維持優勢？評析美國近期的四項軍事科技

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摘 要

美國的軍事優勢近年來日益鬆動，為了維持優勢美國努力發展新的軍事科技，其中有四個項目特別引起注目：迷你無人科技、優勢機動科技、長程打擊科技、與導能武器科技。然而，本文發現，這四項科技不是發展曠日廢時、緩不濟急，技術障礙嚴峻，就是基於矛盾錯誤的想定，或是會產生新的弱點，均無法維繫美國的軍事優勢。

關鍵詞
美國軍事優勢、迷你無人科技、優勢機動科技、長程打擊科技、導能武器科技

壹、前言

冷戰結束、蘇聯瓦解之後，美國成了軍事上唯一的主宰者。美國擁有世界上最先進也最強大的軍力，軍事支出更佔全球軍費總額的一半，其他強權無不瞠乎其後。[1]在此一獨強的態勢之下，美軍總是能在開闊的空間中（空中、海上、與平坦空曠的地面）迅速、輕易地擊毀對手的正規抵抗，構成了美國的軍事優勢。因是之故，1990 年代的美國是大量刪減國防預算而仍能頻繁對外動武；進入 2000 年代，九一一恐怖攻擊事件開啓全球反恐戰爭(Global War on Terrorism, GWOT)，美國更派兵侵入阿富汗與伊拉克，此後國防支出雖隨之大幅膨脹，但並不抵在這兩個開闊空間以外的環境長期實施佔領、進行非正規反叛亂(Counter- Insurgency, COIN)式低強度衝突（Low Intensity Conflict, LIC）的龐大開銷；接著進入 2010 年代，金融海嘯的衝擊又重創了美國的經濟，國防經費益加捉襟見肘。[2]揮霍無度、入不敷出、寅食卯糧之下，美國的軍事優勢就在這 20 年間，一點一滴地流失。爲了另闢蹊徑維持優勢於不墜，美國在這 20 年間同樣也不斷努力構思、發展各種新的軍事科技，在這眾多的科技之中，有四個項目特別引起注目：迷你無人科技(Mini Unmanned Technologies)、優勢機動科技(Dominate Maneuver Technologies)、長程打擊科技(Long Range Strike Technologies)、與導能武器科技(Directed

[1] International Institute for Strategic Studies, *The Military Balance 2010* (London: International Institute for Strategic Studies, 2009), pp. 462-469; Barry R. Posen, “Command of the Commons: The Military Foundation of U.S. Hegemony,” *International Security*, Vol. 28, No 1(Summer 2003), pp. 5-46.

[2] “Quadrennial Defense Review Report 2010,” *U.S. Department of Defense*, <http://www.defense.gov/qdr/images/QDR_as_of_12Feb10_1000.pdf>(February 6, 2010), pp. 20-21.

Energy Weapon Technologies)。[3]然而，這四個科技項目是否能產生效果呢？是否是正確的方向呢？答案是否定的。本文將以美國政府的正式政策文件、實際進行的發展方案、與其他相關的研究與報告爲基礎，以其運用想定邏輯分析與技術發展進度實況的角度，進行一通盤的檢視，並分成四個部分依序探討。

第一部份探討迷你無人科技，也就是各種單兵以下無人系統的發展與應用，使人員遠離危險並克服人體的侷限，擔任迄今仍只能由人執行的步兵戰鬥任務。[4]只是，這樣的科技不僅是發展緩不濟急，應用價值也只是在反叛亂式的低強度衝突，是在美國的對手面臨美國的軍事優勢時，才會採取的非傳統、非正規策略，迷你無人科技其實是以美國軍事優勢爲前提，而無助於此一優勢的維繫。第二部分討論優勢機動科技，也就發展重量輕但不減損戰鬥效能的裝甲車輛，以及機動性超高的運輸機種，提昇部隊的機動性與可部署性，著眼於由來已久的大型區域戰爭(Major Theater War)想定，並因應與日俱增的反介入(Anti-Access)威脅，

[3] 此一透過發展新科技以獲得優勢的努力，即是尋求以往所說的「軍事事務革命」(Revolution in Military Affairs)。可參閱：Robert L. Paarlberg, "Knowledge as Power: Science, Military Dominance, and U.S. Security," *International Security*, Vol. 29, No. 1(Summer 2004), pp. 122-151; Andrew F. Krepinevich, "Cavalry to Computer: The Pattern of Military Revolutions," *The National Interest*, No. 37(Fall 1994), pp. 30-42, Robert Tomes, "Revolution in Military Affairs--A History," *Military Review*, Vol. 80, No. 5(September/October 2000), pp. 98-101; Michael E O'Hanlon, *Technological Change and the Future of Warfare* (Washington D.C.: Brookings Institution Press, 2000); MacGregor Knox & Williamson Murray, eds., *The Dynamics of Military Revolution 1300-2050* (New York: Cambridge University Press, 2001); Martin van Creveld, *Technology And War* (New York: The Free Press, 2002).

[4] 無人系統的分級，一般所謂「迷你」指單兵即可背負攜行，至於「微型」則約略是手持大小。爲了行文的通順，本文以「迷你」一詞統稱單兵以下的無人科技。可參閱：Timothy Coffey and John A. Montgomery, "The Emergence of Mini UAVs for Military Applications," *Military Technology*, Vol. 28, No. 7(July 2004), pp. 20-28; Bill Sweetman, "Mini- UAVs - The Next Small Thing," *Jane's International Defense Review*, Vol. 38, No. 6(June 2005), pp. 58-63; Damian Kemp, "Micro Wave," *Jane's Defense Weekly*, February 23, 2005, pp. 22-25.

寄望可從戰區之外直接進入，而不仰賴戰區內的機場或港口等重大交通設施。[5]不過，這樣的構想不僅也是緩不濟急，更是建立在一些缺漏、矛盾的假定之上，還會製造出新的弱點，仍無助於美國軍事優勢的維繫。第三部分討論長程打擊科技，也就是發展長距離的精確打擊機種，同樣在大型區域戰爭想定與反介入威脅之下，不仰賴戰區內的前進基地而直接從戰區外發起空襲。然而，這樣的構想不是也建立在缺漏、矛盾的假定之上，就是發展曠日廢時、緩不濟急，仍無助於美國軍事優勢的維繫。第四部份則討論導能武器科技，主要是高能雷射(High Energy Laser)武器與高能微波(High Power Microwave)武器。這是延續自冷戰時代的「戰略防衛先機」（Strategic Defense Initiative, SDI，也就是一般所熟知的「星戰計畫」Star War），是真正革命性的新科技，但卻是發展困難且挫折不斷，亦無助於美國軍事優勢的維繫。

貳、迷你無人科技

第一項所構思維持美國軍事優勢的科技領域，是迷你無人科技，也就是各種單兵以下無人武器系統的發展與應用，企圖使人員遠離危險並克服人體的侷限，大幅提昇戰鬥效能與使用彈性。迷你無人科技在 2001

[5] 「反介入」一詞近年來頗受重視，往往也與中國人民解放軍聯繫在一起。然而，「反介入」此一構想並非解放軍所專有，而是所有美國可能對手都可以應用的概念；美國針對此一威脅的回應，也不僅限於海空軍，亦包括陸軍在內。可參閱：Andrew F. Krepinevich, “Why AirSea Battle?” *Center for Strategic and Budgetary Assessments*, <http://www.csbaonline.org/4Publications/PubLibrary/R.20100219.Why_AirSea_Battle /R.20100219.Why_ Air Sea_Battle.pdf>(February 19, 2010), pp. vii-viii; H. Thomas Fields Jr., “Can it Transform the Nature of Rapid Contingency Operations?” *Army*, Vol. 54, No. 1(January 2004), pp. 21-23.

