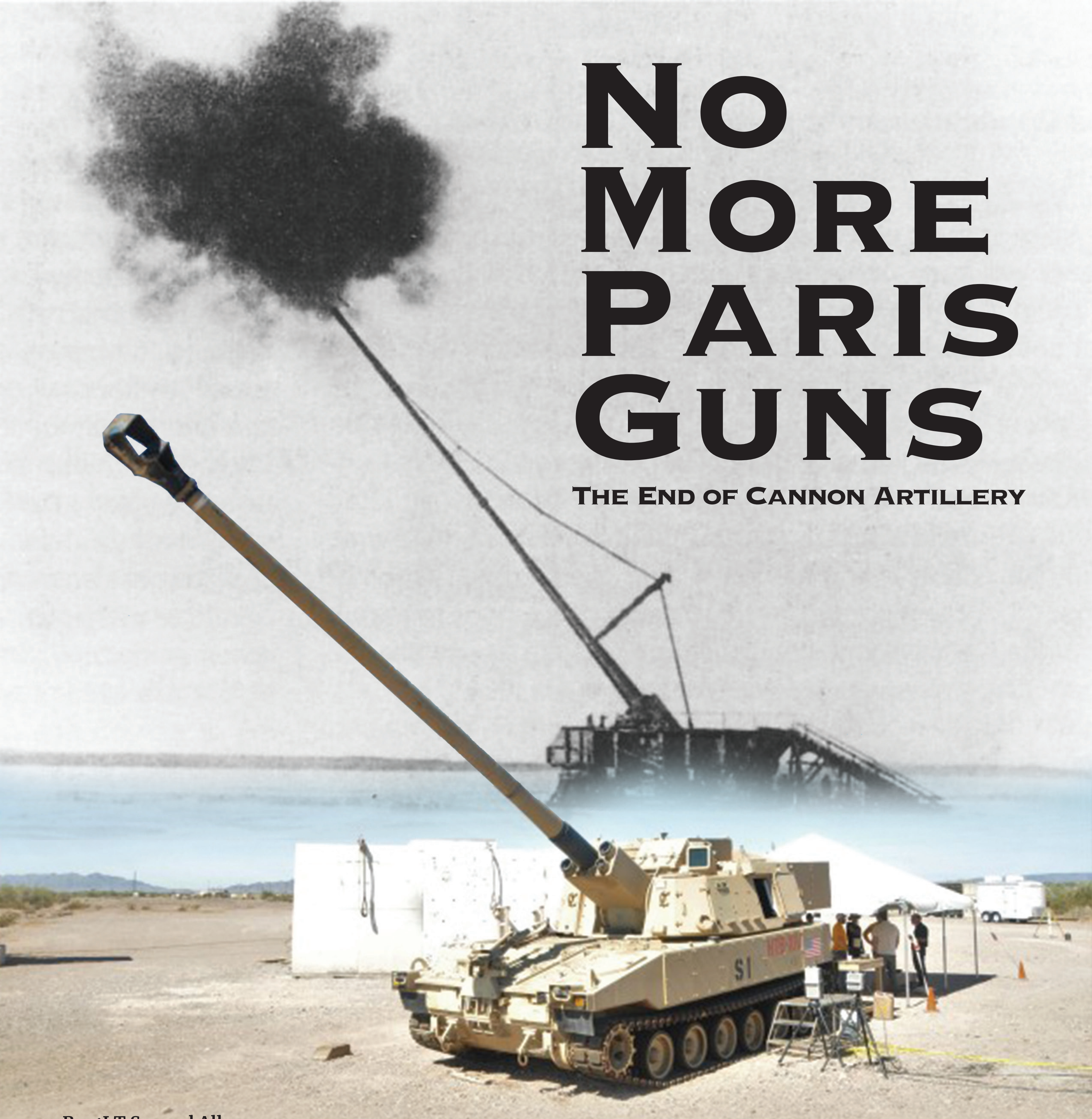


No More Paris Guns

The End of Cannon Artillery

By: 1LT Samuel Allen

History buffs love to recall the massive "Paris Gun" of World War I, a German behemoth capable of launching a 234-lb shell 130 kilometers. In World War II, various mega weapons advocated by Adolph Hitler similarly made it through various stages of development and procurement, including the cumbersome "Gustav Gun". None made a significant impact to the World Wars, and most are remembered as testaments to German military hubris.

