管式火砲仍是美軍未來戰場重要火力支援平臺？

Is Tube Artillery a Viable Fire Support Platform for the United States Military on the Battlefields of the Future?

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Abstract

Historically, tube artillery has been the primary fire support platform in the United States military due to its all-weather responsiveness, superior ability to mass fires and suppress targets, and the devastating effects it has on enemy forces making it the biggest killer on the battlefield. However, the evolution of weaponry technology and the advent of precision guided munitions （PGMs）, multiple launch rocket systems, and unmanned aerial vehicles has served to diminish and undervalue tube artillery in the United States military present day. This treatise will examine the use of PGMs, the evolution of howitzer employment, and the marginalization of the field artillery branch in recent conflicts relative to other fire support weapon systems and assess how in order to remain a vital, cost-effective, fire support platform, tube artillery must continue to improve its mobility, range, and accuracy, and ultimately earn the confidence of maneuver element commanders to employ it when troops are in contact and lives are on the line.

摘要

管式火砲向來是美軍的主要火力支援武器，係因其具有全天候反應能力、優越的大量密集火力與壓制目標的能力、摧毀敵軍的效果，使其成為戰場上的頭號殺手。然而，隨著武器技術的演進，以及精準導引砲彈（precision guided munition, PGM）、多管火箭系統（multiple launch rocket system, MLRS）、無人飛行載具（unmanned aerial vehicle, UAV）的問世，使得管式火砲在今日美軍式微且重要性被低估。因此，本研究將檢視精準導引砲彈的使用、火砲運用的演進，以及相較於其他火力支援武器系統，這支野戰砲兵部隊在近期衝突中被忽視的情形，並評估管式火砲如何才能繼

續成為重要且具成本效益的火力支援武器。管式火砲必須持續提升其機動力、射程、準確度，最終能讓戰鬥部隊指揮官有信心在部隊接戰及生死關頭適時運用管式砲兵火力。

Introduction

Throughout the history of modern warfare, tube artillery has been the combat arm that has consistently provided the most responsive fire support to maneuver elements with devastating effects making it the biggest killer on the battlefield. In the United States military, tube artillery has been used to great effect in a variety of conflicts since World War II including the Korean, Vietnam, and Persian Gulf Wars. However, as the nature of warfare and weaponry technology has transformed with the advent of precision guided munitions （PGMs）, multiple launch rocket systems, and unmanned aerial vehicles, tube artillery in the United States military has been undervalued. This treatise will examine the use of PGMs, the evolution of howitzer employment, and the marginalization of the field artillery branch in recent conflicts relative to other fire support weapon systems. In order to remain a vital, cost-effective, fire support platform for the United States Military, tube artillery must continue to improve its mobility, range, and accuracy, and ultimately earn the confidence of maneuver element commanders to employ it when troops are in contact and lives are on the line.

前言

縱觀現代戰爭史，管式火砲總是具備摧毀效果，能即時提供戰鬥部隊所需有效火力支援的戰鬥兵器，使其成為戰場上的頭號殺手。在美軍，管式火砲從第二次世界大戰、韓戰、越戰、波灣戰爭等各種衝突中，都發揮了極大的效用。然而，由於戰爭性質及隨著精準導引砲彈、多管火箭系統、無人飛行載具的問世等武器技術轉型，管式火砲在美軍的重要性被低估了。本研究將檢視精準導引砲彈的使用、火砲運用的演進、這支野戰砲兵部隊在近期衝突中相較於其他火力支援武器系統被忽視的情形。為了繼續成為美軍重要且具成本效益的火力支援武器，管式火砲必須不斷提升其機動力、射程、準確度，最終能讓戰鬥部隊指揮官有信心在部隊接戰及生死關頭適時運用。

Brief History of Artillery in the United States military from WWII to present

The United States has achieved advances in artillery technology dating back to World War II when, thanks to improved fire direction, spotting techniques and employment tactics, American artillery was particularly feared by the German Army.[1] Although the United States Armed Forces entered the Korean and Vietnam wars with essentially the same field pieces that were used in World War II, the U.S improved artillery mobility with the advent of transporting howitzers via fixed wing and rotary air assets.[2] The Vietnam War saw further developments in employment tactics, based upon the nature of the counterinsurgency fighting, as artillery batteries were frequently positioned at firebases and often fired missions in close support of friendly troops which demanded improved accuracy to reduce the chances of friendly casualties.[3]

從第二次世界大戰迄今的美軍砲兵簡史

美國的砲兵科技早在第二次世界大戰期間就已經很先進了，由於當時具有改良的射擊指揮、標定技術、運用戰術，所以德國陸軍特別畏懼美國火砲。[1] 雖然美軍在韓戰及越戰時部署的火砲，基本上與第二次世界大戰使用的相同，但隨著美國開始透過定翼及旋翼機運輸火砲，改良了火砲機動力。[2] 越戰期間在運用戰術上有了進一步發展，基於反叛亂作戰性質，砲兵連通常位於火力基地及執行近迫支援友軍的發射任務，且需要更佳準確度以降低友軍傷亡機會。[3]

By the advent of the Persian Gulf War in 1990, American artillery had significantly improved its ordnance and employment. Of particular note was the effectiveness of the dual-purpose, improved conventional munitions rounds （DPICM） which were detonated in an airburst at an optimum altitude to rain sub-munitions down on armored or personnel targets. These DPICM rounds were particularly effective against Iraqi mechanized infantry and armor and were referred to as “steel rain.” [4] In addition, in reminiscence of Napoleon’ s aggressive manner of employing his artillery during his campaigns in Europe, the Army and Marine Corps conducted combined arms raids along the Kuwait-Iraqi border using artillery batteries displaced to firing positions close to the border, light armored infantry vehicles, and air assets to locate, fix, and destroy Iraqi artillery and infantry in quick

night-time strikes.[5] The Persian Gulf War also saw a historic first war- time use of an artillery laid minefield when a Marine Corps Artillery Battalion laid a FASCAM （field artillery family of scatterable mines） minefield emplaced in combat during the Battle of Khafji.[6] Additionally, this conflict witnessed the introduction of Multiple Launch Rocket Systems （MLRS） and an early version of PGMs in the M712 Copperhead artillery round being used in combat for the first time.

到了 1990 年的波灣戰爭，美軍砲兵已大幅提升其彈藥與運用方式。殊值一提的是「雙效子母彈」（dual-purpose, improved conventional munition, DPICM）的效果，係在最佳高度引爆空炸散撒多枚子母彈攻擊裝甲或人員目標。雙效子母彈用於對付伊拉克機械化步兵或裝甲部隊特別有效，被稱為「鋼鐵雨」（steel rain）。[4] 此外，回想起拿破崙在歐洲戰役期間積極運用火砲進攻的態勢，美陸軍與陸戰隊沿著科威特與伊拉克邊界實施的聯兵襲擊，也是運用砲兵連在靠近邊界部署發射陣地，聯合輕型裝甲步兵車、空中裝備實施偵蒐、標定，在夜間發動快速攻擊摧毀伊拉克砲兵與步兵部隊。[5] 波灣戰爭出現了史上首次在戰時運用火砲布雷，當時美軍陸戰隊某砲兵營在「卡夫吉之戰」（Battle of Khafji）的戰鬥期間，運用佈雷彈（family of scatterable mines, FASCAM）設置地雷區。[6] 這場衝突還見證了多管火箭系統及早期型式精準導引砲彈 M712 銅斑蛇（Copperhead）砲彈首次用於戰鬥。

Improved Artillery Technology since the Persian Gulf War

The time period since the Persian Gulf War has seen significant technological advances in both land and air based weapon systems and munitions with many of these developments positively impacting the requirements for accurate artillery fire. Dating back to the time of World War I and as taught at the United States Army Fires Center of Excellence and Field Artillery School, the five requirements for accurate （artillery） fire are: accurate target location and size, accurate firing unit location, accurate weapon and ammunition information, accurate meteorological information, and accurate computational procedures. [7] Of particular note is the deployment of GPS technology which, coupled with PGMs, has substantially reduced the margin for error of target and firing unit location which, in turn, has reduced the number of adjusting rounds needed to walk effects onto target. This advancement is significant

for tube artillery as the greatest casualties come from first round effects on target when enemy forces are caught unaware and have not had time to disperse or take shelter.[8] While GPS and PGM technology were utilized to great effect during Operations Iraqi Freedom （OIF） and Enduring Freedom （OEF）, the nature of these conflicts and the manner that the U.S. Military used tube artillery has caused some to question its viability as a primary fire support platform for ground combat forces in the future.

