REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
27APR17	Research	AY 2016-17

4. TITLE AND SUBTITLE
Big Data and the King of Battle: Methods for Improving the Army's Cannon Artillery System

5a. CONTRACT NUMBER
N/A

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
N/A

6. AUTHOR(S)
MAJ Jonathan W. Erwin

5d. PROJECT NUMBER
N/A

5e. TASK NUMBER
N/A

5f. WORK UNIT NUMBER
N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
USMC School of Advanced Warfighting
Marine Corps University
2044 South Street
Quantico, VA 22134-5068

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
N/A

10. SPONSOR/MONITOR'S ACRONYM(S)
N/A

11. SPONSORING/MONITORING AGENCY REPORT NUMBER
N/A

12. DISTRIBUTION AVAILABILITY STATEMENT
Unlimited

13. SUPPLEMENTARY NOTES
N/A

14. ABSTRACT
The United States Army's Field Artillery community faces a myriad of challenges on the modern battlefield, which is tending toward urban, built-up areas that include population centers and large amounts of civilian infrastructure. Designed as an area fire weapon, a howitzer firing conventional 'dumb' rounds has limited precision. The responsiveness of cannon artillery platforms is constrained by de-confliction procedures and collateral damage requirements. Furthermore, cannon artillery platforms are ineffective when they require multiple adjustments to achieve effects on target. Big Data technology may assist the Army's cannon artillery units in being more precise, responsive, and effective by improving the accuracy of conventional artillery munitions, accelerating the target identification process, rapidly de-conflicting airspace, and speeding up the sensor-to-shooter link.

15. SUBJECT TERMS
Big Data Technology

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE	UU	22	Marine Corps University / School of Advanced Warfighting
Unclassified	Unclassified	Unclassified			19b. TELEPONE NUMBER *(Include area code)* (703) 432-5318 (Admin Office)

United States Marine Corps
School of Advanced Warfighting
Marine Corps University
3070 Moreell Avenue
Marine Corps Combat Development Command
Quantico, VA 22134

FUTURE WAR PAPER

Big Data and the King of Battle: Methods for Improving the Army's Cannon Artillery System

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF OPERATIONAL STUDIES

MAJ Jonathan W. Erwin

AY 2016-17

Mentor: Dr. Rudd

Approved: ______________

Date: 10 MAY 2017

Disclaimer

DISCLAIMER

THE OPINIONS AND CONCLUSIONS EXPRESSED HEREIN ARE THOSE OF THE INDIVIDUAL STUDENT AUTHOR AND DO NOT NECESSARILY REPRESENT THE VIEWS OF EITHER THE SCHOOL OF ADVANCED WARFIGHTING OR ANY OTHER GOVERNMENTAL AGENCY. REFERENCES TO THIS STUDY SHOULD INCLUDE THE FOREGOING STATEMENT.

INTRODUCTION

The United States Army's Field Artillery (FA) community faces a myriad of challenges on the modern battlefield. Areas of Operations (AOs) for Army units deployed overseas are trending toward urban, built-up areas that include population centers and large amounts of civilian infrastructure. These AOs are crowded and contain numerous targets that are interspersed amongst large populations of non-combatants. Targets in these environments are often fleeting, presenting Commanders (CDRs) with small windows for conducting an engagement. In order to remain relevant in these AOs, cannon artillery units require precision, responsiveness, and effectiveness. Designed as an area fire weapon, a howitzer firing conventional 'dumb' rounds has limited precision. In an urban setting, the responsiveness of cannon artillery platforms is constrained by de-confliction procedures and collateral damage requirements. Furthermore, cannon artillery platforms are ineffective when they require multiple adjustments to achieve effects on target.

Big Data technology may provide the means to assist the Army in tackling some of the above-mentioned challenges. Big Data technology may assist the Army's cannon artillery units in being more precise, responsive, and effective by improving the accuracy of conventional artillery munitions, accelerating the target identification process, rapidly de-conflicting airspace, and speeding up the sensor-to-shooter link. The following sections will address the advent of Big Data technology and the methods in which Big Data technology can be applied to the cannon artillery system to improve precision, responsiveness, and effectiveness.

BACKGROUND

Big Data technology aids the user in inferring probabilities through the application of math to huge quantities of data.[1] In other words, it empowers users to make predictions about the future with a high degree of accuracy. As an example, the online retailer Amazon uses Big Data technology to speculate on the buying habits of its customers.[2] If a customer has recently purchased a pair of running shoes via Amazon's online store, the customer's Amazon homepage will include advertisements related to running accessories. In order to determine what items to advertise on a specific customer's homepage, Amazon leverages Big Data technology to analyze other customer's buying habits. Amazon can run an algorithm through its databases to determine what item customers most often purchase after purchasing a pair of running shoes. If Amazon determines that the majority of its customers buy a digital watch after purchasing running shoes, then a customer can expect to see advertisements for digital watches on their home screen immediately after purchasing a pair of running shoes. To be clear, Amazon does not choose to advertise items that fall in the same category as the original purchase. Instead, they analyze the buying habits of previous customers to determine the next probable purchase for another customer.