These big, intimidating yet ineffectual guns are examples of the limitations of cannon artillery in general. Lobbing shells puts a tremendous amount of force on a firing mechanism, which must significantly increase its weight in proportion to the force applied to a shell. The massive weight of big guns, which has historically restricted them to impractical employment as railway guns, fixed fortifications or super-heavy tractor with debilitating mobility issues, proves an impassable mechanical limit to the scaling-up of cannon artillery.

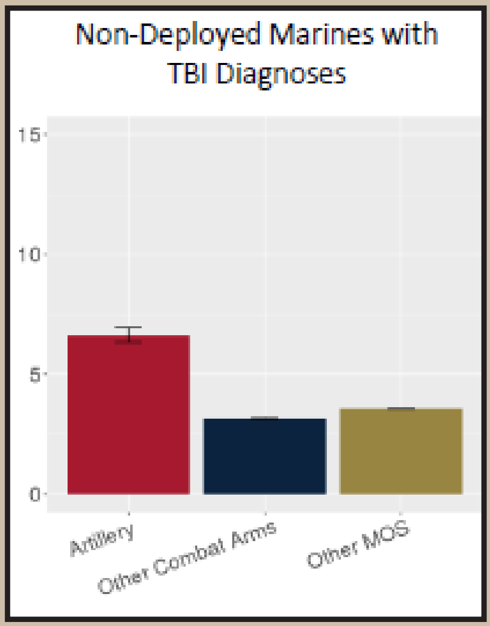
Cannon artillery cannot fire more powerful shells, nor can it shoot them farther, if they are to remain a reasonable size and weight to maneuver in a near-peer conflict. So it's curious that the Army's new Extended Range Cannon Artillery (ERCA) is repeating the same hubris that led to the unwieldy Paris and Gustav guns of the past. The ERCA's 70km range is meant to outgun the 40km achieved by the Russian 2S33 Msta-SM2, though it's perhaps already outmatched by the purported 70-kilometer range of Russia's new 2S35 Koalitsiya-SV. ERCA's range, over double that of the Army's current rocket-assisted projectiles, is achieved with an extended barrel, super-charged propellant and 1,000 additional pounds, compared to the existing M109A7 self-propelled howitzer. While these may sound like worthy trade-offs for greater range, they either exacerbate or do not address the real problems limiting the capabilities of cannon artillery, which are blast overpressure, limited rate of fire, stress on electronics and predictable ballistic trajectories. Consider them by turn.

Blast overpressure: the propellant charges used to fire artillery shells are traumatic to the human brain. Already, commanders are known to give Artillerymen 24-hour breaks after firing 10 charges of 5H, one of the most powerful in widespread use. To shoot a projectile over twice as far, ERCA will be exerting over twice the stress on cannon crew members. This may take Artillerymen out of the fight and prove a ticking time bomb for neurological disorders, similar to the latent effects of concussions in football players.

Limited rate of fire: the time required to load each round, and the heating and wear on the firing components, pose another barrier to innovating cannon artillery. They cannot be innovated to fire much faster than they currently do while remaining a reasonable size. For example, the Navy's 5-inch guns fire 70-pound shells at a rate of 20 per minute – however, the gun weighs almost 24 tons, over five times the weight of an M777 for a shell a quarter lighter than the M777's 155-millimeter shell. Plans to add an autoloader doubling ERCA's rate of fire have already reduced its projected ammo capacity from 31 to 23 rounds, adding untold weight and another intricate system that must withstand its immense recoil.

Stress on electronics: sensitive electronics, such as computers and Global Positioning System/Inertial Navigation System (GPS/INS), may have difficulty acquiring satellites and retaining accuracy in even the best circumstances. Building such systems capable of withstanding the thousands of G forces applied to artillery shells is costly and decreases reliability. This problem has already hampered the Navy in its attempt to upgrade its deck guns. The Excalibur GPS/INS-aided shell, only able to hit predesignated grid squares, has succeeded in both legacy systems and ERCA. However, the Field Artillery is notably lacking in advanced fuses capable of hitting moving targets, loitering, identifying radiation signatures or any number of capabilities found in missiles throughout the military's arsenal. Without the accuracy provided by advanced electronics, the Field Artillery also has no shell capable of piercing enemy armor, other than imprecise cluster munitions that may prove as hazardous to friendly units as the enemy. While such advanced munitions have been delivered by air throughout our COIN fights of the past 20 years, a fight against Russia or China would challenge our air superiority. As the high G forces inherent to cannon artillery have hampered the development of electronically advanced shells, a fight with a near-peer country would mean a gaping hole in our combined-arms strategy, where enemy armor could travel unimpeded.