年反恐戰爭開始後即廣受重視，[6]並持續呈現在美國 2010 年版的「四年期國防總檢討」(*Quadrennial Defense Review*)，與其他如「機器人策略白皮書」(*Robotics Strategy White Paper*)與「無人系統整合路線圖」(*Unmanned Systems Integrated Roadmap*)等定期提出相關的官方文件之中。[7]目前，在空中、海中、地面的操作環境裡，無人飛行載具(Unmanned Aerial Vehicle, UAV)、無人水面載具(Unmanned Surface Vehicle, USV)、無人水下載具(Unmanned Underwater Vehicle, UUV)、與無人地面載具(Unmanned Ground Vehicle, UGV)的發展是日益蓬勃、應用也不斷擴大。[8]如今，已經有許多迷你無人科技應用在戰場上，[9]例如美軍已廣泛使用遙控車大小的機器人，進行即造爆裂物(Improvised Explosive Device, IED)的拆解，與各類破門、深入洞穴的搜查工作，另外也發展了一系列功能相似的新裝備，例如可由單兵徒手佈放的無人地面感測器(Unattended Ground Sensors, UGS)，以及可在街道間懸停飛行的微型無人飛機(Micro Air Vehicle, MAV)，[10]日後也將朝各種系統的整合，由無人系統進行團隊行動。[11]對於迷你無人系統所可擔負的工作，美國目前優先著眼於偵察

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[6] Nick Cook, “Out in Front,” *Jane’s Defense Weekly*,January 16, 2002, p. 24.

[7] “Quadrennial Defense Review Report 2010,” U.S. Department of Defense, p. 10; “Robotics Strategy White Paper,” *Army Capabilities Integration Center*, <http://www.arcic.army.mil/Key%20Documents/Robotics StrategyWhitePaper_19Mar09.pdf>(March 19, 2009), pp. 5-6; “FY 2009–2034 Unmanned Systems Integrated Roadmap,” *Office of the Under Secretary of Defense for Acquisition, Technology & Logistics*, <http://www.acq.osd.mil/psa/docs/UMSIntegrated Roadmap2009.pdf>(April 6, 2009), pp. 2-3.

[8] Mark Hewish, “GI, Robot: Unmanned Platforms Are Taking over Dirty, Dangerous, and Dull Missions,” *Jane’s International Defense Review*, Vol. 34, No. 1(January 2001), pp. 34-40.

[9] Andrew White, “Good Things Come in Small Packages: The New UAV Family,” *Jane’s International Defense Review*, Vol. 43, No. 5(May 2010), pp. 51-54.

[10] Caitlin Harrington, “US Army Eyes Accelerated FCS Production,” *Jane’s Defense Weekly*, August 13, 2008, p. 10; Scott R. Gourley, “US Army User-tests ISR ‘Spin Out’ Technologies,” *Jane’s Defense Weekly*, September 9, 2009, p. 18.

[11] 可參閱： “U.S. Army Roadmap for Unmanned Aircraft Systems: 2010-2035,”

監視、目標獲得、除雷、與核生化偵檢等四項，[12]並爲往後 25 年的發展規劃了分屬後勤、安全、工程、醫療、保修等五個領域的 32 項功能。[13]儘管有如此蓬勃的發展與願景的勾勒，但從兩個方面來看，迷你無人科技終究無法維繫美國的軍事優勢。

一方面，是發展緩不濟急。畢竟，迷你無人科技最大的價值，就是減少人類生命遭受的危險，而對傷亡的難以容忍也正是目前美國軍力最大的弱點。傷亡最多的單位無疑是使用人力最多的單位，也就是步兵單位，只要機器人能夠代替士兵，美軍這最大的缺憾也就被克服。然而，如同上文所列，無論是已經擔任的功能，或是未來將能擔任的功能，迷你無人科技在目前的預想中，都還是限於戰鬥支援與勤務支援等比較單調而固定的工作。至於直接與敵人交火、複雜多變的戰鬥任務，也就是某種形式的戰鬥機器人(combat robot)，[14]仍不在往後 25 年的預想任務清單中，還是得由士兵自己進行。[15]這方面的技術發展障礙，不只人類是對於全自動識別人物並對人開火射擊的信心仍然不足，[16]也在於行動能力與適應性。雖然在耐用、維修、動力供應方面已大有進步，現在的機器人大多還是用履帶與車輪的方式移動，在還能行駛的地帶也許比士兵雙腳的奔跑要更有利，但論及攀爬翻越這一項在城鎮或山嶺中最大的考

Federation of American Scientists, <http://www.fas.org/irp/program/collect/uas-army.pdf>(April 16, 2010), pp. 1-3.

[12] 見：“Robotics Strategy White Paper,” *Army Capabilities Integration Center*, pp. 5-6.

[13] *Ibid*., pp. 9-20, 28-33.

[14] Scott R. Gourley and Tony Skinner, “Robot Wars,” *Jane's Defense Weekly*, June 4, 2008, pp. 28-31.

[15] 可參閱：“FY 2009–2034 Unmanned Systems Integrated Roadmap,” *Office of the Under Secretary of Defense for Acquisition, Technology & Logistics*, pp. 27-33.

[16] 在瞬息萬變的步兵交火中，機器人是否能正確辨識平民、敵軍、與友軍，會是個嚴酷的挑戰。可參閱：Roland Brachman, “Taming the Monster: The Next Computing Revolution,” *Military Technology*, Vol. 28, No. 9(September 2004), pp. 71-73; Andrew White, “Step Chang in Urban Operations as UGVs Face up to Enemy,” *Jane's International Defense Review*, Vol. 40, No. 6(June 2007), pp. 40-46.

