Title: Quick Response Application of Insensitive Munitions (IM) System Solutions: An example of applying lessons learned to a successful, quick, low-cost IM improvement

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Abstract:
The Low Collateral (LoCo) Bomb is a Quick Response Weapon System developed by the Naval Air Warfare Center Weapons Division (NAWCWD) through funding provided by Naval Air Systems Command (NAVAIR), PMA-201. This 500-pound bomb is similar to the MK-82 / Bomb Live Unit (BLU)-111 weapon but is designed to uniquely provide significantly reduced collateral damage. In order to meet the urgent schedule requirements, it was determined only specific and mature IM technologies would be incorporated in this weapon application. This paper will present the decision process to select the technologies incorporated and how they fulfilled IM implementation in less than 18 months from program inception.

This approach leveraged the accomplishments of the U.S. Navy and Air Force Joint IM Improvement Program for the general purpose (GP) bomb family that began in 2005. Several IM technologies existed at this time and the final designs for each size of the GP bombs incorporated multiple mitigation techniques in order to satisfy their unique constraints. After completing the designs, the preliminary analysis, and testing, all three weight classes of GP bombs were then tested according to MIL-STD-2105C. The LoCo Bomb Program then selected technologies that could be incorporated within the schedule constraints and proposed a technical approach to fulfill the IM requirements.

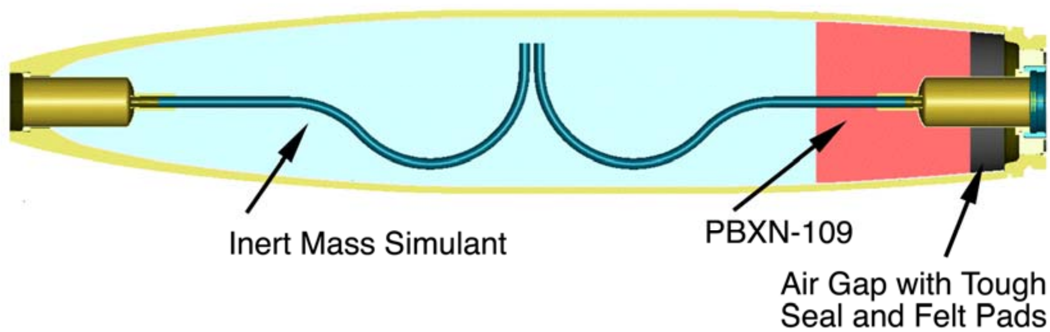
This paper details the process used to arrive at the final IM design for this weapon application and the steps utilized, as well as some of the pitfalls avoided, to successfully implement a systematic solution set through IM testing, qualification, and fielding. This paper also presents lessons learned and how they were incorporated into the process from a systems perspective.

LoCo System Background:

United States Warfighters urgently requested an air delivered, precision-guided weapon that could provide an effect on an urban target set while meeting collateral damage Rules of Engagement. LoCo addresses the Joint Services Capability Gap for urban, asymmetric, and expeditionary operations. It provides a capability to conduct close air support in an urban environment with fixed wing aircraft. PMA-201 conceptualized the low collateral damage (LCD) warhead as a product improvement program to the BLU-111 GP bomb. The LoCo, otherwise known as the BLU-126/B, bridges a capability gap by effectively striking urban targets while meeting collateral damage objectives.

The key feature of this bomb concept was modifying the BLU-111 500-pound bomb to reduce fragment quantity and velocity. The modification reduces the mass of the main-charge explosive to less than 30 pounds. The removed explosive mass is replaced with inert material that maintains the mass properties. State-of-the-art repeatable precision attack weapon systems allow this low collateral damage concept to be viable. The result is a very inexpensive bomb concept comparable to the cost of the

BLU-111. Additionally, the BLU-126/B is compatible with current BLU-111 fuzes, guidance kits, and components.



Concept illustration shows the BLU-126/B's significantly reduced explosive mass.

