Integrating New Engagement Types in Live Training Exercises

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ABSTRACT

Integrating geographically adjudicated devices, such as mortars, into a laser-based Live Training environment necessitates a change in how damage is adjudicated compared to point-to-point targeting of lasers. Currently, at US combat training centers, indirect fire is simulated centrally through the exercise control with battle damage assessment being pushed to the affected trainees. This approach reduces training realism because the soldiers are not provided with an origin in the field or the ability to counter-fire. There have been numerous attempts to create devices that would trigger laser receptors or otherwise imitate an area effect response, but they have not been incorporated into US combat training centers. Advancing technology has introduced new mechanisms to simulate weapons which may have an area of effect and make use of those models in Force-on-Force collective training. This paper discusses changes to the live environment to more fully exercise brigade combat team capabilities using advanced mortar, grenade, and mine simulators. The approach used to develop and test the devices is discussed along with plans for continuing to integrate devices into the existing Live Training environment. Although this paper is focused on integration with the live training instrumentation system, it shows challenges and advantages of integrating new capabilities into large complex systems.

Keywords: MORTAR, INDIRECT FIRE, LIVE TRAINING, ADAPTABILITY, ARCHITECTURE, CONCEPTUAL MODELING, DATA, ENVIRONMENTS, TERRAIN, URBAN ENVIRONMENT, SOLDIER TRAINING

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BACKGROUND

Many of the US Army's Live Force-on-Force (FoF) Training Systems have lasted the test of time but have several shortfalls creating unrealistic training scenarios. These systems can train bad habits depending on the materiel solution. For example, current laser-based systems do not account for weapon/ammunition trajectory, speed, and range. Laser-based systems have limitations, such as penetration through thick vegetation, heavy precipitation, or dust storms. Weapon effects at the Point of Impact do not crater or cause collateral damage, which means the participants do not gain a complete appreciation of weapon systems. Also, the inability to realistically portray other weapon systems such as indirect fire (e.g., mortars) can overlook the correlation between gun data and where the round should land. Unit Commanders decide the purpose of a live training event as they determine the collective training tasks for echelons, from Team/Squad to Brigade Combat Team level. Commanders also determine the intent of training by utilizing the crawl-walk-run method. Commanders sequence training events from relatively simple to increasingly more complex. This method develops unit training proficiencies in a progressive sequence. It ensures that task proficiencies build on each other, laying a solid foundation before moving on to more complex tasks and increasingly difficult conditions. The commander increases the Operational Environment challenges as the training unit proficiency increases. The crawl-walk-run approach will demand high levels of fidelity in terrain when precision is essential. In doing so, the engagements provide higher accuracy and create a realistic training event. This is especially true of engagements that current Live training solutions cannot replicate, such as indirect fire and thrown objects.

There are gaps in the types of weapon systems that are replicated in the U.S. Multiple Integrated Laser Engagement System (MILES) catalog. Lasers do a good job in replicating direct fire weapons of many calibers. They do not do a good job in replicating indirect fire or area effect weapons. Current estimates are that 40 percent of the US capabilities are not well replicated by MILES as reported by Synthetic Training Environment (STE) Cross Functional Team (CFT) (2020).

Previous Efforts to Fill Gaps

Various efforts have been made to fill portions of the gap left from laser-based training systems. Back in the late 80’s there were comments regarding the gap in training realism with respect to realistic indirect fire simulation. The deficiency in indirect fire simulation decreases understanding of the effects of mortars during combat operations (Hollis, Miller, 1987). Although computer-based simulations of fires effects have improved since that time, they do not provide the level of realism of having a weapon simulator in the exercise. Fire markers in the exercise give warning as to when indirect fire can be expected, and soldiers move away from the area in response to that warning which is not present in actual combat. Although counter-fire radars can be used with simulated indirect fire, the realism associated with these activities is reduced when the mortar crews are not physically present in the exercise. Overall, the lack of physical devices for use by indirect fire crews reduces the value of live training for both those crews and soldiers who may fight in opposition to indirect fire.

There have also been suggestions of using geo-pairing to simulate weapons effects (Trivette, Deres, and Youmans, 1999). The precision needed to pair target with shooter for small arms direct fire is a challenge, but area effect weapons do not require the same level of precision. With improving technology, the ability to make use of geometric pairing and smaller form factor computing devices enable the use of a mortar simulator for live training exercises.
More recently, a simulated mine was investigated which would trigger the laser sensors on existing MILES gear with a range consistent with a Claymore (Markowitz, O’Neil, Cole, Tomik, 2020). While grenades are not indirect fire weapons, they share similarities in that the effects are not easily replicated by laser sensors. Grenades and Claymore

have different triggering mechanisms and produce a (smell) area of effects as opposed to the point impact of direct fire small arms. With industry interest in promoting solutions for new engagement types, the government needed a means to get devices on to training ranges to gather information regarding which solutions were viable.

