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November – December 2016

Fires

The Army's Branches

The Evolving Duo

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Fires, November-December 2016

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Purpose

Originally founded as the Field Artillery Journal, Fires serves as a forum for the discussions of all Fires professionals, Active, Reserves and National Guard; disseminates professional knowledge about progress, development and best use in campaigns; cultivates a common understanding of the power, limitations and application of joint Fires, both lethal and nonlethal; fosters joint Fires interdependency among the armed services; and promotes the understanding of and interoperability between the branches, all of which contribute to the good of the Army, joint and combined forces and our nation.

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Your Knowledge Management Team would like to introduce you to the Lessons Learned link on FKN. (Left side sliding banner on FKN)

The mission of Lessons Learned is to collect, analyze, disseminate, archive and provide for the implementation of Fires, Air Defense and Field Artillery combat relevant lessons learned and best practices which impact Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF). Recommend and effect changes to Fires, Air Defense and Field Artillery operations and reverse negative trends using best practices and DOTMLPF solutions. Using your Common Access Card (CAC) enabled device, visit https://www.us.army.mil/suite/page/130700 and click on Lessons Learned.

"One Learns, Everyone Knows"

Organizational domain

The key to future air defense artillery structure

Brig. Gen. Randy McIntire
U.S. Army Air Defense Artillery School commandant

The challenge of protecting America and her allies from potential air breathing and ballistic missile threats is an Army problem which the air defense artillery must take a definitive action in shaping and solving. It is incumbent upon us, as our nation's premier air defenders, to step up to this challenge and remain the most dominant and lethal air defense force in the world. We continue to enhance our capabilities with technological upgrades such as the Radar Digital Processor; develop deadlier interceptors like the Missile Segment Enhancement missile; while linking our capabilities together with the Integrated Air and Missile Defense Battle Command System (IBCS).

As we look toward the future, one of the most critical components to success – is becoming a balanced well-constructed force. We will ground ourselves in developing an air and missile defense (AMD) force that embodies the air defense principles: mass, mix, mobility and integration. These time-honored principles provide the foundation for the employment doctrine and building future fighting formations.

Arthur Helps, the brilliant British educator, once said, "In a balanced organization, working toward a common objective, there is success."

This simple quote is the embodiment of how the air defense artillery force must manage the organization "O" domain of the Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel and Facilities as we move forward. How we configure future battalion and brigade organizations will have a direct impact on the prompt conduct of combat operations by ADA forces, as well as manning, equipping and training that force. At the 2016 Association of the United States Army Annual Meeting, the 39th Chief of Staff of the Army, Mark A. Milley, stated the "Character of war is changing." As such, we must move beyond the "sectored and static defense mindset" and contemplate a well thought out organization that is capable and flexible enough to execute an array of complex missions into the 21st century.

The organization domain within the Army Operating Concept directs that our forces be prepared for a broad range of contingencies and must be flexible, tailorable, scalable and adaptable. As discussed during the 2016 Fires Conference, we are looking at future modified tables of organization and equipment (MTOE) courses of action to meet this end. For example, reducing the headquarters battery force protection ability while consolidating a larger force protection capability within the battalion; reorganizing the battalion S3 section and fire direction center into an engagement operations center in order to execute the full array of IBCS functions; and growing the signal platoon from three communication relay groups to 12 integrated fire control network relays. Additionally, the reorganization the Patriot battery's fire control platoon and system support elements into engagement operations and sensor sections; reorganization of three sections of two launchers each to two sections of three launchers; and reducing the number of tactical wheeled vehicles per battalion to 11.

We are on the verge of bringing "game changing" capabilities to the AMD force and as we field new equipment, we must look through different lenses to achieve our full potential:

1. Enhancing our ability to better defend our critical assets with a layered and 360-degree approach.
2. The ability of potentially covering more battle space with our network of sensors and shooters.

We must look beyond the old ideas of "places and faces," and ask ourselves the difficult questions. How do we shape the formations to take advantage of the capabilities IBCS brings to the fight; where do we need the right mix of skillsets to achieve the best results; and at what point do we need to provide the right mix to support the maneuver commanders' fight? There is a point in the future, as we field IBCS, where the current personnel system of based military occupational specialties (MOS) will no longer be functionally applicable to the AMD force. Currently, our ADA MOSs are centered on weapon systems. Functionally aligning the MOSs streamlines and improves Soldier skillsets, tasks and provides for a greater common experience across Army Integrated Air and Missile Defense (AIAMD) functions, instead of on the weapon systems.

Our new functional MOSs will represent multiple ADA systems that have like components, which perform common functions similar to command and control, radar and launcher. AIAMD presents an opportunity to overhaul the MOS while providing a

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Col. Stephen Maranian
U.S. Army Field Artillery School commandant

The United States Field Artillery Vision

As we continue to operate within a dynamic world, change is occurring in both the operating and generating field artillery forces at a rapid pace. In order to guarantee we maintain an advantage, we must ensure we are thoughtful and make wise decisions as we strive to achieve the right balance of manpower, materiel and readiness.

We have a vision

In order to appropriately shape and develop the field artillery now and for the future, we have published a vision that addresses this challenge.

"Be the world's premier field artillery force; modernized, organized, trained and ready to integrate and employ Army, joint and multinational Fires, across multiple domains, enabling victory through unified land operations." (See Figure 1 below.)

As we crafted this vision, two elements inevitably stood out; the imperative to enable the operational force and the requirement to remain focused on our quality of training. Our vision will be merged into the

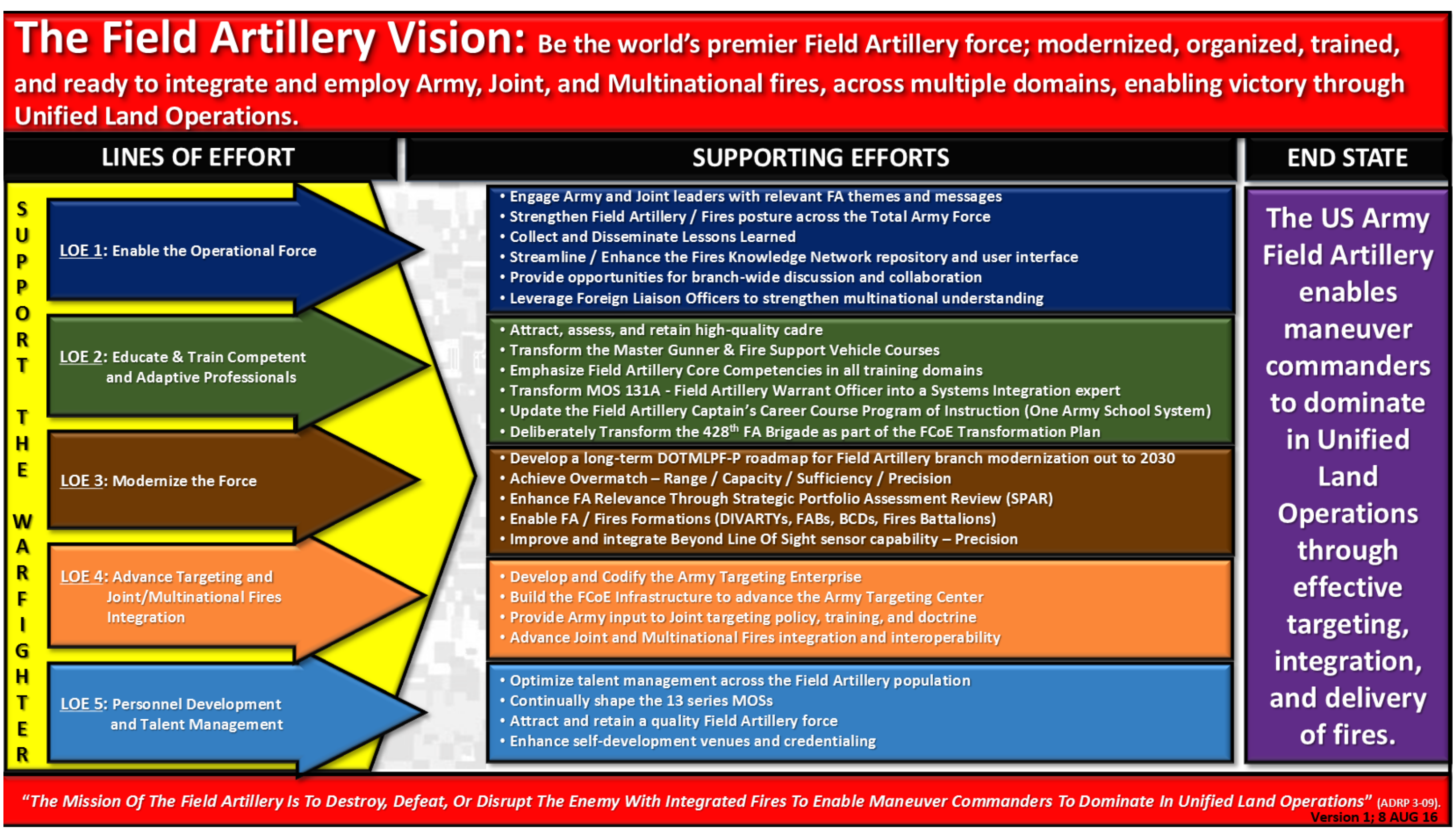

Figure 1. The Field Artillery Vision. (Courtesy illustration)

Soldiers assigned to 1st Battalion, 37th Field Artillery Regiment, 2nd Infantry Division Artillery, 7th Infantry Division, fire an M777 towed 155 mm howitzer at Orchard Combat Training Center, Idaho, Oct. 10, 2016. The Soldiers are part of a task force of over 1,000 7th ID Soldiers participating in Raptor Fury, a major training exercise to validate 16th Combat Aviation Brigade's mission readiness. (Capt. Brian Harris, 16th Combat Aviation Brigade)

fiscal year 17 Field Artillery Training Strategy to be published this fall. It is important to get our training strategy right, as the primary mission of the United States Army Field Artillery School is to enable the operating force. We provide this support across the Doctrine, Organization, Training, Materiel, Leader Development, Personnel, Facilities and Policy (DOTMLPFP) domains. All our lines of effort lend support in one way or another to the warfighter.

Five lines of effort

Within this vision we have defined five lines of effort (LOE) which span the DOTMLPFP spectrum. These are: enable the operational force; educate and train competent, adaptive professionals; modernize the force; advance targeting and joint/multinational Fires integration; and personnel development and talent management.

Enable the operational force

Enabling the operational force will require many initiatives. Paramount to this LOE is routine and consistent dialogue with our Fires and maneuver operational leaders. We will also endeavor to collect valuable lessons learned, conduct multinational engagements and integrate the Army National Guard field artillery forces into our total Army approach.

To capitalize on 15 years of combat experience, we must be single-minded in capturing lessons learned. We must glean information from intra-branch discussions and collaboration on relevant and timely joint Fires issues and topics. We must also better leverage our foreign liaison officers' knowledge to strengthen our multinational understanding, as every conflict in the future will be a multinational effort. Additionally, we are always looking for ways to enhance cooperation and understanding between the field artillery and our multinational partners with a goal of increasing interoperability between our nations. All these endeavors must be distilled into our programs of instruction (POI) so we can provide the best training possible for our field artillerists.

While we strive to improve training and instruction, we must also enable the operational force by fully integrating the Army National Guard field artillery forces into our total Army approach. We will align National Guard organizations and active-duty formations to improve readiness and enhance our capacity to deliver Fires.

Educate and train competent adaptive professionals

The Field Artillery School and leaders of the branch must prepare artillerists to be masters of their craft. As a critical part of the combined arms team, it is important that our joint Fires professionals make an immediate positive impact upon arriving at their unit. To ensure this, we will continue to enhance the quality of training of our Soldiers and leaders at every level. For great training to succeed we must have high-quality cadre. We will continue to seek experienced instructors to train our force. Additionally, we must update our POI; the most pressing in need of reform are the Master Gunner Course, the Bradley Fire Support Vehicle Course, the Captains Career Course, as well as the Joint Operational Fires and Effects Course.

Master Gunner Course

Traditionally, the Master Gunner Course has been limited by its two-week duration. The plan is to significantly lengthen the course in order to teach the more technical nature of the position, resulting in all 13B, 13F, 13M, 13R and 13J MOSs, gaining a wealth of knowledge and expertise in their facet of the Fires system. Three distinct tracks will be offered; delivery, sensor and fire control.

Bradley Fire Support Vehicle

We are transforming the Bradley Fire Support Vehicle (BFIST) Operator's Course from a vehicle-driving/main-gun focused course for Advanced Individual Training graduates to a Fire Support Vehicle Operator's Course focused on the mission equipment package for all 13F staff sergeants and FA lieutenants. This critical makeover will allow us to address a chronic gap in fire support vehicle training and give our 13F30 staff sergeants and FA lieutenants a better training opportunity to learn to operate the fire support vehicle's mission equipment package.

Captains Career Course

It has been a number of years since the last major revision to the FA Captains Career Course (CCC). We are currently working toward having the CCC students do their fire support and mission planning on the Advanced Field Artillery Tactical Data System. A major part of the CCC update is a revision to the Reserve component Field Artillery CCC course. This program is to be brought on par with the active component resident course, maximizing the contact hours available to grow these critical field artillery leaders.

Joint Operational Fires and Effects Course

The Joint Operational Fires and Effects Course (JOFEC) has again been funded and will begin again in second quarter FY17. The operational impact of JOFEC is significant and tangible. JOFEC helps fill a gap in Fires leader education at the operational level in support of joint force commander mission and priorities. This course was created because combatant commands repeatedly requested that action be taken to fill that Fires leader education gap. JOFEC accomplishes this by providing students the baseline knowledge of joint service Fires capabilities, platforms, doctrine and the joint targeting process allowing them to function at an operational level and execute the targeting process.

JOFEC is also the only educational opportunity for Soldiers and leaders to receive training working in division and higher Fires cells or battlefield coordination detachments. This is significant with the return of the Division Artilleries (DIVARTYs) and the need to re-establish core Fires capability and competencies.

Modernize the force

To maintain our status as the world's premier field artillery force we need to continue to develop and modernize. To accomplish this we need to chart a course to gain future capabilities and technologies that will ensure our multi-domain fighting edge over our peer and near-peer competitors. This roadmap will be used to budget for development and acquisition of these advanced capabilities.

We must give our operational Fires headquarters all the tools necessary to deliver Fires in support of their maneuver headquarters. This includes updating the Field Artillery Brigade Army Techniques Publication (ATP), finalizing the DIVARTY ATP and being heavily involved in the development of the Deep Operations ATP. This also includes giving these headquarters the organizational, materiel and training tools necessary to succeed on the battlefield.

DIVARTYs and field artillery brigades must provide division and corps commanders with the ability to integrate operational and tactical-level, multi-domain Fires. As the field artillery headquarters for the divisions and corps, FA units' integration and synchronization of Fires is the critical link between Fires and maneuver which will enable maneuver commanders to dominate in unified land operations.

Advance targeting, joint and multinational integration

To bring all assets to bear, we must continue to coordinate and integrate Army, joint, interagency, intergovernmental and multinational (JIIM) Fires, and conduct targeting across all domains to defeat the enemy and preserve freedom of maneuver and action across the range of military operations. To achieve this, we will develop and mature the newly designated Army Targeting Center with the best qualified Fires professionals. We will empower them to effectively execute their role as the Army's proponent for targeting by putting them in line with the other service components' targeting centers.

As the targeting lead for the Army, the ATC must leverage the targeting proponency authorities across DOTMLPFP. The ATC will take the lead for the Army, Fires Center of Excellence and the Fires community in the joint training, policy and doctrine arena setting the conditions for the land component to be fully integrated into the joint targeting process.

Personnel development, talent management

Sustaining the field artillery force long-term is inextricably linked to how we manage and balance our force structure, maintain our level of manning readiness and how we recruit and retain quality Soldiers. Talent management accounts for the individual skills, knowledge, attributes and behaviors of Army professionals and the potential that they represent. The Army seeks to select, develop and effectively employ well-rounded leaders based on the talents they possess—talents derived not only from operational experience, but also from broadening assignments, advanced civil schooling and professional military education. We will invigorate the process of broadening career paths, providing our leaders with opportunities to diversify their professional development and increase their value to the Army. As we build cohesive teams comprised of high-performing individuals with the right talents, we build a stronger Army.

The way ahead

This vision provides strategic direction. As we move forward, it is clear our approach must include a strategy for training that focuses on these LOEs. The key to achieving our vision lies in effective leadership at all levels. Leaders must receive the training and professional military education necessary to prepare them for a Fires profession that is built on standards and is prepared for expanded operational challenges. Commanders and leaders must have the tools and technology to maximize limited training time, achieve higher performance levels and motivate our young leaders with challenging, operationally relevant training.

Organizational Domain

Continued from page 4.

deeper and broader developmental path for Soldiers. The important question is how and where to place them within the organization to obtain the best skill set match?

The Capabilities, Development and Integration Directorate force development department and my staff have some initial drafts of what we believe "right looks like." But, we need comments and input from the force to ensure we have a current understanding of the operational prospective.

The question is, do these developments support the ability of the air defense brigades and battalions to task organize based on the projected mission sets?

Feedback from the operational force on how we can accomplish our goals will be greatly appreciated. Our ADA Fires Knowledge Network (FKN) representatives built a page to collect feedback and comments from the field. Please follow the URL below and let us know how you think your future MTOE/TDA's should be built to support your needs. Tell us what do you need as battalion assets; and what we should look like at the battery level? https://www.milsuite.mil/book/message/667823#667823

The heart of future ADA organizations is flexibility. Our new planned net-centric operations, showcasing a predicted ability to construct a common defense design, allows us to build an AMD task force tailored to specific mission requirements. The key to that future lays within our ability to overcome current AMD system-centric organizational constraints and develop an organization that will support the full range of commanders' needs while at the same time meet our joint, combined and multi-national partners' calls for support.

First to Fire!

Multi-function air defense units for maneuver force

By Capt. Douglas Brown

The Army's air defense forces are the most deployed, or rotated, forces in the U.S. military. Air defense currently cover missions in, and provides protection to, the Middle East, Europe, parts of Asia and the U.S. The Army and Northrop Grumman are developing the Integrated Air and Missile Defense Battle Command System (IBCS). With this new capability, the ADA must develop a means to provide air and missile defense to maneuver forces.

Theoretically, the IBCS system will link all shooters and sensors in any theater. This will enable the shooter to conduct an engagement from the data provided by the sensor on the Integrated Fire Control Network (IFCN). The centralized method of control from the engagement operations center would involve commanders in the engagement process. It will allow us to create "mission tailored" air defense packages to counter local threats. Finally, it will provide a way to move away from only defending assets on the Defended Asset List and give maneuver units access to the protection of our systems while conducting operations.

This system is currently in testing and the Army plans to begin integrating it in the near future, radically changing the way air defense forces operate. This requires us to relook current doctrine, adapt it in order to match the new capabilities that IBCS offers and become a force that can also provide protection to maneuver forces.

Military intelligence multi-function teams

The military intelligence community faced a similar issue during Operation Iraqi Freedom regarding how to turn an inherently immobile force into one that could be flexible enough to operate directly with maneuver forces. Like air defense, military intelligence organized their units by system, or discipline, and they all remained in each of their locations to provide situational awareness to the warfighter.

The warfighter wanted an intelligence element that could provide them with immediate and actionable intelligence on an objective in order to facilitate further missions and maintain momentum. The intelligence community answered this request by creating multi-function teams (MFTs). An MFT is made up of approximately seven personnel from human intelligence, counter intelligence, signals intelligence and other intelligence disciplines and one lieutenant. These teams have the ability to lead maneuver forces onto an objective, collect all types of intelligence from the objective and provide that intelligence to the warfighter. This empowered them to maintain momentum and continue to carry the fight to the enemy before the enemy had a chance to regroup. Additionally, prior to deployment, the MFTs participated in multiple exercises with their assigned maneuver units thus allowing them to create relationships of trust and integrate into their forces successfully. In garrison, MFTs remained organic to the battlefield surveillance brigades (BFSBs) allowing them to train on their respective systems and disciplines in order to ensure they remained proficient. Finally, the BFSBs still maintained the ability to carry out normal functions by leaving other parts of the unit unchanged in their mission and force structure.

The multi-function team concept in air defense

I believe a similar concept is viable when looking at the force structure changes necessary to make IBCS flexible enough to provide air defense capabilities to maneuver units. Air defense, however, would have to do this on a larger scale than teams of seven personnel. I recommend the creation of IBCS brigades with the specific task, or mission, of providing air defense capabilities to maneuver units while maintaining the number of legacy Patriot units required to fulfill our obligations in the Middle East. An IBCS brigade would contain two IBCS battalions to support a division-sized maneuver unit, and each battalion would be able to provide capabilities to a brigade combat team-sized element.

We should also move the air defense and airspace management cells to the IBCS/ADA brigades so they can train with air defense forces and then attach them to maneuver units for training and deployments to act in their actual roles of advisors and not as battle captains. Each IBCS battalion would have four IBCS batteries, a THAAD battery, a maintenance company and a headquarters battery. Each IBCS battery would have a Patriot launcher section with four launchers and a ground-moving target or forklift for reload, an Avenger section with four Avengers, a radar section with two Sentinel radars and one Patriot radar, a C-RAM platoon, a mission-command platoon with an engagement operations center and a headquarters/maintenance platoon. Later, the Indirect Fire Protection Capability (IFPC) platoons could replace, or augment, the C-RAM platoons after IFPC comes to the force.

The battalion's THAAD battery could provide the BCT's footprint defense and early warning against the larger, and longer flying upper-tier threats, while each IBCS battery could provide their assigned maneuver battalions with defense against all smaller and lower flying lower-tier threats. This also facilitates layered radar overage and the creation of a robust IFCN throughout the brigade's area of operations. While Patriot and C-RAM protect each battalions' forward operating base or attack position, the Avengers could move with the maneuver forces on patrols, convoys and other missions to provide a level of defense while on the move. With IFCN in place all weapon systems, to include the Avengers on the move, and their operators would share the same air picture and have the ability to detect, track and engage the enemy threats against the maneuver force. Thereby, each battery could support the movement and missions of a battalion and be flexible enough to move with them without sacrificing the protection of other assets. Each battery would also have all of the assets required to reload and maintain their systems and operate with a considerable amount of self-sufficiency. They would rely on minimal support from the IBCS battalion's maintenance company for system specific supplies and receive all other support, to include security, from their respective maneuver units. In this construct, one IBCS brigade could effectively support the missions of up to eight maneuver battalions.

This type of force structuring would allow each of the IBCS units to train on air defense tasks while in garrison, build unit cohesion and trust within each of the batteries and allow each battery to conduct training with the units with which they will be deploying. The ability to train with the unit they will be supporting will allow the IBCS battery commander to build a relationship of trust with the maneuver battalion's commander and give them the knowledge and understanding of air defense that will lead to effective use of the forces when deployed. After training and certifying as batteries, their final certification prior to deployment would become the combat training center rotations that they would conduct with the maneuver unit they will support in combat.

After operating in relatively the same manner since the advent of air defense, we are now facing multiple threats that do not operate the same and a maneuver force that lacks proper air defense coverage. Should IBCS work as promised, air defense forces will be able to break out of our current molding and create a force that is better prepared to meet the current challenges and remain flexible enough to defend against future threats. In order to do these things, we must structure the force in a way that allows for unit training and cohesion and supports the maneuver force. However, I believe that we must keep some units in their current force structure to remain flexible and able to maintain our presence in the Middle East and South Korea.

Capt. Douglas Brown is the 10th Air and Missile Defense Command Current Operations Section battle captain. He served in multiple roles as an air defense officer, to include tactical control officer and tactical director. Prior to commissioning through Officer Candidate School in 2010, he served as an enlisted Arabic linguist in the 504th Battlefield Surveillance Brigade during which he joined the unit on two deployments to Iraq in support of maneuver operations.

Pvt. Emanuel Zavala, a cannon crewmember with 1st Battalion, 37th Field Artillery Regiment, 2nd Division Artillery, 7th Infantry Division, helps set up an M777 howitzer during a training event at Yakima Training Center, Yakima, Wash., Feb. 24. (Sgt. Cody Quinn/28th Public Affairs Detachment)

Close Ties

Tomahawks and Red Lions

By 1st Lt. Michael Edwards

Since the invention of artillery in the mid-12th century, militaries have increasingly integrated indirect Fires with maneuver units in order to destroy enemies at depth with layers of weapon platforms and munitions. During the course of our nation's wars, the field artillery, nicknamed the *King of Battle*, has molded an inseparable relationship with the infantry, nicknamed the *Queen of Battle*. Although both the field artillery and the infantry operate at many echelons in existing combined arms maneuver formations in the U.S. Army, few other relationships have evolved quite like that of the 2nd Infantry Division's 1st Battalion, 37th Field Artillery Regiment, known as the *Red Lions*, and the 1st Battalion, 23rd Infantry Regiment, known as the *Tomahawks*. The units work daily to maintain a high level of combat readiness with their battalion headquarters only 50 meters apart and their units' ties even closer.

Originally constituted as a degraded infantry regiment in 1812 and a single firing battery in 1918 respectively, 1-23rd Infantry and 1-37th FA have enjoyed acclaimed histories with active participation in the following American wars: The Indian Wars, the Civil War, the Spanish American War, World War I, World War II, the Korean War, Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF), according to the Center of Military History. Throughout four of these campaigns (WWII, the Korean War, OIF and OEF), the regiments served in combat together creating a relationship that continues to grow and evolve bounded by changes to equipment, technology, doctrine and global threats.

As direct support for 23rd Infantry Regiment during WWII, 1-37th FA introduced new tactics, techniques and procedures (TTPs) that provided maneuver forces with field artillery Fires never before seen in the Army. Among these TTPs was the centralization of the call for fire, which provided greater oversight and procedural verification of artillery fire missions. The artillery's increased number of operational field radios allowed virtually every Army lieutenant the ability to call for fire. Soldiers in 1-37th FA also accelerated mobility via self-propelled guns and motorized howitzer displacement and re-emplacement, effectively providing an exponential increase in range for Fires to support 1-23rd Infantry Regiment.

As a result, 1-37th FA effectively delivered Fires in support of the 23rd Infantry Regiment in Normandy, Northern France, the Rhineland, Ardennes-Alsace and Central Europe ("World War II Technology").

The units' WWII partnership forged most notably during the Ardennes Forest Battle of Elsenborn Ridge in December 1944, which was the only sector of the American front lines at the Battle of the Bulge where the Germans failed to advance (Cole, 113). After enduring a strong German offensive on Dec. 16, the 2nd Battalion, 394th Infantry Regiment retrograded West of Elsenborn Ridge to the town of Murringen, while 1-23rd Infantry prepared to reinforce their position and halt the German advance through the Ardennes by capturing and defending a village 1,500 yards south of Murringen (Cavanagh, 83). In concert with a 1-23rd Infantry counter-offensive on Dec. 17, Lt. Charles W. Stockell, a forward observer with 1-37th FA, "raced across the open fields," and established a prime observation post inside a church steeple; Stockell proceeded to adjust fire on the German assembly area effectively disrupting their formation and neutralizing the impending attack (Cavanagh, 85). According to Capt. F. Luchowski, the battalion operations officer, Stockell's fire missions "gave them [the Germans] Hell," and characterized a critical event that enabled the Americans to defend their sector successfully (Cavanagh, 85).

Another direct support assignment that impressively solidified 1-37th FA's relationship with the 23rd Infantry occurred during the famous Korean Battle of Chipyong-ni (February, 1951). According to historians and service members, Chipyong-ni represented the decisive battle that halted Chinese communist forces and turned the tide of the Korean War in the Americans' favor. During the course of the battle, 1-37th FA successfully accomplished its mission of digging in perimeter defensive positions outside the town of Chipyong-ni, firing hundreds of artillery missions with thousands of rounds, while simultaneously reinforcing the infan-

Soldiers from 1st Battalion, 23rd Infantry Regiment, 1st Brigade, 2nd Stryker Brigade Combat Team, conduct a simultaneous ground and air assault from Joint Base Lewis-McChord into Yakima Training Center in late February 2016. (Courtesy photo/U.S. Army)

try front lines with cannoneers who served as riflemen ("Chipyong-ni").

Prior to the three-day conflict, Liaison Officer Capt. John A. Elledge, acting in a role similar to that of a battalion fire support officer in 2016, planned and integrated fires with Company G to support a joint defense established to stop Chinese advancement further into Korea. In the heat of battle, Elledge selflessly laid his life on the line running back and forth between the howitzer gun line, the fire direction center, and the thin infantry front lines in order to physically place reinforcements at the front and flanks. Despite receiving shrapnel from a grenade, Elledge carried out the mission in support of the infantry defensive stand. More importantly, Elledge and his fellow artillerymen represented the valor and strength of the 1-37th FA and its cannoneers' willingness to accomplish the mission in support of the infantry. Thus, having driven the Chinese out of Chipyong-ni, the Soldiers of 23rd Infantry Regiment, with their 1-37th FA brethren alongside them, handed the Chinese their first defeat since entering the Korean War ("Chipyong-ni").

In a similar role, 1-37th FA supported various missions conducted by 1-23rd Infantry during OIF and OEF as part of the 3rd Battalion, 2nd Stryker Brigade Combat Team. In April 2004, 1-37th FA and 1-23rd Infantry collaborated as members of Task Force Duke (TF Duke), which operated near the Iraqi cities of Mosul and Hammam al-Alil with the mission of quelling armored division to effectively control the area (McGrath,114).

"While 1-37th FA provided robust support from the Al Qayyara region just south of Hammam al-Alil, we [1-23rd Infantry] and the other TF Duke elements conducted both convoy escort operations on the main supply route, and security operations around Mahmudiyah and Yusufiyah in the South," said Lt. Col. Teddy Kleisner, 1-23rd Infantry Regiment commander. Kleisner formerly served as a battle captain in the 1-23rd Infantry element of TF Duke.

After two weeks of fighting Shia insurgents who attacked both American and Iraqi troops with mortars, rocket-propelled grenades, small arms and improvised explosive devices (IEDs), TF Duke successfully defeated the opposition, enabling 1st Armored Division to effectively control the area(McGrath,114).

The *Red Lion*'s brilliant integration while directly supporting the 1-23rd Infantry Regiment in WWII, the Korean War, OIF and OEF merely represent the early stages of an association that thrives today. In March 2015, 1-37th FA became attached to the 2nd Infantry Division Artillery centralizing all artillery assets under one command within 2nd ID. Nevertheless, 1-37th FA continues to provide direct support fires for 1st Brigade Combat Team, which includes 1-23rd Infantry. The return of DIVARTY will improve Soldiers' artillery and fire support competency through standardized certification and gated training that will provide a more capable combined arms team in future conflicts and on future battlefields.

The 1-37th FA and 1-23rd Infantry relationship is celebrated through Soldiers like Stockell and Elledge whose courageous actions undoubtedly deserve credit for both units' numerous honors. Both regiments proudly possess presidential unit citations and campaign streamers for their Soldiers' actions in France and Korea. Additionally, 1-23rd Infantry was awarded the Meritorious Unit Commendation and Streamer for actions in Iraq in 2004 (Center of Military History). Moreover, the training and integration during 1-37th FA's transition from Stryker Brigade Combat Team to DIVARTY provides 1-37th FA and 1-23rd Infantry a seamless opportunity to build upon experiences, enhance the support to the SBCT, and establish a highly trained combat arms team.

"The historic relationship between these two units is humbling. Two units that have been closely aligned for nearly a century. Landing at D Day and WWII; landing at Pusan; the Battle of Chipyong-ni; deploying three times to Iraq; deploying in 2011 to Afghanistan … the same infantry battalion counting on the same artillery battalion to deliver Fires. The same artillery battalion answering the calls-for-fire from the same infantry battalion. It truly is a historic relationship. Moreover, I think it is our leaders' responsibility to share this relationship with present day Soldiers in both the *Red Lions* and the *Tomahawks*. We are adding chapters to the maneuver-Fires relationship, every day," said Lt. Col. John D. Williams, 1-37th FA battalion commander.

Ready to face an ever-changing enemy on a fluid battlefield, 1-37th FA and 1-23rd Infantry look to the past to reinforce successes; train and evaluate in the present to refine skills; and look to the future to anticipate concerns and shape the environment for future leaders. The *Red Lions* of 1-37th FA and the *Tomahawks* of 1-23rd Infantry remain the Army's premiere field artillery and infantry battalions. When the call of duty rings through the halls of these storied units, they will be more than ready to gather arms once again and just like at Elsenborn Ridge in WWII, at Chipyong-ni in Korea, and at Al Qayyara in Iraq, stand side-by-side to defend each other.