Amazon's use of Big Data technology to discern buying habits does not imply that Amazon can determine the causal relationships behind a customer's purchase decisions. Rather, Amazon uses Big Data to reveal the correlations between separately occurring purchase events. Analyzing massive amounts of data facilitates the discovery of correlation, not causation.[3] Correlation provides probability, not certainty. Probability can inform someone about *what* might happen, but not necessarily *why* it happened. Using a data-driven approach to determine the correlations between various phenomena can get you results much faster than trying to determine the causal relationship.[4] As a Fire Direction Center (FDC) crew member, knowing the net effect of a weather condition on the impact point of a howitzer crew's rounds is more important than knowing *why*. If the FDC crew member knows the effect, he can make proper adjustments for the howitzer crew to ensure their rounds impact on target. Knowing the *why* doesn't help accomplish the mission.

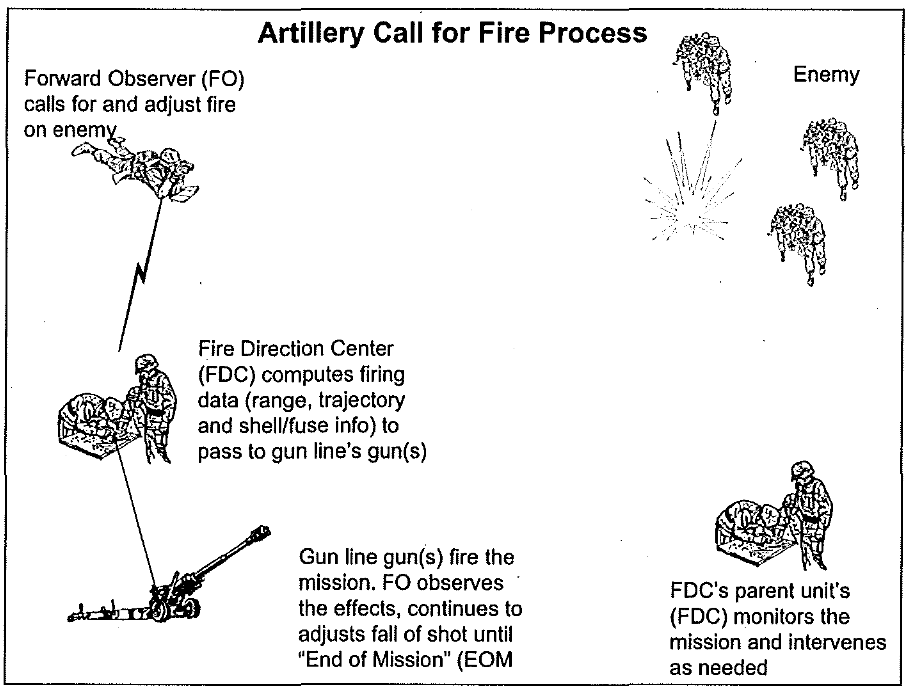
In order to reap the benefits of Big Data technology, there are three key requirements: processing, storage power, and analytical tools.[5] Processing refers to the computing power necessary to search through and sift large troves of data. Storage power refers to the physical hardware that is required to capture and maintain the datafyed information. Lastly, the analytical tools refer to the algorithms that data scientists produce in order to mine data sets.[6] Processing and storing the information could be considered the science of Big Data technology, while the development of algorithms could be considered the art. The algorithms require creativity and critical thinking, since they serve as the primary tool for gleaning the relationships between various data sets.

Another important requirement to maximize the benefit of Big Data technology is datafication, or the capturing of quantifiable information for subsequent storage, processing, and analysis.[7] Fortunately, the Army can datafy many aspects of cannon artillery operations. Targeting and fire mission processing produce large amounts of data. Existing fire control systems, such as the Advanced Field Artillery Tactical Data System (AFATDS), capture much of this data. However, other data will require the development of new methods to measure and capture the information to facilitate analysis by computer.

Before delving into methods for applying Big Data technology to the cannon artillery system, it is first important to explain the components of the system and its design. The cannon artillery organization has three main components: the firing platform, the fire direction center (FDC), and the forward observer (FO).[8] The firing platform is the shooter, and the forward observer is the sensor. The FDC is the link between the sensor and the shooter (see figure 1).

The FDC receives the target location from the FO, and subsequently translates the target location data into firing data for the howitzer. In addition to the FO, numerous other sensors now exist that are capable of providing target location information to an FDC. Examples include the various Unmanned Aerial Systems (UAS) in the Army's inventory, as well as the Persistent Threat Detection Systems (PTDS) found on many forward bases in Iraq and Afghanistan. Rotary-wing and fixed-wing aircraft pilots are also capable of transmitting target data to FDCs. The FO is not obsolete, but he is now just one of a vast number of sensors that communicate with an FDC.