STAAR Activities & Transition from STAAR

Recently, the Program Executive Office Simulation, Training and Instrumentation (PEO STRI) stood up the PEO STRI's Agile Acquisition Response (STAAR) Team to provide initial testing of weapon simulation prototypes by soldiers. The STAAR team sets up soldier touch points to have vendor supplied prototypes operated by soldiers on a training range. They collect feedback and recommendations from the soldiers, and vendors refine the based this initial field experience. Prototypes may go through repeated testing over the course of many months as they are used by multiple people and in different environmental conditions. As the designs for the prototypes mature, the devices are moved from the STAAR team to the Project Manager Soldier Training (PM ST) to mature for future acquisition. Part of preparing for acquisition is integrating the new devices into training exercises. Currently, the following prototypes are transitioning from STAAR onto a path for deployment to the live force-on-force training environment:

i) 81mm mortar
ii) 60mm mortar
iii) Grenades
iv) Claymores

The remainder of this paper describes plans, activities, and results for moving these prototypes into a state where they are mission capable and have passed an independent assessment of operational capability.

ARCHITECTURE OF INTEGRATION

Live training exercises have four phases: plan, prepare, execute, assess. As support for new engagement types is developed it needs to be included in each of these phases. Figure 1 shows these phases and the many different engagement types which combine to support training engagements. Work from the STAAR team focuses on how the prototypes will function during the training exercise. Less attention is paid to how the devices are set up prior to the exercise or what data can be collected from them to support After-Action Reviews (AARs). Part of the work of PM ST is to delineate the communication and data needs to support the training engagements and the follow up reviews.

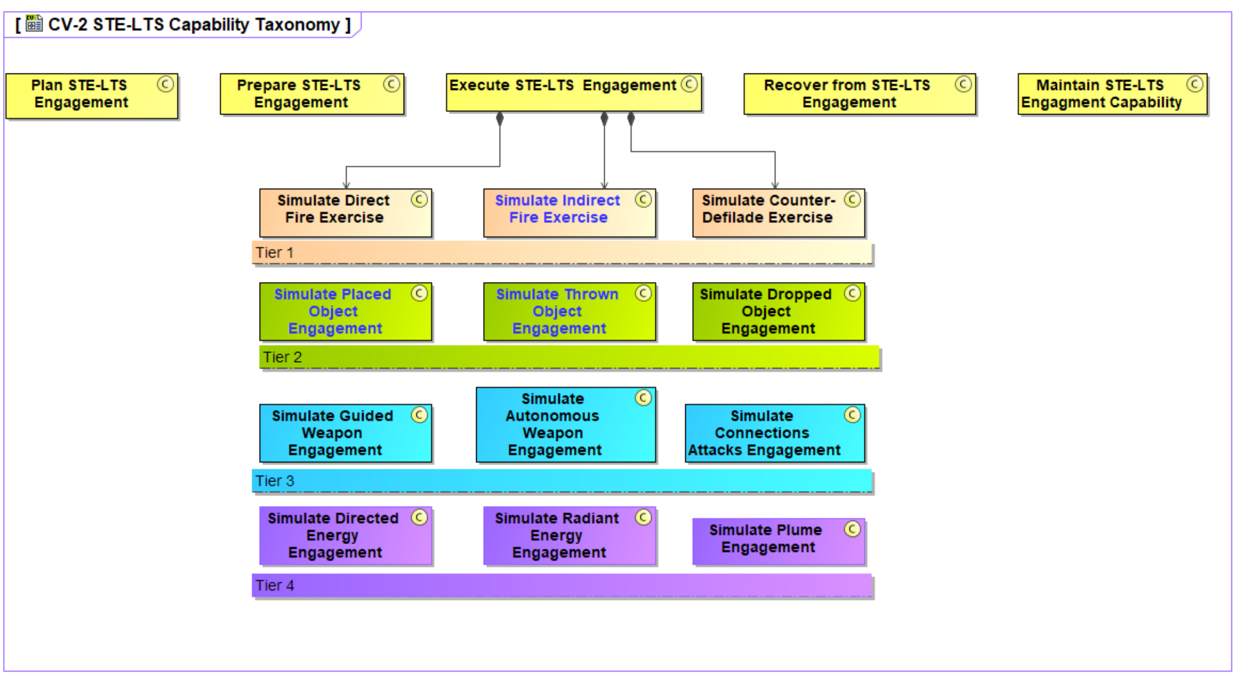

Figure 1. Breakout of Engagement Types within The Execution Phase of Training

The soldiers dependably train with provided equipment, but the new devices need to be included in planning and preparing so the devices can be put to appropriate use during the execution phase. This means planning exercises where the added engagement types are likely to be an appropriate response to some of the scenarios. During preparation for the exercises, the new devices are primed and issued to the units most likely to be called upon to perform that type of engagement. Soldiers must be trained in how to use the simulation devices to produce the weapon effects. To avoid negative training, the devices operate in a manner like the weapons being simulated, but there are simulation specific instructions to facilitate the exercise. Finally, part of training is reviewing what was done looking for areas of improvement and discussing team performance. The new simulation equipment needs to trigger sufficient effects in the instrumentation system to allow for feedback after the exercise. Individuals who used these weapon simulators should be able to review the results of their actions and look for ways to improve their performance.

