Maximizing Engagement Area Lethality

A Tale of Two Doctrines

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The cold winds of the winter of 1944 blow across the front line. As the squad leader kneels next to his machine-gun team going over the engagement area plan, he hears an all-too-familiar sound that sets him on edge. Two soldiers who fled their observation post across the field stretched out in front of them confirm his fears: "Tanks!" they shout. Suddenly, a pair of Sonderkraftfahrzeug 251 *half-track armored personnel carriers burst through the opposing tree line, flanked by two Panzer IV tanks. Riflemen and machine gunners along the line watch in terror as the .30 carbine ball rounds from their M1 rifles ping helplessly off the armor while the company commander calls for the bazooka men. These brave men risk their lives running forward, or at angles, in a desperate attempt to hit the Panzer IVs' flank or a flat part of the half-tracks.*

This well-recognized scene, often portrayed in pop culture, permeates the thoughts and feelings of many soldiers, sailors, airmen, and marines, especially those without heavy weaponry, as they consider defending against a mechanized or armored onslaught from a modern peer or near-peer adversary. However, if adequately equipped with the knowledge of modern munition terminal ballistics that showcase how small arms can have a big impact on modern armor, today's squad leader does not need to suffer the same level of fear.

Although engagement-area development doctrine provides a solid foundation at all echelons of planning, the inclusion of joint weaponeering (the process of matching munitions with targets to achieve specific effects) can maximize engagement area lethality to unprecedented levels by enabling leaders to better understand modern munitions' terminal ballistics when planning. Modern small-arms munitions' ability to penetrate more than 12 mm of rolled homogeneous armor and simultaneously maximize terminal ballistic damage on soft targets opens an array of possibilities on the battlefield. Regardless, training centers have highlighted the necessity to refocus on engagement area development, especially fighting at appropriate doctrinal ratios, as an essential effort for all training levels across the joint force.[1] An important component of this effort is understanding how weapons perform inside engagement areas. Leadership across the joint force understands the need to better grasp modern weapon systems' effects. This requirement indirectly includes using some forms of modeling used in weaponeering. For example, one general officer has experimented with using the surface danger zones calculated via weaponeering models for Department of Army Pamphlet 385-63, *Range Safety*, to maximize the overlap of higher probability of hit zones of various weapons in fires planning.[2]

Additionally, some papers have addressed distribution modeling of direct fire against an infantry formation to better understand the probability of hit.[3] These efforts are innovative and can serve to improve the capability of military formations in close contact. However, these

A German *Sonderkraftfahrzeug* 251 half-track armored personnel carrier January 1940 in Berlin. (Photo courtesy of the German Federal Archive via Wikimedia Commons)

efforts do not provide a doctrinal approach to understanding weaponeering's potential impact at the combat formation level. The joint force can gain advantages by evaluating the existing engagement-area development doctrine, developing a sense for the application of weaponeering doctrine, and applying the advantages of integrating the two doctrines. However, the first step to understanding this potential merger is to examine how direct fire and indirect weapons, and their associated munitions, have evolved since the Second World War.

Not Your Grandparents' Munitions

Today's small arms carried by the U.S. military have much in common with those in World War II. Notably, the Department of Defense has made significant efforts to reduce the weight carried by combatants across the branches by using lightweight materials and better engineering. Many of the weapon systems' actions and general performance characteristics remain similar, albeit with mild improvements over time. Reference table 1 (on page 23) to see an indication of this slow adaptation.[4]

Larger weapon systems have evolved dramatically since World War II. These changes include some critical breakthroughs with joint artillery systems in recent years. Notably, the Army's showcasing of strategic long-range cannons and precision strike missile systems demonstrates incredible breakthroughs to enable effective dynamic force employment.[5] Furthermore, the recent use of 155 mm artillery systems to intercept and destroy a cruise missile points to the continuing evolution of joint artillery, munitions, and cueing systems integration required by the joint all-domain command and control construct.[6] Although, as demonstrated by table 1, small arms have not seen as dramatic a change in weapon performance, each weapon's associated munition's terminal ballistic performance has changed significantly over the years. For example, the 1926 .30 caliber M1 munition featured a "boat tail" lead design that could penetrate the estimated equivalent of 4 mm of rolled homogeneous armor (RHA) at 91 meters.[7]