1st Lt. Michael Edwards is an artillery officer currently serving as a battalion ammunition officer in 1st Battalion, 37th Field Artillery.

Soldiers assigned to A Battery, Field Artillery Squadron, 2nd Cavalry Regiment, conduct a continuous fire mission on an M777. (Staff Sgt. Ricardo HernandezArocho/U.S. Army)

Bringing digital capabilities back to the field artillery squadron

By Chief Warrant Officer 2 Ryan Groves and Chief Warrant Officer 2 David Zamora

The journey of regaining fire support proficiencies began in July 2014 with the arrival of our new squadron commander, Lt. Col. Deric Holbrook, whose focus was fire support. The fiscal year 14 Modified Table of Organization and Equipment (MTOE) changes brought fire support elements (FSE) back to the field artillery squadron and an energized staff in the 2nd Cavalry Regiment, Field Artillery Squadron. When combined, the conditions were set for success to regain digital capabilities and core competencies.

The establishment of digital fire support communications can be a simple process influenced by a number of complex factors. In August 2014, Field Artillery Squadron, 2nd Cavalry Regiment, set out to reestablish digital fire support communications, encountering a number of unforeseen obstacles. This situation could be paralleled to what happened on April 11, 1970, when NASA launched its seventh manned mission to space and third planned mission to land on the moon. Apollo 13, however, had a different fate, encountering a number of obstacles that required engineering expertise and troubleshooting procedures to bring the crew home safely. Over the course of six months, as digital communications were being re-established, it felt as if the FA Squadron was trying to assist Apollo 13 on their mission home. While a number of the obstacles encountered were not directly related to digital communications, they influenced our unit's ability to effectively regain confidence and support along our digital quest. Some of the obstacles included MTOE changes, neglected equipment, untrained Soldiers, multiple contracts, lack of Stryker-specific work packages to support maintenance operations, and an overall lack of understanding as to how the mission equipment package (MEP) operates when paired with the M1131A1 Stryker.

After several months of focused training and maintenance, the FA Squadron, 2nd Cavalry Regiment established digital links among all 13 fire support vehicles (FSVs) but had a difficult time maintaining digital capabilities with all 13 FSVs in a single training exercise. As the weeks turned into months, all identified faults were job ordered for repair. At times, multiple hindrances and obstacles all pointed in the direction of failure; however, we achieved many successful milestones to include a better understanding of how even unpretentious goals can contain complex problem sets.

The FY14 MTOE changes brought the fire support elements back to the FA squadron. A number of manning, equipping, training and maintenance deficiencies across the FSE formations were identified. The greatest obstacles encountered equated to neglected fire support equipment and decayed knowledge of basic digital fire support tasks. Having the entire fire support system consolidated under the FA squadron allowed us to provide a focused energy to solve our manning, equipping, training and maintenance problems.

Phase 1: Training for digital fire missions

After reconsolidation of all the fire supporters and equipment from the infantry squadrons, the regiment's fire support (FS) combat power became more effective and our focus shifted towards individual observer skills and proper manning. To maximize the effectiveness of our fire support elements training objectives, the regimental fire support noncommissioned officer in charge developed a roster that tracked each individual by skill set: Joint Fires observer, target mensuration only; Joint Firepower Course, collateral damage estimation; Battle Staff Course, Electronic Warfare 1J, and a number of other courses. The individual skill sets were then paired with longevity and rotational needs. As the FSE's were manned by skill sets, a detailed training plan was developed to fill knowledge gaps.

With individual collective task being completed, the line of effort shifted towards team-focused training. We thought our FSVs were fully functional, but discovered the MEP that provides the digital capability had been neglected for the better part of a decade and required extensive maintenance. Several factors contributed to this neglect. The FA Squadron was activated after the modular re-alignments moved fire supporters to the infantry squadrons, and regiment continuously transitioned from Operation Iraqi Freedom to Operation Enduring Freedom deployments since its activation. Fire supporters had never been consolidated under the Field Artillery Squadron, 2nd Cavalry Regiment. In addition, the FSVs are among the oldest Stryker's in the Army and have not deployed or properly reset in seven years. The combination of these factors led to decayed technical knowledge on the operation and maintenance of the Stryker and MEP.

The first subcomponent of the MEP that we identified as a training deficiency was the stand alone computer unit (SCU) that runs the forward observers software (FOS). To correct this deficiency, we contacted the Fires Center of Excellence and coordinated a mobile training team from CGI Federal. The initial onset of requesting a MTT was identified during the Stryker War Fighting Forum and further developed through repetitive contact between FCoE and the leadership of Field Artillery Squadron, 2nd Cavalry Regiment.

This training focused solely on the SCU operations. To facilitate training a large group of fire supporters, the CGI instructor dismounted the SCUs and conducted the training in a classroom environment. This environment allowed fire supporters to gain confidence in the SCU. In hindsight, we practiced poor habits by failing to integrate the SCU into the MEP, not exercising the tactical network and instead relying on single channel/plain text frequencies and external power supplies.

Given that the SCU is an interface that allows communication between MEP components we should have placed more focus towards how the MEP components interact. While this is not part of the outlined training for the SCU and FOS, this is one of the moments when we felt as if we were trying to land Apollo 13 on the moon, rather than accomplish a basic digital call for fire.

Our complex problems began shortly after the FOS trainer departed in late September 2014. The new FOS software was not compatible with the outdated Fire Support Sensor System (FS3) software. This limited us to manually generating targets on the SCU to send them to the AFATDS. Further research into the problem determined that our software issues spanned several components of the MEP. We identified dated software on the Target Station Control Panel (TSCP), and the Mission Processing Unit (MPU). In addition to the software issues, a number of hardware issues were identified that included not mission capable wiring harnesses, improperly installed cables and missing cables.

Phase 2: Deadlining the regiments' fire support system

Our noncommissioned officers' and Soldiers' training on the M1131A1 Stryker and its capabilities to this point had been limited to automotive training. The fire supporters' lack of knowledge on the M1131A1 stems from years of constant deployments, that exclusively focused on the use of theater provided equipment (TPE) as it pertained to the non-standard missions that required limited FS knowledge. As we visualized the magnitude of the problem, the squadron commander decided to deadline all 13 FSVs; the MEPs' state of disrepair was too much to consider them fully mission capable (FMC).

To establish a baseline to begin repairing the FSVs, we reached out to field service reps from Communications Electronics Command and Tank Automotive and Armament Command in hopes of obtaining Stryker specific schematics of the wiring diagram, which would allow us to initiate troubleshooting procedures. Up until this point we had been using schematics that were developed for the M117 and M1200 Armored Knight platform.

Although our CECOM and TACOM representatives worked well together, isolating the faults in each Stryker was challenging because each fault repaired during a CECOM technical inspection uncovered another fault, drawing TACOM back in for troubleshooting. In addition, no single source of documentation exists for troubleshooting the M1131A1 Stryker FSV MEP. All work packages that had been provided by CECOM and TACOM were generally reference material developed for the M117 and M1200 Knight platform. While the provided material did reference Stryker specific issues, it failed to identify corrective actions, part numbers and detailed schematics to begin proper trouble-shooting procedures. To further complicate the process, fire support teams continued to identify new problems during weekly digital sustainment training (DST). We turned in every FS3 for software updates and learned that annual services and software updates had been overlooked for at least five years.

Phase 3: Fixing the problems and regaining expertise

Once we had finally fixed the majority of the cables, every FSV in our formation had the same fault. With CECOM and TACOM assistance, we identified that TSCPs and MPUs were running outdated software. We found the problem! Our concern quickly returned; we learned the MEP components are managed by several different contracts. Disappointment set in when we learned that the FSV Technical Manual did not contain instructions to re-load the new software. By this time we had estab-

Soldiers assigned to A Battery, Field Artillery Squadron, 2nd Cavalry Regiment, conduct a continuous fire mission with their M777 during the Saber Strike 16 Combined Live Fire Exercise at a training site near Tapa, Estonia, June 20, 2016. Exercise Saber Strike 2016, is a U.S. Army Europe-led cooperative training exercise designed to improve joint interoperability to support multinational contingency operations. (Staff Sgt. Ricardo HernandezArocho/U.S. Army)

Soldiers from Archer Battery, Field Artillery Squadron, 2nd Calvary Regiment, conduct a combined forces live-fire exercise along with other multinational participants in the Saber Strike 16 at Tapa, Estonia, June 20, 2016. (Spc. Sandy Barrientos/U.S. Army)

lished weekly teleconferences with PM Stryker, TCM Fires and DRS Technologies, who designed and engineered several of the MEP components. The weekly teleconferences with all enablers allowed us to isolate the new fault identifying outdated software on our TSCPs and MPUs, which caused compatibility issues among all MEP components. TCM Fires and PM Stryker provided a link to download the software and the procedures to update the TSCPs and MPUs.

We immediately hit roadblocks installing the software. After a week of trial and error, we finally had one vehicle take the software update for the TSCP but could not replicate this process across our formation. Our FSV repair team spent two more weeks in the hull of the Stryker attempting to load the MPU and TSCP Software. PM Stryker and DRS Sustainment Systems asked us to send one MPU and TSCP to the DRS lab in St. Louis for testing to identify the procedural issues we were experiencing.

Simultaneously, our weekly teleconferences prompted PM Stryker to send a technical inspector from DRS Technologies to evaluate the problem set firsthand. While he completed technical inspection of the FSVs, DRS in St. Louis found a hardware fault linked to all MPUs and TSCPs. The upgraded software package they had published required higher data storage rates than our outdated MPU and TSCPs supported. DRS quickly loaded the new flash drives at their lab and shipped them to the technical inspector to install before he departed.

To complement the technical inspections, PM Stryker sent a training team that arrived one week after the DRS inspector. Initially, we thought the week-long delay between inspections and training would be sufficient. The technical inspections produced more faults, requiring parts that could not arrive in time to repair vehicles for training. To overcome this challenge, we designed a training program that rotated two to three crews through a condensed version of training on our best Strykers over a two-week period.

Lessons learned

We had five of 13 FSVs fully digitally capable and 13 of 13 trained crews after three weeks of intensive training and maintenance. Weekly digital sustainment training (DST) over the next four weeks, focused on operator-level training, commu-

nication parameters and tactical network establishment.

The aforementioned poor habits from the SCU training plagued DST. We thought that putting everyone on the same single channel/plain text net would make crawling through digital training easier. In fact, our efforts to simplify the training with TTPs from classroom SCU training over-burdened the net and prevented us from seeing our success. Once we established and transitioned to the regiment's digital architecture, we had 10 Stryker's sending digital calls for fire from the FS3, through the MEP and SCU, to the AFATDS.

In hindsight, we did not allow enough time between the technical inspections and training. Had we waited two to three weeks between the inspection and training, we could have had 13 of 13 vehicles FMC and allowed the crews to train on their own vehicle as a team. One month after the trainers and technical inspector departed, our fleet of FSVs has established digital connectivity from sensor to shooter with all 13 FSVs. We currently sit at 13 of 13 FMC FSVs.

To ensure our crews remain trained and have confidence in the equipment, we have developed several short training videos, created a FSV MEP smart book, and are in process of developing two ranges in the United States Army, Europe training areas to determine our average grid error through long-range confidence checks.

Assisting the FA community

Units looking to replicate our success must begin by assessing the mechanical maintenance status of their fleet. Once all mechanical maintenance issues have been addressed units should verify that all versions of software that pertain to the MEP are current. From this point, a solid baseline can be established that allows technical inspections to properly direct towards the MEP. Using TACOM, CECOM, PM Stryker and the other enablers is critical to this step. It is difficult to isolate faults and repair the Stryker MEP when Soldiers and NCOs do not have the expertise or documentation to guide them along the process.

As the technical inspections near completion units will have a solid foundation to develop training and repair plans that foster team development, working on the actual equipment they will deploy with. This is important as every individual Stryker will present its own unique maintenance quirks. As the crews train on their own equipment, those quirks can be addressed and handled in a proper manner. This not only decreases the maintenance status, but crew members learn troubleshooting procedures first hand.

As technical inspections near completion, the FSE's focus should shift towards training. This process should not be rushed and is based on identified faults and repair timelines. Training for each Stryker crew should last at least five days. Day 1 should focus on how the MEP is properly started, how to identify and correct known faults, and proper shut down procedures. Day 2 should incorporate the actions learned during Day 1 and provide a solid introduction into bore sighting and FS3 operations. Day 3 should recap all training provided up to this point and incorporate the units' digital architecture; establishing communications between troop level SCUs and AFATDS. Day 4 should be used to identify any training shortfalls and cross-section training goals and preparation for a digital communications exercise (COMEX) should be completed. Day 5 should focus on crew-level operations that support an instructor-led digital COMEX. While the COMEX is facilitated by the instructor, crews should have the baseline knowledge to operate independently.

In summary, I decisively believe involvement from all levels of leadership, our civilian counterparts and all fire support related MOS's must take ownership and share collective wisdom in order to evolve and adapt the Fires war-fighting function. Positive attitude is a must throughout the ranks; every member of the FA team is important to mission success, and must understand their role which is essential to overall mission accomplishment.

Additional information

FIST OP provides information software, sensors and mounted platforms. Additional information can be viewed at https://www.us.army.mil/suite/page/111551. Common Access Card (CAC) required.

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Archer achieving accuracy

Manual fire direction across a Universal Transverse Mercator

By 1st Lt. Thomas Devane and 1st Lt. Geoffrey Poss

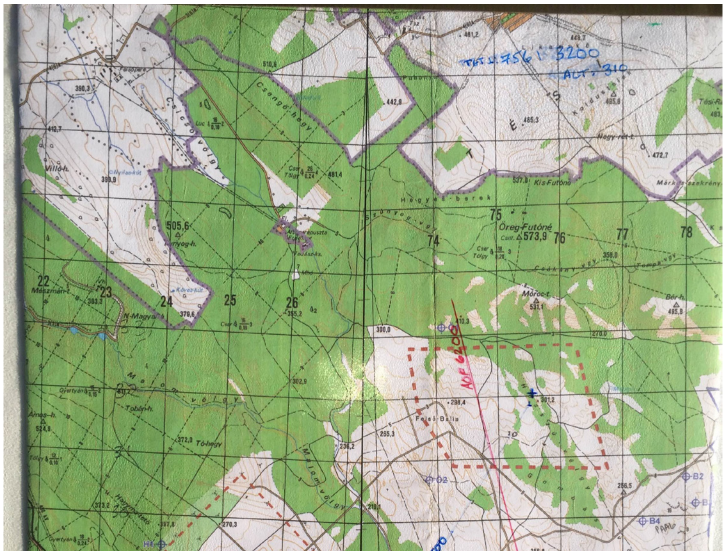

Figure 1. Universal Transverse Mercator Junction in Combined Exercise Shooting Range, Hungary. (Courtesy image)

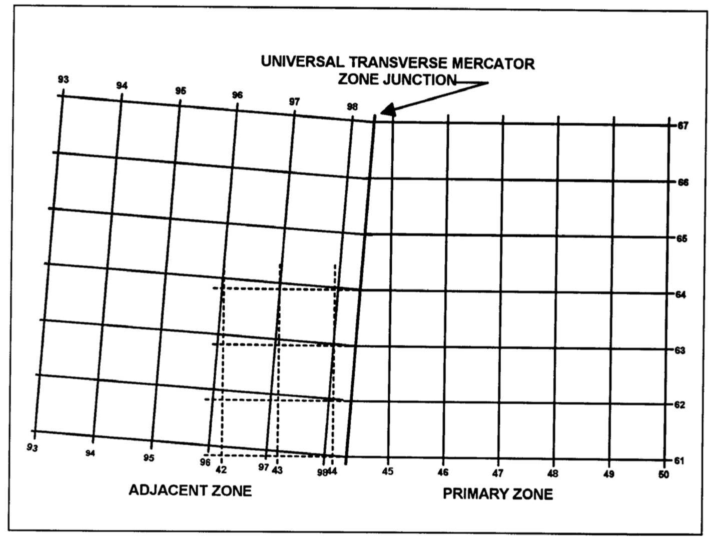

Figure 2. Joining two grid sheets for zone-to-zone transformation. (U.S. Army)

Manual fire direction may be on the defensive, but its relevance is not lost on the Soldiers of *Archer Battery*, Field Artillery Squadron, 2nd Cavalry Regiment. In the fall of 2015, the unit was deployed to Hungary as part of Task Force Saber and Operation Brave Warrior. The eight-week operation featured several live-fire exercises and tasks focused on enhancing allied interoperability. *Archer Battery* specifically demonstrated freedom of maneuver and refined crew drills in partnership with the Hungarian military. Operation Brave Warrior culminated in a joint, multinational, combined-arms capabilities demonstration. While conducting critical live-fire operations, *Archer Battery* encountered a rare obstacle to shooting on the Combined Exercise Shooting Range (CESR) training area. The CESR, just north of Veszprem, features firing points uniquely located at the edge of a Universal Transverse Mercator (UTM) (Figure 1).

The UTM system is a mapping system adopted by the U.S. Army in 1947 for designating rectangular coordinates on large-scale maps for the entire globe. The Earth, between latitudes 84 degrees north and 80 degrees south, is divided into 60 zones, each six degrees wide in longitude (Moore, 1997). This system helps project a more accurate two-dimensional depiction of a three-dimensional world. Therefore, a UTM junction of two separately mapped areas does not align, leaving partial grid squares and non-parallel grid lines. In the case of the UTM in CESR, the two maps joined at about a five-degree angle causing the UTM to split the maps, diverging as they proceed south. Across UTM junctions, manual fire direction proves difficult. The firing chart is normally constructed using one continuous UTM zone. “Tactics, Techniques, and Procedures for Field Artillery Manual Cannon Gunnery,” Field Manual 6-40, was the field manual in use at the time and provided limited guidance for how to shoot over a UTM. It provided two courses of action in Annex H: the two grid sheets method and the graphic method. Both methods have their advantages and disadvantages. The two grid sheet method requires the least materials, references and calculations, but may be less accurate (Figure 2).

The graphic method holds the potential to be more accurate but requires more materials, calculations and is less conducive to a field environment. One absolute requirement for both of these methods is an accurate map of your area of operations (AO). A 1:25,000 scale map is a minimum requirement to achieve the accuracy required to replicate the UTM zone on a firing chart. Without this, one cannot accurately measure and convert the UTM angle to the chart. As any fire direction center (FDC) member knows, the accuracy of the firing chart is paramount. It is used as a secondary, independent check to assure the chief and fire direction officer (FDO) that their firing data is indeed accurate. The tolerances for checking firing data are +30 meters for range and +3 mils for deflection. Accuracy is subject to human limitations in the laying of the chart (U.S. Army, 1999). All methods were considered for application in CESR, Hungary.

Fortunately for those on Operation Brave Warrior, the Hungarian artillery was well versed in how to fire manually within CESR, as they only calculate indirect firing data using manual methods. Maj. Barnabas Bartok, of the Hungarian 101st Artillery Battalion, provided helpful guidance to both FDC sections. He explained the way that the Hungarian artillery addressed the UTM and that influenced *Archer Battery*’s course of action. Fortunately, one Soldier from *Archer Battery* also had the opportunity to discuss artillery methods used by allied partners at a multinational, NATO command-post exercise. One commonly used method involves drawing the projection of the alternate UTM zone on the primary UTM zone on a map and extracting a "false grid" for the firing unit or target. Another method is to use field equipment (i.e. Lightweight Laser Designator Rangefinder, Vector or Trigger) to measure an accurate distance and direction

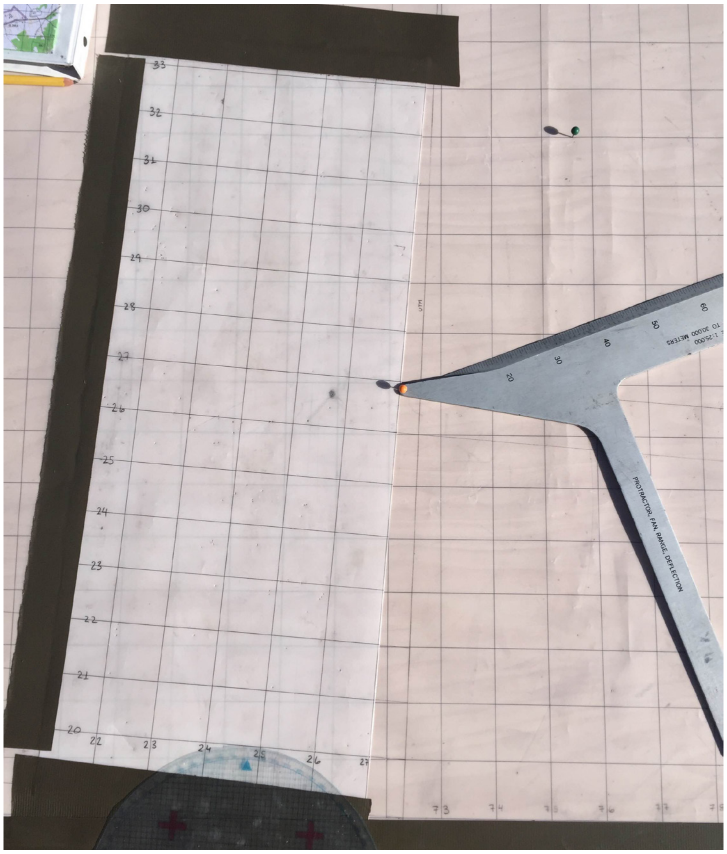

Figure 3. Fire Direction Center 1 chart method. (Courtesy photo)

Figure 4. Fire Direction Center 2 chart method. (Courtesy photo)

to a known point across the UTM boundary. With this information, a map resection technique can be used to extract the same "false grid." The second method is significantly more accurate. *Archer Battery* explored nearly every option for manual firing safety.

The greatest challenge in tackling the two grid sheets method was achieving the desired accuracy with map measurements. *Archer Battery*, with two FDCs, proved that the two grid sheets method could be achieved in two unique ways. First platoon FDC chose to project the primary UTM zone (target area) onto the adjacent UTM zone (firing battery location) deliberately (Figure 3). The second FDC replicated the map with three sections of chart paper to depict the adjacent UTM zone, UTM boundary zone, and primary UTM zone (Figure 4). In both cases, measurements were made of eastings along each grid northing for a stretch of nearly 10 kilometers. We discovered that measuring a 1:50,000 map did not result in an accurately laid chart. Specifically, the constructed chart did not produce firing data that met tolerances when checked against the Advanced Field Artillery Tactical Data System (AFATDS) firing solution. Instead, it was necessary to record measurements from a 1:25,000 map in the same manner to achieve the necessary accuracy. These doctrinal interpretations and procedures proved successful in both cases for safe fire direction across the UTM junction.

Word of this unique fire direction situation arrived back at the Field Artillery Squadron, 2nd Cavalry Regiment, and the squadron commander had the opportunity to engage it. Since the summer of 2014, the Field Artillery Squadron had been heavily engaged in regaining the core competencies of fire support. In that time, several squadron-level training events focused on a return to doctrine and explored the significant gaps in artillery experiences which resulted from over a decade of counterinsurgency combat operations. The environment for mastering these branch skills and discovering innovative tactics, techniques and procedures (TTPs) proved particularly advantageous in U.S. Army Europe. Both fire direction centers confidently displayed this rejuvenated artillery expertise, helping advance the technical knowledge of their unit and the field artillery branch. By sharing these manual techniques with their Hungarian counterparts, they also enhanced multinational interoperability and demonstrated the readiness of Soldiers and leaders to return to conventional field artillery practices and procedures.

Ultimately, while there are other methods of achieving safe and accurate Fires across the UTM Zone, *Archer Battery* found success by applying two distinct interpretations of the two-grid sheets method. The information found in the FM 6-40, as well as the advice and training received from the Hungarian 101st Artillery Battalion, was crucial. Between the two fire direction centers, and the gunline, *Archer* safely fired more than 450 rounds, proving this method's effectiveness.

As *Archer Battery* learned during Operation Brave Warrior, firing artillery across a UTM junction is not a novel concept to our allied partners. Many of our allies exclusively compute fire direction manually. In order to meet the demands of interoperability, we recommend our field artillery community train towards a common literacy for manual fire direction across UTM junctions. This is especially important considering that the classification status of Advanced Field Artillery Tactical Data System and other automated fire direction tools do not lend themselves to multinational operations at a tactical level. With our lessons learned, we hope future field artillery units can be successful in delivering safe and accurate Fires across UTM junctions.

1st Lt. Thomas Devane deployed with Archer Battery to Hungary for Operation Brave Warrior from September to November 2015.

1st Lt. Geoffrey C. Poss deployed with Archer Battery to Hungary for Operation Brave Warrior from September to November, 2015.

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Fighting battery operations at the National Training Center

Lessons learned from a decisive action rotation

By Capt. William Fleming

During National Training Center, Fort Irwin, Calif. Rotation 16-06, A Battery, 1st Battalion, 37th Field Artillery, 2nd Infantry Division, fought a decisive action rotation against the Donovian aggressors, in support of 1st Battalion, 2nd Stryker Brigade Combat Team, by organizing and fighting as a battery versus platoons.

Left: A U.S. Army Soldier assigned to the 1st Battalion, 37th Field Artillery Regiment, 1st Brigade Combat Team, 34th Infantry Division, searches for targets during Decisive Action Rotation 16-07 at the National Training Center in Fort Irwin, Calif. (Spc. Daniel Parrott/NTC Operations Group)

Based on the additional capabilities gained in the fire direction center (FDC), increased local security posture, the ability to maintain and resupply the howitzer sections and the improvements in mission command, all M777A2 batteries across the Army should consider organizing as batteries to fight in similar environments as the NTC. Doctrine states, “The capability of the cannon battery is enhanced through the flexibility and survivability of the platoon-based organization.” (ATP 3-09.50) However, this paper will demonstrate that the effectiveness of a firing battery is increased by organizing as a single firing element.

The capabilities of the FDCs under battery operations are enhanced. Battery operations enhance the ability to process fire missions. The lag time in the Centaurs slows fire mission processing times, ultimately breaking time standards, and further delaying effects on the battlefield. Battery operations allow the use of two Advanced Field Artillery Tactical Data Systems (AFATDs) to process missions. This provides the required two independent checks while removing lag time. Utilizing two AFATDS provides the following benefits:

1. Meteorological data updating times were cut down from five minutes to roughly 10 seconds.
2. High angle, Dual Purpose Improved Conventional Munitions, remedial action plan and illumination mission processing times were cut down to less than one minute.
3. All fire missions with multiple aim points were processed in under two minutes since the FDC did not have to shoot each individual aim point with the Centaur.

A sister battery in the battalion didn’t place both AFATDs in the FDC; they placed one in

U.S. Army Soldiers assigned to the 1st Battalion, 37th Field Artillery Regiment, 1st Brigade Combat Team, 2nd Infantry Division, position an M777 towed 155 mm howitzer during Decisive Action Rotation 16-06 at the National Training Center in Fort Irwin, Calif. (Spc. Jeffery Hagan/NTC Operations Group)

the FDC and one in the battery operations center (BOC). Although successful, fire mission processing times were quicker with this method. Having both AFATDS in the same vehicle, there is a risk to both being destroyed if the FDC is attacked. However, this risk was mitigated through the placement of the headquarters element; positioning the FDC a kilometer from the gunline outside the positioning area for artillery (PAA) and in the best cover and concealment possible. Tactical displacement of the battery, using terrain to increase distances between howitzers, mitigates the enemy counterfire success.

In terms of fire mission processing, firing as a battery with a single controlling FDC allows the battery to mass all howitzers while still being flexible enough to shoot multiple missions with precision timing. With all six guns under their control, the fire direction officer and fire direction noncommissioned officer are able to process missions that typically require more than three howitzers, such as smoke screens, without the need to coordinate with an adjacent platoon and utilize detailed timing techniques to maximize their effects on a target. For example, at NTC the battery was able to shoot a 40-minute smoke screen, 200 meters long. All six howitzers were used to build an initial volley with one round each and then fire each sustaining volley every 2 minutes by alternating aim points in groups of three (i.e. Guns 1,3,5 fired a sustaining volley and then 2,4,6 fired the next volley).

Utilizing one FDC vehicle with two separate crews negates the need for a battery operations center-platoon operations center FDC changeover. Normally, the battery employs two FDC vehicles, each with an AFATDS and Centaur. In order to switch the hot FDCs (FDC changeover) the gunline has to be notified to switch digital frequencies to the new controlling FDC, execute a bump fire mission on the two mission processing systems and execute an FDO back brief via FM radio. Now, with one FDC truck and both AFATDS as the primary FDC, the FDC changeover drill is as simple as the new controlling FDC entering the vehicle and the cold FDC exiting the vehicle (and a bump fire mission). This allows for the changeover to be only a few seconds and each member of the FDC is able to back-brief their replacement face-to-face.

One common problem encountered by units at the NTC is crew rest for FDC personnel. By consolidating the FDCs, crews can rotate on work-rest cycles to prevent burnout. One enabler is the capabilities of the Soldier Extension Network (SNE) provided out of the M-ATV (MRAP All-Terrain Vehicle) assigned to both FDCs. The SNE allows FDCs to have satellite-digital communications with the battalion FDC at all times, regardless of the FDCs location.

Before battery operations, batteries would have to locate FDCs in positions where a whip antenna could maintain line-of-sight FM radio communications with the battalion. With the SNE, FDCs are able to maximize cover and concealment because the SNE always has communication capabilities. The use of a quick erect antenna mast, which extends to over 30 feet in the air, also extended voice communications. By consolidating equipment and personnel in one FDC vehicle and utilizing digital communications through the SNE, the effectiveness and sustainability of both FDCs is increased while conducting battery operations.

The increase in local security is another advantage provided to a firing unit conducting battery operations. The battery PAA normally occupies a 2 kilometer by 2 kilometer area with the headquarters element no more than a kilometer outside the PAA. This close proximity enables a battery to organize and mount a timely and aggressive quick reaction force in response to a local threat.

Howitzer sections are close enough to support each other with crew-serve weapon systems and provide aid and litter teams, if necessary. By having all six howitzers in the same area, the first sergeant and the battery medic can move to, treat and evacuate casualties without requiring additional personnel from the firing elements. This allows the battery to keep more howitzers in the fight when the battery takes casualties. Doctrine states, "Indirect fire is the greatest threat to the field artillery (ATP 3-09.50)." The assumption that locating the entire battery within a 1 or 2 kilometer area exposes it to a higher threat from enemy indirect fire is valid. However, this risk can be mitigated through frequent survivability moves, site selection and the tactical implementation of the firing batteries by the fire support coordinator. In the event that the battery receives indirect fire, there are still ways to mitigate the effects and the primary way is through occupation formations.

The most common formation used during occupation is the Lazy W. The Lazy W formation allows for quick and fluid survivability moves. Despite the relative closeness of each howitzer, if given a standard PAA and occupied in zones not quadrants, each howitzer can still achieve a dispersion of 300 meters or more from the adjacent howitzer sections.

If the enemy indirect is less of a concern than the threat from mounted and dismounted attacks, the battery star is an effective formation to implement. In a battery

PAA, a battery star, encompasses one single kilometer grid square with 200-250 meters of dispersion between gun locations. This formation allows the gunline to maintain a 360-degree security posture more effectively than a lazy W while still allowing for gun dispersion.

The battery star formation is predicated on having a significant amount of open terrain, also found in the Mojave Desert. Danger Area Echo is a consideration that must be accounted for utilizing a star formation. If the howitzers in the rear of the star are too close to the howitzers in the front, windshields may be destroyed by the overpressure and personnel could be at risk. Seven-hundred-meter dispersion is recommended to prevent incidents. By massing the firepower of the six howitzers sections and headquarters platoon, the battery is able to defend itself much more adequately while fighting as a battery. Regardless of whether a unit is fighting as a platoon or battery, the risk of indirect fire remains. However, occupation as a battery greatly increases the local security posture.

