U.S. Navy Insensitive Munitions Handbook

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ABSTRACT

The Naval Ordnance Safety & Security Activity (NOSSA) is developing a "U.S. Navy Insensitive Munitions Handbook" as a comprehensive source of information tailored for the Navy Insensitive Munitions (IM) community, specifically for the munitions Program Offices that are required to develop and conduct IM Programs for their munitions. This paper is intended as an advance introduction to the Handbook and provides summary discussions of handbook contents, such as: (a) Selected history of the IM Program, (b) Navy IM policy and guidance, (c) The Navy IM development process, (d) The Joint IM Strategic Planning (IMSP)/Plans of Action and Milestones (POA&Ms) process (e) Selected IM research projects, (f) Threat Hazard Assessments, (g) IM qualification, and (h) IM compliance. The IM research projects and the relevant points of contact are based on information, from the FY17/18 IMSP/POA&Ms and documentation from technology programs with IM related efforts (Joint Munitions Program (JMP), Joint IM Technology Program (JIMTP), IM Advanced Development (IMAD) Program, and IM Technology Transition Program (IMTTP). The 2017 information is included in the Handbook to provide recent examples of the extent of IM research and collaboration that is indicative of the range of possibilities for future areas for IM research and development. Upon completion of the Handbook, NOSSA plans are to issue and maintain the Handbook on its secure website.

Introductory Sections of the Handbook

The Navy Goals for the IM Program

The Navy's goal is to fully implement the Department of Defense (DoD) IM Program. The Navy's approach is to address:

a) **IM Technology** - Identify IM technology shortfalls for Navy and Joint munitions, conduct a robust Science and Technology (S&T) program to develop solutions for the shortfalls, and identify windows of opportunity for the Program Offices (POs) to insert the solutions in their munitions improvement/development programs.
b) **IM Improvements** – Without regard to program acquisition category, all Department of Navy (DON) munitions are to be designed/improved to meet IM requirements. Operational capabilities and performance are to be attained without compromising system and platform safety.
c) **IM Compliance** – A munition is certified to be IM compliant when it is assessed/scored by the Navy Munitions Response Evaluation Board (MREB) or by another appropriate Service Review Authority, to pass all required IM tests. The

Navy Munitions POs are to conduct coordinated IM/Hazard Classification (HC) testing that addresses the passing criteria for the six IM Threats (Fast Cook-off (FCO), Slow Cook-off (SCO), Bullet Impact (BI), Fragment Impact (FI), Sympathetic Reaction (SR), and Shaped Charge Jet (SCJ)). Achieving IM compliance is to be viewed over the munition program's entire life cycle. Passing all IM tests (full IM compliance) for a munition requires: **a)** A Burn Reaction or better (No Sustained Reaction) for the FCO, SCO, BI, and FI IM tests and **b)** An Explosion Reaction or better (Deflagration Reaction, Burn Reaction, or No Sustained Reaction) for the SR and SCJ tests.

Objectives of the Handbook

The objective of the Handbook will be to provide the Navy IM community with a reference and tutorial guide for executing a Munition's IM Program. The document addresses: **a)** A brief history of the IM program, **b)** The current IM policy and guidance as implemented by the Navy (**NOTE:** Copies of the current IM related Navy Instructions are provided in the Appendices, **c)** A description of the Navy's IM development process, **d**) Guidance on how to implement the Joint IMSP/POA&Ms process for the munitions in their portfolio, **e)** Information on sources of Navy, Joint, and other Service IM technology solutions and developments that can address IM technology shortfalls identified in the Munitions POs' POA&Ms, **f)** Guidance on preparing an IM Threat Hazard Assessment (THA), **g)** Guidance on complying with Qualification and Final (Type) Qualification requirements for Navy explosives (explosives, propellants, and pyrotechnics), **h)** Guidance on complying with the harmonized IM /HC testing and analysis requirements, and **i)** Guidance on evaluating the results of the harmonized IM/HC test results to assess a munition's compliance with IM criteria.

