Progress, Challenges and Way Ahead for the Navy Insensitive Munitions Program

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Abstract
The U.S. Navy Insensitive Munitions Program has identified and responded to technical challenges since its inception in 1984. Progress has included participation from government and industry personnel who have creatively collaborated to push the bounds of technology in energetics, packaging, and systems design. There are still significant IM technology hurdles that must be overcome so that we can provide the safest and most effective munitions to our warfighters. This paper identifies the state of the art in IM technology with a brief retrospective of the technology challenges by the Navy approximately 7 years ago to develop an understanding of how well we've responded to those challenges. The paper includes a detailed presentation of IM technology requirements assimilated from the Navy PEOs' FY2005/2006 IM Strategic Plans.

Introduction

The United States Navy (USN) has long recognized the need for conventional munitions that reduce collateral damage when they are exposed to thermal, shock, and impact threats. Concentrated efforts to develop explosives that are less sensitive to thermal threats, in particular, began in the 1950's and 1960's. The well documented aircraft carrier incidents during the 1960's and 1970's accelerated the efforts to design, develop, and deploy munitions that offer increased protection to our service personnel and platforms.

There has been significant progress especially in the areas of high explosives and rocket motor casing. The Navy has Qualified or Final (Type) Qualified more than 20 plastic bonded explosive (PBX) formulations that have improved sensitivity characteristics compared to traditional trinitrotoluene (TNT)-based formulations. Composite motor cases with either hydroxylterminated polybutadiene (HTPB) or hydroxylterminated polyether (HTPE) propellants offer potential improvements to propulsion systems compared to steel motors with HTPB, single base or double base propellants.

In July 2004, the US Department of Defense (DoD) established a requirement for each Program Executive Officer (PEO) with munitions inventories to develop an Insensitive Munitions Strategic Plan (IMSP) to document the path by which the PEO would pursue IM compliance for its munitions. Integral to the IMSPs is the identification of IM technology required to address IM deficiencies. The Navy IM Office, in its role as manager of the Navy IM Advanced Development (IMAD) Program, is coordinating with the PEOs and the Navy technical community to focus technology development efforts in concert with the PEOs' requirements. This coordinated technology development effort extends throughout the US DoD and with our allies on applicable munitions programs.

Background

The USN IMAD Program has, since 1984, provided leadership in IM technology development and transition. The IMAD Program benefited – especially in the area of explosives – from the precursor Navy Explosives Advanced Development (EAD) Program, which laid the groundwork for development on non-TNT based explosives. The Navy's interest in IM as a systems solution to reduce collateral damage from accidents was bolstered following incidents aboard USS Oriskany (1966), USS Forrestal (1967), and USS Enterprise (1969). These shipboard accidents, together with in-bore explosions and transportation accidents, provided the catalyst for a Navy technology program.

The IMAD Program addresses high explosives, gun propulsion, ordnance technology, and propulsion. Figure 1 identifies the leadership and the Technical Coordinators for each technical domain. IMAD efforts are coordinated with colleagues within the US DoD and with our allies to leverage lessons learned and the knowledge, skills, and abilities of the IM technical community.

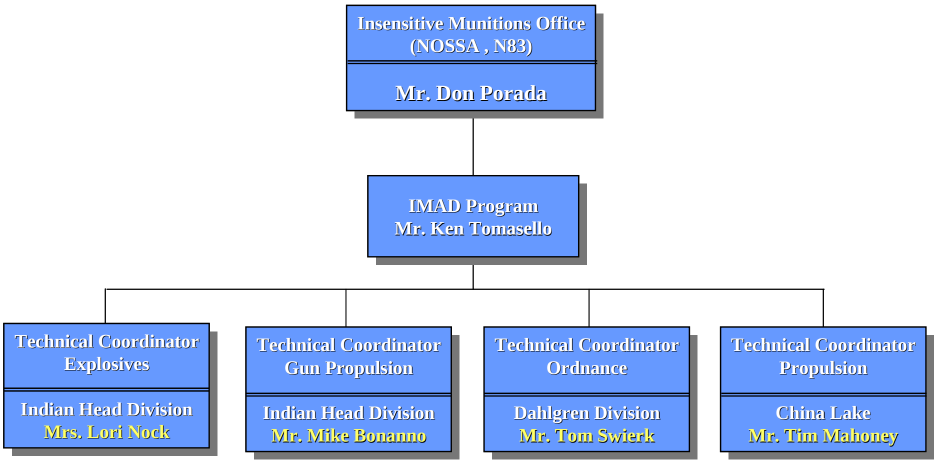

Figure 1. Navy IMAD Organization and Technical Focus

The IMAD Program bridges the gap between the basic research and development activities and the weapon programs. IM technology is scaled to demonstrate applicability and scalability to larger systems This approach, illustrated in Figure 2, leverages the successes from across DoD, NATO, and industry to minimize development and integration risks to the weapon Program Managers.