Logistics and maintenance were additional areas that were benefited by battery operations. Gunny and the maintenance team are able to conduct daily checks on all howitzer sections by having the entire battery in the same 2 kilometers by 2 kilometers PAA. This enables a rapid response to any deficiencies identified and the battery keeps more howitzers in the fight throughout the duration of the rotation. The battery supply section is able to conduct resupply trips to the gunline to distribute Class I to the Soldiers daily. When hot chow is available, it can be taken directly to each individual howitzer section, allowing the howitzer to remain ready to deliver Fires. Having a dedicated operations center, the BOC, battle track sustainment enables the commander to apply the appropriate amount of leadership and oversight to ensure that all classes of supply did not reach critical levels and that all inoperable parts are ordered. The headquarters platoon leader is responsible for traveling back and forth between the battery PAA, battalion ammunitions and logistics operations center, and the battery support area. By having the battery located in relatively close proximity, it enables supplies to be pushed directly to each section. The BOC assumes responsibilities for merging and submitting logistical and maintenance reports which enables leaders to stay focused on the fight, while simultaneously ensuring the battery receives support from higher headquarters. Battery operations greatly increases the commander's ability to ensure that Soldiers and equipment are ready and can stay in the fight, maximizing the delivery of Fires for maneuver formations.

Mission command of a unit conducting battery operations is easier and more efficient than conducting platoon operations. The proximity to subordinate leaders enables the battery commander to make direct linkup with subordinates to disseminate information and command the formation. The commander has the flexibility to be in the FDC to monitor all fire missions from one central location, or the commander has the freedom of movement afforded by the BOC to be outside of a vehicle and personally check on the howitzer sections. The close proximity of the entire battery enables the rapid dissemination of information and quick course corrections when needed. During the orders process, the commander is able to deliver operations orders to all section chiefs and above, in one location, to ensure plans are understood and products are disseminated. The commander is able to receive back briefs from those same section chiefs, in front of all battery leadership, to ensure that all subordinates share understanding.

An effective TTP is the use of a spare platoon frequency to establish a battery command net. This removes administrative traffic off of the battery Fires net. The battery command net can be utilized to pass reconnaissance, selection and occupation of position reports, movement times, relay information from battalion and to discuss any issues. The command net allows the commander to maintain situational awareness required to make decisions from subordinate leaders. Commanders are able to lead their formations without having to be tied to mission command systems and are able to receive and distribute information personally, increasing shared understanding across the formation.

Despite all the evidence provided above, others will still argue that platoon operations are the only way to fight. Doctrine will be cited and deviating from anything not written in an approved Army publication will be discouraged. Our unit did feel the same way initially. It was argued, at length, that platoon operations enable flexibility and survivability and that battery operations would fail. Primary causes for failure were that the formations would be too large and easy to identify and would therefore end up being destroyed by effective indirect fire.

Despite all those arguments and the merit inherit to them, it was ultimately demonstrated at the NTC that battery operations were successful as witnessed by the destruction of Donovian aggressors.

Overall, battery operations proved to be successful at the NTC. By leveraging the capabilities of an entire battery, organizational effectiveness increases. Fire direction centers were more responsive due to the consolidation of AFATDS and the continuity provided from utilizing one vehicle. Soldiers and leaders never become so fatigued that they could not continue operating effectively. Prolonged logistics and maintenance operations are able to be executed that keep guns in the fight and personnel sustained. Leaders are able to be at points of friction and apply the appropriate level of leader oversight. Batteries are able to secure themselves by providing overwhelming fire power on local security threats and alleviates the enemy indirect fire threat. Despite initial reservations about the effectiveness of battery operations, it was found to be a viable method to employ a field artillery battery at the NTC. Army leaders are adaptive enough to employ both formations successfully based on the terrain. Doctrine has articulated that platoon operations are preferred, but this paper argues that it fails to account for environments where battery operations are not only possible, but can actually increase the capabilities of a firing battery.

Environments such as the NTC, similar to desert environments where U.S. Army formations might deploy, are places that battery operations can be employed to enable artillery units to provide more timely, accurate, and sustainable Fires to maneuver units, enabling them to fight and win.

Capt. William Fleming is a battery commander for A Battery, 1st Battalion, 37th Field Artillery (155 mm, towed) at Joint Base Lewis McChord, Wash.

MODERN RADAR

CAN ONE RADAR FIT ALL?

BY RETIRED COL. KURT HEINE AND DR. PHIL REINER

Since World War II, Radio Detection and Ranging (radar) has had a dramatic impact on the way we conduct war and provide for our national defense. There is a growing desire to consolidate radar functions and transition to multi-purpose, single platform radar systems. This paper presents various characteristics of radar systems and explores and discusses key aspects that determine just how far we can (or should) go to achieve that objective.

Today, radar systems are used to provide air, sea, ground and space defense, target tracking and cueing, air-traffic control, weather monitoring, warhead arming and fuzing, environmental sensing and a number of other functions. Military applications can be strategic or, more often, operational and tactical in nature, which then drive the requirements for the radar system and the functions they need to support various weapons systems and platforms. The materiel developers are faced with a wide variety of options and constraints that need to be met to serve various mission needs. In addition, rapid technological advances, both in radar technologies and methodologies to defeat them, drive the need for upgrades to both hardware and software of radar systems.

Several radar technologies have emerged over the years to meet specific performance, cost, size and capability requirements. The cost of these systems, coupled with the increased technological capabilities being developed, cause some military planners to want to consolidate radar systems into common radar platforms capable of performing multiple functions. For example, U.S. Army air defenders must be capable of defeating the full range of enemy air and missile threats in strategic, operational and tactical situations. Threats can include tactical ballistic missiles, cruise missiles (CM), unmanned aircraft systems (UAS), rockets, artillery and mortars (RAM), fixed wing and rotary wing weapons. From a design consideration, the mission of the radar, the characteristics of the target(s) themselves, and the requirements levied upon it, affect the size, weight, and power required to complete the mission. And from a cost consideration, bring us to accept "real life" decisions based upon available budget, or military urgency. Certainly, other factors cause us to accept risk from many of the "ilities," such as mobility, transportability, maintainability, etc. and weigh equally as important in the acquisition of a new radar system. Potentially, as new technologies mature, the ability to combine functions is certainly becoming more of a reality. This paper addresses the questions, "How viable is a single radar solution in meeting current and perceived (future) needs and how far can we really go in developing a 'one solution fits all' radar system?"

Radar history

Early in the 19th century, experiments by Heinrich Hertz showed that metallic objects reflected radio waves. Not until early in the 20th century did German inventor Christian Hülsmeyer design and build a simple ship detection device intended to help avoid collisions in fog. Prior to WWII, radar was first implemented using low frequency radio bands in the 20-30 megahertz range where current AM and FM radio bands reside. At the start of WWII, Great Britain assembled 21 early warning radar sites along its east coast. This network had a range of ~300km with a peak power of 350kW. The system was bi-static, meaning the transmitter and receiver antennae were separate systems. Radar took a giant leap forward with the invention of the multi-cavity magnetron in 1935 by a German electronics specialist. The designs were then refined by British physicist John Randall in 1937.

This invention revolutionized radar systems because it allowed for development of shorter wavelength (X-band) systems that operated at ~10GHz. These systems were much more compact and were easily transported and could be mounted and operated in airplanes. Commensurate with the development of the magnetron, super-heterodyne radio receivers and transmitters were developed that provided the needed means for generating, detecting, amplifying and processing radar signals. Bell Labs used this technology to produce the first active electronically-steered array radar system in 1960. This was another major advance that provided the means to replace the bulky mechanically rotating antennae with smaller electronically-steered arrays. Major advances in signal processing techniques allowed the Bell scientists to perform long-distance detection, generate target track data, discriminate between warheads and decoys, and provide tracking of outbound interceptor missiles. Many of these techniques are still in use today and we owe much of our modern signal processing techniques to their pioneering work.

The next revolution occurred with the invention of the Gunn diode by John Gunn in 1963 followed quickly by the development of microwave striplines and co-planar waveguides circa 1969 by Julius Lange and Cheng Wen respectively. These two inventions resulted in the development of the first chip-scale microwave devices known as Monolithic Microwave Integrated Circuits, or MMICs, by Ray Pengelly and James Turner in 1975. These devices allowed radar developers to reduce the size and weight of systems by more than a factor of 10 and paved the way for developing radars that employed on-board complex signal processing. The final revolution came with the development of solid state phased array radar systems by several groups in the late '70s and early '80s. These innovations are the basis for all modern radar systems.

Fast forward to the present — modern military radar applications are pushed to the extreme and have evolved through a host of technologies that allow operation in several bands that span the electromagnetic spectrum all the way from a few MHz through 100s of GHz frequency range. Radars now perform a wide variety of complex functions such as target detection, classification and discrimination, multi-target ranging and tracking, frequency hopping, jamming, advanced noise and clutter rejection and more. As is the case in commercial electronics and communications, the evolution from purely analog designs to hybrid analog/digital designs continues to drive advances in radar system capabilities and performance.

Radar signals are becoming increasingly agile and signal formats and modulation schemes, pulsed and otherwise, continue to become more complex. As a result, developers are faced with demands for wider bandwidth in more narrow spectrums. This is exacerbated as commercial use of these bands in the private sector increase. Advancements can also be hindered by material limitations. Architectures such as active electronically steered array (AESA), for example, rely on advanced high-speed, low-loss semi-conductors and other materials to implement phased-array antennas that provide greater performance in beam forming and beam steering. Within the operating environment, the range of complexities that must be addressed to achieve mission requirements may include ground and sea clutter, jamming and interference, unwanted wireless communication signals and other

Radar	Mission	Operating Band	Range, kilometers (km), miles (mi.)	Power Required, kilowatts (kW)	Support Required
AN/TPQ-36	Firefinder, counter target acquisition/mortar	X-Band	24 km 15 mi.	10 kW > 23 kW peak transmission	2 HMMWV 9 Soldiers
AN/TPQ-37	Firefinder, counter target acquisition/mortar	S-Band	50 km 30 mi.	60 kW >120 kW peak transmission	1 HMMWV 2 M925A2 12 Soldiers
AN/TPQ-50	Counter target acquisition/rocket, artillery and mortar	L-Band	10 km 6 mi.	5 kW	Man portable 2 Soldiers
AN/TPQ-53	Counter target acquisition/rocket, artillery and mortar	S-Band	**90 degree:** 60 km 36 mi. **360 degrees:** 20 km 12 mi.	10 kW	1 FMTV 5 Soldiers
AN/MPQ-53	Missile/cruise missile, Patriot guidance, electronic counter-countermeasure	C-Band	100 km 60 mi.	2 x 150 kW 100 kW	1 M983 tractor 1 M860 semi-trailer 4 Soldiers
AN/MPQ-64	Low-altitude, medium-range air defense	X-Band	**AN/MP-64** 40 km 25 mi. **AN/MP-64F1** 75 km 47 mi.	10 kW	1 HMMWV 2 Soldiers
AN/TPY-2	Ballistic missile detection, terminal high altitude air defense target and track	X-Band	1000 km 600 mi.	1300 kW	2 HEMTT 8 Soldiers

Figure 1. A comparison of common ground-based air defense and field artillery radar systems.

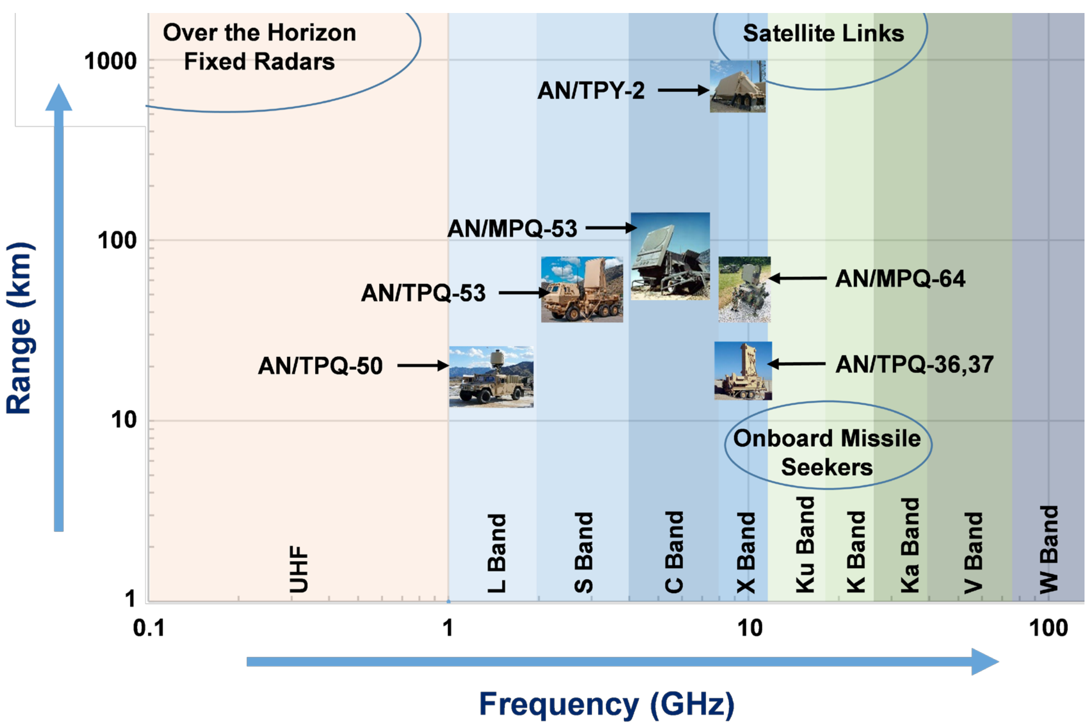
forms of electromagnetic noise. Modern systems must also have the ability to prosecute multiple targets, many of which use materials and technologies that present a reduced radar cross section.

Current radar systems

A wide variety of radar systems are currently in use by the Army. Figure 1 includes some of the more familiar short, medium, and long-range systems currently in our inventory. For this study, we include only the ground-based systems, but it should be noted that different forms of radar are employed in most aircraft systems and in several missile systems. The table shows the types of ground-based radars in use, their effective range, the wavebands in which they operate, and the power requirements and/or peak power output. It should be noted that there are often many variants of these systems and the key parameters listed here are their nominal values for general comparison.

This table shows the ground-based radar systems are generally confined to L, S, C and X-band wavelengths (frequencies) which span the range from ~1GHz up through 18 GHz. Later, we will point out the reason why this is so. The data here also points out that longer detection range requires higher power. One often overlooked factor is the trade-off between range and mobility. Generally, the longer the range required, the larger the power requirements and the less mobile the system becomes. The AN/TPY-2 is a very large system that requires a set of tractor-trailers (heavy expanded mobility tactical trucks) for transport of the radar and separate 1.3MW power generator. It is usually set up for long term operations. Figure 2 shows the relationship between the operating bands and range for

Figure 2. Comparison of operating frequency bands and range for common radar assets.



these systems along with fixed radar sites and missile seekers for perspective.

Historically, each radar was developed to perform a specific mission. As technologies improved, they were routinely upgraded to increase range and resolution on a case-by-case basis. Questions about who has the mission and how those assets are resourced and maintained are all driven by the threat and how we resource to meet those threats. Counter target acquisition (CTA) radars were originally designed to provide counter-battery capability against artillery and mortars. However asymmetric threats such as missiles and UAS have spurred the development of newer systems capable of tracking more types of targets. Communicating in an integrated air and missile defense environment dictates these systems can communicate with other air defense command and control entities in order to "see" the complete air defense operational picture, with the eventual goal that commanders can shoot any weapon available to destroy any target specified.

Real-world budgets, along with resource requirements influence the Army with the goal to increase efficiencies in support, logistics and numbers of systems and to reduce duplication of systems by combining missions. This was envisioned in early 2002 and stated that in the future, the (then) multi-mission radar (MMR) would support air surveillance, air defense, counter-target acquisition (CTA) and air traffic control. The goal of the MMR was to close traditional gaps in current radar applications, including lack of multi-mission functionality, 360-degree coverage with a single radar, precise counter battery/counter mortar capabilities, classification of threats and positive identification. Multi-mode radars continue to develop, although there are none at this time that can accomplish 100 percent of the air defense missions.

An AN/MPQ-64 Sentinel Air Defense System from South Carolina Army National Guard's 263rd Army Air and Missile Defense Command is set up in preparation for the Vigilant Shield Air Defense Artillery Field Training Exercise on August 14, 2016. (Cpl. Joseph Morin/Canadian Armed Forces)

The physics of radar systems

Imagine you decide you want to use your minivan to compete in a Formula One Race. It is doubtful that your van will take corners at over 100 mph more than once. Truthfully, the design of the minivan does not satisfy the physics-based requirements of getting around a corner at those speeds. You need to design a vehicle specifically to meet the requirements of the mission. Similarly, the design of radar systems is governed by physical laws that dictate performance parameters such as transmitter power, gain of the transmitting antenna, radar cross section, size of the radar aperture, required bandwidth, type of radar interrogating signal and the algorithms employed to complete the desired mission. These parameters provide a trade space that determines how well the system will perform. They must be balanced against target type and distance, temperature, radar noise, clutter and environmental effects.

To begin this discussion, we describe the basic radar range equation. It's the basis for understanding the physics of radar systems, their capabilities and resulting decisions that have to be made to ensure optimal performance. The equation has not changed, nor has the physics or mathematical principles since the inception of radar.

The basic radar range equation

Conceptually, each radar consists of a source antenna which transmits a pulse of radio waves outward and a receiver that collects signals reflected off objects within the field of view of the radar. In most modern systems, the source antenna and receiving antenna are one and the same and special switches are used to alternate between transmit mode and receive mode. If all goes well, the transmitted pulse of radio frequency energy reflects off the target and is collected by the receiver and analyzed.

The basic radar equation shows that the size of the returned signal depends on four key variables:

1. Output power of the transmitter
2. Gain of the antenna
3. Operating wavelength
4. Range to the target

This equates to the ultimate signal to noise ratio.

This points out two of the fundamental limitations that drive the size and power requirements of modern radars.

1. The higher the power and gain of the antenna, the larger the return signal (greater signal to noise ratio). Conversely, the farther the object is from the transmitter and receiver, the smaller the return signal becomes. In fact, the return signal drops off as the fourth power of the range. For example, if the radar transmitter puts out a total power of 1kW into an antenna with gain of 100, a 1 m2 target at a range of 1km will at best return a signal of 100 nW/m2. (Essentially for each watt of signal going out, only 1 billionth of a watt gets returned.) In practical terms, this means that we need to have as much power coming out of the transmitter as possible and we need

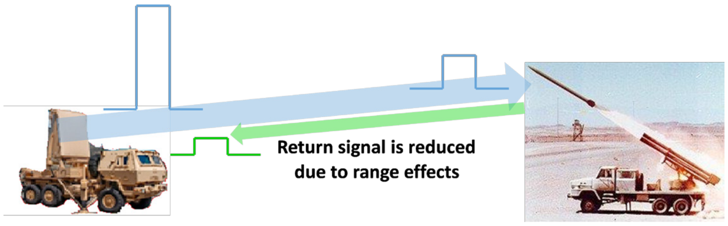


Figure 3. Illustration showing the effect of range on target return signals. (Courtesy Illustration)

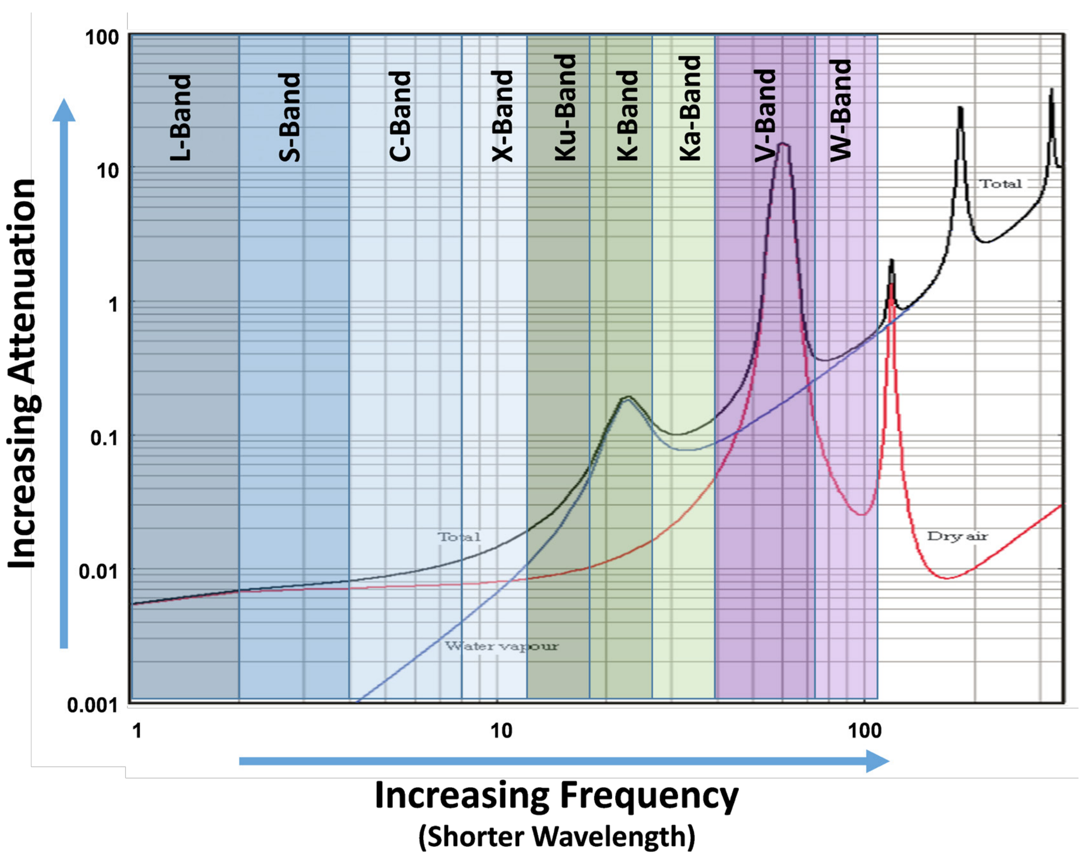
to couple that to an antenna with large gain. (This last fact is what drives us to use parabolic reflectors and phase array antennas for common radar scanning systems.) The larger the gain, the better the radar return signal, but we also have to have as large a receiving antenna as possible to collect the return signal. The effects of range are illustrated in Figure 3. The illustration shows how the signal naturally decreases simply due to the expansion of the radar wave as it exits the transmitter. This effect occurs regardless of the type or size of the radar system. (The blue colored pulse represents the outgoing or transmitted radar signal and the green colored pulse represents the return signal from the target.)

2. The second and less obvious limitation is that the return signal varies directly with the square of the wavelength. This means the range that we can achieve increases by increasing the wavelength, which in turn implies both a larger transmitting and receiving antennae. For instance, an S-Band radar operating from 4 to 8 GHz (with a wavelength of ~8 cm to 4 cm) has inherently less attenuation and capability to detect targets at longer range than an X-band radar operating from 8 to 12 GHz (with a corresponding wavelength from 4 cm to 2.5 cm). However, as a rule the S-band radar components are nearly twice the size of X-band components. Figure 4 shows the reason why this is the case. Two of the major constituents in the atmosphere are oxygen and water and these components absorb radio frequency energy. As shown by the black line in the figure, the higher the frequency, the more they absorb and hence, the less energy our transmitter can place on the target. In order to detect a target at a given range, we either must transmit more power or move to a lower frequency. In addition, there are specific wavelength regions where the absorption is so high that it is impractical to operate a radar system. These are the high spikes shown in Figure 4. This is the reason K and V-bands are not typically used for ground and sea-based radar systems.

As previously stated, these two limitations are the major drivers for the size and power requirements of modern radar systems. Additionally, the size will be dictated by the mission requirements. For instance, the desired detection range for acquiring and tracking incoming ballistic missiles is ~120 miles, while the requirements for detecting rockets, artillery and mortars (RAM) is considerably shorter (12-36 miles). Often, the radar designer must trade size and power (along with operating frequency) for range and resolution. For example, the AN/TPQ-53 is a mobile S-band radar system for RAM and has a nominal output of 8KW. To get better target resolution at ranges needed for detection of ballistic missiles, the AN/TPY-2 operates at X-band frequencies with a larger antenna and a much higher power output (typically ~1.3MW). These two systems also typify the additional problem that the size and power requirements drive the logistics footprint of the RADAR system as well as its maneuverability. The AN/TPY-2 system requires multiple tractor trailers to include power generation trailers, target command module and other ancillary equipment. The AN/TPQ-53 is a highly mobile, self-contained, dual vehicle platform. Note however that it can sometimes be used with a single vehicle however this is not the intended operational configuration.

Another significant limitation is driven by environmental (atmospheric scatter) effects. Generally, rain, snow, dust and smoke in the atmosphere scatters the radar signals and decreases both the strength of the

Figure 4. Atmospheric attenuation of radar signals as a function of frequency. (Courtesy illustration)



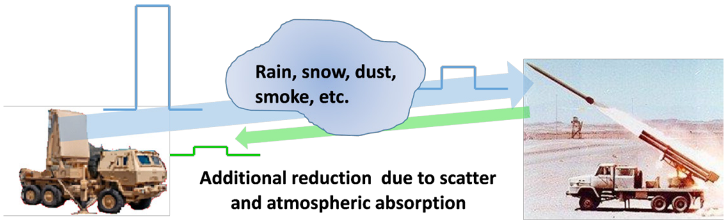


Figure 5. Illustration of additional attenuation due to scatter and absorption due to dust, rain and smoke. (Courtesy illustration)

outgoing (interrogating) signal and the target (return) signal. Figure 5 illustrates how radar signals are attenuated by these effects. The figure illustrates how dust, smoke, rain and snow reduce the transmitted and received signals even further.

Another major driver for radar systems is the ability to accurately determine position and range. Position is largely driven by how tightly the radar beam is formed. Essentially, the higher the antenna gain, the tighter the beam and hence the more accuracy in determining the location of the target. This is another reason why scanning radars for airports use parabolic shaped antennae. The parabolic shape affords a very high gain which in turn implies sharper focus of the radar beam and better target position determination. This same high gain is now achieved using flat panel arrays called phased array antennae. The arrays consist of a series of transmitter modules designed to focus the radar beam down range. The advantage of these systems is that they are much more agile than rotating parabolic reflectors and also support more than one radar function at a time. They also weigh less and take up less space.

The ability to determine the range of a target is governed by two factors. The first factor is how short the radar pulse is and the second factor is the operating frequency of the radar. The shorter the pulse and the higher the operating frequency, the better the range resolution. In addition, the radar designer must also be able to provide the ability to resolve multiple closely spaced targets or discriminate targets from decoys using fine target features. Again, higher frequencies imply better target resolution and better ability to detect structural features on the target. This points out a major trade analysis that needs to be performed for any radar system. One the one hand, we desire to use lower frequencies to get our transmitted signals out as far as possible to obtain better range coverage, but we need higher frequencies to get better target range tracking data. Figure 6 illustrates the effects of frequency on the ability to discern targets. In the upper portion of the figure, a lower frequency signal can detect that some kind of target is there, but a higher frequency signal as shown in the lower portion is needed to resolve the return signal into two separate targets.

These effects are the fundamental drivers that dictate how many and what type of radar systems are needed. For expeditionary and fast moving forces, smaller, lighter and cheaper is better but there is a limit on how small we can go driven by the factors already discussed.

Designing a radar: What is required?

The next consideration for radar systems is their intended mission. We have already pointed out the need for different range capability. What was not discussed is the fact that different radars have different functions and the scope of those functions is constantly increasing. The ability to meet these demands are often driven by technological advances and their maturity level and availability.

When designing a radar system, here are some of the primary considerations:

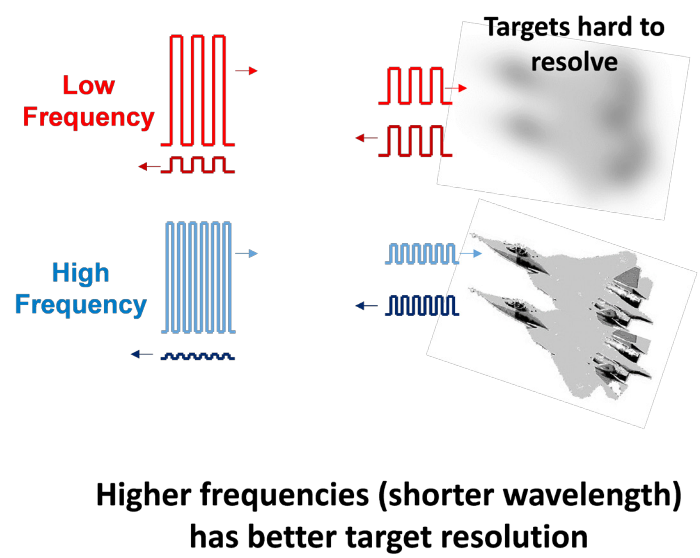
- Mission requirements: Do I require the ability to perform:
  - ◊ Weather monitoring
  - ◊ Fire-control
  - ◊ Target search and track capability
  - ◊ Target illumination
  - ◊ Target discrimination
  - ◊ Target tracking, i.e. single versus multiple targets
  - ◊ Continuous operations or short-lived operation
- Physical system requirements: What capability does the radar need? What are the specifications for:
  - ◊ Scan capability including scan angles and rate
  - ◊ Detection or illumination range
  - ◊ Target resolution at maximum range
  - ◊ Target tracking rate and accuracy, (Do I need Doppler and if so, how accurate?)
  - ◊ Size, weight, and power (SWAP) constraints
  - ◊ Mobility requirements
  - ◊ Platform requirements, etc.
- Support requirements: Do I require:
  - ◊ High mobility, i.e. smaller, lighter, lower power
  - ◊ Large or small support team
  - ◊ Interconnectivity with higher and lower combat units
  - ◊ Continuous, sustained operations
  - ◊ Auxiliary power
  - ◊ Redundancy
  - ◊ Ability to upgrade, etc.

Each of these requirements can and usually is a driver that must be considered in the radar system design. In the following sections we discuss some of these aspects in more detail.

Convergence of military electronics systems

State-of-the-art military sensors have unprecedented requirements to measure and process large volumes of data. To handle this data and provide "actionable intelligence" to the Soldier as soon as possible, sensor system logic requires opti-

Figure 6. Illustration of the effects of frequency on the ability to resolve targets. (Courtesy illustration)



Soldiers assigned to the 1st Battalion, 113th Field Artillery, North Carolina Army National Guard, prepare a radar display at Bulboaca Training Area, Moldova, Sept. 14, 2016, as part of multinational exercise Fire Shield 2016. The exercise, hosted by the Republic of Moldova Sept. 9-25, 2016, is an opportunity for the NCNG's 1-113th FA and 1st Battalion, 120th Infantry Regiment to develop relationships and improve capabilities with European partners. (Sgt. 1st Class Robert Jordan/U.S. Army National Guard)

mized combinations of logic and digital signal processing (DSP) density high-speed transceivers, power-versus-performance design flexibility, and high-assurance design flow to meet end-user requirements. U.S. military systems and vehicles have traditionally housed many separate electronic subsystems associated with radar. Among the most sophisticated of these is targeting radar and surveillance radar. Within the air defense mission, both functions are equally important. The more capable the radar, the greater the range and ability to resolve the target, the faster the enemy can be detected, assessed and prosecuted with the number and type of weapons available. These functions have been slowly converging over time, mainly due to increases in material sciences, and computing (Moore's Law) and other electronic technologies. Many Army radar systems are moving towards the use of multi-mode active electronically scanned arrays (AESA). These AESA systems provide advantages in the ability to quickly form multiple beams and to use each transmit and receive module (TRM) for concurrent roles, i.e. simultaneous scanning and detection, and produce "active arrays." However, as these systems become more complex, there need significantly increases for both the digital- and state-logic requirements of the system, which in turn demands industry responses for more sophisticated software solutions, power generation, and certainly with more sophisticated fixed and programmable logic devices (PLDs).

Technology to meet increasingly difficult missions

Army missions are beginning to overlap significantly, mostly because of an uncertain enemy, and the asymmetric nature of warfare. Set boundaries between traditionally defined front line areas and rear areas have all but disappeared, and the expectation that an agile enemy can attack with a variety of systems, from conventional ammunition such as mortars or UAS of varying sophistication to advanced missiles and fighters, is all within the realm of the possible. Therefore, the explosive growth in memory and semi-conductor capacity capability to perform these activities has enabled the growth of multi-role systems. Field-programmable gate array (FPGA) and structured application-specific integrated circuits (ASIC) continue to play a significant part in building the backbone of solid-state transmit and receive modules used in our most modern radars, i.e. AESA radars, also known as active phased array radars (APARs). Complex phased array radars may have thousands of transmit/receive modules operating in parallel. In addition, these may rely on a variety of sophisticated techniques to improve performance, to include: side lobe nulling, staggered pulse repetition interval, frequency agility, real-time waveform optimization, wideband chirps and target-recognition capability.

