大數據與管式砲兵之革新

Big Data meets King of Battle：Methods for improving Army’s cannon artillery system

取材：美國《火力雜誌》2018年5月號（Fires, May-June, 2018）

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Introduction

The United States Army’s field artillery 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 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 deconfliction procedures and collateral damage requirements. Furthermore, cannon artillery platforms are ineffective when they require multiple adjustments to achieve effects on target.

前言

美國陸軍的野戰砲兵界在現代戰場上面臨著無數的挑戰。海外陸軍部隊的作戰地區（AO）多為人口密集，且有大量民用基礎設施的城鎮。諸多目標出現在大量非戰鬥人員散布其間的擁擠空間。在這種環境下，目標通常短暫出現，指揮官能接戰的時間亦極短。為了適合這些作戰地區特性，砲兵部隊必須精準、快速、有效。傳統榴砲使用的所謂「笨彈」（dumb rounds）主要是為面積火力所設計，武器的精確度有限。在城鎮戰條件下，砲兵的反應速度往往又受到避免衝突程序（deconfliction procedures）及降低附帶損害等要求所限制。此外，砲兵火力必須歷經多次修正方能達到預期效果，致使效率不彰。

Big data technology may provide the means to tackle 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.

大數據科技或許可解決上述挑戰。大數據科技可以提高傳統火砲彈藥的精準度、加快目標識別過程、迅速解決產生衝突的空域、加速偵感器與射手之間的連結，幫助陸軍的砲兵部隊更精準、反應更迅速、產生更佳的射效。以下先就大數據科技簡要介紹，然後說明如何將大數據科技應用於砲兵系統，以提高精準度、反應速度及射效。

Big data

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.

大數據

大數據科技主在以數學方式處理大量數據，幫助（某些狀況發生）概率之推斷。[1]也就是說客戶藉此得以相當準確地預測未來。亞馬遜即為運用大數據科技來推斷客戶的購買習慣的網路零售商。[2]當顧客經由亞馬遜的網路商店購買了一雙跑鞋，則該顧客的亞馬遜網頁上就會出現與跑步配件相關的廣告。為了確定在特定顧客的網頁上刊登哪些商品廣告，亞馬遜以大數據科技來分析其顧客的購買習慣。亞馬遜運用其數據庫運算，確定某一顧客購買一雙跑鞋後，最可能續購的商品。如果亞馬遜判定顧客在購買跑鞋後，大部分隨後會選購數位手

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[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] 2José 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

錶，那麼顧客在購買跑鞋後網頁立即可以看到數位手錶的廣告。簡言之，亞馬遜不一定宣傳與原購買品種相同產品，而是經由分析顧客購買習慣，來決定下一位顧客可能購買的商品。

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.3Correlation 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 give results much faster than trying to determine the causal relationship.4As a fire direction center（FDC）crewmember, 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 crewmember knows the effect, they can make proper adjustments for the howitzer crew to ensure their rounds impact on target. Knowing the why doesn’t help accomplish the mission.

亞馬遜運用大數據科技來辨別購買習慣，並不意味著亞馬遜能知道客戶購買決心背後的因果關係，大數據僅找尋個別購買事件之間的關聯性。分析大量數據可以發現不同事件之間的關聯性，而非因果關係。[3]關聯性提供的是可能性，而不是必然性。概率可以告訴我們可能發生的事情，但不一定會發生。以數據做為依據，來確定各種現象之間的關聯性，比試圖找出其間的因果關係要快得多。[4]射擊指揮所（FDC）人員，了解氣象狀況對射彈的影響比知道箇中原因更重要。只要 FDC 人員知道這些影響，就可以加以修正，以確保其對目標產生預期的射擊效果。了解為什麼，對達成任務並沒有多大幫助。

In order to reap the benefits of big data technology, there are three key requirements: processing, storage power and analytical tools.5Processing 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 datafied information. Lastly, the analytical tools refer to the algorithms that data scientists produce in order to mine data sets.6Processing 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

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[3] Viktor Mayer-Schonberger and Kenneth Cukier, Big Data, 7.
[4] Viktor Mayer-Schonberger and Kenneth Cukier, Big Data, 55.

gleaning the relationships between various data sets.

欲獲得大數據科技的好處，必須滿足三項關鍵要求：處理、存儲能量、分析工具。[5]處理是指搜尋與篩選大量數據所需的計算能力；存儲能量是指尋獲並加以維護尋獲數據資訊所需的硬體；分析工具則是數據科學家為挖掘數據群所需的運算法。[6]資訊之處理與存儲可被視為是大數據的科學面，而運算法的研發則屬於藝術面。運算法需要創造性和批判性思維（譯註：critical thinking 並非凡事予以否定或充滿懷疑，而是在重要轉折點，跳脫既有框架做獨立思考。港譯「慎思式思考」），因為它們是找出各種數據群之間關係的主要工具。

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.7Fortunately, 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.