波灣戰爭以來提升的砲兵科技

自波灣戰爭以來的這段時期，陸基及空中武器系統與彈藥的科技已有長足進步，其中的許多發展正實際影響砲兵精準射擊需求。回顧第一次世界大戰期間及美陸軍「火力卓越中心暨野戰砲兵學校」（Fires Center of Excellence and Field Artillery School）教導的砲兵準確射擊五項要求：準確的目標位置與大小範圍、準確的射擊單位座標、準確的武器與彈藥資訊、準確的氣象資訊、準確的計算程序。[7] 值得注意的是展開與精準導引砲彈搭配的全球定位系統（GPS）科技，已大幅減少目標與射擊部隊位置的誤差，亦即減少了調整砲彈有效攻擊目標所需數量。這項進步對管式火砲影響重大，因為最大傷亡是來自對目標的第一發砲彈成效，讓敵軍在措手不及之下遭到攻擊，無暇分散或掩蔽防護。[8] 儘管全球定位系統與精準導引砲彈科技在伊拉克自由作戰（Operations Iraqi Freedom, OIF）及持久自由作戰（Operations Enduring Freedom, OEF）期間，發揮了極大效用時，但由於這些衝突的本質及美軍使用管式火砲的方式，已引起某些人質疑管式火砲未來能否成為地面戰鬥部隊的主要火力支援武器。

Artillery in Operation Iraqi Freedom

Operation Iraqi Freedom saw a major change in the use of tube artillery. The invasion of Iraq, in March 2003, witnessed the amassing and employment of a large, conventional American land force composed of armor, mechanized infantry, artillery and necessary logistics support, though this composition was distinguished by the lowest ratio of artillery to maneuver units since the Spanish-American War.[9] During the initial advance to Baghdad, artillery was used in its traditional missions of direct support, reinforcing, general support, and general support reinforcing to maneuver units. However, as the war transitioned from a large-scale mechanized land battle to a

counter-insurgency fight, the role of artillery changed as well. The relatively expeditious defeat of the Iraqi military negated the need for mass artillery fires as the fire support requirements changed to missions such as Harassing and Interdiction （H&I） fires as used by the U.S. Army 4th Infantry Division at Tikrit in “proactive counterfire” missions to suppress enemy mortar and rocket locations.[10] However, improved developments in artillery range and accuracy, significantly influenced by the introduction of PGMs and Multiple Launch Rocket Systems （MLRS） in theatre, contributed to the ability to effectively employ fires in counterinsurgent engagements while minimizing collateral damage. As the fighting in Iraq progressed, artillery was used selectively with differing degrees of effectiveness in missions such as terrain denial-counter-fire though in some instances it was brought to bear in a more traditional role. An example of this being during the second battle for Fallujah in 2004, when Marine Artillery fired more than 4000 shells in support of operations to retake the city.[11] Other instances involving the effective use of PGMs by tube artillery include missions shot by the Colorado National Guard, 169th Fires Brigade, whose commanding officer Kenneth Lull reported firing “17 Excalibur rounds for the 3-2 SBCT when it cleared Baqubah of insurgents in intense combat during Operation Arrowhead Ripper. In one mission, we fired Excalibur on a known enemy safe house. Although it did not level the building, it killed everyone in the building without harming children who were playing outside in front of the house next door about 30 yards away.” [12] The potency of artillery PGM in OIF was noted by then LTG Raymond T. Odierno, commander, Multinational Corps-Iraq （MNC-I）, who stated that 155mm Excalibur and guided multiple-launch rocket system （GMLRS） unitary PGMs, “...were extremely effective. In fact, GMLRS and Excalibur were my brigade commanders’ weapons of choice.” [13]

伊拉克自由作戰中的砲兵

從伊拉克自由作戰看到管式火砲運用之重大改變。2003 年 3 月美軍進攻伊拉克，見證了美國集結與運用由裝甲兵、機械化步兵、砲兵及所需後勤支援組成的大規模傳統地面部隊，而砲兵卻在這次的戰鬥部隊組合所佔比率，創下美西戰爭（Spanish-American War）以來的最低紀錄。[9] 在起初推進到巴格達（Baghdad）期間，砲兵被用於執行其傳統任務：直接支援、增

援、一般支援、一般增援戰鬥部隊。然而，隨著這場戰爭從大規模機械化地面戰轉變為反叛亂戰，砲兵的角色也隨之改變。相當快速擊潰伊拉克軍隊，否決了運用大量密集砲兵火力之需，因為火力支援需求已改變為實施諸如美陸軍第 4 步兵師在提克里特（Tikrit）執行「先制反火力」（proactive counterfire）任務中的「襲擾與阻絕」（Harassing and Interdiction, H&I）射擊，以壓制敵迫砲及火箭陣地。[10] 精準導引砲彈及多管火箭系統出現在戰場，大幅影響了砲兵在射程與準確度的精進發展，有助於砲兵能夠在反叛亂接戰中有效運用火力以降低附帶損害。隨著在伊拉克的戰事進展，砲兵在某些情況中，仍擔負更傳統的角色，例如在執行地形「阻絕式反火力」（denial-counter-fire）任務中，砲兵被選擇用於發揮不同程度的威力。其中一項案例是 2004 年進行的第二次法魯加（Fallujah）之戰，當時美軍陸戰隊砲兵發射 4,000 多枚砲彈以支援奪回法魯加作戰。[11] 其他案例則是有效運用管式火砲發射精準導引砲彈，這其中包含科羅拉多州國民兵第 169 火力旅（Fires Brigade）執行的射擊任務；該旅旅長勒爾（Kenneth Lull）報告指出:「在 3-2 史崔克旅級戰鬥部隊（SBCT）於『箭頭開膛手作戰』（Operation Arrowhead Ripper）激烈清剿巴古拜（Baqubah）叛亂分子的戰鬥期間，為該旅發射了 17 枚神劍（Excalibur）精準導引砲彈。在某次任務中，我們對一個已知的敵避難所發射了神劍砲彈，儘管未炸平該建物，但擊斃了建物內所有人，且未傷及在距離 30 碼外隔壁屋外玩耍的孩童。」[12] 時任「多國駐伊拉克部隊」（Multinational Corps-Iraq, MNC-I）指揮官奧迪爾諾（Raymond T. Odierno）中將，對於火砲發射精準導引砲彈在伊拉克自由作戰期間的效能表示，155 公厘神劍砲彈及導引式多管火箭系統（GMLRS）之整體精準導引砲彈「……非常有效。事實上，導引式多管火箭系統及神劍砲彈是我方旅長們的精選武器」。[13]

Marginalization of Artillery

As the war in Iraq transformed from a high intensity conflict to a counterinsurgency, concerns about collateral damage led the U.S. military to employ tube artillery less. Subsequently, artillery units were being utilized in other mission essential roles such as provisional infantry, civil affairs, and security missions.[14] Artillery units were seen as an appealing option for these missions since they had the basic combat skills and weapons proficiency as well as an ample organic inventory of

vehicles and communications equipment.[15] Artillery units were further tasked with providing training to Iraqi Security Force （ISF） units and advising on combat operations.[16] While there are valid concerns about collateral damage, antiquated notions of the gross inaccuracy of artillery fire seemed to contribute to the restrictions and relative limited of use of artillery throughout OIF. However, while close air support （CAS） continued to be an important fire support asset for maneuver units, the dependability and responsiveness of artillery ensured that it was not ever completely transitioned into non-traditional security roles though its role as the primary fire support element for maneuver units began to noticeably diminish. The introduction of the Excalibur PGM in 2008 served, to some degree, to mitigate concerns about collateral damage from artillery fire. After overcoming some initial coordination issues regarding authorization to fire it, the Excalibur PGM was used with great effect to support troops in contact during various engagements.[18]

被邊緣化的砲兵

由於伊拉克戰爭從高強度衝突轉變為反叛亂作戰，對於附帶損害的關切，導致美軍較少運用管式火砲。後來，砲兵部隊被用在其他任務中擔任基本角色，執行諸如臨時性的步兵、民事、安全等任務。[14] 砲兵部隊似乎成為執行這些任務的好選擇，因為他們具有基本的戰鬥技能與武器熟練度，而且編配足夠的車輛與通信裝備。[15] 砲兵部隊進而派遣到伊拉克安全部隊（Iraqi Security Force, ISF），提供訓練及作戰行動建議。[16] 儘管當時合理的關切附帶損害，而且舊有主張認為砲兵射擊都不準確，這些似乎導致在整個伊拉克自由作戰期間，制約及相對限縮了運用砲兵，空中密接支援（close air support, CAS）則是持續成為戰鬥部隊重要的火力支援武器，而砲兵具有的可恃性與反應性，確保其無法完全轉變為從事非傳統安全角色，但已開始明顯減少砲兵擔任戰鬥部隊的主要火力支援單位。[17] 2008 年，神劍精準導引砲彈開始進入服役，某種程度上已減輕對於砲兵射擊造成附帶損害的顧慮。克服授權發射等起初的一些協調問題之後，神劍精準導引砲彈在支援部隊進行各類接戰期間，發揮了極大成效。[18]

While the wars in Iraq and Afghanistan progressed, the continued deployment and utilization of artillery soldiers and Marines outside of their traditional cannoneer and fire support duties slowly began to erode the core competency of artillery units to

effectively perform their mission. In 2010, The U.S. Army National Training Center & Joint Readiness Training Center reported that over 90% of Field Artillery military occupational specialty （MOS） soldiers were deploying outside of their traditional skill set. This atrophy in artillery related skills eventually translated into maneuver commanders losing confidence in artillery support.[19] This high degree of concern led three former U.S. Army Brigade commanders to draft a white paper in 2010 titled *The King and I: The Impending Crisis in the Field Artillery's Ability to Provide Fire Support to Maneuver Commanders.* They cited the "lack of modularity…lack of training," and how maneuver commanders were now responsible for training fire support personnel.[20] Furthermore, the loss of core competency by field artillerymen became such a concern that General McCrystal, Commander of the International Security Assistance Force in Afghanistan, issued a memorandum outlining the need for increased fire support training, among his other directives.[21]

