



NDIA

2022

# INSENSITIVE MUNITIONS AND ENERGETIC MATERIALS (IMEM) TECHNOLOGY SYMPOSIUM

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**Enhancing The Performance of Insensitive Munitions**

October 18 – 20, 2022 | Indianapolis, IN | [NDIA.org/IMEM](https://www.ndia.org/IMEM)

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## NDIA

### WHO WE ARE

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

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# SCHEDULE AT A GLANCE

### MONDAY, OCT 17

**Registration**  
Cosmopolitan Foyer  
4:00 pm - 6:00 pm

### TUESDAY, OCT 18

**Registration**  
Cosmopolitan Foye  
8:00 am - 5:30 pm

#### Keynote: Dr. Brian Fuchs

Cosmopolitan AB  
8:10 am - 9:00 am

#### Reception

Cosmopolitan Foyer  
5:10 pm - 6:10 pm

### WEDNESDAY, OCT 19

**Registration**  
Cosmopolitan Foyer  
7:00 am - 12:00 pm

#### Keynote: Dr. Robert Wardle

Cosmopolitan AB  
8:35 am - 9:15 am

### THURSDAY, OCT 20

**Registration**  
Cosmopolitan Foyer  
7:00 am - 5:00 pm

#### Keynote: Dr. Jason Jouet

Cosmopolitan AB  
9:00 am - 10:00 am

# WELCOME TO 2022 IMEM TECHNOLOGY SYMPOSIUM

On behalf of the Insensitive Munitions and Energetic Materials Committee and our MSIAC partner, I would like to welcome you to the 2022 Insensitive Munitions and Energetic Materials Technology Symposium. This international gathering of the top chemists, system designers and engineers from government laboratories, industry, and academia provides a venue for the exchange and dissemination of the latest research in synthesis, formulation, system design, testing, characterization and safety – all aimed at advancing munitions effectiveness while improving safety for the warfighter. In recent decades, great advances

have been made and our munitions are less vulnerable to attack than ever before; however, challenges persist. It is through the continuing work of the authors, presenters, sponsors, and attendees at this conference and across our worldwide defense industry that these challenges will be overcome resulting in safer munitions being produced in our factories and fielded to our warfighters.

**Paul Braithwaite**  
Fellow, Propulsion Systems IR&D Lead  
Northrop Grumman Corporation

## GET INVOLVED

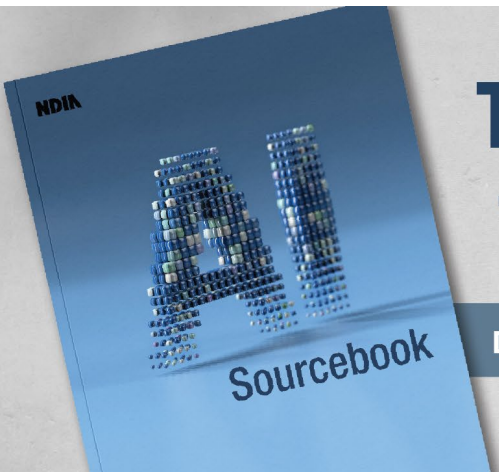
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# MUNITIONS TECHNOLOGY

## WHO WE ARE

The Munitions Technology Division maintains an open exchange of technical information among government and industry programs and technical managers, and to identify changes and trends in policy, guidance, and organizational functions that impact the development, production, maintenance, and demilitarization of munitions.



## The definitive guide to AI providers

DOWNLOAD YOUR FREE PDF

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# EVENT INFORMATION

## LOCATION

Hyatt Regency  
One South Capital Avenue  
Indianapolis, IN 46204

## ATTIRE

Civilian: Business Casual  
Military: Uniform of the Day

## SURVEY AND PARTICIPANT LIST

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

## EVENT CONTACT

**Kimberly Hurley**  
Director, Meetings  
(703) 247-9494  
[khurley@NDIA.org](mailto:khurley@NDIA.org)

## PLANNING COMMITTEE

**Paul Braithwaite**  
Symposium Chair

**Ken Graham**  
Committee Member

**Christelle Collet**  
Committee Member

**Steve Nicolich**  
Committee Member

**Stephen Struck**  
Committee Member

## SPEAKER GIFTS

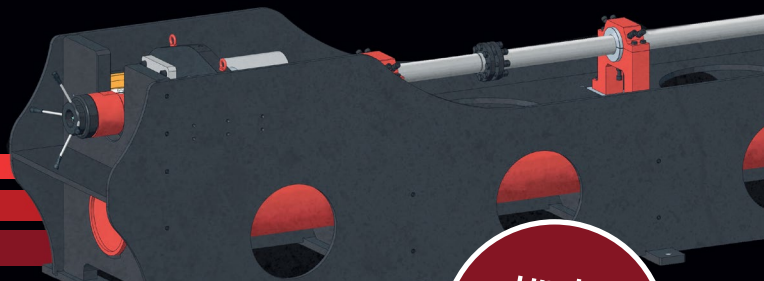
In lieu of speaker gifts, a donation is being made to the Fisher House Foundation.