欲將大數據科技效益最大化，另一個重大要求是數據化，亦即將後續存儲、處理、分析所需之的資訊予以量化。[7]幸運的是，砲兵早已具備數據分析的基礎。目標處理與射擊任務過程中，都會產生大量數據。現有的火力控制系統，如「先進野戰砲兵戰術資料系統」（AFATDS），就能搜尋大部分這些數據。然而其他電腦分析所需數據，就必須另尋新方法加以量測。

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 FDC and the forward observer （FO）.8The 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 （UASs） in the Army’s inventory, as well as the Persistent Threat Detection Systems found on many forward bases in Iraq and Afghanistan. Rotary-wing and fixed-wing aircraft pilots are also capable

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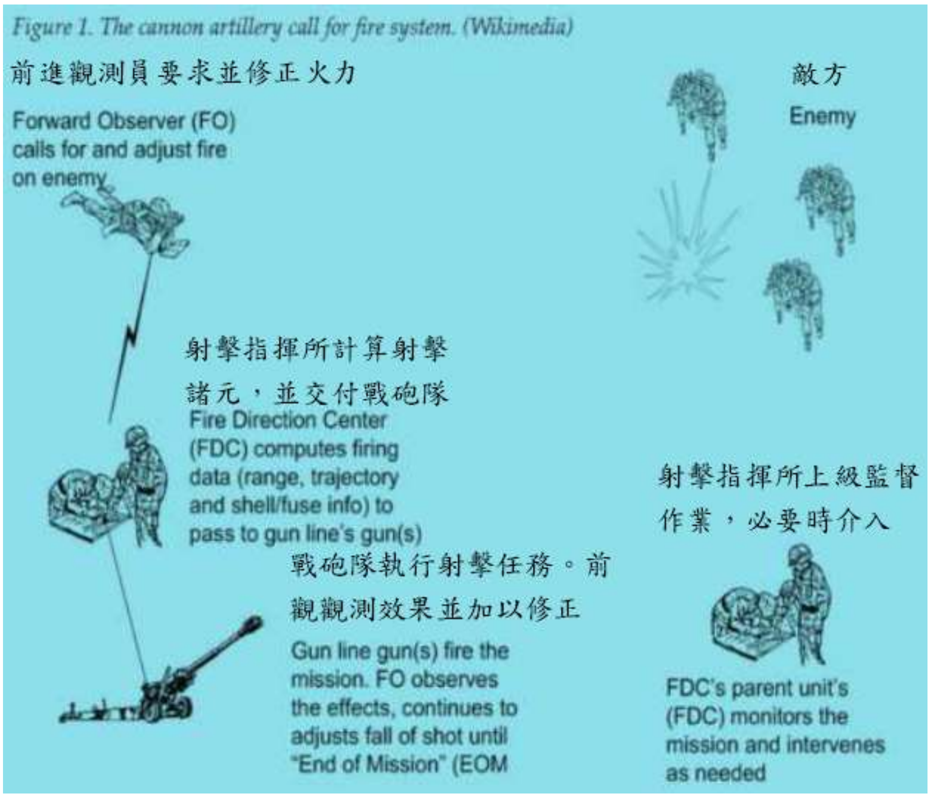
5 Viktor Mayer-Schonberger and Kenneth Cukier, Big Data, 27.

6 Viktor Mayer-Schonberger and Kenneth Cukier, Big Data, 125.

7 Viktor Mayer-Schonberger and Kenneth Cukier, Big Data, 15.

of transmitting target data to FDCs. The FO is not obsolete, but is now just one of a vast number of sensors that communicate with an FDC.

在深入研究將大數據技術應用於火砲系統的方法之前，首先要解釋砲兵系統的結構及其設計。砲兵系統基本上分為三大部分：射擊平臺、射擊指揮所、前進觀測員（FO）。[8]射擊平臺是射手，前方觀察員是偵感器。射擊指揮所是偵感器與射手之間的聯繫（見圖一）。射擊指揮所從前進觀測員接收目標位置，隨後將目標位置數據轉換為火砲的射擊數據。除了前進觀測員外，現在還有許多向射擊指揮所提供目標位置的偵感器。如現今的各型無人機系統（UAS），以及在伊拉克和阿富汗許多前沿基地的「威脅持續偵測系統」（Persistent Threat Detection Systems）。同時旋翼機與定翼機飛行員，也能夠將目標數據傳輸到射擊指揮所。前進觀測員並未過時，但現在只是眾多與射擊指揮所通連的偵感器之一。



圖一 管式砲兵火力要求體系

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

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

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]

改進精度

在現代戰場上，附帶損害是地面部隊指揮官（ground force commanders, GFC）的首要關切。作戰中過多的附帶損害最易為敵所利用。當敵人處於能夠迅速傳播信息的作戰環境（operating environment, OE）中，會利用這些附帶損害事件加以宣傳，以削弱地主國對美軍的支持，美國國內觀眾也同樣受到影響。在這種環境中，部隊戰力之發揮必須力求精準。但若無精準彈藥，砲兵的精度就有限。M982 神劍（Excalibur）之類的精準彈藥，價格非常昂貴，每發砲彈將近 70,000 美元，而 M795 等高爆彈價格不過 333 美元。[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 Training Circular 3-09.81 （Field Artillery Manual Cannon Gunnery） as those errors “beyond control or ... impractical to measure.”[10]

為了提高傳統砲彈藥的精度，AFATDS 的射擊諸元運算方式必須改進。射擊諸元是射擊指揮所處理來自前進觀測員或其他偵感器的目標情報後產生的射擊數據。目前射擊諸元的計算並沒有考量「存在誤差」（inherent error），在訓練通告 3-09.81《野戰砲兵射擊指揮》中這種誤差被定義為：「無法控制，或者……不需量測」的誤差。[10]