在進行伊拉克及阿富汗戰爭期間，不斷將砲兵及陸戰隊部署與運用於執行傳統砲兵及火力支援職掌以外的任務，已開始逐漸弱化砲兵單位有效遂行其任務的核心技能。2010 年，「美陸軍國家訓練中心暨聯合整備訓練中心」（U.S. Army National Training Center & Joint Readiness Training Center）的報告指出，有超過 90%具有野戰砲兵「軍職專長」（military occupational specialty, MOS）的官兵，被部署從事其傳統技能以外的任務。這種砲兵相關技能萎縮情況，最終導致戰鬥部隊指揮官對砲兵支援失去信心。[19] 基於對此點的高度關切，促使 3 位前美國陸軍旅長在 2010 年撰寫了一份報告，名稱為《國王與我：野戰砲兵提供戰鬥部隊指揮官火力支援能力的迫切危機》（The King and I: The Impending Crisis in the Field Artillery's Ability to Provide Fire Support to Maneuver Commanders.）。他們指出「缺乏模組化……缺乏訓練」及戰鬥部隊指揮官現在還要負責訓練火力支援人員。[20] 此外，野戰砲兵人員流失核心能力的問題，已引起駐阿富汗的國際安援部隊（International Security Assistance Force）指揮官麥克里斯特爾（McCrystal）上將關切，他曾發出一份備忘錄，其中包含了必須增加火力支援訓練等指令。[21]

Other Fire Support Assets in U.S. inventory: Multiple Launch Rocket Systems

The lessening role of tube artillery can be attributed, to some degree, to the advent and evolution of alternative fire support platforms, as well as improved technology for existing platforms. A comparative review of these platforms starts with the Multiple Launch Rocket System （MLRS） which, in some variation, have been used by the United States military dating back to World War II. The current M270 version and its variants, adopted by the U.S. Army in 1983, saw their first combat action in the Persian Gulf War in 1991.[22] The premise of this weapon system is a rocket launching system mounted on a track or vehicle chassis, capable of shooting multiple rockets simultaneously with precision accuracy in a fire support role. Unlike the accuracy of the traditional free-flight MLRS rocket that degrades as the range to the target increased, guided rockets, which are the primary munitions currently employed, use a GPS aided navigation system which provides consistent, improved accuracy from a minimum range of 15 kilometers to a maximum of 60 to 70 kilometers to attack area and point targets.[23] Designed for and proven to be very effective in high intensity conflicts, the M270A1 launcher has not been able to support light infantry and air assault missions nor had the ability to deploy in forced entry environments.[24] Accordingly, a variant identified as the M142 High Mobility Artillery Rocket System （HIMARS） launcher on a wheeled platform was developed and fielded providing the Army and Marine Corps with a critical precision deep fires capability better suited for light and early entry forces.

美軍其他火力支援裝備：多管火箭系統

管式火砲的角色日漸式微，在某種程度上可歸咎於其他火力支援載具的問世與演進，以及對既有載具的技術提升。本研究先從多管火箭系統開始，對這些載具進行比較檢視。美軍自第二次世界大戰就已經使用多管火箭系統，歷經多年變化，美陸軍目前使用的是 M270 及其衍生型，1983 年開始服役，1991 年波灣戰爭首次出現執行戰鬥行動。[22] 此武器系統基本上是一個安裝在履帶車或一般車輛底盤上的火箭發射系統，能同時發射多枚火箭執行精準火力支援任務。不像是傳統式自由飛行的多管火箭系統火箭，準確度會隨著目標距離增加而降低，導引式火箭則是美軍目前使用的主要彈藥，以全球定位輔助導航系統提供穩定且更佳的準確度，攻擊區域

及單點目標的射程從最少 15 公里到最大 60－70 公里。[23] 雖然旨在用於高強度衝突的 M270A1 履帶式發射車，業經驗證非常有效，但不能支援輕裝步兵及空襲任務，也無法部署於強勢進入環境。[24] 因此，衍生發展及部署的 M142「高機動砲兵火箭系統」（High Mobility Artillery Rocket System, HIMARS）輪型發射車，正提供美陸軍及陸戰隊具備重要的精準縱深火力，更適合用於支援輕裝及早期進入部隊。

In a comparison of capabilities, there are some significant advantages that MLRS and HIMARS possess over tube artillery and other fire support platforms. For example, the ability to mass fires for first round effects is easily accomplished with several launchers which each can fire six precision guided rockets simultaneously allowing for a higher concentration of fire from fewer weapons platforms than is possible with tube artillery. Additionally, MLRS launchers have the capability to rapidly displace after conducting fire missions thereby minimizing the risks posed by counter-battery fire or enemy air attacks. A critical advantage that MLRS has over tube artillery is the range of its target fan; depending on the type of munitions, MLRS rockets can range out to 82 kilometers while it can also shoot tactical missiles out to 150 km; substantially more target range than tube artillery which currently maxes out at 30 kilometers with rocket assisted projectiles （RAP） and 40 km with PGMs.[25] While MLRS brings with it the significant capabilities to provide precision mass fires as well as substantially outrange foreign and friendly tube artillery, this weapons platform does have some inherent shortcomings relative to other ground based fire support weapons platforms. With MLRS designed as either a tracked or wheeled （HIMARS） weapons platform, certain types of terrain limits the ability of the MLRS or HIMARS systems to traverse or deploy. Additionally, the weight of MLRS rockets limits the transport quantity of its mobile combat load as well as its ammunition re-supply. For example, MLRS rocket munitions M26 227 mm high explosive fragmentary （HE FRAG） rounds weigh 675 pounds and are transported in Heavy Expanded Mobility Truck M985 （HEMT） and a Heavy Expanded Mobility Trailer （HEMAT） M989.[26] Each can carry four launch pod containers for a total of 48 rockets in a HEMT/HEMAT load.[27] Each launch pod container weighs 5200 pounds.[28] If an aerial resupply is sought and is tactically possible, a

CH-47 helicopter can carry 24,000 pounds internally which amounts to only four launch pods.[29] When compared to the 98 pound weight for a 155 mm tube artillery shell, this weight differential significantly limits the mobile combat load and the ability of MLRS to carry on sustained firing operations when removed from resupply hubs. In addition to the weight of the ammunition, the size and weight of the weapons platforms themselves causes deployment limitations. The HIMARS system weighs 24,000 pounds while the MLRS weighs approximately 52,990 pounds.[30] Because of its size, the MLRS can only be transported by heavy transport aircraft such as C-141, C-5, and C-17 while the HIMARs is transportable via C-130 aircraft.

多管火箭系統及高機動砲兵火箭系統的能力，與管式火砲及其他火力支援載具相比較，具備某些明顯優點。例如，能夠以數輛發射車，每輛可同時發射 6 枚精準導引火箭，形成大量火力輕易發揮首發成效，比起從管式火砲更少的武器載具遂行更高度集火射擊。此外，多管火箭發射車能在執行發射任務後快速轉換陣地，進而降低遭到反砲兵火力或敵空中攻擊的風險。多管火箭系統相較於管式火砲的一項重要優點是其目標涵蓋範圍，視彈種，多管火箭系統的火箭射程可達 82 公里，也可發射射程達 150 公里的戰術飛彈；目標距離比起管式火砲目前發射最大射程 30 公里的火箭增程彈（rocket assisted projectile, RAP）、射程 40 公里的精準導引砲彈大很多。雖然多管火箭系統具有能夠提供大量精準火力之重要能力，且射程大幅超過外國及友軍的管式火砲，但這項武器載具與其他陸基火力支援武器載具相比，本身確實存在一些缺點。無論多管火箭系統的載具是設計為履帶式或輪型（高機動砲兵火箭系統），某些地形會限制多管火箭系統或高機動砲兵火箭系統的行駛或部署能力。此外，多管火箭系統的火箭重量，限制其機動戰鬥負載及彈藥補充的攜行量。例如，多管火箭系統的火箭 M26 227 公厘高爆破片彈（HE FRAG）重 675 磅，由 M985「重型增程機動戰術卡車」（Heavy Expanded Mobility Tactical Truck, HEMTT）及 M989「重型增程機動彈藥拖車」（Heavy Expanded Mobility Ammunition Trailer, HEMAT）載運。[26] 每輛可載運 4 具發射艙共 48 枚火箭。[27] 每具發射艙重 5,200 磅。[28] 如果空中運補在戰術上可行，一架 CH-47 直升機可裝運 24,000 磅，僅能載 4 具發射艙。[29] 與 155 公厘管式火砲的 98 磅砲彈相比，此重量差距，大幅限制多管火箭系統的機動戰鬥負載及從彈藥補給中心運補執行持續發射作

