

拜拉克塔爾 TB-2 無人機與投彈型四軸飛行器：

烏俄戰爭與納卡衝突凸顯現行防空弱點及無人機需求*

Bayraktars TB-2 and Grenade-Dropping Quadcopters: How Ukraine and Nagorno-Karabakh Highlight Present Air and Missile Defense Shortcomings and the Necessity of Unmanned Aircraft Systems

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The increased use of unmanned aircraft systems (UAS) in modern war is no surprise. Modern drones provide outstanding aerial capabilities at all echelons, from a frontline infantry soldier using a small, commercial quadcopter to surveil enemy positions, to large UAS equipped with advanced precision munitions and the ability to operate beyond line of sight from its operator. Necessarily, armed groups seek to counter their adversaries' UAS capabilities by destroying, disabling, or negating them and their effects on the battlefield.

前言

在現代戰爭中，無人機系統使用率日益增加並不令人意外，因為現代無人機可為各層級部隊提供卓越的空中能力，舉凡從前線步兵使用小型、商用四軸飛行器來監視敵位置，乃至配備先進精準彈藥，以及在視距外操作的大型無人機系統。武裝團體必然會在戰場上運用硬殺摧毀、阻斷信號、或讓無人機運作失效等手段，從而反制對方的無人機系統能力。

While we can look to almost any conflict fought in the last decade for important lessons on the use and countering of UAS, two of the most recent conflicts provide numerous examples of how modern militaries are fighting the

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UAS fight. The 2020 Nagorno-Karabakh war between Armenia and Azerbaijan saw widespread use of UAS but also the weaponization of information about that use. The ongoing war in Ukraine reinforces many observations from Nagorno-Karabakh, but it also shows how modern warriors not only would prefer to have, but inherently require, UAS at the lowest echelons. Russian's full-scale invasion of Ukraine reveals how small UAS (sUAS), sometimes purchased commercially or even donated through crowdfunding campaigns, can provide an offensive capability against a larger, technologically capable adversary.

雖然我們可以從過去十年間各場衝突中獲致運用與反無人機系統的經驗教訓，但毋須捨近求遠，近期兩場戰事即已提供眾多實際例證說明當代軍隊如何應對無人機戰爭：一是 2020 年亞美尼亞與亞塞拜然兩國在納戈爾諾－卡拉巴赫地區（簡稱納卡區）武裝衝突中，我們可以看見無人機不僅獲得廣泛使用，還作為資訊宣傳的武器；二是當前烏俄戰爭強化許多從納卡區得到的觀察，說明當代戰士不僅希望擁有、也需要無人機支援基層部隊的作戰行動。俄羅斯對烏克蘭的全面入侵凸顯小型無人機系統之重要性，不管是經由商業管道購買，甚或透過群眾籌資所捐贈，它們的攻勢能力足以對抗強大科技能力之敵。

The numerous lessons could likely fill an entire journal, so this article focuses on four lessons: First, we saw the effective use of one specific UAS platform in both conflicts: the Turkish-produced Bayraktar TB-2. The TB-2 flew into popular war songs and crowdfunding campaigns as the world watched clip after clip of TB-2s effortlessly destroying enemy air defenses, tanks, command posts, and supply convoys.¹ With its lethal effects on the battlefield, the TB-2 and similar UAS will undoubtedly be ubiquitous in future conflicts. Second, all sides of the conflicts have used UAS in information operations. The abilities of UAS on the battlefield have captured the public mind, and government information outlets have capitalized on that by publishing video feeds from their UAS or sharing statistics and footage of their forces destroying an enemy's UAS. Third, more specifically in Ukraine, military forces have acquired drones outside their military procurement channels to equip frontline forces with sUAS to execute the tactical fight, often with strategic effects. While not a new tactic in war, Ukrainian and Russian forces alike have made widespread use of modifying commercial sUAS to drop munitions on enemy forces, providing their forces with an accurate, immediately correctable offensive weapon. Fourth,

despite the widespread use and success of UAS, both conflicts reveal how present air defense systems and tactics currently fail to provide adequate counter-UAS (C-UAS) defense against these threats.