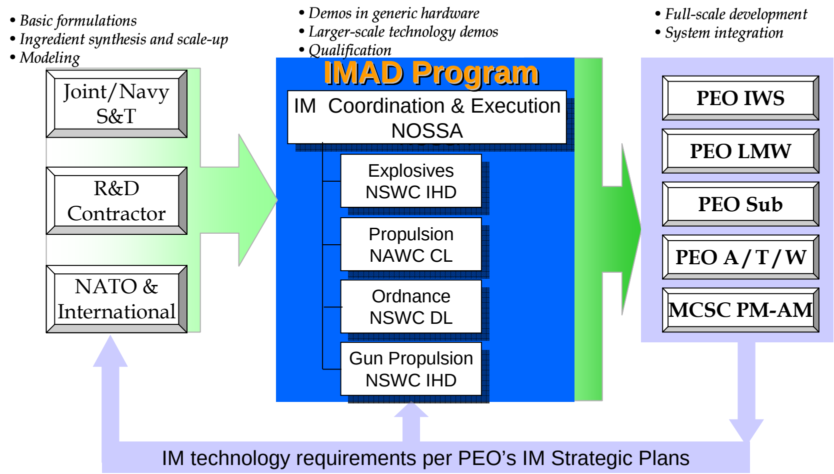

Figure 2. IMAD Fills a Vital Role in Transitioning IM Technology to Munitions Programs

Progress to Date

IMAD products are numerous and prolific in the US Fleet. There have been IM technology integrations in more than 40 weapons systems. Table 1 illustrates the breadth of these technology developments and their integration in current Fleet munitions.

Table 1. IMAD Products In Fleet Service

Technology Applications	In-Service Systems
General Purpose Explosives PBXN-109	General Purpose Bombs; Penguin; BLU-118/B
Metal Accelerating Explosives PNXN-9 PBXIH-135 PBXN-10 PBXW-11 PBXN111 PBXN-112	HARM; Tomahawk; STANDARD Missile; MK50 Torpedo; Hellfire; Anti-Personnel Obstacle Breaching System (APOBS); JSOW (BLU-97/B Warhead); SMAW; Phoenix; TOW; MK54 Naval Gun Ammunition; ERGM/Excalibur' WAM-Hornet; Mongoose; AGS LRLAP
Underwater Explosives PBXN-103	Mine Neutralization Devices; MK50 Torpedo; Sonobuoys
Reduced Smoke Propellants	Penguin, Evolved Sea Sparrow Missile (ESSM); Sidewinder
Ordnance Design (e.g., stress risers, eutectics)	Tomahawk; Penguin
Rocket Motor Mitigation Technology	AMRAAM; HARM
Containers, Barriers, and Shielding	Standoff Land Attack Missile (SLAM); MK50 Torpedo
Booster, Lead, and Primary Explosives	STANDARD Missile; GP Bombs

The technical accomplishments are not limited to improvements in the IM posture of our munitions. They have meaningful impact to our active duty military personnel. For example, more than 9,000 lbs of PBXIH-135 was mixed and cast into test articles and BLU-118/Bs in a 60-day period during Operation Enduring Freedom . The BLU-118/B was certified by the AF for the GBU-15, GBU-24, and the AGM-130.

Additionally, PBXIH-135 was Qualified by the IMAD Program and sent to Afghanistan in 2002. This was the first U.S. explosive fielded (BLU-118/B) using Extremely Insensitive Detonating Substance (EIDS), a new class of insensitive explosive . This material provides greater degree of insensitivity than previously developed Navy explosives.

These technologies provide warfighters with enhanced capability to defeat targets in caves, bunkers, and urban environments. This capability has become increasingly important during the Global War on Terror (GWOT).

Process Changes

Historically, the IMAD Technical Coordinators (TCs) collaborated with individual weapon program representatives to develop and transition technology applicable to munition families. The IMSP approach now allows the IMAD TCs to address technology with a focus on the prioritized requirements within a given PEO's inventory. Figure 3 illustrates the linkage between the PEO IMSPs, IM Plans of Action and Milestones (POA&Ms) for priority munitions, and the necessary investment in IM Science and Technology (S&T).