Advanced radar sensor requirements

The challenges in military advanced sensor design are demanding. Below are some examples of some of the technical design constraints that affect the size, weight and power, of the radar and directly influence other decisions, such as cost, supportability, maintainability, agility, etc. Some examples of these technical constraints are:

- High serial data-streaming capacity: Digital antenna technology moves analog-to-digital conversion closer to the receiver, and requires more signal resolution in order to perform digital filtering.
- Complex math operations: Signal pre-processing and matrix operations require large numbers of digital signal processing block elements to assume the roles traditionally filled by digital signal processors.
- Sensitivity to heat dissipation: Sensor systems often have a long, if not continuous, mission life, requiring the dissipation of heat from continuous operation.
- Logic density for multi-role electronics: With so many military missions being performed with the same array, logic requirements are extremely high in transmit and receive electronics.
- Speed and latency performance: The speed grade and latency of the logic devices in a sensor array, as well as all the latency of interfaces between logic devices, affect the reaction times and beam-forming algorithm performance.
- Parts availability: Sensor systems are very complex, and the impact of even one part received behind schedule can have consequences for both operations and sustainment costs and operational readiness.
- Tool-flow ease of use: As millions of logic elements are integrated into a system design, the design, compilation and test of large pieces of logic code is a substantial driver of both cost and schedule.
- Signal integrity: As more receiver elements provide data to be correlated with one another in final processing, small signal errors have larger impacts on sensor algorithms. Signal integrity in digital components is therefore paramount.

One of the major innovations that forever changed the way we think about radar systems is the advent of monolithic microwave integrated circuits (MMIC) technology in the 1970s. It paved the way for reduction of component size and allowed exploration of miniaturized radar systems. Up until this time, radar systems relied heavily on hollow waveguide systems and components resembling square pipes. These "pipes" conduct the radar signals to and from the microwave sources, signal processors and antennae elements. MMIC technology essentially provided low loss waveguides and components at the integrated chip level that reduced the size of microwave systems by more than an order of magnitude. MMIC circuits increase the incoming radar signals while decreasing the signals (noise) coming backwards through the radar amplifier. The key benefit of this technology is the ability to create agile scanning systems (phased array radar) with greatly reduced size, power and weight. Not withstanding, the aperture size of the antennae required remains the same.

Material science improves radar designs

There have been interesting breakthroughs in material science, which have and will continue to enhance radar design and technology. One such example is metamaterials. Material engineers define metamaterials as artificially engineered materials that have properties not yet found in nature. Metamaterials derive their properties not from the compositional properties of the base materials, but from their exactingly designed structures.

Potential applications of metamaterials are diverse and include remote aerospace applications, sensor detection and infrastructure monitoring, smart solar power management, public safety, radomes, high-frequency battlefield communication and lenses for high-gain antennas, improving ultrasonic sensors and even shielding structures from earthquakes.

How do these new materials help? A key feature of radar systems is the ability to scan in two or three dimensions. There are two basic technology choices for scanning radar. Today, radars are migrating (in general) from the older mechanically scanned systems (MSRs) in which an antenna (such as a parabolic dish or slotted wave-guide) rotates to cover a wide field of view, usually 360 degrees to electronically scanned radars (ESRs).

In the older mechanical systems, the rate at which we scan the image is constrained by the speed of the mechanism chosen. In ESRs, beam steering is achieved electronically with a passive or active phased array, as in PESA or AESA. Depending on the frequency and aperture size, there could be thousands of individual amplifiers, phase shifters, and other components spread across the antenna, adding cost and complexity. What the Army needs is a very low cost radar technology that can also deliver wide-angle ESR performance. ESRs are difficult to integrate, hard to thermally manage, extremely expensive and are generally reserved for high-value applications.

Because of the unique advantages of metamaterial, there is an expectation to develop new kinds of affordable, compact and lightweight scanning radar products. As an example, metamaterials surface antenna technology (MSA-T) antenna designs can step-up the antenna's radiated power, and aid applications in radar such as wide-angle beam steering. Why is that important? Conventional antennas that are very small compared to the wavelength usually reflect most of the signal back to the source. A MSA-T antenna behaves as if it were much larger than its actual size, because its novel structure stores and re-radiates energy.

Use of AESAs for design flexibility

As stated earlier, AESAs are a powerful technology for creating highly adaptive steerable beams. In turn, these beams are able to track multiple targets or focus electromagnetic energy in one location. In order to take full advantage of a system's steering capabilities, designers work to move as much signal processing capability as possible into the forward radiating elements of the system. This may include waveform creation and compression, beamforming, correlation, and pre-processing. AESAs perform and optimize more and more functions, parallel FPGA logic, beamforming algorithms and waveform adaptivity can be accelerated, increasing reaction times in the system. High-density series FPGAs are the right tool for optimizing radar system performance. High logic density allows more functions in a single chip. Increased DSP elements streamline matrix mathematical functions and increase flexibility. Highly flexible 18x18-bit multipliers can be split into 9x9-bit elements, or combined into power and logic-efficient 54-bit multipliers for floating-point operations.

Other technology considerations

The proliferation of active arrays in sensors is the primary technology driver in logic device content. A larger number of array elements equals more design work, more beamforming algorithms, more integration and testing, and a longer logistics tail for the system. In order to meet the diverse computing needs for air defense systems, Army customers have been investing in reconfigurable processors that can perform both front-end and back-end processing. Programmable logic has been the interim design step for critical sensor requirements.

A new dimension to sensor design is experimentation with multiple-input, multiple-output (MIMO) sensor arrays. Receivers in a MIMO system perform phase-delay correlation between multiple orthogonal transmitted waveforms, exploiting advances in electronics density and computing capability. OEMs and developers who will lead in this market will be the ones that best take advantage of the most advanced and logic-intensive devices with the simplest design flow and most efficient compilation profiles.

Radar designers are confronted with a number of trade-offs. One of the most important is the trade between required range and available resolution. This trade exists because as we stated before, for a given power level, the effective range of a radar decreases with increasing frequency. At the same time, target resolution generally increases with increasing frequency. Hence the designer must pick a frequency which balances the range requirements with the needed resolution. This is depicted in Figure 7. There is usually a "sweet spot" where the range versus frequency curve (shown in blue) crosses the resolution versus frequency curve (shown in red). This "sweet spot" can be moved to higher frequencies by increasing the power output of the radar system. This is the reason that the AN/TPY-2, which operates in the X-band, requires a power output of 1.3 megawatts. The high output power guarantees that the system can maintain the high resolution requirements afforded by operating in the X-band and still achieve ranges out to 1000 km. Said another way, if the system were designed for the L-band, the required power to reach 1,000 km would be much less, but the system would have nearly a factor of 10 poorer resolution.

There are also system level trades (size, weight and power, also known as SWAP) to be made, particularly when we include supporting hardware such as generators, vehicles, and radar pointing and elevation control platforms. Generally, for a given range capability, as the operating frequency increases, the size, weight and power draw of the components decrease. This is largely due to the fact that the wavelength is shorter for higher frequencies so the components are simply smaller than their long wavelength counterparts. As a result, the radar platforms generally get smaller along with the generators needed to power them. In turn, this means that the mobility goes up with higher frequencies. Figure 8 depicts these trends. The blue line shows how the SWAP requirements decrease with increasing frequency. At the same time, the mobility increases. This is one of the reasons that we use K-band radars on the PAC-3 (Patriot) missile system rather than an S-band system for instance. An S-band system is simply too large and heavy to consider for that application. Another example is the difference in support requirements for the AN/MPQ-64 compared to the AN/TPY-2. Both of these radar systems operate in the X-band. The longer range of the AN/TPY-2 over the AN/MPQ-64 (1000 km versus 64 km) requires nearly twenty times the power. Obviously, the equipment is much heavier and as a result, the AN/TPY-2 requires two (2) HEMTTs for transport compared to one (1) HMMWV for the AN/MPQ-64.

Life cycle considerations

The development of these complex radar systems with complex sensors tends to be among the most difficult projects to manage. As shown in Table 1, current radar systems

Figure 7. Illustration of how frequency relates to range and resolution. (Courtesy illustration)

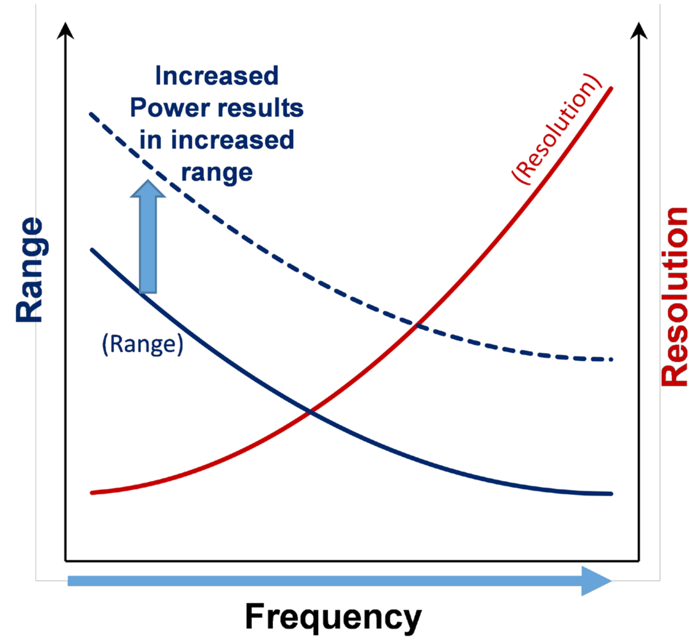
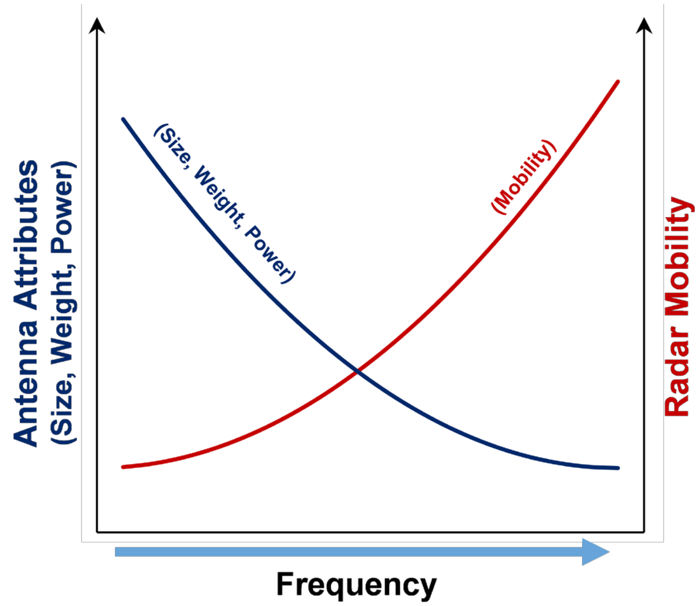


Figure 8. Illustration of how frequency relates to antenna size and mobility. (Courtesy illustration)



From the left, Chief Warrant Officer 2 Chris Fortune, Spec. Mike Stevenson and Warrant Officer Candidate Armand Hunter assemble the AN/TPQ-50 Lightweight Counter-Mortar Radar system, July 23, 2016, as part of annual training with the 1st Battalion, 101st Field Artillery Regiment, at Joint Base McGuire-Dix-Lakehurst. (Staff Sgt. Steven Littlefield/1st BN, 101st FA)

have undergone years of development and testing before their fielding. Over time, those systems continue to improve as breakthroughs in technology continue to make systems more efficient. The Army tends to use their radars for many years, relying on engineering upgrades as technology moves forward. To build a radar today, there are literally dozens of technologies that require integration. Some technologies, such as metamaterials, are untested beyond initial brass board prototypes. The logistics chain, supportability and maintainability are key "ilities" in the consideration of the cost of not only building, but also maintaining a radar system.

S&T and logistics

Clearly, an opportunity exists to continue to work with early developers, including Army Materiel Command and its partnerships with industry and academia, as well as with Army requirements generators in Army Training and Doctrine Command and within the Assistant Secretary of the Army for Acquisition, Logistics and Technology, to determine the relative glide path of future radar technology, and how AMC can best insure we are synchronized to influence the science, but also the transition of technologies in a way that encompasses the best material and technological solutions to support the warfighter once the system is fielded. Considerations to the industrial base requirements may be different for future systems, precious materials, and the development of complex modules and software. Clearly, given a set of clear guidelines, Army Materiel Systems Analysis Activity can help define what "right" will look like from a life-cycle perspective. There should be a logical sequence of meetings within the Army, and with Industry to determine our future for radar.

One radar fits all? Probably not, but...

The radar range equation has not changed, physics has not changed, and the laws that govern electronic signals, wavelengths and frequencies have not changed. It will be hard in the near-term to build radar that meets all the qualifications/Key Performance Parameters (KPPs) of current single systems to any degree of satisfaction. There is no point in designing and building a radar that can't meet all the current KPPs of the radars it is projected to replace. Modern AESA radars have the most design constraints, the longest design cycles and the largest design management needs because of large engineering and verification teams. There are also significant trades in radar design to accomplish in order to size and tailor the radar for its mission. The more capability a single radar must have, i.e. MMR "class" of radars projected to accomplish multiple takes, requires more complex designs, and significantly more complex hardware tooling and accompanying software to test the radar, and will likely increase the per unit cost. Trade space for weight, power, transportability and maintainability become harder to make as the demands on a single system increase. Can it be air transportable, moved by a light vehicle and detect an incoming cruise missile far enough away to react, and at the same time protect a forward operating base from incoming mortar or artillery rounds? Can the radar see through the atmosphere at ground lower angles and be just as successful with smaller targets as it is with higher targets? Can the radar communicate within its mission and communicate with other radar systems in a more strategic view, and with command authorities in a global view? Can your Mini-van compete well in Formula One racing?

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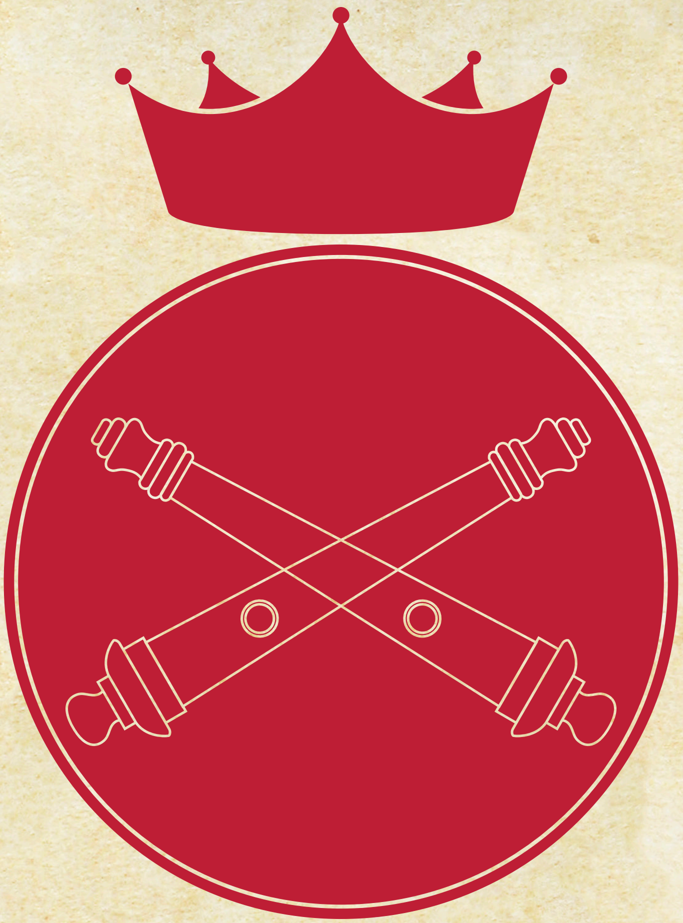


Keeping the king on his throne, Part II

The timely delivery of multinational Fires

By Maj. (P) Jason Carter, Maj. (P) Joshua Severs and Capt. Robert Auletta

The theme of the "Keeping the king on his throne," series is a shift from tactical isolation to consistent integration as a warfighting function. In the first article published in the September-October 2016 edition of the Fires Bulletin, we highlighted the purpose of multinational Fires and the uniqueness of the Fires warfighting function at the Joint Multinational Readiness Center, mainly deterrence and the requirement for interoperability during unified land operations (ULO) in a decisive action training environment (DATE). Although members of the Fires community are technically competent, Fires as a multinational warfighting function is often tactically isolated. This is due to an inability of many fire supporters to competently and confidently advise commanders to a standard that allows them to visualize how Fires enable their operational plans. It is compounded by commanders who lack a foundational knowledge of Fires integration.

The effectiveness of allied forces in peace, crisis or in conflict, depends on the ability of the forces provided to operate together coherently, effectively and efficiently. Allied joint operations should be prepared for, planned and conducted in a manner that makes the best use of the relative strengths and capabilities of the forces which members offer for an operation.

AJP-01(D) Allied Joint Doctrine.

While inadvertently omitted from the first article, this advice should also include leveraging the *King of Battle* to affect not only enemy forces, but also their systems. The psychological impact of being ground to a halt because area Fires have destroyed a peer/near peer enemy's logistics capabilities is tremendous and can give us a decisive advantage against the enemy's capability and capacity to be offensive.

This article focuses on the timely delivery of multinational Fires in support of a commander's operational plans. Specifically, we will highlight airspace control (AC) and digital interoperability challenges in a multinational environment.

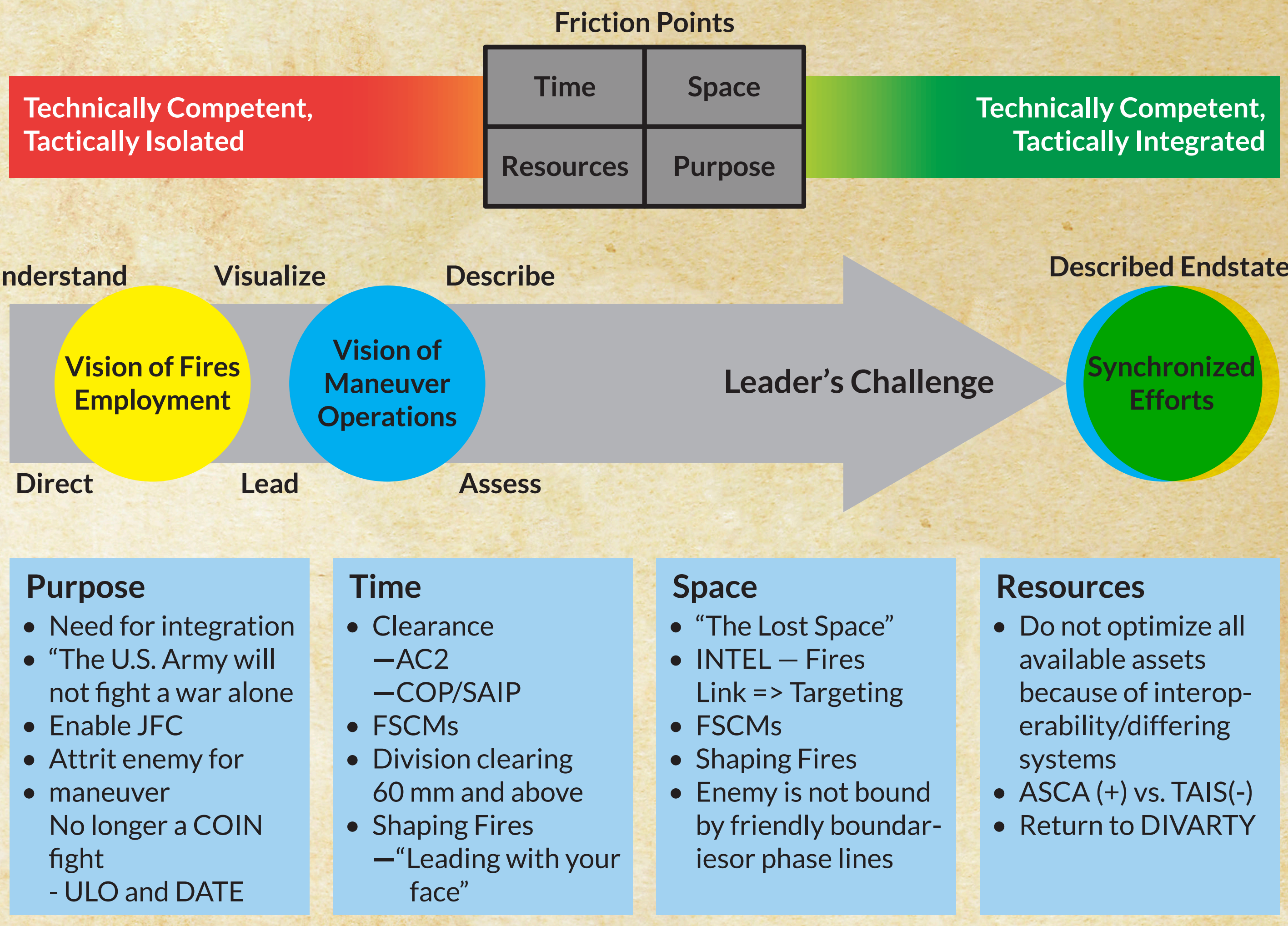
Lt. Col. Pat Proctor's observations at JRTC noted in his "Clearance of Fires Part II: Air clearance of Fires" article are consistent with those at the JMRC. Brigade combat teams consistently struggle to establish and manage airspace coordinating measures and routinely struggle to incorporate airspace management processes into their clearance of Fires battle drills. Further, in a multinational environment, the lack of a single integrated air picture and varied multinational adherence to fire support coordination measures and airspace coordinating measures further complicate that challenge.

Current NATO and U.S. force airspace control doctrine do not complement each other. NATO doctrine still focuses on centralized airspace management processes while U.S. doctrine has moved to more decentralized processes that allow airspace clearance approval to be conducted at the tactical level.

Army battle command systems in a multinational environment

An interoperability challenge for digital airspace management surfaced during a recent multinational rotation at the JMRC when the U.S. digital system and the NATO digital system were unable to communicate. The joint task force (JTF) command post was a U.S. division with two subordinate brigades. One brigade was a U.S. brigade combat team. The other was a multinational brigade combat team. The U.S. – both at the joint task force (division) level and brigade level – managed airspace using the Tactical Airspace Integration System (TAIS), while the multinational brigade used the Integrated Command and Control (ICC) system, which is common to NATO (See Figure 2). The airspace system operators for each bri-

Figure 1. An illustration of the "Keeping the King on His Throne Concept." (Rick Paape)



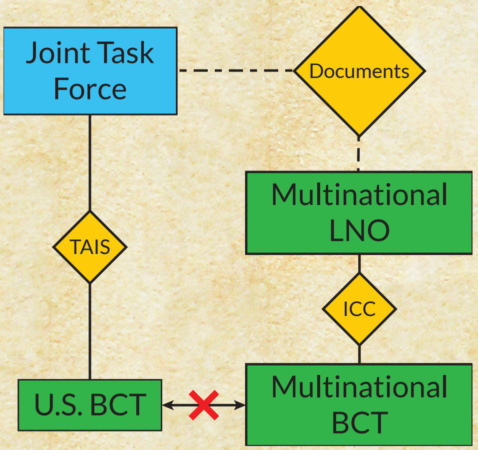


Figure 2. An illustration depicting Joint Task Force Airspace Control Systems during the recent Decisive action training environment rotation. (Rick Paape)

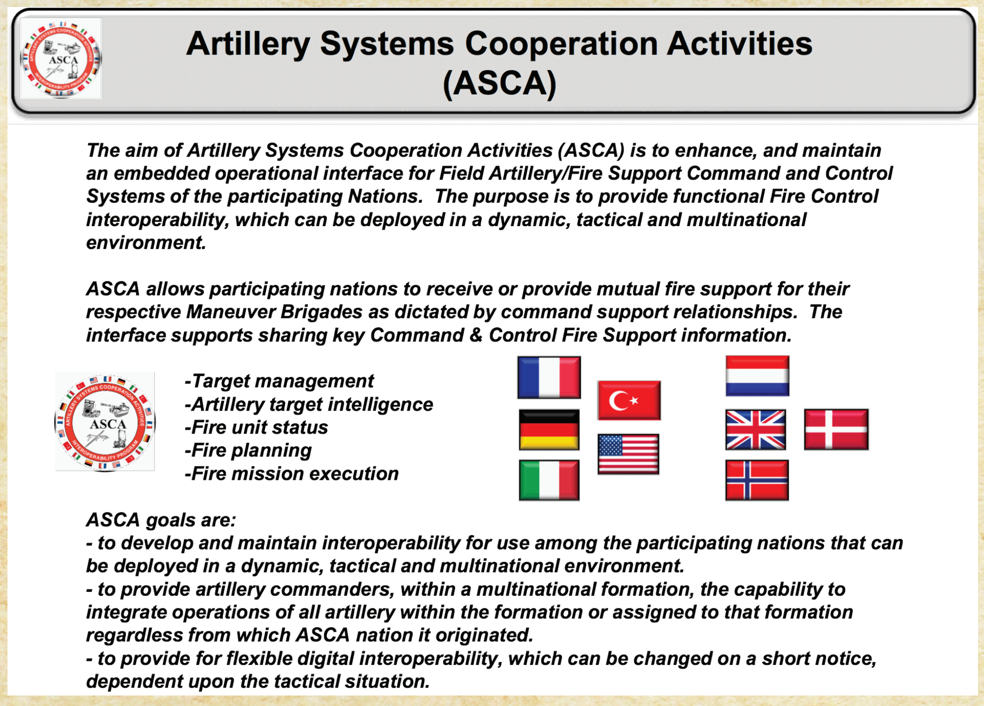


Figure 3. Artillery Systems Cooperation Activities' goals. (Courtesy illustration)

gade believed that ICC would not accept the formatting used by TAIS to distribute airspace coordinating measures (ACMs), the airspace control order (ACO) and the unit airspace plan (UAP). Because none of the observer controllers at the JMRC had faced this problem set before, they believed the same to be true. As a result, the joint task force used its multinational liaison office (LNO) cell to manually input all airspace management data into ICC for distribution from a Microsoft Word document created by the JTF and placed it on a shared portal. Two problems surfaced.

First, the sheer volume of ACMs (grids for dimensions, altitude blocks, active times, operating airspace users and controller information) and dynamic nature of the DATE left the ICC operator constantly playing "catch-up" to manage and approve airspace. While manageable given the size of the Hohenfels training area, managing airspace like this in a real-world NATO operation would overwhelm any ICC operator. Further, there is potential for increased risk of human error when responding to dynamic airspace clearance requests.

Second, because of a lack of a single integrated air picture below the joint task force (division) level, the joint task force initially controlled all airspace from the surface to 12000' mean sea level (MSL), which was the coordinating altitude with the Combined Forces Air Component Command. Non-existent digital interoperability and positive control meant there was uncertainty as to what ACMs the multinational force had and which ones they didn't. Therefore, the JTF was initially clearing every fire mission, from 60 mm mortars to rockets being fired from its general support field artillery battalion. Manning shortages and the DATE volume of Fires quickly oversaturated the joint task force, and fire mission processing times were severely degraded. Commanders were left without fire support on several occasions.

The JTF's solution

In the absence of a digital solution that would have allowed all airspace management systems to communicate and provide a more permissive environment for multinational Fires, the JTF delegated airspace control to each of its brigades. After establishing a 2500' MSL coordination level for rotary wing and transit corridors between brigade boundaries, the JTF delegated airspace control up to 10000' MSL to each of the brigades and retained control of airspace from 10000' to 12000' MSL. Artillery battalions then established artillery mission areas and managed charges to keep all Fires under this coordinating altitude. The JTF retained the authority for clearance of all cross-boundary and general support Fires. While this removed some of the burden from the JTF and resulted in a more permissive Fires environment for the brigades, there was still a level of risk involved because digital interoperability was still missing. Further, the enemy is not bound by friendly boundaries, so several missions still went to the division for clearance because they required cross-boundary Fires.

This type of delegation of airspace management to the brigade level is in line with FM 3-52's doctrinal method. If the premise is true that the United States will never fight alone again and will always commit to collective defense in support of NATO Article V, then NATO airspace doctrine should be updated to spell this decentralization out. Additionally, there must be a digital solution to optimize interoperability for multinational airspace management.

The good news is that the solution already exists. The bad news is that there doesn't seem to be a lot of systems operators that know about it.

The (temporary) digital solution

While there is no direct ICC to TAIS interface, operators can create ACMs on ICC and save that file in a location that is accessible by both TAIS and ICC. Once the ACMs are saved on the drive, then TAIS can import that file into its data controller. Andy Duque, General Dynamics Mission Systems supporting product manager - air traffic control at Redstone Arsenal, is considered to be a TAIS-ICC interoperability subject matter expert. His team participated in multiple interoperability "labs" for machine-to-machine interfacing and testing with coalition partners' Fires and airspace control systems. In May 2016, Duque published a report which stated, "TAIS 11.1 and ICC 2.8.2 can exchange airspace information. ICC supports the export and import of USMTF 2000 ACO [airspace coordination order] messag-

Paratroopers from 4th Battalion, 319th Field Artillery Regiment (Airborne), 173rd Airborne Brigade, load into a UH-60L Black Hawk helicopter. Paratroopers conducted over 200 airborne proficiency jumps from two UH-60L Black Hawk helicopters from 3rd Battalion, 227th Aviation Regiment, Task Force Spearhead, Feb. 18, 2016, at Bunker Drop-Zone Grafenwoehr, Germany. (Sgt. Thomas Mort/12th Combat Aviation Brigade)

es. TAIS can also export and import USMTF 2000 ACO messages." The report continues by guiding readers through a sequence of steps that demonstrate ACO exchanges between ICC and TAIS and vice versa.

The team believes that operators simply are not aware that a digital solution exists, and that those that are aware have transitioned to different positions. In the case of several NATO partners, they simply aren't aware of the capability because it is not codified in their airspace doctrine. Some partners prefer a dynamic clearance ("I need airspace now") over airspace approval via a change to the ACO that is published in a digital system like TAIS or ICC. Ultimately, commanders can decide the approval process, but the important thing is that they've got to know all of the airspace management options that are available to them.

Information dissemination: The U.S. Army Joint Support Team

One possible way to increase awareness of integrating airspace into the operations process and digital solutions is to leverage the U.S. Army Joint Support Team (AJST). The AJST "supports [Mission Command Training Program] [observer controller teams] and unit-level Fires and aviation personnel to effectively integrate joint air capabilities into their planning and execution of joint air-ground combat operations." Their current focus for digital interoperability is primarily on U.S. joint digital systems. Upon request, AJST can reach out to U.S. units participating in a multinational rotation or other similar events to ensure they possess the information required to inform the commander prior to him, or her deciding how to manage multinational airspace. Once operators understand the process, units can exercise it, each time demonstrating the rapidity of airspace management using digital solutions. Taking it a step further, developing an interface that allows the systems to talk in their own languages would negate the need to perform the workaround solution described above. The next step would then be to demonstrate how it works in the field. Demonstration of the capability would be compelling to both U.S. and NATO partners uncomfortable or unfamiliar with the digital exchange of information. Looking at what Artillery Systems Coordination Activities (ASCA) has accomplished for the field artillery through years of testing and demonstration is a good place to start.

ASCA: A model for interoperability

One possibility for exposure would be to model the exposure of digital airspace interoperability after the way the ASCA has been exposed to our NATO partners during its nearly 30-year evolution. The impact ASCA has had on the timeliness of multinational Fires is significant.

"Participating nations agree to use the ASCA...as the standard to be adopted by NATO nations for the purpose of establishing field artillery/fire support data interoperability between national fire control systems," STANAG 2245 ARTY, 10 NOV 05.

The ASCA initiative is a concept that started in 1987 when digital field artillery systems across most allied nations started to emerge. Since then, the multination-

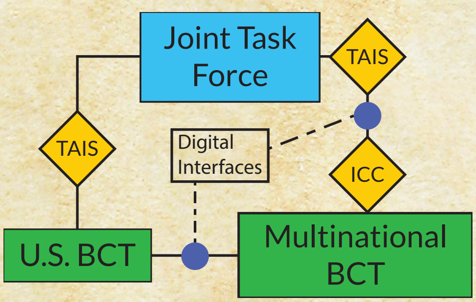


Figure 4. Artillery Systems Cooperation Activities allows interoperability between U.S. and multinational units. (Rick Paape)

al environment in which we operate has stressed and validated the need for a capability to talk across differing Fires digital systems (much like those identified for our common operating picture), other Army battle command systems, and in this case, our airspace control systems. When properly employed, ASCA members send digital fire missions from sensor to shooter across multiple nations without a dedicated LNO communications package for each unit. The next version of ASCA will allow coalition Fires command and control systems to directly pass ACMs within the coalition Fires network. For example, the German Adler system will be able to send ACMs to a U.S. Advanced Field Artillery Tactical Data System (AFATDS) and vice versa via the ASCA interface. This will facilitate establishing procedural control of airspace but will not facilitate real-time (positive) airspace management.