If one considers the integration of a jigsaw puzzle, just getting all the pieces together does not create a coherent picture. The pieces need to be fitted together in a specific manner and it is useful to consider the best way to get the pieces to their desired places. In the same way, obtaining physical devices to support new engagement types does not integrate them into a force-on-force training exercise. In addition to the devices, integration requires an understanding of how the devices will be used and the way they will operate with respect to other devices in the exercise. Figure 2 shows how engagement devices are gathered into the full Force-on-Force (FoF) engagement system that simulates the tactical weapon systems in support of a Live Training exercise.

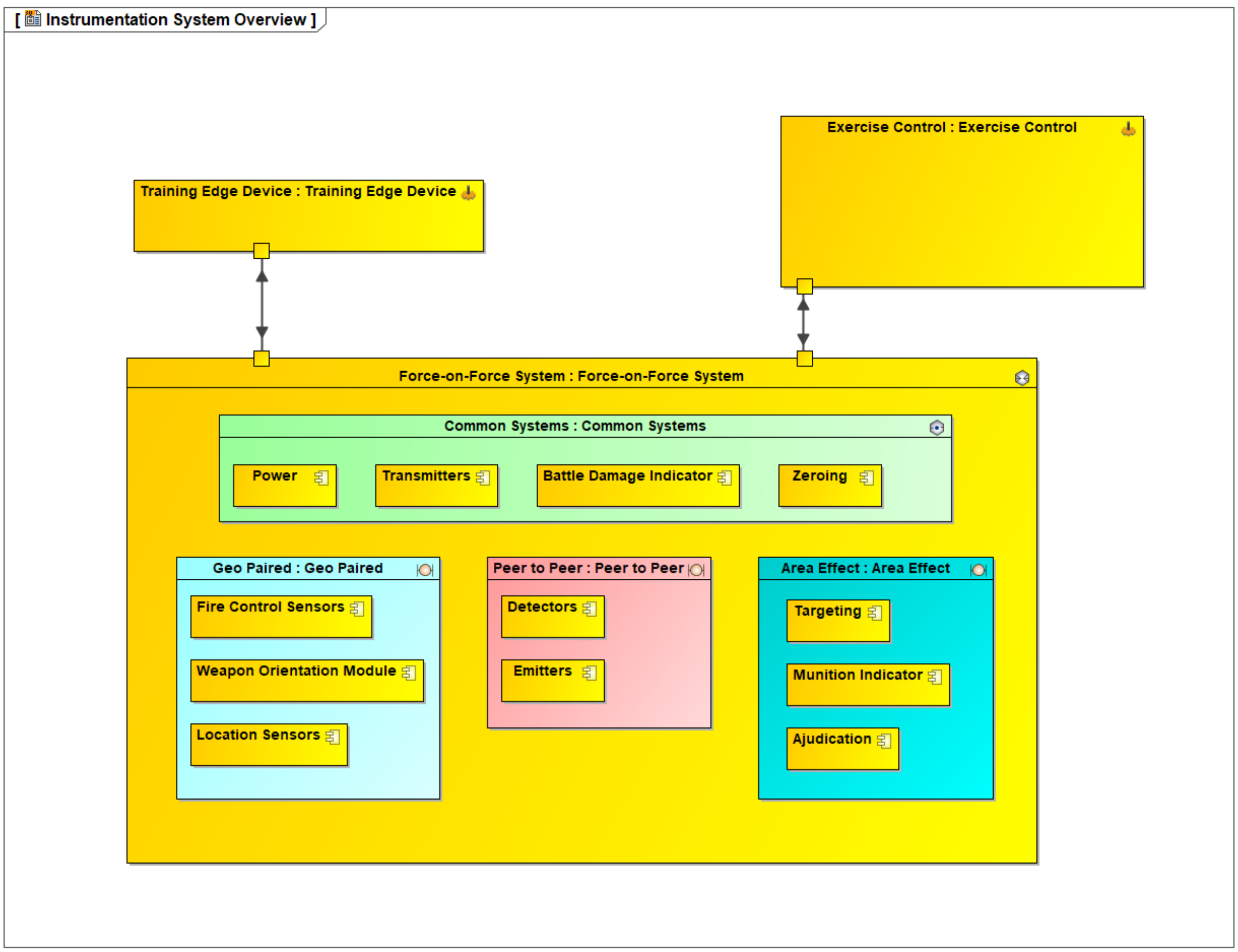

Figure 2. Instrumentation System with Expanded Force-on-Force System

Figure 2 shows three key components of the Instrumentation System. The Training Edge Device (TED) provides digital communication between individual participants and the overall Instrumentation System. Individual TEDs communicate to supply updates for the people, vehicles, or other equipment using the TED. The Exercise Control System (EXCON) is responsible for maintaining the current state of the exercise and its participants. It is the authoritative source for models regarding terrain, fly-out models, and battle damage assessment data. The legacy Force-on-Force system consists of MILES equipment that is mounted on to weapons and vehicles to simulate weapon fire. Future prototypes are looking at pairing weapon fire and targets based on geographic location rather than laser emitters and detectors. The prototypes discussed in this paper simulate area of effect weapons where the range of soldiers from an impact point can be detected. The components to support this type of simulation are on the right side of Figure 2.

Versions of the TED interface with legacy MILES and may replace some components in the Individual Weapon System (IWS). The mortars, grenades, and Claymores discussed in this paper can affect targets with legacy equipment. Processing within the Instrumentation System is used to adjudicate weapons effects and provide situational awareness for exercise control. Upgraded or advanced versions of the TED and may offer additional features to participants especially regarding electronic casualty reporting. Information from the TED is also used to support AARs and provide feedback to the training unit.

INTEGRATION ACTIVITIES

Putting these devices into use requires three different integration activities. The first activity is the development of scenarios and exercises which make use of the devices. In a training exercise this is part of the planning of the exercise. For integration purposes several basic scenarios were developed for each prototype. The second activity is development, evaluation, testing and procurement of the physical devices. While initial development occurred with the STAAR team, further refinement of the devices is done for integration. The third activity is the integration with the Instrumentation System and potentially with other devices in use during the training exercise. While these may appear to be sequential steps, in reality, the tasks occur in parallel and in an iterative fashion. The Synthetic Training Environment – Live Training Systems (STE-LTS) team at PEO STRI is coordinating these activities.

Scenario Integration

Simply having the equipment and knowing how to use it does not result in training. Force on force training is carefully planned far in advance of the training exercises. Initial planning for large scale exercises at the combat training centers often starts a year in advance. More detailed planning occurs as the event draws closer (Stikkers & Kent, 2014). Prior to determining the specific quantities of individuals and equipment, the goals of the exercise are set. Scenarios are developed to enable the rotational unit to meet the exercise goals. As additional engagement types are included in the training equipment, they can take on a role in that scenario development.