戰的能力。除了彈藥的重量問題之外，武器載具本身的體積與重量也導致部署受限。高機動砲兵火箭系統重 24,000 磅，而多管火箭系統重約 52,990 磅。[30] 由於多管火箭系統的體積，所以只能以 C-141、C-5、C-17 等重型運輸機載運，而高機動砲兵火箭系統則是要由 C-130 飛機運輸。

Unmanned Aerial Vehicles （UAVs）

A fire support platform that has brought deep strike capability above and beyond any ground based weapon system is the Unmanned Aerial Vehicle （UAV）. Though UAVs have been used by the United States military since the Vietnam War, their use as an offensive weapons platforms came to prominence in the war against terrorism starting in 2002. [31] While the first UAV to be utilized in an offensive strike capacity was the MQ-1 Predator, the first UAV to be used in a true "hunter-killer" role in Iraq and Afghanistan is the MQ-9 Reaper.[32] The Reaper is capable of carrying AGM-114 Hellfire missiles, GBU-12 Paveway Laser Guided Bombs, and GBU-38 JDAM bombs.[33] With a fully armed Reaper loaded with 1000 pounds of ordnance having an endurance time of 14 hours, and up to 42 hours with external fuel tanks, UAVs provide the United States military with a weapons platform that can surgically strike both high value and conventional targets no matter where they are located.[34] The advantages of utilizing UAVs as a fire support platform are numerous; perhaps none being bigger than the benefit of carrying out offensive strike capabilities without posing any direct risks to U.S. personnel operating the equipment. Additionally, the ability to carry a heavy payload of PGMs allowing UAVs to surgically strike designated objectives while minimizing collateral damage makes it the preferred weapons platform for high-value target missions. Furthermore, the surveillance capabilities of UAVs allow for real-time battle damage assessment, intelligence collection, and identification of potential follow-on targets. Additionally, the enhanced loiter time of UAVs increases the targeting window and allows for both rapid response target engagement or sufficient time for target development or analysis. Lastly, the relatively small profile of UAVs makes them less likely than manned fixed wing or rotary aircraft to be detected and face ground fire or counter measures.

無人飛行載具

無人飛行載具（UAV）是擁有超過任何陸基武器系統縱深打擊能力的火力支援載具。儘管美軍自從越戰以來就已經使用無人飛行載具，但在 2002 年開始的反恐戰爭才明顯成為攻勢武器的載具。[31] 無人飛行載具首次被運用於發揮攻勢打擊能力的機型是 MQ-1 掠奪者（Predator），而真正開始擔任「獵殺」角色在伊拉克及阿富汗執行任務的機型是 MQ-9 死神（Reaper）。[32] MQ-9 能攜掛 AGM-114 地獄火（Hellfire）飛彈、GBU-12 鋪路（Paveway）雷射導引炸彈、GBU-38 聯合直攻彈藥（JDAM）。[33] MQ-9 在全負載 1,000 磅彈藥時，可滯空 14 小時，外掛油箱可航行達 42 小時，這些無人飛行載具成為美軍能夠精準打擊各地高價值及傳統目標的武器載具。[34] 運用無人飛行載具擔任火力支援載具的優點有很多，或許其最大的優點莫過於美軍操作裝備人員遂行攻擊時，免於暴露在任何直接風險下。此外，無人飛行載具能夠酬載大量精準導引砲彈，使其能精準打擊指定目標，且將附帶損害降至最低，使其成為攻擊高價值目標任務的理想武器載具。再來就是無人飛行載具的監視能力，可執行即時戰損評估、情蒐、辨識後續可能目標。再加上無人飛行載具更長的滯空時間，增加了標定目標的機會，以及能快速因應目標接戰或有充分時間開發或分析目標。最後則是無人飛行載具的外型相對小，使其比有人駕駛的定翼機或旋翼機更不容易被偵測及遭遇地面火力或反制措施。

For all of the notable advantages that UAVs offer as a fire support platform relative to other weapons systems, there are also some vulnerabilities that must be taken into consideration. As demonstrated by platform losses in Libya and Iran, UAVs are vulnerable to sophisticated air defense systems. [35] Specifically, UAVs are vulnerable to radars, manned aircraft, anti-air missiles and anti-aircraft artillery, electronic jamming, hacking, and spoofing. [36] As the UAV platforms stand currently, survivability in high threat environments will require modifications in techniques, tactics and procedures, as well as system upgrades and improvements such as stealth capabilities to avoid radar detection, greater speed, and jammers. [37]

相較於其他武器系統而言，無人飛行載具擁有擔任火力支援載具的多項重要優點，但還是存在一些弱點必須納入考量。毀損在利比亞及伊朗的無人飛行載具，證實易於遭受精密的防空系統攻擊。[35] 尤其是在面臨雷

達、有人駕駛飛機、防空飛彈與防空火砲、電子干擾、電子駭客、電子愚弄式欺騙時。[36] 就目前的無人飛行載具而言，要能在高威脅環境中存活，勢須精進其戰術、戰技及程序，並在諸如匿蹤躲避雷達偵測的能力、更大速度、干擾器等方面進行系統提升與改良。

Manned Aircraft

While artillery has served as the primary fire support platform for U.S. ground forces and maneuver elements since the days of the Continental Army, the employment of fixed and rotary wing aircraft in a close air support （CAS） role has served as a vital and complementary fire support element from World War II through the present date. The capabilities that air assets bring to the fight are lethal and varied with guns, bombs, rockets and missiles being among the ordnance that can be brought to bear. Effective utilization of CAS requires detailed integration and coordination by ground forces so as to ensure the safety of friendly troops as well as proper target identification and engagement. This coordination for the U.S. military is conducted by Joint Terminal Attack Controllers （JTAC） and Forward Air Controllers （FAC） attached to ground troops and maneuver elements.[38] There are a number of distinct advantages that CAS platforms have over ground based fire support assets; notably the ability to strike targets at ranges far greater than can be engaged with ground fire support. Additionally, CAS has the ability to identify and strike targets that may be concealed or in defilade and not identified by ground forces. Furthermore, air platforms, such as the A-10 Thunderbolt, are traditionally more effective against certain types of targets such as enemy armor and mechanized infantry. The variety of air platforms offers a multitude of weaponry and ordnance that can be selectively utilized depending on the type of engagement. For example, if a friendly position is in danger of being overrun, an AC-130 gunship, with its arsenal of weaponry, can circle the area engaging enemy targets until the momentum of the attack is broken.

有人駕駛飛機

雖然火砲是美國地面兵及戰鬥部隊自大陸軍（Continental Army）時期以來的主要火力支援載具，而運用定翼及旋翼機擔負空中密支角色，則是從第二次世界大戰迄今，重要且相輔相成的火力支援武器。將空中裝備的

能力用於戰鬥具有致命性，且作用隨著攜帶的槍砲、炸彈、火箭、飛彈等武器而有所不同。有效發揮空中密支，需要由地面部隊詳盡整合與協調，俾能確保友軍安全及適當的目標識別與接戰。美軍負責此項協調作業的是配屬於地面部隊及戰鬥部隊的聯合終端攻擊管制員（Joint Terminal Attack Controller, JTAC）與前進空中管制員（Forward Air Controller, FAC）。[38] 空中密支載具有數項明顯優於陸基火力支援裝備的能力，最明顯是打擊目標的距離遠大於地面火力支援可及範圍。其次，空中密支能夠辨識與打擊掩蔽或未被地面部隊發現的隱匿目標。此外，諸如 A-10 雷霆（Thunderbolt）攻擊機，係傳統上更能有效對付敵裝甲與機械化步兵等特定類型目標的空中載具。各種不同的空中載具可視接戰類型選用攜掛眾多武器與彈藥。例如，若是友軍陣地處於遭侵襲的危險中，一架攜掛武器彈藥的 AC-130 砲艇機，可盤旋該空域接戰敵目標，直到瓦解敵攻勢。

For all of the devastating effects that CAS brings to the fight, air assets have a number of vulnerabilities that limit its ability to be an all-encompassing fire support platform. The great equalizer that will always limit CAS’ s ability to be brought to bear is weather; poor meteorological conditions can delay or eliminate altogether the ability of air assets to participate in combat operations. This limiting factor is obviously a critical shortcoming should fire support be needed when the weather is bad. Another potentially significant vulnerability of air power is the threat posed to it by integrated air defenses （IAD）. In low intensity conflicts such as the wars in Iraq and Afghanistan, this threat varies and is not always a limiting factor. However, when facing a foe such as Russia, China or Iran with technologically advanced air defenses, IAD becomes a real problem. Surface-to-air missiles （SAMs）, anti-aircraft artillery, and heavy machine gun fire all pose very serious threats to CAS assets. Additionally, opposing forces that have sophisticated air defenses will often have their own air interdiction aircraft that can pose a threat to air assets. Another challenge involved when using CAS is the potential difficulties that air assets can have with distinguishing between friendly and enemy forces. Though doctrine dictates that terminal control of CAS be directed by a JTAC or FAC, the confusing and fluid nature of ground combat actions can make accurate targeting of ordnance challenging.