The end of World War II and progression through the Cold War would see dramatic changes in munitions with the adoption of U.S.-led NATO munition standards. Chief among these were the M80 7.62 mm and M193 5.56 mm NATO rounds.[8] The smaller and lighter

Table 1. Limited Weapon Performance Change over Time

World War II				
Weapon	*Effective Range*	*Rate of Fire*	*Muzzle Velocity*	*Weight*
M-1 Garand	457 m	40–50 rpm (rapid sustained)	2,800 ft/s	9.5 lb
M1918 "BAR"	460 m	500–650 rpm	2,822 ft/s	19.4 lb
M1919 Browning	1,280 m	600 rpm	2,800 ft/s	31 lb
Modern Day				
Weapon	*Effective Range*	*Rate of Fire*	*Muzzle Velocity*	*Weight*
M-4 Carbine	500 m	45 rpm (rapid sustained)	2,970 ft/s	6.3 lb
M-249	600 m	750–850 rpm	3,000 ft/s	17 lb
M-240B	800 m	650–950 rpm	2,800 ft/s	27.6 lb

(Note: Performance characteristics vary by model, variant, and manufacturing year; table by author, data derived from multiple sources [see note 4])

M193's lead-antimony alloy core could only achieve a 50 percent probability of penetration against an estimated 4 mm RHA equivalent at 37 meters (This is hereafter expressed as Range Probability [either 50 percent or 90 percent] of distance X: "R50 of 37 meters").[9]

Challenges in Vietnam led to the design of the more modern M855 5.56 mm lead and steel split-core round that increased soft tissue damage and armor penetration.[10] However, in Operations Enduring and Iraqi Freedom, feedback from the field led to the creation of the M80A1 and M855A1 enhanced performance rounds shortly after the creation of the M995 and M993 armor piercing (AP) rounds.[11] The inclusion of the M855A1 in the rifleman's inventory, for example, gave each shooter the ability to achieve an impressive R50 of 350 meters against an estimated 4 mm of RHA while increasing soft tissue damage performance.[12] Furthermore, the creation of the enhanced performance rounds and inclusion of the M993 and M995 AP rounds gave any soldier a myriad of capabilities, including the ability to achieve an R50 of 172 meters against 12 mm of RHA.[13] These new enhanced performance rounds, combined with the ballistic performance of modern AP ammunition, provide a significant capability against armored targets, as indicated in table 2.[14] Furthermore, the ongoing development of additional rounds to replace the M993/5 series, such as the XM1158 advanced AP round, will continue to enhance small-arms capabilities on the modern battlefield.[15]

Ultimately, the warfighter has underappreciated the advances in terminal ballistic performance by improved munition designs and their effects on peer and near-peer adversaries. Modern armored personnel carriers and armored vehicles often feature hull armor thicknesses between 7 mm and 18 mm, depending on applique armor.[16] A 1993 test demonstrated the .50 caliber API round's ability to repeatedly penetrate the hull of a BMP-2 infantry fighting vehicle at five hundred meters with a 68 percent probability of damage to the BMP's commander, highlighting the possibility of direct-fire munitions creating casualties to crew members and passengers.[17] The rapid development of terminal ballistic performance for rifles and light, medium, and heavy machine-gun munition performance is impressive. Still, it comes with a lack of doctrine to harness its advances in the execution of engagement areas. To intelligently cover this gap, warfighters should evaluate the state of engagement-area development doctrine and determine how to incorporate the joint weaponeering process.

