Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC)

MILES Emitter Unit Integration for Area Coverage Weaponry

Samantha Markowitz	**Brendan O'Neil**	**Edward Cole**	**Matthew Tomik**
U.S. Army CCDC AC	**U.S. Army CCDC AC**	**U.S. Army CCDC AC**	**U.S. Army CCDC AC**
Picatinny Arsenal, NJ	**Picatinny Arsenal, NJ**	**Picatinny Arsenal, NJ**	**Picatinny Arsenal, NJ**
samantha.a.markowitz.civ	**brendan.f.oneil.civ**	**edward.cole74.civ**	**matthew.h.tomik.civ**
@mail.mil	**@mail.mil**	**@mail.mil**	**@mail.mil**

ABSTRACT

Incorporation of the Multiple Integrated Laser Engagement System (MILES) into Warfighter training can result in enhanced learning and performance over non-MILES training by improving simulated combat realism. MILES is designed to mimic active battle during Force-on-Force training by simulating weapon lethality and providing real-time casualty assessment. However, MILES integration for area coverage weaponry is largely nonexistent. This paper outlines the development, challenges, and benefits of incorporating MILES into such weaponry. Among these challenges are variation in MILES capability between and within training centers, with older hardware being unable to recognize some weapons-specific signals, and the way in which MILES hardware processes received signals. The development of the Claymore Training Aids, Devices, Simulators, and Simulations (TADSS) system was able to successfully incorporate a MILES Emitter Unit (MEU) to replicate the lethal area coverage of the tactical Claymore through a combination of lasers and LEDs used to send MILES signals. A test emitter was developed that permitted modification to the signal emitted by the MEU, the power levels, and the angles of engagement with the MILES equipment. Extensive field testing, which involved firing the MEU over various distances and orientations at the MILES hardware, was conducted to verify characterization of the MEU signature. Additional testing showed reliability over a range of environmental and light conditions. The MEU was ultimately able to induce MILES response over the kill area over 80% of the time while accurately replicating Claymore effective range. The methodology and test data obtained during this development can provide a pathway for the creation of future training systems to be integrated with MILES, providing more realistic simulation of weapon lethality for soldiers in training.

ABOUT THE AUTHORS

Samantha Markowitz is a Mechanical Engineer with the U.S. Army Combat Capabilities Development Command Armaments Center. She has worked on Networked Munitions, Training Aids, and Maneuver Support for 4 years with additional experience in additive manufacturing. Ms. Markowitz functions primarily in design, prototyping, development, and testing of new systems.

Brendan O'Neil is an Electronics Engineer with the U.S. Army Combat Capabilities Development Command Armaments Center. He has worked on Networked Munitions and Area Denial for 14 years. Mr. O'Neil works on programming embedded systems, circuit design and layout, radio communications, and system architectures. He also serves as IT support.

Edward Cole is a Mechanical Engineer with the U.S. Army Combat Capabilities Development Command Armaments Center. He has worked on Networked Munitions and Area Denial for 20 years. Mr. Cole works on mechanical design, system integration and prototype/field testing. He also serves as the program lead for Training Aids.

Matthew Tomik is a Mechanical Engineer with the U.S. Army Combat Capabilities Development Command Armaments Center. He has worked on Large Caliber Artillery systems, Automated Mortars and Networked Munitions. Mr. Tomik is a licensed professional engineer with 15 years of experience. He primarily works on design and development of new systems.

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samantha.a.markowitz.civ	**brendan.f.oneil.civ**	**edward.cole74.civ**	**matthew.h.tomik.civ**
@mail.mil	**@mail.mil**	**@mail.mil**	**@mail.mil**

BACKGROUND

The Multiple Integrated Laser Engagement System (MILES) is used by the United States as well as various international militaries in support of Force-on-Force soldier training. MILES integration into weaponry is significant in improving training realism. During training, soldiers wear MILES gear equipped with sensors that read signals from weapons that, when fired, report to the gear whether the user would have been killed during the engagement. In real time, soldiers are aware of their vital status based on auditory output from their wearable gear. Although common for firearms, MILES integration for area coverage weaponry is largely nonexistent. During development of the Claymore Training Aids, Devices, Simulators, and Simulations (TADSS) system, a MILES Emitter Unit (MEU) was able to be incorporated into the design. Integration of the MEU allowed for the accurate replication of the lethal area coverage for the tactical Claymore, thereby improving the effectiveness of the training system. An MEU was also used in the earlier development of the Spider TADSS system with success. Lasers and LEDs on the MEU electronics board send the MILES signals used to duplicate coverage of the associated system. The lasers are used for sending longer range signals while the LEDs are used for shorter range signals.