本文囿於篇幅並無法探討納卡衝突與烏俄戰爭中眾多的經驗教訓，因此著重於以下四項重點：

一、我們在兩場戰事中看見有效運用特定的無人機系統，也就是土耳其製拜拉克塔爾 TB-2 無人機，該型無人機已成為現代戰爭中的元素，還是群眾募資購置武器的首選，它輕易摧毀敵防空、戰車、指揮所及補給車隊等諸多影片，不斷在網路世界流通並為人觀看。¹ 由於 TB-2 無人機在戰場上的致命成效，無疑將讓其與同類型無人機在未來衝突中為人所青睞。

二、兩場戰事中的各方都將無人機系統運用於資訊戰上，不僅無人機在戰場上表現已吸引公眾目光，而且政府資訊媒體管道也獲益於發布自家無人機影片，或是公布摧毀敵無人機的統計數據。

三、值得一提的是，烏克蘭軍隊已經從非軍事採購管道獲得 TB-2 無人機，供前線部隊運用於戰術作戰，這種無人機作戰方式將帶動大規模戰略效應。雖然這並非戰爭中的新戰術，但不管是烏軍或俄軍都大量使用經構改的商用小型無人機向敵軍施放彈藥，也成為各自部隊一種準確、可即時修正的攻勢武器。

四、雖然無人機在兩場戰事中廣泛為人運用與戰績顯著，但背後也凸顯目前防空系統與戰術不足以反制無人機這類威脅。

These lessons reveal critical shortcomings in the United States' C-UAS—specifically C-sUAS—capabilities, as well as the lack of organic tactical sUAS capabilities, training, and fielding for use by our forces. Future conflicts, regardless of the adversary, will inevitably require U.S. forces and our allies to protect against enemy UAS. As the conflicts show, any viable C-UAS program requires widespread air defense and force protection capabilities at all echelons, not just one short-range air defense (SHORAD) battalion per Army division that rarely, if ever, train together. It will require novel C-sUAS capabilities and tactics in addition to traditional SHORAD and C-UAS defense. And, just as important as negating an adversary's UAS is providing the benefits of such UAS to friendly forces at all echelons and for all types of units.

1 Mark Krutov, "'Show What You Can Do!' Lithuanian Citizens Raise \$6 Million to Buy an Attack Drone for Ukraine," Radio Free Europe/Radio Liberty, 1 June 2022, <https://www.rferl.org/a/ukraine-lithuanian-bayraktar-crowdfunding/31878797.html>; Сухопутні війська України [Land force of Ukraine], "Капа за українських дітей; грузинів, сирийців, чеченців; та кримських татар – Bayraktar" [Punishment for Ukrainian children; Georgians, Syrians, Chechens; and Crimean Tatars – Bayraktar], Instagram video, 28 February 2022, https://www.instagram.com/tv/CaiTrp_DMx5/?igshid=YmMyMTA2M2Y=.

這些經驗教訓也是在提醒美國反無人機能力遠遠不足，尤其是在反小型無人機能力方面，而且也應強化部隊的小型無人機建制戰術能力、訓練及實戰運用等。面對未來衝突之敵，美國及其盟友都須保護自家軍隊免受無人機之威脅。誠如這些衝突所示，任何可行的反無人機計畫都需要在各層級部隊廣泛部署防空兵火力能力，不能單靠每個美陸軍師中的短程防空營，更何況這些營鮮少有機會在一起共同訓練。除了傳統的短程防空與反無人機防禦外，美軍還需要新式反小型無人機能力與戰術，同樣重要的是，在對抗敵無人機的同時，也要為友軍各層級部隊和各軍兵種提供這類無人機的優勢作戰能力。

Bayraktars in Nagorno-Karabakh and Ukraine

For decades, the United States and other technologically advanced militaries were the only ones with the technical expertise and money to put unmanned aircraft in the sky. However, as both military-designed and commercial drones become cheaper, more plentiful, and easier to operate, they will continue to proliferate to militaries and armed groups around the world, bringing their deadly capabilities with them.²