Figure 1: Cannon Artillery System



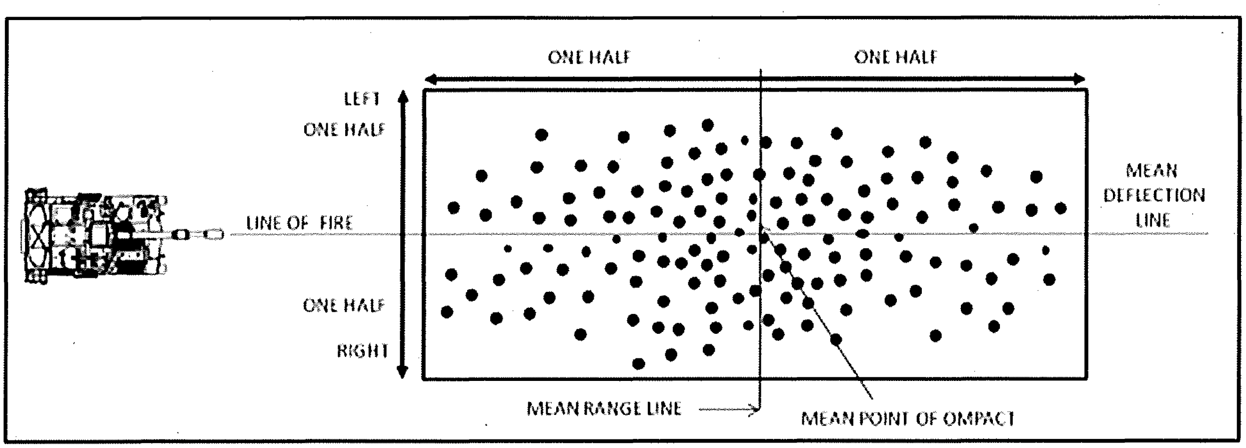
Source: https://commons.wikimedia.org/wiki/File:Arty_Call_for_Fire_1.jpg

IMPROVING PRECISION

On the modern battlefield, collateral damage is a primary concern for ground force commanders (GFCs). Excessive collateral damage during operations presents adversaries with the opportunity to exploit the employment of certain tactics. In an operating environment (OE) where adversaries can rapidly disseminate information, those adversaries can propagandize collateral damage incidents to erode host nation support for United States Army activities. United States domestic audiences are subject to influence by the same propaganda. In such environments, Army units must be consistently precise when applying combat power. However, the Army's cannon artillery platforms have limited precision when employed without precision munitions. Precision artillery rounds such as the M982 Excalibur are available, but are exceedingly expensive at almost $70,000 per unit. On the other hand, a dumb artillery round such as the M795 High Explosive projectile has a production cost of only $333.[9]

In order to improve the precision of conventional cannon artillery munitions, AFATDS' gunnery solutions require improvement. The gunnery solution is the firing data the FDC produces after it processes target information from the FO, or other available sensor. The gunnery solution does not account for inherent error, which is defined in TC 3-09.81 (FA Manual Cannon Gunnery) as those errors "beyond control or…impractical to measure".[10] Inherent errors in the Army's cannon artillery platforms result in the dispersion of rounds relative to a given target location (see figure 2). Minor differences in projectile weight, propellant

Figure 2: Dispersion Rectangle



Source: Department of the Army, *Field Artillery Manual Cannon Gunnery,* TC 3-09.81 (Washington, DC: HQDA, April 16, 2016), 3-16.

temperature, tube erosion, and meteorological data affect the impact point of a dumb artillery round relative to the actual target location.[11] The bottom line is that these errors are the primary drivers of dispersion, and dispersion makes cannon artillery an area fire weapon. But what if these errors *could* be controlled? What if errors are no longer "impractical to measure" because of advancements in measurement technology? Increasing the number of measureable data points associated with the firing of a conventional artillery round could provide data scientists the means for using Big Data technology to reduce the size of dispersion patterns. [12]

Although the FDC already accounts for data associated with criteria such as powder temperature and projectile weight, refining these measurements to more precise metrics would improve the predictive capability of Big Data technology. Instead of measuring propellant temperature to the nearest degree, measurements should be taken to the tenth or the hundredth of a degree. Moreover, cannon artillery units should seek to improve their ability to measure components of the firing system that are not taken into account in fire mission processing. Capturing real-time measurements of tube wear, tube temperature, gun displacement, and powder burn rates would assist in the analysis to further reduce dispersion. Advancements in measurement technology for cannon artillery platforms and munitions are necessary to accomplish these tasks, but the fundamental design of the platform should not require alteration.

In addition to capturing more data from the firing platform and associated munitions, combining the data points from all the Army's platforms should yield a massive amount of data to infer more accurate probabilities. Combining data points from all cannon units requires the creation of an information network. This network should permit cannon units across the entire Army to send and receive information to and from one another. The Army should establish FA-specific data storage facilities that constantly upload data from this network of cannon units.

When processing fire missions, all AFATDS should network to this central storage facility so they can account for the vast amount of firing data from other units. If AFATDS are given enough processing power, they should be able to mine this large trove of data to improve their gunnery solutions. As more and more data uploads to the network, the ability of AFATDS to produce better gunnery solutions should improve over time.

AFATDS software should incorporate machine learning technology, so that it can begin to self-correct its own gunnery solutions. In a hypothetical scenario, an AFATDS produces a gunnery solution that results in rounds impacting on the exact target location. The AFATDS software should inform the system that this result is the 'desired result'. Over time, the AFATDS will have access to increasing numbers of gunnery solutions that produce more 'desired results'. As the 'desired results' database increases in size, the AFATDS should recognize that this specific database employed the best gunnery solutions. Ideally, AFATDS would be able to refine its own fire mission processing algorithms as it identifies the gunnery solutions that achieve the operator's 'desired result'. Rather than requiring software updates every few months, the AFATDS software should be programmed to self-learn and self-adjust by analyzing the vast troves of data that will exist on its network.[13]