Engagement Areas Revisited

An engagement area is defined as "an area where the commander intends to contain and destroy an enemy force with the massed effects of all available weapons and supporting systems."[18] Army Techniques Publication 3-21.10, *Infantry Rifle Company*, further stresses that "the success of any engagement area depends on how

Table 2. Comparison of Estimated RHA (eRHA) Performance

Munition	*eRHA Penetration*
.30 M1	R_{50} 4 mm* at 91 m
.30 M2 (AP)	R_{50} 11 mm* at 30 m
M855A1	R_{50} 4 mm at 350 m
M995	R_{50} 12 mm at 172 m
M993	R_{50} 18.9 mm at 100 m

(Note: Typical RHA hardness values vary slightly since 1945; table by author)

Left: A shell casing flies out with a trail of smoke as U.S. Army Pfc. Michael Freise, 1st Battalion, 72nd Armor Regiment, fires an M-4 rifle during reflexive fire training 23 March 2005 at the Rodriguez Live Fire Complex, Republic of Korea. (Photo by Staff Sgt. Suzanne Day, U.S. Air Force, courtesy the National Archives)

Right: Marine infantrymen fire M1 Garand rifles at a simulated enemy position March 1952 as they advance with tanks during training behind the lines in Korea. (Photo courtesy of Wikimedia Commons)

effectively the commander integrates the direct fire plans, indirect fire plan, the obstacle plan, [and various fires and supporting plans] … and the terrain within the engagement area to achieve the tactical purpose."[19] The doctrinally tested steps of engagement area development lay out a detailed series of considerations for planning to ensure that enemy tactics, enemy formations, the operational environment, available forces, and control measures receive close attention (see figure 1, page 25).[20] However, existing doctrine gives vague guidance to the alignment of weapon systems to targets to enable the leader to leverage modern munition ballistics intelligently.

The same techniques publication discusses the need for considering the maximum ranges and line of sight concerns, as well as positioning weapon systems to achieve "overwhelming effects."[21] Still, it does not assist a leader in understanding just how and what will achieve those effects. Doctrine discusses "engagement priority" to ensure leaders assign priorities based on the threat and the range from friendly forces and the requirement to "match organic weapon systems capabilities against enemy vulnerabilities."[22] Even so, the doctrine provides this guidance without explaining how to ensure a weapon or munition employed matches a target's vulnerabilities. Furthermore, during step 5 of engagement area development, doctrine directs the leader to select fighting positions to "achieve the desired effect for each target reference point."[23] This doctrinal guidance is again without specific reference to evaluating various weapon systems' capabilities in achieving the desired effect against a wide range of targets.

As ground combat units in the U.S. military refocus on the challenges of peer and near-peer competition worldwide, many have begun a renewed focus on engagement area development at training centers. The Army has undoubtedly led the way in many efforts to refocus on the threat of future peer and near-peer competition. Renewed focus on these adversaries is essential considering that dynamic force employment drives various units to reorganize or train to fight in smaller, more agile tactical teams.

The Army has also highlighted and proposed planning solutions for the observation that "light infantry formations typically struggle to conduct [engagement area development] suited for an armored/mechanized near-peer threat in a compressed timeline."[24] Furthermore, the Joint Multinational Readiness Center noted that important lessons learned for brigade-level deliberate defense included a need to study the terrain physically to better understand and react to enemy movement within engagement areas.[25] Leaders are relearning lessons about the importance of terrain and maneuver in fast-paced modern warfare. The issues noted through countless training

Engagement-Area Development

1. Identify likely enemy avenues of approach
2. Identify most likely enemy course of action
3. Determine where to kill the enemy
4. Position subordinate forces and weapon systems
5. Plan and integrate obstacles
6. Plan and integrate fires
7. Rehearse the execution of operations within the engagement area

(Figure by author; adapted from Army Techniques Publication 3-21.10, *Infantry Rifle Company* [May 2018])

Figure 1. Engagement-Area Development Steps

center rotations in all the branches show the complexities and challenges facing our unit leaders. Engagement area development doctrine is proven but still presents challenges, as noted by Kyle Frazer and others, in enabling success against all modern threats.[26] In the context of the rapid, impressive evolution of modern munition terminal ballistics, the existing doctrine does not provide a tool set for understanding how and where to harness modern munitions' incredible lethality. But that exact problem set is answered elsewhere.