在納卡區與烏克蘭的拜拉克塔爾 TB-2 無人機

過去數十年來，只有具備專業技術與資金的美國和一些軍事科技先進國家，才有能力發展無人機系統。不過，隨著軍用與商用無人機成本逐漸下降、種類眾多及操作更為便利，它們開始在各國軍方及全球武裝團體中廣泛使用，也帶給使用者致命的攻擊能力。²

Take the Azeri's Bayraktar TB-2s. When Azerbaijan launched its offensive against Armenian and Artsakh forces in 2020, it made effective use of the TB-2s. It destroyed Armenian air defenses, tanks, battle positions, and much more, thereby enabling ground forces to maneuver effectively against Armenian forces and rapidly advance through the territory of Nagorno-Karabakh.³ Armored assets in fortified battle positions with cover and concealment as well as air defense systems actively searching for air tracks were not safe from Azeri TB-2s.⁴ Yet, Azerbaijan had only just acquired the TB-2 a few months prior to the war. The government announced the acquisition in June 2020 and were employing them on the battlefield by November 2020.⁵ Similarly, Ukraine received its first TB-2s in July 2021 and used them

2 Michael C. Horowitz, Sarah E. Kreps, and Matthew Fuhrmann, "Separating Fact from Fiction in the Debate over Drone Proliferation," *International Security* 41, no. 2 (Fall 2016): 11–12, <https://www.jstor.org/stable/24916748>; Andrea Gilli, *Drone Warfare: An Evolution in Military Affairs*, NDC Policy Brief No. 17 (Rome: NATO Defense College, October 2022), 1.

for its first kinetic strike in the Donbas region against militants of the Donetsk People's Republic on 26 October, just three months later.⁶ Ukraine's acquisition and use of such an advanced UAS was a potential impetus, or at least a purported one, for Russian President Vladimir Putin's decision to begin building up forces along the Ukrainian border before the full-scale invasion on 24 February 2022.⁷

以亞塞拜然的拜拉克塔爾 TB-2 無人機為例，亞塞拜然在 2020 年運用 TB-2 無人機作戰能力向亞美尼亞與阿爾察赫共和國發動攻勢時，摧毀亞美尼亞的防空系統、戰車、作戰陣地，甚至還促成地面部隊直搗亞美尼亞軍事基地，加速向納卡區之推進。³即使是隱蔽與掩蔽在堅固作戰陣地的戰甲車，以及主動搜尋的防空追蹤系統，也都無法倖免於亞塞拜然的 TB-2 無人機攻擊。⁴亞塞拜然是在戰爭前幾個月預先籌獲 TB-2 無人機，也就是政府在 2020 年 6 月宣布採購計畫，緊接著在 11 月時將之部署於戰場。⁵同樣地，烏克蘭在 2021 年 7 月接收首批 TB-2 無人機，並僅在 3 個月後（10 月 26 日）就首度運用其硬殺打擊火力，對付位於頓巴斯地區的頓涅茨克人民共和國武裝份子。⁶俄羅斯總統普丁於 2022 年 2 月 24 日全面入侵前先在烏克蘭邊境集結軍隊，當時烏克蘭手上的 TB-2 無人機儼然成為嚇阻俄國的最佳利器。⁷

Both Azerbaijan and Ukraine were able to acquire, field, and employ the TB-2 in just a few months. While both militaries are relatively modern and well-equipped, they are not what the United States would typically consider near-peer or a comparable conventional adversary. This shows how easily modern militaries can acquire, train on, and effectively deploy a UAS comparable to the

3 Edward J. Erickson, "How Do We Explain Victory? The Karabakh Campaign of 2020," in *The Nagorno-Karabakh Conflict: Historical and Political Perspectives*, ed. M. Hakan Yavuz and Michael M. Gunter (New York: Routledge, 2023), 236–41; Gilli, *Drone Warfare*, 3.

4 See John Antal, *7 Seconds to Die: A Military Analysis of the Second Nagorno-Karabakh War and the Future of Warfighting* (Philadelphia: Casemate, 2022).

5 Burak Ege Bekdil, "Azerbaijan to Buy Armed Drones from Turkey," *Defense News*, 25 June 2020, <https://www.defensenews.com/unmanned/2020/06/25/azerbaijan-to-buy-armed-drones-from-turkey/>.