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**POWDER GUNS ZOLTAN 40 & ZOLTAN 90**

up to  
2530m/s  
at 15m

**IMPACTS OF FRAGMENTS**

**EVALUATION & DEVELOPMENT OF INSENSITIVE AMMUNITION**

**EVALUATION OF ARMORED VEHICLES' LEVEL OF PROTECTION**



**STANAG  
AOP 4496**

**QUALITY OF IMPACT**

- Impact point at 15mm maximum from the aimed point at 15m
- Tilt at impact less than 2° at 15m
- Total separation of the sabot before impact



**EASE OF USE**

- Complete supply including launcher and projectiles
- Easy installation and removal of the launcher without special adjustment



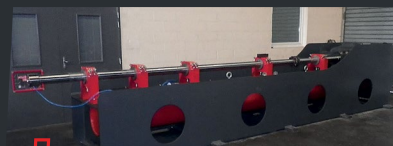
**SMART MAINTENANCE**

- Easy cleaning after each shot
- 30 shots before replacement of wear parts
- 300 shots before replacement of the interchangeable part of the tube



Customization of the launcher depending on the nature of the powder used by the customer\*

**TECHNICAL CAPABILITIES**



**ZOLTAN 40 Ø**

14.30mm @ 18.6g FSP  
V 15m: 2530 ± 90m/s  
20.00mm @ 52.73g FSP  
V 15m: 1830 ± 60m/s



**ZOLTAN 90 Ø**

Up to 300g fragment  
V 15m: 2000 ± 90m/s

**THIOT INGENIERIE**

www.thiot-ingenierie.com

contact@thiot-ingenierie.com

+33 (0)5 65 38 36 07

830 route Nationale  
46130 Puybrun - FRANCE

\*performance to be validated according to the nature of the powder

# AGENDA

## MONDAY, OCTOBER 17

4:00 – 6:00 pm      **REGISTRATION**  
COSMOPOLITAN FOYER

## TUESDAY, OCTOBER 18

7:00 am – 5:30 pm      **REGISTRATION**  
COSMOPOLITAN FOYER

8:00 – 8:10 am      **WELCOME REMARKS**  
COSMOPOLITAN AB  
  
**MG James Boozer, USA (Ret)**  
Executive Vice President, NDIA

8:10 – 9:00 am      **KEYNOTE: INSENSITIVE MUNITIONS, IMPORTANT NOW MORE THAN EVER**  
COSMOPOLITAN AB  
  
**Dr. Brian Fuchs**  
Senior Research Scientist, Inensitive Munitions, U.S. Army Picatinny Arsenal

9:00 – 9:40 am      **MSIAC AWARDS PRESENTATION**  
COSMOPOLITAN AB  
  
**Christelle Collet**  
Technical Specialist Officer, MSIAC

9:40 – 10:10 am      **NETWORKING BREAK**  
COSMOPOLITAN FOYER

10:15 – 10:35 am      **ENERGETIC MATERIALS & THE DEFENSE PRODUCTION ACT**  
COSMOPOLITAN AB  
  
**Anthony Di Stasio**  
Director, Industrial Base Support, USD (A&S)

10:35 – 10:55 am      **COMPARISON OF IM THREATS VERSUS THE REAL WORLD**  
COSMOPOLITAN AB  
  
**Christelle Collet**  
Technical Specialist Officer, MSIAC

10:55 – 11:15 am

**NATO INSENSITIVE MUNITIONS PORTFOLIO PROGRESSION  
LEADING TO INSENSITIVE MUNITIONS – HAZARD CLASSIFICATION  
(IM-HC) HARMONIZATION**

COSMOPOLITAN AB

**Daniel Pudlak**  
CCDC-AC, U.S. Army

11:15 – 11:35 am

**INSENSITIVE MUNITIONS – HAZARD CLASSIFICATION HARMONIZATION  
WORKING GROUP (IM-HC WG) UPDATE & DEVELOPMENT OF AOP-4864**

COSMOPOLITAN AB

**Daniel Pudlak**  
CCDC-AC, U.S. Army

11:35 – 11:55 am

**MSIAC HIGHLIGHTS & FUTURE PRIORITIES**

COSMOPOLITAN AB

**Christelle Collet**  
Technical Specialist Officer, MSIAC

11:55 am – 1:00 pm

**NETWORKING LUNCH**

COSMOPOLITAN AB

**CONCURRENT BREAKOUT SESSIONS**

	<b>In insensitive Munitions Policy &amp; Requirements</b>	<b>Energetic Material Formulations &amp; Synthesis</b>
	COSMOPOLITAN AB Session Chair: Joseph LiVolsi	COSMOPOLITAN CD Session Chair: Dr. Jacob Morris

1:00 – 1:20 pm

**24847 – The Status of International &  
National IM Policies Across Nations**

**Christelle Collet**  
Technical Specialist Officer, MSIAC

**24923 – Estimation of Elastic Constants  
of Composite Energetic Materials**

**Dr. Kevin Jaansalu**  
TSO Materials Technology, Munitions Safety  
Information and Analysis Center (MSIAC)

1:25 – 1:45 pm

**24765 – An International Review of  
Stanag 4488 Gap Testing**

**Dr. Ernest Baker**  
Warheads TSO, NATO MSIAC

**24861 – Improved Continuous  
Microfluidic Synthesis of  
Energetic Compounds**

**Dr. Christina Christensen**  
Principal Research Scientist,  
Northrop Grumman Corporation

1:50 – 2:10 pm

**24766 – Recent Advances of the MSIAC Gap Test Tool & Database**

Dr. Ernest Baker  
Warheads TSO, NATO MSIAC

**24850 – The Story of Ethylenedinitramine (EDNA): Synthesis, Crystallization, Formulation & Applications**

Dr. Arthur Delage  
R&D Project Manager, EURENCO

2:15 – 2:35 pm

**24854 – Comparison Of Performance & Insensitivity Properties of Enhanced Blast Plastic Bonded Explosives with Conventional Explosives**

