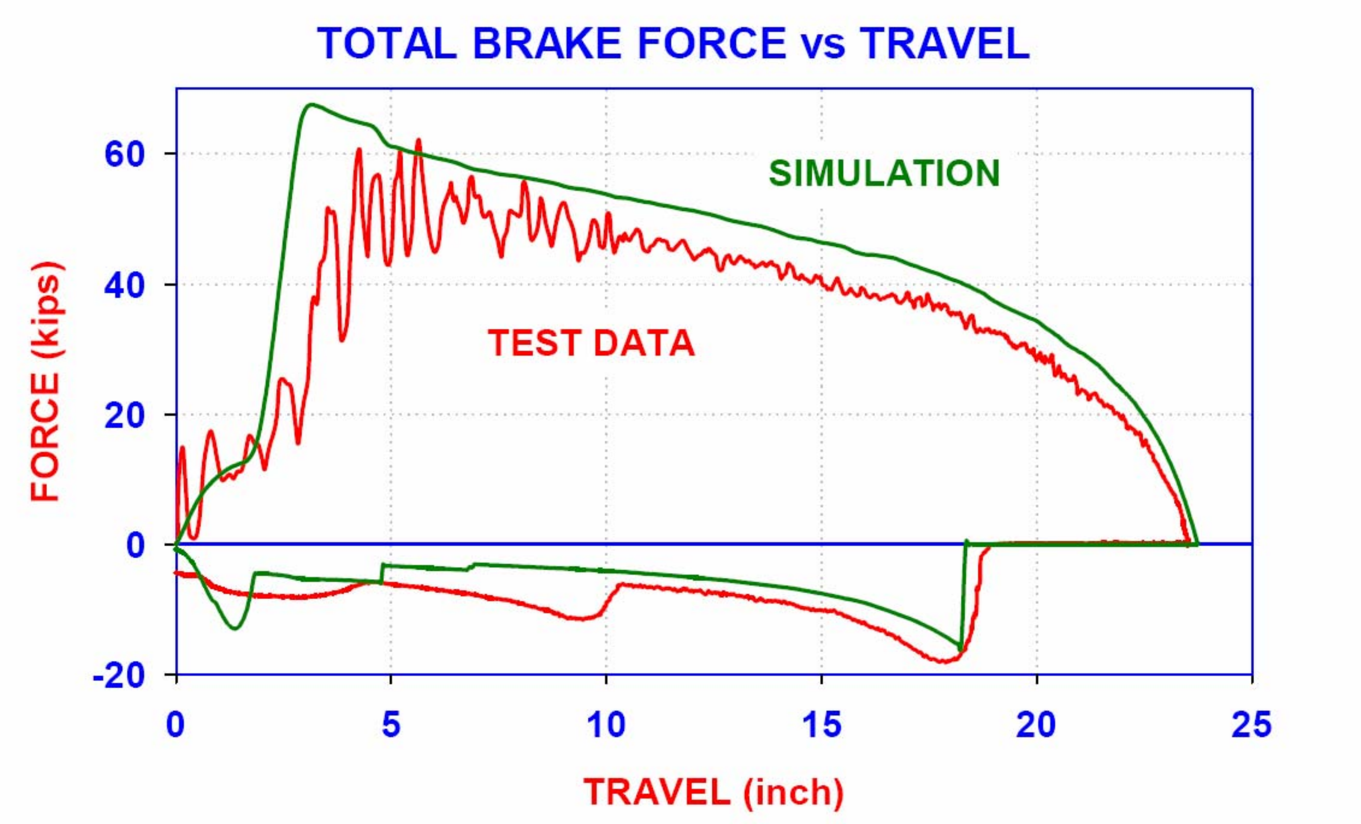

ATD #1 RECOIL SYSTEM TEST RESPONSETEST ROUND #3 (7/20/04) M829A2 w/ 10 ROWS MUZZLE BRAKE HOLES

LOS/BLOS ATD GUN PRELIMINARY TEST RESULTS

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ROUND M829A2 @ 70DegF

ATD - TEST	BALLISTIC IMPULSE	IMPULSE at TRUNNION	PERCENT REDUCTION
1 (3)	6428	4818	25.0
2 (10)	6327	4803	24.1

ROUND M831A1

ATD - TEST	BALLISTIC IMPULSE	IMPULSE at TRUNNION	PERCENT REDUCTION
1 (3)	5645	4322	23.4
2 (10)	5560	4442	20.1

ROUND M865

ATD - TEST	BALLISTIC IMPULSE	IMPULSE at TRUNNION	PERCENT REDUCTION
1 (3)	4833	3628	24.9
2 (10)	4825	3549	26.4

LOS/BLOS ATD GUN
TEST RESULTS/STATUS

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LOS/BLOS ATD GUN
TEST RESULTS/STATUS

ISO 9001 Certified
FS15149

ATD MOCK GLACIS ASSEMBLED AT ABERDEEN TEST CENTER

LOS/BLOS ATD GUN TEST RESULTS

ISO 9001 Certified
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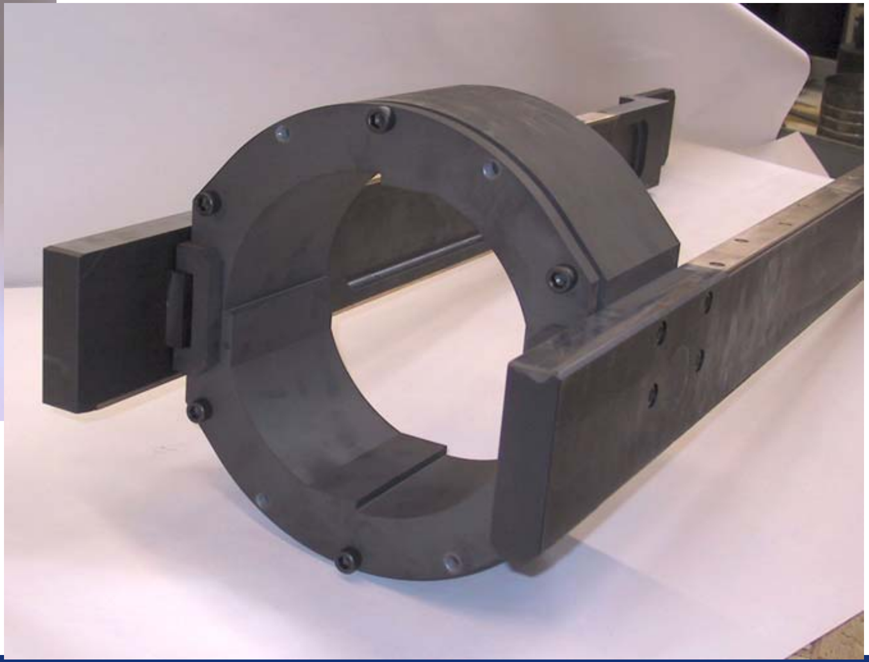
ATD 3 TITANIUM RAILS, YOKE & ADAPTOR