6 See "Ukrainian Military Gets First Turkish Bayraktar UAV Complex," *Ukrinform*, 15 July 2021, <https://www.ukrinform.net/rubric-defense/3281272-ukrainian-military-gets-first-turkish-bayraktar-uav-complex.html>; Tayfun Ozberk, "Turkey Delivers First Armed Drone to Ukrainian Navy, Much to Russia's Ire," *Defense News*, 26 July 2021, <https://www.defensenews.com/unmanned/2021/07/26/turkey-delivers-first-armed-drone-to-ukraine-much-to-russias-ire/>. 烏克蘭首度運用 TB-2 無人機，參見 Генеральный штаб ЗСУ [General Staff of the Armed Forces of Ukraine], "From 14:25 to 15:15, a battery of howitzers D-30 of the Russian terrorist forces fired on the positions of the joint forces in the area of the settlement of Hranitne," Facebook video, 26 October 2021, <https://www.facebook.com/watch/?v=467614907881638>; "Ukraine Uses Turkish Drone against Russia-Backed Separatists for First Time," *Radio Free Europe/Radio Liberty*, 27 October 2021, <https://www.rferl.org/a/ukraine-turkish-drone-separatists/31532268.html>.

7 Andrew E. Kramer, "How a Dispute over Groceries Led to Artillery Strikes in Ukraine," *New York Times*, 15 November 2021, <https://www.nytimes.com/2021/11/15/world/europe/ukraine-russia-war-putin.html>.

TB-2's capabilities. While such systems are surely not impervious to current air defenses, video feeds from both conflicts show a startling ability to fly directly above enemy air defenses unthreatened, targeting and destroying them instead.

雖然亞塞拜然與烏克蘭都能在短短幾個月內獲得、使用和部署 TB-2 無人機（如表 1），兩國軍隊也都相對現代化且裝備精良，但它們實力卻不是美國所界定的近乎匹敵者或足以較量的常規對手。不過，從另一角度而言，現代化軍隊都有能力輕易獲得、從事訓練並有效部署與 TB-2 無人機作戰能力相當的無人機系統。儘管無人機系統並不一定能完全免疫於防空系統，但來自這兩場戰事的影片畫面顯示，無人機有能力在不受敵情威脅下直接突破敵防空系統，鎖定並摧毀任務目標。

UAS like the TB-2, which are larger and require more logistical and communications support to operate, are classified as Group 4 or 5 UAS.⁸ They often provide an organic kinetic strike capability in addition to reconnaissance, intelligence, surveillance, and target acquisition (RISTA). As a result of real-time information sharing, these UAS can also perform immediate battle damage assessment (BDA) and provide data for prompt correction of artillery or other fires on a target, as Azerbaijan and Ukraine have done.⁹ The proliferation of Group 4 and 5 UAS will give many militaries and armed groups the abilities that Ukraine and Azerbaijan employed to great effect. The TB-2 has already seen use in various African states, and worldwide sales show no signs of slowing down.¹⁰ United States and allied ground forces and their leaders should expect any adversary to effectively employ such UAS against them. Even if a potential adversary does not possess such UAS now, Ukraine and Azerbaijan's rapid acquisition and deployment of the TB-2 demonstrate that any modern military can, and likely will, acquire Group 4 and 5 UAS and use them to great effect, often sidestepping current air defense platforms. Such UAS may even soon become a C-UAS weapon in its own right.¹¹

TB-2 屬於第四或五類較大型規模的無人機，其在運作時將需要更多後勤與通信支援，⁸除了作為情、監、偵、獲用途使用外，也為建制單位提供硬殺打擊能力。TB-2 無人機不僅具備即時資訊共享能力，還能執行即時戰損評估，並提供即時目標修正數據供火炮或其他打擊火力運用，誠如亞塞拜然與烏克蘭所做的

8 Army Techniques Publication (ATP) 3-01.81, Counter-Unmanned Aircraft Systems Techniques (Washington, DC: U.S. Government Publishing Office [GPO], April 2016), para. 1-9–1-10, fig. 1-1.