In addition to inherent errors, human error in fire mission processing contributes to inaccuracy. Human error often centers on the inputting of incorrect data into the AFATDS computer. If the AFATDS could identify such outliers before processing fire missions, firing incidents should be reduced dramatically. In an FDC, a human operator who types in an incorrect grid location for a firing platform will cause that firing platform to shoot out of sheaf for a multi-gun mission.[14] Noticing such an error usually happens *after* the firing of that mission. When such an incident occurs, a manual troubleshooting process initiates that requires FDC personnel to examine each aspect of the fire mission to identify the inconsistency. This can often be a time-consuming and laborious process, and sometimes no one can identify the inconsistency, resulting in the continuous firing of rounds that don't impact the designated target area. With a database of troubleshooting errors, Big Data technology could facilitate analysis of all the different errors associated with fire mission processing. In a best case scenario, the AFATDS would inform the operator whenever it detects an inconsistency in a fire mission. Through predictive capability, AFATDS could identify when an input appears to be an outlier, without having to wait for the actual processing of the fire mission.

At present, the AFATDS produces gunnery solutions that place impact points on the horizontal plane. In built-up areas, however, CDRs need to affect targets on the vertical plane (for example, an enemy fighter standing in the 4th story window of a 10-story apartment building). In order to target on the vertical plane in the given scenario, AFATDS would need to process information from 3-D maps that account for the entire urban infrastructure in a given area (see figure 3). AFATDS software currently incorporates 3-D mapping technology, but not

Figure 3: Example of 3-D Urban Map

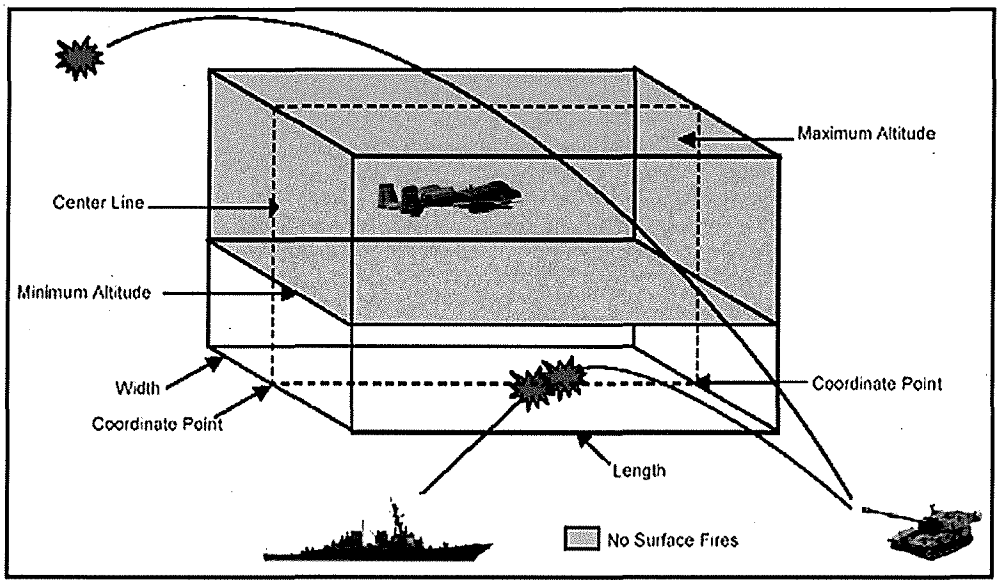
Source: http://www.3dcadbrowser.com/download.aspx?3dmodel=60783 to the extent required to target on the vertical plane.[15] The maps would have to include the geographic location of each building so AFATDS could account for it. The use of such maps could allow AFATDS to target on the vertical plane. 3-D maps with geolocation information would add a massive amount of data to the AFATDS database, since every building, window, door, etc. would require datafication. AFATDS could analyze this data to produce gunnery solutions for the vertical plane. CDRs could employ cannon artillery to strike the sides of buildings, or suppress a floor of windows. Vertical plane targeting would add a new tool to the GFC's kit bag in the urban fight.

IMPROVING RESPONSIVENESS

The delivery of timely surface-based indirect fires requires rapid de-confliction of airspace. Unfortunately, airspace de-confliction is often a time consuming process that precludes the timely use of cannon artillery platforms. Joint aircraft platforms often stack at multiple altitudes above target areas, and the proliferation of UAS on the modern battlefield only complicates efforts to clear airspace for artillery munitions. In order to gain visibility of all aviation systems in a given AO, units have to submit a query to their higher headquarters (HQ) and then wait for higher headquarters to respond. Sometimes, units have to submit queries to multiple HQs before firing units can receive confirmation that the airspace is clear.

With the latest version of AFATDS software, FDC operators can plug airspace coordination measures (ACMs) into the computer.[16] When AFATDS processes a fire mission, it will verify that the ballistic trajectory of the rounds do not violate any of the active ACMs in its database. This is one way to execute airspace de-confliction. However, airspace de-confliction measures can be fairly restrictive since they often account for a large buffer area to reduce the risk of collision between an aircraft and an artillery round (see figure 4). A much more effective

Figure 4: Formal Airspace Coordination Area



Source: Department of the Army, *Army Airspace Command and Control in a Combat Zone,* FM 3-52 (Washington, DC: HQDA, August 1, 2002), 4-11.

method for de-conflicting airspace could focus on the probability of intersection of aircraft and artillery trajectories. Big Data technology could predict the likelihood of an intersection between two fast-moving objects in the same airspace. In this manner, artillery rounds could be shot through airspace in vicinity of aircraft. With Big Data technology, aircraft and artillery could share the same airspace. In order for this to work, AFATDS computers would have to tie into a network that provides information about the real-time location of all aerial platforms in a given area. If the AFATDS could monitor specific aerial platform locations, it could de-conflict its own fire missions. If the possibility exists for a collision, then the AFATDS could delay the fire mission and thus de-conflict by time. Ultimately, this manner of de-confliction could prove much more effective than blocking off huge chunks of airspace as no-go areas for artillery munitions.