雖然空中密支對戰鬥具有各種摧毀效應，但空中裝備有一些弱點會限制其成為全能的火力支援載具，而限制空中密支能力發揮的最大因素是天候；惡劣的氣象狀況會遲滯或排除空中裝備一齊加入戰鬥行動的能力。當需要火力支援卻天氣惡劣時，這項限制因素顯然是一項關鍵弱點。空中武力的另一項重大弱點是「整體防空」（integrated air defense, IAD）對其的威脅。在諸如伊拉克及阿富汗戰爭等低強度衝突中，這項威脅的程度不一且不是必然限制因素。然而，在面對俄羅斯、中共或伊朗等擁有先進防空科技的敵人時，整體防空就成為一項真正的麻煩問題。地對空飛彈（surface-to-air missile, SAM）、防空火砲、重機槍火力都會嚴重威脅空中密支裝備。此外，擁有精密防空系統的敵軍，通常會有攔截機，可對空中裝備形成威脅。運用空中密支涉及的另一項挑戰，則是空中裝備可能難以分辨敵軍與友軍。雖然準則律定由聯合終端攻擊管制員或前進空中管制員引導進行空中密支的終端管制，但地面戰鬥行動狀況混亂且瞬息萬變，都會影響彈藥武器準確標定。

Current Capabilities of U.S. Tube Artillery

Tube artillery’s devastating effects on enemy troops and it’s ability to shape the battlefield has provided for the artillery branch’s traditional role as a sizeable component of the United States military’s ground combat forces in the both the Army and Marine Corps. However, restructuring of the U.S Armed Forces has resulted in a downsizing of artillery assets. Currently the Army has 100 battalions of tube artillery in the active duty, reserve and national guard components, while the Marine Corps has 21 artillery batteries organized into seven battalions; this staffing represents a 50% reduction of the artillery assets the U.S. military had in 1985.[39]

美國管式火砲的能力現況

管式火砲摧毀敵軍的效力及其形塑影響戰場的能力，已使砲兵成為美陸軍及陸戰隊地面戰鬥部隊的傳統大型兵科。然而，美軍部隊編裝改組，導致砲兵裝備縮編。目前美陸軍現役、後備、國民兵部隊共有 100 個管式火砲營，陸戰隊則有 21 個砲兵連編成 7 個營；此砲兵編裝縮減為美軍在 1985 年的一半。[39]

The reduction in artillery battalions has been a reflection of the decreasing size of the Army and has also been in accordance with the Army and Marine Corps’

transformation to a lighter, leaner force; moving away from being oriented for fighting large scale air- land battles to being postured towards more effective engagement in low intensity conflicts. Currently the U.S. military has three howitzers in the inventory that are actively being employed: M119A3 105 mm towed howitzer （includes M119A2 variant）, M777 155 mm towed howitzer, and the M109A6 Paladin self-propelled 155 mm howitzer. The Army fields all of these howitzers plus the latest self-propelled variant, the M109A7 which is scheduled to go into full production in 2017, while the Marine Corps only employs the M777.[40] The M119A2/A3 as a lighter, more mobile field piece is deployed with airborne and light infantry units and can be transported via sling load under a UH-60 or CH-47 or air dropped in airborne operations.[41] The primary howitzers of the U.S. military presently, however, are the M109A6 and M777. The ammunition and powder utilized by these two weapons platforms is standardized and features a variety of shell/fuze combinations including: high explosive （point detonation/air burst）, smoke, white phosphorous, illumination, area denial munitions, rocket assisted projectiles, and improved conventional munitions. All of the aforementioned munitions are not precision guided and are fired using conventional fire direction control methods. Both weapon systems have a .39 caliber gun tube which provides for a range of 24 km for HE and other conventional rounds and 30 km for rocket assisted projectiles, while precision guided munitions can range out to 40 km. [42] The towed and self-propelled platforms each afford certain advantages and disadvantages. The M109A6’ s armored cab affords crew protection from shrapnel and small arms fire while also providing for internal ammunition storage of thirty-nine 155 mm shells. [43] Additionally, an internal navigation system and sensors to detect where the howitzer is laid allows the M109A6 to stop, load, and fire within 30 seconds with the same accuracy as howitzers that require being emplaced and laid on a target azimuth.[44] The Paladin has the further advantage of quick displacement to avoid counterbattery fire or air strikes and tactical maneuverability to being able to keep up with armored and mechanized infantry formations. The primary advantage afforded by the M777 towed howitzer, relative to the Paladin, is its lighter weight which enhances its air mobility via rotary or fixed wing aircraft for employment in firing

positions that could not be accessed by a self-propelled howitzer. Additionally, maintenance upkeep on towed howitzers is typically much more manageable relative to the work required to keep the tracks and engines running on self-propelled howitzers.

砲兵營數量減少反映了美陸軍的縮編，同時這也是配合美陸軍與陸戰隊轉型成為更輕裝、精實部隊的要求；從遂行大型空地作戰轉變為能在低強度衝突中更有效接戰。美軍目前有三種現役火砲：M119A3 105 公厘牽引砲（包括 M119 A2 衍生型）、M777 155 公厘牽引砲、M109A6 帕拉丁（Paladin）155 公厘自走砲。美陸軍部署這三種火砲，以及預計於 2017 年進入量產的自走砲最新衍生型 M109A7，而陸戰隊僅使用 M777。[40] M119A2/A3 係更輕型且機動的野戰火砲，部署於空降及輕裝步兵單位，可透過 UH-60 或 CH-47 吊掛運輸或在空降作戰中空投。[41] 不過，美軍現在的主力火砲還是 M109A6 及 M777。這兩種火砲使用的砲彈已一致標準化，且有多種不同的砲彈/引信組合，包含高爆（瞬發/空炸）彈、煙霧彈、黃磷彈、照明彈、區域阻絕彈、火箭增程彈、雙效子母彈。上述砲彈都不是精準導引型，使用傳統式射擊指揮控制方法，武器系統都是 39 倍徑砲管，可發射 24 公里射程的高爆彈及其他傳統砲彈、30 公里射程的火箭增程彈、40 公里射程的精準導引砲彈。[42] 牽引砲及自走砲各有其優缺點，M109A6 的裝甲駕駛艙能保護組員避免破片與輕兵器火力，內部也可存放 39 枚 155 公厘砲彈。[43] 此外，其內部的導航系統與感測器可偵測 M109A6 自走砲本身位置，得以在 30 秒內駐止、裝彈、射擊，具備了火砲必須放列及裝定射擊諸元的相同準確性。[44] 帕拉丁自走砲的另一優點是能快速變換位置，以避免反砲兵火力或空中攻擊，且具有能夠與裝甲及機械化步兵部隊一齊行動的戰術機動力。M777 牽引砲相較於帕拉丁自走砲的主要優點在於重量較輕，能提升其空中機動力，可透過定/旋翼機運送至自走砲無法進入的發射地點。還有就是牽引砲的維修保養，比起自走砲運轉的履帶與引擎所需維修容易許多。

Technological advances for tube artillery

Artillery in the U.S. military has traditionally been employed as an area fire weapon that relied upon massed fires to have effects on target, whether it be formations of infantry or armor, or hardened targets. However, recent technological

advances have dramatically improved artillery’ s ability to have first round target effects which historically has resulted in the most casualties. Notably, the profusion of ground position sensor （GPS） technology has dramatically reduced the mean point of impact error conventionally calculated into artillery fire direction computations with the ability to accurately locate target and gun locations, two of five the requirements for accurate artillery fire as set forth by the U.S. Field Artillery School.[45] As technological advances have taken hold across the spectrum of weaponry and ordnance, the development of PGMs has significantly impacted how artillery can be employed on the battlefield. The M982 Excalibur PGM is a GPS guided shell with a range of approximately 40 meters with a circular error probable （CEP） of 5-20 meters.[46] When compared to the CEP of a conventional unguided artillery shell which stands at 267 meters, the precision of the Excalibur round enhances the capability to safely fire artillery in the close vicinity of friendly troops or non-combatants.[47] Tests have shown that one Excalibur shell can accurately hit an intended target that would typically take 10 to 50 non-guided artillery shells. [48] The effectiveness of this shell was demonstrated in June 2012 in Helmund Province, Afghanistan, when Battery G, 2nd Battalion 11th Marines dropped an Excalibur round on insurgents 36 km away marking the longest operational shot in the history of the M777 howitzer.[49]

管式火砲科技的進展

火砲在美軍向來被用來做為面積射擊武器，以大量密集火力攻擊步兵、裝甲部隊，或是強固目標等。不過，近期的科技進展，已明顯提升火砲第一發對目標的成效，而首發效力射長久以來皆能獲致最大戰果。尤其全球定位系統科技的高度發展，大幅減少了平均彈著點誤差（通常是將計算資料傳入火砲射擊指揮電腦，能準確定位目標與砲的位置），這是美國野戰砲兵學校說明的砲兵準確射擊 5 項要求之其中 2 項。[45] 隨著武器與彈藥的科技已全面進展，精準導引砲彈的發展也明顯影響火砲在戰場的運用方式。M982 神劍（Excalibur）精準導引砲彈是全球定位系統導引彈，射程約 40 公里、圓形公算偏差（circular error probable, CEP） 5－20 公尺。[46] 就圓形公算偏差的比較而言，傳統無導引式砲彈是 267 公尺，所以神劍彈的精準性提升了在鄰近有友軍或非戰鬥人員時，安全發射火砲的能力。[47] 測

試顯示，一枚神劍砲彈可準確命中所望目標，而無導引砲彈通常要發射 10－50 枚才能辦到。[48] 這種砲彈的效用在 2012 年 6 月阿富汗赫爾曼德省（Helmund Province）業經驗證，當時美軍第 11 陸戰隊第 2 營 G 連以 M777 對 36 公里外的叛亂分子發射 1 枚神劍砲彈，創下 M777 最遠的作戰發射距離。[49]

Another technological development that has positively impacted artillery fires and employment is the M1156 Precision Guided Kit （PGK） smart fuze that can be fired on M795 high explosive or M549 rocket assisted projectiles. The PGK serves to make conventional artillery shells into smart weapons with the capability of impacting within 50 meters of the target at any range.[50] While not having the degree of accuracy or range of the Excalibur shell, the PGK does provide precision-guided munitions capability at a fraction of the cost.