Predictable ballistic trajectories: shells fired from a cannon follow predictable flight paths, which can be instantaneously tracked by counterbattery radar and lead to the destruction of the firing unit. Though the Excalibur takes an unpredictable flight path once it receives a GPS signal, this maneuvering only occurs later in flight, and does not occur at all if it fails to receive a GPS signal. Thus the US has no artillery designed to confuse counterbattery radar, and, moreover, such a system would be difficult to implement in cannon artillery, since even a guided a shell would be able to significantly alter its flight path only long after exiting the tube.



Why the Answer is Missiles

These flaws, faced by all cannons, mean that cannon artillery is a dead-end to innovation. The ERCA is not the first American system developed in a vain attempt to add more capability in this zero-sum game. The XM2001 Crusader was a remarkably similar program cancelled almost 20 years ago for flaws already plaguing the ERCA and its 1C planned autoloading variant: massive weight, concerns of tube wear and overheating during rapid fire and the complexity of creating new rounds specifically for it. It's not surprising that the Field Artillery is once again attempting to innovate past the limitations in range and rate of fire of legacy cannons. It's surprising that the proposed solution is roughly the same as 20 years ago.

Perhaps innovations in artillery shells will solve the problems discussed here. Shells capable of hitting moving targets, and equipped with ramjets for extended range, may come to fruition. But here we come to the problem identified by the Navy in its attempt to build next-generation cannons, best explained in an excerpt from a 2018 New York Times story on the subject:

> *"When you try to make a rocket-boosted projectile that can steer itself to a target, you basically have built a guided missile," said Tony DiGiulian, a retired engineer who has studied all these weapons and runs NavWeaps, a website on the subject of naval weapons and technology. One problem with gun-fired guided shells, he said, was that, when fired, sensitive electronics inside the projectile were exposed to exponentially more stress than if they were launched in a traditional missile. Protecting those electronics, DiGiulian said, added to the shells' cost. "So why not just build missiles in the first place?" he said. "That's what you'll end up with anyway."*

The future of the Field Artillery belongs to missiles, if for no other reason than they can be innovated past the mechanical constraints discussed here. This doesn't mean just strategic weapons like the upcoming Long Range Hypersonic Weapon (LRHW) or the medium-to-long ranges achieved by the High Mobility Artillery Rocket System (HIMARS) or Multiple Launch Rocket System (MLRS); rather, missile systems must also be developed to replace legacy artillery cannons in tactical fire support. To understand why missile systems must replace cannon artillery at all levels, we can see how the limitations of cannons discussed in this article don't apply to missiles.

Weight of firing mechanism: since missiles can be fired with little to no recoil, there's no need for a heavy firing mechanism capable of handling significant recoil. This results in less wear on the firing platform's components.

Blast overpressure: missiles accelerate quickly, but don't even approach the instantaneous explosive force of an artillery charge. This leaves artillery crew members safe no matter the desired range of the projectile.

Limited rate of fire: in cannon artillery, all rounds must exit through the same tube. This is inherently slow, as each round must be individually loaded, and a misfire on one round will prevent all others from being fired until the issue is solved. Moreover, the single tube must withstand the wear and heat from multiple rounds, which means gains in rate of fire will fail to be exploited as the gun overheats. Missiles, on the other hand, may be launched with multiple, independent tubes, meaning instantaneous massing of fire, no bottlenecks upon misfires and no overheating.

Stress on electronics: the comparatively gradual acceleration of missiles as opposed to cannon shells means currently available sensors, navigation systems and other electronics may be easily applied to a new suite of artillery missiles. This means artillery missiles will be cheaper than advanced artillery shells, which must be ruggedized and thoroughly customized to withstand high-G forces.

Predictable ballistic trajectories: missiles' gradual acceleration and greater capacity for onboard electronics will mean they can vary their flightpaths straight out of the tube. This will defeat enemy counterbattery radars, as they will track missiles that conceal both their point of origin and point of impact. This means greater safety for the artillery crew and greater lethality for their projectiles.

What Would this Missile Artillery System Look Like?

Missiles have always been lacking in fire support roles, for reasons of either inaccuracy (dumb rockets are less accurate than dumb artillery) or cost (smart missiles are costlier than dumb artillery). But because the Field Artillery is now expected to hit targets at 70km with the expensive and problematic ERCA and a planned suite of expensive and problematic shells, these demands can clearly be better met by missiles. And as we have seen the zero-sum nature of scaling cannons up, it will be much easier to scale missiles down to fill any number of fire-support roles.