The Claymore TADSS system was fully designed and developed at the United States Army Combat Capabilities Development Command Armaments Center (CCDC AC) located at Picatinny Arsenal, NJ. Development took place in cooperation with Program Executive Office Simulation, Training and Instrumentation (PEO STRI) Live Training Systems (LTS) and the Maneuver Support Center of Excellence (MSCoE) for Project Manager Close Combat Systems (PM CCS).

### Multiple Integrated Laser Engagement System (MILES)

MILES is used by the Unites States military and multiple international allies to facilitate Force-on-Force soldier training and is able to provide real time casualty assessment to the user. Dismounted soldiers typically wear a vest outfitted with multiple MILES sensors and a halo of sensors attached to their helmet. Training devices equipped with MILES laser emitters mimic the effective range of the associated tactical weaponry. When a soldier's MILES gear receives a signal from a weapon, the system uses a random number roll and casualty probability look up table to determine the lethality of the encounter. These MILES integrated training devices reduce the need for Observer Controller (OC) personnel in the training field to act as overseers and decide whether a soldiers' engagement would have been lethal. OCs can be equipped with a God Gun which allows them to initialize, kill, or reset a player's MILES gear at will among other functions. Instead, soldiers know their vital status in real time based on the specific weapon interaction and resulting auditory output from their gear. For instance, a long tone is used to indicate a "kill" while shorter beeps will indicate a "near miss" situation in which a soldier may have been in close proximity to a weapon, but not in lethal range. An OC is not as well-equipped to make this determination between a kill and near miss. Use of MILES in place of an OC serves to better replicate combat and improve training realism.

Different versions of the MILES systems exist between and within combat training centers. Capabilities of the different versions vary, with newer systems specifically recognizing a wider range of weapons. This posed a challenge during development of the Claymore TADSS MEU as the MEU had to be capable of integrating with all MILES systems in use at the training centers. The random number roll and casualty probability look up table process used by MILES gear to determine lethality of an encounter can also make it difficult to simulate reliable lethality in a weapons training system. The MILES Individual Weapon Systems (IWS) vests were the version primarily used during development and testing of the Claymore TADSS MEU. Instrumented Tactical Engagement Simulation System (ITESS) and legacy vests were also tested. The MILES IWS vests have an LED read out that specifically identifies

which weapon killed the vest. Three of these vest were on hand from Ft. Dix, NJ for testing. The newer ITESS vests include the same sensors as the IWS vests and function in primarily the same way, but are updated with software improvements. The legacy vests have only an audible sound to identify if the wearer has been killed with no visual readout that can be consulted for additional information.

Spider TADSS Overview

The Spider TADSS training device depicted in Figure 1 was designed to replicate the function of a tactical Spider antipersonnel munitions system. The tactical Spider is a hand-emplaced, networked munitions system consisting of a Munitions Control Unit (MCU) with six ports to which Miniature Grenade Launchers (MGLs) can be attached. The MCU can also be used as an initiation system for other devices by connecting the port to the desired sub-munition in place of the MGL. In addition to providing soldiers the ability to train emplacement, operation, and retrieval of the tactical Spider, the Spider TADSS system is also able to simulate the tactical system's effective range via the MEU, which integrates with the soldiers' MILES body sensors. The MEU developed for the Spider TADSS program and lessons learned were ultimately able to be leveraged in the later development of the Claymore TADSS system.
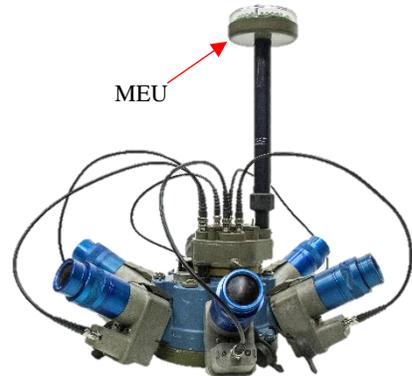
Figure 1. Spider TADSS