M1156「精準導引套件」（Precision Guided Kit, PGK）則是另一項已確實影響砲兵火力與運用的科技發展。此套件的智慧型引信可安裝在 M795 高爆彈或 M549 火箭增程彈發射。精準導引套件旨在讓傳統砲彈成為智慧型武器，具備能夠彈著目標 50 公尺範圍內。[50] 雖然 M1156 的準確度及射程不如神劍砲彈，但的確能以低廉成本發揮精準導引砲彈的能力。

Advances in fire direction technology for both the Paladin and M777, to include self- contained digital fire control and inertial navigation systems, have substantially diminished the time required to occupy a firing position, initiate fire missions, then displace. These developments have significantly impacted the survivability of artillery on the battlefield as this window is when artillery batteries are the most vulnerable to detection and attack.[51]

帕拉丁及 M777 在射擊指揮科技的進展，包含內建的數位射控與慣性導航系統，已大幅減少進入發射地、展開射擊任務、撤離所需時間。這些發展重大影響了火砲在戰場的存活力，因為砲陣地是最容易遭到偵測及攻擊之處。[51]

All of these technological advances have been critical to ongoing efforts to sustain artillery’s viability as the “go to” fire support element for maneuver forces and attaining increased levels of precision remains a key priority for senior military planners and the artillery community. However, the ability to acquire and

employ this technology at costs that are manageable given current budget constraints is a key consideration that must be taken into account for future strategic planning. Incorporating technological advancements for artillery and other weapons platforms while trying to control their costs remains one of the biggest challenges that the Department of Defense faces going forward.[52]

所有這些科技進展對於持續支持砲兵能夠「成為」戰鬥部隊的火力支援單位至關重要，而且達成提高精準度，更一直是高階軍事計畫者及砲兵圈內人的優先要項。然而，基於當前的預算限制，設法處理獲得與運用此科技的費用，則是必須納入未來戰略規畫的重要考量。要納入火砲及其他武器載具的科技進展，又要試圖控制這些費用，形成國防部面臨的下一步最重大挑戰之一。[52]

Viability of Cannon Artillery in the future relative to other Weapons Systems

Although there have been dramatic technological improvements in the ordnance precision and deep strike capability of these alternate platforms, tube artillery should remain as the primary fire support element for the United States military due to its mobility, ordnance variety, ability to mass fires, all-weather availability, and perhaps most important, it' s relative cost effectiveness.

未來管式火砲與其他武器系統相比的可用性

雖然上述這些載具在彈藥精準性及縱深打擊能力的科技進展很大，但管式火砲仍應繼續成為美軍的主要火力支援武器，因為具備了機動力、砲彈多樣化、能夠發射大量密集火力、全天候可用性，以及或許最重要的是比其他武器系統具有成本效益。

TABLE 1: FIRE SUPPORT PLATFORM COST COMPARISION

Weapon System	Per Unit Cost	Flight Hour Cost
M777 155 mm howitzer	$2,500,000[53]	N/A
M109A7 155 mm howitzer	$10,300,000[54]	N/A
M270 MLRS	$2,300,000[55]	N/A
M142 HIMARS	$2,950,000[56]	N/A
AH-64E Apache	$35,500,000[57]	$3581[58]
AH-1Z Viper	$29,890,000[59]	$1757[60]

A-10 Thunderbolt	$18,800,000[61]	$17,716[62]
AC-130U Spectre Gunship	$210,000,000[63]	$45,986[64]
F/A-18 E/F Super Hornet	$60,900,000[65]	$10,507[66]
F-15E Eagle	$29,900,000[67]	$42,200[68]
MQ-1B Predator	$5,000,000[69]	$3769[70]
MQ-9A Raptor	$16,050,000[71]	$4762[72]

表1: 火力支援載具的成本比較

武器系統	單價	每小時飛行成本
M777 155公厘牽引砲	2,500,000美元[53]	N/A
M109A7 155公厘自走砲	10,300,000美元[54]	N/A
M270多管火箭系統	2,300,000美元[55]	N/A
M142高機動砲兵火箭系統	2,950,000美元[56]	N/A
AH-64E 阿帕契（Apache）直升機	35,500,000美元[57]	3,581美元[58]
AH-1Z蝰蛇（Viper）直升機	29,890,000美元[59]	1,757美元[60]
A-10 雷霆攻擊機	18,800,000美元[61]	17,716美元[62]
AC-130U鬼怪（Spectre）砲艇機	210,000,000美元[63]	45,986美元[64]
F/A-18 E/F 超級大黃蜂（Super Hornet）戰機	60,900,000美元[65]	10,507美元[66]
F-15E 鷹式（Eagle）戰機	29,900,000美元[67]	42,200美元[68]
MQ-1B掠奪者	5,000,000美元[69]	3,769美元[70]
MQ-9A死神	16,050,000美元[71]	4,762美元[72]

The rapid ascent of PGM technology and improved weapons system capabilities has seen a corresponding increase in production and operating costs of fire support weapons platforms in the inventory of the United States military. As set forth in Table 1, from a purely cost per unit perspective, there is a not a significant cost divergence between M777 and the M270 and M142 rocket launcher systems while the M109A7 Paladin comes with a substantially higher price tag though this does also include an ammunition carrier as the howitzer and carrier are sold as a set. Though not

quantified numerically, the M777 has a lower maintenance and upkeep relative to the other weapon systems that have self-contained propulsion systems.

快速進步的精準導引砲彈科技及提升的武器系統能力，正相對增加了美軍火力支援武器載具的生產與操作成本。如表 1 所示，單純從個別單價的觀點來看，M777 牽引砲與 M270、M142 多管火箭系統的成本差距不大，但 M109A7 帕拉丁自走砲的報價就高出很多，縱使這是包含了一輛彈藥運輸車與自走砲的組合價。儘管沒有量化數據，但 M777 的保養維修費用低於其他自走武器系統。

When compared to manned rotary and fixed wing aircraft utilized in the CAS role, tube artillery presents a massive savings. For example, the per unit cost level of howitzers ranges from .5% to 6% of that of each aircraft. Furthermore, the added expense of cost per flight hour, which for fixed wing platforms, can become substantial ranging up to over $45,000 for the AC-130. It is evident, from the per unit cost analysis that the deep strike and precision guided targeting capabilities afforded by manned air assets comes at a significant cost upgrade relative to ground platforms. Additionally, the substantial cost per unit of manned aircraft translates into fewer being produced which, as older airframes are retired, ultimately results in a smaller composite force available to provide CAS support. Similar to manned air assets, a review of the unit costs of UAVs shows significant cost differential to ground fire support platforms with howitzers costing from 16% to 64% of that of UAVs on a per unit basis. UAVs afford many of the capabilities of manned air assets but at a lower unit and hourly flight cost and without any risk to a pilot.

與用於空中密支的有人駕駛定/旋翼機相比較，管式火砲的費用少很多。例如，各型火砲的單價是飛機的 0.5-6%。此外，就 AC-130 定翼機的每飛行小時成本而言，就增加了高達 45,000 美元。顯然，從每一架/輛的成本分析來看，具備縱深打擊及精準導引標定能力的有人駕駛飛機，付出的費用高出地面載具很多。再者，將龐大經費負擔較少量已製造的有人駕駛飛機所需，隨著機齡老舊汰除，最終導致可用於提供空中密支的組合部隊規模較小。如同有人駕駛飛機，無人飛行載具的單價比地面火力支援載具高很多，火砲的單價是無人飛行載具的 16-64%。無人飛行載具具備有人駕駛飛機的許多能力，但單價及每飛行小時費用又比有人駕駛飛機低，而且飛

行員沒有任何風險。

Another point of comparison is the relative cost of ordnance. As effective and deadly as PGMs are, their price tag is substantial relative to conventional ordnance as seen in Table 2.