IM Background

In 1994, Ray Beauregard wrote an excellent paper entitled "History of the U.S. Navy Insensitive Munitions Program," **http://www.insensitivemunitions.org/**) on the history of the Navy's IM program, which was subsequently revised in 2005 and 2009. Starting with the Chief of Naval Operation (CNO) issuing OPNAVINST 8010.13, the Handbook provides a selected listing (23) of DoD, Joint, and Navy guidance and policy issuances related to the U.S. Joint and DoD IM program.

IM Policy and Guidance

The Handbook provides the Navy Munitions Program Managers (PMs) and their program development teams the relevant U.S. law and DoD, Joint, and Navy policy and guidance regarding IM. The Handbook provides excerpts of important IM policy and guidance for executing the DoD IM Program, which are taken from the U.S. Law and DoD, Joint Chiefs, and MIL-STD issuances listed below:

U.S. Law - **USC, Title 10, Chapter 141, Section 2389** December 2001.

DoD Policy - **DoDD 5000.01**, The Defense Acquisition System May 12, 2003, Certified Current as of 20 November 2007, E1.1.23. Safety and **DoDI 5000.02**, Operation of the Defense Acquisition System, Encl. 3, System Engineering, January 7, 2015.

Joint Chiefs Policy - **CJCSI 3170.01I**, Joint Capabilities Integration and Development System, 23 January 2015.

MIL-STDs - **MIL-STD-882E**, Department of Defense Standard Practice, System Safety, 11 May 2012. and **MIL-STD-2105D**, Hazard Assessment Tests for Non-Nuclear Munitions, 19 April 2011. (Appendix C in Handbook.)

Navy IM Policy - The Navy implements the DoD/Joint IM Program via three Navy instructions:
OPNAVINST 8010.13E, Department of Navy Policy on Insensitive Munitions, 14 January 2014. (Appendix D in Handbook.)
NAVSEAINST 8010.5C, Insensitive Munitions Program Planning and Execution, 15 September 2015. (Appendix E in Handbook.) – This instruction:

a) Promulgates procedures and the Navy organizational structure for planning and executing an integrated DON IM Program, and amplifies IMSP policy and guidance provided in the DoD Standard Operating Procedure (SOP) for Insensitive Munitions Strategic Planning (IMSP) and Plans of Action and Milestones (POA&Ms) Defined by Joint Services Business Rules.
b) Provides procedures for out-of-cycle waiver requests.
c) Explains Joint Staff's Joint Requirements Oversight Council (JROC) responsibility to approve munitions procurement.
d) Explains Navy's Weapon System Explosives Safety Review Board (WSESRB) responsibility for approval for service use.
e) Establishes responsibilities, with respect to the IMSP/POA&M process, for the Commander, Marine Corps Systems Command (COMMARCORSYSCOM) Project Manager for Ammunition (PM AMMO).
f) Establishes responsibilities, with respect to the IMSP/POA&M process, for the IM Council (IMC) and its members, NOSSA N8 (Weapons Assessment Directorate), and the Naval Warfare Centers.
g) Establishes responsibilities for Navy Munitions Program Executive Officers (PEOs) to comply with Navy IM policies and procedures for conducting an IM Program.
h) Requires that:
    i. All energetic material be qualified and undergo Final (Type) qualification per NAVSEAINST 8020.5C Qualification and final (Type) Qualification Procedures for Navy Explosives (High Explosives, Propellants, Pyrotechnics, and Blasting Agents), 05 May 2000 (Appendix I in Handbook).
    ii. IM be integrated into a total system safety program per MIL-STD-882E.
    iii. Each munition address FCO, SCO, BI, FI, SR, and SCJ threats per MIL-STD-2105D and applicable NATO Standardization Agreements (STANAGs). To be considered IM compliant, a munition item must, at a minimum, satisfy the passing criteria for the Joint Requirements Oversight Council/Office of the Under Secretary of Defense (JROC/OUSD) Joint Standard IM Tests.

NOSSAINST 8010.1A, Munitions Reaction Evaluation Board (MREB), 30 August 2017. (Appendix F in Handbook.) - This instruction states the mission, authority, responsibilities, and membership of the DON MREB. The MREB major responsibilities are to review for concurrence (in conjunction with the DoD Explosives Safety Board (DDESB) for HC testing): **a)** Detailed IM/HC test plans in concert with NOSSA N8's approved THAs and **b)** IM and basic safety test results to obtain an official (score) assessment of record of the reactions. NOSSA N8 renders a decision on final approval with MREB recommendation for approval of test plans and findings/recommendations.

