Government Business Council

DEFENSE ISSUE BRIEF

# Optimizing Insensitive Munitions

## for the Armed Forces

Sponsored by: Orbital ATK

Front: Senior Airman Justyn Freeman/United States Department of Defense

## OPTIMIZING INSENSITIVE MUNITIONS FOR THE ARMED FORCES

The Defense Department (DoD) has worked for years to develop munitions that maintain lethal performance on the battlefield while ensuring maximum safety for the warfighters operating them. These "insensitive" munitions (IM) are designed to be chemically stable and impervious to fire, kinetic impact, electrical interference, and other unplanned stimuli. By focusing on IM as a goal, the military can ensure that its missiles operate as intended, protecting the U.S. from hostile forces while minimizing collateral damage to American soldiers, resources, and operational readiness.[1]

Delivering effective IM to the battlefield is not a new priority for the DoD, but the changing nature of warfare and recent breakthroughs in IM capabilities have ensured it carries critical urgency for 2018 and beyond. As a result, the U.S. must invest in weaponry that are effective against hostile forces while ensuring the safety of our own military men and women. Advancements in IM capabilities have finally made this possible.

## BRIEF HISTORY

The decision to develop effective IM was in part prompted by a series of fatal incidents involving U.S. service members. In 1967, an unguided Zuni rocket was accidentally launched aboard the U.S.S. Forrestal, striking another aircraft in its path and creating a fuel fire on deck that, in turn, caused one of the bombs in the ship to detonate and release a chain reaction. Multiple munitions exploded, killing 134 Navy personnel and injuring 161 others.

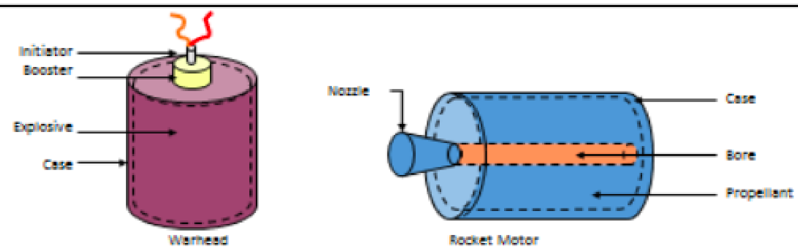
In 1991, tragedy struck again at Camp Do-Ha in Kuwait: a malfunctioning heater in an ammunition supply truck quickly grew to engulf the Army camp. 55 soldiers lost their lives due to the fast cook-off of 155mm Howitzer shells erupting in the fire. Just 13 days after this first incident, three more soldiers died when attempting to clear the site. As one report mentions, more tanks were destroyed by these episodes alone than in the entire war itself.[2]

In response, the U.S. and its international partners took steps to mitigate such accidental losses of life going forward. The NATO IM Information Center (NIMIC) was created in 1991 to provide an international point of reference for IM development and research.[3] In 1996, the Office of the Secretary of Defense (OSD) updated acquisition code to include IM-compliant requirements, which are still in effect to this day:

> "The Secretary of Defense shall ensure, to the extent practicable, that munitions under development or procurement are safe throughout development and fielding when subjected to unplanned stimuli."[4]

## CHALLENGE: HIGHER PERFORMANCE, LESS SENSITIVITY

While IM-compliant regulations were a step in the right direction, they yielded a second, less-desired outcome: munition developers struggled to satisfy what were seemingly contradictory aims spelled out in the law — how to add firepower and reactivity, while drastically reducing sensitivity to environmental stimuli. Since weapons experts view munitions as a "system issue," given that the makeup of any one component influences how other components operate, the challenge of creating IM-compliant materials was especially difficult.[5] The igniter, chemical propellant, warhead type, case material, and launch container design all factor in the design, with enhancement of any one part restricting or altering how the other parts perform.




| Stimuli | Some Potential Responses | |
|---|---|---|
| • Impact & Shock<br>– Drop<br>– Bullets<br>– Fragments<br>– Shaped-charge jets | • None<br>• Ignition<br>• Burning<br>• Propulsion<br>• Explosion | • Blast<br>– Shockwaves<br>– Overpressure<br>• Fragments<br>– Small, high-speed |
| • Thermal<br>– Fires<br>– Slow heating<br>– Hot spall fragments | • Detonation<br>• Heat<br>– Radiant<br>– Hot gases<br>– Plasma | – Large, lower speed<br>• Combinations of the above |

Source: Insensitive Munitions – US Problems and Solutions

## STIMULI TYPES AND TESTS

- **Fast cook-off**: exposure to rapid heat generation, "engulfing the munition in a fuel fire and recording its reaction as a function of time."
- **Slow cook-off**: exposure to gradually increasing thermal environment at a rate of 6 degrees F/hr, typically performed by "placing item in disposable oven and heating [it] with circulating heating air."
- **Bullet impact:** two tests are conducted, one that shoots bullets at the "largest explosive component, and the other at the most shock-sensitive explosive component," with a range of 20-30 meters to the target and a fire rate equivalent to 600 +/- 50 rounds/minute.
- **Fragment impact:** exposure to simulated high-velocity impact from artillery fragment, with fragment having a mass of 19.6 grams and impact velocity reaching 8300 +/- 300 fps.
- **Sympathetic reaction:** simulates response to detonation of an adjacent munition occurring as a result of accident or hostile event, with the intent of subjecting acceptor munitions to "worst case credible reaction of an identical donor munition."
- **Shaped charge jet impact:** subjects test item to direct impact of a shaped charge jet, equivalent in force impact to that of rocket propelled grenades, landmines, or guided weapons.