The proposed BLU-126/B design solution was developed under the following constraints:

- Provide a significant reduction in collateral damage
- Provide an effective lethality versus range profile
- Maintain interoperability while retaining compatibility with current BLU-111 fuzing, guidance kits, and operational flight programs
- Maintain existing BLU-111 flight characteristics
    - Maintain existing aerodynamic shape
    - Maintain existing mass properties
- Maintain external geometry
- Minimize logistics impact
- Maintain existing packaging, handling, storage, and transportation (PHS&T) elements

The BLU-126/B design has resulted in a greater than 90% reduction in fragment quantity and a greater than 50% reduction in range for collateral damage. This weapon, BLU-126/B, allows more effective use of precision strike weapons for military operations in urban terrian and for close air support applications.

In order to meet the program needs, an abbreviated IM schedule was proposed and accepted by appropriate program levels. The IM improvements and verification were only one small aspect of this overall program. Yet, how these IM goals were accomplished is the basis of this paper.

<u>The IM Approach for this Program</u>

It was critical to understand the IM requirements in order to propose a plan that would meet these requirements while also meeting the project objectives. Gaining this understanding was based on the standard requirements for development, assessment, and testing found in MIL-STD-2105C; the pass/fail criteria found in STANAG 4439 (NATO 2006); and the guidance on the development, assessment, and testing found in AOP-39. As this project spanned a number of years from inception to conclusion, it also coincidently spanned the harmonization of IM and hazard classification (HC) testing. Further, the Joint Requirements Oversight Council (JROC) memorandum subsequently provided a standardized, single set of IM tests and passing criteria to be used (Reference: JROCM 235-06 Memo 2006, Standardization of IM Test and Passing Criteria).

As the BLU-126/B bomb was an adaptation of the BLU-111, it was proposed to only incorporate the IM technologies being developed for the General Purpose Bomb System. However, the BLU-111's IM venting demonstration had not completed qualification by the time the LoCo project implementation was approved. The IM threat reactions of the BLU-126 were predicted to be "no worse than" the BLU-111 bomb. Therefore, the LoCo Program proposed to produce and qualify the first quantity of weapons without the planned BLU-111's IM improvements. Specifically, it was requested that the initial LoCo be deployed with the current base plate. Due to the weapon's reduced explosive quantity, it was proposed to conservatively accept the existing IM scores and HC of the BLU-111 for this initial production run of weapons.
The final element of this proposal was to incorporate the BLU-111 IM technology, once qualified, into subsequent BLU-126 productions. This approach was successfully presented to the Navy Insensitive Munitions Office (IMO) at the Naval Ordnance Safety and Security Activity (NOSSA) and to the Weapons Systems Explosive Safety Review Board (WSESRB) for their concurrence.

When the General Purpose Bomb Program finally completed its Joint IM improvement, it incorporated a vented base plate and maintained the PBXN-109 explosive fill used in the 500-pound bomb. This same vented base plate was then, as agreed, incorporated into the LoCo System.

The LoCo Program followed the prior approach of proposing an IM qualification plan to the appropriate offices for their review and approval before conducting further work with the IM improved LoCo. It was proposed that leveraging the previous testing from the BLU-111 qualification just completed could reduce IM testing of these improvements in the LoCo. The IM threat reactions of the BLU-126/B were again predicted to be "no worse than" the IM-improved BLU-111 bomb. Therefore, each of the threats was evaluated and a specific approach was proposed.

In the IM threat environments where the BLU-111 garnered a passing reaction and/or was not technically expected to perform any worse in the new system's configuration, no testing was recommended. Therefore, the following tests were not advised:

- Fast Cook off (FCO)
- Bullet Impact (BI)
- Shaped Charge Jet Impact (SCJ)

It was presented that since the BLU-111 had passed the FCO and the BI, and since it was not technically expected to perform any worse in this system's configuration, these tests would not be repeated.

Although the BLU-111 failed the SCJ test when undergoing qualification testing with the IM base plate, no further testing was recommended. Since initiation of the PBXN-109 explosive material was anticipated, although less material was present, the overall reaction was predicted be no different for the LoCo.