If modern battlefields will predominate in urban areas, then such battlefields will be crowded. Discriminating between combatants and non-combatants in urban areas is a challenging, dangerous, and time consuming process. Traditionally, Soldiers monitor video screens linked to sensors to identify combatants for targeting. This takes time and often the Soldier is not 100% effective in identifying targets even when the sensors are cued to look in the right area. Enemy combatants have become much more adept at concealing their locations. Sometimes, Soldiers confuse non-combatants for combatants, and vice versa. Moreover, the human and physical terrain of the modern battlefield complicates efforts to provide continuous surveillance.

Artificial intelligence (AI), in combination with Big Data technology, could assist commanders with target identification.[17] Already, the Army is already procuring machines that can identify the human form from video images. In addition to the human form, they can also discern various types of combat vehicles and equipment. This form of AI can certainly assist the FA community in speeding up the targeting cycle. If UAS and other aerial platforms with digital video capabilities can pre-program to identify targets, then individual service members would no longer have to tie themselves to video screens and wait for targets to appear. Upon identification of a possible target, the sensor would immediately transmit the target location data to an FDC. In addition to the target location data, a screen shot could transmit to the FDC for the operators to verify that the target is worthy of engagement. Rapid target identification through AI would accelerate the 'detect' phase of the Army's Targeting Methodology (Decide, Detect, Deliver, Assess) since it relies less on human attentiveness and human observation to identify well-concealed targets.

To take this scenario further, numerous aerial and ground sensors with digital video capability network together and link in with FDCs. A common database accessible to all components on the network maintains target information data that includes images of the targets from various angles. A central computer continuously downloads images from the various sensors on the network to compare the sensor images to pre-existing target images in its database. If that specific target begins to move out of range of a given sensor, the central computer automatically directs another sensor to key in on the target location. When the central computer confirms a match between sensor and pre-existing images, it sends a message to a human for target engagement approval. Upon approval, the platform communicates the target location information to an FDC with howitzers in range of the target. The FDC sends a fire mission to the guns. After firing, the sensor observes the rounds in relation to the target and provides battle damage assessment (BDA) data to the FDC. Using the same AI to identify the target, the sensor determines the distance between the target and the impact point, and then communicates this information to the FDC.[18] The FDC can re-process the information and re-attack, or merely record the BDA if the fire mission produces the desired effect.

IMPROVING EFFECTIVENESS

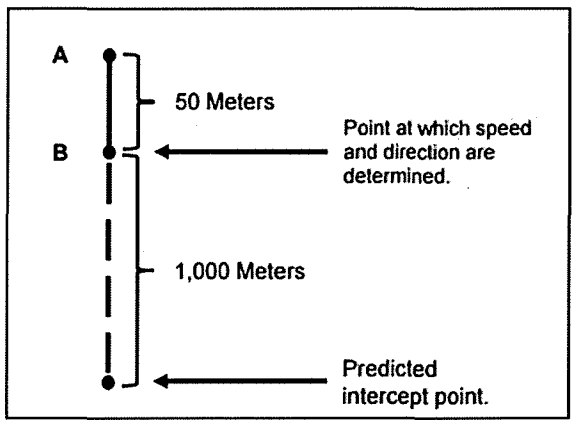
On modern battlefields, targets are often fleeting. Small windows of opportunity exist to engage targets, especially during counterinsurgency and counterterrorism operations. Upon identification, firing platforms must rapidly engage targets. This requires well-established sensor-to-shooter links and the rapid communication of target data between sensors and delivery platforms. Identifying numerous targets simultaneously requires prioritization. Engaging numerous targets at the same time necessitates the allocation of various delivery platforms to each target. Decision aids exist to assist CDRs in this process, but crowded battlefields may overwhelm a CDRs ability to prioritize and engage targets in a timely manner.

During highly kinetic operations in which numerous sensors request fire missions, the fire direction officer (FDO) can begin to struggle in choosing the most efficient method for employing his battalion's firing platoons to execute fire missions. When a battalion FDC receives a fire mission request from any of the various sensors on its fire support communication net, the FDO must decide which of his firing assets is in the best position to execute the fire mission. Upon making his decision, the FDO directs his AFATDS operator to transmit the request to one of his platoon FDCs. The platoon FDC must then process the same fire mission. The process may result in delays and prevent certain howitzer platoons from performing at their maximum capacity. In applying Big Data to the problem, algorithms could identify inefficiencies in the employment of each firing platform. For example, Big Data could identify the correlations between target engagement times and the usage rates of certain firing platoons. Upon identification of these correlations, AFATDS could learn to make recommendations to the FDO to maximize his ability to service all the fire mission requests with the number of firing platoons he has available. Big Data technology would not replace the FDO, but empower him to better perform his duty.[19]