Figure 4 shows what airspace management could look like with an ASCA-like system to achieve interoperability with a U.S. JTF and multinational (MN) subordinates. In this case, a U.S. JTF could disseminate airspace management data via TAIS and a MN or NATO force would receive it in its ICC format due to the digital interface.

ASCA started with only five signatory nations. Through demonstrations of capabilities across multiple JMRC rotations and unit-level live fire and command post exercises, four additional nations have committed to become ASCA members. By the end of 2016, there will be nine ASCA member states, all of which became members after recognizing the need for interoperable Fires.

Now, there is a need for interoperable, timely, airspace management. Not only does interoperability build the confidence of NATO in its ability to invoke Article V, but it also provides the JFC commander with confidence that his maneuver forces will not have to wait on Fires to be delivered in support of his operational or tactical plans because they're coming from MN formations. Additionally, the deterrent effect of demonstrating transparency on the digital Fires networks of nine NATO countries with different sensor and delivery systems is immeasurable. An interoperable airspace control network would only bolster this strength as a multinational Fires system.

Leaders can leverage the Army Joint Support Team, which already teaches U.S. joint interoperability, to gain a better understanding of U.S.-NATO interoperability. While even the U.S. is challenged by clearance of Fires at the brigade combat team level, managing multinational airspace compounds that challenge. Nations, including the U.S., that are reluctant to change can be compelled to do so with inarguable demonstrations of increased capability as proven through the accomplishments of ASCA for digital field artillery systems. If the U.S. will never "go it alone" again in war, optimizing interoperability is not negotiable.

Leading with your face: The risk of suboptimal interoperability

To summarize, suboptimal interoperability creates untimely Fires. Untimely Fires create opportunities for the enemy. Timely Fires are relative to the physical, temporal and mental position of the enemy. If he thinks he can win, he will seek to do so because he thinks there's nothing there to stop him and he is under no obligation to coordinate his Fires with us. This is exemplified when we think of the overwhelming firepower of the International Security Assistance Force coalition and their inability to shake off the Taliban who were able to isolate and defeat coalition combat outposts. We lose battlefield clarity and the responsiveness of Fires when fire support coordination measures and airspace coordinating measures are employed like a rubber stamp without adequate planning, consequential considerations and understanding by all allied/coalition partners. Problems providing Fires at the time and space which best enable the commander equates to isolation as a multinational-war fighting function.

The third and final article in the "Keeping the king on his throne" series will highlight multinational Fires in space. Specifically, we will discuss what we refer to as "the lost space," which is created when commanders fail to target beyond the maximum effective range of their organic artillery systems. All too often at the JMRC, units either limit the impact of multinational Fires, enhancing the problems for the close maneuver fight, or they forego operational shaping altogether.

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Soldiers from "Hamilton's Own," 1st Battalion, 5th Field Artillery Regiment, 1st Heavy Brigade Combat Team, 1st Infantry Division, fire "Old Thunder," a Revolutionary War-era canon, March 7, 2012. The Soldiers were taking part in a ceremony at Fort Riley, Kan. (Amanda Kim Stairrett/1st Infantry Division)

Entangled history

How the field artillery and air defense artillery separated

By Dr. Boyd Dastrup

Over the years, the field artillery and the air defense artillery have shared a close association, dating back to the birth of the Continental Army's Artillery on Nov. 17, 1775. During the early years of the country's history, the coast artillery, the ancestor of air defense artillery, and the field artillery composed the War Department's artillery forces. While the coast artillery defended the country's harbors from enemy naval attack, the field artillery provided fire support on the battlefield. With the rise of airpower in the first decades of the twentieth century, the Army created the anti-aircraft artillery as component of the coast artillery to defend the ground forces from enemy air attack. The advent of modern naval guns and aircraft in the twentieth century, meanwhile, rendered coastal fortifications armed with heavy coast artillery obsolete. Together with the need to modernize the Army's force structure, the out-of-date coastal fortifications eventually led to the Army Reorganization Act of 1950. In the act Congress gave statutory recognition to the infantry, armor and artillery as combat arms, among other things. The act also inactivated the coast artillery and merged the field artillery and the anti-aircraft artillery into one artillery branch. When this arrangement proved unworkable, the Army separated the two artilleries in 1968. For almost four decades, the two artilleries went their own ways until 2005 when Congress approved the recommendation

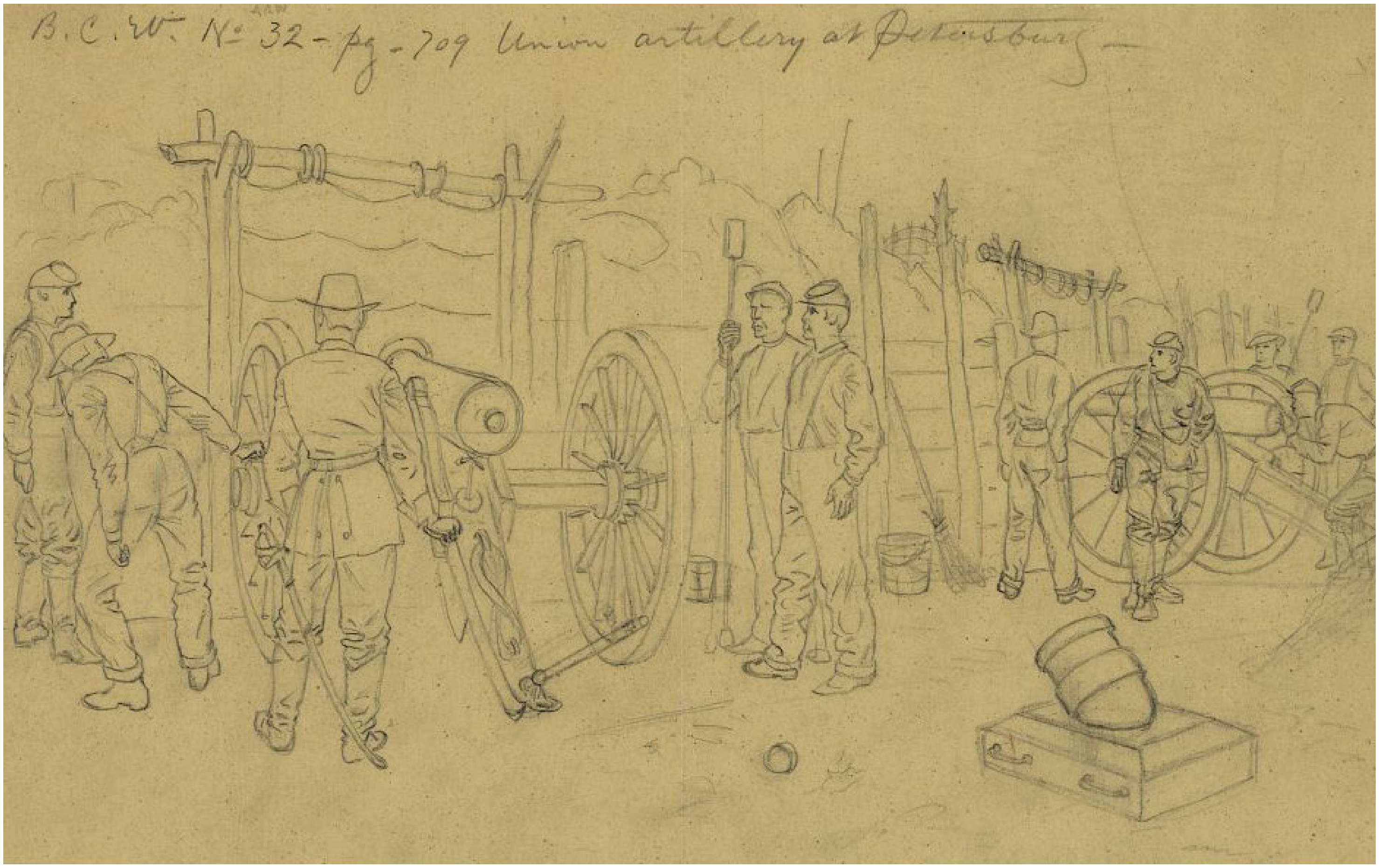
A steel engraving titled 'A Soldier's wife at Fort Niagra,' depicts a woman lifting cannon balls in an artillery bunker during a battle at Fort Niagara, N.Y., during the War of 1812. (T. Walker/Library of Congress repository)

of the Base Realignment and Closure (BRAC) commission to consolidate the two artilleries at Fort Sill, Okla., to save money.

During the American Revolution of 1775-1783, the regimental system governed artillery organization. Following the colonies' disastrous defeats in New York in 1776, the Continental Congress reorganized the Continental Army by providing for 88 infantry battalions and five artillery battalions, also called regiments. However, only four regiments were ever created; and they consisted of foot artillery (a branch of field artillery) where the cannoneers walked beside the draft animals pulling the cannon, siege artillery and garrison artillery. Such composite regiments forced artillerymen to be trained to serve on all three kinds of artillery to provide flexibility in assigning officers and Soldiers.

Following the American Revolution, Congress repeatedly restructured the Army and its artillery over the next three decades to keep them in harmony with national security requirements. In the spring of 1785, the standing Army of the United States consisted of the First Regiment of eight infantry companies and two artillery companies to guard the frontier. Two years later, Congress permitted Secretary of War, Henry Knox, to organize the artillery as a separate battalion to give the standing Army of the United States one infantry regiment and one artillery battalion with artillerymen serving primarily as infantry on the northwest frontier. As the tensions with Native Americans increased on the northwest frontier and Great Britain over its failure to cede its forts in the territory gained by the United States in the Peace Treaty of 1783 that ended the American Revolution, the size of the Army grew. Following the disastrous defeats of Josiah Harmer's column in 1790 and Arthur St. Clair's column in 1791, both at the hands of Native Americans in the Ohio River Valley, Congress created the Legion of the United States in 1792 with an organic battalion of foot artillery. Under Maj. Gen. Anthony Wayne, the legion marched into the Ohio River Valley and decisively defeated Native American tribes at Fallen Timbers in August 1794. Although the Legion had 3-inch howitzers with it at the Battle of Fallen Timbers, the broken terrain covered with fallen trees prevented their effective employment and reaffirmed the difficulty of using artillery in mobile warfare against Native Americans. Artillery of the day, including the small 3-inch howitzers, was simply too heavy and cumbersome to drag along when campaigning against Native Americans on the trackless frontier. As a result, the artillery on the frontier existed in name only; and artillerymen functioned mainly as infantry on the frontier through the rest of the 1700s even though they were responsible for the care of the guns and equipment.

With a war looming with Great Britain in 1794 and later France in 1798, Congress reorganized the Army's artillery. Besides fund-



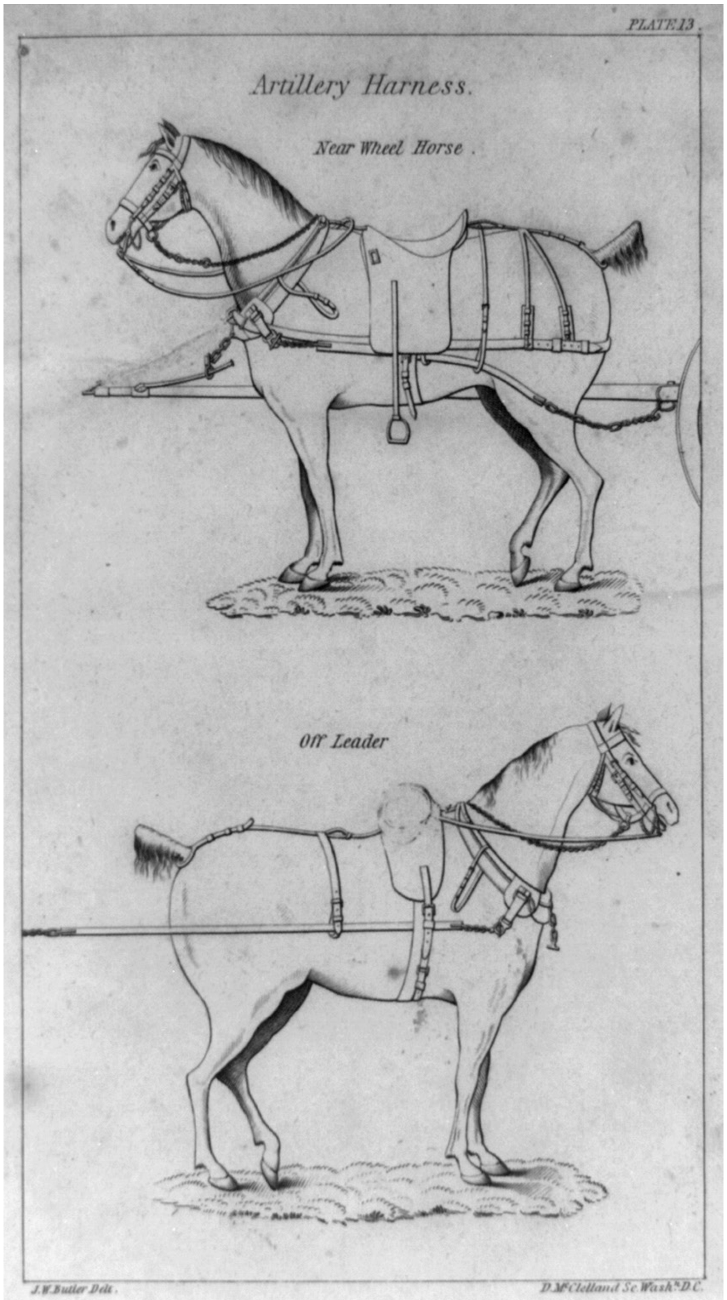
A sketch of Union Army artillery at Petersburg, Va., drawn 1864. (Alfred Rudolph/Library of Congress repository)

ing earthen and masonry redoubts along the Atlantic Ocean, a Congressional Act of 1794 created the Corps of Artillery and Engineers that absorbed the existing artillery battalion from the Legion of the United States and authorized the President to employ the corps on the frontier or the coast as he saw fit. This meant that artillerymen had to be trained to serve in either foot artillery or coast artillery units. Because the British threat to the coasts was more serious, the Army shifted artillery from its frontier posts to the coast to arm coastal fortifications. Later in 1798, the prospect of war with France prompted Congress to create a regiment of artillery and engineers to augment the corps to give the Army two artillery units. As with the Corps of Artillery, the regiment's artillerymen had to serve on coast and foot artillery cannons, but they served primarily in coastal fortifications which were seen as the greatest security requirement. When the threat of war disappeared, President Thomas Jefferson and Congress separated the artillerists from the engineers. They created the Corps of Engineers and simultaneously decreased the number of artillery regiments from two to one in 1802 with the artillery's primary responsibility revolving around defending the ports on the Atlantic Coast.

Imitating the successes of the Europeans with horse artillery, a branch of field artillery where the cannoneers rode on horses to give more mobility than existing foot artillery, the Americans subsequently organized the Light (Horse) Artillery Regiment in 1808. Although this action recognized the distinct differences in missions between light artillery and coast artillery, provided for training and equipping the batteries of light artillery and intended to end the practice of rotating officers and Soldiers between coast and light artillery units, it accomplished little. A parsimonious Congress failed to provide the funds to equip the regiment as light artillery except for one company formed under Capt. George Peter. At the Fourth of July celebration in Washington D.C. in 1808, Peter's battery demonstrated its ability to maneuver and fire its weapons and impressed Congress and onlookers. However, Secretary of War William Eustis subsequently dismounted the battery, sold the horses because feeding them was too expensive, and issued muskets to the cannoneers to serve as infantry on the frontier.

Although the Light Artillery Regiment remained on the books and served with mixed results in the War of 1812, the Reorganization Act of March 1815 recognized its utility. The act created the Corps of Artillery by merging the 1st, 2nd, and 3rd Artillery Regiments that had been formed in the war to defend the coasts and retained the Light Artillery Regiment with the intention of properly equipping it. In its haste to reduce the wartime Army and conserve money, Congress unfortunately permitted the regiment to disappear except on paper.

Additional restructuring followed in a few years. The Reorganization Act of 1821 consolidated the Corps of Artillery, the Light Artillery Regiment and the Ordnance Department into the Corps of Artillery composed of four regiments of nine companies each. Of the nine companies, eight were coast artillery, and one was designated as light artillery. By combining the Ordnance Department, the Corps of Artillery and the Light Artillery Regiment into one organization and creating four composite artillery regiments as a cost-saving measure, the act effectively legislated the first and only light artillery regiment out of existence and threatened artillerists with



The artillery harness developed for field artillery units during the U.S. Civil War. (Library of Congress repository)

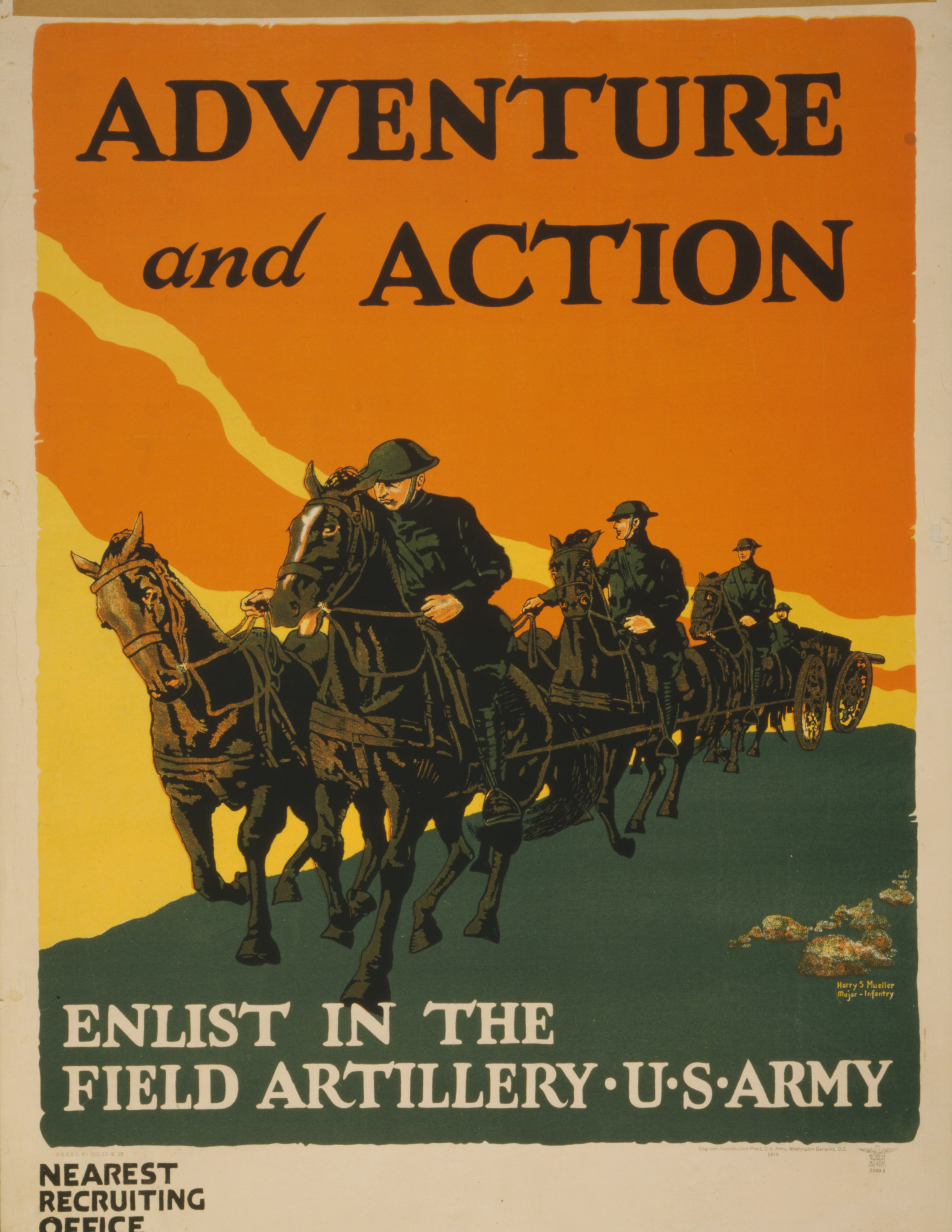
duty in any kind of artillery unit. Recognizing the need for trained artillery officers and enlisted Soldiers with the ability to serve on field, coast and siege artillery weapons, the War Department later established the Artillery School at Fortress Monroe, Va., in 1824 as a school of practice for artillerymen. The school emphasized coast artillery training because it was viewed as the most pressing need to a country with a long, vulnerable coast line. Without an urgent requirement for trained light artillerymen, the War Department allowed the light artillery to languish until 1838 when Capt. Samuel Ringgold assumed command of the first horse artillery battery. The following year, the other light artillery batteries received their horses. However, they were organized as mounted (a branch of field artillery) artillery where the cannon crew rode on the limbers and caissons because it was less expensive than horse artillery.

Although field artillery performed well in the Mexican War of 1846-1848 and the American Civil War of 1861-1865, Congress established the peacetime artillery organization at five regiments of twelve batteries each in 1866. Two of a regiment's batteries were field artillery; and the rest were coast artillery. While coast artillery batteries stood as the guardians of American harbors against enemy naval attack, the field batteries were scattered on remote posts in the Trans-Mississippi West where commanding officers generally saw little or no use for them in campaigns against Native Americans. With the exception of Maj. Gen. Nelson A. Miles, most commanders believed that field artillery hampered their mobility and had limited utility against Native Americans who relied upon hit-and-run tactics and mobility for survival. As a result, field artillerymen were frequently pressed into service as infantry and cavalry and with a few exceptions served on a gun. Such circumstances caused their field artillery skills to deteriorate.

By dictating officer assignments the regimental organization also adversely influenced field artillerymen. Because of the heterogeneous regiments created after the Civil War and economy measures, the War Department continued the pre-war practice of rotating officers and Soldiers between coast and field artillery batteries. This obliterated the differences between the two artilleries and further eroded the skills of field artillerymen. Not even the School of Application for Cavalry and Light Artillery created in 1892 at Fort Riley, Kan., to train field artillery officers and units could offset the policy of rotating officers and Soldiers between the two artilleries, creating a generic artilleryman. Shortages of personnel and detached service for units that took them away from training for other more pressing duties also prevented the school from providing effective training.

Along with indirect fire that was beginning to replace direct fire, the Spanish-American War of 1898 where the Spanish employed state-of-the-art Krupp smokeless propellant 3-inch field guns with on-carriage recoil systems highlighted the Army's dependence upon obsolete field artillery (M1885 and M1897 3.2-inch field guns) and reinforced the need for reform. In view of such circumstances, Congress passed the Reorganization Act of 1901. Among other things, the act created a Chief of Artillery to oversee all artillery activities with Brig. Gen. Wallace F. Randolph serving as the first chief. The act also abolished the regimental system for artillery and replaced it with an Artillery Corps of 126 companies of coast artillery and 30 batteries of field artillery. While the coast artillery retained its mission of defending the country's harbors, the field artillery supported the infantry and cavalry. This reorganization act officially recognized the difference in fire missions between the coast artillery and the field artillery and made provisions for them. Yet, it failed to abolish the harmful practice of rotating officers between the two artilleries. Preserving such a practice continued hampering the creation of competent officers for either artillery branch. This was particularly true of field artillery officers and Soldiers because the Artillery School at Fortress Monroe, which focused on coast artillery training, closed down its meager field artillery training in 1906. The Mounted Service School at Fort Riley that opened in 1907 to pick up the slack and replaced the School of Application for Cavalry and Field Artillery at Fort Riley, formerly the School of Application for

Opposite page: An Army recruiting poster states, "Adventure and action. Enlist in the field artillery, U.S. Army." The recruiting poster showing Soldiers on horseback while pulling an artillery cannon. The poster was created in 1919. (Harry Mueller/Library of Congress repository)


ADVENTURE
and ACTION
Harry S Mueller
Major - Infantry
ENLIST IN THE
FIELD ARTILLERY · U·S·ARMY
A.G.O.R.S. No 232, 12-8-19
Engineer Reproduction Plant, U.S. Army, Washington Barracks, D.C.
1919
2248-1
NEAREST
RECRUITING
OFFICE

Top: Soldiers from Fort Story, Va., operate an azimuth instrument to measure the angle of splash in sea-target practice, March 1942. (Alfred Palmer/Library of Congress repository) Bottom: An artilleryman from Fort Story, Va., mans a 16-inch coast artillery gun, March 1942. (Alfred Palmer/Library of Congress repository)

Cavalry and Light Artillery, never lived up to the War Department's expectations. Focusing upon equitation, the school failed to graduate competent field artillerymen with the ability to maneuver their guns around the battlefield with the infantry.

The dearth of qualified field artillery officers and Soldiers created by the rotation policy and the lack of appropriate training prompted successive chiefs of artillery during the first decade of the 1900s to campaign for the complete separation of the two artilleries and specialized training for each. Convinced by this logic, Congress passed an act on Jan. 25, 1907, that created two distinct artillery branches — the coast artillery and the field artillery. The 30 field batteries in existence at the time were increased by six; and these 36 batteries were organized into six field artillery regiments of two battalions each. Equally important, the act ended the pernicious practice of rotating officers between the two artillery branches and promoted specialization. It also paved the way for reorganizing the Artillery School at Fort Monroe as the Coast Artillery School in 1907 to signal its sole mission of training coast artillerymen and the founding of the School of Fire for Field Artillery, the forerunner of the Field Artillery School, at Fort Sill in 1911.

Although the field artillery performed effectively in World War I, the War Department convened a board of officers in April 1919 under Maj. Gen. Joseph T. Dickman who was a corps commander in the war to examine coast and field artillery missions in light of wartime experiences and to determine their appropriate relationship. The Dickman board believed that the introduction of motor vehicles had given even the heaviest artillery pieces, such as coast artillery, unprecedented mobility and had erased the differences between the two artillery branches. As such, the board concluded that coast artillery was a naval function and that heavy, mobile artillery for supporting the field army should be a field artillery function. By taking such a position, the Dickman board proposed stripping the coast artillery of its historical harbor defense mission and giving it to the Navy.

In his annual report to the Chief of Staff in October 1919, the Chief of Coast Artillery, Maj. Gen. Frank W. Coe, subsequently responded. He urged the War Department to reconsider his branch's mission. According to Coe, the day was over when the coast artillery should be thought in terms of only maintaining platform-mounted heavy artillery and mine defenses for harbor defense. Recognizing that modern naval guns had rendered coastal fortifications obsolete, that tractor-drawn and railway-mounted coast artillery guns of the coast artillery had performed well during the war as field artillery to attack strong fortifications, and that thousands of coast artillerymen had served in field batteries, he urged merging the two artilleries. The lack of mobility for heavy artillery, one of the primary reasons for the separation in 1907, no longer existed while coast artillerymen functioned as field artillerymen during the war. Together, they blurred the distinction between the two artilleries and justified merging them.

The debate over the future of the coast artillery continued. In 1920 Congress passed the National Defense Act which governed Army organization until 1950. The new law retained the coast artillery and field artillery as separate branches even though the motor vehicle gave unprecedented mobility to the former to fight on the modern battlefield, defined their missions, preserved the Chief of Coast Artillery, and created the Chief of Field Artillery. Notwithstanding this congressional legislation, the possibility of merging the two arose in 1927 as an economy measure. This prompted the War Department to issue General Order 22 to define missions for both artilleries. While the field artillery supported the other combat arms on the mobile battlefield and included pack artillery, division artillery, corps artillery with the exception of anti-aircraft artillery, and general headquarters artillery, with the exception of anti-aircraft artillery and railway artillery, the coast artillery defended the harbors and received the anti-aircraft artillery mission. In 1939, an economy drive by the War Department prompted examining the integration of the artilleries once again. When a staff study revealed that such a measure would produce only minor savings, the War Department dropped the matter for the duration of World War II.

With World War II ending, the Chief of Staff of the Army, Gen. George C. Marshall, appointed a board of officers under Lt. Gen. Alexander M. Patch in the fall of 1945. Patch had the assignment of investigating the roles and missions of the various branches of the Army and making proposals for post-war organization with the goal of streamlining organization and saving money. After careful study, the Patch board recommended combining the coast artillery with its anti-aircraft artillery mission and the field artillery to form

Soldiers of an artillery unit stand by and check their equipment while the convoy takes a break during a maneuver in Belgium. (US. Army Signal Corps/ Library of Congress repository)

one artillery. Although the coast artillery's irrelevance in the face of modern naval guns and aircraft undoubtedly influenced the recommendation, other reasons played a prominent role. The fear of losing anti-aircraft artillery to the Army Air Force that was pushing for independence from the Army and budget and personnel reductions in the wake of demobilization also drove the recommendation. Budget and personnel reductions meant the War Department had to find ways to conserve and use resources wisely. In view of this, the War Department urged Congress in 1946 to consolidate the coast artillery and the field artillery as one artillery branch.

Before Congress could act on the recommendations, the Army combined what it legally could in its drive to reduce overhead. Influenced by Brig. Gen. Bruce C. Clarke, the operations officer (G-3) of the Army Ground Forces that had responsibility for all institutional training, the War Department acted. Effective Nov. 1, 1946, the War Department redesignated the Field Artillery School as the Artillery School with the Anti-aircraft Artillery School at Fort Bliss, Texas, and Sea Coast Artillery School, at Fort Winfield Scott, Calif., as branches of the Artillery School. The merger did not mean physical collocation. Each school stayed at its existing location. In keeping with the need to economize with the attending requirement for personnel flexibility, the three schools created a basic integrated course for all newly commissioned officers where they would learn the fundamentals of the three artilleries by moving from school to school. The schools also developed an integrated advance course for officers with three to 10 years of experience for additional training on all three artilleries. Like the lieutenants, captains would move from school to school for training. Instituted in 1947, cross training or integrated training as this practice was called, permitted moving officers from branch to branch (called cross assigning) to husband scarce personnel resources, de-emphasized specialized training and created a generic artillery officer. According to Lt. Gen. Jacob L. Devers, the commanding general of the Army Ground Forces, artillery officers would be ground force officers first and gunners second. Ironically, this consolidation of training, the revival of rotating officers between the artilleries and training on all the artillery systems came at the precise time when technology was becoming more sophisticated and required even more specialized training than in the past.

Three years later, Congress picked up where the Army had left off in 1946-1947 when it passed the Army Reorganization Act of 1950. The act legally recognized the infantry, armor and artillery as statutory combat arms, among other things. The Army inactivated the coast artillery and the Sea Coast Artillery School, legally merged anti-aircraft artillery and field artillery as one branch to economize, and solidified the practice of integrated training for officers and cross assigning them while preserving specialized training for enlisted personnel as either field artillerymen or anti-aircraft artillerymen.

For the next 19 years the merger produced mixed results. It saved money, allowed moving officers easily between the anti-aircraft artillery (renamed air defense artillery in 1957) and the field artillery, and produced a generic artillery officer. Because of the growing complexity of equipment related to field artillery and anti-aircraft artillery, the differing employment techniques, and the failure of integrated training to provide adequate preparation for an officer to serve in either artillery effectively, the Continental Army Command took action. Believing that the Army no longer could train all artillery officers in both field artillery and anti-aircraft artillery tactics, techniques and procedures and that officers should be either field artillery or anti-aircraft artillery, especially second and first lieutenants, it formulated a plan in 1955 to restructure officer training. It wanted to develop separate basic courses in field artillery and anti-aircraft artillery for new officers. It also wanted to move all surface-to-surface rocket and missile courses and weapon systems from Fort Bliss to Fort Sill. With support from the Army's Assistant Chief of Staff for Training, the Continental Army Command subsequently created separate basic courses for the two artilleries in 1957. The command also moved all surface-to-surface rocket and missile courses and systems to Fort Sill. In the meantime, the Continental Army Command retained the integrated artillery advance course for officers with five to eight years of experience because of pressure to maintain flexibility in officer assignments and the shortage of officers.