那樣。⁹第四或五類無人機之普及化，將讓各國軍隊與武裝團體擁有作戰能力，類似於亞塞拜然與烏克蘭的成功運用案例，而且非洲許多國家已在使用 TB-2 無人機，全球市場也是銷售熱絡。¹⁰美國及其盟邦地面軍隊和軍方高層，都應預期敵人將運用此類無人機執行攻擊任務，即使是潛在之敵尚未獲得這類無人機的能力，但亞塞拜然與烏克蘭的快速籌獲與部署案例表明，任何現代軍事單位在獲得第四或五類無人機方面都沒太大問題，並能有效運用於規避當前的防空系統偵測。至於一體兩面的是，無人機也能成為反無人機的一種武器。¹¹

UAS in the Information Fight

As critical as the TB-2 and other UAS were to the parties of both conflicts on the battlefield, they were also a major factor in the information wars. Government media outlets shared drone feed footage of their UAS striking or surveilling enemy forces. In the face of such public fascination with the purported successful employment of UAS, the opposite side would often attempt to discredit such reports, usually by sharing footage or reports of shooting down UAS. Both conflicts clearly show how important UAS have become in the information domain, as the public perceives successful UAS use as crucial to battlefield success.

TB-2 無人機在資訊戰之運用

對兩場戰事的交戰方而言，TB-2 無人機或是其他無人機系統的打擊效用至關重要，此外，無人機還能在資訊戰上扮演重要角色，像是政府官方媒體可以透過無人機向外界分享對敵監視或打擊之畫面，這也導致大眾往往認知無人機理應有效達成任務，因此敵對雙方會盡其所能分享無人機遭擊落畫面或報告，藉此打擊對方士氣。由此可見，這兩場戰事凸顯無人機系統在資訊戰中的重要性，因為公眾已認知適切部署無人機將是任務成功之關鍵。

9 Ibid., para. 1-9.

10 Stijn Mitzer, "Drone Warfare Turns Hot over Ethiopia's Oromia Region," Oryx, 17 January 2022, <https://www.oryxspioenkop.com/2022/01/drone-warfare-turns-hot-over-ethiopia.html>; Stijn Mitzer and Joost Oliemans, "An International Export Success: Global Demand for Bayraktar Drones Reaches All Time High," Oryx, 2 September 2022, <https://www.oryxspioenkop.com/2021/09/an-international-export-success-global.html>; Tony Osborne, "Poland Takes Delivery of Bayraktar TB2 Drones," Aviation Week, 1 November 2022, <https://aviationweek.com/defense-space/aircraft-propulsion/poland-takes-delivery-bayraktar-tb2-drones>; "Turkey's Baykar to Deliver Drones to Kuwait in \$370 Million Deal," Reuters, 18 January 2023, <https://www.reuters.com/world/middle-east/turkeys-baykar-deliver-drones-kuwait-370-million-deal-2023-01-18/>; Selçuk Baykar, Baykar's chairman of the board and chief technology officer, has declared: "The whole world is a customer." Nailia Bagirova, "Exclusive: After Ukraine, 'Whole World' Is a Customer for Turkish Drone, Maker Says," Reuters, 30 May 2022, <https://www.reuters.com/business/aerospace-defense/exclusive-after-ukraine-whole-world-is-customer-turkish-drone-maker-says-2022-05-30/>.

11 "Turkish Drone Company Baykar to Develop Air-to-Air Missiles to Counter Kamikaze Drone Attacks in Ukraine," Kyiv Independent, 30 October 2022, <https://kyivindependent.com/news-feed/turkish-drone-company-baykar-to-develop-air-to-air-missiles-to-counter-kamikaze-drone-attacks-in-ukraine>.

In Nagorno-Karabakh, Azerbaijan published numerous clips of its TB-2 feeds and its Israeli-made Harpy drones, which are one-way loitering attack UAS that fly into their targets to destroy them.¹² These clips showed the destruction of Armenian vehicles, artillery, troop positions, and more. Azeri government outlets shared these clips on social media sites like Twitter directly on the official ministry of defense page for the world to access and view. Third-party sites like Funker530, a combat footage website, and other social media users and platforms reshared these clips, increasing worldwide viewership.¹³ Fascination with the Azeri's use of UAS presented an image that the Azeri military was highly successful and effective on the battlefield. The government's goal was clearly to paint a picture of battlefield success to ensure domestic support and international awe at the military's effectiveness.