LOS/BLOS ATD GUN
TEST RESULTS/STATUS

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ENVIRONMENTAL/SIGNATURE SHROUD COMPOSITE SECTIONS (POST CURE) MADE AT BENET

ENVIRONMENTAL/SIGNATURE SHROUD ASSEMBLIES BEING TEST FIT TO TUBE AT BENET

LOS/BLOS ATD GUN IN HOUSE TESTING

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COMPOSITE TUBE (ATD 3) STRAIN TESTING AT BENET

HIGH TENSION COMPOSITE SPECIMEN

LOS/BLOS ATD GUN
IN HOUSE TESTING

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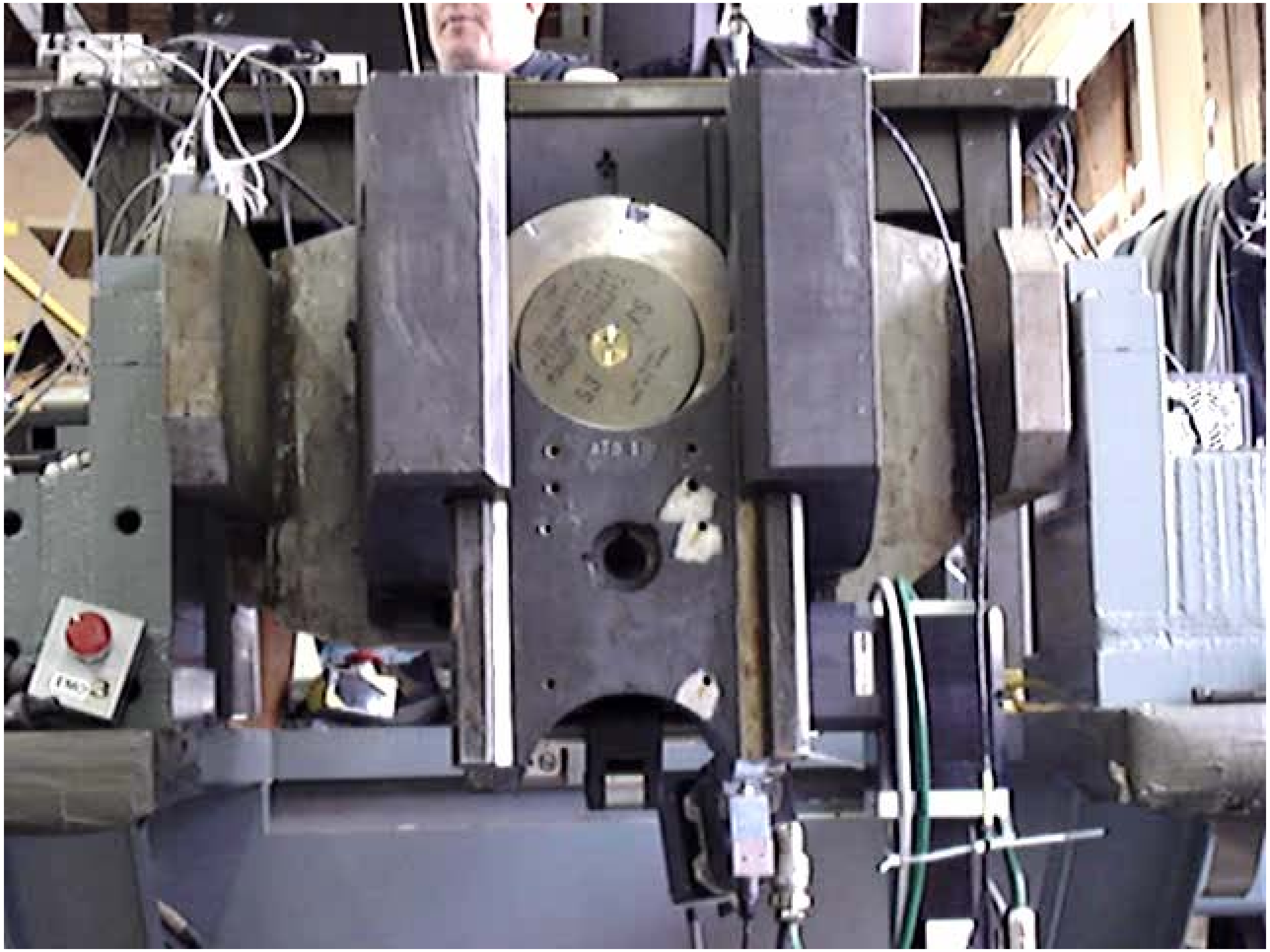

LOS/BLOS ATD GUN PATH FORWARD

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FS15149

- COMPLETE ANALYSIS OF ALL TEST DATA OF LOS/BLOS ATD TEST PHASES (ONGOING THROUGH MAY 05) AND INCORPORATE INTO GUN TECHNICAL DATA PACKAGE
- START NEW STO PROGRAM “LIGHTWEIGHT ARMAMENT ENHANCEMENTS”
  - EXPLORE/MATURE HIGHER RISK ARMAMENT WEIGHT REDUCTIONS AND ACCURACY ENHANCMENTS
  - DEMONSTRATE TECHNOLOGIES FOR TRANSITION INTO SDD
- SDD PROGRAM START
  - TAILOR GUN INTERFACES FOR THE MCS
  - REFINE TECHNICAL DATA PACKAGE TO OPTIMIZE COST & PERFORMANCE
  - INCORPORATE INTERFACES FOR NEW MUNITIONS

FCS/MCS LW120 GUN
DESIGN CONCEPT – GUN ASSY WEIGHT

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	M256	SDD	LAEP
	(M1A2)	Estimate	Estimate
Breech Ring & Block Assemblies	1525	1,072	842
Breech Mech. Housing Assembly	(included)	42	42
Breech Actuator Assembly	N/A	43	43
Gun Tube	2350	1960	1590
Thermal Shrouds	180	77	77
MRS	0	0	0
Blast Deflector	N/A	90	65
Cradle Assembly	2560	532	532
Replenisher Assembly	(included)	18	18
Elevation interface plates	(included)	78	78
Recoil Brakes (2)	(included)	164	100
Recuperators (2)	(included)	84	75
Rails, Yoke, Adapter	(included)	283	168
Bore Evacuator	50	N/A	N/A
Total Weight (lbs)	6,665.00	4,443.00	3,630.00

-180 LBS - FULL THREAD
-50 LBS - TI BLOCK

-200 LBS – COMPOSITE
-100 LBS - SUHSS
-70 LBS – DUAL AUTOFRETTAGE

-25 LBS – BLAST DEFLECTOR

-64 LBS - BRAKES
-9 LBS - RECUPS

-115 LBS – ATD DESIGN DEMO IN LAEP

813 LBS savings

M256 GUN WEIGHT DOES NOT INCLUDE ROTOR SHIELD
LAEP WEIGHT SAVINGS OF 813 LBS
SDD ESTIMATE INCLUDES OTHER WEIGHT REDUCTION INITIATIVES NOT SHOWN IN PREVIOUS SLIDES