Furthermore, AFATDS operators must manually input 'method of attack' information into their computers when they process fire missions. When determining the 'method of attack', the AFATDS operator considers the number of howitzers to fire, the type of round, the number of volleys, and other information related to how the cannon crewmembers employ their platforms to achieve the desired effect on a target. This is all important information, but it is time consuming to input and relies on imperfect human judgment. An improvement to this system would be the use of Big Data technology to discern the best possible 'method of attack'. Data scientists would need to produce algorithms that compare successful BDA to specific 'method of attack' data to determine what 'methods of attack' were most successful against specific target types. Subsequently, AFATDS programmers could design software to automatically recommend 'method of attack' guidance for various targets on the battlefield. This change would save time, and ensure targets were attacked in the most effective manner.

One aspect of targeting that remains a challenge for cannon artillery units is the engagement of moving targets. Methods exist for FDC crewmembers to produce target data for moving targets, but it relies on math steps and a cooperative enemy that maintains a steady rate of advance toward a single point on the ground (see figure 5). Instead of relying on a singular

Figure 5: Traditional Method of Determining Intercept Point of Moving Target



Source: Department of the Army, *Observed Fire,* FM 6-30 (Washington, DC: HQDA, July 16, 1991), 5-24.

target location to engage a moving target, it would make more sense to create a target area that comprised possible locations that a vehicle or troop formation might occupy at a given point in time. As an example, AFATDS would designate a firing battery of six guns to fire at a moving target. Incorporating 3-D mapping technology, the AFATDS could predict aim points for each gun along the route of march to account for the possibility of the target slowing down or speeding up. Rather than the FDC operator having to compute math steps, the AFATDS computer would calculate the probable vehicle locations, and then communicate separate firing information to each howitzer in the battery. Although this may not be a perfect solution to the moving target problem, it would certainly be an improvement to the current method for engaging moving targets.

IMPLICATIONS FOR ORGANIZATION AND MATERIEL

Improving cannon artillery's precision, responsiveness, and effectiveness through the application of Big Data technology will require new equipment and infrastructure in FA organizations. A server will need to be built to store and maintain the enormous amounts of data produced by the operating force. This server will act as the central storage location for all the data produced by the cannon artillery community. The server will require network connection with all of the Army's cannon artillery units so that it can continually retrieve all the data produced by the various sensors and FDCs throughout the operating force.

The digital network used to connect each cannon artillery unit with the central server is another key piece of infrastructure that requires development. Currently, digital communication networks exist to connect a unit's firing platforms with the AFATDS in their platoon FDCs. Also, the AFATDS in platoon FDCs can communicate with the AFATDS in both battalion FDCs and brigade fire support cells. The SINCGARS radio is presently used to facilitate the digital networks that connect the various AFATDS computers. However, there is no overarching network that connects all of the Army's cannon artillery units. Besides just connecting AFATDS computers to the central server, the network would require connection with all sensor platforms that are organic to a brigade combat team. The central server would need access to all digital video and imagery produced by brigade sensors to ensure that information is available for processing and analysis. To enable the airspace de-confliction procedures already mentioned, AFATDS would require access to the radar networks that aviation units employ to monitor the locations of their aircraft. The groundwork is being laid for this access, considering the latest version of AFATDS incorporates improved connection capabilities, such as the Link 16 protocol.[20]

The AFATDS computer itself would require significant updates to accommodate the other changes listed above. The computer would need much more processing power to sort through and analyze the increasing amounts of data transmitting on the network. It would need new hardware to facilitate digital connectivity with a central server. It would also need new connections to link in with any BCT sensor capable of producing target location data. AFATDS software would need to be capable of receiving real-time updates from the central server. For example, server managers should be able to push new fire processing algorithms down to firing unit FDCs to improve gunnery solutions. The software should update automatically anytime improvements are sent from the central server. Furthermore, AFATDS software should automatically upload the data it produces from processing fire missions to the central server. All these activities should occur without active involvement from FDC personnel. The transfer of data between the AFATDS and the central server should be transparent to the operator.[21]

The management of a central server would require the hiring of additional personnel. These new personnel would have several different functions. Not only would they need to manage the server and the network that connects the server to the Army's FA units, but they would need to analyze the data consolidated on the server. Specifically, the Army would need to hire data scientists who can find creative ways to mine the data for correlations that will assist the cannon artillery community.[22] Upon finding these correlations, the data scientists would need to work hand in hand with computer and software engineers to produce newer versions of AFATDS that incorporate the lessons learned from the data analysis. The data scientists would need to remain in constant contact with the operating force to stay abreast of the most pressing battlefield challenges. Since the job of the data scientist is exceedingly specialized and technical, it would likely need to be a contracted position.

CHALLENGES AHEAD

Two major challenges exist: 1) the reliance on a digital network during combat operations to apply Big Data solutions and 2) the vulnerability of the network to enemy attack. The creation of a central server in CONUS with the ability to connect to operating units around the world assumes a viable network that is always up and running. Network operations would require access to electricity and the ability to send and receive signals over some type of communications network. However, operations in austere environments may preclude access to electric energy. Moreover, enemy capabilities may preclude the use of any equipment that runs on a digital platform. An electro-magnetic (E-M) attack would force Army units to rely solely on mechanical warfighting systems. Any warfighting system that relies on a digital capability would immediately become obsolete in an environment where E-M weapons persist.