STE-LTS works with Joint Readiness Training Center (JRTC) operations group to determine scenarios that represent the way these new devices are likely to be employed during a training rotation. It is important to test these devices in the conditions in which they will be used. It is also important to develop procedures for getting training rotations to make use of these new devices. While it seems like units would be eager to employ new capabilities and try new activities, it is also true that the units need realistic expectations on when to use these devices. The use of these devices should also promote more realistic defensive training, so our soldiers have a better sense of how to defend against these weapon types. This means the opposing force (OPFOR) at JRTC should have lots of ways to deploy these devices.

Scenarios may be defined to encourage the use of mortars. Alternatively, there may be additional points where the tactical advantage from Claymore mines is part of the scenario because it supports the overall exercise goals. The development of scenarios to take on new engagement types and allow units opportunities to employ these devices during training is key to gaining more use during combat operations. Prototype testing and integration testing suggest ways in which the new engagement types will be incorporated in overall exercise scenarios. Previously, simulated engagements of this type may have been pushed from an exercise control while they can now be executed by soldiers in the field.

Using the devices in training is essential, but it is also imperative that their use is documented for inclusion in AARs. The developed scenarios used in the exercise tie to the planning for the AARs. Discussion at the AAR will include how well the training unit meets the exercise goals and how well they perform during the scenario. Use of specific engagement types is included, and the results are included in the overall situational awareness picture provided by EXCON. This situational awareness allows for immediate feedback from observer/controllers and later feedback during an AAR.

Device Integration

Many different prototypes have been evaluated by the STAAR team. Most of these articles continue to be refined as technology improves and soldiers provide feedback to the developers. Some of these have reached a level of maturity where integration with a larger exercise is possible. This paper focuses on the integration activities associated with 81mm mortars, 60mm mortars, hand grenades, and Claymore mines. These articles are shown in Figure 4 along with one other prototype that is not being integrated currently. These devices were selected based on both the maturity of the prototypes and the need to fill the gap in training capabilities. The gap in training devices in this area is evident to individual soldiers. It does not require a training professional to realize that you are more likely to use equipment in combat if you had more opportunity to practice with them. Having realistic effects and the opportunity to do Force on Force practice with mortars and grenades improves the readiness and lethality of our forces. During initial prototype testing one mortar team was so excited about the possibilities to improve training they wrote their own feedback paper. Soldier engagement with these prototypes generated discussion and enthusiasm for getting them into force-on-force training. Although integration is proceeding the design specifications for the delivery, details are still being refined. There is desire to continue to improve the prototypes as technology changes and as user feedback is delivered.