Serhat Bilgen  
Senior Research, TUBITAK SAGE

2:35 – 3:10 pm

**NETWORKING BREAK**  
COSMOPOLITAN FOYER

**CONCURRENT BREAKOUT SESSIONS**

	<b>Insensitive Munitions Test Methods</b>	<b>Energetic Materials Processing</b>
	COSMOPOLITAN AB Session Chair: Nausheen Al-Shehab	COSMOPOLITAN CD Session Chair: Wendy Hummers

3:10 – 3:30 pm

**24857 – The Fundamentals of IM Testing**

Jon Toreheim  
Marketing and Sales Manager, Bofors Test Center

**24781 – Development of ResonantAcoustic® Continuous Microreactor and ResonantAcoustic® Continuous Crystallizer**

Dr. Joseph Mayne  
Senior Chemical Engineer, Resodyn Corporation

3:35 – 3:55 pm

**24865 – Air Drag Measurements for the NATO Insensitive Munitions Fragment**

Kevin Miers  
Mechanical Engineer, U.S. Army DEVCOM Armaments Center

**24834 – Process Improvement of Melt Pour Explosive 3,4-Dinitropyrazole (DNP)**

Dr. Tomasz Modzelewski  
Principal Scientist, BAE Systems, Inc.

4:00 – 4:20 pm

**24852 – Mitigation of Flat 2-Dimensional Shocks to Prevent Sympathetic Reactions**

Stefan de Koster  
Junior Scientist Innovator, TNO

**24843 – Continuous ResonantAcoustic® Production of Energetic Material**

Joe Mayne  
Senior Chemical Engineer, Resodyn Corporation



4:25 – 4:45 pm

**CLOSING REMARKS**

**Nausheen Al-Shehab**  
Chemical Engineer, U.S. Army DEVCOM AC

**24862 – Advances in Resodyn  
Acoustic Mixer Processing  
Methods & Characterization**

**Justin Whaley**  
Senior Controls Engineer, Resodyn Corporation

4:45 – 4:50 pm

**CLOSING REMARKS**

**Wendy Hummers**  
Program Director, Elbit Systems Ltd.

5:10 – 6:10 pm

**RECEPTION**

COSMOPOLITAN FOYER

**WEDNESDAY, OCTOBER 19**

7:30 am – 12:00 pm

**REGISTRATION**

COSMOPOLITAN FOYER

8:30 – 8:35 am

**OPENING REMARKS**

COSMOPOLITAN AB

**Paul Braithwaite**

Fellow, Propulsion Systems IR&D Lead, Northrop Grumman Corporation  
*Symposium Chair*

8:35 – 9:15 am

**KEYNOTE: PATHS FOR EM/IM TO PROVIDE STRATEGIC DIFFERENTIATION**

COSMOPOLITAN AB

**Dr. Robert Wardle**

Principal, Wardle Enterprises: Energetics, Services and Technologies, LLC

9:15 – 10:00 am

**ENERGETIC MATERIALS: MOVING FORWARD IN THE 21ST CENTURY**

COSMOPOLITAN AB

**Paul Braithwaite**

Fellow, Propulsion Systems IR&D Lead, Northrop Grumman Corporation  
*Moderator*

**Dr. Jacob Morris**

Chief, Energetics Material Branch, Munitions Directorate, Air Force Research Laboratory

**Laurent Bonhomme**

Roxel Group

**Dr. David Price**

Director of Business Development, NALAS Engineering

**Jon Toreheim**

Marketing and Sales Manager, Bofors Test Center

10:00 – 10:30 am

**NETWORKING BREAK**

COSMOPOLITAN FOYER

## CONCURRENT BREAKOUT SESSIONS

	Insensitive Munitions Modeling	Energetic Material Characteristics
	COSMOPOLITAN AB Session Chair: Dr. Ernest Baker	COSMOPOLITAN CD Session Chair: Melissa Mileham
10:30 – 10:50 am	<p><b>24851 – Implementation of Munition Vulnerability Models in the Ship Vulnerability Code Resist</b></p> <p>Gert Scholtes Senior Research Scientist, TNO DSS</p>	<p><b>24839 – Characterization of Impact Induced Reaction of Explosives Using the AFRL High Explosive Survivability Test (HEST)</b></p> <p>Dr. Jesus Mares, Jr. Engineer, U.S. Air Force Research Laboratory</p>
10:55 – 11:15 am	<p><b>24860 – Evaluation of Critical Temperatures via Thermal Runaway Models and Slow Cook Off Testing</b></p> <p>Dr. Jeremy Headrick R&amp;D Technical Manager, BAE Systems, Inc.</p>	<p><b>24872 – Life Cycle Assessment and Aging Characteristics of Novel Signal Pyrotechnics, and Comparison to a Military Reference Composition</b></p> <p>Dr. Richard Bouma Senior Scientist, TNO</p>
11:20 – 11:40 am	<p><b>24993 – Concept for Improving Cook-off Performance of Propellants &amp; Explosives</b></p> <p>Dr. Jon Yagla Mechanical Engineer, Axient</p>	<p><b>24844 – Recent Advancement on Enhanced Blast Explosives Manufacturing at Holston Army Ammunition Plant</b></p> <p>Kyle Bittner R&amp;D Formulation Chemist, BAE Systems, Inc.</p>
11:45 am – 12:05 pm	<p><b>CLOSING REMARKS</b></p> <p>Dr. Ernest Baker Warheads TSO, NATO MSIAC</p>	<p><b>24893 – Comparison of the High-Speed Deformation Behavior of Cast &amp; Additive Manufactured Polymer Bonded Mock Explosives</b></p> <p>Kerry-Ann Stirrup PhD Candidate, Impact Science Laboratory, Purdue College of Engineering</p>
12:05 – 12:10 pm		<p><b>CLOSING REMARKS</b></p> <p>Dr. Melissa Mileham Staff Research Scientist, Northrop Grumman Corporation</p>
12:10 pm	<b>ADJOURN</b>	