Even if the Army is able to establish and maintain a digital network that connects numerous cannon units, sensors, and radars, that network may become a highly lucrative target for our enemies. The expansion of the network implies that a tremendous amount of operational information becomes consolidated on that very network. If an adversary develops the capability to penetrate the network, they would have immediate access to firing unit locations, aircraft flight paths, and a myriad of other data points that would give them a significant intelligence advantage. In addition to the intelligence value, the enemy could execute a cyber-attack on that network that would have far-ranging implications for many joint warfighting systems.

CONCLUSION

Large-scale conventional conflict, as seen in World War II or the Korean War, favored massive artillery bombardments with little regard for damage to the host nation's infrastructure. In the information age, smart phones can depict collateral damage from a battlefield just moments after it occurs. These images can sway entire populations in a matter of hours. Moreover, targets on the modern battlefield are rarely static. They constantly move, and find ways to blend in with the population or urban infrastructure. If the trend from the past 15 years continues, the majority of adversaries would not be easy to identify. They would not wear recognizable uniforms or operate traditional military platforms. Engagement windows would be small, and would require the delivery of desired effects on the first strike. Opportunities for re-attack would be few, or non-existent.

The modern battlefield will require the United States Army to deliver effects that are precise, responsive, and effective. In order to remain relevant, the Army's cannon units must tackle these challenges head on. Although Big Data is no panacea, Big Data technology could be a stepping stone to better position cannon units for future conflict. Indeed, new equipment and additional personnel are required to incorporate the changes recommended throughout this paper. Engagement and coordination with other services and intergovernmental organizations is also necessary. But these changes do not require a fundamental redesign of force structure or organization. Rather, the changes will rely mostly on innovative Soldiers to determine the best way to operationalize this existing technology. This notion ties in neatly with the Department of Defense's Third Offset Strategy, which focuses on the ability of individual service members to apply their critical and creative thinking skills to maintain an edge on the battlefield.[23]

The addition of precision weapons to the cannon unit's arsenal was a boon for the FA community, since it met a major requirement for GFCs in Iraq and Afghanistan. If the cannon artillery community can achieve similar effects with conventional munitions, while simultaneously updating its other processes, then the King of Battle will have a renewed sense of importance amongst its maneuver brethren and keep its edge on the 21st century battlefield.

[1] Viktor Mayer-Schonberger and Kenneth Cukier, *Big Data: A Revolution that will Transform how we Live, Work, and Think* (New York: Houghton Mifflin Harcourt, 2013), 12.
[2] José van Dijck, "Datafication, Dataism and Dataveillance: Big Data between Scientific Paradigm and Ideology," *Surveillance & Society* 12 (2): 200.
http://search.proquest.com.lomc.idm.oclc.org/docview/1547988865?accountid=14746
[3] Viktor Mayer-Schonberger and Kenneth Cukier, *Big Data*, 7.
[4] Viktor Mayer-Schonberger and Kenneth Cukier, *Big Data*, 55.
[5] Viktor Mayer-Schonberger and Kenneth Cukier, *Big Data*, 27.
[6] Viktor Mayer-Schonberger and Kenneth Cukier, *Big Data*, 125.
[7] Viktor Mayer-Schonberger and Kenneth Cukier, *Big Data*, 15.
[8] Headquarters, Department of the Army. *Field Artillery Manual Cannon Gunnery*. TC 3-09.81. Washington, DC: Headquarters, Department of the Army, April 13, 2016: 1-1 to 1-2.
[9] http://www.globalsecurity.org/military/systems/munitions/m795.htm
[10] TC 3-09.81, 3-15.
[11] TC 3-09.81, 3-14.
[12] Viktor Mayer-Schonberger and Kenneth Cukier, *Big Data*, 78.
[13] Trevor Meier and Robert D. Wilson, "Advanced Field Artillery Tactical Data System Gets Dramatic Upgrade," *RedLeg Update*, Sep-Oct 2016.
http://sill-www.army.mil/USAFAS/redleg/archive/2016/sep-oct-2016.pdf
[14] Jim Collins and Joshua Herzog, "Every Mil Matters: One Battalion's Fight Against Error," *Fires*, Sep-Oct 2016.
http://sill-www.army.mil/firesbulletin/
[15] Trevor Meier and Robert D. Wilson, "Advanced Field Artillery Tactical Data System Gets Dramatic Upgrade".
[16] Trevor Meier and Robert D. Wilson, "Advanced Field Artillery Tactical Data System Gets Dramatic Upgrade".
[17] Benjamin Jensen and Ryan Kendall, "Waze for War: How the Army can Integrate Artificial Intelligence," War on the Rocks. September 2016.
http://warontherocks.com/2016/09/waze-for-war-how-the-army-can-integrate-artificial-intelligence/
[18] Kevin Murray, Che Bolden, Scott Cuomo, and James Foley, "Manned/Unmanned Teaming to Transform the MAGTF," *Marine Corps Gazette*100 (2016): 70-75.
http://search.proquest.com.lomc.idm.oclc.org/docview/1793868254?accountid=14746
[19] Benjamin Jensen and Ryan Kendall, "Waze for War: How the Army can Integrate Artificial Intelligence".
[20] Trevor Meier and Robert D. Wilson, "Advanced Field Artillery Tactical Data System Gets Dramatic Upgrade".
[21] Trevor Meier and Robert D. Wilson, "Advanced Field Artillery Tactical Data System Gets Dramatic Upgrade".
[22] Viktor Mayer-Schonberger and Kenneth Cukier, *Big Data*, 125.
[23] Sydney J. Freedman, Jr., "Centaur Army: Bob Work, Robotics, & the Third Offset Strategy," Breaking Defense, 9 November 2015.
http://breakingdefense.com/2015/11/centaur-army-bob-work-robotics-the-third-offset-strategy/