Claymore TADSS Overview and Requirements

The Claymore TADSS system (see Figure 2), which includes the MEU and Non-pyrotechnic Claymore Simulator (NPCS), was designed to mimic the use and lethality of the tactical M18A1 Claymore mine and to be used for safe and effective soldier training. Previous Claymore trainers did not indicate firing or integrate with MILES making them less realistic as tactical trainers. The developed Claymore TADSS system is able to provide the required auditory and visual indication of firing to soldiers in training via LEDs and a burst disk located on the front of the device. The burst disk chamber on the front of the NPCS can be loaded with powder and capped with a burst disk. When the system fires, the disk ruptures, providing the auditory indication of firing as well as a visual signal from the release of the powder. LEDs on the front of the NPCS blink during initiation, providing an additional visual indication of firing and making the initiation more visible in low light conditions
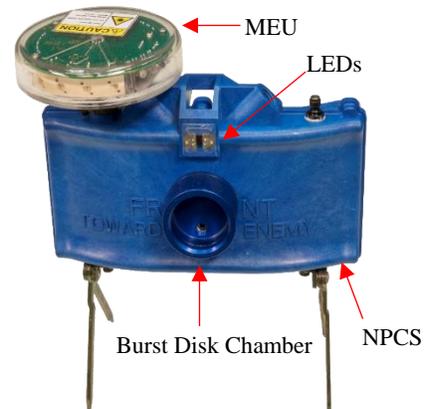
Figure 2. Claymore TADSS

The Claymore TADSS MEU is responsible for simulating Claymore effects by integrating with MILES. Lethality requirements for the Claymore TADSS MEU include a simulated forward output kill range of 50m and a near miss range of 75m (Threshold) or 100m (Objective). These ranges shall be provided in a 60° fan-shaped MILES signature that is at least 2m high at 50m. The system shall also simulate back blast effects at a range of 16m over the remaining 300° fan. Lasers and LEDs mounted to the MEU electronics board were used to provide the necessary area coverage. The lasers send longer range MILES signals while the LEDs are used for the shorter range MILES signals.

METHOD

Programming

To develop of an effective Claymore TADSS MEU, programming and ambiguity in signal processing of the MILES hardware had to be taken into consideration. Age of MILES vests varies between and within training centers resulting in differing capabilities. For instance, older vests will not recognize the specific "Claymore" signals emitted by the Claymore TADSS MEU. To combat this, the MEU also emits "Light Hit" signals universally recognized by all MILES gear in use. If a soldier's MILES gear receives either a "Claymore" or "Light Hit" signal, it will result in a kill. To test software effectiveness at mimicking tactical Claymore lethality, extensive field testing had to be undertaken in

order to generate enough data points to find consistent response patterns given the random number roll and casualty probability MILES gear runs through after receiving a signal. Programming for the MEU was, therefore, finalized through field testing of different software versions.

The MEU was programmed to the *PMT 90-S002M Multiple Integrated Laser Engagement System (MILES) Communication Code (MCC)* standard dated 8 February 2011 which outlines the standard MILES communication code structure. The output signal emitted by the MEU is made up of a series of words that indicate to the MILES gear worn by the soldier what kind of weapon has been encountered. The gear uses this information to process a result, indicating to the user whether the encounter was lethal. Words include "Claymore" and "Light Hit" to indicate the weapon functioning at its effective range, and "Near Miss" to indicate a close encounter. The software for the MEU was originally written in such a format as to easily change the firing voltage, number of words being used, and the type of words being sent out as testing revealed performance shortfalls and patterns. This was integral to the ability to rapidly test firing voltages for distance on the MEU lasers.