The HIMARS and MLRS are incapable of filling the roles currently held by cannon artillery, nor do its rockets currently have the anti-vehicular and anti-moving target capabilities needed in the near future. The MLRS, much less the HIMARS, lacks the volume of missiles necessary for massed or sustained fire by one vehicle, and both are subject to lengthy reload times. While both systems are capable of sending a volley of missiles blanketing a square kilometer, this is only achievable with cluster munitions, which are both against international norms and highly dangerous to allied troops later moving through the affected area, due to significant dud rates. And compared with cannon artillery, the systems' unitary rockets, namely the M31 GMLRS, are overkill, with 200-pound war-

heads capable of reaching 70-plus kilometers, compared to the 16-pound warhead capable of travelling 30 kilometers in cannon artillery's M549 High-Explosive Rocket Assisted (HERA) 155-millimeter shell.

Better examples of missile artillery systems can be best drawn from Russia, which has historically saturated square kilometers with wasteful barrages of dumb rockets, but has more recently added smart capabilities. If looking for a missile artillery system that could be adapted for both the range and rate of fire of the autoloading ERCA 1C and the lower cost and mechanical stresses of our legacy cannon artillery, the Tornado-G is the best example. At only 14 tons, its truck-mounted missile rack contains 40 tubes, each with a missile capable of ranging 40km with a 55lb warhead; it can fire all 40 rounds in 20 seconds, and its reload time is seven minutes. And though its 40km range is less than ERCA's 70km, its warhead weight is almost four times heavier. If the Field Artillery were to produce a counterpart to the Tornado-G, our doctrinal need for accuracy would require smart missiles that may appear more expensive than dumb cannon artillery shells. However, the greater accuracy of smart missiles means fewer rounds will be expended to achieve the same effect as a dumb cannon shell. Additionally, the Tornado G's rate of fire over 20 seconds could only be matched by a battalion-plus of 20 M777A2 howitzers firing their smaller warheads; in sustained fire, four Tornado-Gs could keep up with the same battalion of howitzers, despite having two crew members each to the howitzer's 10. In other words, smart missiles would more than make up for their costs through efficient massing of fire, while putting fewer Artillerymen at risk.

Nor would the broad adoption of smart missiles mean greater vulnerability to hacking or spoofing than existing alternatives. At long ranges, any artillery round would require GPS for accuracy, as the ERCA employs. At short ranges, GPS may be unnecessary, or similar capabilities could be met with the less accurate but un-spoofable INS alone.

This missile system could be deployed in any number of variants. Have some tubes prepared with long-range missiles, sacrificing explosive weight for distance; prepare others with short-range missiles carrying heavier warheads; have some anti-vehicular missiles and others anti-personnel. Of course, any effect currently produced by cannon artillery would be replicated, including illumination and smoke, as well as fuses such as proximity and delay. The simplicity of the missile rack means it could also be scaled down for application on airborne vehicles, or applied to tracked vehicles in Armored Brigade Combat Teams. And again, this is all available with existing technology, not only more effective than scaled-up cannons but simpler and cheaper.

Conclusion

Missiles are the future, if only for the reason that they can be innovated. Lacking the mechanical constraints that limit the range, rate of fire and predictable trajectories of cannons (excepting enormous, impractical designs), missiles can be innovated with existing technology to fill the gaps between howitzers and aircraft, which will face extreme risk against any military with modern air-defense systems.

The days of cannon artillery are over. Modernizing cannons would be one step forward when we need two. The Field Artillery will literally and figuratively live or die on its technology, so it must embrace the adaptability of missiles, lest the branch become a dead end like its cannons.

About the Author:
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Image 1, Paris Gun: Nieuwint, J. (2016, December 1). The German Paris Gun - Super Gun Of WWI. WAR HISTORY ONLINE. www.warhistoryonline.com/
Image 2, ERCA: ERCA Autoloader is being tested for first time at Yuma Proving Ground. www.army.mil. (2019, August 15). www.army.mil
Image 3, TBI diagnoses, based on recent Marine Corps study on blast overpressure among artillery crews: Marine Corps Directorate of Analytics & Performance Optimization. (2019, March). Blast Overpressure Effects.
Image 4, M142 HIMARS: Military Today. (n.d.). www.military-today.com
Image 5, Tornado-G: Military Today. (n.d.). www.military-today.com