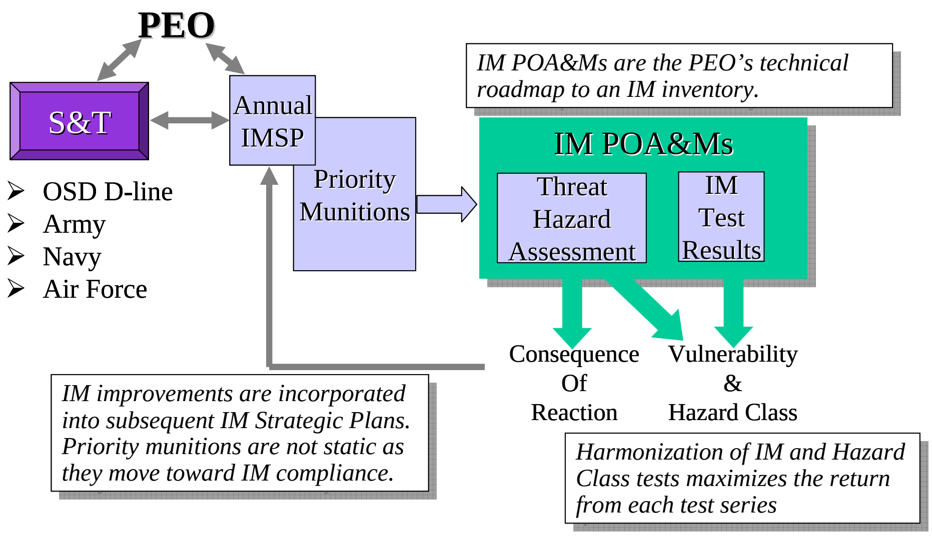

Figure 3. IMSPs Are Now Integral to Identifying IM Technology Needs

A critical element of this construct is the IM Threat and Hazards Analysis (THA). There is considerable discussion within the technical community regarding the tailoring of IM tests (e.g., fragment size and velocity, temperature rise rate, bullet velocity). The most effective application of THAs is likely to be the development and implementation of a standardized THA that promotes consistency across the munitions inventory for weapons that see similar life cycles.

Improved test and evaluation methods will contribute to IM success by offering greater insight into reaction phenomena and increased understanding regarding the physics of IM reactions. Much progress has been achieved in the standardization of IM tests within NATO. The Standardization Agreements (STANAGs) have been harmonized within the IM and Hazard Classification (HC) communities and have contributed to a common approach among nations so that test results can be compared across the international community. Additional benefits will accrue from increased harmonization between IM and HC testing in those areas where complete agreement was not reached. In times of declining R&D and procurement funding it is essential to maximize the results available from a given test series.

Improvements in Modeling and Simulation (M&S) also offer benefits to the technical community including reducing the cost of testing, obtaining more reliable IM assessments, allowing statistical evaluation and improving design process. Within the US, there is a robust M&S program focused on IM that includes participation from the DoD as well as the Department of Energy (DOE). The DOE participants include national laboratories (e.g., Los Alamos National Laboratory, Sandia National Laboratory) that have tremendous computing capabilities complementing their strength in detonation physics.

IM S&T is receiving increased visibility and support throughout DoD. There are coordinated efforts to focus on core technologies across the community so that the results have application for multiple Army, Navy, Air Force, and Marine Corps munitions. Technical representatives from the Military Services evaluated proposals for IM S&T efforts from Government laboratories and centers. These technical personnel, constituting the Joint Services IM Technical Panel (JSIMTP), prioritized technology needs based on the cumulative input from PEOs across the DoD. In this collaborative fashion, five technical focus areas were selected for focused S&T development as shown in Figure 4.

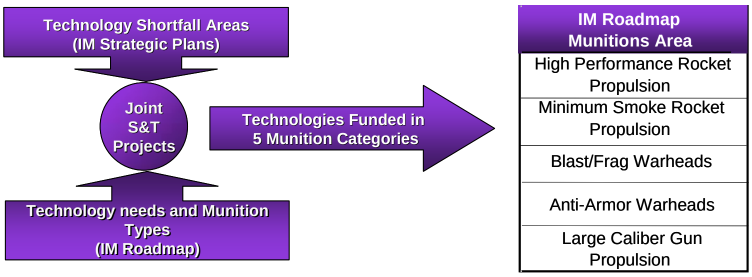

Figure 4. Technical Focus for DoD IM S&T Investments

Technology Challenges

Dr. Richard Bowen, during his tenure as Director of the Navy IM Program, issued a technical challenge to the attendees of the 1999 IM Symposium in Tampa, Florida. Dr. Bowen presented the “IM stoplight” in Figure 5 to highlight IM technology status – and by inference – technology needs in general munitions categories.