## THURSDAY, OCTOBER 20

- 8:00 am – 5:00 pm      **REGISTRATION**  
COSMOPOLITAN FOYER
- 8:50 – 9:00 am      **OPENING REMARKS**  
COSMOPOLITAN AB  
  
**Paul Braithwaite**  
Fellow, Propulsion Systems IR&D Lead, Northrop Grumman Corporation  
*Symposium Chair*
- 9:00 – 10:00 am      **KEYNOTE: NATIONAL ENERGETIC PLAN**  
COSMOPOLITAN AB  
  
**Jason Jouet**  
Director of Munitions Technology, Office of the Under Secretary of Defense for Research & Engineering (OUSD(R&E))
- 10:00 – 10:30 am      **NETWORKING BREAK**  
COSMOPOLITAN FOYER
- 10:30 – 10:50 am      **RECENT VULNERABILITY EVENTS DUE TO NON-IM MUNITIONS**  
COSMOPOLITAN AB  
  
**Dr. Ernest Baker**  
Warheads TSO, NATO MSIAC
- 10:50 – 11:10 am      **THE MSIAC SELF-AUDIT TO IMPROVE HOW TESTING FACILITIES CONDUCT IM & HC TESTS**  
COSMOPOLITAN AB  
  
**Christelle Collet**  
Technical Specialist Officer, MSIAC
- 11:10 – 11:30 am      **COOKOFF ANALYSIS USING AN IMPLICIT AMR APPROACH**  
COSMOPOLITAN AB  
  
**Dr. J. Keith Clutter**  
Senior Consultant, Integrated Solutions for Systems (IS4S), Inc.
- 11:30 – 11:50 am      **GUN BARREL & PROJECTILE HEATING FOR HOT GUN SAFETY**  
COSMOPOLITAN AB  
  
**Dr. Jon Yagla**  
Mechanical Engineer, Axient
- 11:50 am – 1:00 pm      **NETWORKING LUNCH**  
COSMOPOLITAN AB

# CONCURRENT BREAKOUT SESSIONS

	Insensitive Munitions Protection Systems	Energetic Materials Modeling
	COSMOPOLITAN AB Session Chair: Ken Graham	COSMOPOLITAN CD Session Chair: Gert Sholtes
1:00 – 1:20 pm	<p><b>24749 – Novel Rocket Motor Protection</b></p> <p><b>Daniel Turner</b> Senior Design Authority, Roxel (UK Rocket Motors), Ltd</p>	<p><b>24869 – A Numerical Model for Explosive Cook Off</b></p> <p><b>Dr. Brian Fuchs</b> Senior Research Scientist, U.S. Army Picatinny Arsenal</p>
1:25 – 1:45 pm	<p><b>24864 – Lightweight IM Impact Protection System for Reducing Reaction of Solid Rocket Motors</b></p> <p><b>Andrew Witzig</b> President &amp; CEO, Shearwater Technology, Inc.</p>	<p><b>24959 – A Comprehensive Approach for the Development of the Fundamental Comprehension of How Energetic Defects Form, Propagate &amp; Affect Initiation</b></p> <p><b>Daniel Pudlak</b> CCDC-AC, U.S. Army</p>
1:50 – 2:10 pm	<p><b>24867 – SR Barriers for IMX-104 Filled 155mm Artillery Projectiles</b></p> <p><b>Kevin Miers</b> Mechanical Engineer, U.S. Army DEVCOM Armaments Center</p>	<p><b>24955 – AI For Energetic Defect Characterization</b></p> <p><b>Antonio Aguirre, Jr.</b> Mathematician, Picatinny Arsenal</p>
2:15 – 2:35 pm	<p><b>24866 – Steel FI Barriers Hardness &amp; Obliquity Effects</b></p> <p><b>Kevin Miers</b> Mechanical Engineer, U.S. Army DEVCOM Armaments Center</p>	<p><b>24856 – Sample Extraction &amp; Analysis Techniques for Simultaneous Determination of Legacy &amp; IM Constituents</b></p> <p><b>Dr. Austin Scircle</b> Research Chemist, USACE Engineer Research &amp; Development Center</p>
2:35 – 3:05 pm	<p><b>NETWORKING BREAK</b> COSMOPOLITAN FOYER</p>	