在納卡衝突中，亞塞拜然發布眾多 TB-2 與哈比無人機（以色列製）從事自殺式遊蕩攻擊片段影片，凸顯成功瞄準並摧毀亞美尼亞目標物的戰果，其中包含各式車輛、火炮、部隊陣地等。¹²亞塞拜然藉由像推特這種社群媒體管道傳播這些影片，甚至直接在國防部網站上提供觀看連結供全世界瀏覽，除了像 Funker530 這類第三方網站可以找到與戰鬥相關短片外（如圖 1），其他社群媒體使用者與平臺也會轉傳這類短片，從而增加全球的觀看人數。¹³亞塞拜然在戰場上有效運用無人機的實況，已在世人面前塑造良好形象，而其政府目標也是在藉由公布無人機戰場成功畫面，以確保國內支持並引起國際對其軍事效能之刮目相看。

The Armenian government sought to counter this information, especially as the forces of their military and that of their ally, Artsakh, lost territory during the conflict. As domestic turbulence grew in light of Armenia's losses, the government published its own footage showing an air defense intercept and destruction of an Azeri UAS, a modified AN-2 Colt. Armenia shared this footage on its Twitter page as well, likely hoping for high viewability just as Azerbaijan was able to garner with its drone footage.¹⁴ Government accounts also tweeted photos purporting to show debris from Azeri TB-2s after being shot down. While Azerbaijan's injection of UAS footage dwarfed Armenia's C-UAS information

12 See an Azeri Ministry of Defense tweet with TB-2 feed footage: Azerbaijan Ministry of Defense (@wwwmodgovaz), "#Azerbaijan Army destroyed #OPs of armed forces of #Armenia located in Azerbaijan territory," Twitter, 9 October 2020, 12:40 a.m., <https://twitter.com/wwwmodgovaz/status/1314440465920528385>.

13 "Azerbaijani Kamikaze Drones Are Crushing Armenian Military Targets," Funker530, 2 December 2020, <https://funke530.com/video/azerbaijani-kamikaze-drones-armenian/>.

operations, it was still an interesting development. That Armenia felt the need to respond to the effects of Azerbaijan's drone information operations illustrates how important and effective they can be. The 2020 Nagorno-Karabakh conflict ushered in a new technique of state-sponsored UAS-related information operations that Russia and Ukraine have exploited.

亞美尼亞試圖反制這種資訊宣傳，尤其是與盟國阿爾察赫共和國軍隊在衝突期間失去領土的情況下，隨著亞美尼亞節節敗退也引起國內動盪不斷，政府為扳回劣勢便發布一則影片，展示自身防空系統成功對一架經改裝的亞塞拜然無人機進行攔截與摧毀。亞美尼亞之所以在推特網頁上發布無人機短片，可能是希望想跟亞塞拜然一樣藉此獲致高點閱率，¹⁴政府推特帳號還推文秀出遭擊落的亞塞拜然 TB-2 無人機殘骸照片。值得注意的有趣現象是，即使亞美尼亞做出反無人機的資訊宣傳，但亞塞拜然在網路上的無人機影片聲量仍遠蓋過亞美尼亞。亞美尼亞果斷做出反制亞塞拜然無人機影片的資訊宣傳，也說明這種資訊宣傳行動的重要性與影響力。2020 年納卡衝突的案例說明，由國家贊助支持的這種新式資訊宣傳行動逐漸成形，而且另一場烏俄戰事也是如此。

Ukraine's government outlets also quickly published TB-2 recordings on official government channels such as the messaging application Telegram. They included strikes on the Russian backed-up convoy outside Kyiv, thwarting Russia's attempt to topple the capital.¹⁵ These clips have also featured in Ukraine's recent counteroffensives such as showing the destruction of air defenses and boats on the strategically and symbolically important key terrain of Zmiinyi (Snake) Island, which forced Russia to withdraw on 30 June 2022.¹⁶ Just like in Nagorno-Karabakh, third-party sites republished these clips, increasing viewership and global fascination. The TB-2 became so famous that Ukrainian fighters wrote songs and shared videos of them dancing along.¹⁷