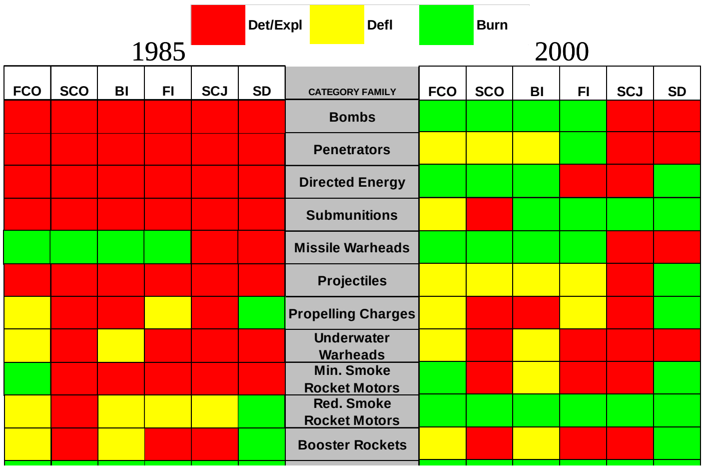

Figure 5. IM Technology Status Circa 2000

There has been incremental success against the technology shortfalls depicted in the figure but much remains to be done. The threat from shaped charge jet, in particular, has become more significant during Operation Enduring Freedom as threats proliferate from rocket propelled grenades (RPGs) and improvised explosive devices (IEDs).

The Navy Fiscal Year 2007 (FY07) IMSPs identified more than 60 IM technology needs from the Navy PEOs to address IM deficiencies across the Navy's munitions inventory. These technologies have been evaluated for commonality to aggregate into a cohesive plan that addresses priority requirements. Table 2 provides a partial listing of these requirements, aligned with IMAD technical domains, focusing on those that have applicability across the Navy PEO's inventory.

Table 2. IM Technology Needs Identified in FY07 PEO IM Strategic Plans

IM Technologies	Potential Weapon Transitions
High Explosives - Scale-up and demonstration of new melt cast formulations - Scale-up and demo of advanced PBXs - BDNPN-RDX replacement	BLU-110/111; Penguin; JSOW Unitary; Harpoon; JDAM; Tomahawk BLK IV; GBU-24B/B; Hellfire AGM-114M; MK 80 Series Bombs; FOTS; Javelin; Predator; SMAW; Sidewinder; 5"54 Gun Ammo; 155mm Artillery; 76mm Gun Ammo; BLU-109 HTP; Tactical Tomahawk; Torpedoes
Propellants and Propulsion - Develop new binder systems for HTCE propellant - Evaluate high energy density materials - Evaluate non-aluminized propellants (non-AP) - Scale-up baseline high performance propellant [HTCE-based, aluminized, reduced	STANDARD Missile; ESSM; Harpoon; Tomahawk; 2.75" Rocket Motor; Predator; Javelin; TOW; Hellfire; Sidewinder AIM-9X; AMRAAM

IM Technologies	Potential Weapon Transitions
smoke	
Ordnance Technology - Leverage advanced coating technology for gun-launched and missile systems to improve thermal protection and possibly improve blast performance - Exploit S&T development in reactive liners to improve IM response in large diameter warheads	5” Navy Gun Ammo; 76mm Navy Gun Ammo; 155mm Advanced Gun System; 57mm Close-in Gun System (CIGS); STANDARD Missile; ESSM; Tomahawk; GP Bombs
Gun Propulsion - Develop and transition insensitive primers - Insensitive gun propellant development, demonstration and qualification - Improve current case venting and closure plug techniques to increase IM performance	5” Navy Gun Ammo; 76mm Navy Gun Ammo; 105mm Artillery; 155mm Artillery; 20mm Gun Ammo; 25mm Gun Ammo; 30mm Gun Ammo; 40mm Gun Ammo

The technology needs in the table highlight the need for new molecules for energetics, binders, and associated plasticizers and continuation of a systems approach. Current formulations have optimized the IM benefits for current systems within the confines of known explosives and propellants. The challenge for industry and government chemists and engineers is to design, develop, and demonstrate new energetic molecules that provide superior survivability, enhanced performance, improved processibility, and comparable or lower manufacturing costs than currently fielded materials and to incorporate the advanced energetics into systems that fully meet IM.

The efforts within the Navy IMAD Program are coordinated with thrusts across the US DoD. The USMC, for example, is working in tandem with the Army’s PEO for Ammunition which leverages the PEO’s efforts in ground ammunition technology. Additional collaboration will occur via the S&T projects that include participation of laboratories throughout the DoD. The future of IM technology development, especially as the GWOT demands a significant portion of military procurement funding, is clearly dependent on collaborative efforts and the sharing of lessons learned. This is critical to identify solutions that are successful as well as paths that once seemed promising but did not provide appropriate outcomes. Much is learned in studying both scenarios.