Figure 3. Prototype Devices for Initial Capability Integration

Technical specifications

After initial integration testing the STE-LTS team began generating detailed specifications for the production devices. To create these particulars, the team started from the specifications of the weapon system being simulated. In addition to having effects that match the tactical weapon (U.S. Army Futures Command, 2021), the devices need to conform to existing equipment size and form. It is important that devices such as grenades, fit in the standard grenade pouch. This emphasized muscle memory for reaching and pulling developing a conditioned response that requires little attention to perform correctly. The devices also need to have comparable hit radius as compared to the actual munition. To these specifications there are additions to mitigate safety concerns. There is foam padding around all parts of the thrown grenade to reduce the risk of injury during training. There are considerations for battery life, for lights to aid in retrieving devices after an exercise, and for durability. Ultimately, these specifications and the training requirements will be validated through the prototypes and then incorporated into an acquisition program.

Training Edge Device Integration

Simulated battles are useful in training. Simulation equipment that supports the results of those engagements improves the quality of that training. The simulators should trigger some type of effect on the participants who are hit so they can react and so they have a realistic expectation of the weapons they may face in the future. Each engagement device must generate an appropriate response from the equipment the soldiers are wearing. For the mortars, the soldiers within the area of effect receive a kill tone. For the grenades and Claymores, the participants had a receiver unit connected to their MILES vest. The receiver unit would determine the distance from the mine or grenade and send a message indicating a wound, kill, or near miss.

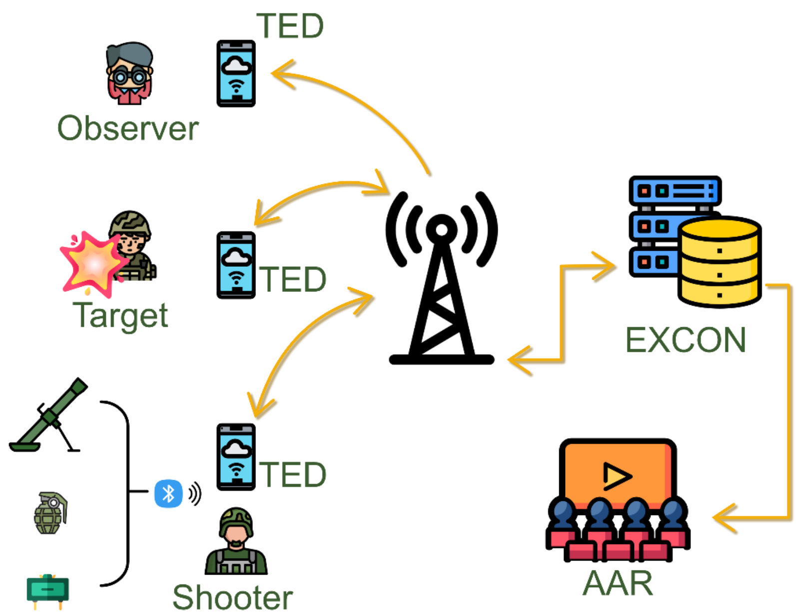

Figure 4. Integration of Prototype Devices across the Training Network

Battle Damage Assessment (BDA) can be calculated locally by the target, or it can be determined based on centralized fly-out modeling. There are advantages and disadvantages to each approach. Centralized adjudication facilitates the inclusion of area effect weapon systems. It allows for rapid calculation of effects across a large number of participants. It can provide rapid processing for many different fly-out models. However, centralized BDA may not be aware of the specifics of individual participants. There is also a challenge in distributing the damage information to the participants.
Alternatively, when damage is decentralized, each participant needs to calculate the fly-out and impact. That runs a risk of a different results between participants and the computing resources necessary to run the models must reside with each participant. The advantage is that the participants know their positions and BDA may be determined based on that status.

Network Integration

The Instrumentation System orchestrates the activities and results of many engagement simulators across a large exercise range via an array of networking devices. Existing Instrumentation System software is built on microservices. Network integration includes extending those services to provide support for network traffic and messages from the new training devices. Figure 5 provides an example of network messaging to support indirect fire. Some of these messages are simple voice communication which require no changes. Others will involve expanding existing Live Training standards to include new message types. In addition to the message standards, the communication protocols in use vary based on the equipment involved. Integration testing ensures the protocols are available to support the message traffic from planned scenarios. For example, mortars can make use of existing software governing area affect weapons to adjudicate the mortar engagement based on known locations of individuals within the exercise. To support this use case, the STE-LTS team developed and tested new messages supporting the sending of targeting information and associated parameters of the mortar ammunition. The type of network traffic that is generated by a mortar round with a forward observer is shown in Figure 5 below. It is not necessary to follow the details of the message traffic in this diagram, but to recognize that each new message must adhere to the protocols already in use on the network and must be tested.