驗，現在的機器人科技還有很長一段路要走。[17]

另一方面，更根本的說，迷你無人科技其實是以美國軍事優勢爲前提，本身無助於維持這樣的優勢。實際上，「無人」科技早已是現代戰爭中的重要部分，除了 19 世紀以來的魚雷，或是 1950 年代以來的飛彈，當今所談的各種無人載具(U“X”V)也都已不同的名稱存在了數十年之久，譬如無人飛機在越戰與中東戰爭中的使用，或是無人潛艇在獵雷方面的功能。[18]不諱言，太陽底下並沒有「全新」的事物，但無人科技在今天應用的擴大，往單兵以下的迷你層面發展，卻較少是科技進展的結果，而較多是反恐戰爭任務需求所致，以往應用這類科技的必要性其實不大。[19]過去各類無人科技應用，大多是單兵以上但仍小到不足以載人的規格，[20]主要是魚雷或飛彈這般屬於彈藥的消耗性裝備。它們能感測外界並智慧地回應，主要就是爲了標定敵人，而在敵人規模與裝備都很龐大、出現也頻繁時，這種標定往往就是摧毀前的最後的確認而已，也

[17] Daniel Wasserbly, “US Receives ANS prototype Approval,” *Jane's Defense Weekly*, May 19, 2010, p. 9. 人形在許多步兵任務中的必要性，使得目前一部份的研究努力走向「外骨架」(exoskeletons)的動力輔助系統，增加士兵的力量。可參閱：Lauren Gelfand, “Design for Strife,” *Jane's Defense Weekly*, February 4, 2009, pp. 24-27; Rupert Pengelley and Huw Williams, “Tail to Teeth: Unmanned Haulers Ease the Soldier's lot on the Battlefield,” *Jane's International Defense Review*, Vol. 43, No. 2(February 2010), pp. 58-65.

[18] 這方面的應用在近年來的發展，可參閱：Richard Scott, “Unmanned, Undersea,” *Jane's Defense Weekly*, June 12, 2002, pp. 28-34; Mark Hewish and Joris Janssen Lok, “Silent Sentinels Patrol the depth,” *Jane's International Defense Review*, Vol. 36, No. 4(April 2003), pp. 49-54; Richard Scott, “Clearing the Way: UUVs Evolve to Meet Front–line MCM Requirements,” *Jane's International Defense Review*, Vol. 41, No. 5(May 2008), pp. 49-54; Casandra Newell, “Making Big Strides in Mine Countermeasures,” *Jane's International Defense Review*, Vol. 42, No. 2(February 2009), pp. 50-53; Tim Fish and Charles Hollosi, “Demining the Deep,” *Jane's Defense Weekly*, June 3, 2009, pp. 24-29.

[19] 譬如說，無人潛艇應用的稀少，就是因爲水雷反制從來都是件被遺忘的工作。韓戰之後被遺忘了，一次波灣戰爭後又再次被遺忘。可參閱：Mark Hewish, “Wanted: A Quiet Walk on the Beach,” *Jane's International Defense Review*, Vol. 36, No. 3(March 2003), pp. 70-78.

[20] Bill Sweetman, “Tactical UAVs Redefining and Refining the Breed,” *Jane's International Defense Review*, Vol. 38, No. 9(September 2005), p. 70.

就不太需要屬於載具可以重複使用的迷你無人科技。至於在反恐戰爭中，敵人的規模與裝備就變得極其微小、出現也不頻繁，常常是偵測但無目標可摧毀。面對這樣強度低、時間長的衝突型態，得在狹窄的小徑、巷弄、房舍、甚至是洞穴中，從大量可疑的目標（人、車、船舶、貨櫃、建築物等等）裡，識別出很少數必須攻擊的目標（恐怖份子、民兵），[21] 這才需要屬於載具可以重複使用的迷你無人科技。

然而，在反恐戰爭中，為何美國敵人的規模與裝備會變得微小、出現也不頻繁？這無非是因為面對美國的軍力優勢，集中、具體的大型目標，將無抵抗之力而被毀滅。只有在美國繼續保有這樣的優勢時，美國的敵人才會有必要用這樣疏散、躲藏的策略，以非傳統、非正規的方式與美國周旋，慢慢消耗美國的實力。一旦美國的軍力優勢無法維持，美國的敵人也就可以化零為整，重新聚集成大型的力量，而以傳統、正規的方法與美軍較量，於是這些為了對付間歇、零星敵人的迷你無人系統，也就無用武之地了。這正是反恐戰爭 10 年來的效果，連年戰事使美國精疲力竭、開始撤出伊拉克與阿富汗，[22]而美國為了反恐戰爭所消耗的資源，就侵蝕了美國原先在傳統、正規戰爭中的優勢。[23]要擊毀眾多「大型」的目標，無論是對付車輛、飛機、還是船艦、乃至於工廠、城市，戰爭早已是無人的了，早在核子飛彈出現以後，按鈕與電腦戰爭就是一種很現實的描述，只要戰爭還是一種政治的延伸，這在遠端發號施令的決定權，就還是得操在人的手中，不會再進一步委之於機器，發展迷你

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[21] Timothy R. Reese, "Precision Firepower: Smart Bomb, Dumb Strategy," *Military Review*, Vol. 33, No. 4(July/August 2003), pp. 46-53.

[22] Michael Knights, "Withdrawal Symptoms: What Will Happen after the US Leaves Iraq?" *Jane's Intelligence Review*, Vol. 21, No. 10(October 2009), pp. 38-43; Daniel Wasserbly, "US Force Analyse Future Role of Advise-and-assist Brigade in Iraq," *Jane's International Defense Review*, Vol. 43, No. 1(January 2010), p. 5.

[23] Michael J. Mazarr, "The Folly of 'Asymmetric War'," *The Washington Quarterly*, Vol. 31, No. 3(Summer 2008), pp. 33-53.

無人科技無法維繫美國的軍力優勢。

參、優勢機動科技

第二項所構思維持美國軍事優勢的科技領域，是優勢機動科技。這主要包括兩個方面，一是輕量化（因而易運送）但戰力不減損的裝甲車輛，另一則是結合速度、航程、與起降性能的空中載運工具。兩相結合將可擺脫基礎設施對部隊部署的牽絆，甚至打破現行戰爭在地面上移動的連續線型態，轉變成由空中聯繫的不連續點型態。[24]優勢機動是 1990 年代以來美國陸軍主要的思路，希望能建立起旅級規模的新一代地面部隊，也反映在許多相關裝備發展計畫之上。[25]此一優勢機動科技所根植的想定，是類似第一次波灣戰爭(First Gulf War)的大型區域戰爭，對手是所謂「流氓國家」(Rogue State)或「邪惡軸心」(Axis of Evil)的區域性強權，擁有不很先進但規模相當大的武力。一次波灣戰爭期間，美國與盟國集結部隊的浩大工程，與過程中彈道飛彈的騷擾與生化武器揮之不去的陰影，使美國發現其戰區內的後勤體系，正是這種戰爭想定中最大的弱點，[26]易受敵人不對稱武器的傷害：要是敵人真有足夠數量的彈道飛彈甚至是核子武器，則美國在戰區中的機場港口連同抵達的部隊，將遭滅頂之災。隨著先進軍事科技的擴散，在 10、20 年內美國可能遭遇的區

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[24] Bill Sweetman, “US Heavy-lift Aircraft Will Stretch State of Art,” *Jane’s International Defense Review*, Vol. 39, No. 4(April 2006), pp. 50-51.