Weaponeering as a Doctrine

Weaponeering is an older joint doctrine, originating in the Air Force and Army, defined as "the process of determining the quantity of a specific type of lethal or nonlethal means required to create a desired effect on a given target."[27] Perhaps a more specific definition is offered by former Naval Postgraduate School professor Morris R. Driels:

> In general terms, Weaponeering can be defined as the process of determining the quantity of a specific type of weapon required to achieve a defined level of target damage, considering target vulnerability, weapon effects, munitions delivery error, damage criteria, probability of kill, weapon reliability, and so forth.[28]

The process of weaponeering became firmly rooted after the Close Air Support Board of 1963 began noticing issues with data published on air-to-surface nonnuclear munitions.[29] The *Joint Munitions Effectiveness Manual* (*JMEM*) became the joint solution as a comprehensive repository of munitions capabilities in defeating various threats. The Army was tasked to lead the creation of the Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME) in fall of 1965 and focused on target vulnerability, chemical and biological weapons, and air-to-surface munitions.[30] The JTCG/ME would undergo multiple changes and revisions over the years, expanding to evaluate both the surface-to-surface and surface-to-air computations.

After the major reorganization of the JTCG/ME in 1994, the *JMEM* Weaponeering System (JWS) combined two role-specific computerized solutions and replaced the original *JMEM* hard copy of data and methodologies for calculating weaponeering solutions.[31] JWS enables users to access various models like the Monte Carlo simulation to statistically compute the probability to hit a target in a certain number of engagements or the Mott and Weibull distribution models to estimate the probability of fragment hits from warheads.[32] Users can even combine these complex statistical probability models to estimate the probability of hit and probability of incapacitation of enemy dismounted infantry at a specific range by a particular weapon system.[33] Figure 2 (on page 26) demonstrates the wide variety of variables for both fragmentary and nonfragmentary direct-fire munitions used to compute these probabilities inside of the JWS system.[34] The JTCG/ME has used the doctrine of weaponeering extensively for acquiring and testing a myriad of weapon systems for decades, but with a heavier emphasis on heavy-caliber arms than on small arms.

Significantly, these weaponeering solutions can help predict the probability of munitions creating specific damage conditions to a target (whether person or

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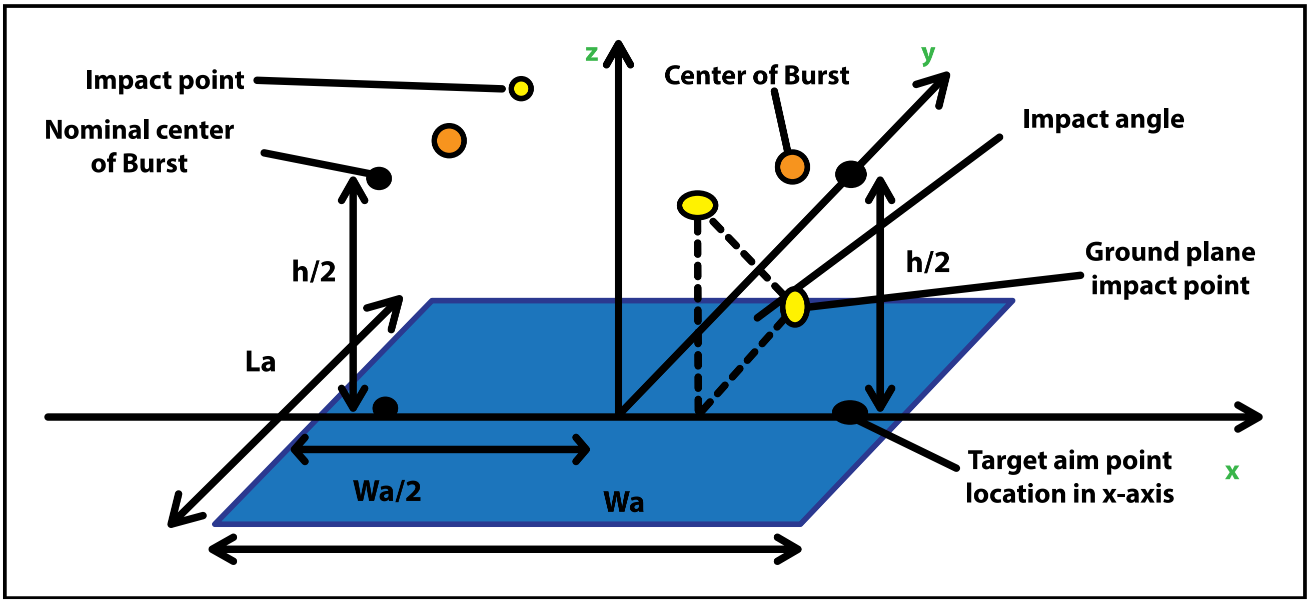