Early in testing, it was revealed that there was an incorrect number of Claymore words being sent out: eight (8) instead of four (4). This was changed to comply with the standard. However, due to the user requirement that the Claymore TADSS system be compatible with all MILES vests in use, the kill code used was ultimately modified from the active specification. The specification requires that the output code includes four (4) Claymore words followed by 128 Light Hit words followed by 128 Heavy Near Miss words (United States Army PEO-STRI, 2011). Heavy Near Miss signals, however, are not currently understood by all vests in circulation at the training centers. In order for all MILES vests in use to be able to give a warning of a near miss encounter, Light Near Miss words must be used in programming. It was also determined through testing that the 260 words required by the standard was in excess of what the MEU lasers and Claymore TADSS power source could handle. This caused melting of components on the boards. The number of words used was ultimately reduced to 44 total in the final version: 4 Claymore, 16 Light Hit, and 24 Near Miss. This represents the software version 5.4 configuration.

Signal output is achieved via the lasers and LEDs on the MEU's electronics board. The 4 Claymore, 16 Light Hit, and 24 Near Miss words that make up the output signal are transmitted by two different forward facing sectors of lasers on the board. A further 4 Claymore words and 16 Light Hit words are sent out on the rear facing sector consisting of non-lasing LEDs (see Figure 3) to achieve the full area coverage indicative of tactical Claymore lethality.
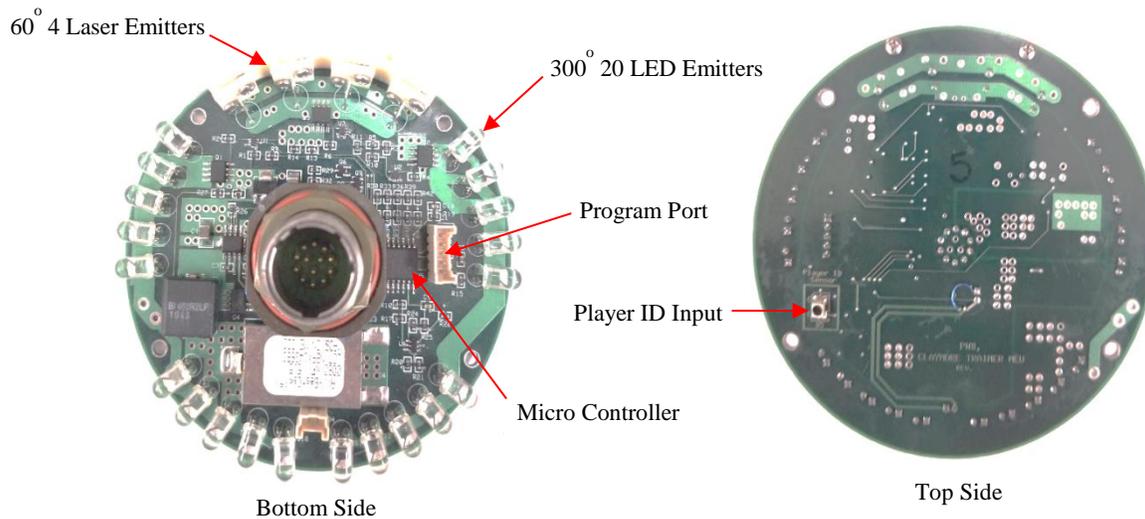
Figure 3. Claymore TADSS MEU Electronics Board

Testing results presented in later sections will be representative of the software version 5.4 MEU configuration. Field testing for characterization of software version 5.4 took place primarily between 30 June 2017 and 28 September 2017 with data being added to the overall response rate as further Claymore TADSS testing was completed.

Field Testing for MEU Characterization

The primary objective of field testing was to evaluate the ability of the MEU to achieve Hit/Near Miss responses from the wearable MILES system at varying ranges. A majority of the MEU testing took place on the golf course outside of building 94 at Picatinny Arsenal, NJ. Date, time, sunlight, and weather data was noted during each test day. The MEU extension pole, an accessory provided to adjust the height of the MEU above the NPCS, was not used.