Navy IM Development Process

The elements of the Navy's IM development process for planning and conducting an IM program, which generally takes from 1 to 15 years, is portrayed in Figure 1 and discussed below:

a) Navy Weapons PEOs/PMs
    i. PEOs/PMs initiate planning a munition development program.

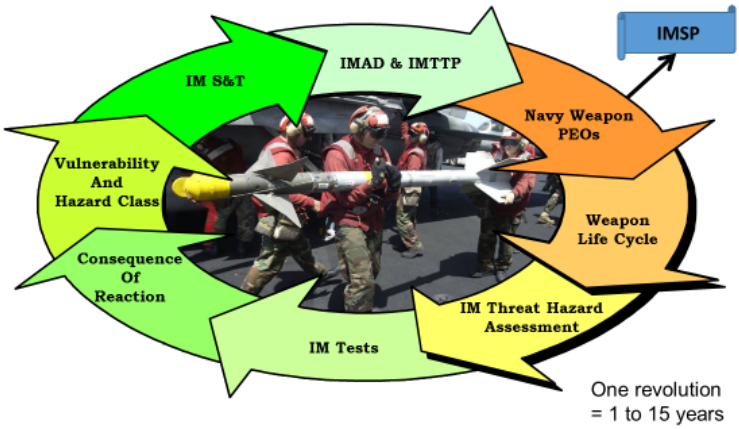

Figure 1. The Navy IM Development Cycle

ii. PMs are given a requirement from the Fleet or otherwise determine that there is a requirement for a new or improved munition.

iii. Munition design solutions are selected based on many factors including cost, schedule, warfighter and performance requirements, safety (including IM), THA, technology availability, reliability and maintainability, etc.

iv. One of the steps for planning a munition development is preparing an abbreviated or full IM POA&Ms.

b) Weapons Life Cycle

i. Based on requirements documentation, the PM determines (or validates if the development program is for improvement of an existing munition) the munition's life cycle and establishes:

(i) Operational environment - Where will the munition be used? — **(i)** Surface (land or sea), **(ii)** Underwater, **(iii)** Air launched from fixed wing or rotary aircraft and **(iv)** Continental United States (CONUS) or Outside the United States (OCONUS).

(ii) Logistical environment – How and where will the munition be stored and transported? — **(i)** Truck, ship or air transportation or **(ii)** Depots and/or ship storage.

c) IM THA

i. PM evaluates the life cycle environmental profile of a munition to determine the threats and hazards to which it may be exposed throughout its entire life cycle. The THA:

(i) Identifies the threats and hazards that the munition may be exposed to during its life cycle.

(ii) Analyzes the underlying causes, and assesses the potential results of exposure to these threats and hazards. — **(i)** This assessment of the potential threats and hazards includes those posed by friendly munitions, enemy munitions, accidents, handling, environmental lifecycle conditions, etc. and **(ii)** Provides rationale for which of the standard IM tests should be conducted on the munition, which tests may be deleted, as unnecessary/not appropriate and what additional testing that may be required to assess the basic safety of the munition.

ii. Preparation of a THA is a required step in the development of an IM Program for an IM priority munition. (Section **7.2. Definitions of Terms for the Joint IMSP and POA&M Process**. of the Handbook) in the DoD SOP.
iii. A summary of the THA, or updated changes as necessary, is a required element of the munitions' POA&M.

d) IM Tests
   i. Based on the approved THA and harmonized IM/HC Test Plan, the PM conducts the Joint Standard IM Tests per the JROC/OUSD and required by MIL-STD-2105D. The Tests include FCO, SCO, BI, FI, SR, and SCJ.
   ii. Note: In a harmonized IM and HC test program, there are two additional HC-only required tests: Thermal Stability Articles and 40 Ft Drop.