(Figure by author)

Figure 2. Direct Fire Weapons Distribution Calculations

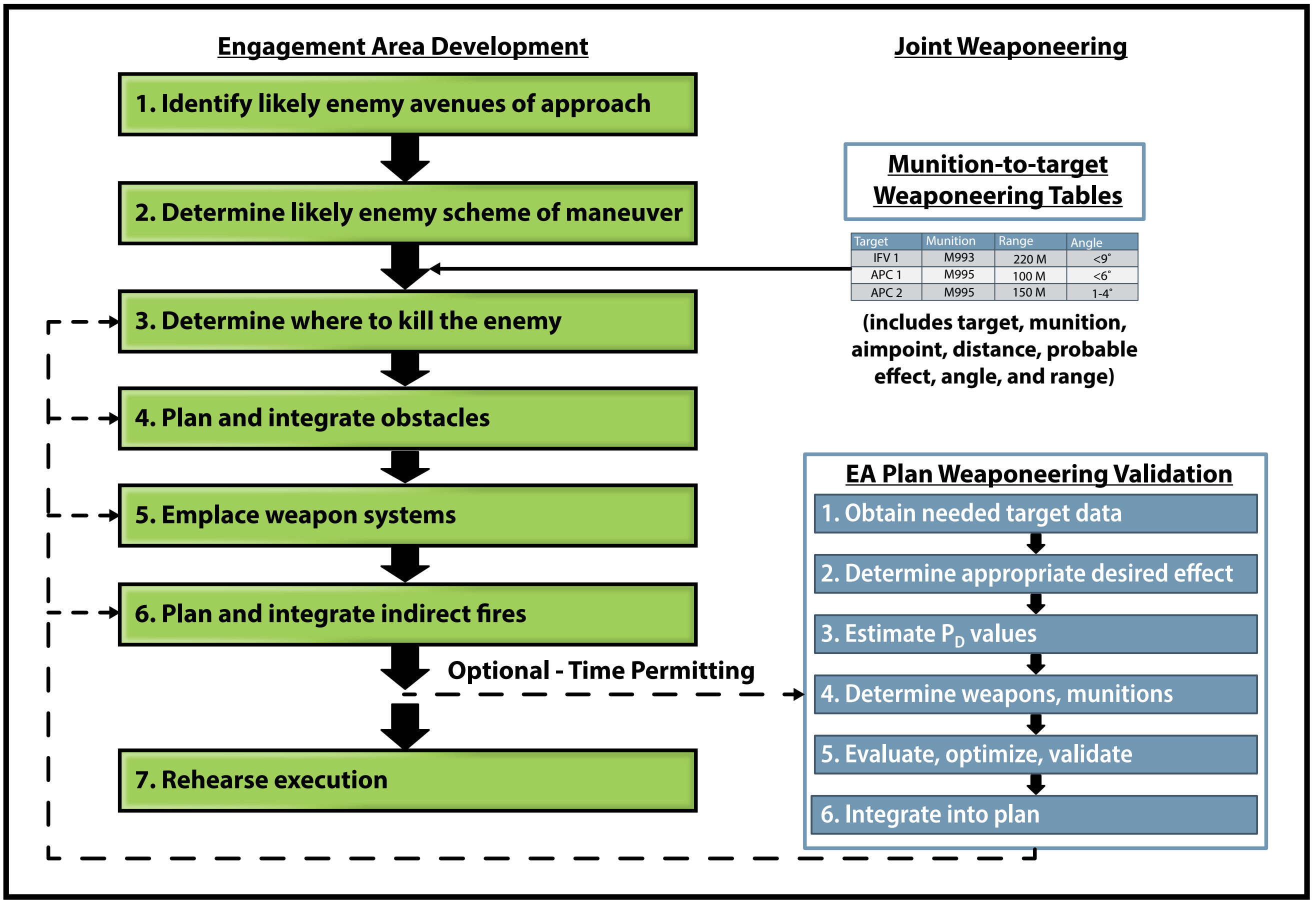
vehicle)—such as the ability to achieve a mobility kill, firepower kill, or a total catastrophic kill—by analyzing the expected outcome of postpenetration impacts. The analysis includes the estimated times or windows that these effects may be in place as vehicle crews or individual soldiers react to get back into the fight. Depending on the desired effects, the user can pair munitions with higher likelihoods to achieve these specific required effects. Notably, however, the U.S. Air Force has also incorporated weaponeering directly into its execution doctrine.