Before testing, new batteries were installed in the Claymore TADSS prototypes. The Claymore TADSS was then appropriately set up as per its operating procedure, although typically excluding the use of powder and burst disks. Four (4) MILES vests with sensors oriented forward were placed at a testing location (see Figure 4) to serve as targets. They would remain in place for the duration of the test. Three (3) of the vests were placed side-by-side in the equivalent of a standing position while the fourth vest was placed front and center of the standing vests in the equivalent of a crouching position. A light sensor was mounted at chest height of the standing vests to record light reaching the MILES vest sensors. An average reading was recorded for the day when available along with general weather data. After vest setup, a tape measurer was extended from the front of the target setup (0m) to the objective response location (100m) in a straight line. The Claymore prototype(s) was then placed at a straight line distance of 5m from the center of the target setup, as indicated by the tape measurer. The prototype(s) was then fired and the response from the MILES vests recorded in the test data sheet along with identifying information for the prototype used as well as its positioning (see example test data sheet in Figure 5). MILES vest responses

Figure 4. Field Test Setup

included Light Hit, Claymore, or Near Miss and were indicated on the vests' digital readout. In the absence of a response, "None" was recorded in the data sheet. After recording the response, MILES vests could then be reset using the God Gun or equivalent. The MEU was fired four times at each location and responses recorded starting at the 5m mark and moving back in 5m intervals until 100m was reached. The 16m back blast effect was also tested. Early testing adhered strictly to the 5m intervals while later testing, after confidence had been established at close distances, increased interval size. Collected data was used to calculate confidence and map the likelihood of MILES response over the required effective range.

Date	MEU #	Software Version	Claymore	Incline Angle°	Hardware Configuration	Fan Angle°	Distance (m)	Klx*	MILES Response				Pressurized?	Valid Data?	Additional Notes
									1	2	3	4			

Figure 5. Example Data Collection Table

Additional testing utilized a rotary table to check MILES response over the 60° fan representative of tactical Claymore lethality. Test setup remained largely the same as described above, however, the Claymore TADSS unit was mounted to the rotary table and turned to face 0° (straight forward), -30° (toward the left) and 30° (toward the right) at every 5m interval over the 100m range. MILES vest responses were recorded at all locations.

Optics Lab Testing

The Optics Lab at Picatinny Arsenal was utilized in an attempt to create a system to pass/fail new MEUs without field testing. Pass/fail criteria would be based on the output from a verified MEU which had undergone the extensive field testing described in the previous section. This was done in an attempt to save time on characterizing MEUs for the Claymore TADSS system as well as serve as a basis for automated MEU characterization for any TADSS systems potentially developed in the future. The Optics Lab engaged in average power level characterization instead of absolute peak measurement testing. This method gave inconsistent results when compared to field testing and showed no correlation between signal intensity and probability of receiving a kill or near miss response. Several main issues were identified while trying to fully characterize different MEUs. First, the average power level could vary by as much as 57% if an MEU was programmed with a player identification (ID) code, a programmable feature called for in the specification allowing the specific training device to be logged by the MILES gear it interacts with and reviewed post-training. The player ID adds 4 pulses to the output signal which has 11 maximum. Second, there were complications

achieving the precise timing needed to begin recording a signal's power levels effectively. Inappropriate timing would drive down the signal's average power level seemingly at random.

Given the unreliable results and availability of resources at the time, it was decided that direct measurement of the MEU signal through lab testing was too difficult and fruitless to pursue. A simpler and more effective approach for characterizing MEU signatures in the lab could be to use a known sensing device as a go/no go tester and emplace tunable filters in the path of the laser light. Tuning would take place by increasing the amount or opacity of the filters. In this way, a precise measurement on the amount of attenuation being placed on the signal could be gathered before it could no longer be read by the sensor. This could be quantitatively compared to other devices and how they performed in outdoor environments without having to fully recreate a statistical representation of the lethality area of the desired system. However, the necessary resources to achieve this method were not available at the time of testing. Additional MEUs continued to be characterized via field testing though in a condensed form.