[25] Robin P. Swan and Scott R. McMichael, “Mounted Vertical Maneuver: A Giant Leap Forward in Maneuver and Sustainment,” *Military Review*, Vol. 37, No. 1(January/February 2007), pp. 52-62.

[26] H. Thomas Fields Jr., “Can it Transform the Nature of Rapid Contingency Operations?” pp. 21-23.

域強權對手，雖然沒有能力全面翻新其軍備，仍可能獲得彈道飛彈這般不對稱的武器，這是時下所稱反介入威脅中最具體的一面。優勢機動就是要免除這樣的弱點，輕量化的裝甲車輛減少集結部隊的後勤負擔，性能超群的空運機體則不需要戰區內的機場，可直接從敵人的打擊範圍之外部署部隊進入戰場。儘管如此，但從兩個方面來看，優勢機動科技其實無法維繫美國的軍事優勢。

一方面，是發展緩不濟急。具體而言，優勢機動科技中所構想的輕量化裝甲車輛，期望應用資訊科技，在敵人行動、開火之前，搶先發現並擊毀敵人，以資訊制敵機先，來維持與現有裝備同等的戰鬥效能。其整體戰力將有 50%來自網路功能、20%來自機動力、15%來自攔截與干擾、10%來自武裝、裝甲則只佔 5%（現行裝甲車輛的整體戰力則約有 60%來自裝甲、25%來自武裝、10%來自機動力，僅 5%來自網路能力）。[27]但這樣的輕量裝甲車輛發展難度太高，使得時程規劃一再延後，重量規格也不斷放寬，但還是無法順利推展。[28]此一困境終於導致原有「未來戰鬥系統」(Future Combat Systems, FCS)計畫中「載人地面車輛」(Manned Ground Vehicle, MGV)的部分慘遭取消。重組後的接續方案，被稱爲「地面戰鬥車輛」(Ground Combat Vehicle, GCV)，是一項爲了能盡早在 2017 年服役，而會在先進技術與壓低重量兩方面作出讓步的設計。[29]這樣的產品就算製造出來，也只是一種便於容納未來科技的當代平

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[27] 見：Mark Hewish, "Technology Transformation for Armored Warfare, Part I," *Jane's International Defense Review*, Vol. 36, No. 4(April 2003), pp. 33-47.

[28] Nathan Hodge, "Avenues of Approach," *Jane's Defense Weekly*, February 20, 2008, pp. 24-30; Daniel Wasserbly, "Brocken Future: US DoD Officially Moves to Restructure FCS Acquissition Programme," *Jane's International Defense Review*, Vol. 42, No. 8(August 2009), pp. 32-33.

[29] Daniel Wasserbly, "US Army Maps out Plans for Combat Vehicles," *Jane's Defense Weekly*, August 26, 2009, p. 10; Daniel Wasserbly, "US Army Outlines Future Combat Vehicle Plans," *Jane's Defense Weekly*, September 16, 2009, p. 14; Daniel Wasserbly, "US

台，等到相關的技術與裝備逐步成熟並逐一安裝升級之際，可能還是 2030 年以後。

空中載運工具的發展則面臨了不同的障礙，但結果卻很類似。優勢機動科技所構想的空中載運工具，是希望能結合現行固定翼飛機的航程、酬載、與速度，以及近似或等同於直昇機一般的起降性能。過去 20 年來研究的概念包括「超短場起降」(Super Short Takeoff and landing, SSTOL)、「空中機動運輸機」(Air Maneuver Transport, AMT)、「聯合重型舉升」(Joint Heavy Lift, JHL)、「先進聯合空中戰鬥系統」(Advanced Joint Air Combat System, AJACS)、與「聯合未來戰區空運」(Joint Future Theater Lift, JFTL)等等。嚴格的說，就算是稍稍超過預想規格的上限，這樣超級性能的空運機種，都不會超出現有科技的能力範圍，[30]其所面臨的問題是經費。以現在的進度作樂觀的推估，這樣的機種應可在 2020 年以後出廠，單價大約會在兩億美元左右，[31]個別而言雖屬合理，但要足夠載運旅級規模的部隊，得累積三四百架的機隊，需要 10 年以上的持續採購，所以還是在 2030 年以後才能實現。

另一方面，更根本的，優勢機動科技的構想是建立在缺漏、矛盾的假定之上，而且還會製造出新的弱點。優勢機動科技所設想有反介入威脅的大型區域戰爭，刻意遺漏了潛艦的威脅，假定敵人只會獲得彈道飛

Army's GCV Effort Starts to Take Shape," *Jane's Defense Weekly*, December 9, 2009, p. 10; Daniel Wasserbly, "FCS Projects Re-emerge in Wake of Future Combat Systems Demise," *Jane's International Defense Review*, Vol. 43, No. 2(February 2010), pp. 40-43.

[30] John Gordon IV, Peter A. Wilson, Jon Grossman, Dan Deamon, Mark Edwards, Darryl Lenhardt, Dan Norton, William Sollfrey, *Assessment of Navy Heavy-Lift Aircraft Options* (Santa Monica: RAND, 2005), pp. 3, 10-16; Gareth Jennings, "Threatre Lift Takes Centre Stage as Missions and Cargoes Increase," *Jane's International Defense Review*, Vol. 44, No. 4(April 2011), pp. 54-61; Peter Felstead, "Briefing: Big Birds," *Jane's Defense Weekly*, June 15, 2011, pp. 46-62.

[31] John Gordon IV, Peter A. Wilson, Jon Grossman, Dan Deamon, Mark Edwards, Darryl Lenhardt, Dan Norton, William Sollfrey, *Assessment of Navy Heavy-Lift Aircraft Options*, p. 54.

彈而不會獲得潛艦，是一種一方面悲觀一方面又樂觀的矛盾。一旦以潛艦載運飛彈，飛彈的打擊範圍就可再延伸數千公里，優勢機動科技構想下的超級載運機體，航程無法再作同等的延伸，部隊部署時的出發點也就不能再後撤，仍然在這種反介入戰力的威脅之下。對於潛艦構成的反介入威脅，美國在反潛作戰上的對策卻進展有限，可用反潛兵力甚至還在逐步弱化，[32]機動優勢科技的構想，對此根本沒有加以考慮。

同時，優勢機動科技雖想要避開潛在敵人對後勤設施的攻擊，但在朝這個方向努力時卻顧此失彼產生新的破綻，而易受另一些已經存在武器的威脅。優勢機動科技所欲發展的裝備，是以犧牲裝甲防護爲代價，雖然企圖以資訊科技彌補，但卻無法代替裝甲這最基本的防護措施。結果，優勢機動力所仰賴的空運機體本身就是新的要害：簡單用肉眼瞄準的槍砲就具備不對稱的優勢。這類武器因爲不發射任何電子信號偵測目標，所以很難在開火以前發現或壓制；發射之後也不需要導引，因此也無法干擾。[33]區域強權手中最不缺乏的就是這種低度科技的武器，以及操縱它們所需的大量人力，可以用最笨拙的方法來克制優勢機動：把防空砲火佈置在一切可能的要點。如此雖是備多力分，但只要能在交戰的火線上造成 1%的損失率（400 架中擊落 4 架）就成功了，這代表光是最初的侵入就會有十億美元以上的損失。從此我們不難發現，在 20 年內所能建立起的優勢機動能力，其實不能滿足其原始想定所需，這樣的裝備

[32] National Research Council, Naval Studies Board, Committee on Technology for Future Naval Forces, *Technology for the United States Navy and Marine Corps, 2000-2035 Becoming a 21st-Century Force: Vol. 7, Undersea Warfare* (Washington, D.C.: National Academy Press, 1997); “Quadrennial Defense Review Report 2010,” U.S. Department of Defense, p. 46.