## CONCURRENT BREAKOUT SESSIONS

	Insensitive Munitions Technology Applications	Energetic Materials: Design & Integration
	COSMOPOLITAN AB Session Chair: Steve Struck	COSMOPOLITAN CD Session Chair: Dr. Arthur Delage
3:10 – 3:30 pm	<p><b>24840 – Insensitive Hydro-reactive Munitions</b></p> <p><b>Dr. Nicholas Nechitailo</b> Senior Subject Matter Expert, Weapons Effects, Fluid-Structure Interactions, Materials Failure, Naval Surface Warfare Center Indian Head EOD Technology Division</p>	<p><b>24853 – Investigation of Slow Cook-Off Behavior of Castable PBXs</b></p> <p><b>Z. Taner Kaya</b> Senior Researcher, TUBITAK SAGE</p>
3:35 – 3:55 pm	<p><b>24863 – Cook-Off Mitigation for Medium Caliber Ammunition</b></p> <p><b>Nausheen Al-Shehab</b> Chemical Engineer, U.S. Army DEVCOM AC</p>	<p><b>24820 – Development of IM Naval Countermining Charges with Increased Performance</b></p> <p><b>Chris Reams</b> RWM Italia</p>
4:00 – 4:20 pm	<p><b>24848 – New Test Method for Single Package Test for Transportation</b></p> <p><b>Erik Tunestål</b> R&amp;D Project Manager, Eurenco Bofors AB</p>	<p><b>CLOSING REMARKS</b></p> <p><b>Dr. Arthur Delage</b> R&amp;D Project Manager, EURENCO</p>
4:25 – 4:45 pm	<p><b>24876 – Simplified Numerical Methodology to Size Munitions to Withstand Sympathetic Reaction</b></p> <p><b>Sébastien Bodard</b> R&amp;D Modelling Team Lead, EURENCO</p>	
4:55 – 5:00 pm	<p><b>CLOSING REMARKS</b></p> <p><b>Steve Struck</b> Program Manager, U.S. Air Force Research Laboratory (AFRL)</p>	

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# ABSTRACT DESCRIPTIONS

## ENERGETIC MATERIAL CHARACTERISTICS

24839

### **Characterization of Impact Induced Reaction of Explosives Using the AFRL High Explosive Survivability Test (HEST)**

**Dr. Mares, J. Jr.**

We characterize two Air Force explosives and present lessons learned in the development and utilization of the High Explosive Survivability Test (HEST).

24872

### **Life Cycle Assessment and Aging Characteristics of Novel Signal Pyrotechnics, and Comparison to a Military Reference Composition**

**Dr. Bouma, R.**

Novel red and green signal NC-based compositions are being developed. A sufficient thermal stability is demonstrated in accelerated ageing experiments. Assessment of the environmental hazards and human health impacts, and a quick scan life cycle analysis, demonstrated the reduced damage costs in comparison to their current military counterparts.

24844

### **Recent Advancement on Enhanced Blast Explosives Manufacturing at Holston Army Ammunition Plant**

**Bittner, K.**

This paper details the recent advancement in process development, production manufacturing and future process improvement of EB explosives at HSAAP. To date, over 17,000 lbs. of EB explosives had been successfully manufactured at HSAAP; and the quantity will exceed 20,000 lbs. by the end of 2022, and significantly more (> 30,000 lbs.) expected in 2023 and beyond.

24893

### **Comparison of the High-speed Deformation Behavior of Cast and Additive Manufactured Polymer Bonded Mock Explosives**

**Stirrup, K.**

Samples of mock Polymer Bonded Explosives (PBX) were produced using traditional casting methods and via Vibration Assisted Printing (VAP). To evaluate material behavior while deformed at high speeds, samples were impacted using a single stage gas gun located at the Dynamic Compression Sector of the Advanced Photon Source. In-Situ Phase Contrast Imaging (PCI) showed the printed samples failed due to the collapse of pores inherent to the printing process.

## ENERGETIC MATERIAL FORMULATIONS & SYNTHESIS

24923

### **Estimation of Elastic Constraints of Composite Energetic Materials**

**Dr. Jaansalu, K.**

The best model for prediction of elastic composites is a variation of the logarithmic sum. Any further evaluation or model development would be greatly facilitated by more experimental data.

24861

### **Improved Continuous Microfluidic Synthesis of Energetic Compounds**

**Dr. Christensen, C.**

Our group has designed and tested a system for the continuous microfluidic synthesis and in-line extraction and purification of energetic materials using commercially available components. This system will reduce hazards associated with batch synthesis of energetics and the need for attended work by employing remote operation of the equipment. The system has been used to demonstrate the continuous processing of glycidyl nitrate from glycerol, an important precursor to poly(glycidyl nitrate) (PGN), an ingredient of significant interest for use in high performance formulations.

24850

### **The Full Story of Ethylenedinitramine (EDNA): Synthesis, Crystallization, Formulation and Applications**

**Dr. Delage, A.**

EthyleneDiNitrAmine (EDNA, C<sub>2</sub>H<sub>6</sub>N<sub>4</sub>O<sub>4</sub>) has been identified as the best candidate and has been selected as the main filler for new generation powders (thermoplastic) and for explosives applications such as cast PBX formulation based on the less sensitivity of EDNA to shock and friction compared to RDX. This work includes all the steps from synthesis to final applications.