LOS/BLOS ATD GUN ACCOMPLISHMENTS

ISO 9001 Certified
FS15149

ATD GUN MOD 1 FIRING DEVELOPMENTAL MRM CARTRIDGE 19 JUL 04 – SHOT 28

LOS/BLOS ATD GUN ACCOMPLISHMENTS - SUMMARY

ISO 9001 Certified
FS15149

- ACCOMPLISHMENTS
  - ACHIEVED A SYSTEM WEIGHT OF 4,240 POUNDS (ALL STEEL TUBE)
  - IMPULSE WITHIN SPECIFIED LIMIT
  - INITIATED TESTING DECEMBER 2003
  - DEMONSTRATED A MUZZLE BRAKE EFFICIENCY OF 25%
  - TEST FIRED TWO ITERATIONS OF BLAST DEFLECTOR TO REDUCE BLAST OVERPRESSURE
  - TEST FIRED TWO ITERATIONS OF A COMPOSITE OVERWRAPPED GUN TUBE (JUL 04)
  - SUCCESSFULLY PROOF TESTED AN ULTRA HIGH STRENGTH GUN STEEL TUBE (OCT 04)
  - ACHIEVED TRL 6 IN OCTOBER 2004 (CANNON) WITH ALL STEEL TUBE

Missile Systems Lethality Enhancement through the use of a Conducting Aerosol Plasma Warhead

27 April 2005

Allen Stults
US Army RDECOM AMRDEC
AMSRD-AMR-PS-WF
allen.stults@us.army.mil

Multi-Functional Warheads Are Lethal Against a Large Target Set

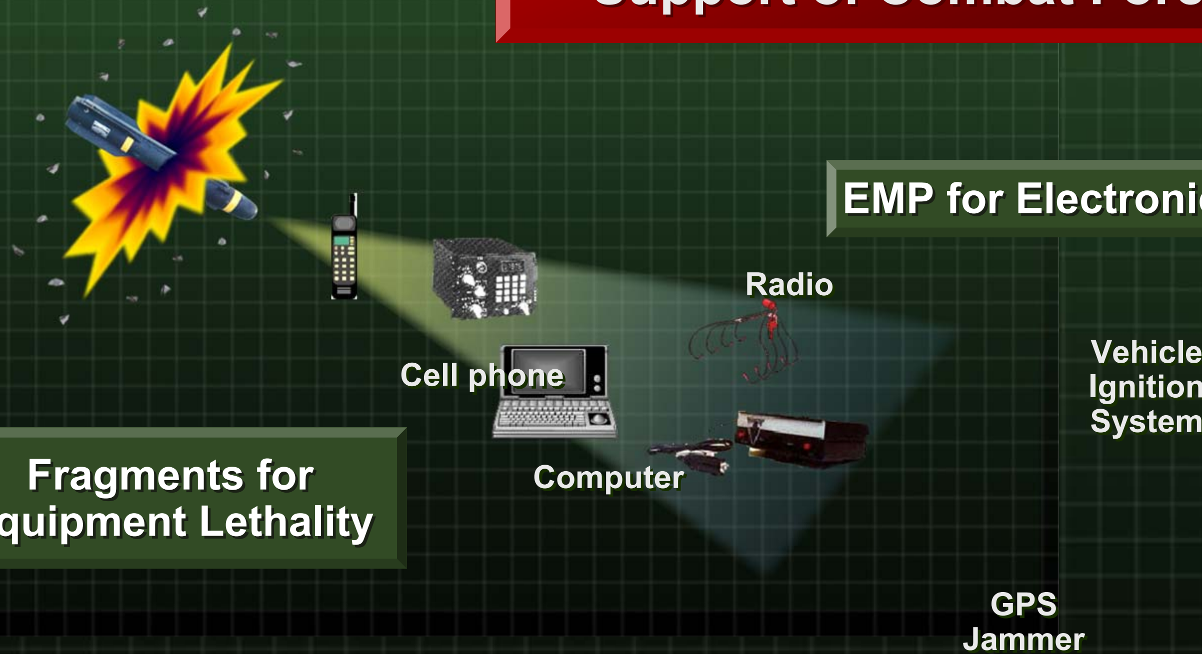
- Enhanced blast and fragmenting warheads have been successfully combined with shaped charges to service multiple target types with the same missile warhead, such as in Joint Common Missile. These are termed multi-purpose warheads.
- The next class of future missile systems can be further improved by adding RF effects to broaden the target set and enhance lethality
- The first step is to demonstrate additional effects without degrading existing capabilities

Multi-Effects Electromagnetic Warhead

Develop and Integrate Warheads into Missile Systems to Destroy and Disable Electronic Systems and their Operators in Support of Combat Forces

Enhanced Blast for Personnel Lethality

EMP for Electronics



Fragments for Equipment Lethality

Three Major Products From Missile Laboratory to Missile Programs

- Improved Anti-Armor Precursor Charge

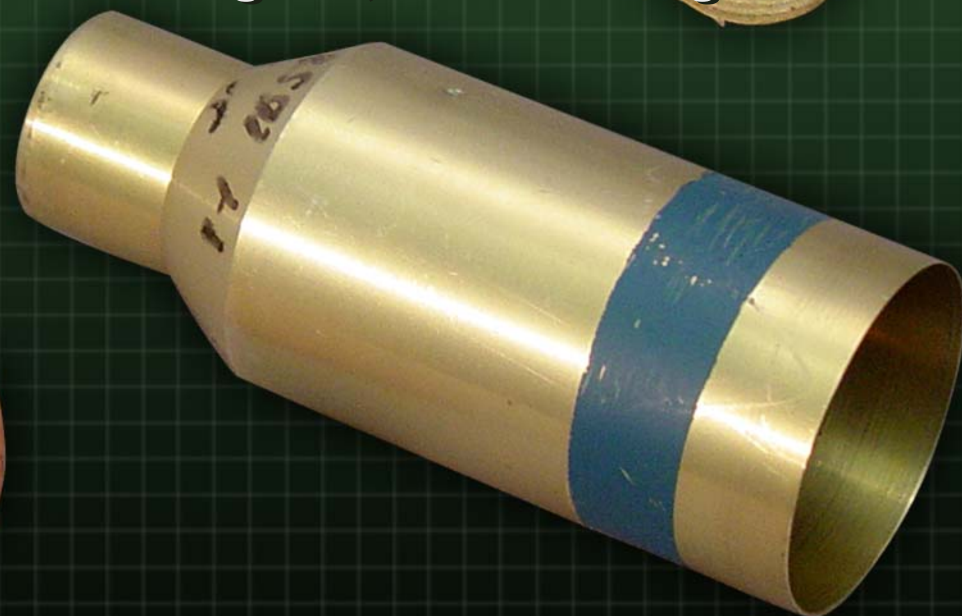
- Enhanced GMLRS Bomblet or Cargo Round payload