另一項比較是針對彈藥的相對成本。就精準導引砲彈的有效性及致命性而言，如表 2 所示，其單價遠高於傳統式彈藥。

TABLE 2: COST OF ORDNANCE

Ordnance Type	Cost per unit
M795 155 mm HE shell	$1600[73]
M982 Excaliber 155 mm PGM	$68,000[74]
M1156 PG Fuze Kit	< $3000[75]
M31 Guided MLRS Rocket	$133,000[76]
GBU Paveway Guided Bomb	$22,000[77]

表2:彈藥成本

彈藥型式	單價
M795 155 公厘高爆彈	1,600美元[73]
M982 神劍155公厘精準導引砲彈	68,000美元[74]
M1156 精準導引套件	<$3,000美元[75]
M31導引式多管火箭系統火箭	133,000美元[76]
GBU鋪路（Paveway）導引炸彈	22,000美元[77]

Paradox of Precision Guided Munitions

While the ability to strike targets at long range with incredible precision and minimal collateral damage is a remarkable capability for the United States military, the excessive costs of producing and operating the weapon systems and expending these munitions are borderline prohibitive and call into question the economic viability of using these types of ordnance in sustained combat operations or for engagement with certain target sets. For example, a "dumb" HE shell costs 2% of that of an Excaliber PGM round; or put another way, 42 M795 shells can be purchased for the cost of one Excaliber PGM. Evidence of concerns related to this have already been seen in Iraq when authorization was required at the Army Brigade Commander level in order to fire the Excaliber PGM.[78] With the precedent being set

of senior commanders needing to be consulted before high cost ordnance is utilized, the question must be considered if future operational planning will factor into some type of decision-making sequence or target matrix to determine what type of enemy targets merit the use of high-priced PGMs? If so this further adds to the complexities and challenges of combatant commanders when justification must be provided for weapons system employment due to cost concerns.

對精準導引砲彈的迷思

儘管精準導引砲彈能夠以驚人的精準度及極低的附帶損害，遠距打擊目標，為美軍提供卓越戰力，但此武器系統的製造與運作費用高，限制了這些彈藥的消耗，且引起質疑認為在持續的戰鬥行動或接戰某些特定目標時，使用這類彈藥的經濟效用。例如，1 枚傳統高爆彈價格是神劍精準導引砲彈的 2%；或是換另一種方式說，1 枚神劍精準導引砲彈的價錢可以買到 42 枚 M795 高爆彈。對此點的關切已實際在伊拉克顯現，當時美陸軍需要由旅長級授權才能發射神劍精準導引砲彈。[78] 隨著使用高價彈藥前，必須請示高階指揮官之案例，不禁令人質疑未來作戰規畫是否會納入某類決策順序或目標劃分，以決定哪類敵目標值得使用高價的精準導引砲彈？如果是，這將更增加作戰指揮官的工作複雜度與挑戰，因為還要基於價格考量，下達運用武器系統的裁示。

It can be argued that PGMs require less expended rounds to have needed effects on target as demonstrated in 2003, when Coalition Air Forces in OIF used an average of 1.5 PGMS per target; a ratio far lower than the vast number of munitions needed to destroy or neutralize targets in previous conflicts such as during the Vietnam War when 30 fighter sorties and 176 unguided bombs were needed on average to destroy one target.[79] However, the PGM per target ratio argument is somewhat muted when considering how the expense of PGMs on the Pentagon’ s budget was clearly felt when a planned purchase of 30,388 Excaliber rounds in 2010 was reduced to only 7058 rounds reportedly based upon high costs.[80] As a comparison, in March 2012 the procurement of the PKM fuze at a much cheaper cost per unit of under $3000 was planned for 23,000 – 25,000 units.[81] While PGMs are, and will continue to be, a critical munition in the U.S. Armed Forces inventory for artillery and other fire support platforms, PKMs provide a more affordable alternative.

主張精準導引砲彈需要消耗的數量較少，即可達成對目標所望效果，這點已在 2003 年得到證實。當時聯盟空軍在伊拉克自由作戰中，對每一目標平均使用 1.5 枚精準導引砲彈；此種比率遠低於在以往衝突中，必須消耗大量彈藥來摧毀或壓制目標，例如越戰時期，平均需要以 30 架次戰機及 176 枚無導引炸彈來摧毀單一目標。[79] 然而，以精準導引砲彈攻擊目標的使用比率主張沉寂下來，從美國國防部的預算就可清楚感受到，由於考量精準導引砲彈的價格昂貴，所以原本計劃在 2010 年要採購 30,388 枚神劍彈，據傳因為太貴而減少為 7,058 枚。[80] 在此做個價格比較，2012 年 3 月以每個低於 3,000 美元的價格規劃採購 23,000-25,000 個精準導引套件。[81] 雖然精準導引砲彈現在及未來會繼續成為美軍火砲或其他火力支援載具的重要彈藥，但精準導引套件是價格更負擔得起的選項。

Relevance of Tube Artillery

The rapid evolution of weapons related technology has significantly improved the capabilities of both air and ground based fire support weapon platforms. While these improvements have led to dramatic improvements in accuracy and range, tube artillery’ s all-weather ability to fix and suppress targets, as well as shape the battlefield through concentrated and massed fires is unrivaled, relative to other fire support platforms. However, in order to retain it’ s relevance on the battlefields of the future and ensure its continued place in the inventory of the U.S. military as a viable fire support platform, tube artillery must continue to improve its technology and employment capabilities, particularly in the areas of mobility, survivability, responsiveness, range, and accuracy.

管式火砲的適用性

隨著武器相關科技的快速演進，大幅提升了空中與陸基火力支援武器載具的能力。儘管這些提升已明顯提高準確度及射程，但管式火砲的全天候戰力，對於拘束與壓制目標，以及能透過密集且大量火力形塑戰場，都是其他火力支援載具比不上的。

然而，為了保有其在未來戰場的適用性，並確保能繼續成為美軍有效可用的火力支援載具，管式火砲必須不斷精進其科技及運用能力，尤其是在機動力、存活力、反應力、射程、準確度等方面。

The mobility of tube artillery will grow increasingly important in order for it to

keep up with armor and mechanized infantry units on the move conducting offensive operations, and perhaps most importantly, survive counter-battery fire and enemy air strikes. Both the M777 and the M109A6 howitzers each have strengths and weaknesses relative to their mobility and the type of terrain they are best suited for. The M777s are at a disadvantage with the constraints of where terrain will permit its prime mover to travel and are also highly vulnerable to enemy air due to longer emplacement and displacement times. Alternatively, the ability to transport towed howitzers via rotary aircraft for remote employment i a significant tactical advantage over self-propelled howitzers. M109A6 howitzers are fully capable of maintaining travel speeds of mechanized forces while being better suited to operating in open terrain but are very heavy and leave a large footprint. While an M777 requires just over two minutes for emplacement and displacement, the M109A6 needs less than a minute.[82] While the emplacement/displacement times for each of these howitzers are dramatic improvements from years past, the radar and UAV capabilities of adversaries dictates that these times need to be reduced to 30-45 seconds for future survivability.[83]

管式火砲的機動力將日漸重要，俾能搭配裝甲及機械化步兵單位移動執行攻勢作戰，以及或許最重要的是要能在反砲兵火力暨敵空襲之下存活。M777 牽引砲與 M109A6 自走砲在機動力及最適合發揮的地形方面，各自有其強弱點。M777 的弱點是其牽引車行駛受限於地形，同時也容易遭到敵空中攻擊，因為其放列及轉移時間稍長，又或者是以旋翼機運輸牽引砲進行遠距運用，這就是一項勝過自走砲的重大戰術優勢。M109A6 自走砲則是能跟上機械化部隊的行進速度，較適合在開闊地型操作，但太重了且後勤錙重需求大。M777 只需要 2 分多鐘就能完成放列及撤離，M109A6 所需時間低於 1 分鐘。[82] 這些火砲的放列/撤離時間在過去數年來已大幅縮短，但基於敵雷達及無人飛行載具的能力，要求這些時間必須減少到 30－40 秒，在未來才有存活能力。[83]

Weapon system ranging capability continues to be perhaps the biggest shortcoming of the 155 mm howitzers in the U.S. inventory. With a maximum range of 30 km for a RAP round and 40 km for a PGM, U.S howitzers are significantly outranged by 23 foreign militaries around the world.[84] However, ongoing R&D with

the M777ER project seeks to lengthen the barrel length of the M777 howitzer therefore increasing range out to 69 km. [85] This improvement will come with an addition of 1000 pounds to the unit’ s weight and cost approximately $700,000 for the conversion kits. [86] While there has been no commitment by the Army or Marine Corps to purchase this conversion kit, the continued progress of this project and other related technology is critically important to keeping U.S howitzers effective and survivable on the battlefields of tomorrow.