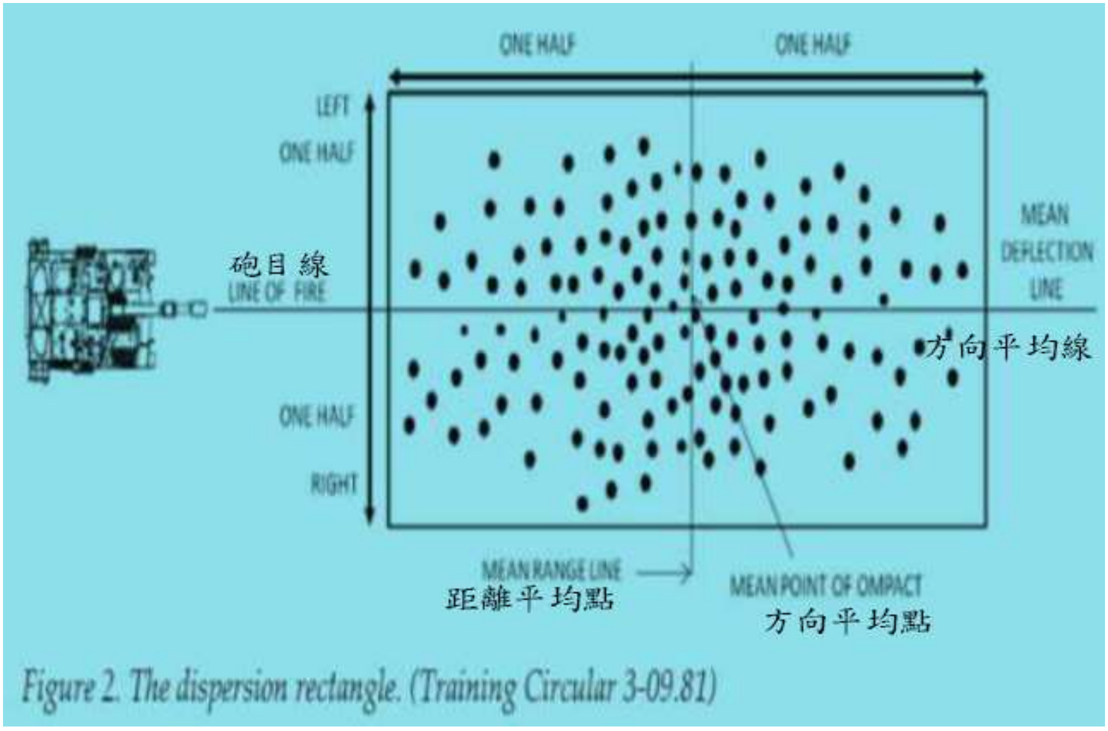
Inherent errors in the Army’s cannon artillery platforms result in the dispersion of rounds relative to a given target location（see Figure 2, opposite page). Minor differences in projectile weight, propellant temperature, tube erosion and meteorological data affect the impact point of a dumb artillery round relative to the actual target location.11The

[9] http://www.globalsecurity.org/military/systems/munitions/m795.htm

[10] TC 3-09.81, 3-15.

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

砲兵射擊平臺的存在誤差，導致砲彈產生散布（見圖二）。彈重、藥溫、砲管磨損和氣象數據的些微差異，影響砲彈彈著點偏移目標實際位置上。[11]這些誤差是造成散布的主因，也由於散布使得砲兵成為面積武器。但若這些誤差可以控制呢？基於量測技術日益進步，若這些誤差不再是「不可測量」呢？增加傳統砲彈相關的量測位置與次數為數據科學家提供大數據分析，當可縮小射彈之散布模式。[12]



圖二　射彈散布矩形圖

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

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[11] TC 3-09.81, 3-14.

[12] Viktor Mayer-Schonberger and Kenneth Cukier, Big Data, 78.

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.*

雖然射擊指揮所已經考慮到藥溫、彈重等相關數據，但若提高量測精度，如藥溫量測精度提高到 1/10，甚至 1/100 度，將可提高大數據科技的預測能力。此外，砲兵部隊應設法提高他們量測射擊系統以往在射擊任務處理過程中沒有考慮的部分，例如擷取砲管磨損、砲管溫度、砲身位移、火藥燃燒速度等之即時數據，如此將有助於進一步縮小散布。射擊平臺和彈藥量測技術的進步，是達成此一任務所必需，但平臺本身基本設計不必要求改變。

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 gunnery solutions. As more and more data uploads to the network, the ability of AFATDS to produce better gunnery solutions should improve over time.

除了從射擊平臺和彈藥擷取更多相關數據之外，結合陸軍所有其他射擊平臺的量測位置，應該產生更多數據，概率推斷將更為精準。欲將所有砲兵部隊量測點加以整合，首須建立共同資訊網路，此一網路應該允許全軍砲兵部隊彼此存取信息。陸軍則應建立野戰砲兵專屬之數據存儲設施，不斷將數據上傳。處理射擊任務時，所有 AFATDS 都應該與這個中央存儲設施連網，以便解讀來自其他部隊的大量射擊數據。若 AFATDS 具有足夠的處理能力，應該能從大量數據中發掘出改進射擊諸元運算的方法。隨著愈來愈多上傳網路的數據，假以時日 AFATDS 必能增強其射擊諸元計算能力。

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

AFATDS 軟體應該結合機器學習科技，讓它自行修正射擊諸元。在假設的情況下，AFATDS 顯示的射擊諸元，必能一發命中目標。AFATDS 軟體應該告知系統此一結果就是「預期效果」。隨著時間的推移，AFATDS 累積越來越多能獲得「預期效果」的射擊諸元。隨著「預期效果」數據庫的規模增大，AFATDS 應該認知，此一特定數據庫裡都是最佳的射擊諸元。最終 AFATDS 將能自行修改的射擊任務處理運算法，因為它可以自己辨識何種射擊諸元可以滿足人的「預期效果」，而不需要每隔幾個月就要進行軟體更新，AFATDS 軟體程式應該可以透過網路上大量數據的分析，自行學習，自我修正。[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.14Noticing 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

[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

capability, AFATDS could identify when an input appears to be an outlier, without having to wait for the actual processing of the fire mission.