RESULTS

Field Testing for MEU Characterization

A single MEU (MEU 6) was used for the characterization of the MILES signal and response. Future Claymore TADSS MEUs were compared to this baseline performance. Testing of the initial MEU took place primarily between 30 June 2017 and 28 September 2017 with some additional testing occurring on 3 April 2018 as part of a functional check out ahead of Claymore TADSS support in a Spider Inc1A exercise. A total of 2106 data points were collected over this time. The MEU testing showed an overall MILES response rate of 85% to 100m with a kill to 50m occurring 95% of the time over the 60° fan representing tactical Claymore lethality. This data is depicted in Figure 6. Here blue represents a successful kill (via a Light Hit or Claymore signal), orange represents a Near Miss, and gray represents instances in which no MILES response was induced.
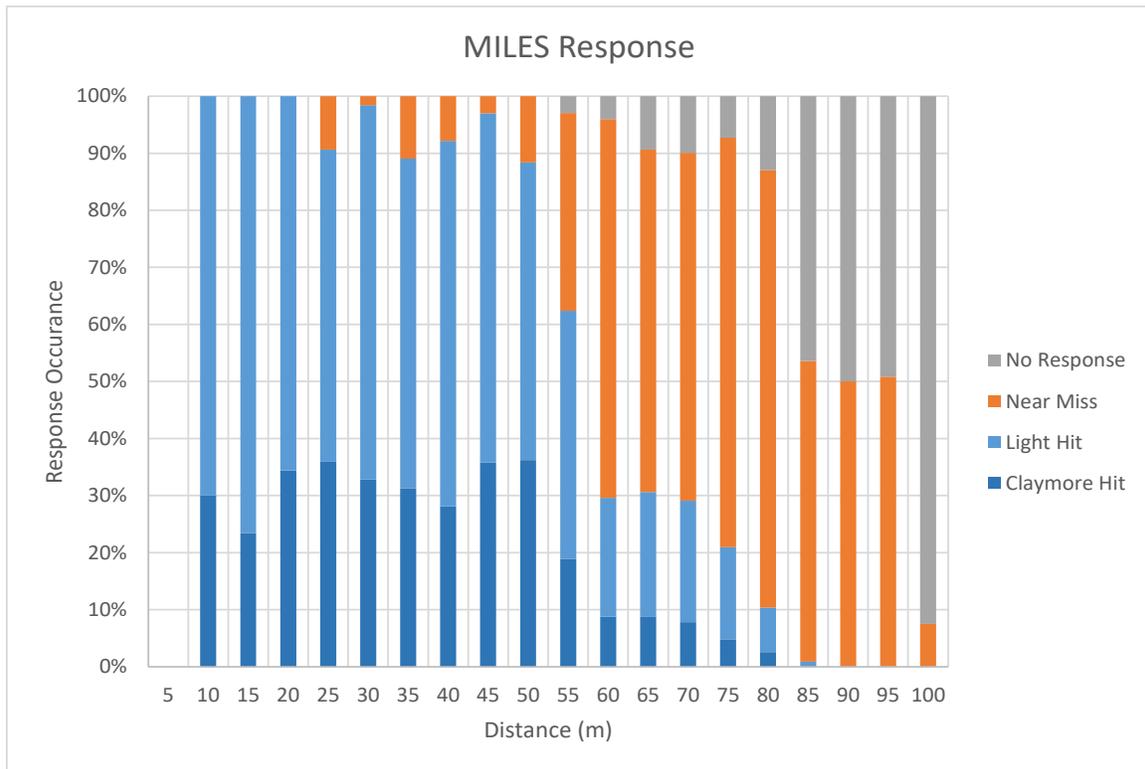
Figure 6. Baseline MILES Response following Initial Characterization