- Next Generation 2.75” Rocket Warhead

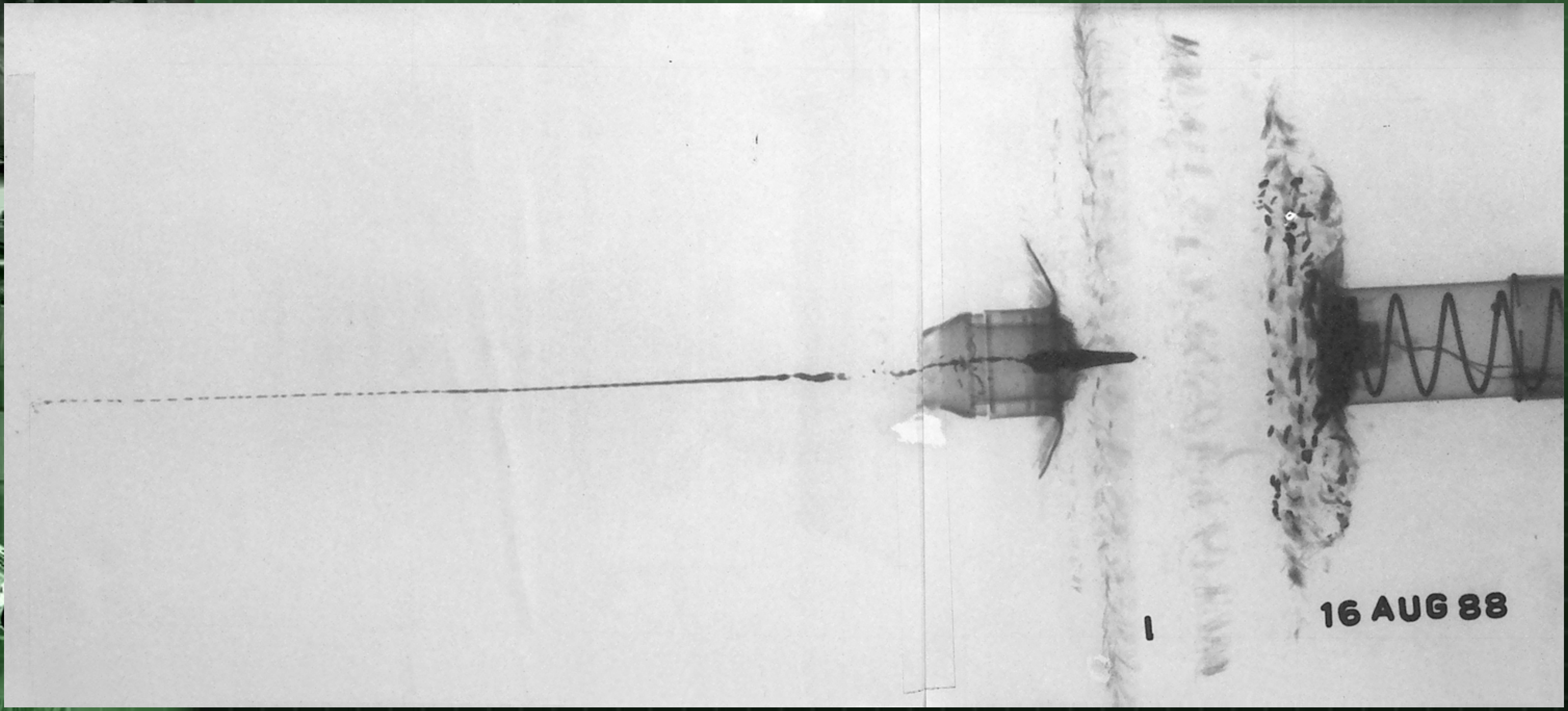
Baseline Warhead Trade Studies

- EM Measurements of Detonations and Plasma Characterizations
- Non-Ideal Explosives for Shape Charges/ Conductive Metal Antennas and Masonry destruction

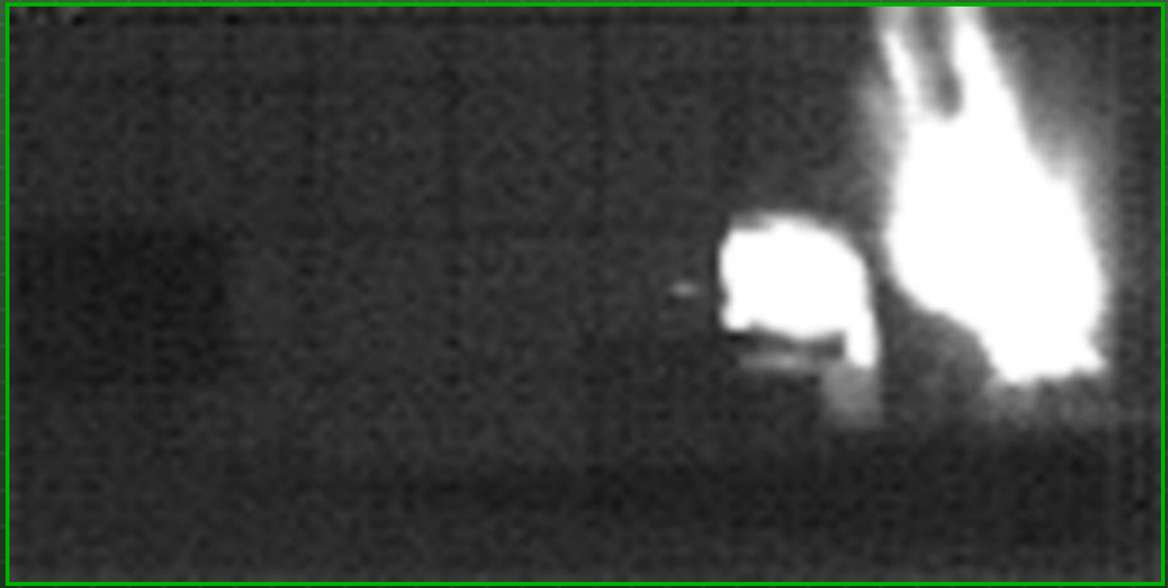
Improved Seed Sources Program, SBIR leverage of FEG and FMG