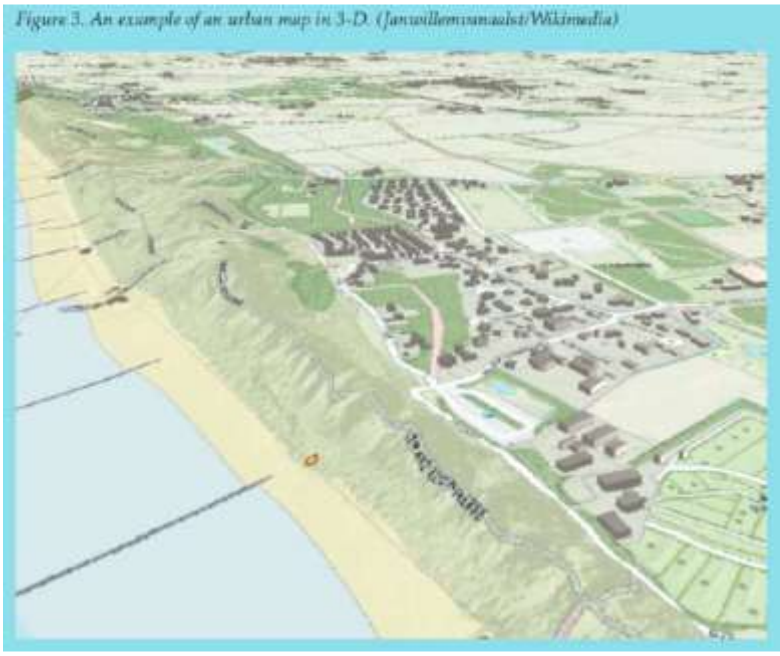
除了存在誤差之外，射擊任務處理過程中也常發生人為錯誤。人為錯誤最常發生在輸入 AFATDS 的數據不正確。如果 AFATDS 能在處理射擊任務前，即辨識出這些異常數值，將大幅度降低射擊意外事件。射擊指揮所作業人員鍵入不正確座標位置，彈幕就會落於不預期位置。[14]通常射擊任務執行後才會發現錯誤。發生此類事件後，人工故障排除程序方予啟動，射擊指揮所全員檢查每一動作，這往往是一個費時費力的過程，有時候沒有人警覺其中的不一致性，而導致連續發射對目標無效的射彈。若經由數據庫的錯誤檢查，大數據科技將協助分析整個過程中發生的錯誤。在最好的情況下，只要 AFATDS 在射擊任務中一經發現問題，就會通知操作員。大數據的預測能力，可以在錯誤輸入時即予以辨識，不必等到射擊任務執行後，方能發現錯誤。

At present, the AFATDS produces gunnery solutions that place impact points on the horizontal plane. In built-up areas, however, commanders need to affect targets on the vertical plane （for example, an enemy fighter standing in the fourth 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 to the extent required to target on the vertical plane. 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. Three-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.15 Commanders 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.

目前 AFATDS 計算出來的射擊諸元，是將彈著點放在同一平面上計算。但在城鎮地區，指揮官或許要攻擊位於垂直面的目標（例如敵人位於 10 層樓公寓的 4 樓窗口）。為標定此一垂直目標，AFATDS 必須處理該地區的三維地圖資訊（見圖三）。AFATDS 軟體目前雖有三維地圖技術，但尚未能處理垂直平面上的目標。這些地圖必須包括每座建築物的地理位置，以便 AFATDS 加以計算。使

[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/

用這種地圖可以使 AFATDS 能夠標定垂直面，但資料占了 AFATDS 數據庫很大位置，因為每個建築物、門、窗等都需要數位化，AFATDS 方能分析這些數據，為垂直目標提供射擊諸元。[15]指揮官可以用火砲射擊建築物的兩側，或者壓制某一層窗戶。垂直面之目標處理，讓地面部隊指揮官口袋裡增添了一項新工具。



圖三 城鎮地區之 3D 地圖

Improving responsiveness

The delivery of timely surface-based indirect Fires requires rapid deconfliction of airspace. Unfortunately, airspace deconfliction 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.

改進反應能力

欲立即發揚曲射武器火力，首須迅速排除空域衝突問題。但空域衝突排除通常是一個耗時的過程，以致於限制了砲兵及時火力發揚。聯合飛機平臺在目標區域上空往往佔據個空層，加上大量無人機系統，使得為砲兵射擊空域淨空作業更形複雜化。為了淨空作戰地區所有航空器，必須向其上級指揮部查詢，