In the IM threat environments where the BLU-126/B was predicted or expected to perform better because of the reduction and placement of explosive fill, the following tests were recommended:

- Slow Cook Off (SCO)–Two tests in logistical configuration
- Fragment Impact (FI)–Two tests, one in tactical and one in logistical configuration
- Sympathetic Reaction (SR)–One or two tests, depending on outcome of first test
- SCJ–None

Since the BLU-111 did not pass the SCO test, the LoCo Program proposed to conduct this test with anticipated improvement. This was based on the fact that (1) the BLU-126/B has approximately 30 pounds of PBXN-109 versus 190 pounds in the BLU-111, (2) the entire explosive quantity is located in the aft end near the vents, and (3) the technical similarities in SCO to a warhead variant of the Hellfire missile. The two weapons have a similar ratio of vent areas to explosive surface areas (60:1) that are exposed to heating in an SCO environment. The current IM BLU-111 with a 5-square-inch vent area has a surface area to vent ratio of over 300:1. Also, the vent path lengths over the outside surfaces of both the referenced Hellfire version warhead and LoCo explosive loads are very similar, about 9 inches. As a result, it was recommended performing two SCO tests in logistical configuration for score.

Using logic similar to that used in the SCO test, two tests were proposed for FI for score: one in tactical configuration and one in logistical configuration.

It was recognized that the IM base plate would not help with the SR test and SR testing was not conducted under the BLU-111 IM Program. However, there is significantly less explosive material present in this configuration. The LoCo Program therefore conducted some basic modeling and simulation of this scenario. This modeling showed failure, and as a result, no further SR testing was recommended for the new, IM improved LoCo.

The IM community supported this approach to testing, as there were no mature and applicable technologies available that could meet the established time frame for a Quick Reaction Program. By presenting the approach to all of the appropriate review boards prior to conducting the program, IM leadership were apprised of the programmatic requirements. Having official endorsement reduced program risk and uncertainty. Further, it identified the Program Office's commitment to incorporate and qualify the IM technologies for subsequent production. Presenting a valid approach early in the process significantly supported the alignment of the IM objectives with the IM community and the Program Office.

The lessons learned through the accomplishment of this project are as summarized:

1. Someone within the program must become aware of the IM requirements, including hazards classification if conducting a harmonized program, and take responsibility for their specific task accomplishment. This individual may or may not be the Program Manager (PM). In fact, in the author's opinion, there are advantages if it is not the PM as long as the responsibility has been specifically assigned. Improvement of IM characteristics is often considered secondary to the greater programmatic objectives. Further, team members should not automatically assume the PM is fully cognizant of the unique or specific requirements for IM or hazards classification. It should be recognized that other aspects of the project may easily overwhelm a project and preclude IM plans from being accomplished in a timely or cost effective process if someone is not monitoring specifically for them.

2. Someone needs to write a plan for how IM objectives will be addressed. The plan needs to be reviewed, approved, and then followed. The plan should NOT be any harder than needed to meet the program's IM objectives. Accomplishing and documenting IM improvements is difficult enough. This IM plan needs to be reviewed and approved by the appropriate offices (Reference: NOSSAINST 8010.1). In general, if the governing review authorities for IM are contacted early in the process (in order to have the plan reviewed and approved), these boards are supportive.

3. The prepared plan must be properly resourced. The specifics of who provides each of the test components, items, recording instruments, and reports should be identified to the greatest extent possible. Identifying and scheduling these types of specifics will reduce the chances of unplanned requirements surfacing or late realization of unidentified costs, thereby increasing the probability of IM success.

4. Finally, the plan then needs to be followed. This may seem a gross over simplification of standard project management, but it should come as no small surprise that many programs attempt to succeed without this basic parameter. Everyone supporting the program should be made aware of the approved IM plan. Whenever there is an IM-related test being performed, it should be referenced back to the IM plan. Experts on the project often understand the historical basis of IM tests, the MIL-STD and STANAG requirements, and typical test configurations. Their understanding, however, may not be in agreement with the test plans that have been negotiated and agreed to for the specific program. Any test not conducted in accordance with the plan not only adds additional costs, it expends what is likely a rare and expensive test asset.