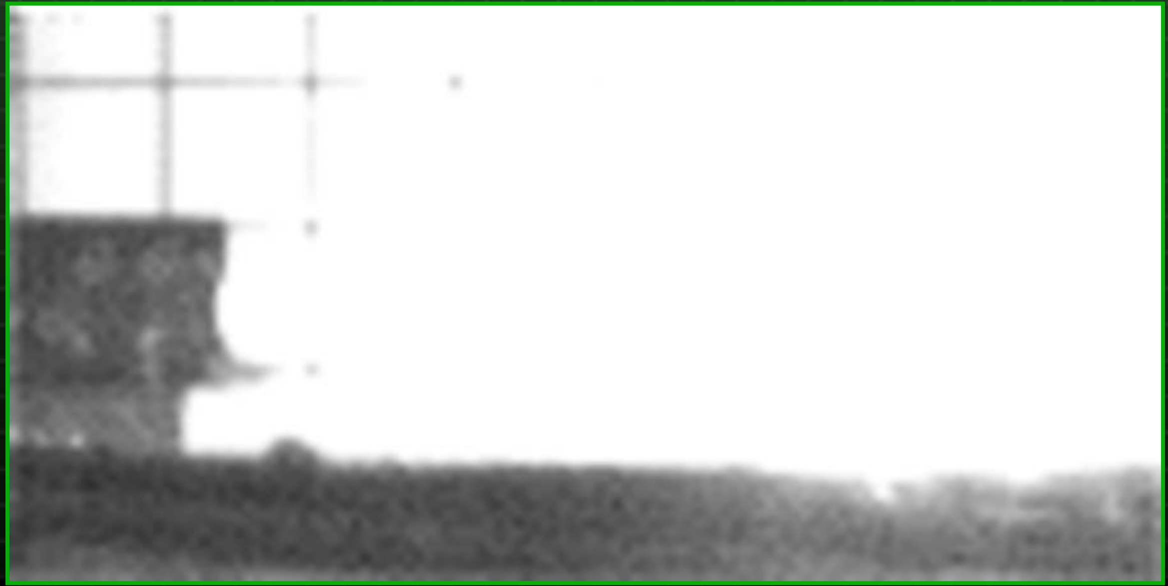


TOW Tip Charge Flash X-ray



Plasma Entrainment





Test Set-Up

Test Article N5 and Metal Fuel Rich Mix

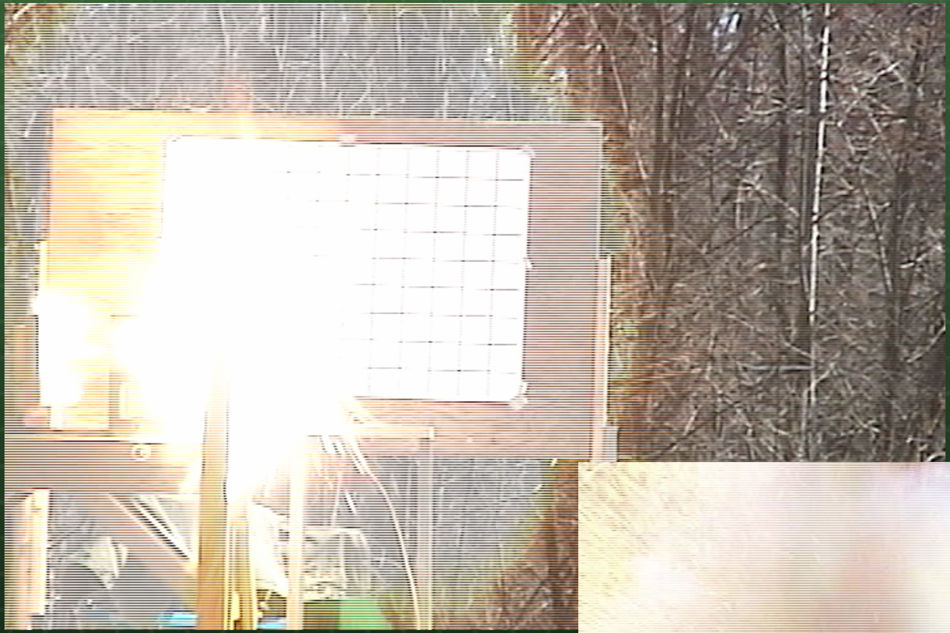
Filled test Article

Representative Cover Plates

Demonstration of Deflagration Effects on Masonry Targets

- Test various mixes of approximately 50 grams of aluminum powder pyrotechnic and thermite
- Gather fireball size, expansion rate and duration data for modeling efforts
- Investigating switch timing requirements to load dynamic plasma antenna
- Demonstrate robustness of masonry destructiveness at 10 CDs stand-off

Test 1



Test 1 Video

Test 1 – High Speed Video

Test 1 – Masonry Destruction

Test 2

Test 3

Test 4

Test 5

Test 6

Test 7

Conclusions and Plans

- Conductive Plasmas made from Deflagrating mixtures have significant destructive effects on masonry
- Significant Differences in Similar Mixes Allow the EM Designer a Robust set of Design Characteristics
- Temperature and Conductivity Effects will be further tested this Summer

Thanks

Joey Reed and Mike Kennemer for all their help in experimental conduct

George Arkoosh for his help in video production

Larry Altgilbers for his encouragement and advice

Royal Navy Small Calibre Gun Research to Defeat the Small Boat Threat

27th April 2005

Jonathan Watkins

Surface Warfare Weapons Team

Naval Systems

Dstl Portsdown West

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Dstl - Naval Systems Department

- The Naval Systems Department provides analysis and top-level platform and weapon systems advice in support of MOD decision making on Naval Systems.
- The Naval Systems Dept comprises of the following groups
  - Above Water Systems - (Surface Warfare - Weapon Systems Team)
  - Littoral Warfare (Operational Analysis)
  - ASW Capablility
  - Under Water Systems

Fast In Shore Attack Craft (FIAC)