The Air Force process, codified into Joint Publication 3-60, *Joint Targeting*, and service-specific doctrine, harnesses the *JMEM*'s weaponeering steps to statistically analyze the probability of effects of specific weapons against specific targets to achieve the optimum weaponeering solution before the target is added to a master air attack plan.[35] This process allows the weaponeering team to consider the range of possible options to achieve the desired effects against a target while considering a wide range of variables across the weapon delivery platform, weapon trajectory, and terminal effects. The *JMEM* identifies six key steps in weaponeering:

1. Obtain [the] needed target data
2. Determine an appropriate desired effect
3. Determine desired probability of damage (PD)
4. Determine available aircraft, ordnance, and tactics to be evaluated
5. Evaluate, optimize, and validate weapons effectiveness
6. Prepare and present weaponeering recommendation (courses of actions, plans, or orders)[36]

This process takes time and traditionally occurs as part of the seventy-two-hour air tasking order cycle and joint air operations planning process. Nonetheless, this more prolonged process of exquisite weaponeering solutions, even featuring the use of JWS software, is complicated in the dynamics of close contact, as quipped by an M1A1 tank commander: "When I see a T-72 tank in my gun sight, I don't consult the JMEM."[37] This problem, however, is not unique to our nameless tank commander. Aircrews flying close air support missions, such as A-10 pilots, often fly their missions with a wide range of weapon systems generically based on the expected targets. Even so, they understand the general terminal ballistic performance parameters of each weapon system against likely targets so that they can make key weapon and tactics selections in the heat of the moment.[38]

These selections are not haphazard but instead are supported by detailed weaponeering solutions against likely targets that become training items. Pilots can use munition performance parameters to make informed and lethal targeting and tactics selections in the fight. A-10 pilots use a planning table based on predetermined



(Figure by author)

Figure 3. Merging the Two Doctrines

probability of damage, with a hierarchical order of best-paired weapon to each target.[39] This, through training, enables quick decisions on which munition should be used first on any target. Through training, this concept of preidentified ballistic parameters becomes a means with which to employ the capabilities of weaponeering in the execution of engagement area development.

Maximizing Engagement Area Lethality

The steps of weaponeering bear some obvious points of connection to engagement area development (see figure 3). Understandably, due to the fluid nature of maneuver in ground combat and the direct tie to the land domain, the warfighter can take the first two engagement-area development steps without immediate feedback from weaponeering. Upon evaluating the likely enemy schemes of maneuver, the weaponeering process and preidentified weaponeering tables can serve as an informative component to respond to and drive adjustments to all steps of the engagement-area development process. Available weapon systems and munitions for those systems can determine where to kill the enemy and how to integrate obstacles to turn and fix enemy forces. Likewise, evaluating munition effectiveness can drive munition changes or dictate how and where to emplace weapon systems in accordance with the enemy scheme of maneuver. An iterative process of using an understanding of munition performance from weaponeering can build a better-informed engagement area. If time allows during the preparation phase of a defense, the defensive operation leader can incorporate specific weaponeering calculations to validate the effectiveness of weapon system emplacement and allow continued optimization.

Nonetheless, this does not need to lengthen the engagement-area development process. As Frazer pointed out, time constraints against modern threats are a continuous challenge in engagement area development.[40]

When time is available, accurate lethality predictions are possible, as is maximizing terminal effects against target sets. If time is not available, known parameters must be premodeled to enable rapid weapons system integration for lethal effects, similar to the A-10 community weaponeering tables. In this case, a light infantry unit expecting an incoming mechanized force can confidently emplace direct-fire weapon systems and integrate indirect-fire planning with high probability modeling to pair munition to target, by range and aimpoint, in a prioritized manner. These parameters will enable practicing of employment ranges, angles, and aimpoints to maximize firepower and generate lethal effects within the engagement area.