[33] John Gordon IV, David E. Johnson, and Peter A. Wilson, “Air-mechanization: An Expensive and Fragile Concept,” *Military Review*, Vol. 37, No. 1(January/February 2007), pp. 63-73.

變得太強調其中一種能力，因而減損了其他達成任務所必須的素質，[34]無助於美國軍事優勢的維繫。

肆、長程打擊科技

第三項所構思維持美國軍事優勢的科技領域，是長程打擊。長程打擊科技所預期的想定，也是有反介入威脅的大型區域戰爭，意欲延伸武器系統的打擊範圍，免除前進部署的必要，從敵人打擊範圍之外直接進擊。這方面的企圖在 2001 年出現，[35]並反映在美國後續的政策規劃裡：2006 年版的「四年期國防總檢討」，宣示將在 2020 年以前部署新一代的長程打擊能力，並在 2025 年時增加 50％；[36]2010 年年度預算中雖未啓動研發計畫，但在 2010 年版的「四年期國防總檢討」中仍表示，已展開後續的研究以形成明確的需求。[37]長程打擊能力的主體必須是轟炸機這樣可重複使用的載台，[38]也必須能夠獨自侵入敵境上空而不需依賴距外(stand-off)武器，[39]消耗性的巡弋飛彈甚或彈道飛彈因成本十分昂貴，只能當作補充。[40]比起優勢機動科技所構想的裝甲車輛與載運機體，長程

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34 Jon Grossman, John Matsumura, Randall Steeb, John Gordon IV, Thomas J. Herbert, William Sollfrey, *Analysis of Air-Based Mechanization and Vertical Envelopment Concepts and Technologies* (Santa Monica: RAND, 2002), pp. 58, 75-77.

35 Malcolm Davis, "Beyond Stealth," *Jane's Defense Weekly*, January 15, 2003, p. 25.

36 "Quadrennial Defense Review Report 2006," *Global Security*, <http://www.globalsecurity.org/military/library/policy/dod/qdr-2006-report.pdf>(February 6, 2006), p. 6, 46.

37 "Quadrennial Defense Review Report 2010," U.S. Department of Defense, pp. 32-33.

38 John A. Tirpak, "Long Arm of the Air Force," A*ir Force Magazine*, Vol. 85, No. 10(October 2002), p. 30; Adam J. Hebert, "The Long Reach of the Heavy Bombers," A*ir Force Magazine*, Vol. 86, No. 11(November 2003), pp. 24-29.

39 Bill Sweetman, "US Finally Looks Beyond the B-2 for Long-range Strike Capability," *Jane's International Defense Review*, Vol. 39, No. 5(May 2006), pp. 40-45.

40 這部分的發展美國現在稱之爲「即時全球打擊」(Prompt Global Strike)，預備將一些

打擊科技核心的新一代轟炸機，其確切性能要求迄今尚無定論，大致上可以分成低風險與高風險兩個發展方向。但正也是從這兩個方面來看，低風險發展方向是建立在缺漏、矛盾的假定之上；高風險發展方向則是發展曠日廢時、緩不濟急。因此，長程打擊科技其實也無法維繫美國的軍事優勢。

低風險發展方向的著眼點，是力求能儘早在 2020 年以前發展出可服役的機體。按照現在的推想，這樣的機種可能會類似現役隱形轟炸機但卻是無人的，或是先保留座艙待日後再選擇性地轉換成無人機，以減少技術風險，增加任務彈性。[41]在此，無人的用意並不是減少人員的傷亡（這類機種將十分昂貴，就是無人也不容損失），[42]而是擺脫人體的限制以延長滯空時間，減少長途往返基地與目標區的次數。[43]這種構想所需要的技術幾乎都是現在已經成熟，或是已有較小尺寸原型機如「穿透高高度耐久」(Penetrating High Altitude Endurance, PHAE)或「無人空中戰鬥系統展示」(Unmanned Combat Aerial System Demonstration, UCAS-D)的計畫再進行，[44]只要有後續的經費挹注，服役是指日可待。但這種發

原有的核子飛彈改裝高精度的傳統彈頭，以在一兩個小時之內攻擊全球各地的目標。可見：Bill Sweetman, "Any Time, Any Place, Anywhere: Us Puts Emphasis on Prompt Global Strike Ability," *Jane's International Defense Review*, Vol. 40, No. 4(April 2007), pp. 32-33; Caitlin Harrington, Sam LaGrone, and Daniel Wasserbly, "Silver Bullets: US Seeks Conventional Weapons with a Global Reach," *Jane's International Defense Review*, Vol. 43, No. 9(September 2010), pp. 50-53.

41 Caitlin Harrington, "Top DoD Official Urges Revision to Long-range Bomber Plans," *Jane's Defense Weekly*, June 11, 2008, p. 9

42 Bill Sweetman, "Revolution or Curiosity? UCAVs Wait for a Mission Statement," *Jane's International Defense Review*, Vol. 38, No. 12(December 2005), pp. 47-51.

43 Damian Kemp, Caitlin Harrington, Denis Fedutinov, "Removing the Human Factor: Air Force Eye Unmanned Bomber," *Jane's International Defense Review*, Vol. 41, No. 5(May 2008), pp. 50-53.

44 Nick Cook, "Skunk Works Unveils Polecat," *Jane's Defense Weekly*, July 26, 2006, p. 4; Gareth Jenning, "USN's X-47B UCAV Makes First Showing," *Jane's Defense Weekly*, January 7, 2009, p. 8.