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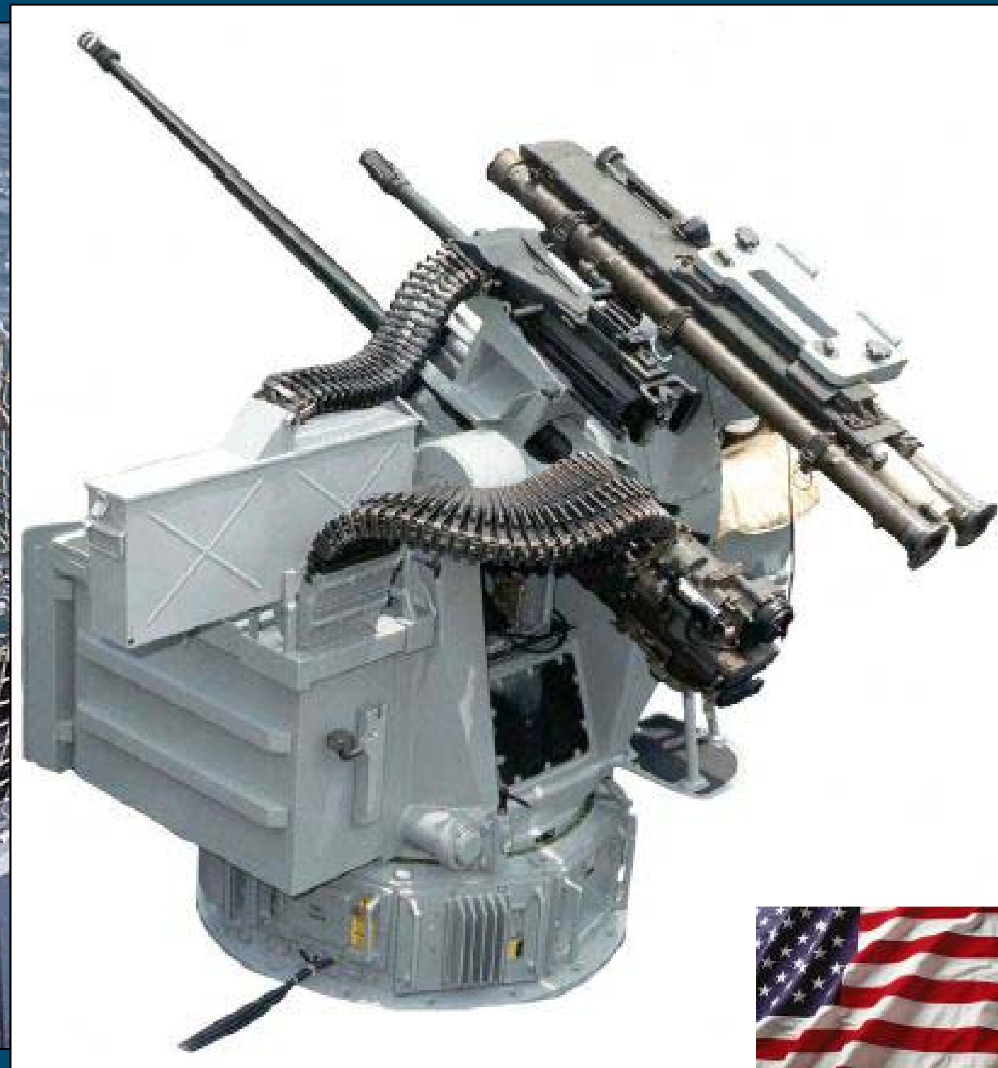
PLAY

Existing Small Calibre Gun



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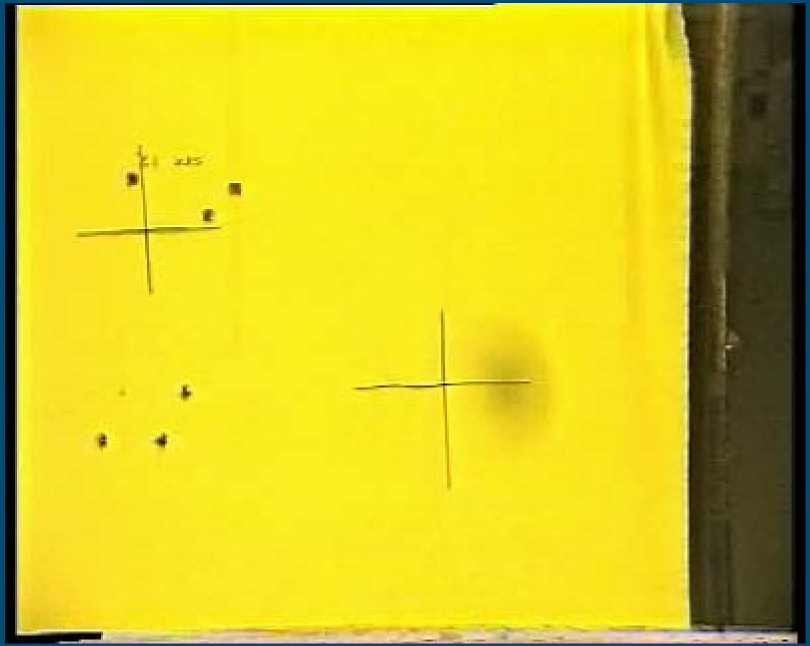
Operator Performance?

HMS Somerset Trial

30mm Cannon - Remotely Controlled from Ops Room

Alternative Cannon

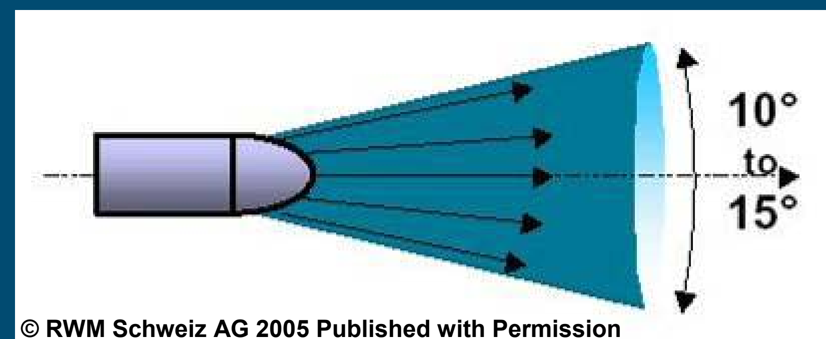
30x173mm MK44 Bush Master II



Proof Firings

Air Burst Munitions

- Key Points for 30x170mm RWM Schweiz AG
  - 162 Sub-Projectile Kinetic Energy Payload
  - Each 1.24 g
  - Programmed to Eject Payload (Burst) Ahead of target



- Potential Advantages of ABM
  - Increased chance of hitting target due to better coverage by sub-projectile payload
  - Hence provides Increased lethality against soft targets

ABM Trial - Shoeburyness, Nov 2003

- Co-operation with USN and USMC & Industry

- Objectives of Trial
  - Assess ABM against representative target
  - Assess Penetration of fragments
  - Assess Fragment Dispersion
  - Assess Burst Point Placement

The Target Matrix

1km Target Matrix 11th November 2003

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The Churchend Range

11th November 2003

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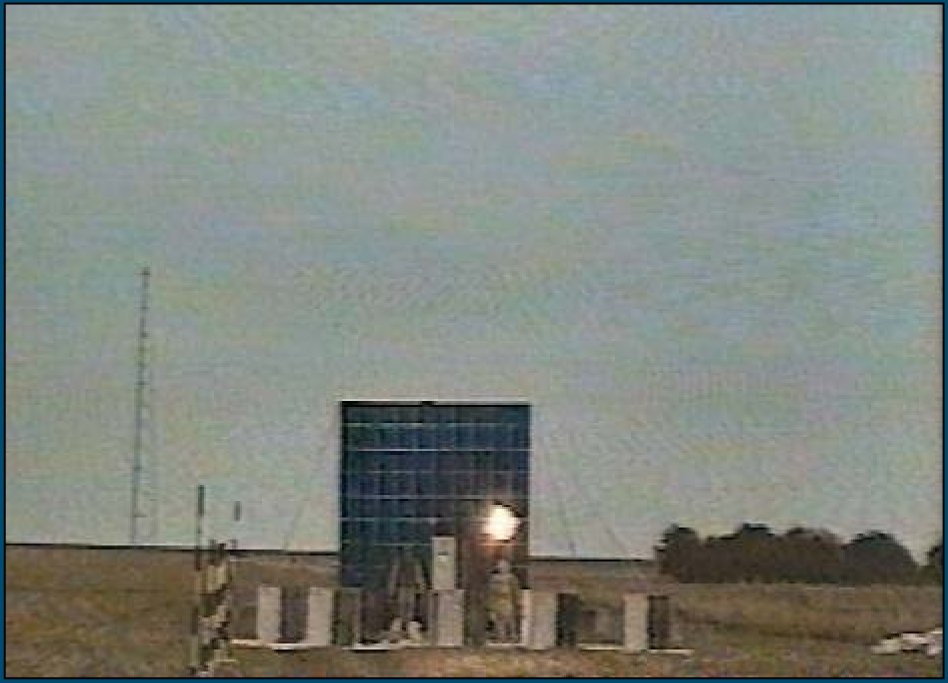
ABM Burst Point Capture