武器系統的射程能力，或許仍持續成為美軍 155 公厘火砲的最大弱點。美軍火砲能發射最大射程 30 公里的火箭增程彈、40 公里的精準導引砲彈，已明顯超越世上其他 23 國的軍隊。[84] 不過，進行中的 M777 增程型（ER）研發案，尋求加長 M777 的砲管，俾將射程增加到 69 公里。[85] 這項提升將比原先多出 1,000 磅重量及增加 70 萬美元以更換套件。[86] 儘管美陸軍或陸戰隊未承諾要採購，但這項專案及其他相關科技的持續進度，對保持美國火砲在未來戰場的有效性與存活力至關重要。

One of the strengths of tube artillery has traditionally been its timely response to calls for fire in all-weather conditions. The ability to put suppressive fires on opposing forces in danger of over running a friendly position, or of being able to quickly dial up a pre- planned target group to disrupt a pending attack has played into the strength of tube artillery in past conflicts and can continue to in the future. Tube artillery’ s all-weather capability is a distinct and significant advantage that it has over air platforms and is an important consideration for its future relevance. In spite of ever-evolving technology for stealth, navigation, and weaponry, poor weather remains a significant constraint for air platforms. Additionally, unless air assets happen to be on station or in the area, response time can lag which can lead to adverse developments for troops on the ground. No matter how precision guidance ordnance is, it is only effective if delivered in a timely fashion pursuant to requests from ground units. Thus, tube artillery is currently, and will continue to be the best fire support asset for timely responsive fires.

管式火砲的傳統優點之一是能在全天候適時回應射擊要求。這項從超越友軍陣地以制壓火力陷敵軍於危險之中的能力，或是能快速了解預劃攻擊的目標群，以瓦解即將發生的攻擊，係管式火砲在過去及未來衝突中的

強項。管式火砲的全天候作戰能力是一項勝過空中載具的獨特且重大優點，而且是其具備未來適用性的要素。雖然匿蹤、導航、武器等科技不斷演進，但惡劣天候依然重大限制了空中載具。此外，除非空中載具已飛臨上空或在戰區中，其遲緩的反應時間會導致地面部隊面臨不利。不論導引彈有多麼精準，唯有以具時效性回應地面部隊要求的發射才有作用。因此，管式火砲在當前及未來，將持續成為提供時效性快速反應火力的最佳火力支援裝備。

Aside from the introduction of PGMs and other improved technology, other employment aspects of tube artillery that highlights its relevance is the superior ability to mass fires and re-engage targets. Additionally, the capability to shape the battlefield and attrite enemy maneuver forces are difficult to replicate with air assets and lends further weight to the need to maintain tube artillery in the U.S. inventory.

管式火砲除了引進精準導引砲彈及其他提升的科技之外，其他能凸顯其適用性的是具有優越的大量集火射擊與再接戰目標能力。此外，其形塑影響戰場及耗損敵戰鬥部隊的能力是空中裝備難以比擬的，吾人應更加重視管式火砲在軍中的必要性。

While the spectrum of missions that the United States military needs to be prepared to support dictates roles for both towed and self-propelled systems, the optimal howitzer of the future should seek to blend aspects of both weapon systems in order to maximize mobility and range. A configuration of a lighter weight, self-propelled howitzer on a wheeled platform, with a .52 caliber tube, capable of emplacing in 30-45 seconds, firing 6-10 shells, then displacing in under a minute would be an optimal future howitzer platform.[87] While there are ongoing efforts in the world of science and technology to look at improving artillery, neither the Army nor the Marine Corps are currently sponsoring R&D into new artillery platforms. Additionally, at the present time the Army plans for the M019A7 Paladin to be its primary cannon artillery howitzer for the next 50 years.[88] To remain relevant on the battlefield of the future, DOD research and development funds must be allocated now to further improve the howitzers currently in the inventory as well as develop new and improved platforms.

軍方必須依據任務範圍進行戰備整備，以支持對於牽引砲及自走砲系

統的要求角色，而未來最佳的火砲應謀求在多方面融合這 2 種武器系統，俾優化機動力及射程。輕型輪式自走砲、配備 52 倍徑砲管、能在 30－45 秒內放列、發射 6-10 枚砲彈後在 1 分鐘內撤離，這將是未來最佳火砲載具的構型。[87] 各國科技都在持續努力尋求提升火砲，但美陸軍及陸戰隊目前未將研發費挹注於新型火砲載具。此外，美陸軍目前規劃將 M019A7 帕拉丁自走砲列為未來 50 年的主力管式火砲。[88] 為維繫火砲在未來戰場的適用性。國防部現在就應該編列相關研發預算，俾進一步提升既有及發展新型與改良型的火砲載具。

Conclusion

The devastating effects of tube artillery on the battlefield has served as the deciding factor in countless battles throughout history. All-weather responsiveness, the ability to mass and concentration of fires to shape battles, and the shock effect on targeted troops are all reasons that tube artillery has been the first option for maneuver commanders when a battle hung in the balance or suppression of enemy forces was needed. However, advances in weaponry technology and the advent of numerous other fire support platforms has called into question tube artillery’ s future viability in the U.S. military. To remain relevant and combat effective on the battlefield, tube artillery must continue to evolve while improving its mobility, responsiveness, accuracy, and range. Regardless, the ultimate test for tube artillery in future conflicts will be whether maneuver commanders have the confidence to call it in as a primary fire support option when troops are in contact and lives are on the line. As the United States faces hard, budget-driven decisions on how to structure the force of the future, the question is not whether the United States military needs the devastating fire support that tube artillery provides, but whether the U.S. can afford to not have this cost effective weapons platform in its inventory.

結語

橫亙歷史，管式火砲在戰場上的摧毀效力，已是無數戰役中的決勝要素。全天候反應能力、大量集火形塑戰場的能力、對射擊目標的震撼效果，這些都是管式火砲成為戰鬥部隊指揮官在戰鬥懸而未決或需要制壓敵軍時的首選理由。然而，隨著武器科技的進展及其他多款火力支援載具的問世，有人質疑未來管式火砲在美軍的有效可用性。為維繫管式火砲在戰

場的適用性及戰鬥成效，必須持續發展提升其機動力、反應力、準確度、射程。無論管式火砲在未來衝突中的最終測試情況如何，以及戰鬥部隊指揮官是否有信心在部隊接戰及生死關頭時，將其視為火力支援首選，在國家囿於預算難以決定如何建構未來部隊之際，問題不在於軍隊是否需要由管式火砲提供的摧毀性火力支援，而是在於國家軍備能否承受沒有此種具有成本效益的武器載具。

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Biography

Supervisory Special Agent Michael Craig Harris entered the Federal Bureau of Investigation （FBI） in 1996. After graduation from the FBI Academy, Special Agent （SA） Harris was assigned to the FBI Houston Division where he investigated White Collar Crime matters. In 1999, SA Harris was transferred to the Los Angeles Division and was assigned to the Southern California Drug Task Force where he conducted drug trafficking and criminal enterprise investigations. While assigned to the Los Angeles Division, SA Harris participated in two Temporary Duty Assignments （TDY） to Iraq and one TDY to Joint Task Force Guantanamo Bay. In 2009 SA Harris was promoted to Supervisory Special Agent （SSA） and was transferred to FBIHQ to work as a Program Manager in the Criminal Investigation Division, Drug Unit. In 2012, SSA Harris was promoted and detailed to the Department of Justice's Organized Crime Drug Enforcement Task Force Executive Office where he served as an Associate Director in charge of the Consolidated Priority Organization Target Program. In December 2013, SSA Harris reported to the Legal Attaché Office at the U.S. Embassy in Kabul, Afghanistan where he served as an Assistant Legal Attaché in charge of the General Investigations Program. In January 2015, SSA Harris was assigned to the International Operations Division, Middle East Unit at FBIHQ. Prior to joining the FBI, SSA Harris served as an Artillery Officer in the United States Marine Corps. SSA Harris is currently a student at the Air War College at Maxwell Air Force Base, Alabama.

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哈里士（Michael Craig Harris）現任美國聯邦調查局（Federal Bureau of Investigation, FBI）特種諜報員主管，1996 年進入該局服務。從聯邦調查局學院（FBI Academy）畢業後，派至該局休士頓（Houston）處，曾調查白領犯罪（White Collar Crime）案。1999 年調到洛杉磯（Los Angeles）處的南加州緝毒隊（Southern California Drug Task Force）執行毒品走私及犯罪企業調查，並曾參加兩次到伊拉克的臨時任務派遣（Temporary Duty Assignments, TDY）及一次到關達那摩灣（Guantanamo Bay）聯合特遣部隊的臨時任務派遣。2009 年，擢升為特種諜報員主管並調至聯邦調查局總部毒品犯罪調查處專案經理。2012 年，晉升並奉派至司法部組織犯罪緝毒任務組執法辦公室（Organized Crime Drug Enforcement Task Force Executive Office）擔任副主任，負責綜合優先級組織目標計畫（Consolidated Priority Organization Target Program）。2013 年 12 月，外派至阿富汗喀布爾（Kabul）美國大使館司法駐外辦公處擔任助理司法代表，負責所有調查計畫。2015 年 1 月，調至聯邦調查局總部位於中東的國際作業處。

他在加入聯邦調查局前是美軍陸戰隊的砲兵軍官，作者曾就讀於美國阿拉巴馬州麥斯威爾（Maxwell）空軍基地的空軍戰院，本文是作者就讀美空軍戰院的畢業論文，指導教授強生（Kenneth Johnson）博士，出版日期 2017 年 4 月 6 日。

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