展方向既然避開大部分的技術挑戰，就不可能應用什麼先進技術，[45]就算是無人而具有種更長的滯空時間，也只是與任務次數作交換，整體而言不過等於是恢復 1990 年代時，本來還要量產的那一百餘架載人隱形轟炸機而已。

這種低風險的發展方向反映的，就是種缺漏、矛盾的狀況想定。除了前述彈道飛彈對於前進基地所構成的反介入威脅，潛在敵手可能也會取得新型防空飛彈系統，形成另一種反介入戰力，因而需要利用與現有隱形轟炸機一般的匿蹤（stealth，或曰低可視 low observable）技術來穿透防空網。[46]然而，正如同前文所述對於潛艦的刻意忽略，這樣的想定又再刻意忽略了以先進戰機構成的反介入戰力，假定敵人只會獲得防空飛彈而不會獲得戰機，也是一種一方面悲觀一方面又樂觀的矛盾。不同於防空飛彈，戰機具有更高的智慧（飛行員）、速度、與續航力，可以自行在較大的範圍內搜尋目標。匿蹤科技主要的作用只是減少被精確偵測的機會，而無法完全隱瞞機體的行蹤，而今隨著電腦處理能力的一日千里，各種偵測前追蹤(track before detect)技術的發展，[47]匿蹤科技更是難以防止對手的概略偵測，而這樣的概略偵測雖然不足導引防空飛彈，但已足夠指引戰機進行攔截。畢竟，匿蹤技術無論如何仍對肉眼無效，目前美國空軍並不在白晝使用隱形轟炸機，就是為了避免與敵人戰機不期而遇被目視發現。就算提高飛行高度可讓極高空（七萬五千呎以上）天

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45 Caitlin Harrington, “USAF Keeps Sight Set on New Long-range Bomber,” *Jane’s Defense Weekly*, May 20, 2009, p. 10.

46 Mark A. Gunzinger, “Sustaining America’s Strategic Advantage in Long-Range Strike,” *Center for Strategic and Budgetary Assessments*, <http://www.csbaonline.org/4Publications/PubLibrary/R.20100914.Sustaining_America/R.20100914.Sustaining_America.pdf>(September 14, 2010), pp. ix-xi.

47 Mark Hewish and Charles Gilson, “Cruise Control,” *Jane’s International Defense Review*, Vol. 34, No. 9(September 2001), pp. 50-52; Bill Sweetman, “Worth the Cost?” *Jane’s Defense Weekly*, July 19, 2006, pp. 59-63.

然的持續黑暗即可不分晝夜地遮蔽機體，[48]但黑夜並無法阻止紅外線系統的偵測，而且極高空之中更沒有干擾紅外線系統運作的各種天候。於是，這種低風險方向下發展出來的機種，充其量只能在相對比較溫和、沒有敵方先進戰機活動的空域行動，稱不上是維持美國的軍事優勢。

一旦同意有潛艦與戰機威脅的徹底最壞狀況假定，就必須採取高風險的發展方向。這樣的機種不僅需長航程與匿蹤設計，來因應彈道飛彈與防空飛彈的反介入威脅，還需要高速來減少往返於更後方基地（美國本土）與目標區的飛行時間，並避開敵方戰機的攔截。的確，超音速乃至倍音速飛行都已是半世紀前的成熟技術，目前甚至已有超音速私人飛機的構想，[49]本身並不是什麼技術挑戰。只是，速度、高度、匿蹤、長時間滯空、與長程飛行，這些能力分開來不是問題，結合在一起就會衍伸出許多挑戰。匿蹤與超音速飛行所需的外型相衝突，[50]而高速與長程長時間飛行也需要不同的引擎特性，這些都是目前沒有現成發展計畫的範圍。[51]此外是噪音，要具備足夠的航程、滯空時間、與武器酬載，可能會導致相當巨大的機體，而巨型的超音速機體會產生很大的音爆，不僅會在操作與訓練上會造成困擾（目前許多法令仍禁止穿越陸地上空的超音速飛行），甚至也可能被敵方的防空網當作初步指引的依據，引導其

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[48] Bill Sweetman and Stephen Trimble, “Few Signposts for LRS,” *Jane’s Defense Weekly*, July 26, 2006, p. 22.

[49] 例如，超音速航太國際(Supersonic Aerospace International, SAI)在 2004 年即提議了一個名為「寧靜超音速客機」(Quiet Supersonic Transporter, QSST)的商用計畫，潛在客戶是鎖定在全球 300 個極度富有的企業或個人，預計是一架長約 40 公尺、擁有 12 人座客艙、重量 70 噸，可以 1.6 至 1.8 馬赫巡航的私人商務客機，可見：Nick Cook, “Skunk Works Shakes Up Major Projects,” *Jane’s Defense Weekly*, February 14, 2007, p. 5; Bill Sweetman, “Skunk Works Plans Worldwide Network of Thunderbirds-style Supersonic Jets,” *Jane's Information Group*, <http://www.janes.com/transport/news/misc/janes060727_1_n.shtml>(July 27, 2006)

[50] Caitlin Harrington, “Race Starts for Long-range Strike,” *Jane’s Defense Weekly*, October 4, 2006, p. 12.

[51] Bill Sweetman and Stephen Trimble, “Few Signposts for LRS,” p. 22.

他的感測器進行追蹤。[52]為了解決這些困難，可能會需要更高的飛行速度與高度，以完全擺脫大氣內的防空威脅，這都會再增添所需科技的困難度。[53]不諱言，比起優勢機動科技所設想的裝甲車輛與載運機體，這樣高風險發展方向下的長程打擊機體，所要載運的不是部隊裝備而是直接殺傷敵人的武器彈藥，相對輕小且不需要機體進入敵人低度科技的反擊範圍，確實是可行性較高也不會顧此失彼出現弱點，但仍需要相當的時間才能克服各種技術挑戰，這樣曠日廢時、緩不濟急的途徑，仍無法維繫美國的軍事優勢。

伍、導能武器科技

第四項所構思維持美國軍事優勢的科技領域，是導能武器。導能武器是一系列武器的通稱，特徵是不發射任何實體彈頭，而直接發射電磁能量傳遞破壞，以光速運行可瞬間通過數百甚至數千公里的距離，[54]不是現在以火箭動力推進的飛彈所能比擬，因而可以在飛彈尚在升空加速階段，還未放出彈頭與干擾措施以前，迅速、大量地予以截擊。迄今研究較多的導能武器主要有兩種，其一是高能雷射武器，以雷射能量引爆易燃的火箭燃料，另一種則是高能微波武器，則以微波能量破壞飛彈的電子系統。[55]這類的構想是 1980 年代「戰略防衛先機」計畫的重點，而

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[52] Bill Sweetman, “Skunk Works Confident over Supersonic Design for LRS,” *Jane's Defense Weekly*, August 2, 2006, p. 19.

[53] Caitlin Harrington, “US to Issue RfP for Hypersonic Aircraft Work,” *Jane's Defense Weekly*, March 12, 2008, p. 10; Richard P. Hallion, “Hypersonic: Time is Now,” *Jane's Defense Weekly*, June 20, 2007, p. 23.

[54] Gerd Wollman, “Directed Energy Weapons: Fact or Fiction?” *Military Technology*, Vol. 27, No. 4(April 2003), pp. 80-85.