Summary

The technical challenges are significant but so, too, are the potential benefits. Figure 6 illustrates the relative benefits in terms of insensitivity gains but also an important consideration that is sometimes overlooked in the technical discussions. There is a time lag, sometimes significant, between the development of successful IM technology and its integration into munitions.
IM can be an enabling resource for our warfighters.

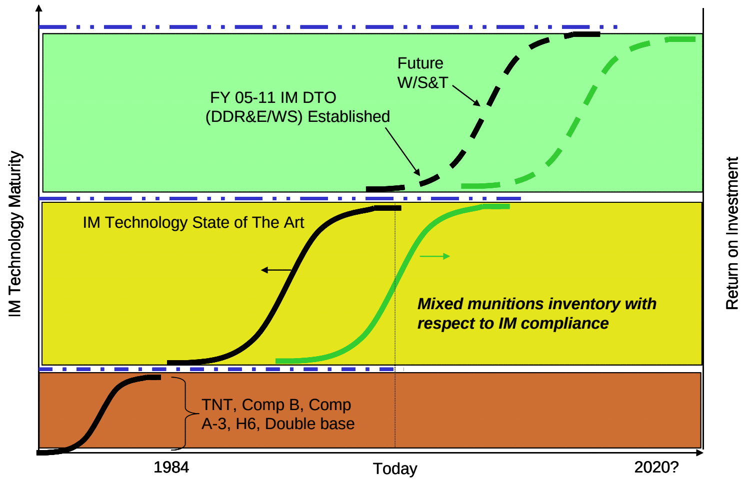

Figure 6. Relationship Between IM Technology Development and Integration

IM benefits include:

- Improved safety and warfighter survivability
  - Reduced munition response to unforeseen and asymmetrical threats to warfighters and munition stores
- Increased system effectiveness
  - Reduced platform weight and potential design options with current or improved survivability provides options for additional effectiveness
- Decreased storage infrastructure
  - Decreasing HD from 1.1 to HD 1.2.3 can result in requirements decrease for open storage and storage in an Earth Covered Magazine
- Improved Sortie Generation Rates
  - Potential increase in sortie rates during High Tempo Ops due to reduced safety restrictions
- Reduced collateral damage
  - Orders of magnitude reductions in damage from ammo storage, shipping, or training accidents due to eliminating or controlling propagation of reaction
- Life cycle storage/shipment costs
  - Potential decrease in Life Cycle storage costs and greater flexibility in containerization and shipment

It is, therefore, essential that we take advantage of every opportunity to exploit lessons learned and leverage technology efforts so that our service personnel receive the full benefits of our efforts as soon as possible. IM, enhancing warfighter survivability...through system engineering.

Biographies

Mr. Donald Porada has over 30 years of experience working for the U.S. Navy in various engineering and management positions for the Naval Sea Systems Command and Naval Air Systems Command. Most recently Mr. Porada has served in the Navy Insensitive Munitions Office (IMO) starting as the technical director of the Navy Insensitive Munitions Advanced Development Program and currently serving as the director of the IMO at the Naval Ordnance Safety and Security Activity, Indian Head, Maryland. Under direction, numerous explosives, warhead concepts, propellants, and rocket motor technologies were developed to enhance the survivability of the Navy's weapon systems and ships and to reduce the environmental impact in weapon manufacturing and demilitarization. In addition to managing the overall Navy Insensitive Munitions Program his duties include Qualification and Final (Type) Qualification of energetic materials, and U.S. member of the NATO Munitions Safety Information Analysis Center (MSIAC). Mr. Porada holds a BS Mechanical Engineering, Brown University.

Mr. Gerald King has 20 years of professional experience including Insensitive Munitions (IM) engineering, technical and programmatic support for the U.S. Army, Navy, Air Force, Marine Corps, Office of the Secretary of Defense, and the private sector. He has, for more than 19 years, provided support to the U.S. Navy Insensitive Munitions Office. He leads team of engineers and analysts supporting all facets of ammunition management and energetic materials assessments for increased weapon and platform survivability. Mr. King assisted the U.S. Army, Navy, Marine Corps, and Air Force in developing prioritization methodologies to enhance the survivability of ground and air weapons, ships, and weapon platforms. Mr. King holds a M.S. Information Management, Marymount University and a B.S. Chemical Engineering, University of Tennessee.