24854

### **Comparison of Performance and Insensitivity Properties of Enhanced Blast Plastic Bonded Explosives with Conventional Explosives**

**Bilgen, S.**

In this study, plastic-bonded EBXs that contain different type of energetic materials (RDX, HMX) and different amount of metallic powder (30wt% and 45wt%), namely TSP-01-2, TSP-02-1 and TSP-02-2 was developed and compared with conventional explosives such as TNT and Comp-B in terms of performance and insensitivity properties. For performance properties, total pressure impulse, thermal performance (fireball diameter and fireball duration time) properties, detonation velocity and fragmentation test results were compared. For insensitivity properties, shock sensitivity measurements of EBXs were compared with literature values of conventional explosives.

## ENERGETIC MATERIALS MODELING

24869

### A Numerical Model for Explosive Cook Off

Dr. Fuchs, B.

The generalized equation for conductive heat transfer (without mass transfer) with internal heat generation in a spherical configuration and allowing for degradation was used to study general trends in cook-off behavior. The explosive RDX was selected for the study, as it is a common energetic material used in many compositions. A Python language computer program was written to study two cases, initially uniform material with the surface maintained at a uniform temperature, and a uniform temperature material with the surface heated at a steady rate. It was determined that, slower heating rates tend to have reactions towards the center of the charge, but increase the amount of material degradation, and that there may be no observable heat rise on the surface to indicate impending violent reactions.

24959

### A Comprehensive Approach for the Development of the Fundamental Comprehension of How Energetic Defects Form, Propagate, and Affect Initiation

Pudlak, D.

Defects in artillery High Explosive (HE) main-fills have caused catastrophic failures during gun launch, resulting in fatalities and damage to personnel and their weapon systems/platforms. With the new Long Range Performance Fires (LRPF) requirements exceeding gun/barrel designs and flight environments, energetic defect characterization is now more important than ever. Several attempts to

investigate particular facets of energetic defects are still on-going, however a new, comprehensive effort has been developed that addresses all facets of energetic defects, in an all-compassing manner. The U.S. Army, DEVCOM-AC is currently executing a comprehensive effort, 'Energetic Defect Characterization – Capability Development Effort (EDC-CDE)', that focuses on the development of the fundamental understanding of energetic defects, including how they form/propagate, how they affect initiation (focusing on interior ballistics specifically, but also taking into account their exterior and terminal ballistics influences), determination of critical defects (including critical parameters, metrics, criteria, etc.), and ultimately the mitigation of critical defects, with visionary goals of implementing improvements to the LAP inspection equipment/processes, such as Smart XCT 3D (X-Ray) embedded with w/ Automated Intelligence / Machine Learning (AI/ML) codes.

24955

### AI For Energetic Defect Characterization

Aguirre, A. Jr.

24856

### Sample Extraction and Analysis Techniques for Simultaneous Determination of Legacy and IM Constituents

Dr. Scircle, A

Novel methodology development using artificial intelligence to augment human-in-the-loop efforts for identifying the presence of defects in x-ray image datasets of explosively filled ordnance.

## ENERGETIC MATERIALS PROCESSING

24781

### Development of ResonantAcoustic® Continuous Microreactor and ResonantAcoustic® Continuous Crystallizer

Dr. Mayne, J.

Resodyn has developed novel continuous chemical reactor and continuous crystallizer technologies built on the ResonantAcoustic® Mixing (RAM) platform. This technology is applied to the synthesis and recrystallization of energetic and energetic precursor compounds.

24834

### Process Improvement of Melt Pour Explosive 3,4-Dinitropyrazole (DNP)

Dr. Modzelewski, T.

Development of a highly simplified, and environmentally and economically friendly, synthesis method for the manufacture of 3,4-Dinitropyrazole (DNP)

24843

### Continuous ResonantAcoustic® Production of Energetic Material

Dr. Joseph Mayne

A Continuous Acoustic Mixing (CAM) Clean-in-Place (CIP) process has been developed at Resodyn Corp. to significantly increase the safety, reduce the cost, and reduce the environmental impact of producing Plastic Bonded Explosive (PBX) and propellant.

24862

### Advances in Resodyn Acoustic Mixer Processing Methods and Characterization

Whaley, J.

ResonantAcoustic® Mixers (RAM) have become a technology of choice in the energetics but operation can be non-intuitive to the mixologist accustomed to using conventional mixing processes. Even for advanced users, the behavior of materials can vary drastically in responses to subtle parameter changes. To fully utilize the advantages of RAM manufacturing a set of mixing metrics is used for improving the RAM process and measuring mixedness of the product.

## ENERGETIC MATERIALS: DESIGN & INTEGRATION

24853

### Investigation of Slow Cook-off Behavior of Castable PBXs

Kaya, T. Z.

Slow heating response of small-scale test items and full-scale munitions due to thermal decomposition of castable polymer bonded explosives (PBXs) (PBXN-109/110/111/113 composition equivalents) was investigated by testing and thermal/CFD modelling efforts.

24820

### Development of IM Naval Countermining Charges with Increased Performance

Reams, C

RWM Italia have developed new naval countermining charges to replace legacy, non-IM munitions that were at the end of their service life. The new munitions showed much better IM characteristics and also improved performance vs the legacy munitions.

## INSENSITIVE MUNITIONS MODELING

24851

### Implementation of a Munition Vulnerability Models in the Ship Vulnerability Code Resist

Scholtes, G.

Stochastic approach to implement munition vulnerability models in platform vulnerability codes to estimate the response of stored munition after a hostile impact.

24993

### Concept for Improving Cook-off Performance of Propellants and Explosives

Dr. Yagla, J.