Moreover, knowing that mechanized threats may be a potential in conflict requires reference to weaponeering data to determine if the traditional enhanced-performance rounds are suitable or if a request for M993 or M995 AP ammunition is warranted. Similarly, it can aid in the choice of white phosphorous, high explosive, or dual-purpose improved conventional munition (DPICM) by associated fire support units through a detailed understanding of the probability of effects on specific targets matching the desired effects (mobility kill or firepower kill, and duration) against a target. This understanding gives the commander the capability to deal with mechanized forces or modern infantry with ballistic-protective vests or plate carriers by maximizing the type and amount of fire and lethal employment of munition to target.

One benefit of joint weaponeering favored by airmen is the ability to ensure efficiency of munition delivery. Although munitions expenditure efficiency could be a byproduct of the inclusion of weaponeering into the existing engagement-area development doctrine, that would not be the primary reason for weaponeering's use. Obviously, aerial delivered munitions' incredible expense drives a concern of not wasting munitions for too little or too great an effect for the combined joint forces air component commander. Though, in the chaos of contact between land maneuver forces, firepower's psychological effects on the battlefield can be as critical as the terminal effect itself. Proper massing of direct and indirect fire has its own varying levels of impact on the enemy soldier by inducing confusion, stress, and reduced reaction based upon several variables.[41] Weaponeering's inclusion, as proposed here, is not intended to remove the need for various fire schema to achieve psychological effects in the engagement area, but instead to maximize the lethality of weapons and munition employment, as to magnify that very effect.

Conclusion and Recommendations

Engagement-area development doctrine is nearly timeless. The doctrine provides a sound series of steps to ensure a leader correctly analyzes the factors at hand to influence the enemy's maneuver and direct its own forces and weapons for a decisive engagement. However, this doctrine lacks the tool set to guide the leader into harnessing modern terminal ballistic effects to maximize engagement area lethality. Including a library of munition-to-target weaponeering that identifies the munition, distance, angle, and range combinations for various aimpoints to achieve mobility, firepower, or catastrophic kills against dismounted and vehicle targets significantly enhances the ability to rapidly create lethal engagement areas. When time allows in both the defense and offense, plans can harness real-time weaponeering to validate or adjust munitions planning to maximize the probability of achieving the desired target effect on the first attempt.

Overall, these changes can accelerate planning speed in the defense, gain soldier and leader confidence, increase soldier and team lethality and flexibility, and even better enable mission command tactics. Furthermore, by harnessing weaponeering as a planning and execution tool, those in the field can provide far more specific feedback to the JTCG/ME than previously offered before the creation of the enhanced performance round series. Shorter feedback loops can drive an even faster and more specific response to the field's needs in the terminal, midcourse, or boost ballistics of munitions or the supporting weapon systems.

As the joint force looks at major combat operations against peer and near-peer adversaries, these doctrinal changes will bring about a greater understanding of what can and cannot be done against various modern infantry, mechanized, and armored threats. Additionally, these changes can assist in formulating far more effective offensive and defensive schemes of maneuver. Furthermore, as the joint force continues to work through dynamic force employment challenges, this evolution in weaponeering will allow it to maximize the capabilities brought forward by smaller teams, like those involved in the Air Force's "Agile Combat Employment."[42] These teams struggle to pare down equipment and still be capable of self-defense, and doctrinal changes like the integration of weaponeering can ensure success and help validate developing tactics, techniques, and procedures. To realize these changes, the following items are recommended:

First, additional research and refinement of the doctrinal concept proposed herein is required to enable this shift. Ultimately, how leaders include weaponeering in engagement area development will change slightly or substantially with trial and error.

Second, JTCG/ME needs funding and requirements provided to enable live-fire testing, and/or modeling and simulation of specific peer and near-peer target sets against exiting munitions ranging from small arms to indirect fire platforms to develop these basic terminal performance parameters. This would enable a greater understanding of what munitions have the highest probability of achieving firepower, mobility, or catastrophic kills and what various munitions are likely to do in the areas they can perforate.