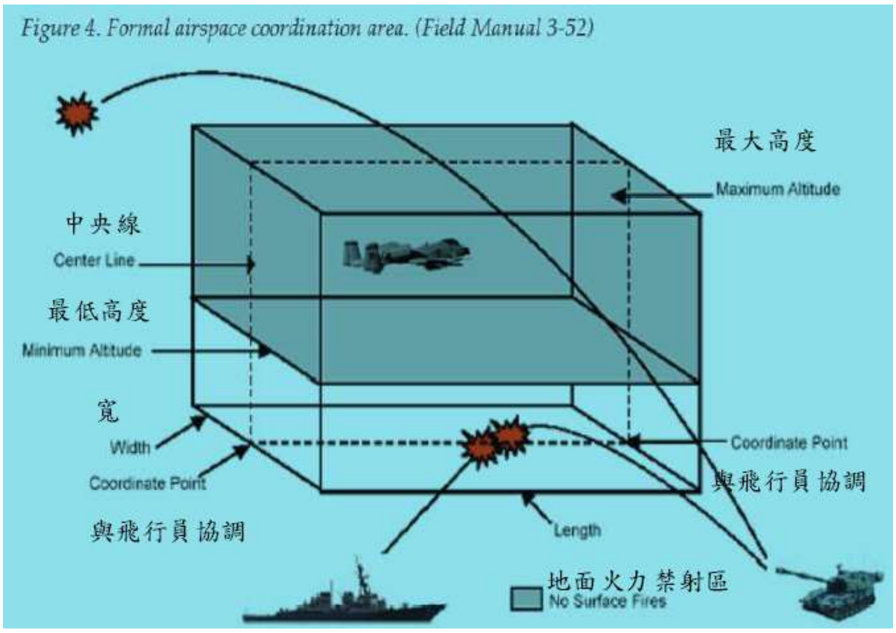
[15] Trevor Meier and Robert D. Wilson, “Advanced Field Artillery Tactical Data System Gets Dramatic Upgrade.”

然後等待更高層指揮部回應。有時甚至必須向多個指揮部查詢，射擊單位才能收到空域已淨空的確認信息。

With the latest version of AFATDS software, FDC operators can plug airspace coordination measures （ACMs） into the computer.16When 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 deconfliction. However, airspace deconfliction 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 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 deconfliction could prove much more effective than blocking off huge chunks of airspace as no-go areas for artillery munitions.

最新版本的 AFATDS 軟體，射擊指揮所操作員可以將「空域協調措施」（airspace coordination measures, ACM）灌入電腦內。[16]當 AFATDS 處理射擊任務時，它將檢查彈道軌跡是否與數據庫中的任何有效的空域協調措施相衝突。這是排除空域衝突的一種方法。然而，空域管制措施可能相當嚴格，通常佔用相當大的緩衝空域，以降低飛機與砲彈發生碰撞的風險（見圖四）。另一種更有效的排除空域衝突的方法，是將考量重點放在飛機和砲彈彈道相交會的可能性上。大數據科技可以預測同一空域內兩個快速移動物體相交的可能性。以這種方式，砲彈可以在飛機附近的空域內射擊。利用大數據科技，飛機和火砲可以共享同一個空域。為了實現這一點，AFATDS 計算機必須連接到一個能提供有關特定空域內所有空中平臺的即時位置資訊的網路。如果 AFATDS 可以監測特定空中平臺位置，就可以在執行射擊任務時排除空域衝突，若有任何碰撞可能，AFATDS 可以將射擊任務稍作延後而避免空域衝突。這種排除衝突的方式可能比封鎖大塊空域作為禁射區更有效。

[16] Trevor Meier and Robert D. Wilson, “Advanced Field Artillery Tactical Data System Gets Dramatic Upgrade.”



圖四 正式之空域協調區

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 percent 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.

現代戰場以城鎮戰居多，戰場必然擁擠不堪。戰鬥員和非戰鬥員之辨識極為困難，且其過程既危險又耗時。傳統上，士兵必須緊盯著連接到偵感器的螢幕，搜尋可能成為目標之戰鬥員，耗費相當多時間，而且即使偵感器已經監控到正確的區域，尚且無法以人工 100%辨識目標。敵戰鬥員愈來愈懂得隱蔽掩蔽，士兵經常將兩者互相混淆。基於現代戰場的人員與地形因素，使得持續監視作為益形複雜。

Artificial intelligence （AI）, in combination with big data technology, could assist commanders with target identification.17The 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.

人工智慧（AI）與大數據科技相結合，可以幫助指揮官辨識目標。[17]陸軍已經開始採購可以從監控錄影圖像，識別人體形態的裝備。除了人的外形，他們還可以辨別各種類型的戰車和裝備。這種形式的人工智慧當然可以協助砲兵快速標定。如果無人機系統與其他具有數位影像傳輸功能的高空平臺可以預先設定確認目標程式，那麼操作人員就不必將自己綁在螢幕前等待目標出現。一旦目標出現，偵感器即將目標位置數據與螢幕截圖傳送給射擊指揮所，驗證目標是否值得攻擊。人工智慧迅速識別目標，使得「目標處理」程序中（決定、偵蒐、打擊、評估）的「偵蒐」階段更加快速，因為不再需要依賴人的眼睛與注意力的集中，來揪出隱掩蔽良好的目標。

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.18The FDC can re-process the information and re-attack, or merely record the BDA if the fire mission produces the desired effect.

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

將上述場景更進一步向前推，許多具有數位化視訊功能的空中和地面偵感器網路彼此連接並與射擊指揮所連接。網路各用戶可以在共同數據庫中自由存取，建立並維持本身需要的目標資訊，甚至包括同一目標不同角度的圖像。中央電腦不斷從網路內各偵感器下載圖像，同時與數據庫內預存目標圖像比對。如果某特定目標離開特定偵感器範圍，則中央電腦自動轉移另一偵感器繼續監控。當中央電腦確認偵感器與預存圖像匹配時，即發送訊息要求射擊。射擊要求批准後，目標位置資訊即傳送至射擊能力範圍內砲兵部隊的射擊指揮所。射擊指揮所下達射擊任務。發射後，偵感器觀測射彈與目標之誤差，並提供戰果評估（BDA）數據。運用同樣的人工智慧來識別目標，偵感器確定目標與彈著點之間的距離，然後將此資訊傳送給射擊指揮所。[18]射擊指揮所可以重新處理資訊並重行射擊，若已達預期效果，則僅記錄戰果評估。

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 commanders in this process, but crowded battlefields may overwhelm a commander’s ability to prioritize and engage targets in a timely manner.