Concept For Improving Cook-off Performance of Propellants and Explosives – Oriented fibers or strands of material of high thermal conductivity are embedded in a mass of energetic material. The strands are arranged to draw heat out of potential hot spots to prevent thermal runaway and explosive reactions. Examples, mathematical principles, and possible means for orienting the strands are provided.

24860

### Evaluation of Critical Temperatures via Thermal Runaway Models and Slow Cook Off Testing

Dr. Headrick, J.

Evaluation of critical temperatures of RDX & HMX explosives formulations via thermal runaway modeling and slow cook off testing.

## INSENSITIVE MUNITIONS POLICY & REQUIREMENTS

24847

### The Status of Internal and National IM Policies Across the Nations

Collet, C.

The recent review that was conducted at MSIAC provides insight to international and national IM policies. After an overview of the IM policy in place for each nation, an analysis of the differences across policies is provided that highlights possible ways of improvement at a NATO level. This overview may also provide useful information to those nations that have not yet implemented their own IM policy.

24765

### An International Review of STANAG 4488 Gap Testing

Dr. Baker, E.

MSIAC has recently completed an international review of STANAG 4488 Gap Testing.

24766

### Recent Advances of the MSIAC Gap Testing Tool and Database

Dr. Baker, E.

MSIAC recently completed a project that extended the NEWGATES database for gap test results and increased its predictive capabilities. As a result, an updated version of NEWGATES (v1.12) has been released.

## INSENSITIVE MUNITIONS PROTECTION SYSTEMS

24749

### Novel Rocket Motor Protection

Turner, D.

Roxel UK have been investigating the potential of a new, novel, armour system to provide protection to rocket motors against impact IM threats to mitigate against the use of higher performance, more sensitive, propellants."

24864

### Lightweight IM Impact Protection System for Reducing Reaction of Solid Rocket Motors

Witzig, A.

This paper details the development and evaluation of a lightweight insensitive munition ballistic protection system for reducing the reactive response of solid rocket motors.



24867

**SR Barriers for IMX-104 Filled 155mm Artillery Projectiles****Miers, K.**

SR barriers were computationally designed, fabricated and tested on IMX-104 filled 155mm artillery projectiles. At least one of the designs provided a successful passing reaction, and this work documents the design process and experimental results.

24866

**Steel FI Barriers Hardness and Obliquity Effects****Miers, K.**

Steel armor has traditionally been able to mitigate the NATO FI threat in a cost effective and reasonably weight-efficient manner. However it has been suggested that further improvements in FI mitigation may be achieved by increasing steel hardness and toughness, as well as by taking advantage of potential obliquity effects. Steel plates of 4340 RC38 and D2 tool steel hardened to RC60 were fabricated and subjected to FI testing at both 0 and 45 degrees obliquity. The behind armor debris was captured with celotex panels, and the residual velocity was measured with high speed video. It was determined that spall failure dominates the fragment breakup behavior, and that the improvement in velocity reduction afforded by increased hardness and obliquity is limited by brittle failure.

**INSENSITIVE MUNITIONS TECHNOLOGY APPLICATIONS**

24840

**Insensitive Hydro-Reactive Munitions****Dr. Nechitailo, N.**

This paper describes the explosive reaction of aluminum projectiles with wet sand. Understanding the underlying phenomena may lead to the development of a new class of low-cost no-fuze, no-explosives insensitive munitions.

24863

**Cook-Off Mitigation for Medium Caliber Ammunition****Al-Shehab, N.**

This paper discusses development of Particle Impact Mitigation Sleeve (PIMS) to improve munition response to Fragment Impact Threats.

24848

**New Test Method for Single Package Test for Transportation****Tunestâl, E.**

Eurenco has developed and evaluated a new test method for 16.4.1 Test 6(a) Single package test. The new method has a quick setup method, can be pre-fabricated and from the tests a methodology to classify propellants without testing has also been proposed.

24876

**Simplified Numerical Methodology to Size Munitions to Withstand Sympathetic Reaction****Bodard, S.**

In this presentation, we address a step by step numerical methodology to study sympathetic reaction modeling, from 1D computation to select viable candidates, to 2D computations with validated hypothesis for finer analysis. This methodology aims to be fast and general enough to treat cases where the donor has fragmented or not before interacting with the acceptor.

**INSENSITIVE MUNITIONS TEST METHODS**

24857

**The Fundamentals of IM Testing****Toreheim, J.**

In this presentation a detailed method of how to design test setups and how to conduct each of the six standardized IM tests in a cost efficient way is given.

24865

**Air Drag Measurements for the NATO Insensitive Munitions Fragment****Miers, K. T.**

In this work, we have performed a series of drag coefficient measurements for the NATO IM fragment at the test velocities of interest (2530 m/s). The theory of drag measurement is discussed, with accurate measurements requiring many timing stations and long total range lengths in excess of 1000 calibers for hypersonic projectiles. Several experiments were performed indicating a drag coefficient of approximately 1.2-1.5, on the high end of what was expected. Accounting for air drag and correctly computing velocity should help provide increased confidence that the required impact velocities are being achieved for a given test configuration.

24852

**Mitigation of Flat 2-Dimensional Shocks to Prevent Sympathetic Reactions****De Koster, S.**

Investigation in the mitigation of a flat 2-Dimensional shock wave to prevent sympathetic reactions of plastic explosives in a wooden box.