Although warheads have grown more insensitive in recent years, designing IM-compliant rocket motors proved more difficult. Past IM research and development has tended to focus exclusively on propellant and explosive formulation rather than the full range of system components contributing to overall performance. These components, which include case design, grain design, closure design, and various mitigation devices, each influence how the other parts in the system behave.[6] They bring up important considerations such as system weight and operating pressure, which are both dependent on the type of casing material and configuration of active and passive mitigation devices. As a result, experts are now examining composite materials as a substitute for traditional metal casing, as composites can be stronger, lighter, and more insensitive to impact and thermal stimuli because of their failure modes.[7]

| Passive | Active |
|---|---|
| Memory Metal Alloys and Bimetallics | Thermally Initiated Vent System (TIVS) |
| Bore Mitigants | Explosive Bolts |
| Pulse Motor | Impact Switches |
| Composite Cases | Thermal Switches |
| Slotted Cases | Case Bar Cutter |
| Case Embrittlement Concepts | External Thermite Case Penetrator |
| Hybrid Cases | Internal Thermite Case Penetrator |
| Steel Strip Laminate Cases | Explosive Case Separator |
| Metal Matrix Composite Cases | Multihazard Threat Mitigation System |
| Roll Bonded Cases | |
| Shear Vent Patch Strip | |
| Packaging | |
| Shock absorbing materials | |

Source: Insensitive Munitions – US Problems and Solutions

In fact, this is the same approach that testers first used to reduce sensitivity in warheads. The Navy's Surface Warfare Center Division recognized that conventional materials for the M229 warhead were failing to meet IM compliance and began looking at it as a system issue. Replacing the warhead's original cast iron nose with a plastic adapter enabled venting on both ends, such that when the plastic was exposed to fuel fire it would melt off and allow explosive fill to react and vent from both sides. This in turn resulted in improved IM performance in slow-cookoff and fast cook-off testing.[8]

## CHALLENGE: LACK OF COORDINATION AMONG SERVICES

In the past, the military has tended to approach IM according to the unique mission needs of their service. For example, the Navy sought IM applications to its underwater munitions; the Air

## ORBITAL ATK'S PERSPECTIVE

As battlefield threats evolve, our warfighters need the best tools and technologies to execute their missions safely and successfully. The U.S. Army Aviation and Missile Research Development and Engineering Center (AMRDEC) has prioritized delivering mature insensitive munitions (IM) technology to the front line where the threats are high. With the recent introduction of IM technology to Orbital ATK's rocket motors for the Guided Multiple Launch Rocket System (GMLRS) and HELLFIRE® missiles – among the first rocket motors ever to fully integrate IM technology – our nation is taking a major step in meeting new standards of weapon safety.

A common misconception is that new technology requires a complete overhaul. To the contrary, this IM rocket motor technology can be tailored to fit both new and existing tactical systems, affordably. In fact, Orbital ATK has successfully introduced all the safety benefits of IM technology to the rocket motors without significantly changing the current design of legacy systems, ensuring performance remains intact and unmatched.

Orbital ATK is proud to serve the warfighter. That responsibility drives our team to invest, improve, and innovate. This summer, the company will expand its capabilities at the Allegany Ballistics Laboratory (ABL) in Rocket Center, West Virginia when it opens its new Large Tactical Motor Manufacturing Facility specializing in high efficiency manufacturing of IM-Compliant motors. Looking ahead, Orbital ATK will continue to develop and qualify similar rocket motor technology for other military applications, fielded systems, and next generation upgrades, in order to improve the strength of our armed forces.

Force approached IM with a focus on aircraft-borne missiles; and the Army looked for ways it could implement IM for its artillery and man-portable missiles.[9] These different environments produced a range of solutions that complicated any one unified strategy to IM development.

In 1984, the Navy became the first branch to establish a program dedicated to IM research and operations. Both the Army and Air Force developed their respective IM programs not long after, but motivations for doing so varied. The Air Force, unlike the Navy and Army, was more interested in IM that could reduce "quantity distance requirements in and around airfield munition storage areas" to maximize efficiency of space available.[10] For reasons like these, IM development largely remained a service-specific problem for years, which likely contributed to fragmented solutions and less progress in the long term.[11]

This changed when OSD established the Joint Insensitive Munitions Technology Program (JIMTP). Managed by the U.S. Army, JIMTP aims to "provide a Science and Technology base to support the Secretary of Defense in ensuring that munitions under development or procurement are safe throughout their lifecycle when subjected to unplanned stimuli to the maximum extent practicable."[12]

To pursue this mission, JIMTP instituted a grading system to measure cross-service IM progress over time along different technical proficiencies. Since its creation, JIMTP has helped transition IM successes to the field, most recently with high-performance reduced smoke propellants, booster explosives, improved explosive fills for the HELLFIRE/JAVELIN programs, as well as advanced casing materials and mitigation devices.[13] By opening channels for collaboration and sharing best practices, the different branches are continuing to advance IM-compliant systems that can replace less-safe, existing alternatives.