Third, graphic training aids (GTAs) or other items are required for the joint force's training and reference to harness this knowledge and begin to consider how to exploit these advantages tactically. These GTAs can be included in modern battlefield situational awareness systems like the Android and Windows Tactical Assault Kits for quick reference in the field or even included in future iterations of advanced technology. GTAs could span from inclusion in joint all-domain command and control systems to advanced optics for immediate reference by a weapon system operator.

Fourth, the various services' training centers and training and doctrine hubs would need to consider training programs, exercises, and evaluations to enable this data's use and validate changes in unit effectiveness.

Remember the helpless squad leader fighting German armor? These changes could dramatically alter the outlook of defense against a mechanized attack.

With the inclusion of weaponeering during the execution of modern-day engagement area development, our squad leader looks upon the battlefield with steely-eyed determination as the specialist next to him reports a mechanized formation approaching. The squad leader looks forward as the vehicles cross along the anticipated avenue of approach toward the trigger line. The M-240 gunners beside him take up aimpoints on the infantry fighting vehicles just above the front wheels, confident that their M993 munitions will give at least a five-minute mobility kill by slicing into the driver's abdomen.

The M-2 machine-gun position aims just above the center wheel well of the turreted armored personnel carrier, knowing her M903 saboted light armor penetrator round will sow confusion with a high probability of wounding the commander and gunner. The forward observer notes the supporting main battle tank is only a slight adjustment from the target reference point. He calls for a tight cluster of white phosphorus and DPICM rounds to damage the optics and electronic warfare defense system with molten metal to temporarily firepower-kill the tank, while DPICM impacts attrit the explosive reactive armor defenses. This should buy enough time for the well-concealed Carl Gustav recoilless rifle team to use their prioritized variety of munitions to defeat the target.

The fight is on. ■

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32. Ibid. 54–58.

33. Ibid., 587–90.

34. Yong Shern Neo, "Computation of Weapon System Effectiveness," 112. Figure 2 showcases the ability of a Monte Carlo statistical modeling program to calculate the probability of incapacitation of a target by a single hit. Using uniform aimpoints based on training data, statistical probability of hitting the target on the ground plane begins the calculation. If the aimpoint hits the target, it assesses then whether the target is incapacitated using a random number generator and the target's probability of incapacitation given a hit in that location by that specific munition within the terminal ballistics modeling. The Monte Carlo model then can be continued removing a target from the total number of targets and calculations ran to provide the average of the total number of iterations (shots) required to provide the desired probability of incapacitation. Any variable from shooter accuracy (based off unit range data for example) to the type of munition and weapon system, distance/angle/armor of targets can be modified to change the expected outcome.

35. Air Force Doctrine Publication 3-60, T*argeting* (Maxwell Air Force Base, AL: LeMay Center for Doctrine, 2019), 69.

36. Joint Technical Coordinating Group for Munitions Effectiveness Program Office (JTCG/ME PO), *Joint Munitions Effectiveness Manual Weaponeering Guide* (Aberdeen Proving Ground MD: JTCG/ME PO, 2018), 2-11–2-16.

37. Driels, *Weaponeering*, 585.

38. Joey Morrin, interview by author, 15 April 2021, Maxwell Air Force Base, AL, regarding A-10 operations and weaponeering.

39. Ibid.

40. Frazer, "Engagement Area Development," 24.

41. Robert H. Scales Jr., "Firepower: The Psychological Dimension," *Army* (July 1989): 43–50.

42. Scott D. Adamson and Shane "Axl" Praiswater, "With Air Bases at Risk, Agile Combat Employment Must Mature," Defense News, 12 November 2020, accessed 14 July 2021, https://www.defensenews.com/opinion/commentary/2020/11/12/air-bases-are-at-risk-without-the-agile-combat-employment-approach/. Agile combat employment is "an operational concept that leverages networks of well-established and austere air bases, multi-capable airmen, pre-positioned equipment, and airlift to rapidly deploy, disperse and maneuver combat capability throughout a theater."