# KEYNOTE BIOGRAPHIES



## DR. BRIAN FUCHS

*Senior Research Scientist*  
U.S. Army Picatinny Arsenal

Dr. Brian Fuchs is the Senior Research Scientist for Insensitive Munitions at the Combat Capabilities Development Command Armaments Center at Picatinny Arsenal. Fuchs conducts research pertaining to energetic materials, energetic materials printing, warheads technology and explosive safety. He serves as a technical consultant in the areas of Insensitive Munitions, testing, safety and detonation physics to other organizations.

Employment highlight include having been awarded the department of the Army Research and Development Achievement Awards in 1989, 1999, 2002, 2003, and 2009, and the Army Research and Development Achievement Award for excellence in Leadership in 2009. He received the 2016 National Defense Industrial Award Firepower technology Award. He is a member of the Army Insensitive Munitions Board, past chairman of the Joint Services Insensitive Munitions Technical Panel, serves on the Combat Capabilities Development Command Armaments Center, Energetic

Material Qualification Board for Explosives and is Chairman of NATO's Munitions Safety Information Analysis Center steering Committee (MSIAC).

Fuchs has received 13 patents in the areas in the areas of explosive formulations, loading techniques, warheads, fuze technologies, printed detonators, and printed electronics. He is a faculty member for Picatinny Arsenal's Armament Graduate school and an adjunct professor for the Stevens Institute of Technology.



## DR. ROBERT WARDLE

*Principal*  
Wardle Enterprises: Energetics, Services and Technologies, LLC

Dr. Robert Wardle is the principal at Wardle Enterprises: Energetics, Services & Technologies. Before holding his current position, he was senior director of advanced programs at Northrop Grumman (NGC) and he spent 35 years at the research and development department at Northrop

and predecessor organizations back to Thiokol Corporation. He received his Ph.D. in chemistry from Caltech. At NGC since 1986, he was involved in synthesis, characterization, formulation, fielding and aging/surveillance of energetic materials. At NGC, he moved through a series of increasingly responsible positions from lab chemist to director of R&D Laboratories.

In his role as Senior Director of Advanced Programs, he led the Propulsion Systems IR&D effort, built and commissioned a full scale AP plant, led hypersonic glide body development and production, synthesis of energetic materials including CL-20, production of military flares and decoys, and a broad spectrum of propellant, explosives and pyrotechnics related R&D programs.



## DR. JASON JOUET

*Director of Munitions Technologies*  
Office of the Under Secretary of Defense for Research and Engineering

Dr. Jason Jouet is responsible for the strategy, oversight, and supervision of the Department's munitions-relevant science and technology (S&T) investments. Munitions S&T comprises activities to improve or enhance kinetic weapon lethality, propulsion, target detection, fuzing, guidance, navigation and control, manufacturing, and advanced material development. Jouet also directs the OSD Joint DoD/DOE Munitions Program and the Joint Enhanced Munitions Technology Program with a total cumulative budget of \$64m, maturing cross-cutting, enabling technologies that are beyond service risk

tolerance, to increase lethality, performance, and readiness for warfighters' weapons systems to bolster U.S. technical superiority for decisive and asymmetric advantage.

Prior to this appointment, Jouet was Deputy Director for Manufacturing Technology within the Manufacturing & Industrial Base Policy office of OUSD (AT&L). In this role, he directed the OSD Manufacturing Science & Technology Program, focusing on the advancement of cross-cutting manufacturing technology to enable production of technology at cost, quality, and quantity suitable for acquisition.

Prior to coming to OSD, from 2001 to 2016, Jouet served as the Head, High Energy Materials Branch, Senior Research Scientist, and Program Manager at the Naval Surface Warfare Center Indian Head Division and was a recipient of the Dr. Dolores M. Etter Award for Top Navy Scientists and Engineers of the Year in 2010.

Jouet earned a Bachelor of Science in Chemistry from the University of Texas-Austin in 1995 and a Ph.D. in Chemistry from Duke University in 2000.

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Maritime Electronic Warfare | Naval Fires And Aviation | Seabasing



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



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February 27 – March 1, 2023 | Columbus, OH

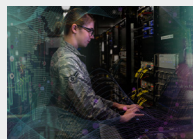
Autonomous Vehicles | Electric Drive | Modernization & Sustainment | Acquisition



## 25<sup>TH</sup> ANNUAL SYSTEMS & MISSION ENGINEERING CONFERENCE

November 1 – 3, 2022 | Orlando, FL

Program Management | Security Models | Test & Evaluation | Manufacturing



## 2023 HUMAN SYSTEMS CONFERENCE

March 1 – 2, 2023 | Arlington, VA

Human Systems Integration | Human Factors Engineering | Artificial Intelligence



## 33<sup>RD</sup> ANNUAL NDIA SO/LIC SYMPOSIUM

November 17 – 18, 2022 | Washington, DC

Special Operations Forces | Strategic Competition



## 2023 PACIFIC OPERATIONAL SCIENCE & TECHNOLOGY (POST) CONFERENCE

March 6 – 9\*\*, 2023 | Honolulu, HI

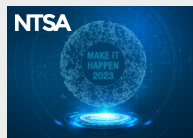
Regional Security | Science & Engineering Technology | Technology Engagement



## I/ITSEC 2022

November 28 – December 2, 2022 | Orlando, FL

Simulation | Training | Virtual Reality



## MODSIM WORLD 2023

May 22 – 23, 2023 | Norfolk, VA

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