e) Consequences of Reaction
   i. Based on the IM test results, what is the impact of the IM reactions on the warfighter, weapons platform, or logistical environment (storage or transportation)? Would the IM results lead to an event that could be catastrophic, resulting in potential loss of life and equipment? Or is the impact of the IM reactions so low such that there are little or no injuries or equipment damage? In other words, were the IM test results passing or failing the Joint Standard IM Tests pass/fail criteria?
   ii. Is there technology available to reduce the severity of the IM reactions or is new IM technology needed?

f) Vulnerability and Hazard Classification
   i. The reactions of munitions to the IM/HC threats/tests are used to determine the vulnerability of munitions in the environments (platform / transport / storage) that are encountered during the munitions life cycle.
   ii. PMs must hazard classify their munitions per DoD 6055.09-M, DoD Ammunition and Explosives Safety Standards: General Explosives Safety Information and Requirements and NAVSEAINST 8020.8C (TB 700-2 / TO 11A-1-47), DoD Ammunition and Hazard Classification Procedures, to address threats to munitions during transport and storage.

g) IM Science and Technology (S&T)
   i. The Office of Naval Research (ONR) programs and OUSD's JIMTP and the DoD/Department of Energy (DOE) JMP evaluate the munition program IM deficiencies as identified in IM testing and establish programs to address those deficiencies. If new less sensitive energetic molecules or binder materials are needed, efforts to fund such research would be funded by Basic Research, 6.1 Research, Development, Test & Evaluation (RDT&E) funding. If more advanced solutions are needed such as new energetic (explosive or propellant) formulations, new case materials or designs, or modeling and simulation to predict munition energetic responses in lieu of destructive testing, then research efforts would be funded by Applied Research, 6.2 RDT&E funding, and/or Advanced Technology Development, 6.3 funding.
   ii. The PMs work closely with the Office of Naval Research (ONR), JIMTP and JMP so that those S&T programs can develop the technologies to address munitions' IM deficiencies and Fleet operational requirements.

h) IMAD and IMTTP
   i. As S&T IM technologies mature and are successful, the next step is demonstration and validation, with 6.4 RDT&E funding, prior to implementation and transition to the Navy PMs' munitions. IMAD and IMTTP are the Navy's 6.4 Demonstration and Validation programs with the goal of maturing and transitioning 6.3 IM technologies for application by PMs in their munition development programs.
   ii. The focus of IMTTP is Air-launched weapons. IMAD was established to develop, mature and transition IM technology for all DON munitions.

iii. The IM technologies available for transition include new explosives and warheads, new propellants and rocket motors, advance gun propulsion systems, new container materials and shielding. Successful IM technologies from IMAD and IMTTP reduce the munitions sensitivity to the IM threats while maintaining or exceeding operational requirements.

i) Return to Navy Weapon PEOs/PMs
   i. The PM's IM POA&M documents their munition programs' IM approach and progress and is included in the PEO's biennial IMSP.
   ii. When deficiencies are found for a given developmental munition in IM testing, the development cycle may be repeated if the IM technologies do not exist to effectively address the IM deficiencies and meet operational requirements.

Joint IMSP/POA&Ms Process

OUSD (Acquisition, Technology and Logistics), OUSD (AT&L), issued the initial policy for IMSP in 2004. DoD SOP for IMSP and POA&Ms, 3rd Revision, March 2017 is the current issuance that promulgates the policy and mandatory requirements for IMSP. In addition, the SOP provides the IM community "business rules," additional business processes, to enhance the overall management of the IMSPs, to include assigning roles and responsibilities for conducting reviews of the IM POA&Ms. The objective of Section **7. Joint IMSP/POA&Ms Process** of the Handbook is to provide Navy Munitions PEOs/PMs and their munitions program development teams with a summary of the mandatory guidance in the SOP. The policy and mandatory guidance for the IMSP process provided in the SOP is summarized in the Handbook Specifically, the Handbook addresses:

a) **Schedule** - Provides a notional Navy IMSP schedule for the preparation of the IMSPs developed by the Navy Munitions PEOs, which include the relevant POA&Ms developed by the munitions PMs as appendices. The IMSPs/POA&Ms are submitted to the JROC for approval biennially to address the planning process for a two-year period starting with an odd numbered year.
b) **Approval Process** - Describes the Navy-specific IMSP approval process.
c) **Development Process** - Describes the IMSP/POA&M Development Process. Several important points include:
   i. Each DON Munitions PEO/PM is responsible for developing and maintaining a munitions Portfolio containing all munitions they procure, as well as for all munitions for which they have a Configuration Management (CM) role whether they are being actively procured or not.
   ii. Approval of the IMSP by the JROC constitutes the authority to procure non-IM compliant items for the two-year period covered by the IMSP.
   iii. The authority to procure a non-IM compliant item not contained in any Service IMSP requires an "out-of-cycle waiver," which must be obtained from the JROC through a separate process.
d) **Preparing IMSP/POA&Ms -** To support the Navy Munitions PEOs/PMs and their teams in preparing their IMSP and POA&Ms, NOSSA IMO (N855) maintains an IMSP/POA&Ms Scorecard Template on the NOSSA Secure Website for reviewing/scoring IMSP Key Elements prescribed in the SOP (Part A, Section 4.0) and summarized in the Handbook. The Scorecard Template is an excellent tool/guide that should be used by the Navy Munitions PEOs/PMs and their teams in their development of acceptable / approvable IMSPs/POA&Ms.
   i. **IMSP Key Elements** - The format for the IMSP is left to the discretion of the reporting PEO/PM. However, specific key elements (Section **7.8.2 IMSP Key**

Elements. of the Handbook). are to be included in the development of the IMSP.

ii. **POA&M Formats** - Prescriptive formats (Section **7.8.3 POA&M Formats.** of the Handbook) have been established by the JSIMTP and the DoD IM IPT for the POA&Ms to ensure uniformity in documenting the IM efforts across the Joint Service IM community.

IM Technology

As per NAVSEAINST 8010.5C policy, Munitions PMs under cognizant PEO or Systems Command authority, are to seek every window of opportunity to incorporate appropriate technologies developed by the JMP, JIMTP, IMAD Program, and IMTTP, and similar programs of other Services, to provide IM-compliant munitions for the Naval Fleet. The objective of Section **8. IM Technology** of the Handbook is to provide Navy Munitions PMs and their munitions program development teams with a broad overview of the resources available to them that has IM RDT&E technology concepts and data that may have applicability to the IM Improvement Programs for their priority munitions. The IM efforts span Applied Research (6.2), Advanced Technology Development (6.3), and Demonstration and Validation (6.4) RDT&E funding as well as international projects, and seek solutions to gaps in IM technology that inhibit development of IM-compliant munitions. Identifying research projects that have application to the Program's specific munition can lead to collaborative efforts to pursue, and/or leverage, relevant solutions to successfully address the standard IM threats or any additional threats identified by the munitions' THA. The Handbook:

a) Provides brief descriptions of the IM technology programs JMP, JIMTP, IMAD Program, and IMTTP, discusses the missions and IM technology focus areas and provides recent (Fiscal Year 17 (FY17)) example IM research project titles, as available, and identifies the POCs. References are provided for the FY17/18 Navy, Army, Missile Defense Agency (MDA), and U.S. Special Operations Command (USSOCOM) IMSP/POA&Ms.
b) Discusses partnering agreements that describe an understanding of mutual interest regarding an IM technology.
c) Describes existing (and under development) web-based repositories/portals for data generated by the IM technology programs.

Threat Hazard Assessments

A THA is an evaluation of the life cycle environmental profile of a munition to determine the threats and hazards to which it may be exposed throughout its entire life cycle. The munitions life cycle covers the years-long period from concept development to final disposition, whether the end state is operational employment against a target, expenditure in training or testing, or demilitarization/disposal. The THA identifies the threats and hazards that the munition may be exposed to during its life cycle, analyzes the underlying causes, and assesses the potential results of exposure to these threats and hazards. The THA provides rationale for which of the standard tests should be conducted on the munition, and which tests may be deleted, as unnecessary. The THA may also propose additional testing that may be required to assess the basic safety of the munition. The preparation of a THA is a required step in the development of an IM Program. And a summary of the THA, or updated changes as necessary, is a required element of the munitions' POA&M. To support the Navy Munitions PEOs/PMs and their teams in preparing THAs, NOSSA IMO (N855) is preparing a THA Template to be maintained on the NOSSA Secure Website.