1.5km Range



Front Camera

Side Camera

Target Plate Analysis

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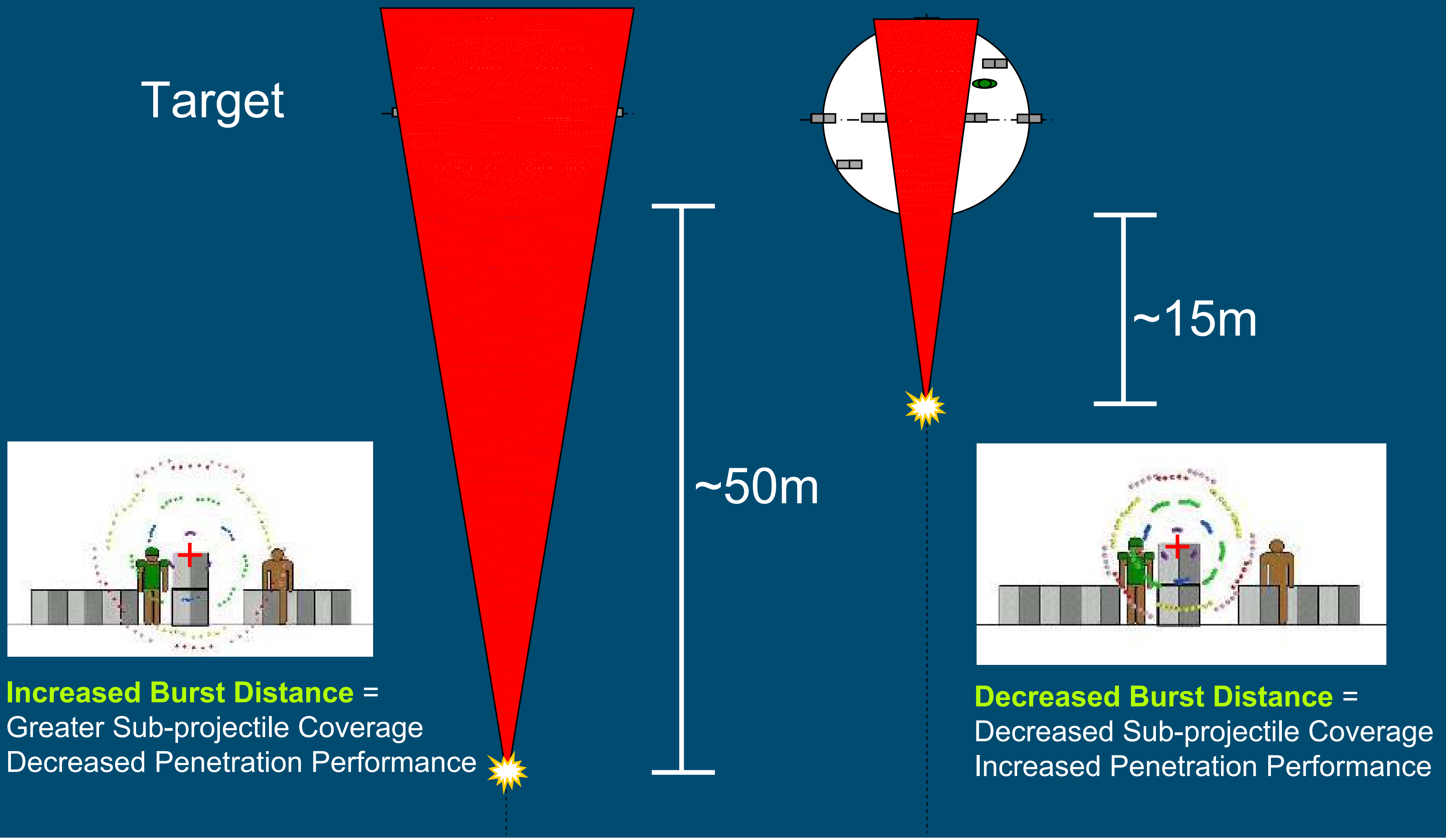
Effects of Burst Distance

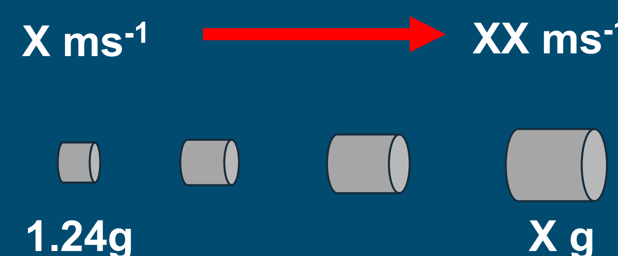


ABM Future Work

- Trial planned for May - Jun 05
  - Different Design of ABM by General Dynamics (High Explosive Air Burst)
  - HEI rounds will be fired for direct comparison against target plates

GENERAL DYNAMICS
Ordnance and Tactical Systems

- Gas Gun firings and Modelling to determine optimum sub-projectile size and associated lethality against threat set



- Results feed directly into both UK and US Navy Procurement Programmes
  - T23 Upgrade
  - US LPD17 & EFV

Potential Platforms for ABM

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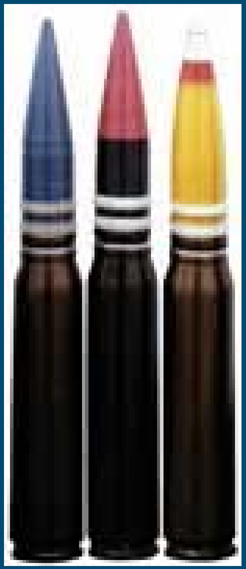
Effects of High Explosive Rounds

Future Ammunition Work

- Investigate Lethality of a COTS range of Ammunition against precisely defined representative targets
- Larger calibres considered
- Using Typical threat materials and suitable position (e.g. angles)
- Determine required gun/ammunition lethality against the threat set



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Hybrid Gun Mount

- 70mm Low Cost Rocket
- 6km Range (Increased with Guided Variant)
- Studies Conclude Launcher fit is feasible
  - Issues with Local Control Position