## RECENT BREAKTHROUGHS COULD ELIMINATE NEED FOR IM WAIVERS

Achieving compliance with OSD's IM requirements has proven challenging. While the initial goal was to replace existing munitions with IM-compliant munitions by 1995, the technology did not exist at the time to make this possible. In the interim, a waiver process was established that would allow branches to procure munitions even when they did not meet complete IM-compliance.[14]

This waiver system has largely continued to be used to the present day, being subject to an annual review and ensuring that program offices continue to seek out acceptable IM replacements.[15]

However, this system may no longer be necessary going forward. Advancements of the last few years have produced IM capabilities that achieved high marks when subjected to the standard gauntlet of tests. As a result, the Army is now preparing to deploy the improved IM capabilities across a range of applications, including its guided multiple rocket launch program (GMRS), long-range precision fires, as well as the Hellfire missile program. The latter may eventually be folded into its Joint Air-to-Ground Missile (JAGM) program once IM technology is made ready.[16]

## CONCLUSION

In its mission to maintain superiority on the battlefield while minimizing the danger posed to its own service members, the military finally has both the strategy and technology to scale up its IM capabilities. By opening more channels to facilitate 'jointness' in IM policy across the services and approaching IM-compliance as a systems issue, the military can continue to maintain high-performance weapons while keeping its men and women safe from munition accidents.

Government Business Council

## ABOUT GOVERNMENT BUSINESS COUNCIL

As Government Executive Media Group's research division, Government Business Council (GBC) is dedicated to advancing the business of government through analysis, insight, and analytical independence. An extension of *Government Executive*'s 40 years of exemplary editorial standards and commitment to the highest ethical values, GBC studies influential decision makers from across government to produce intelligence-based research and analysis.

**Report Author:** Daniel Thomas

For more information, email us at research@govexec.com.

## ABOUT ORBITAL ATK

Orbital ATK is a global leader in aerospace and defense technologies. The company designs, builds and delivers space, defense and aviation systems for customers around the world, both as a prime contractor and merchant supplier. Its main products include launch vehicles and related propulsion systems; missile products, subsystems and defense electronics; precision weapons, armament systems and ammunition; satellites and associated space components and services; and advanced aerospace structures. For more information, visit www.orbitalatk.com.

# SOURCES


1 Anthony Di Stasio: "Joint Insensitive Munitions Technology Program Overview." https://ndiastorage.blob.core.usgovcloudapi.net/ndia/2016/IMEM/18748_DiStasio.pdf

2 Kenneth J. Graham: "Insensitive Munitions - US Problems and Solutions."

3 Ibid.

4 U.S. Code, Title 10-Armed Forces, Section 2389. https://www.gpo.gov/fdsys/pkg/USCODE-2010-title10/pdf/USCODE-2010-title10-subtitleA-partIV-chap141-sec2389.pdf

5 Kenneth J. Graham: "Insensitive Munitions - US Problems and Solutions."

6 Kenneth J. Graham: "Insensitive Munitions – Industry Problems and Solutions."

7 Ibid.

8 Joni Johnson: "Improved Insensitive Munitions Performance of an HE Rocket Warhead". http://www.dtic.mil/dtic/tr/fulltext/u2/a394601.pdf

9 Kenneth J. Graham: "Insensitive Munitions - US Problems and Solutions."

10 Raymond Beauregard: "The History of Insensitive Munitions." http://www.insensitivemunitions.org/history/army-and-air-force-insensitive-munition-programs/

11 Donald M. Porada: "Progress, Challenges and Way Ahead for the Navy Insensitive Munitions

Program." https://imemg.org/wp-content/uploads/IMEMTS%202006_Porada_paper3A.pdf

12 Anthony Di Stasio: "Joint Insensitive Munitions Technology Program Overview." https://ndiastorage.blob.core.usgovcloudapi.net/ndia/2016/IMEM/18748_DiStasio.pdf

13 Donald M. Porada: "Progress, Challenges and Way Ahead for the Navy Insensitive Munitions

Program." https://imemg.org/wp-content/uploads/IMEMTS%202006_Porada_paper3A.pdf

14 Raymond Beauregard: "The History of Insensitive Munitions." http://www.insensitivemunitions.org/history/revision-of-the-navy-insensitive-munition-policy/

15 Anthony J. Melita: "U.S. DoD Insensitive Munitions Program." https://ndiastorage.blob.core.usgovcloudapi.net/ndia/2003/gun/mel.pdf

16 Nikki Montgomery: "DoD collaboration researches munition safety." October 23, 2015. https://www.army.mil/article/157599/dod_collaboration_researches_munition_safety


Government
Business
Council
Sponsored by
Orbital ATK