IM Qualification

NAVSEAINST 8010.5C requires that “IM must be successfully integrated into a total system safety program” per MIL-STD-882E. As stated in NAVSEAINST 8020.5C, *“Qualification is the assessment of the explosive material to determine whether it possesses properties that make it safe and suitable for consideration for use in its intended role. Final (Type) Qualification is granted when the qualified explosive has been assessed as part of the design of a specific munition and predicted to be safe and suitable for military operational or training use.”* NAVSEAINST 8020.5C applies to explosives at Navy installations and aboard Navy ships or aircraft, whether designed and built by the Navy or developed by other Services, private industry, or foreign sources and whether intended for operational use, testing, training, or transport. Fleet ballistic missile strategic weapons and nuclear weapons are excluded.

The Qualification and Final (Type) Qualification, per NAVSEAINST 8020.5C, of all energetic material in Navy munitions is essential to the Navy implementation of the IM program. This ensures that the energetic materials are safe and suitable for use in Navy munitions before operational, safety and IM evaluation of the end item munition. The Naval Sea Systems Command (NAVSEASYSCOM) is assigned the Navy-wide responsibility for energetic materials, explosives safety and IM policy. Lead Systems Command responsibilities include the approval authority for Qualification and Final (Type) Qualification of explosives.

IM Compliance

IM Requirement., USC, Title 10, Chapter 141, Section 2389 December 2001 states “§ 2389. Ensuring safety regarding insensitive munitions. The Secretary of Defense shall ensure, to the extent practicable, that insensitive munitions under development or procurement are safe throughout development and fielding when subject to unplanned stimuli.”

As per OPNAVINST 8010.13E, all DON munitions, without regard to program acquisition category are to be designed to meet IM requirements. Operational capabilities and performance are to be attained without compromising system and platform safety. IM should be integrated using a systems safety approach. Achieving IM compliance or incremental improvement in IM compliance is considered over the program's entire life cycle.

Munition POs’ IMSP/POA&Ms, which are submitted to the JROC and OUSD(AT&L) (now OUSD (Acquisition and Sustainment (A&S)) biennially, document the program, progress and status of the POs’ munitions IM improvement program for achieving IM compliance.

Harmonized Joint IM/HC Testing, Requirements, and Passing Criteria - The Joint IM community began to coordinate IM testing with the Joint Hazard Classifiers with the publication of MIL-STD 2105B in January 1994. OUSD Memo dated 01 February 2010 approved the set of IM standardized tests and criteria.

Table 10-1. in Section **10.2.1 Joint Standard IM Tests** of the Handbook, lists the JROC/ OUSD approved set of Joint standardized IM tests and the additional two HC-only required tests, the passing criteria, the required number of tests, and the test munition configuration (whether logistical or operational). Figure 2 defines the IM threats associated with each of the six Joint IM Tests, the potential munition responses (reaction types) to the IM tests, and the passing criteria for each test to obtain IM compliance.