改進效能

在現代戰場上，特別是綏靖與反恐作戰，瞬間目標居多。能攻擊的時間窗口有限。目標識別後，射擊平臺必須迅速發起射擊任務。這需要建立完善的偵感器到射手之間的數位鏈接，以及能迅速將目標數據傳送至射擊平臺的快速通信。識別眾多目標必須訂定優先順序；同時接戰多個目標，則需要將不同目標分配給不同射擊單位執行。這個過程中存在幫助指揮官做決策的輔助工具，但擁擠的戰場，短促的時間，極可能讓指揮官區分優先順序與攻擊目標的能力受到考驗。

During highly kinetic operations in which numerous sensors request fire missions, the fire direction officer （FDO） can struggle in choosing the most efficient method for employing the battalion’s firing platoons to execute fire missions. When a battalion FDC

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[18] Kevin Murray, Che Bolden, Scott Cuomo, and James Foley, “Manned/Unmanned Teaming to Transform the MAGTF,” Marine Corps Gazette100 (2016): 70-75. http://search.proquest.com.lomc.idm.oclc.org/docview/1793868254?accountid=14746

receives a fire mission request from any of the various sensors on its fire support communication net, the FDO must decide which of the firing assets is in the best position to execute the fire mission. Upon making a decision, the FDO directs the AFATDS operator to transmit the request to one of the 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 the ability to service all the fire mission requests with the number of firing platoons available. Big data technology would not replace the FDO, but empower them in their duties.19

在高強度的作戰中，許多偵感器要求射擊任務，營射擊組長（FDO）為如何最有效運用所轄戰砲排執行射擊任務，經常陷於困境。當營射擊指揮所從其火力支援通信網路上的任何一個偵感器接收到火力要求時，射擊組長必須決定哪個射擊單位陣地位置最洽當，然後射擊組長指示 AFATDS 將射擊要求通知某一個排射擊指揮所。排射擊指揮所則負責處理該射擊任務。整個過程仍稱冗長，限制了砲排發揚大規模火力。若運用大數據運算法，可以識出某一射擊平臺使用率不足。大數據可以確定某一戰砲排之射擊時間與該排的使用率之間的關聯性。確定這些關聯性後，AFATDS 就可以學習如何向射擊組長提出以現有可用戰砲排，最大限度發揚火力的建議。大數據科技不會取代射擊組長，而是讓其更有效履行其職責。[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

[19] Benjamin Jensen and Ryan Kendall, “Waze for War: How the Army can Integrate Artificial Intelligence.”

attack guidance for various targets on the battlefield. This change would save time, and ensure targets were attacked in the most effective manner.

此外，AFATDS 操作員在處理射擊任務時必須以人工將「攻擊方式」資訊輸入電腦。確定攻擊方法時，AFATDS 操作員考慮射擊火砲數、彈種、彈數，及其他達到射擊效果的資訊。這都是相當重要資訊，但是輸入並且依賴於不完美的人類判斷非常耗時。系統的改進，是運用大數據科技來找出最佳，最可行的攻擊方法。數據科學家必須研發運算法，將成功的戰果評估與特定的攻擊數據方法進行比較，以確定哪種攻擊方式對特定目標最有效。然後 AFATDS 程式員，設計自動針對不同類型目標提出攻擊方式建議的軟體。這種改進將節約時間，並確保以最有效的方式攻擊目標。

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 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.

砲兵部隊對移動目標射擊仍屬不易。當前 FDC 有對付移動目標的方法，但有賴於繁複的數學計算和一個合作的敵人，目標的速度穩定不變，方向也要不變（見圖五）。若不以單一目標視之，而是以包括車輛或人員縱隊，在某一時間佔領特定位置時，則以目標區視之較為合理。例如，AFATDS 將指定由六門火砲組成的戰砲連，結合三維地圖，加上敵加減速之可能，預判沿敵行軍路線上每門火砲的彈著點，以攻擊此一移動目標。AFATDS 操作員不必做任何計算，電腦自行計算敵車輛可能位置，分別將射擊諸元傳至各砲。或許這不一定是對付移動目標的完美解決方案，但肯定會改進目前的方法。

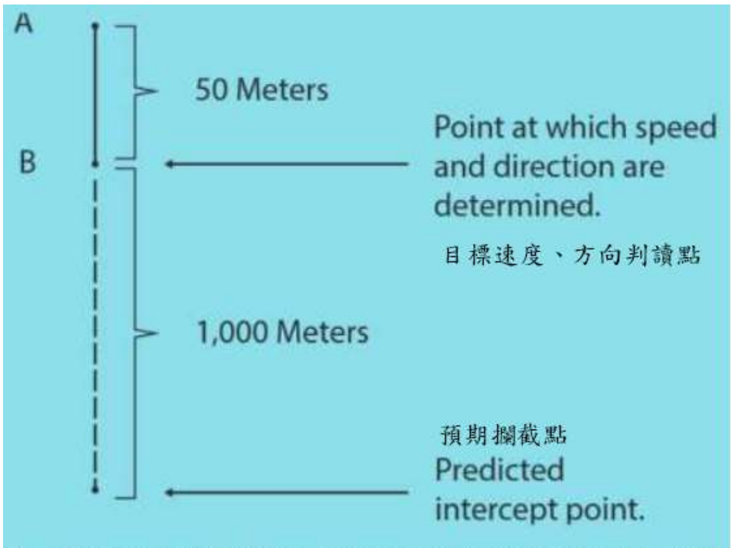

Figure 5. Traditional method of determining intercept point of moving target. (Army Techniques Publication 3-09.30)

圖五　決定運動目標射擊點之傳統方法

Implications for organization, 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.