[55] Tony Skinner, “Seeing the Light” *Jane's Defense Weekly*, April 16, 2008, pp. 22-27; Bill

其科技的發展往前至少也可追溯至 1970 年代，往後則一直延續到目前的飛彈防禦計畫，[56]而有空載雷射(Airborne Laser, ABL)測試機的出現。[57]不同於迷你無人科技、優勢機動科技、或長程打擊科技，在邏輯上，導能武器科技確實能夠維繫，甚至能擴大美國的軍事優勢。然而，在實際上，導能武器的發展雖有四十餘年的努力、也有冷戰高峰期的源源經費挹注，但迄今仍無太多突破。2010 年與「四年期國防總檢討」一同提出的「彈道飛彈防禦檢討報告」(*Ballistic Missile Defense Review Report*)中，即再進一步推遲了相關的研發，並取消空載雷射第二架測試機的建造，[58]反映了技術上嚴峻的障礙。在無法從理想進入實現的情況下，導能武器科技遂也無法維持美國的軍事優勢。

在邏輯上，導能武器科技的革命性，在於它能突破當前的核子相互保證毀滅(Mutually Assured Destruction, MAD)，也是美國軍事優勢迄今無法撼動的障礙。如同美國 2010 年「核子態勢報告」(*Nuclear Posture Review Report*)所反映，美國目前的軍事優勢並不及於核子領域，美國與俄國的核武裁減條約，仍承認俄國在核子武力上有與美國對等的地位。[59]

Sweetman, "Fact or Fiction?" *Jane's Defense Weekly*, February 22, 2006, pp. 24-29; Roman Schweizer, "Directed Energy Weapons: Lighting the Way for the Next Revolution at Sea," *Naval Forces*, Vol. 26 No. 2(February 2005), pp. 52-55.

[56] 飛彈防禦計畫中迄今已實現的，都還是以飛彈攔截飛彈的系統。見：Richard Scott, "Setting Higher Standers: Missile Line Takes Aim at New Targets," *Jane's International Defense Review*, Vol. 42, No. 5(May 2009), pp. 40-46; Doug Richardson, "Boosting Missile Defense: Technologies Focus on Early Interception Challenges," *Jane's International Defense Review*, Vol. 43, No. 1(January 2010), pp. 32-33; Richard Scott, "Aiming High," *Jane's Defence Weekly*, January 7, 2009, pp. 22-27.

[57] David R. Tanks, *National Missile Defense: Policy Issues and Technological Capabilities* (Cambridge: Institute for Foreign Policy Analysis, 2000).

[58] "Ballistic Missile Defense Review Report 2010," *U.S. Department of Defense*, <http://www.defense.gov/bmdr/docs/BMDR%20as%20of%2026JAN10%200630_for%20web.pdf>(February 1, 2010), pp. 11-12, 40-41.

[59] "Nuclear Posture Review Report 2010," *U.S. Department of Defense*, <http://www.defense.gov/npr/docs/2010%20nuclear%20posture%20review%20report.pdf>(April 7, 2010), p. v.

核子飛彈結合了速度與破壞力的，使得對之的防禦極其困難：洲際彈道飛彈兩小時之內即可達到全球任何一個角落，攔截的時間只有這短短的兩小時；而同樣因爲核子飛彈的速度是如此之快，絕大多數的武器都只能望之興嘆。目前，能夠攔截核子飛彈的武器，只得是另一枚同樣使用火箭動力推進的飛彈，速度上究竟無法超越因而困難重重。[60]何況，核子彈頭的威力又是如此之大，一枚可產生數十萬噸炸藥威力的核彈，重量也不過是數百公斤，只要一枚彈頭即足以摧毀一座數十萬人口的都市，面對成百上千的來襲彈頭，即使能部分予以截擊也無濟於事。導能武器可以改變的這樣的現象，它雖然不會使其他的武器全然失去價值，但只要導能武器出現就必須先在導能武器上競爭，直到形成彼此抵銷的均勢，才會轉以其他次級的武器進行競爭。類似冷戰時代美蘇是先在核子武器上競爭，當相互保證毀滅的均勢逐漸形成，雙方才重回傳統武器的範疇競爭。[61]意即，如果美國率先將導能武器實用化，將可重現美國在二次大戰之後的核子獨佔，所擁有的軍事優勢將比今日更絕對、更全面。

就是因爲有此一對核子武器的影響，另一些常被提及的新奇構想與科技，[62]都無法產生與導能武器科技相同的作用。人類或許還能研發出威力更強大的超級武器，但正因爲核子武器的破壞力已經過量，更大的破壞力也逃不出恐怖平衡的嚇阻邏輯，此一邏輯也就說明了一系列未來可能的破壞方式，爲何不都會具有革命性。譬如說，虛擬空間的資訊攻

[60] 可參閱：Michael Sirak, “The End Game,” *Jane’s Defense Weekly*, September 15, 2004, pp. 24-29.
[61] 參見：John J. Mearsheimer, *Conventional Deterrence* (New York: Cornell University Press, 1983); Austin Long, *Deterrence from Cold War to Long War: Lessons from Six Decades of RAND Research* (Santa Monica: RAND, 2008).
[62] 可參閱：John B. Alexander, *Future War* (New York: Thomas Dunne Books, 1999).

擊或網路戰，[63]的確是無遠弗屆且在電光火石之間，也能對資訊社會產生很大的損害，[64]但這究竟只是停擺而不是實體的毀滅。類似的，電磁脈衝(electromagnetic pulse)武器就算能瞬間破壞幾千公里範圍內或深埋地底的電子儀器，卻不能摧毀建築與生物；[65]而基因武器雖能殺人於無形，甚至可以有物種的針對性，但卻也只是殺人而不毀物。無論這類新奇的破壞方式多麼有效、多麼難以防禦，它們的威力都不會超過核子飛彈，充其量不過是在衝突升級階梯上的較低位置，只是把戰略核武之下已被限武談判捨棄的各級戰術核武，又再加回去而已。

同樣的道裡，新的投射工具在核子武器固有的性質之下，也不會有革命性。譬如，可能在 2030 年或 2040 年以後，就可以製造出以超音速燃燒衝壓引擎(supersonic combustion ramjet, scramjet)為動力，[66]可以十馬赫高超音速飛行在大氣層邊緣的近太空飛機，並作為太空軌道發射載具。[67]這種工具是可像彈道飛彈一般，在一兩小時內攻擊全球任何一點，但更具重複使用的經濟性。只是，核子彈頭已經是一種太輕的酬載了，核子戰爭一旦爆發也許在幾小時之內就結束，短時間的最大投射數量才

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[63] 可參閱：Tony Skinner, “War and PC,” *Jane’s Defense Weekly*, September 24, 2008, pp. 38-45; Gerrard Cowan, “Defending against a New King of Warfare,” *Jane’s Defense Weekly*, July 8, 2009, p. 25; Levi Gundert, “Total Gridlock: Cyber Threat to Critical Infrastructure,” *Jane's Intelligence Review*, Vol. 21, No. 11(November 2009), pp. 25-27.

[64] Joseph S. Nye Jr., *The Paradox of American Power: Why the World's Only Superpower Can't Go It Alone* (New York: Oxford University Press, 2002), p. 41.