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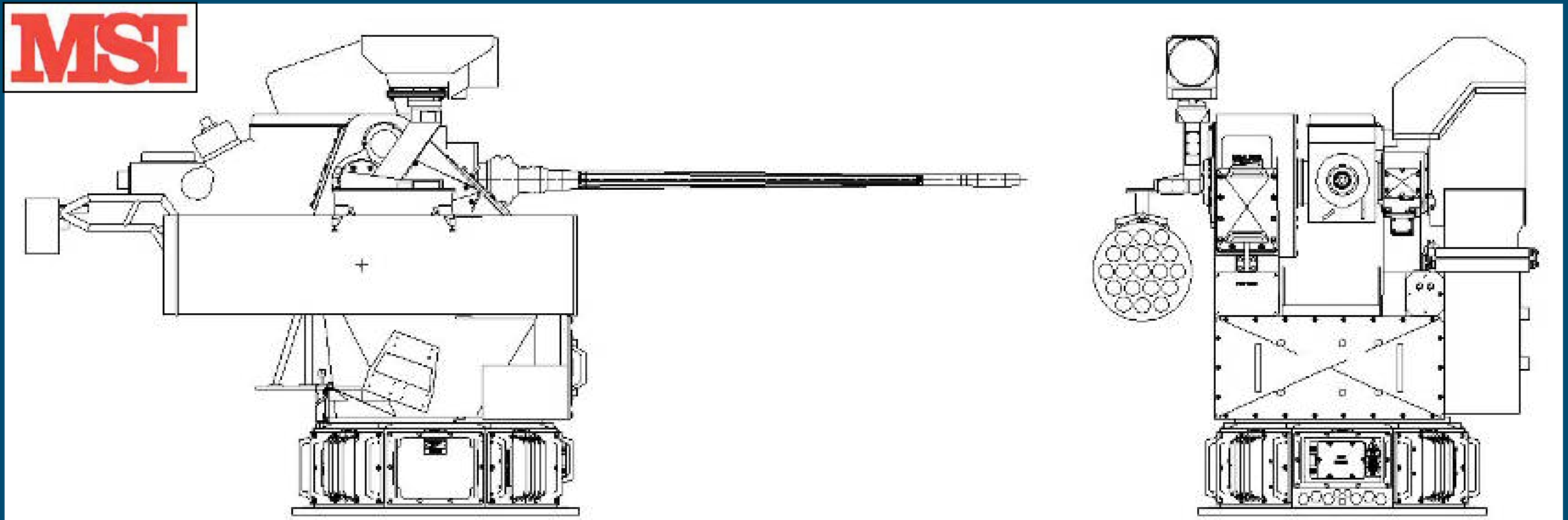

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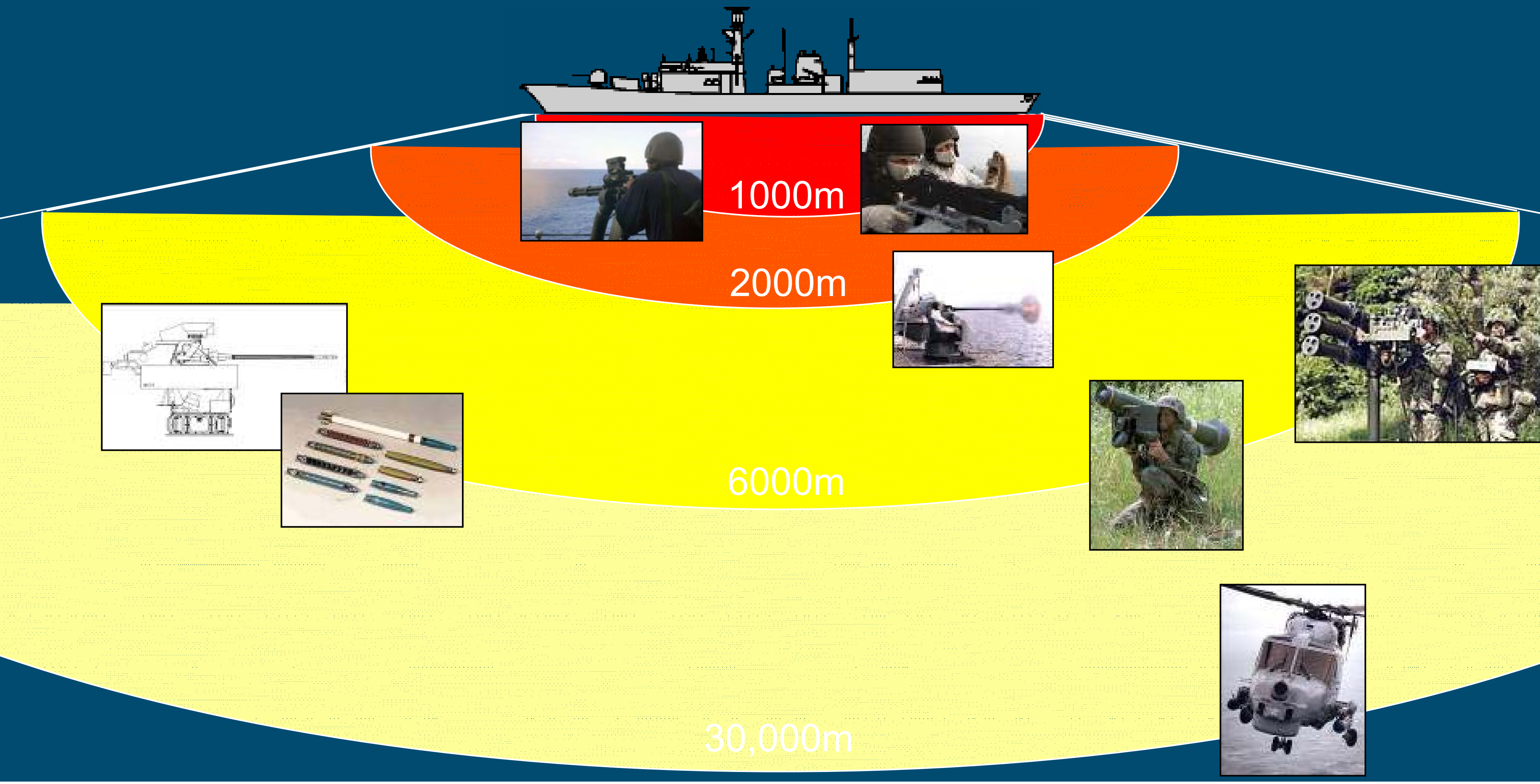
A Layered Defence



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Implications of Swarm Attack

- Investigate Impact of dealing with a FIAC Swarm Attack from a SCGS

- Human Factors
  - Examine Human Computer Interface for Operator control
  - Prevent the operator from being overwhelmed?

- Can Technology assist?
  - Target Prioritisation?
  - BDA?