對編制及裝備的影響

以大數據科技來提高火砲精度、反應度、效能，砲兵編裝上都需要新的裝備及基礎設施。伺服器用來存儲並維護大量數據，也是所有數據的中央存儲位置。該伺服器必須與陸軍所有砲兵部隊建立網路連接，以便全軍持續檢索各種偵感器及 FDC 產生的所有數據。

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 Single Channel Ground and Airborne Radio System 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 deconfliction 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

用於連接各砲兵單位和中央伺服器的數位網路，是另一關鍵基礎設施。目前數位通信網路的存在是為了將射擊平臺與其排 AFATDS 連接起來，同時戰砲排的 FDC 中的 AFATDS 可以與營的 FDC 及旅火力支援單位的 AFATDS 通聯。單波道地空無線電系統目前也可用於加強 AFATDS 數位網路。但是缺乏能全軍砲兵互聯的數位網路。除了將 AFATDS 電腦與中央伺服器連接之外，尚需與旅戰鬥隊所有偵感器相連接。中央伺服器必須能存取全旅所有偵感器偵得的數位錄影或圖像，以供處理或分析。前述排除空域衝突程序，AFATDS 須能進入航空單位監管其飛機位置的雷達網路。建立上述存儲功能的基礎，最新版本的 AFATDS 亦須考慮加入各種先進連結功能，如 Link 16 協定。[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

AFATDS 電腦本身需要重大更新，以滿足上述的各項需求。需要更強大的處理能力來分類，及分析經由網路傳來愈來愈多的數據，必須以新的硬體來強化與中央伺服器的數位連接。需要新的連接位置與旅戰鬥隊所有能產生目標數據

[20] Trevor Meier and Robert D. Wilson, “Advanced Field Artillery Tactical Data System Gets Dramatic Upgrade.”

的偵器相連接。AFATDS 軟體方面，必須能經由中央伺服器及時予以更新。例如，伺服器管理員應該能夠將新的火力處理運算法前推至射擊單位的射擊指揮所，以改善射擊諸元運算。無論何時從中央伺服器發出改進信息，軟體就應自動更新。此外，AFATDS 軟體應自動將其處理的射擊任務產生的數據上傳到中央伺服器。所有活動都應在沒有 FDC 人員積極參與的情況下進行。AFATDS 和中央伺服器之間的數據傳輸對操作員而言應該是透明的。[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.22Upon 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.

中央伺服器的管理需要雇用額外的人員。這些新進人員不僅必須管理伺服器和將伺服器連接到砲兵部隊網路，還需要分析伺服器上整合的數據。具體來說，陸軍必須聘請數據科學家，他們可以找到創造性的方法來挖掘數據的關聯性，這將有助於砲兵社群。[22]發現這些關聯性後，數據科學家必須與電腦軟、硬體工程師攜手合作，製作新版 AFATDS，其中包含從數據分析中學到的經驗教訓。數據科學家需要與操作人員經常聯繫，以便及時了解最緊迫的戰場挑戰。由於數據科學家的工作極其專業化和技術化，因此可能必須成為一個合約職位。

Challenges ahead

Two major challenges exist: 1. The reliance on a digital network during combat operations to apply big data solutions. 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

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.

austere environments may preclude access to electric energy. Moreover, enemy capabilities may prevent 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.

未來之挑戰

未來有兩項主要挑戰：1.戰鬥中需要依賴數位網路，方能運用大數據。2.網路一旦遭敵攻擊時的脆弱性。

在美國本土（CONUS）中建立一個能夠連接到世界各地作戰單位的中央伺服器，必須是一個始終正常運作的可靠網路。網路運作需要足夠電力，同時能透過某種類型的通信網收發信號。但是在嚴酷的作戰環境下，未必有充足電力供應。敵方更想方設法使我裝備無法正常運作。電磁（E-M）攻擊將迫使陸軍部隊完全依靠機械式作戰系統。任何數位作戰系統在電磁武器持續存在的環境下，都會立即無效。

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.

即使陸軍能夠建立和維護連接無數砲兵部隊、偵感器、雷達等的數位網路，這個網路就極可能成為敵人的高價值目標。網路的擴展意味著大量的作戰資訊，必須在網路上得到鞏固。如果敵方發展出穿透網路的能力，他們可以立即入侵射擊單位、飛機航路，以及其他無數的數據點，從而爭取到情報優勢，並可以咨意攻擊網路，對許多聯合作戰系統都影響深遠。

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, smartphones 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.