In the 1960s, the pressure to abolish integrated training and cross assigning and to separate the two artilleries mounted. Based upon the Army Officer Education and Review Board of 1958, the Continental Army Command reintroduced separate basic officer courses in 1962 to provide specialized training for new officers that they were not receiving with the integrated courses. Meanwhile, the drive for flexibility in assignments so that the Army could shift artillery officers easily between air defense artillery and field artillery to offset officer shortages caused the Continental Army Command to retain the integrated officer advance course for officers with five-to-eight years of experience. A student thesis written at the Army War College by Col. William F. Brand challenged the wisdom of this practice. He argued that integrated training provided inadequate training in either branch. As a result, officers left the integrated advance course without mastering any of the weapons and without any real expertise in either branch. In view of this, Brand urged separate training for each branch. At the direction of the Continental Army Command, the U.S. Army Artillery and Missile School and the U.S. Army Air Defense Artillery School explored the desirability of dividing the artillery into two branches. In 1963 they recommended separation because of the difficulty of furnishing integrated training, the continued production of generic artillery officers, and the growing differences between the two artilleries. In line with this, the authors of "The Artillery Branch Study" of 1966 wrote that integrated training "spawned mediocrity."

The demand for competent field artillery officers for duty in Vietnam in 1965-1966 finally caused the Army and the Continental Army Command to reorganize the artillery and artillery training. Because the one-year tour of duty left little time for on-the-job training, combat in Vietnam required the officer to arrive as a proficient field artilleryman and not a hybrid field and air defense artilleryman. In view of this, "The Artillery Branch Study" urged abandoning integrated training and forming two separate artilleries.

The Army concurred with the recommendations and split the field artillery and air defense artillery into two distinct combat arms with their own training programs in 1968. This freed field artillery and air defense artillery officers to concentrate on becoming experts in their respective branches. Yet, separating the two artilleries had little impact on the U.S. Army Artillery and Missile School, renamed the U.S. Army Field Artillery School in 1969, and the U.S. Army Air Defense Artillery School because they were already focusing their energies on their areas of expertise.

By separating the two artilleries, the Army reaffirmed the folly of merger of 1946-1968 and the wisdom of forming two distinct branches in 1907. When both artillery branches were together at different times in the 1800s as part of a composite artillery regiment and 1946-1968 as one artillery branch, mediocrity reigned, especially for officers. Officers simply did not have the time to learn the intricate skills of both branches and became generic artillery officers.

Although the field artillery and the air defense artillery remained separate entities over the next 36 years, national security concerns changed that relationship. Between 1988 and 1995, the BRAC process closed 112 Army installations and realigned 26 others to create more efficiency and effectiveness within the Army's installation infrastructure. In view of this achievement, three successive Secretaries of Defense urged further rationalization of the military's infrastructure through additional BRAC actions to save billions of dollars annually, to free up excess capacity, to permit funding facilities that were actually required, to support warfighting and to furnish quality of life improvements for the military services. Yet, the secretaries found little Congressional support.

In the fiscal year (FY) 2002 National Defense Authorization Act, Congress finally permitted a BRAC to be conducted in FY 2005. As Secretary of Defense Donald Rumsfeld explained in November 2002, BRAC 2005 would permit reconfiguring the Department of Defense's current infrastructure to maximize warfighting capability and efficiency. It would also create multi-mission and multi-service installations, would optimize military readiness and would help create significant monetary savings.

As anticipated, BRAC 2005 produced significant changes with the field artillery and the air defense artillery. To save money and improve warfighting capabilities, BRAC 2005 recommended relocating the Air Defense Artillery Center and School from Fort Bliss to Fort Sill and consolidating it with the Field Artillery Center and School to form a Net Fires Center, later renamed the Fires Center of Excellence in mid-2005. This would consolidate field artillery and air defense artillery training and doctrine development at a single location and would functionally align related branch centers and schools at one location to foster consistency, standardization and training proficiency. At the same time creating the Fires Center of Excellence would permit the Army to reduce the total number of military occupational skills (MOS) training locations and support Army Transformation by colocating institutional training and would be accomplished by 2011. Yet, colocating at Fort Sill did not mean merging the branches into one as the Army had recently done between 1946 and 1968 and reviving integrated training and cross assigning officers so that they could serve in both artilleries. The branches would remain separate.

As such, the lessons of the past had been learned. Although the collocation of the two branches and schools would generate monetary savings and provide other benefits, the BRAC process retained the field artillery and the air defense artillery as separate branches to retain their integrity. A merger of two branches into one would not occur. Artillery Soldiers would serve in the air defense artillery or field artillery and not both.

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A Soldier observes as a Paladin weapon system fires during a rotation to the National Training Center, Fort Irwin, Calif. (Courtesy photo)

Executing effective decisive action Fires based on observations at the National Training Center

By Maj. Fred A. Janoe

Over the last two years of rotations in the Decisive Action Training Environment (DATE) at the National Training Center, persistent observations were identified by the NTC Fire Support Team Wolf, indicating a clear deficiency in fire support planning and integration. The purpose of this article is to share the top persistent observations negatively affecting joint Fires synchronization at the NTC and highlight key aspects of a mission essential task list (METL) based training plan that will enable future field artillery battalions' success at the NTC.

The baseline for developing a training strategy for field artillery battalions and leaders is outlined in ADRP 7-0, Training Units and Developing Leaders. However, many FA battalions still struggle with establishing and assessing thorough training plans that are nested with the brigade combat team's (BCT's) METL. By forecasting and planning a well-resourced unit training plan (UTP), some of the issues causing unresponsive, or ineffective fire missions can be mitigated.

NTC persistent observations

In the summer of 2015 at the NTC, the commander of operations group identified several challenges with Fires integration since the incorporation of DATE rotations at the NTC in early 2014. He then held a meeting with the Wolf Team and the fire support observer/coach/trainers (OC/Ts) from the maneuver teams across operations group to discuss delays in Fires integration, fire mission processing timeliness and effectiveness of Fires in the decisive action fight. The following primary persistent observations highlight the results of that meeting. As units develop their respective UTPs, these common observations are provided as references and possible solutions when executing training plans to prepare for a decisive

Commander's Intent for Fires Checklist

Commanders intent must focus on how fire support will influence and support the scheme of maneuver.

- **Ground Scheme of maneuver.**
  - ◊ Guidance for FSTs.
- **Purpose of Fires.** How FS will support scheme of maneuver.
  - ◊ Use Fires battalion to neutralize the threat's dismounted attack forward of Phase Line Purple.
  - ◊ Cover all obstacles with observation and Fires.
  - ◊ Mass artillery, combat air support and attack aviation into EA Scrum to disrupt the threat's mounted attack.
  - ◊ Conceal TM Armor's movement to attack-by-fire positions.
- **Priority of fire.** Which unit has fire support priority by phase.
  - ◊ Initially to Task Force (TF) 1, TF 2, then TF 3, in order.
  - ◊ When the fixing force penetrates Phase Line Green, priority of fire (POF) shifts to TF 2, TF 3, then TF 1, in order.
  - ◊ Upon commitment of the reserve, POF shifts to TM Armor.
- **Priority of targets.** Which targets and length of priority status.
- **Effects of Fires.**
  - ◊ Suppression - Prevent effective fire on friendly forces.
  - ◊ Neutralization - Target combat ineffective/unusable for temporary period.
  - ◊ Destruction - Target permanently combat ineffective.
  - ◊ Harassing - Disturb the rest of threat troops, curtail movement, lower morale.
- **Employment of mortars, air-delivered weapons and NGF.**
- **Special munitions employment.**
- **Force protection priorities (FSCM).**
- **Restrictions.**
  - ◊ Establish NFAs for all population centers and sensitive places.
  - ◊ Do not employ cratering munitions on MSRs, LZs and/or air strips.

Figure 1. The National Training Center's Wolf Team fire support trainers' commander's intent for Fires checklist. (Rick Paape)

action training environment and ultimately, for combat operations.

Fire support planning

Fire support planning at the BCT and battalion level has been consistently challenged in a few critical areas. The observation from NTC is that the commander's intent for Fires from the BCT commander is not communicated effectively to task force and FA battalion planners such as the fire support coordinator (FSCOORD), brigade fire support officer (BCT FSO), targeting officer, and FA battalion operations officer (S3). Leaders are also finding it difficult to identify when and how to engage targets to ensure the BCT fire support plan is synchronized with the BCT's scheme of maneuver. Lastly, when communications systems fail or terrain and distance pose significant challenges, units are not identifying redundant communications assets to facilitate the massing of joint Fires.

Commander's guidance

Understanding the BCT commander's intent and guidance for Fires is essential to the FSCOORD and BCT FSO developing relevant fire support tasks (FSTs) and the FA battalion S-3 developing field artillery tasks (FATs). The FSCOORD, FA battalion S-3, and the BCT FSO must understand where the commander sees the decisive point on the battlefield, and what effect is desired (ex: obscure, neutralize, disrupt, etc.). All components of the fire support system must know how the commander wants to fight with joint Fires, and then provide recommendations on ways to meet his intent.

Initial FSTs are created during mission analysis, and then vetted to ensure they are consistent with the commander's intent. Once FSTs are approved, they are pushed down to the FA battalion to allow parallel planning in order to develop initial FATs during the FA battalion mission analysis. In order to create synergy, all Fires planners in the chain should proactively maintain running estimates, ensure FSTs and FATs are still valid and monitor to ensure that units can action those tasks with resources on hand throughout the planning process. Increased levels of shared understanding throughout the BCT will enable the employment of joint Fires to shape the BCT fight.

As the BCT FSO moves to course of action development, they develop the target, trigger, location, delivery system, attack guidance and comm net (TTLODAC), and observation plan, which should be clearly defined. All elements of the fire support chain, including scouts and mortar crews, should comprehend the desired effects from fire support in order to participate in top-down, bottom-up refinement of the fire support plan. The following example checklist outlines areas to consider when developing the commander's intent for Fires.

Triggers, targets

Detailed observation planning is critical to the success of the BCT fire support plan. Unidentified tactical triggers and underdeveloped observation plans complicate processing times and expectations of achieving a measure of effectiveness with fire support tasks. The BCT fire support element (FSE) should develop the observation plan in conjunction with the BCT S2 (intelligence officer) for BCT-level targets, then that observation plan should be pushed to subordinate elements for refinement.

In order to develop triggers, fire support planners should clearly demonstrate an understanding of the BCT focus of Fires at all levels: the planning and preparation for the FA battalion, the transition between the BCT Fires in depth (deep) and close supporting Fires, and when an FST has been accomplished to standard. The FSO and S2 should have collective participation in targeting and development of the intelligence collection (IC) plan. It is imperative that the staff, especially the FSO and S2, continuously coordinate and update target information as conditions change, and clearly define composition of enemy formations in order to specify what observers are looking for and also to assist them with time and distance analysis in the computation of technical triggers. A major planning shortfall observed at the NTC is that resources and platforms are regularly not in place at the right time to bring effects on planned targets. Disciplined enabler coordination throughout the BCT is needed to synchronize all warfighting functions.

With an average processing time of over 20 minutes for cannon delivered Fires at the NTC, observers are often not prepared to engage targets on the battlefield, since they are unable to effectively anticipate the time required to process fire missions. Computing technical triggers becomes more complicated when the processing time becomes longer and unpredictable due to units that do not utilize or enforce target selection standards (TSS) and the attack guidance matrix (AGM).

Communications plan

Another major friction point is the shared understanding of which communication systems to use and when to use them. At the NTC, primary, alternate, contingency and emergency (PACE) plans are often not planned in detail or utilized. With the accessibility of secure-voice-over-Internet-provider, FM radio, FM digital, Jabber, Advanced Field Artillery Tactical Data System (AFATDS) freetext, email, Command Post of the Future (CPOF) etc., units across the BCT use several methods to communicate with the BCT Fires cell and adjacent units. A lack of communications discipline causes decreased situational awareness between fire supporters and delivery assets throughout the BCT. The ability to maintain continuous communication is the lifeline of the brigade's entire fire support system. Paragraph five of the operations order, as well as Annex D and Annex H, should state the PACE plan, communications card and

A Soldier loads a round into a howitzer during a unit rotation to the National Training Center, Fort Irwin, Calif. (Courtesy photo)

locations of communication retransmission sites. Additionally, FA battalions often lack an understanding of tactical site selection and line-of-sight analysis for communications nodes. The brigade communications officer (S6) must integrate the needs of the FA battalion's fire direction officer, S6, and S3, at all times.

Recommendation

During the military decision making process, running estimates from the staff are imperative to developing a sound and executable plan. The plan should be validated during the wargaming process. Commanders must give clear guidance for Fires. If he does not, the staff should ask questions so that his intent is understood across the formation. By understanding the commander's guidance for Fires, tactical triggers and a clear concept of how to communicate, many challenges during the execution phase can be alleviated. The FA battalion commander, as both the FSCOORD and force field artillery commander, must ensure that the BCT FSO and the FA battalion S3 closely coordinate preparation of the fire support plan (Annex D) and the field artillery support plan (FASP). Additionally, the FA battalion S2 should coordinate Intelligence Preparation of the Battlefield (IPB) and targeting with the targeting officer and the BCT S2. When developing the unit training plan (UTP), the following tasks are recommended for increased efficiencies in the decisive action environment.

- (06-6-1118) Conduct fire support planning
- (71-8-5114) Conduct Fires planning
- (171-133-5201) Assist the S3 in programming and recommending allocations of ammunition and equipment fire support preparation

Units should train heavily on conducting FA tactical, FA technical and fire support rehearsals in detail. Many units do not prioritize or allocate time to execute proper rehearsal execution at home station as they prepare for operations. Rehearsals provide an invaluable means of ensuring actions during training are synchronized and executed to standard. Often, rehearsals at the NTC are not actually a rehearsal of the plan, but merely a back-brief to the commander. Lastly, rehearsals provide a mechanism for leaders and Soldiers to visualize what is supposed to happen, and to correct any shortcomings prior to execution.

Rehearsals

In order to achieve maximum efficiency and shared understanding, FA technical rehearsals should be conducted digitally from sensor-to-shooter. An agenda/outline should be published and followed during every rehearsal and all attendees and briefers should have the agenda to ensure everyone is tracking accurate information and expectations. During NTC rotations, FA technical rehearsals are rarely executed from sensor-to-shooter, and the PACE plan is not exercised within the rehearsal. Additionally, alternate delivery systems and observers are often not identified or rehearsed. Three common friction points during technical rehearsals are the command post (CP)/leaders are routinely not involved, the digital architecture is not tested and fire missions are not sent to the delivery asset. Junior leaders and NCOs should be trained on how to properly execute their part of a technical rehearsal, not just the operator behind an AFATDS or the radio/telephone operator.

FA battalions frequently lack the understanding of who needs to attend FA tactical and fire support rehearsals, and the scheme of maneuver and Fires execution by phase. The challenges include priority of Fires by phase, de-confliction of assets, observation post (OP) planning and the ability to execute pre-planned targets. When time allows, a best practice at the NTC is to ensure the following products are discussed, understood and integrated into the BCT fire support rehearsal and in most situations, the BCT combined arms rehearsal:

- High payoff target list (HPTL)
- Hire support tasks (FSTs)
- Scheme of Fires (Fires paragraph)
- Concept of Fires (para 3, Annex D)
- Attack guidance matrix (AGM)
- Target selection standards (TSS)
- Target list worksheet (TLWS)
- Target synchronization matrix (TSM)
- Fire support coordination measures (FSCM)
- Fire support execution matrix (FSEM)
- Annex D
- Field artillery support plan (FASP)

Additionally, changes to the plan after a rehearsal are frequently not annotated in a fragmentary order. A validated SOP is a best practice to standardize a script for all methods of rehearsals in order to maintain predictable situational awareness. Despite the reinforcement of rehearsals in both doctrine and leader training programs, units habitually struggle to conduct to-standard rehearsals at the brigade combat team, field artillery battalion, or task force/battalion level. Rehearsals that do occur are, generally, poorly scripted and do not address the basics of the plan such as target, trigger, location, observer, delivery asset, ammunition, communications (TTLODAC), time-space relationships between units, named area of interest to target area of interest linkages, and airspace de-confliction. In addition to the lack of detail during the rehearsal, personnel and units critical to mission success do not attend; or in some cases, personnel attending are not empowered to make decisions on behalf of the unit.

Soldiers fire an M777 during a rotation to the National Training Center, Fort Irwin, Calif. (Courtesy Photo)

Recommendation

Addressing points of friction will help the rotational unit with the conduct of rehearsals. The first way is through the establishment of a schedule and scripts. Units should devise scripts that are flexible enough to account for mission variables yet still address the topics covered in FM 3-09. Beyond simply establishing the basic requirements for rehearsals, units must rehearse the rehearsal prior to arriving at the NTC for training. Executing detailed iterations of the fire support rehearsal and FA tactical rehearsal prior to any field artillery training exercise will reinforce both the conduct of the rehearsal as well as the necessity to execute one. Time is often the biggest challenge units face when attempting to conduct fire support rehearsals. Self-induced friction such as delayed orders production and dissemination, lack of warning orders to help initiate necessary troop leading procedures and unfamiliarity with the rehearsal process all lead to sub-standard rehearsals.

In order to maximize the amount of time available, units should consider codifying multiple rehearsal techniques in their tactical standard operation procedure (TACSOP) and practice the variations during deliberate staff exercises at home station. A rehearsal format that integrates digital and tactical components as discussed in FM 3-09, p. 3-10, is well scripted, nested within the overall planning timeline and rehearsed with time as a constraint will allow the unit to conduct at least one consolidated fire support rehearsal that achieves shared understanding. Center for Army Lessons Learned Publication 13-07, "Fires Rehearsals," is another great resource that gives examples and best practices for developing rehearsal SOPs. When developing the UTP to focus on this task, the following collective subtasks are recommended as focus areas.

- (06-1-5076) synchronize Fires
- (061-284-4006) synchronize fire support operations
- (06-5-5089) conduct rehearsals (CO/TRP FIST)
- (71-8-5122) perform a rehearsal (battalion-corps)

Executing the Plan

Common friction points during execution of decisive action operations primarily revolve around operator proficiency and competency on mission command systems. The FA battalion and FSE continually struggle with clearance of Fires battle drills. The inexperience of leaders across the brigade in managing their digital fire support systems reduces the effectiveness of Fires in support of maneuver. When duties and responsibilities in the main CP are unclear, battle tracking and fire support coordination measures (FSCMs) management becomes difficult to maintain. These issues compound to reduce situational awareness and result in extended processing times. As a result of the lack of utilization of mission command systems, the majority of fire missions at the NTC are initiated and executed via FM voice. An example of negative effects of inefficient Fires execution at the NTC are an average of two to three indirect fire fratricides per rotation, and an average of over 20-25 minutes from sensor to shooter processing time with FA delivered Fires.

Clearance of Fires

During the last two years, over 75 percent of rotational units at the NTC do not effectively clear ground and air for fire missions, establish no-fire areas, or update maneuver or fire support graphics. Historically, BCTs often lack a clearance of fire battle drill in their SOP or have not rehearsed it at home station, resulting in an inability to rapidly clear Fires in a dynamic environment. Integrating Fires and maneuver below the coordinating altitude is also a crucial skill that is rarely practiced at home station. Challenges such as AFATDS to Tactical Airspace Integration System interoperability, and integrating triggers for aviation, close air support, and Fires are challenges that many units do not fully appreciate until they are engaged in a combined arms environment. Additionally, clearance of Fires procedures can be facilitated by airspace coordination areas that support placement of position areas for artillery. Home-station training should stress fire support communication structure, the FA battalion's ability to conduct split main/tactical CP operations, and the ability to provide timely and accurate Fires in support of the brigade fight.

Duties and responsibilities

Another challenge is that duties and responsibilities within the FA battalion main CP are unclear and priorities of work are not established. Clearly defined roles and responsibilities for sections should be established in the FA battalion TACSOP or TOCSOP. Field artillery battalions should train realistic scenarios to exercise systems and battle drills, and incorporate all available Army Mission Command Systems (AMCS) tools (joint capabilities release/ Force XXI Battle Command Brigade and Below, CPOF, Soldier network extensions, AFATDS and FM) to build understanding of the brigade and current situation and disposition. During home station training, all levels of fire support, including the staff, should be incorporated into digital systems sustainment training (DSST). If the main CP personnel actively participating in a command post exercise or NTC rotation are not present for routine DSST, unrealistic battle drills and TTPs are established, and friction will likely occur.

Digital fire support systems

Field artillery battalions and fire supporters often assess that they have conducted sufficient training on digital systems while executing their gated training strategy. However, training is not being conducted in a way that reinforces confidence in the brigade's AMCS software, especially with fire systems such as the Stand-alone Computer Unit (SCU), Lightweight Forward Entry Device (LFED) and Pocket-sized Forward Entry Device (PFED). An additional effect of insufficient digital capability is that FSCMs below the maneuver battalion level are only tracked on analog systems which require manual management before and during the fight. FSCMs must be distributed to be effective. According to Chapter 4, FM 3-09, "FSCMs are disseminated by message, database and/or overlay through command and fire support channels to higher, lower, adjacent and support units."

When used properly, digital fire support systems streamline data dissemination and result in a far more accurate and safe operating environment. Common observations indicate insufficient operator proficiency with equipment and software version management. In the last 16 DATE rotations at the NTC, less than 10 percent of company/troop fire support teams are able to utilize the SCU and LFED in order to generate digital calls for fire capability, and all calls for fire initiated at the company level have been either FM voice, FBCB2 freetext or joint capabilities release chat.

Mission command systems

The FA battalion relies heavily on upper tactical internet (TI) and loses situational awareness when it only uses lower TI, since the BCT primarily uses upper TI to generate products and maintain its operating picture. FSCMs are rarely transferred to analog trackers or plotted on an operations or Fires map, which becomes an issue when digital connectivity is lost. Field artillery battalions that routinely execute a Fires sync to distribute and refine information have a much higher degree of success than those FA battalions who do not. Over half of rotational units within the last year have struggled heavily with AFATDS database management. Typically, the battalion fire direction center (FDC) is the center of gravity within the FA battalion during decisive action. The FDC should have all maneuver graphics published and distributed, and the current fight should be managed through CPOF and AFATDS. Responsiveness of Fires is increased when units have a good understanding of the maneuver plan, such as the counterfire plan, and engagement areas in the defense. Lastly, units that develop and distribute fire support products are able to execute the plan, but few in the battalion main CP and FDC understand the commander's guidance for Fires. Decreased situational awareness between the force field artillery headquarters and the BCT FSE leads to Fires that are unresponsive to maneuver commanders.

Recommendation

Home-station training should strive for mastery of mission command systems while clearing ground and airspace. A sound DSST plan, conducted at echelon, will increase proficiency and situational awareness with the mission command nodes in all components of the fire support system. Mastery of digital fire support systems and processes will greatly enhance the ability of indirect Fires assets to provide timely and responsive Fires in support of maneuver. AMCS operators that are trained and systems that are updated with current software will have the capability to achieve more efficient battle drills and timely delivery of Fires. Additionally, maximizing training opportunities at each installation's mission training complex (MTC) will greatly benefit interoperability of AMCS systems and the Soldiers who operate them. Finally, in order for the fire support system as a whole to operate efficiently, it is vital that leaders ensure everyone understands their roles, as well as the capabilities and limitations of their equipment. When developing the UTP, the following tasks are recommended to gain proficiency in battalion operations:

- (061-284-4006) Synchronize fire support operations
- (71-8-3000) Conduct fire support (battalion-corps)
- (06-6-5431) Execute targeting process
- (06-1-5076) Synchronize Fires

Points to consider

While not all challenges units face at the NTC are identified in this article, the major focus areas have been outlined. There are multiple tools such as ADRP 7-0, Combined Arms Training Strategy and the Army Training Network that are used for assessing the Unit Training Plan and METL. The following checklist was developed by the NTC Wolf Team based on observations from multiple NTC rotations. This list offers some points to consider for units trying to see themselves and maximize training opportunities prior to a NTC rotation or preparing for combat operations.

Conclusion

The fire support related challenges most observed at the NTC are related to core collective tasks. Units should prioritize the opportunity to train on these tasks to a level of proficiency prior to arriving at the NTC and also while preparing for combat. By forecasting and planning well-resourced training that is nested with the BCT's METL, the Fires support system's efficiency and capabilities will continue to increase. An artillery battalion in direct support is only as effective as the supported battalion/BCT's fire support system will allow.

A common mantra among the fire support community is, "Fires without maneuver is a waste of ammunition, and maneuver without Fires is suicide."

The effective integration of fire support assets into combined arms maneuver demands comprehensive planning, as well as properly resourced and collective training on both sides of the radio. In conclusion, by placing emphasis on the discussed observations within the areas of planning, rehearsals and mission command, units can mitigate friction within the field artillery battalion and BCT fire support system, and integrate more effectively with the BCT in the DA environment.

As conditions and observations at the NTC evolve, the NTC Wolf Team regularly posts information online using Joint Lessons Learned Information System at the following link: https://www.jllis.mil/index.cfm?do=binders:binder.summary&binderid=10595

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Setting the pace for expeditionary precision Fires in an immature theater

By Maj. Charles M. Knoll, Capt. Anthony R. Padalino, Capt. Michael F. Dunn, and 1st Lt. William C. Fleshman

"It's never going to happen," said multiple officers during the four months preceding the delivery platoon "fly away" package.

It did happen. Moreover, it occurred in the midst of a relief in place and at the most inopportune time.

This article intends to provide expeditionary techniques, training areas of focus and thought processes for preparing, deploying and sustaining a self-propelled howitzer package to an immature theater relying solely on air lines of communication.

Developing, maintaining and executing expeditionary competencies involves a change in mindset geared towards constant readiness and flexibility, as well as enacting internal systems to support sustained readiness and deployment capacities. The same holds true to provide expeditionary Fires to the supported commander. The end state is a constantly postured and scalable combat capability to provide commanders options with a diminished yet optimal logistical and tactical footprint.

Third Battalion, 29th Field Artillery, *Pacesetters*, a direct support M109A6 equipped battalion, is assigned to the 3rd Armored Brigade Combat Team, 4th Infantry Division. The battalion deployed in support of U.S. Central Command in February 2015 where it assumed its theater reserve mission subset, as well as a training and multinational partnership focus. Preceding the deployment, 3-29th FA conducted a decisive action National Training Center rotation that included a brigade-level live fire exercise, a battalion qualification and a brigade fire control exercise. All of these training events developed an expeditionary capability across the brigade, and were critical in developing proficiency for the Fires warfighting function. The battalion also implemented its FY15 deployment unit training plan that directed the three firing batteries into a ready-training-reset training management rotation to ensure a high state of expeditionary readiness while in theater.

As the theater reserve, 3rd ABCT, 4th ID is also a force provider to the supported commander and it was under this construct that 3-29th FA received notification for the request of a M019A6 Paladin expeditionary firing package to deploy in support of Operation Inherent Resolve (OIR) within 96 hours. After analysis of the personnel constraint, it was determined that the delivery package would consist of three qualified Paladin sections, one qualified platoon fire direction center, mechanics and a mission command element. The personnel identified reflected the minimum required to operate, sustain and provide mission command during 24-hour continuous operations. The command and support relationship was defined as operational control to the combined forces land component commander – Iraq (CFLCC-I) and tactical control to the special purpose Marine air ground task force. Administrative control remained with 3-29th FA.

It was under these planning factors that the *Pacesetter Battalion* deployed the first surface-to-surface Fires capability in support of OIR. Given the austere environs and immature sustainment nodes in OIR, normally assumed aspects, such as the ability to meet the five requirements for accurate Fires, supply flow and multiple lines of communication for movement were either non-existent or diminished and required detailed planning to address. The sustainment and movement, training and operations preparation and precision Fires execution techniques and methods were used to mitigate those concerns and successfully deploy an expeditionary Fires package, which encapsulated the key les-

Figure 1. Expeditionary firing unit personnel matrix. (Rick Paape)

First Section	Second Section	Third Section	Fire Direction Center	Maintenance	Mission Command
Howitzer section chief	Howitzer section chief	Howitzer section chief	Fire direction officer	Paladin mechanic	Platoon leader
Gunner	Gunner	Gunner	Fire control sergeant		Gunnery sergeant
Cannoneer	Cannoneer	Connoneer	Fire control sergeant		
Driver	Driver	Driver	AFATDS specialist		
			AFATDS specialist		

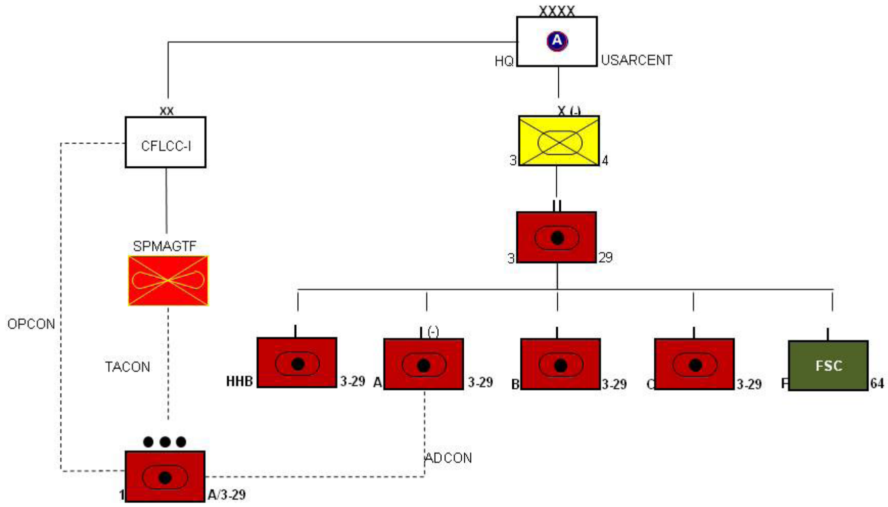


Figure 2. 3rd Battalion, 29th Field Artillery task organization. (Courtesy illustration)

sons learned for 3-29th FA. Although there may be theater and mission uniqueness to certain facets, the *Pacesetter Battalion* wishes to promulgate these lessons learned across the force.

Movement, sustainment of the delivery package

The end state destination for the expeditionary firing unit did not have sustainment systems set up to support a self-propelled howitzer package. What developed with these considerations became the plan to build up and fill initial supply push packages, conduct unit movement and sustain the forward-based delivery package for the duration of the deployment.

Planning for sustainment began with the battalion S4 in conjunction with the 3-29th FA Forward Support Company. A specifically tailored 463L palletized movement package to fly with the unit was developed and consisted of class (CL) I, III(P), IV, and IX to set the firing platoon up for sustainment success in the short term. Eight days of supply (DOS) of MREs and thirteen DOS of cased water compromised the CL I package. This is essentially one 463L pallet packed full. The CL I push lessened the sustainment impact on the gaining unit due to the initial influx of personnel. Additionally, a CL IV package consisting of sand bags and concertina wire was required to aid in perimeter expansion for the vehicles and personnel. More so, the FSC created CL III(P) and IX pallets to sustain the combat systems in a forward deployed area that lacked a supply and support activity. Maintenance personnel utilized historical data to produce and pack a listing of common failure parts on the M109A6. A full complement of CL III(P) also shipped to maintain readiness, in addition to one 5K generator for the fire direction center in the event of a power failure. The gaining unit did not have shop stock to facilitate repair for tracked combat equipment. This required future supply and parts requests to originate from and fly to Kuwait. With this basic load of supplies and equipment, 3-29th FA postured itself to support the mission from the sustainment perspective. In order to maintain expeditionary readiness in support of other Army Central Command contingencies, the battalion immediately built an additional 463L pallet package pre-positioned in Kuwait, in a sense reconstituting the reserve, with the same 96-hour ready-to-deploy timeline.

The battalion and brigade property book officers developed a new Department of Defense activity address code that eventually

Soldiers load a M109A6 Paladin weapon system onto an aircraft. (Spc. Gregory Summers/3rd Armored Brigade Combat Team)

An M109A6 Paladin weapon system loaded on to a C-17 Globemaster III. (Spc. Gregory Summers/3rd Armored Brigade Combat Team)

routed CL III and IX directly to the 3-29th FA forward elements. Orders were completed after the forward unit trained personnel with regular updates via Secret Internet Protocol Router Network and an enhanced work station configured in Kuwait. In the event of a critical failure on a Paladin or other ancillary equipment that is not part of the battalion shop stock, 3-29th FA utilized command substitution to pull parts from rolling stock already in Kuwait to hedge against long shipping times. The parts were then hand-carried to the airfield and on the next flight. Using this method, the battalion was normally able to have parts to the end-user within 24 hours instead of waiting for the parts flow system.