[65] 其實，這樣大的殺傷範圍需要核武來當作能量來源，如果只以傳統炸藥為能量來源，破壞範圍可能還不如同重量的炸藥。可見：Doug Beason, “The E-Bomb: Changing the Way Future Wars Will Be Fought,” *RUSI Defence Systems*, Vol. 9, No 1(Summer 2006), pp. 90-93; Bill Sweetman, “Full Power Ahead?” *Jane’s Defense Weekly*, August 30, 2006, pp. 22-26.

[66] 目前相關的技術正在飛行實驗階段，可參閱：Gareth Jennings, “Boeing prepares X-51A Vehicle for Hypersonic Flight,” *Jane’s Defense Weekly*, May 27, 2009, p. 10;.Gareth Jennings, “WaveRider Begins Launch Aircraft Integration Trials,” *Jane’s Defense Weekly*, August 12, 2009, p. 7.

[67] Bill Sweetman, “Final Frontier Revisited: the US Responds to Space Requirements,” *Jane’s International Defense Review*, Vol. 39, No. 6(June 2006), pp. 56-61.

是最重要的，根本不必算計那末日之後的平均壽期成本。類似的，目前研究中的電磁砲(electro-magnetic guns)雖然更是種全然不同的投射工具，不必以燃燒排氣產生推力，而直接以電磁能源加速，[68]但就算日後能製造出射程及於全球的裝置，[69]其以繁複設施發射簡單砲彈所希望獲致的，也是在核子戰爭中那失去意義的重複使用經濟性。

儘管在前述的邏輯中，導能武器因爲能有效攔截核子飛彈，故足以維繫甚至擴大美國的軍事優勢，但導能武器在實際上卻面臨極大的技術障礙。以過去 40 年的發展而言，導能武器的發展是步履蹣跚而進展有限，命運多舛曲折。雷射與微波用於通訊或偵測已有很久的歷史，但要進一步成爲武器，最大的困難就在於「高能」：如何提高能量轉換效率並解決能源供應與散熱問題，以持續發出高功率的電磁能量、產生足夠的破壞力。意即，難題是如何縮小系統並延伸射程。一些可用於爆裂物處理、暴動控制、或反砲兵任務的短程的系統已經接近實用程度，[70]但真正有革命性意義的長程系統，仍只處於實驗階段，迄今所進行過所謂成功的測試，大多也只是在模擬或實驗條件下，距離全系統的實戰環境應用，還有一段很大的距離。[71]在這理想與現實的落差之下，導能武器科

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[68] Andrew Koch, "Electro-magnetic Railguns: Fire Support Revolution," *Jane's Defense Weekly*, April 16, 2003, p. 5; Richard Scott, "Off the Rails," *Jane's Defense Weekly*, May 23, 2007, pp. 24-27.

[69] 目前的計畫目標，是在 2020 至 2025 年造出射程超過兩百浬，彈頭速度約七倍音速的電磁砲。可參閱：Nick Brown, "Make or Break: Trials Hold the Key to US Navy's Firepower Decision," *Jane's International Defense Review*, Vol. 41, No. 4(April 2008), pp. 52-58.

[70] Richard Scott, "USN Seeks to Add Phalanx Laser Engagement Capability," *Jane's International Defense Review*, Vol. 42, No. 10(October 2009), p. 24; Nick Brown, "US Navy Successfully Tests Laser with Close-in Weapon," *Jane's Defense Weekly*, July 14, 2010, p. 6.

[71] 可參閱： Andrew Koch & Nick Cook, "US DoD Push for Laser, Microwave Weapons," *Jane's Defense Weekly*, August 7, 2002, p. 8; Andrew Koch, "Navy Directed-energy Programme Moves On," *Jane's Defense Weekly*, September 1, 2004, p. 12; John McHale, "The Airborne Laser: It's Huge, It Flies, and It Blows up Missiles," *Military & Aerospace Electronics*, Vol. 15, No. 8(August 2004), pp. 20-25; Michael Sirak, "USAF Faces Highs

技也無法維持美國的軍事優勢。

陸、結語

從本文的分析可以發現，美國近 20 年來所構思、努力的四項新軍事科技領域，迷你無人科技、優勢機動科技、長程打擊科技、與導能武器科技，其實都是錯誤的方向，無法達到發展的初衷、無助於維繫美國的軍事優勢。迷你無人科技，不僅是發展緩不濟急，應用價值也還是在反叛亂式的低強度衝突，其實是以美國軍事優勢爲前提，而不能維持此一優勢。優勢機動科技，雖著眼於大型區域戰爭想定，及與日俱增的反介入威脅，發展卻也是緩不濟急，同時更是建立在缺漏、矛盾的假定上，還會製造出新的弱點，無法維持美國的軍事優勢。長程打擊科技，同樣是出於有反介入威脅的大型區域戰爭想定，但這不是建立在缺漏、矛盾的假定之上，就是發展曠日廢時、緩不濟急，亦無助於維持美國的軍事優勢。至於導能武器科技，雖然是真正有革命性，但這在邏輯上的理想，卻無法克服多年來在實踐上的挫折，仍無助於美國軍事優勢的維繫。不諱言，爲了在永遠無法肯定的未來中防範萬一，美國很難完全停止這四

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and Lows of Directed Energy," *Jane's Defense Weekly*, April 20, 2005, p. 4; Nick Brown, "Beam on: Directed Energy Weapons Get Charged up for Use on the Battlefield," *Jane's International Defense Review*, Vol. 41, No. 9(September 2008), pp. 77-80; Scott R. Gourley, "The Return of Directed Energy Weapons: New Applications Spawn Global Interest," *Jane's International Defense Review*, Vol. 43, No. 5(May 2010), pp. 62-65. 就以研發最久，但仍被取消第二架測試機的空載雷射系統而言，整個計畫進度已經落後了 8 年之久，預算也超支了 40 億美元之鉅。針對空載雷射 2010 年年初測試的結果，美國空軍參謀長表示，儘管那是「重大的技術成就」，但仍「不是某種作戰上可行的東西」。見：Michael Hoffman, "Schwartz: Get those AF Boots off the Ground," *Air Force Times*, <http://www.airforcetimes.com/news/2010/02/airforce_ budget_022610w/>(March 1, 2010).

項科技的發展，但美國恐怕得在其他軍事科技中進行更多方的探索與研究，並擴大對既有科技成熟產品的採購規模，才能有效維持美國的軍事優勢於不墜。

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Sustaining the Preponderance? Critiques on the Four Current US Military Technologies

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Abstract

US military preponderance is increasingly endangered, and four novel approaches are thus envisaged to sustain this preponderance: mini unmanned technologies, dominate maneuver technologies, long range strike technologies, and directed energy weapon technologies. However, all these technologies are either facing formidable technical obstacles, taking too long to realize, driven by problematic assumption, or creating new defects. In sum, none of these four technologies could sustain US military preponderance.

Keywords
US Military Preponderance, Mini Unmanned Technologies, Dominate Maneuver Technologies, Long Range Strike Technologies, Directed Energy Weapon Technologies