Based on the characterization of MEU 6, units developed in the first prototype builds underwent a functional check to ensure they were performing as expected over the effective range. These functional checks were not as extensive as initial characterization testing. As additional MEUs were built, they followed the same condensed functional check procedure. MEUs developed for Military Standard Environmental 810 testing also followed this procedure with functional checks occurring before and after units underwent their designated environmental tests. Environmental testing of the MEU proved successful, with units remain functional after various stressors such as drops, vibration, hot environmental soaks, and cold environmental soaks thus showing high system reliability. All functional checks and other firings of these MEUs was recorded. Including this data in the generated performance chart showed performance across MEUs remained consistent with initial characterization and goals. The overall MEU testing showed a MILES response rate to 100m of 88% with a kill response occurring 86% of the time out to 50m (see Figure 7). This shows adherence to expected Claymore lethality over the designated range with high effectiveness. Data presented in Figure 7 is based on 4696 collected data points and represents all testing of MEUs equipped with software version 5.4 following initial characterization of MEU 6.
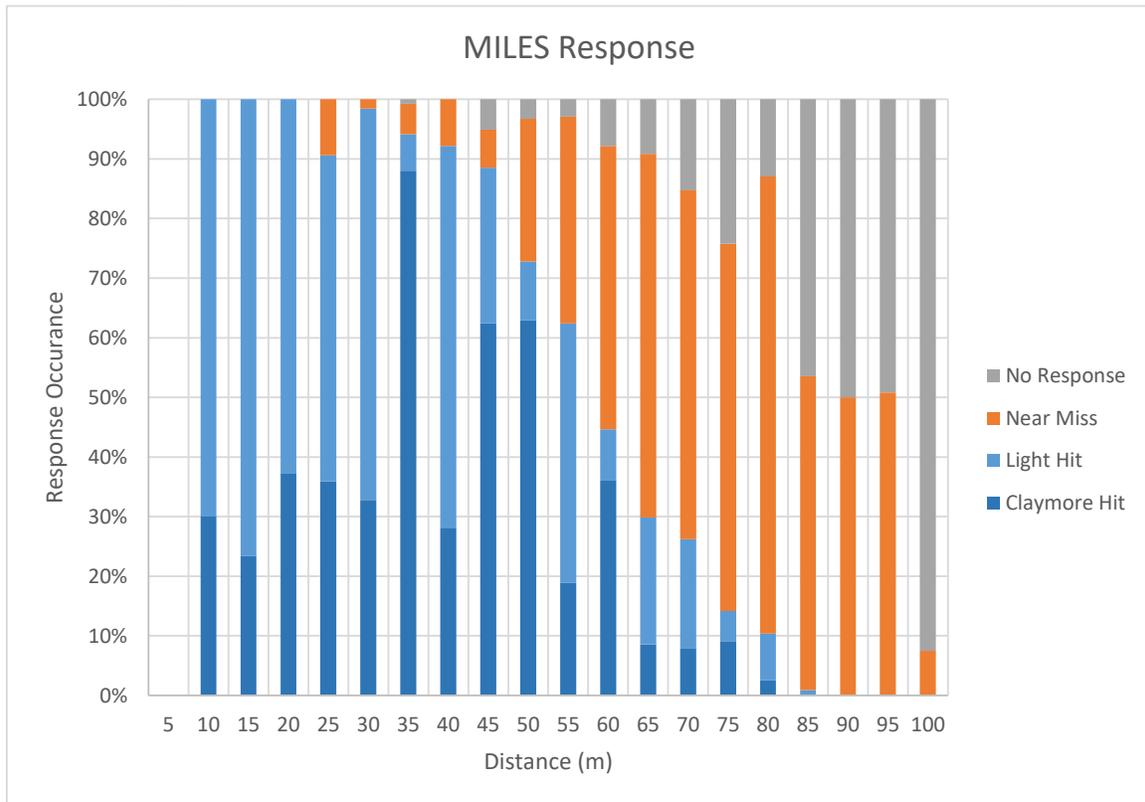
Figure 7. Overall MILES Response

CONCLUSIONS

MEU development for simulation of tactical Claymore lethality proved successful in testing and provided insights that can be applied to future MEU applications. The MEU developed can be tuned to meet the requirements of other systems, expanding MILES enabled training more widely to hand-emplaced, area coverage weaponry as well as saving developmental time and resources. Future MEU testing would benefit from the establishment of a predominantly autonomous test setup for MEU characterization that is capable of capturing and interpreting outputs from the MEU lasers and LEDs without having to test extensively at distance. Characterizing the MEU signature in this way would ensure consistency across current and future units and could be easily adjusted to match the lethality requirements of the system being simulated. By this methodology, MEU technology can be used in the development of future training systems to be integrated with MILES, thereby providing a more realistic simulation of weapon lethality for soldiers in Force-on-Force training and creating a more effective training environment.

ACKNOWLEDGEMENTS

REFERENCES

United States Army PEO-STRI. (2011). *PMT 90-S002M MILES Communication Code (MCC)*. http://www.peostri.army.mil/PRODUCTS/MCC/ECP_FILES/ MCC_Standard_PMT_90-S002M-8Feb2011.pdf.