The final sustainment piece was the resourcing of CL V to the forward unit. The battalion staff conducted the analysis on storage capacity for canisters and rounds in the M109A6 and M992 in addition to the forward location's storage capacity at their ammo holding area (AHA). It was determined that the forward location had yet to certify its temporary AHA, so the battalion was initially restricted to the CL V load capacities of the two M109A6s and M992. Based on mission requirements, the battalion staff determined a 155 mm unit basic load for the forward unit, taking into consideration how artillery ammunition is bundled and shipped to adhere to air shipment requirements. This factor significantly drove the quantity analysis per munition. Once the quantities solidified, the brigade ammunition tech conducted a line-by-line verification of the request. A call forward of ammunition initiated at ARCENT where they processed the ammunition request with the 999 highest priority code. The ARCENT specialty-handling unit built, packaged and de-conflicted the diplomatic clearance procedures for the ammunition, as well as submitted all hazardous material (HAZMAT) waivers for the flight. The initial ammunition package landed 12 hours before guns on the ground. The platoon completed inventories on the ground for verification, and then generated a DA Form 581 for the ammunition allocation. Ammunition number adjustment on the property books went through the administrative adjustment report process and property book officer. Due to forward storage capacity constraints and lag times for CL V resupply, a resupply trigger of 89 percent on hand CL V initiated the backfill of expended ammunition.

Movement of the equipment and supplies required extensive coordination through brigade mobility, ARCENT and Air Force Central. Rolling stock and every 463L Pallet had a DD1384 Transportation Control Movement document to identify weight and dimensions for flying. Also required were HAZMAT declaration forms consisting of the types and quantities with proper packing procedures for air movement. For 3-29th FA's shipment, this focused on fuel, coolant and generator preparation procedures. Additional DD5749 shipment unit packing lists and hazardous diplomatic clearance forms were required per chalk to provide a summary of all equipment flying. Once completed, brigade mobility compiled equipment load plans per aircraft. ARCENT then compiled unit line numbers per chalk and began diplomatic clearance procedures for scheduling the flights.

Ground movement preparations of all rolling stock and equipment from motor pool to the airport of embarkation (APOE) followed strict air preparation procedures to include weight tests, shackling, proper tie downs of ancillary equipment and construction of wood shoring specifically built to the Air Transportability Test Loading Agency standard for each vehicle and pallet. Detailed coordination ensued through movement control teams to schedule heavy equipment transport trailers (HETTs), flatbeds, and cranes to maneuver equipment to the APOE. Twelve hours before the flight, AFCENT conducted a joint inspection of our rolling stock and pallets to verify loads for each flight. After passing the joint inspection and paperwork check, the equipment was ready to load on the C17 cargo aircrafts. Pallets were loaded and Soldiers drove vehicles onto each plane with subsequent chain down by Air Force loadmasters. Equipment and personnel were ready to take off once all sustainment considerations were complete and training validated.

Training, operations, preparations

Section qualification redundancy was of paramount importance for the platoon-sized delivery package to OIR, especially with a force cap and maintaining a 24-hour capability to deliver Fires. The qualification redundancy applies not only for the howitzer sections and for fire direction center but also the crew-served weapons. Prior to the deployment, 3-29th FA live fire qualified both the Paladin section chief and gunner, which in effect generated two qualified crews per section. The same applied to the fire direction center by qualifying both the fire direction officer and fire direction noncommissioned officer with separate advanced field artillery tactical data system operators. These redundancies created more effective shift work, increased 24-hour readiness, and mitigated against potential injuries or illnesses that could break a qualified section. Additionally, it was determined that the expeditionary Fires package should have the ability to augment base security with their assigned crew served weapons. Above allocation CL V requests were submitted and approved to qualify two Soldiers per section on the M2 and MK19 instead of one. Again, this created a bench of qualified Soldiers to continually operate these weapons and combat complacency in a high threat area.

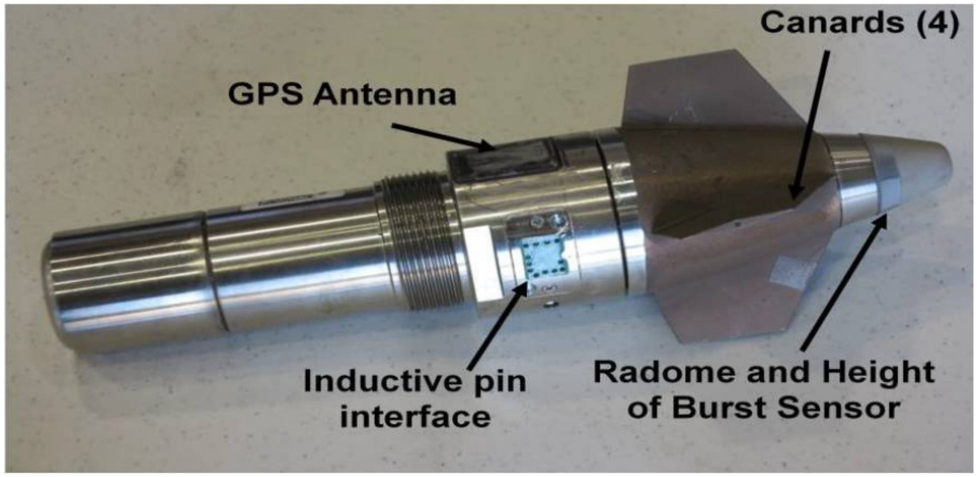


Figure 3. The components of the precision guidance fuze kit. (Special Text No. 3-09.53, Figure 1-1)

Other key training preparations for the expeditionary package included deployment readiness exercises (DREs) and precision guidance munitions (PGM) capability validations. Prior to the departure of the expeditionary Fires package, the battalion and battery conducted multiple DREs to ensure the readiness of the unit. Early morning loudspeaker alerts began an hour countdown followed by personnel and manifest scrubs, intelligence briefings, weapon and combat load issue, packing list inspections, HETT staging and vehicle upload, blood chit and personal locator beacon issue and personnel movement to the APOE to practice and fine tune the deployment sequence. The battalion also directed the expeditionary package to demonstrate their M109A6 PGM capability daily. This daily drill included equipment inspection and operability of the Enhanced Portable Inductive Artillery Fuze Setter (EPIAFS), Platform Integration Kit (PIK), Simple Key Loader and Defense Advanced GPS Receiver (DAGR). The loading sequence and validation of the Cryptographic Black Keys into the DAGR and PIK became the culminating event for howitzer crews to demonstrate their PGM capability.

The battalion leaned forward in preparing the expeditionary Fires package to meet the requirements for accurate Fires. The profiler system would pass meteorological data to the forward deployed firing unit utilizing the Global Broadcast System. As for muzzle velocity variations (MVV), the expeditionary unit would have to use predicted MVVs initially since the battalion had yet to calibrate on the propellant lot in theater war stocks. The firing unit was finally able to calibrate on the theater war stock propellant once the unit arrived at the end state location and received the CL V. Accurate firing unit location was more difficult to achieve initially. Prior to deploying the expeditionary firing unit, the battalion and brigade engineer conducted reach back to the United States Army Corps of Engineers for first order survey control points (SCPs) and benchmarks at the end state destination. The USACE was able to provide all necessary information and site surveys within one week; however, all the benchmarks and SCPs had either disappeared or been paved over from the site survey conducted in 2003. This required the firing unit to use the dual-DAGR method for firing unit location until the battalion was able to coordinate a survey team to install orienting stations, SCPs and fire control alignment stations. When the survey team arrived with the Improved Position Azimuth Direction System, the battalion decreased the firing unit location error induced by using the dual-DAGR method, allowing us to meet all five requirements for accurate fire, and deliver accurate Fires in support of CLFCC-I.

The expeditionary firing unit would be required to conduct precision-strike Fires, counter-fire, and interdiction/terrain denial Fires. The CL V draw reflected the types of Fires from PGMs to smoke and illumination. The target engagement authority or on-scene ground commander's authorization for these types of Fires followed the CFLCC-I target approval process for rules of engagement and collateral damage estimates. The operating environment for the expeditionary firing unit included collateral damage concerns for which the use of PGK fuzes would be necessary. The battalion had

U.S. Indiana National Guard achieved 25 meter circular error probable (CEP)				
CEP Ranges	Impact < 1 CEP (0-25 meters)	Impact < 2 CEP (25 - 50 meters)	Impact < 3 CEP (50 - 75 meters)	Impact > 3 CEP (> 75 meters)
Predicted Percentage	50%	32%	14%	4%
Actual Percentage	52%	24%	19%	5%

Figure 4. Precision Guidance Kit circular error probable performance for the U.S. Indiana National Guard. (Rick Paape)

not received any training from outside sources on PGK at home station or at the National Training Center prior to deployment. The extent of our training on precision guided munitions thus far had been dry fire iterations of Excalibur and PGK.

To close the PGK experience gaps, the battalion contacted the Training and Doctrine Command capability manager for Brigade Combat Team Fires at Fort Sill, Okla. The capability manager pointed us to the ST 3-09.53 TTP for PGK dated October 2014, TB 9-1390-226-12 dated October 2014, and a PGK Quick Reference Guide. All of these references are available on the TCM BCT Fires AKO site to include contact information. The manuals, texts and phone reach back to TCM BCT Fires were invaluable in gaining detailed technical knowledge on PGK employment.

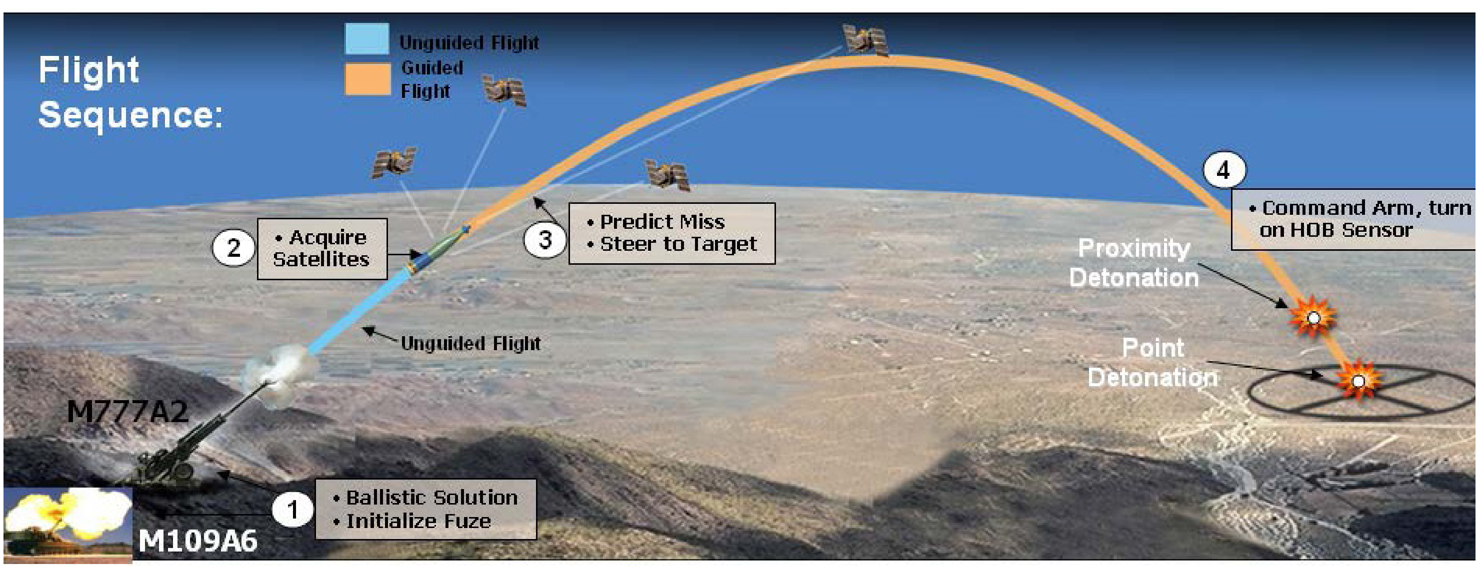
The PGK fuze is compatible with the M795 High Explosive and M549A1 Rocket Assisted Projectiles. It requires a M76 wrench to mate the fuze to the projectile. The EPIAFS sets the PGK in conjunction with the PIK and DAGR. The EPIAFS transfers power into the PGK during the setting process. Internal capacitors maintain power for a limited amount of time, after which, the fuze will lose power and will require resetting before firing. There is no reset limit on the PGK. After firing the projectile, an onboard alternator will keep the capacitors charged.

Precision Guidance Kit settings for proximity or point detonating burst is effective on personnel and light material targets. The fuze setter passes a ballistic trajectory and a number of GPS waypoints to steer the projectile on its path. The fuze requires acquisition of multiple GPS satellites to function. If it fails to acquire the satellites, it will follow the ballistic trajectory and will not function on impact. It also has a built in "should hit" versus "will hit" test and will "dud out" if the projectile impacts outside of a predetermined distance from the intended target grid. The "dud out" feature of the PGK provides the ground commander a tool to limit collateral damage. Collateral damage estimates adhere to the theater specific collateral damage methodology for indirect fire CDE levels. One major lesson learned was the implementation of the collateral effects radius when utilizing the PGK fuze. As stated above, the PGK fuze "safety dud" feature causes the round to go inert if it lands outside of a predetermined distance of the intended target; however, if the munition lands exactly at this distance from the intended target grid it will function and thereby potentially cause effects even further from the target location. It is important for ground commanders to understand the distances at which the PGK will function from the target and to account for this collateral damage concern when using PGK.

The PGK is not Excalibur. The PGK does not turn the projectile into a pinpoint accurate precision system. The fuze has limited correction capability and relies on the five requirements for accurate fire. The fire direction officer should apply the following additional considerations:

1. Accurate target location and size: PGK does not correct for target location error, which will result in a proportional amount of impact location error.
2. Accurate firing unit location: The charge selection for PGK is based on range to target. Refer to the ST 3-09.53 for charge selection tables.
3. Accurate weapon and ammunition information: Accurate MVVs are critical to the effectiveness of PGK. Performance increased after conducting a calibration

Figure 5. An illustration of the Precision Guidance Kit's operational sequence. (Special Text No. 3-09.53, figure 1-4)



Soldiers use an M109A6 Paladin for a Fires mission at Qayyarah West, Iraq, in support of the Iraqi security forces' push toward Mosul, Oct. 17, 2016. The support provided by the Paladin teams denies the Islamic State of Iraq and the Levant safe havens while providing the Iraqi Security Forces with vital artillery capabilities during their advance. (Spc. Christopher Brecht/ U.S. Army)

with the issued propellant lot.

4. Accurate meteorological information: MET should be current within 30 minutes of firing PGK.
5. Accurate computational procedures: Understand the minimum time of flight necessary for the PGK to correct its trajectory. Manipulation of charge or a high angle method of fire may be required to achieve time-of-flight considerations.

When meeting all five requirements, PGK will produce a circular error probable (CEP) of 50 meters or better across all ranges. Circular error probable is the radius from the target in which 50 percent of all rounds impact. The following table illustrates historical performance of the expeditionary firing unit in theater versus the dispersion probability curve found in the FM 6-40. The unit achieved over 50 percent of rounds functioning within 25 meters of the target; a 25 meter CEP.

It is important to convey to maneuver commanders the realistic performance that PGK provides. Ensure the commander understands the CEP and that half of the rounds fired will impact outside of it. Although PGK is not as precise as Excalibur, PGK fuzed high explosive rounds remained the projectile of choice in theater due to its ability to go inert if it falls outside of the 150-meter window.

Expeditionary competencies are becoming increasingly more pertinent, especially for the field artillery where our sensor and surface-to-surface Fires capabilities are growing in demand from supported commanders.

In order to meet these requests from supported commanders, field artillery battalions, particularly our self-propelled direct support battalions, must develop internal systems and training mechanisms to develop readiness and remain postured in the event a request to deploy piecemeal into an immature theater of operations occurs. Thorough staff military decision-making process iterations are essential in developing operational readiness surveys and war-fighting function execution checklists to ensure accountability of all variables when deploying expeditionary units. The unit movement operations, training preparations, sustainment and precision Fires lessons learned from 3-29th FA's expeditionary Fires experience are worthwhile to distill and focus battery and battalion staff training.

Maj. Charles M. Knoll served as battalion executive officer and battalion operations officer, 3rd Battalion, 29th Field Artillery Regiment, 3rd Armored Brigade Combat Team, 4th Infantry Division, Fort Carson, Colo.

Capt. Anthony R. Padalino served as battalion fire direction officer and executive officer, 3rd Battalion, 29th Field Artillery Regiment, 3rd Armored Brigade Combat Team, 4th Infantry Division, Fort Carson, Colo.

Capt. Michael F. Dunn served as executive officer and platoon leader, A Battery, 3rd Battalion, 29th Field Artillery Regiment, 3rd Armored Brigade Combat Team, 4th Infantry Division, Fort Carson, Colo.

1st Lt. William C. Fleshman served as battery fire direction officer and battalion fire direction officer, 3rd Battalion, 29th Field Artillery Regiment, 3rd Armored Brigade Combat Team, 4th Infantry Division, Fort Carson, Colo.

A target drone is used for air-to-air live-fire exercises during a recent counter unmanned aerial systems exercise at Naval Base Ventura Country Point Mugu, Calif. (Petty Officer 2nd Class Antonio Turretto Ramos/U.S. Navy)

Countering the UAS threat from a joint perspective

By Lt. Col. Jeffrey Lamport and Col. (retired) Anthony Scotto

As technology advances and the U.S. military touts the advantages of drone warfare, other countries, terrorist organizations and criminals will continue to develop and procure low-cost unmanned aerial vehicles (UAVs). Often, these small, complex systems are equipped with cameras, laser designators, radio frequency (RF) collection devices and/or weapons to provide battlefield intelligence and engage friendly forces. The size and composite materials used in UAV production make them inherently difficult to defeat with traditional force protection measures and short-range air defense (SHORAD) systems commonly employed by brigade and below maneuver forces.

One of the most significant uses of unmanned systems on the battlefield today is occurring in Ukraine, where both Ukrainians and Russian-backed separatists are operating UAVs in relatively large numbers. They are reportedly operating more than a dozen variants including fixed- and rotary-wing configurations, each functioning at different altitudes with various sensor packages designed to complement each other's capabilities.

The battlefield is not the only susceptible area to the effects of nefarious UAV operators. The nation's capital, nuclear facilities, correctional facilities, borders and sporting venues are among targets already "attacked" with this rapidly proliferating technology. Terrorists leverage UAVs to interrupt the daily routine, while criminals defeat traditional security (e.g., fences, walls and "no-fly" zones) to scout low-risk routes for illegal alien and drug transport across the border and contraband delivery to prisoners. While these are not traditional military missions, Department of Defense specialized equipment and personnel may be tasked to support civil agencies in the

Defense Support to Civil Authorities construct.

For nearly three decades, the U.S. Army and unified action partners have had the luxury of conducting ground and air operations in a virtually uncontested airspace environment. As such, development and fielding of dedicated SHORAD systems has declined and passive air defense skills have atrophied across the force. Continued UAV technology development, UAV fielding acceleration and "bad actor" successes around the world clearly demonstrate that we are faced with a viable air threat. Leaders at all levels cannot be lulled into a false sense of security because of the small size of these UAVs. They are as effective, if not more effective, than traditional manned aircraft (or even stealth aircraft) in reconnaissance, surveillance and target acquisition precision attack and indirect fire support. Troops must assume they are being watched and targeted and take appropriate action to minimize mission impact.

What Soldiers need to know

UAVs can create serious problems for maneuvering or static forces. Their size, composite construction, small radar and electromagnetic signatures and quiet operation make them difficult to detect and track. Their low-cost, lethality and rampant proliferation make them an air threat that we can no longer ignore. Some factors contributing to the counter-unmanned aircraft system (C-UAS) challenge are:

1. Small, slow, and low profiles provide significant challenges to traditional air defenses. Conventional systems often filter out these tracks to avoid confusion with clutter, large birds and aerostats. Systems optimized for this threat often forfeit effectiveness against other target sets (e.g., manned aircraft, cruise missiles, rockets and mortars and ballistic missiles).
2. Reduction of dedicated SHORAD units to maneuver brigades creates potential gaps in air defense coverage.
3. Soldiers are "numb" to UAVs. Recent combat experience in Iraq and Afghanistan indicates troops may be highly accustomed to friendly UAVs and, therefore, less likely to be concerned about them flying overhead and less inclined to actively search for UAVs operating in their battlespace.
4. Many Soldiers lack UAV recognition training. Without training, it is extremely difficult to observe characteristics visually, which can easily distinguish threat UAVs from friendly systems supporting the mission. This issue is compounded by the ever-increasing proliferation of new UAV designs and off-the-shelf systems sold to multiple countries.
5. U.S. Army and joint doctrine have not kept pace with the threat.

Counter-UAS training is not a priority for most units, and many units have not updated plans to address the hazards they present adequately.

Understanding the threat

Unmanned aerial vehicles pose a significant threat to safety and mission accomplishment by providing the enemy critical intelligence such as a unit's precise location, composition and activity. They may also provide laser designation for indirect Fires or direct attacks using missiles; rockets; small "kamikaze" munitions; or chemical, biological, radiological and nuclear weapons. Some payload configurations can contain radar and communications jamming or other cyber attack technology. Unmanned aerial vehicles may operate autonomously with little or no RF signature or under pilot control using a ground control station (GCS). The following list describes its threat characteristics:

1. Typically comprised of a UAV, a sensor and/or weapons package, GCS and communications equipment to support navigation and data transfer.
2. Available on the open market, often "clones" of U.S. systems and cheaper than stealth.
3. Often rely on GPS for guidance/targeting and use multiple RF bands including frequency modulation, ultrahigh frequency, satellite communications and cell phones.
4. Small UAVs have a limited range and flight duration, meaning they are frequently operated from within the observed unit's battlespace.

Threat mitigation

Conduct a comprehensive air threat analysis as part of the intelligence preparation of the battlefield/intelligence preparations of the environment and utilize any resources available to mitigate risks associated with any air threat. Defeating the UAV threat begins with the planning process:

1. Understand the UAV threat. Conduct a deliberate analysis to ascertain the potential type and GCS likely to be employed, understand their capabilities and employment doctrine, predict where and how they will be employed and identify their most likely targets.
2. Honor the threat. Ensure there are adequate/appropriate resources to counter its effects in and around your unit's battlespace. If specialized sensors are not available, be certain to establish "air guards" to scan the airspace continuously. Ensure you understand and are in compliance with the Area Air Defense Plan (AADP).
3. Maintain disciplined flight operations. Although flight clearances for friendly UAVs are sometimes perceived as untimely or overly restrictive, they are critical to ensuring other friendly forces in the area do not engage your UAV. Ensure flights are in compliance with local airspace coordinating measures to aid in proper identification.

C-UAS considerations

Unmanned aerial vehicles are the air threat of the next fight. Unmanned aerial system technology development and employment around the world demonstrates a relevant and viable air threat. Air defense artillery liaison officers cannot be lulled into a false sense of security because of the relatively small size of these platforms. Instead, the officers should consider the following when working with/within the Integrated Air Defense System:

1. Take an active role in AADP development to ensure it adequately mitigates threats to the maneuver force.
2. Suggest UAV-specific rules of engagement when there is a reliable ability to distinguish unmanned platforms to maximize attrition of low-regret targets. Identification and engagement authority for low, slow, small UAVs should rest at the lowest possible tactical level.
3. Ensure criteria for "hostile act" and "hostile intent" specifically address UAVs, are written in terms any Soldier can understand and adequately address ground troop protection.
4. Consider requesting liberal "hostile" symbology use and ID forwarding through the Air Defense and Airspace Management cell to the common operational picture.
5. Ensure all joint data link contributors utilize a common set of track amplification data (i.e. air type, air platform and air activity) to categorize the UAV target set.

Marines assigned to an unmanned aerial system squadron launch an RQ-7B Shadow during an exercise near Yuma, Ariz. (Chief Warrant Officer 2 Jorge Dimmer/U.S. Marine Corps)

National Capital Region and interagency support

Critical assets within the continental U.S. have already been attacked by enemy UAV operators. While no deaths have been attributed to these UAVs, it is only a matter of time before these systems are directly or indirectly responsible for loss of life or interference with critical infrastructure in the homeland. In some circumstances, Title 10 military personnel and equipment may be required to operate subordinate to civil-military organizations, and the following are considerations for working in this environment:

1. Per Department of Defense Directive 3025.18, DoD, resources may be used in an immediate response to prevent loss of life, mitigate damage to infrastructure or in support of mutual aid agreements (Title 42 USC) to address certain pre-coordinated conditions or as directed by the president as part of the national response framework.
2. All DoD activity within the homeland is conducted in support of a primary federal agency to minimize impacts to the American people, infrastructure and environment.
3. It is unlikely that most organic communications systems will be compatible with the civil organization(s) being supported, thereby increasing reliance on knowledgeable liaison officers.
4. Missions may include air defense coverage for the National Capital Region, key power/communications infrastructure, national borders, sporting arenas, political conventions and presidential inaugurations.
5. Technology countering the UAV threat within our own borders must be in compliance with existing Federal Aviation Administration and Federal Communications Commission regulations. Military planners cannot assume they are exempt from fines or prosecution for violating civil airspace or spectrum management policies in the interest of thwarting a potential hazard.

Defeat the threat

Unmanned aerial vehicle development and fielding is gaining momentum with our adversaries, and with each new innovation, they are becoming more capable than the previous generation. We must assume targets of vital interest are being watched and targeted. Unmanned aerial vehicle operations are not limited to the battlefield; they have already been used to disrupt our daily routines at home and violate traditional security measures surrounding our borders, prisons, nuclear facilities and premier sporting venues. Not all may be traditional military missions; civil authorities will also benefit from our research and analysis, leverage our technology, and request assistance defending airspace around sensitive domestic targets. Leaders across all warfighting functions must take an active role in educating themselves and training their units to defeat this threat.

Lt. Col. Jeffrey Lamport graduated from the U.S. Air Force Academy in 1999 and completed assignments as an airlift pilot in both the C-141 Starlifter and C-5 Galaxy. As project lead for the Black Dart Counter-Unmanned Aircraft Systems (C-UAS) Technology Demonstration, Lamport oversaw data collection and analysis efforts leading to decision-quality recommendations in support of Combatant Command, interagency, and industry's C-UAS requirements, capability gaps and fielding and acquisitions efforts. He is currently on the United States Air Force Joint Deployable Analysis Team.

Col. (retired) Anthony Scotto, United States Army, was commissioned as an Air Defense Artillery officer through the Reserve Officer Training Corps at the University of Alabama in May of 1984. His key Army assignments include: The Army's time sensitive targeting officer for the Combined Air Operations Center at Al Udeid Airbase, Doha, Qatar; The chief of engagements for the Multi-National Division in Baghdad, Iraq; and commander of the 3rd Battalion, 346th Infantry Regiment at Camp Shelby, Mississippi. Presently, Scotto is a senior analyst and serves as the lead contractor for the Counter-Unmanned Aerial Systems project for the Joint Deployable Analysis Team.

Bridging multinational joint Fires interoperability with competent fire support liaison

By Capt. Kyle L. McGillen

During Swift Response 15, a multinational task force, consisting of German, Netherlands, Polish and U.S. service members, conducts an air drop during a joint forceable entry exercise, into Hohenberg Drop Zone, Hehenfels Training Area, Germany. (Capt. Kyle McGillen/U.S. Army)

NATO continues to evolve from an operational doctrine that promoted multinational divisions and corps during the Cold War to multinational interoperability at the brigade level and below in current operations. This crucial doctrinal shift to brigade-level interoperability allows NATO to adapt to rapidly changing global security challenges. However, there is a deficiency within NATO doctrine, standardization agreements, standard operating procedures, and disproportionate capabilities and capacities at the battalion level that make multinational interoperability challenging.

These multinational operations are the future of global conflicts and require an acute focus of understanding and integration. For the competent Fires liaison, it is critical to allow formations to work within their tactics, techniques, capabilities, and capacities, while supporting the larger multinational maneuver formation in order to develop a common understanding within joint Fires. These liaison requirements will not be the same for all multinational task forces (TFs). In a multinational brigade with subordinate battalions that have similar doctrine and robust fire support cells in their staffs, minimal liaison support from the brigade is required. However, in a multinational brigade whose battalions have divergent doctrine, incompatible communications, and limited Fires staff cells, the brigade should provide a fire support liaison officer (FS LNO) package to the subordinate battalions.

Developing liaison packages requires detailed understanding of each echelon and in multinational TFs there will likely be a non-reciprocal liaison relationship. Brigade elements will assign a liaison to the battalion TF to create shared understanding and competence across the brigade's Fires warfighting function. FS LNO packages should be able to bridge gaps in capability and capacity between the brigade and the battalion and should account for doctrinal differences. In order to create a fully integrated and synchronized maneuver element, it is vital to establish and build shared understanding of all practices, procedures, and capabilities across all echelons.

Integration of FS liaison personnel

During multinational operations, Fires interoperability at the battalion TF level relies heavily on an effective FS LNO package from brigade. This package requires competent personnel, digital Fires equipment, effective communications equipment, and mobility in support of a rapidly deploying multinational force. The doctrinal Fires differences in Eastern European militaries, Western European militaries, and the United States is diverse and requires a FS LNO package to develop common Fires understanding. The TF FS LNO package can help create common understanding while working with the organic fire support and operations personnel to bring all multinational assets to the fight and support the maneuver commanders' scheme of maneuver. The FS LNOs provide the supported battalion commanders understanding of the brigade's fire support capabilities, the multinational assets that are available, the planning considerations, and are able to rapidly de-conflict the ground and air for joint Fires effects.

Observer coach trainers (OC/Ts) at the Joint Multinational Readiness Center have observed that formations with a strong Western doctrinal foundation interoperate well with units from the United States. Interoperability gaps primarily include the ca-

A German joint fire support team conducts final fire support map rehearsal. (Capt. Kyle McGillen/U.S. Army)

pability of digital architecture, using common communications security (COMSEC), confirming doctrinal terminology, and asset allocation (centralized Fires versus decentralized Fires). JMRC OC/Ts have observed larger deviations of joint Fires capacity, capability, and doctrinal practices with Eastern European battalions. These militaries still mirror the former Warsaw Pact doctrine from 1955-1991. They remain strongly tied to their national doctrinal roots, in that joint Fires is promulgated at the land forces or division level, causing an institutional divide which develops seams in Fires effectiveness.

Lack of battalion-level training with joint Fires causes overreliance on organic mortar systems and underutilization of joint Fires. Some militaries do not even have TF fire support elements (FSEs) or TF fire support officers (FSOs). JMRC OC/Ts have observed TFs that assign the mortar commander the duties of the TF FSO with no additional training or personnel to support the mission.

Eastern European battalions have proven to be well-trained and at times better than some other Western European battalions at employing Fires at the lowest level. However, when offered joint Fires allocation to support the maneuver commander, the challenge of integrating and synchronizing Fires becomes very apparent. Employing Fires using organic mortars is usually executed effectively, but adding other combined or joint assets such as field artillery, general support High-Mobility Artillery Rocket Systems, close air support (CAS), or close combat attack aviation proves challenging and often is executed sequentially rather than simultaneously. Prior to multinational operations, most Eastern European units do not have the opportunity to train with and integrate into a combined arms maneuver operation. These countries tend to use only organic assets during their normal Fires employment, so that they lack a robust and experienced element to support planning, de-conflicting air and ground, and the overall employment of a multitude of assets on their own.

The TF FSO LNO package must be tailored for each battalion in order to address deficiencies in capacity and capability to support the brigade operations. In a battalion that has a more robust joint Fires interoperability, this integration may only require a vehicle and communication equipment. This communication equipment includes radios with common COMSEC features or linked with a tactical voice bridge, the Advanced Field Artillery Tactical Data Systems (AFATDS) if the countries are not a partner with the Artillery Systems Cooperation Activities (ASCA) program, or other digital fire processing links when applicable.

Whether a battalion has experienced joint Fires personnel or has no organic fire support personnel at all, the LNO package must be scaled to facilitate planning, de-confliction, and employment of joint Fires. This LNO package should include a vehicle, radios that can be both vehicle-mounted and remote-mounted in the tactical operations center (TOC), digital connectivity with an AFATDS or other ASCA digital fire processing system, and a sufficient number of personnel to man 24-hour operations to support the Fires planning, the employment of joint Fires, and a tactical air control party for terminal control of CAS assets.

Integration of FS LNO equipment

Critical to identifying the proper equipment for a FS LNO package is early communication and understanding of the subordinate battalion's capacity and capability. Following this coordination, the brigade may be required to adjust the LNO package after first being deployed as some gaps in communications during coordination may create gaps in abilities. Integration of FS LNO equipment early is critical to validating the plan and identifying shortfalls in the LNO package implementation. As early as possible, a multinational battalion should integrate the personnel and equipment, establish critical communication nodes, and rehearse all possible aspects of their employment to confirm that the network and package is capable of accomplishing the mission. JMRC OCTs observe shortfalls in planning, equipment layout, and the utilization of equipment in the TOC during planning and operations. These failures have hindered the LNOs' ability to support the battalion (e.g. having radio with no ability to remote-mount the equipment or having remote-mounted equipment that cannot be used in a mobile fight; both are critical to the modern battlefield).