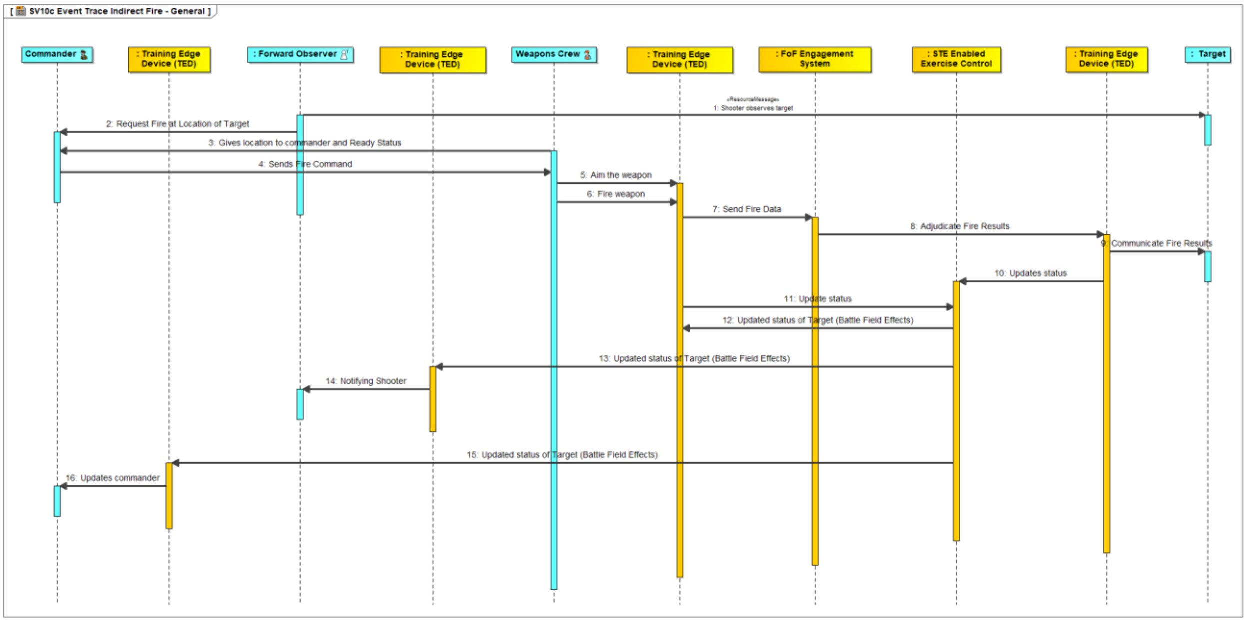

Figure 5. Network Messaging to Support Indirect Fire with Forward Observer

Similarly, additional messaging is created for communication from the grenades and Claymores. The desired characteristics from U.S. Futures Command (2021) include transmitting engagement results, casualty data, and damage assessments in near real time. This data is used to react during the exercise and to create AARs. While part of the value of Live training is gained during the exercise, much is gained by reviewing what occurred and determining alternative courses of action. Accurate data capture to inform the AARs is critical for the tactical engagement simulators. The AARs are based in part on the displays from the EXCON so the simulators and their activity must be displayed in a manner consistent with soldier expectations.

Exercise Control System Integration

Exercise Control, both the human operators and the EXCON software, is responsible for maintaining situational awareness across the live training event throughout its duration. With legacy MILES gear, the status of participants is relayed back to the EXCON based on the results of laser-based engagement simulators. This is sometimes augmented with simulated area effect weapons being run by Exercise Control operators with the results sent to the participants. The same area effect software was used for the mortar engagement simulator results. EXCON then distributed messages back to the participants indicating their status after the impact of the simulated mortar. Given the improvements in the TED, participants can receive a variety of status update including a near miss. As the devices are further integrated there is room for additional fidelity in the damage effects. For example, future versions of the Instrumentation System may send a message with the proximity of the mortar impact and allow the individual player to determine overall damage based on protective gear, amount of cover, and position of the individual. The player unit kit can compute the results rather than having all of the computation handled at the EXCON.

Grenades and Claymore mines function similarly to the laser devices in that adjudication takes place on the TED and the change in participant status is then sent to the Exercise Control. Message details needed to be developed for these two simulators indicating what weapon triggered the change in participant status. It is important that Exercise Control operators and the field participants know when someone was ‘injured’ or ‘killed’ by a grenade or mine as opposed to direct fire. This can be a training point that is brought up by observers during an exercise or during the AAR.