如同二大戰或韓戰期間所見，大規模的傳統衝突下，幾乎完全無視於對當地的破壞，而傾向於狂轟濫炸。在資訊時代，智慧型手機可以在戰事發生後立即拍照存證，圖像在數小時內煽動整個人群。而且現代戰場上的目標很少是靜止的。他們不斷移動，並盡力隱身當地人群或入侵城市基礎設施。若過去 15 年的趨勢繼續下去，大多數的人都不容易辨識。他們不會穿著可識別的制服或操作傳統的軍事平臺。接戰窗口很小，必須在第一次攻擊即達預期效果。重行攻擊的機會不大，或根本不存在。

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, the 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.

現代戰場將要求精確、反應迅速且有效的戰果，因而陸軍的砲兵部隊必須正視這些挑戰。雖然大數據未必是靈丹妙藥，但可能成為砲兵部隊重新得到定位，應對未來衝突的墊腳石。實踐上，本研究的若干建議需要有新的人員與裝備方能達成。與其他軍種及政府組織接觸與協調也屬必要。但這些改變尚不致於動到軍隊結構或組織，而僅需具有創新能力的士兵充分運用此一現存科技。此一構想恰與國防部「第三次抵銷戰略」（Third Offset Strategy）巧妙串接，該戰略側重於各軍種人員，應用其批判性和創造性思維，俾在戰場上保持優勢。

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.23

砲兵部隊庫房裡的精準彈藥是一項聖品，因其足可滿足當前在伊拉克與阿富汗地面部隊指揮官的需求。如果砲兵部隊能以傳統彈藥就達到類似的效果，在過程上推陳出新，為戰鬥部隊維持在 21 世紀戰場上的優勢，方不枉「戰場之王」的美譽。[23]

Bibliography

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/

Interview with CW4 Houston S. Burke, November 13, 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

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 Gazette100 （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.

---

[23] Sydney J. Freedman, Jr., "Centaur Army: Bob Work, Robotics, & the Third Offset Strategy," Breaking Defense, Nov. 9, 2015. http://breakingdefense.com/2015/11/centaur-army-bob-work-robotics-the-third-offset-strategy/

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.

參考文獻

Flores, Rufino B. Jr 及 Galinger, Barry D. II.合撰〈阿富汗之附帶損害評估〉，刊登於 Fires 雜誌。請瀏覽網址：http://search.proquest.com.lomc.idm.oclc.org/docview/1797896381?accountid=14746.
Freedberg, Sydney J.撰〈半人獸陸軍：包柏沃克、自動化機械、第三次抵銷戰略〉，Breaking Defense，瀏覽網址：http://breakingdefense.com/2015/11/centaur-army-bob-work-robotics-the-third-offset-strategy/
專訪四等准尉 CW4 Houston
Lind, William S.、 Keith Nightengale U.S.A.、 John F. Schmitt U.S.M.C.、 Joseph W. Sutton U.S.A.、 Gary I. Wilson U.S.M.C.合撰〈戰爭面貌第四代改變〉，刊登於陸戰隊 Gazette 雜誌 100（3）: 86-90.瀏覽網址：
http://search.proquest.com.lomc.idm.oclc.org/docview/1782793402?accountid=14746.
Lockie, Alex 撰〈數學運算可預測 ISIS 未來行動〉，2015.9.刊登於 Business Insider。瀏覽網址： http://www.businessinsider.com/machine-learning-used-to-predict-and-model-isis-2015-9
McBride, Courtney 撰〈陸軍應詳加評估因應未來衝突〉刊登於 Inside the Pentagon’s Inside the Army 28（38）.瀏覽網址： http://search.proquest.com.lomc.idm.oclc.org/docview/1822934823?accountid=14746.
Meier, Trevor 及 Robert D. Wilson 合撰〈先進野戰砲兵戰術數據系統性能大幅提升〉，刊登於 RedLeg Update, Sep-Oct 2016.瀏覽網址：

http://sill-www.army.mil/USAFAS/redleg/archive/2016/sep-oct-2016.pdf
Murray, Kevin、 Che Bolden、 Scott Cuomo、 James Foley 合撰〈有人/無人系統整合使 2016. MAGTF 轉型〉，刊登於
Marine Corps Gazette100 （6）: 70-75. 瀏覽網址：http://search.proquest.com.lomc.idm.oclc.org/docview/1793868254?accountid=14746.
Norwood, Paul R.、 Benjamin M. Jensen、 Justin Barnes 合撰〈掌握未來戰爭特質〉 2016 年刊登於 Parameters 46 （2）: 81-91.瀏覽網址： http://search.proquest.com.lomc.idm.oclc.org/docview/1816604416?accountid=14746.
O’Hanlon, Michael 及 David Petraeus 合撰，〈美國強大軍力與如何更加精進〉，2016 年刊登於 Foreign Affairs 95 （5）: 10-17.瀏覽網址： http://search.proquest.com.lomc.idm.oclc.org/docview/1815340967?accountid=14746.
Rossi, John 撰〈火力現況〉，2016 年刊登於 Fires: 1-4.瀏覽網址： http://search.proquest.com.lomc.idm.oclc.org/docview/1793935049?accountid=14746.
Rubal, Lawrence、Matthew Lilley、 Robert Walthall、 Shawn Ramirez、 Ian Roth 合撰〈重組 JAGIC:第四步兵師經驗教訓〉，刊登於 Fires 2016 年 7-8 月號，瀏覽網址：
http://sill-www.army.mil/firesbulletin/archives/2016/jul-aug/jul-aug.pdf
Sherman, Jason 撰〈陸軍未來科技展望〉，刊登於 Inside the Pentagon 32 （3），瀏覽網址：http://search.proquest.com.lomc.idm.oclc.org/docview/1758314104?accountid=14746

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