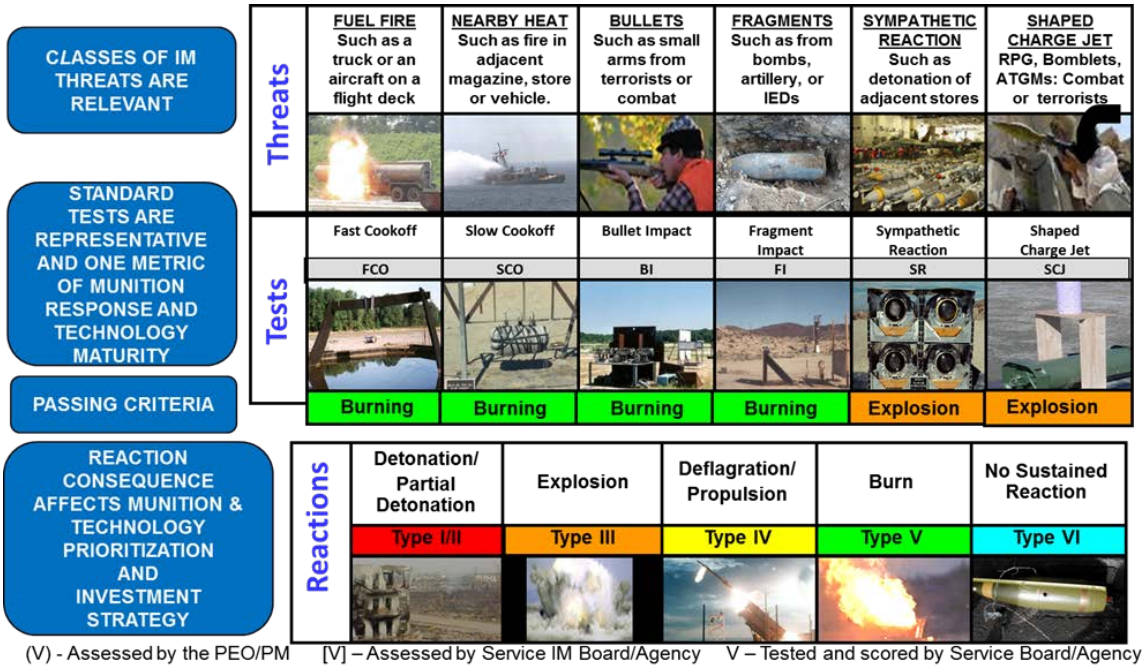

Figure 2. IM Threats, Standard Tests, and Reaction Types

Munitions POs are responsible for preparing an approved munition-specific harmonized IM/HC test plan that is based on the Joint Standard IM and the HC tests, and obtaining the approval of the test plan prior to IM and HC testing. Upon approval of the munition-specific harmonized IM/HC test plan, Munitions POs are responsible for conducting the required IM tests. Final test reports must be submitted to NOSSA IMO N855. Test responses to the IM tests must be validated by the MREB for munitions programs led by the DON or by the appropriate Service board if led by another Service. Test responses to the IM and HC tests must be validated by the Navy (NOSSA N851) and other Service Joint Hazard Classifiers and the DDESB.IM Compliance section.

IM/HC Test Plan Template **-** NOSSA IMO (N855) has developed a template, the **U.S. Navy Munition Test Plan Template for Combined Insensitive Munitions/Final Hazard Classifications,** to provide a tool for the Navy IM and HC communities to prepare coordinated IM and HC test plans with test requirements, guidance, and best practices combined into one harmonized test document. The Template is maintained on the NOSSA Secure Website.

Verifying IM Compliance **-** The MREB, whose mission, authority, responsibility, and membership is prescribed in NOSSAINST 8010.1A, is the responsible body to approve Navy IM/HC test plans for IM, to concur that the IM/HC tests were conducted as approved by the MREB, and to score the munitions' reaction types during the IM/HC tests.

Reporting IM Compliance - Munition POs report the status of their program to achieve IM compliance in their required biennial munition-specific POA&Ms, which accompany their IMSP submission to the JROC and OUSD(A&S). Specifically, the status of IM compliance for a specific munition is reported in a POA&M "IM Reaction Table." Table 11-1 in the Handbook is an example IM Reaction Table, which is taken from the DoD SOP. Table 11-1. was developed for the DoD SOP for IMSP and POA&Ms to portray the progress of the POs' IM Improvement Programs to achieve IM compliance for their munition in their munition specific POA&M.

Concluding Remarks

This paper is an advance introduction to the Handbook, which, upon completion, will be issued by NOSSA on its secure website. NOSSA plans to update the Handbook on its secure website, as necessary. The Handbook will be a comprehensive source of information tailored for the

Navy IM community. The IM research projects and the relevant POCs are based on information from the FY17/18 IMSP/POA&Ms and documentation from technology programs with IM related efforts (e.g., JMP, JIMTP, IMAD Program, and IMTTP). Information on 2017 research programs is included in the Handbook to provide recent examples of IM related research and collaboration that is indicative of the range of possibilities for future areas for IM research and development.

Acknowledgements

The Naval Ordnance Safety & Security Activity sponsored the development of the “U. S. Navy Insensitive Munitions Handbook” and the preparation and presentation of this paper.