At the time of the initial integration testing, there was no process in place to associate the grenade and Claymore devices with individual participants. In practice grenades and Claymores may be thrown or triggered by individuals other than those who carried them. However, the analysists who provide training feedback felt it was important to associate the devices to help determine if they were used by the opposing force or if individuals were affected by “friendly fire” from their unit. The grenades and Claymores do not have a GPS so their position at detonation is not easily captured. However, the effects when they are detonated are apparent based on the players affected. Determining a likely location for the simulation device based on the effects produced is part of EXCON integration. This is useful in retrieving the devices after the exercise as well as for AAR commentary.

INTEGRATION TESTING

At the time of this paper submission, the STE-LTS team has completed two integration tests, one for mortars and a second for mines and grenades. This section briefly describes each test and the activities that occurred during the test. The section ends with a summary of the test results.

Mortar Integration Test

The mortar test includes basic firing scenarios for both 60mm and 81mm mortars. Most of the targets consist of dismounted infantry, but one vehicle target is included. In addition to instrumented live targets, the mortar scenarios include firing on virtual entities based on grid coordinates. The dismounted infantry are outfitted with three variations of instrumentation kits: legacy MILES Individual Weapon System (IWS) vests with a legacy connection to the Instrumentation System, legacy MILES IWS vests connected to a newly developed TED, and a Tactical Vest Modular lightweight Load-carrying Equipment (MOLLE) Plate Carrier with prototype detectors and a different TED configuration. The TED kits can subscribe to receive detonation messages and play audio messages regarding the distance from the detonation. Adjudication for all kits is performed by the Area Weapon Effect Service (AWES) of the instrumentation system. Normally, for area effect weapons there is a randomizer which means not all hits are lethal. During testing this was set to all hits being lethal so the area of effect of the mortar could be measured with certainty. Kill messages are then distributed to the soldier kits to notify the soldier based on the capabilities of the kit. Use of the kit by soldiers during the integration test is shown in Figure 6.

Figure 6. Soldiers Using Simulated Mortar During Integration Testing

With the prototype devices, soldiers can successfully engage live instrumented targets. There are successful test results from soldiers using both 60mm and 81mm rounds using all fuse settings, charge levels, and both instrumented and un-instrumented rounds. In this test, un-instrumented rounds are used with an instrumented cannon to convey data into the Instrumentation System. In addition to dismounted infantry, the 81mm shots can obtain a kill on instrumented vehicle targets. Simulated AWES engagements against the live mortars result in the mortar personnel and the equipment being killed or disabled. When the mortars are in a killed state, they are no longer able to fire rounds. Virtual entities can be added as targets for the live mortars by providing the Fire Direction Center (FDC) with known 10-digit grid coordinates. The FDC then calculates the firing solution and issues fire for effect missions with corrections to place the rounds on target.

Grenade and Claymore Integration Test

Grenade and Claymore testing provides for two variations of dismount kits: legacy MILES IWS vests with a legacy connection to the Instrumentation System and a physical connector to the grenade receiver unit and legacy vests connected to a newly developed TED with a Bluetooth Low Energy (BLE) connection to the grenade receiver unit. The grenade receiver unit also supports the Claymore detonation. Tests are conducted in both indoor and outdoor environments. The urban environment allows testing of the grenade above or below the target as well as testing the effects of different types of cover. Foliage tests for both the Claymores and the grenades provide opportunity to test the effects of different terrain features.

Figure 7. OPFOR Soldiers Testing Hand Grenade Simulators

Prototype grenades at weights of 7.2 oz, 8 oz, and 9.1 oz are tested to gain soldier input as to the best weight. Figure 7 shows JRTC soldiers throwing these grenades at 20m and 30m targets. Soldier feedback indicates a preference for the 9 oz grenade variant.

The test plan allows soldiers opportunities to explore scenarios using the grenades and Claymores after using them in structured tests. Initial free play scenarios include clearing a room and having one soldier shield a grenade with his body to protect others in a room. Later, the soldiers planned and executed an ambush scenario where they used both Claymore and Grenades capabilities in a single scenario. This scenario was executed multiple times with slight variations of Claymore placement.

Overall, the device performance met expectations during the integration tests. There are some anomalies, mostly associated with pairing the TEDs. Some incidents of a grenades detonated without the pin being pulled are noted. Both soldiers and training analysts provide feedback on these devices and the way the devices are integrated with the Instrumentation System. Log files collection and analysis is used to verify system messages and timing. Many of the analyst suggestions involve creating additional system messages to provide better situational awareness during AAR sessions. There is also a desire for more location tracking so that retrieval of the devices from the training area can be facilitated by the Instrumentation System.