BIBLIOGRAPHY

Collins, Jim and Joshua Herzog. "Every Mil Matters: One Battalion's Fight Against Error." *Fires*, Sep-Oct 2016. http://sill-www.army.mil/firesbulletin/

Flores, Rufino B. Jr and Galinger, Barry D. II. 2016. "Conducting Formal Collateral Damage Estimation in Afghanistan." *Fires*: 35-41. http://search.proquest.com.lomc.idm.oclc.org/docview/1797896381?accountid=14746.

Freedberg, Sydney J. "Centaur Army: Bob Work, Robotics, and the Third Offset Strategy." Breaking Defense. November 2015. http://breakingdefense.com/2015/11/centaur-army-bob-work-robotics-the-third-offset-strategy/

Jensen, Benjamin and Ryan Kendall. "Waze for War: How the Army can Integrate Artificial Intelligence." War on the Rocks. September 2016. http://warontherocks.com/2016/09/waze-for-war-how-the-army-can-integrate-artificial-intelligence/

Headquarters, Department of the Army. *Field Artillery Manual Cannon Gunnery*. TC 3-09.81. Washington, DC: Headquarters, Department of the Army, April 13, 2016.

Interview with CW4 Houston S. Burke, November 13th, 2016.

Lind, William S., Keith Nightengale U.S.A., John F. Schmitt U.S.M.C., Joseph W. Sutton U.S.A., and Gary I. Wilson U.S.M.C. 2016. "The Changing Face of War: Into the Fourth Generation." *Marine Corps Gazette* 100 (3): 86-90. http://search.proquest.com.lomc.idm.oclc.org/docview/1782793402?accountid=14746.

Lockie, Alex. "This Algorithm Could Help Predict ISIS' Future Moves." Business Insider. September 2015. http://www.businessinsider.com/machine-learning-used-to-predict-and-model-isis-2015-9

Mayer-Schonberger, Viktor and Kenneth Cukier. *Big Data: A Revolution that will Transform how we Live, Work, and Think.* New York, NY: Houghton Mifflin Harcourt, 2013.

McBride, Courtney. 2016. "Report: Army Must Take Drastic Measures to Prepare for Future Conflicts." *Inside the Pentagon's Inside the Army* 28 (38). http://search.proquest.com.lomc.idm.oclc.org/docview/1822934823?accountid=14746.

Meier, Trevor and Robert D. Wilson. "Advanced Field Artillery Tactical Data System Gets Dramatic Upgrade." *RedLeg Update*, Sep-Oct 2016. http://sill-www.army.mil/USAFAS/redleg/archive/2016/sep-oct-2016.pdf

Murray, Kevin, Che Bolden, Scott Cuomo, and James Foley. 2016. "Manned/Unmanned Teaming to Transform the MAGTF." *Marine Corps Gazette*100 (6): 70-75. http://search.proquest.com.lomc.idm.oclc.org/docview/1793868254?accountid=14746.

Norwood, Paul R., Benjamin M. Jensen, and Justin Barnes. 2016. "Capturing the Character of Future War." *Parameters* 46 (2): 81-91. http://search.proquest.com.lomc.idm.oclc.org/docview/1816604416?accountid=14746.

O'Hanlon, Michael and David Petraeus. 2016. "America's Awesome Military: And how to Make it Even Better." *Foreign Affairs* 95 (5): 10-17. http://search.proquest.com.lomc.idm.oclc.org/docview/1815340967?accountid=14746.

Rossi, John. 2016. "The State of Fires." *Fires*: 1-4. http://search.proquest.com.lomc.idm.oclc.org/docview/1793935049?accountid=14746.

Rubal, Lawrence, Matthew Lilley, Robert Walthall, Shawn Ramirez and Ian Roth. "Re-Shaping the JAGIC: Lessons Learned from 4th ID Warfighter 16-03." *Fires*, Jul-Aug 2016. http://sill-www.army.mil/firesbulletin/archives/2016/jul-aug/jul-aug.pdf

Sherman, Jason. 2016. "Army Commissions Independent Blueprint For Future Technological Overmatch." *Inside the Pentagon* 32 (3). http://search.proquest.com.lomc.idm.oclc.org/docview/1758314104?accountid=14746

van Dijck, José. 2014. "Datafication, Dataism and Dataveillance: Big Data between Scientific Paradigm and Ideology." *Surveillance & Society* 12 (2): 197-208. http://search.proquest.com.lomc.idm.oclc.org/docview/1547988865?accountid=14746

Torruella, Anika. 2016. "Cyber Warfare at the Tactical Edge: Information Ballistics and Cyber Bombs." *Jane's International Defense Review* 49 (10). http://search.proquest.com.lomc.idm.oclc.org/docview/1817031017?accountid=14746.