Following the successful validation of personnel and equipment for the full spectrum of both mobile and TOC-centric mission command, the LNO and FSE must continue to refine and rehearse their mission. Implementation of new equipment and procedures into tactical operations that the TF has not used before can cause adverse delays in Fires execution. Without proper planning and rehearsals, the multinational TFs may work around brigade systems and clear Fires without fully understanding the capabilities of the systems and restrictions from the higher headquarters.

Integration of FS LNOs in planning process

A successful LNO package must have scalable personnel requirements. Early communication and understanding of the nation's abilities and needs is critical to providing an effective LNO team. In many organizations, this may only require the communication structure and a traditional liaison between the two echelons. These organizations are generally structured to plan, coordinate, and employ joint Fires in a manner that mirrors U.S. doctrine. However, requirements for other organizations may be much more robust because of a lack of joint Fires organizational structure.

Integration of the FS LNO team in the battalion's planning process will vary greatly among the different formations. The LNOs may assist with planning or may be the primary FS planners. Being prepared to execute the role that is required, and understanding what is expected of them by the battalion is critical to successfully integrating the FS LNO team and supporting the unit. The FS LNO team must be capable of supporting, advising, and assisting battalion Fires personnel; liaise with brigade Fires; and if tasked, serve as the primary TF FSE.

Identifying most effective LNO package

The best LNO packages not only provide the digital communication requirement to liaise with the higher echelon, but also provide their own competent fire supporters to assist in managing and planning operations. In situations where the LNO will support a unit that doesn't have organic FS personnel, successful interoperability requires the FS LNOs to serve as the TF FSE. The optimal LNO package in these formations is a TF FSE with a senior TF FSO, TF FS noncommissioned officer, two AFATDS box operators/drivers, and two joint terminal attack controller teams.

With current manning constraints, most brigades cannot give up a senior TF FSE to support LNO duties, but it is possible to piece the team together. The TF FSO doesn't have to be the senior battalion FSO in the brigade and the TF FS NCO doesn't have to be a seasoned E-7/OR-7 FS NCO. A competent field artillery FSO and E-6/OR-7 FS NCO with a driver and digital box operator will multiply the multinational formation's fire support capabilities in planning and execution.

Airspace coordination, clearance of Fires battle drill integration

Not all militaries have the same considerations for Fires de-confliction and some are less risk adverse in employing Fires without accurate ground and air de-confliction. The FS LNO needs to be incorporated in the battalion rehearsals and understand the clearance and coordination methods that the TF is planning to use. This is a key component of FS interoperability as many countries are not accustomed to centralized Fires clearance and some are not accustomed to de-centralized clearance of Fires. The FS LNO should help the battalion staff understand Fires coordination, de-confliction, and employment measures the brigade will use.

The earlier the LNO team is able to educate and develop the Fires roles in centralized or decentralized clearance, requesting assets procedures, and employment procedures, the more effective the multinational force will be. The U.S. Army, after 13 years conducting the Global War on Terror, struggles to execute centralized clearance of Fires, as do other countries that are familiar with having artillery aligned with battalions. In any situation, establishing the framework early in the planning process allows the battalion to build an interoperable fire support team.

The FS LNOs need to completely understand the brigade procedures and, if needed, educate the battalion on these procedures. Whatever the process is, all parties involved need to understand their roles and rehearse. Many battalions have a reluctance to rehearse Fires drills in multinational TFs, which is a fault with adverse effects when the time comes to employ assets. The FS LNO should assert the requirement to work through rehearsals and the battle drills with all members. The FS LNO's ability to quickly identify and clear the ground and air while requesting assets is crucial to effectively employing joint Fires in unified land operations.

Integrating different doctrines within a multinational brigade

To achieve tactical interoperability, a multinational brigade must be able to effectively apply different national doctrine in a unified effort. There is a requirement to be flexible on techniques and practices to effectively build a team that will fight in a cohesive multinational brigade. Open and detailed communication is crucial to identifying and understanding each multinational component of the formation. Some militaries are more deliberately aligned with their doctrine and others are more flexible. This can present challenges in merging some doctrinal FS principles, but it requires a willingness to learn.

The FS LNO is a critical conduit for identifying, communicating, and supporting doctrinal differences between the brigade and the battalion. Early in the deployment of a multinational TF, the FS LNO must become well-versed in all aspects of the multinational and allied doctrine, not just FS-related, but also understanding the maneuver plan and anticipating contingencies. The FS LNO should be well integrated with all personnel in the staff sections including the chief of staff, operations officer, intelligence officer, logistics officer, communications officer, Fires personnel, and of course the TF commander. The LNO must take part in formal and informal conversations to ensure understanding of the maneuver commander's plan and to make his role is understood early.

The understanding of how the tactical operation will be controlled and fought is critical. The Eastern European battalions use their forward tactical command post (TAC) to control the fight more than in the U.S. formations. The U.S. will generally deploy a TAC when preparing to jump the TOC or in critical situations when communications require the forward deployment. Many multinational formations deploy the TAC more frequently and some always have the TAC out because of organic communications requirements, commanders wanting to be forward in the fight, and for survivability or succession of command in the event one is attacked.

Understanding how the TF will fight will help identify the personnel requirements and positioning of LNO teams. These teams may be required to split to cover both a TOC and a TAC — this needs to be understood and integrated in the operational employment of the LNO team. Critical planning requirements for LNOs include: understanding the roles of the TAC and TOC, the commander's primary and alternate locations, and if there is an operational change of mission command from the TAC and TOC planned during the operation.

Most multinational armies conduct planning that is similar to the U.S. military

Forward observers from the Czech Republic occupy an observation post. (Capt. Kyle McGillen/U.S. Army)

decision making process (MDMP) or NATO Comprehensive Operational Planning Directive. However, some organizations thrive on a more hasty planning process. Many European battalions use a detailed MDMP process and when time allows, often will go strictly by the manual to develop coherent and detailed plans. However, JMRC OC/Ts have also observed reactive planning processes that made Fires planning chaotic and very difficult. The FS LNO is not going to change the battalion's planning process, but they can support by emphasizing the need to plan and coordinate joint assets early during planning. This planning isn't as effective without the detailed synchronization with the maneuver plan, but it can allow assets to be aligned early enough to be utilized. This may trigger the planning process earlier as the battalion strives to get the LNOs the answers they need.

Commander's guidance for Fires

Interoperability of Fires at the multinational TF level requires shared understanding of the scheme of maneuver, the Fires plan, and the commanders' guidance for Fires at each echelon. The LNO must understand that each multinational formation approaches commanders' guidance differently. Some formations may have extensive micro-details of expectations for Fires, while others might have no guidance until the opportunity to use Fires presents itself. It is important for the LNO to understand the commander's intent for Fires and how he will communicate changes to intent. If the FS LNO's role is providing liaison and assistance, this conversation should be with the S3 or chief of staff and the FSO to understand the doctrinal and personality differences that the commander will present.

The situation is slightly different when the FS LNOs have assumed primary roles as the TF FSE and are the lead planners and employers of joint Fires. In these situations the FS LNOs need to work early with the S3 and commander to understand how the guidance will be given and present the information they need to successfully plan and employ joint Fires. In a formation that doesn't traditionally employ joint Fires, that guidance may lack enough details or it does not exist. The TF FSO must always strive for the shared understanding of the guidance for Fires and all that they can bring to support the commander. The TF FSO should be able to articulate what assets he can support with, what he can request, and what requesting an asset requires from the TF (e.g. DD Form 1972 and immediate CAS request, priority of Fires, brigade target allocations, or primary/alternate observers for a brigade target).

It is important to support the commander's scheme of maneuver with whatever level of detail is given. The FS LNO should build trust and understanding within the team to allow for the FS LNOs to present Fires plan suggestions and help direct the successful employment of joint Fires. The FS LNO should support the TF FSO and the FSE and present suggestions and plans through the organic battalion's FS channels when that opportunity allows in the planning process. The best relationships of FS LNOs are developed by supporting the organic FSE and assisting them in understanding the FS capabilities of the brigade.

Conclusion

New NATO operational constructs have challenged multinational TFs at the brigade level and below as they continue to bridge the gaps of interoperability. Interoperability within the Fires warfighting Function is difficult, but manageable and vitally important to future allied conflicts. While this article presents some specific recommendations for U.S. and allied units, it is important to realize that multinational units can overcome most interoperability challenges through constant dialogue that facilitates shared understanding. This open dialogue early and continuously is the key to developing a scalable liaison package to meet specific Fires interoperability challenges.

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The legacy of The Great War on the development of American air defense

By Col. Matthew Tedesco

The first World War witnessed the introduction of many new technologies used in warfare. The employment of the airplane was one of the new technologies that had a significant influence on warfare. The role of the airplane, introduced less than a decade before the commencement of hostilities, developed rapidly throughout the war. Initially employed to enhance the situational awareness of ground commanders, the airplane's role expanded to include a robust ground attack capability, the struggle for air superiority over the frontline and finally the introduction of strategic bombing that influenced the resolution of the deadlocked ground war. Air defense requirements were developed to counter the rise of air power, and as a means to combat the threat to ground forces and to civil populations.

The challenge of protecting forces from aircraft forced the American Expeditionary Forces (AEF) to adopt new concepts, develop new doctrine and to establish new organizations. American air defender's experience during the Great War, in organizing and training forces for combat, coupled with the techniques and procedures practiced during the war, lead to the development of air defense doctrine. This paper provides a study of the willingness of the AEF to adapt and to address a significant challenge experienced in warfare. These were first learned in a war fought nearly 100 years ago and were developed in a war that is today largely misunderstood and forgotten. The impact of these lessons is still relevant to our contemporary doctrine and the history of AEF resilience can teach us how an organization can adapt under the stress of changing circumstances.

A U.S. Army anti-aircraft gun is fired by the predecessors to the modern air defense artillery Soldiers. (Library of Congress repository)

Birth of a new capability

The U.S. Army did not possess any air defense forces when war was declared in April 1917. The Army required a force dedicated to combat hostile air threats with the intent of defeating them or driving them to higher altitudes and thereby decreasing the effectiveness of observation, fire control and bombardment. The principle of deterring air attacks still remains relevant today characterized by the important impact of combined arms for air defense in the goal of hindering air attacks upon maneuver forces. Additionally, air defense forces were responsible for providing warning of hostile air attacks to friendly forces and to the air service by establishing an observation and communication system. This mission was given to the coast artillery because it was the branch most familiar with firing large caliber weapons at moving naval targets. The Army felt the coast artillery could make the relatively simple transition to firing on targets in the air. Much of the existing force structure within the coast artillery was available for this new mission due to the success of the British blockade of Germany's surface fleet.

Coast Artillery officers under Brig. Gen. James Shipton sailed to France in 1917 to observe both French and British anti-aircraft schools. The assessment of both schools resulted in the adoption of French practices since Shipton deemed the British methods inferior. An American Anti-aircraft Artillery (AAA) School was quickly established in Langres France in 1917, in collaboration with the French military to train American units to utilize French equipment (modified 75 mm guns and the Hotchkiss machine guns) since the Americans had none of their own. The newly-trained American air defenders were soon called 'Archies,' a term adopted from British slang to describe enemy anti-aircraft fire.

American air defense forces (also known at the time as anti-aircraft forces) were organized to protect two distinct areas on the battlefield: the front line defenses and defense of the back areas. The term "front line defense" was defined as the area immediately in the rear of the infantry lines and throughout the corps area of operations. Deterrence of this portion of the battlefield requires a continuous band of protection parallel to the extent of the front lines. The "defense of the back areas" was characterized as the rear area behind the front where the AEF supply and services forces operated, comprised of numerous strategic assets too vast for inclusive protection requiring selective protection.

Seven battalions and 20 separate batteries, amounting to 12,000 men, were deployed to France and trained to execute the air defense mission between 1917 and 1918. These units comprised only a fraction of the 45,000 men scheduled to

The photo titled "American Boys ready for the Enemy Airman," shows a U.S. anti-aircraft machine gun crew at the ready, May 13, 1924. (Library of Congress repository)

deploy for the United States. Of these, only two gun battalions, two machine-gun battalions and supporting searchlight batteries served at the front prior to the end of the war. The majority of the 82,280 coast artillery Soldiers sent to France filled field artillery units. Only 5,185 of these men were assigned to be air defenders, providing a glimpse into the scale of airpower's impact on the overall war. The role filled by the Archies of the AEF was truly in its infancy and needed to be resourced ad hoc until a formal organization could be established. Gun battalions, were manned by coast artillery Soldiers, while the two anti-aircraft machine-gun battalions were manned by infantrymen, and searchlight batteries were operated by engineers.

The organization and training of the anti-aircraft artillery units directly led to their success on the battlefield. Engaging airplanes with anti-aircraft guns using the fire prediction methods of the time was an extremely complex endeavor. This method was described by one of the gunners as the "guess-point-shoot-and-pray system." Taking this challenge into consideration, anti-aircraft training focused on limiting the effectiveness of air attack, rather than on the destruction of enemy airplanes. Gunners were trained that a successful engagement occurred either when they forced an aircraft to prematurely release their ordnance, or when they forced an aircraft to climb to altitudes that made their attacks ineffective or beyond the range of their onboard machine guns. As one coast artillery officer recounted of his experiences following the war, "Our duty is to cause him [enemy pilots] to drop them [bombs] in the wrong place. If he bombs our searchlights or a vacant field nearby, we have accomplished the purpose for which we are working, for while he is bombing us he cannot be dropping bombs within the protected area."

Ultimately, American Archies demonstrated the most successful record of anti-aircraft engagements during the war in terms of proficiency and skill.

This success was attributed to American engagement techniques and the quality of the American Soldiers selected to be Archies. American anti-aircraft personnel were handpicked for the mission while countries like France manned their anti-aircraft ranks with personnel who were unfit for frontline trench duty. American gunners employed a "shoot-look-shoot" firing technique, resulting in improved accuracy, reduced ammunition consumption, and resulting in a higher average of planes brought down per number of shots fired.

American Archies shot down 58 planes between August and November 1918. Seventeen of the 58 were shot down by five batteries of anti-aircraft guns and 41 by two anti-aircraft machine-gun battalions.

The impressive results attained by the Archies during the final four months of the war were the result of their adaptation of British and French air defense tactics and techniques. The collection of these lessons learned during the war led directly to the development of doctrine during the interwar years, and established the foundation of enduring air defense doctrine still practiced today. These lessons learned include air defense principles, employment principles, the importance of early warning and combat identification.

The most important product of the experience in the war resulted in the development of air defense principles and employment guidelines. The principles of air defense consist of the four principles of mass, mix, mobility and integration. These enable air defense forces to successfully perform combat missions and support overall force objectives. Archies applied mass when they concentrated their available weapon systems along the front and critical rear areas to defeat air attacks. These also employed a mix of available systems (75 mm guns and machine guns) to protect ground forces and to help overcome their limitations of range, dead space and the rate of available fire.

The dominance of defensive capabilities during much of World War I limited the application of mobility and maneuver warfare on the Western Front. The lack of mobile communications technology to command and control fighting that occurred over a large area at a high tempo had a significant impact on directing action once maneuver was restored to the Western Front. American air defenders were unique in their experience during the war, because they joined the fight as mobility started to return to the battlefield. Mobile gun batteries were able to keep up with advancing infantry attacks during the St. Mihiel and Meuse-Argonne offensives by leap frogging sections during the advance. The result demonstrated the ability to accomplish their mission by effectively blunting the effects of German air attacks by either driving off attacking planes or keeping them out of range. This action foreshadowed the nature of the next war and was realized by a coast artillery officer at the time, who stated "Open warfare toward the end of the war showed the necessity for an extremely mobile type of anti-aircraft artillery."

Finally, the principle of integration is defined as "the combination of the forces, systems, functions, processes and information acquisition and distribution required to efficiently and effectively perform the mission." Experiences during the war stressed the importance of close cooperation with the air service. One coast artillery officer emphasized an imperative of the time that "the anti-aircraft commander should bear in mind that the Archies must cooperate with and assist friendly aircraft and in no way interfere with their operations. To accomplish this, it is necessary for anti-aircraft officers to cultivate personal friendships among the pilots that operate over his area."

Anti-aircraft artillery has maintained a special relationship with the air service since its creation. The relationship between the two was critical, especially in the days before the invention of radar. The location of Archies on the battlefield in positions along the front — where enemy planes had to cross to attack friendly air fields — gave them an important position in the partnership. Anti-aircraft units had the responsibility for alerting the air service in time and were essential to enabling them to intercept hostile air attacks. The partnership between the Archies and the air service was critical recounted a coast artillery officer because "the air service cannot always be present in sufficient numbers, at the proper altitude, time and place to counter all hostile attacks, nor can they see at night. Therefore we [Archies] must assist them by maintaining a careful and continuous surveillance over the enemy air movements and furnishing information based thereon."

Lessons learned

Archies captured valuable lessons learned from their experiences of planning defense designs and positioning air defense units. These efforts resulted in the development of the six employment guidelines for air defense: mutual support, overlapping Fires, overlapping coverage, balanced Fires, weighted coverage, early engagement and defense in depth. The Archies applied the principle of mutual support by emplacing machine guns in conjunction with their 75 mm gun systems to cover weapon system dead space. Capt. Benjamin Harmon, a veteran of the Great War and coast artillery officer, advocated that the principle of overlapping Fires be applied to the design of air defense plans stating that "the defense must be continuous in width. The enemy soon determines a gap in the defense and utilizes that knowledge for a safe passage over the lines."

Archies practiced the concept of balanced Fires, from experience in the defense of Paris in 1918 wherein many of the anti-aircraft emplacements were manned by freshly-trained American Soldiers. Weapons employed applying these principles enable the delivery of an equal volume of Fires in all directions against the threat of air attack.

The principle of balanced Fires was easily applied to defend large strategic targets like Paris, but often the need for deploying limited resources to protect other locations relied upon the concept of weighted coverage. A.F. Engelhart, a coast artillery veteran of the war, acknowledged the reality that "it is impossible to protect all vulnerable points, so in order to not diminish air defense capabilities to cover a wide area, the protection was concentrated at the vital points."

This change was accomplished by combining and concentrating weapons coverage toward the most likely enemy air avenues of approach. The use of weighted coverage towards the anticipated direction of attack contributed to achieve successful engagements. Harmon also described air avenues of approach as the routes taken by an attacking enemy aircraft leading to its objective or target stating that "these probable avenues of approach must be determined and the defense extended and

Soldiers take aim with an anti-aircraft gun. (Library of Congress repository)

strengthened along these avenues in the order of their probability."

Throughout the war, Americans relied on the existing network of French observers and their communication network (phone network) to exercise early warning and apply command and control. The French had established a series of lines to detect and track German aerial activity. Burgo Gill, another coast artillery veteran and Archie, described the capabilities of the observer network as "each line had listeners equipped with listening apparatus five miles apart, and each such station was in direct communication with its own center."

The AEF planned to establish their own warning and communication system to conduct decisive operations in 1919, but this system still did not exist by the time of the Armistice.

Air defense planners utilized predictive analysis of German air activity (known today as conducting air intelligence preparation of the battlefield) and available sensors to detect German planes before they reached their targets. Weapons were deployed to engage attacking enemy airplanes before they were capable of acquiring friendly targets and releasing their ordnance. Coast artillery officers emphasized this point by applying the maximum range of each gun to engage before the enemy could engage, locating guns away from defended area and as far forward as possible in order to improve firing conditions, improving the success of anti-aircraft defense and deterring positive results for enemy aircraft.

The principle of defense in depth is achieved by positioning weapons and sensors so the enemy is exposed to a continuously increasing volume of fire as it approaches the friendly protected asset or force. This contemporary principle was developed from the Archie's understanding that "defense must be extended in depth in order that planes attempting to cross the lines will be under fire as long as possible."

One of the best ways to support the application of a defense in depth is to leverage the abilities of all available weapons, to include non-dedicated weapons. This measure of active defense led to the development of the concept of combined arms for air defense. The changing reliance on airpower, as well as the limited availability of dedicated air defense assets, was a lesson captured during the war and reflected by Capt. James E. Wharton, an infantry officer, writing in a 1931 article entitled "Protection of infantry against air attack." Wharton stated "since it is generally conceded that the airplane will play a much greater role in the next war than it did during the World War, the protection of troops and installations against attack from the air has become a problem of considerable importance."

Wharton rationalizes that the airplane did not reach its greatest use before the end of World War I. Infantry is concerned about its own protection especially in bivouac or on the march, and the need to train air guards as a part of a layered defense against the air threat.

Combat identification and rules of engagement were also important techniques established by the Archies that had future impact on the execution of air defense. Americans trained their Soldiers on visual identification methods for identifying friend or foe airplanes using aircraft size, wing shape and fuselage characteristics. Trained observers were expected to be able to give the nationality and type of any plane by listening to its motor through sound detection, followed by visual identification techniques. Additionally, a system of challenge and reply for friendly air recognition was established as an early form of what is now called "identification friend or foe." These methods worked during daytime operations, however during night time operations Archies favored searchlights for positive identification of aircraft instead of sound detectors favored by the French.

The signature achievement of the efforts of American air defender's experience during the Great War is witnessed in the National Defense Act of 1920. This act sustained the need for an ant-iaircraft capability within the Army under the direction of the Coast Artillery Corp. It impacted the organizing and training of forces for combat and the development of post-war air defense doctrine drawing on the techniques and procedures practiced during the war. In March 1920, Maj. Gen. Frank Coe, Coast Artillery Corps chief, wrote on the contributions to anti-aircraft artillery and the need to capture lessons learned to develop future capability.

"Our own coast artillery shared in the mastery of the technique of anti-aircraft artillery during the war, although but a small proportion of coast artillery officers were assigned to the anti-aircraft service, yet these few went as far along the road to mastery of this new branch of artillery as did many of the officers of our allies. The immediate need is that the knowledge which they gained should not be lost to them."

Anti-aircraft artillery units fell under the command of the chief of artillery. Some officers within the Coast Artillery advocated they should report to the Air Service Corps instead. This change would reflect the important relationship between the air service and the anti-aircraft artillery operating in the third dimension, and the fact that the field artillery did not appreciate the differences required to employ anti-aircraft. After the war some Coast Artillery officers argued for changing the existing command structure to align air defenders under the air service as noted by one advocate who said, "Aviation is largely controlled by the Army and not the corps, and it is with pursuit aviation that anti-aircraft units must cooperate most closely."

This relationship remained in place after the war, supporting the belief that the ground commander must retain control of his air defense capability. This supported the wise decision to keep air defense units in the Army when the U.S. Air Force was created in 1947. This allowed ground commanders the ability to retain their own organic defensive capabilities, especially valuable when airpower was being applied to other priorities.

The lessons learned by the Archies remain relevant today as the threat whether jet aircraft, ballistic missiles, cruise missiles or the proliferation of unmanned aerial systems continues to evolve. Importance of the contributions of the Archies is captured by the statement made by Harmon shortly following the war. He opined, "Whenever I meet anyone who cannot conceive of the anti-aircraft units accomplishing anything, I cannot help but wonder if he is not related to the expert who predicted that the submarine and the aeroplane would never be of value in warfare, or perhaps to the farmer who saw a giraffe for the first time and remarked, 'There ain't no such animal.'"

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A look back

Story, photos by Monica Wood

History has always fascinated me and I enjoy seeing artifacts and photos in the museums and places around me. Since I work at the Fires Center of Excellence on Fort Sill, Okla. I have an opportunity to see a lot of things that are old and historic (no, I'm not talking about people). I always stop to read the landmarks when I see them and I have explored much about the original buildings from the old Army post built to control the Indians of the Plains.

Recently I was asked to start writing a column on the history of the field artillery and air defense artillery and when I started researching, I found the historian for the Field Artillery School has done a great job of that already. Dr. Boyd Dastrup is fascinating to talk to and knows just about anything you can think to ask him so I decided to take a little different tack.

I decided to take photos of artifacts from both the FA and ADA and post them first on the Fires Bulletin Facebook page and see who could guess what the item is and whether it is part of the FA or the ADA history. Of course, my journey started with a trip to see Frank Siltman, FCoE Museums and Military History director, who introduced me to the curators for both the ADA and FA museums.

According to Siltman, there are numerous "one of a kind" artifacts at Fort Sill that exist nowhere else in the world, with the Field Artillery and Air Defense Artillery museums possessing the premier branch specific artifact collections in the world of U.S., allied and enemy equipment.

"The artillery branch, from which both FA and ADA count their lineage, has served our Army since its inception in November 1775 in the field, on the coasts and defending our airspace," said Siltman. "The branch museums trace that proud heritage from the very beginnings of our Army through today, highlighting the critical roles of both branches and the evolution of technology and tactics through Army history."

For my first column I decided to focus on the Vietnam era since we are within the window of the 50th anniversary of that conflict, which began in 1965 and went through 1973.

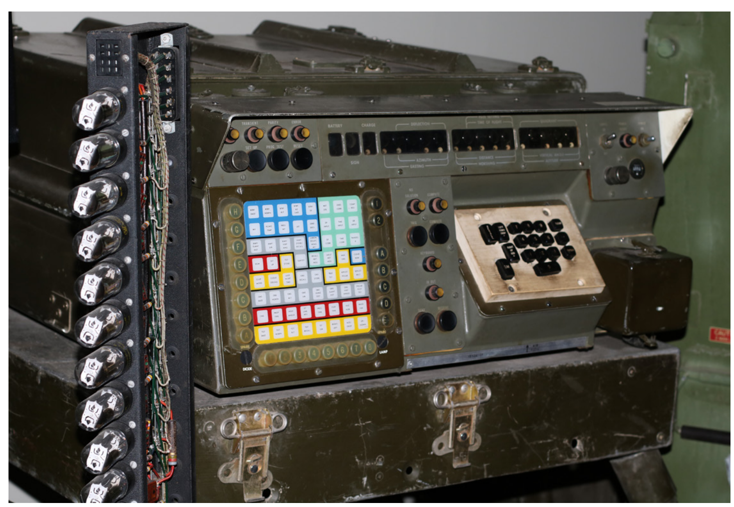
So here are the photos of weapons or implements used by either the FA or the ADA that we posted on Facebook for you to identify. How many did you get right?

ADA - 30" AN/TVS-3 Xenon Searchlight is a very rare piece to find in a museum. Only nine of them were sent to Vietnam in 1969 on what was supposed to be a 60-day trial and they ended up coming out of the country in 1971. These 1.2 billion candlepower lights enabled battlefield illumination of up to 20 miles from the searchlight's location, allowing for instantaneous illumination of remote outposts along the Cambodian and Laotian borders that were subject to frequent nighttime NVA Sapper attacks.

ADA - The M55 Quad- .50 Caliber anti-aircraft system could fire a staggering 2,600 rounds per minute (650 rounds per gun) and was easily transportable. By early 1966, Quad-50s were pouring fire downrange, this time in South Vietnam in support of U.S. forces. Four separate Automatic Weapons Batteries used the M55 system in Vietnam in both the truck-mounted and fixed emplacement firebase defense roles.

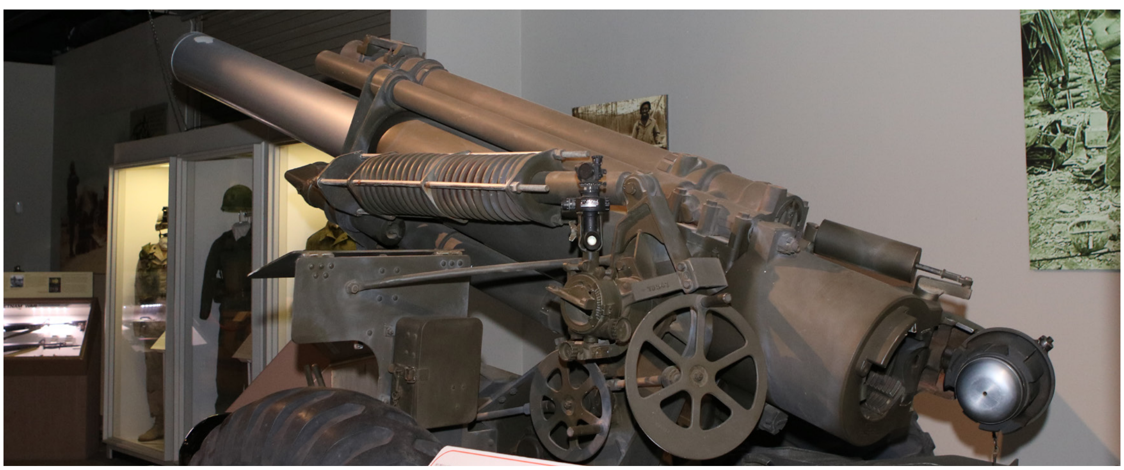
Above: FA – From 1958 to 1968 the artillery branch insignia was identical to the present air defense artillery insignia.
Below: ADA - The MIM-23 Hawk revolutionized tactical anti-aircraft warfare and continues to influence the modern battlefield to this day. The Hawk was first fielded by the U.S. Army in 1959 as a mobile medium-altitude, medium range surface-to-air missile.

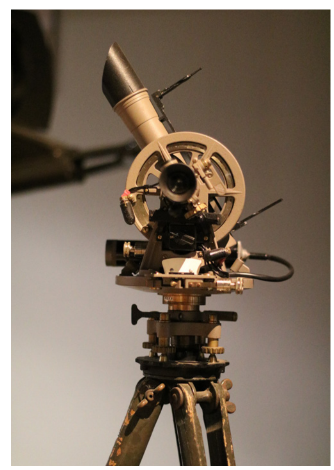
Above: FA – This is a prototype (test) model of the M102 105 mm Howitzer, which entered service in 1964 when it began replacing the M101A1 in Vietnam. The M102 saw considerable use in the Vietnam War where its 360-degrees traverse feature was very useful in a war with no front lines. Several Airmobile units in Desert Storm in 1990-1991 used the M102.



FA - M18 Field Artillery Digital Automatic Computer (FADAC), known as "Freddie." FADAC was the first battery fire direction computer. It was capable of providing firing data for a battery of any type of field artillery weapons, including mortars, guns, howitzers, rockets and missiles. The first FADAC entered service in 1961 and was replaced by the Tactical Fire Direction System in 1980.

Above: ADA - The GS14, a 23-inch xenon searchlight, were simple and effective to use and were small enough to fit on a standard M-151 jeep. The lighter lamps only put out 120 million candlepower.





Top left: FA - M114 155 mm Howitzer was used by the field artillery beginning in 1941 and was the second most commonly used U.S. artillery piece of WWII. It took the nine-man crew approximately five minutes to emplace the howitzer for firing. The M114 saw extensive use in the Korean War and the Vietnam War. It was replaced by the M198 155 mm Howitzer in 1979.

Top right: FA – M-2 Aiming Circle, used for "laying the guns," the aiming circle is a key piece of equipment for pointing the guns in the direction of fire. The executive officer places the aiming circle on a magnetic azimuth and gives an azimuth reading to the gunner. The gunner places the reading on the gun sight and then moves the gun right or left until his crosshair comes back to the aiming circle.

Left: ADA – The Nike Ajax was the world's first operational surface to air missile and began in 1946. The Ajax was eventually redesigned with a new booster and larger airframe and was designated to Nike Hercules. Although the first Nike Hercules battalions began coming online in 1958, the Nike Ajax system remained in service through the mid-1960s, eventually expanding to 265 firing batteries around most strategic locations throughout the United States.

In the next issue of Fires

January-February 2017, The Red Book. The Red Book recaps a year in review for the Fires force including Reserve, National Guard and Marine units. The 2016 Red Book will highlight U.S. Army Field Artillery, Air Defense Artillery and U.S. Marine Corps artillery unit activities at the brigade-level and lower.

The deadline for submissions is Dec. 1, 2016. Submissions should capture significant events, such as deployments, training, etc., for the past year. Send your submissions to usarmy.sill.fcoe.mbx.fires-bulletin-mailbox@mail.mil or call (580)442-5121 for more information.

Soldiers of the 69th Air Defense Artillery Brigade finish the September 11th Memorial CrossFit workout, Sept. 11, 2016, at Al Udeid Air Base, Qatar. Deployed Soldiers and Airmen participated in the workout to come together and honor those whose lives were affected by the 2001 terrorist attacks. (Sgt. Brandon Banzhaf/U.S. Army)

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