Integration Test Results

Both tests were successful in that mortars registered hits on targets down range, grenades registered hits on targets in range and kills on those in close range, Claymores registered hits based on the proximity of the target and the cover between the target and the detonation. Hits from the devices showed up in the EXCON. As a result of the two integration tests, there is a list of approximately fifty changes relating to the three prototypes. For Force-on-Force training, both the grenade and claymore need to provide louder sound. Claymore backsplash needs improvement. The soldier detonating the claymore was killed in multiple events when they should have been out of range. Additional requests at initial integration testing were to be able to filter for the effects of grenades or Claymores as part of the existing filtering interface. Others relate clearly to integration activities though not necessarily to technical changes. In the preparation phase of an exercise, the grenades and Claymores will be assigned to an owner based on the battle roster. This will help with tracking soldiers affected by “friendly fire” from grenades and Claymores.

There are plans for a series of validation exercises prior to a final operational assessment. The findings from the initial validation results were prioritized so the essential for meaningful use of the prototypes could be implemented prior to the validation exercises. Others, such as those related to support for the retrieval of the grenades, will be completed closer to the operational assessment. Due to resource constraints and the ongoing changes to the live training systems not all requested changes will be implemented in the initial fielding.

INTEGRATION RESULTS

Figure 8 shows how training equipment, shown in orange, interacts with participants and other devices to support an exercise. The new engagement types are added by developing sensors and transmitters that allow weapons to interact in the training environment. Once they are fully integrated into this model, the new tactical engagement simulators use the TED to update other participants based on the actions done with the simulator.

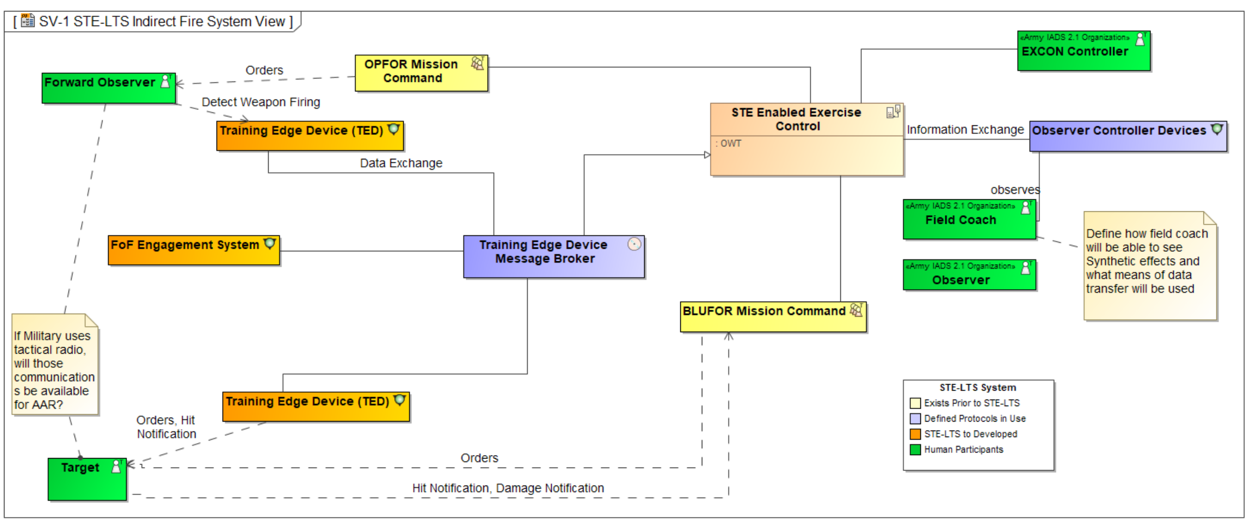

Figure 8. Training Devices and Participants during Force-on-Force Exercise

The results of integration are a training environment that more closely mirrors combat capabilities, an AAR capability that allows meaningful discussion on the use and effectiveness of mortars, grenades, and Claymores, an increase in the use of these weapons systems during training exercises and an overall increase in readiness to use them in combat. Practice with these weapons individually provides the base skill for soldiers to use them when needed. Including them in a more complex live training scenario starts to build knowledge of occasions when they are the most appropriate choice of engagement. Increasing the occasions when these weapons are engaged during training provides a practical means to build confidence and skills through repetition with dynamic results based on changing conditions. The critical nature of integration activities should not be overlooked. Great technology and excellent equipment can go unused unless proper care is taken to make them part of existing activities.

CONCLUSION

This paper describes the activities to integrate a technically viable prototype into the existing U.S. Army Live Training Environment. It describes the planning and preparation needed to create scenarios and then test the prototype devices. The technical details involved with connecting a new device to existing networks and having them appear on legacy systems are discussed. The results of initial integration testing are presented and the next steps to move mortar, grenade and Claymore mine simulators into the exercise environment are presented. Finally, the overall goal of the resulting integration effort is shown via the planned modular architecture. The intent is to enlighten the training audience and set expectations for this and future capability delivery.

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