烏克蘭的官方媒體也迅速在 Telegram 等社群媒體平臺發布 TB-2 無人機相關影片，其中包含在基輔外圍向俄軍護衛支援車隊進行攻擊，阻止俄軍攻克首都之企圖，¹⁵這些影片還成為烏克蘭反攻宣傳的最佳代言人，如展示摧毀俄軍在蛇

14 Ministry of Defense of Armenia (@ArmeniaMODTeam), "Destruction of an #Azerbaijan'i drone," Twitter, 1 October 2020, 12:08 p.m., <https://mobile.twitter.com/ArmeniaMODTeam/status/1311699432132546564>; "Karabakh Air Defense Shoots Down Another Turkey-Made Bayraktar Drone of Azerbaijan," News.am, 8 November 2020, <https://news.am/eng/news/612134.html>.

15 Defense of Ukraine (@DefenceU), "Знищення з БПЛА 'Bayraktar TB2' російського ЗРК 'Бук' біля с. Іванків Київської області. Все буде Україна!" [Destruction of the Russian "Buk" air defense system from the "Bayraktar TB2" UAV near the village of Ivankiv, Kyiv region. Everything will be Ukraine!], Twitter, 28 February 2022, 10:47 a.m., <https://twitter.com/DefenceU/status/149832406>.

島這個戰略要地的防空設施與船艦，迫使俄軍於 2022 年 6 月 30 日撤軍。¹⁶納卡區與烏俄戰事的案例顯示，在第三方社群媒體平臺發布影片，除了讓更多人知道外，也增加全球的關注。TB-2 無人機變成常勝軍後，舉凡軍方的文宣或影片都少不了它的存在。¹⁷

And just as Armenia sought to counter this information effect, Russia shared stories of shooting down TB-2s. They even went so far as to stage a fake air defense kill of a TB-2, all to appear to be successfully countering Ukraine's UAS employment.¹⁸ Ukrainian government sites have also touted their own C-UAS capabilities, sharing videos of shooting down Russian UAS, posing with downed UAS, and sharing destroyed UAS counts in their daily briefings.¹⁹ While all sides oftentimes inflate such counts and reports in a conflict, the fact that they are so central and oft-reported reveals how important the conflict parties view them in their information operations.

俄羅斯當然也想跟亞美尼亞一樣做出反無人機的資訊宣傳，同樣也發布擊落 TB-2 無人機的影片，甚至弄出虛構的防空系統擊落 TB-2 無人機事件，無非是為了要讓自己看起來可以有效反制烏軍無人機。¹⁸烏克蘭政府網站也宣傳自身反無人機之能力，發布擊落俄軍無人機及其殘骸影片，並在每日簡報中公布摧毀俄軍無人機的數量。¹⁹各方在衝突中往往會誇大無人機的統計數據與報告，這也說明無人機是重要的新聞報導議題，可為各方在資訊戰行動中所用。

In future conflicts, the United States should expect that the success of UAS and C-UAS employment, whether real or purported, will be an increasingly important aspect of information operations. Successful UAS employment is therefore significant not only for the effects they bring to the tactical battlefield but also on mobile devices and social media platforms. The public is

16 Defense of Ukraine (@DefenceU), "Ukrainian Bayraktar TB2 destroyed another Russian ship. This time the landing craft of the 'Serna' project. The traditional parade of the Russian Black Sea fleet on May 9 this year will be held near Snake Island - at the bottom of the sea." Twitter, 7 May 2022, 7:15 a.m., https://twitter.com/DefenceU/status/1522897994701549573?s=20&t=uFJUQ_7q7RF2DgnwSTmp_A; Antonia Colibășanu et al., The Strategic Importance of Snake Island (Washington, DC: Center for European Policy Analysis, 27 September 2022), <https://cepa.org/comprehensive-reports/the-strategic-importance-of-snake-island/>.

17 Сухопутні війська України, "Кара за українських дітей."

18 David Axe, "The Russians Got Caught Faking a TB-2 Drone Shoot-Down," Forbes, 28 April 2022, <https://www.forbes.com/sites/davidaxe/2022/04/28/the-russians-got-caught-faking-a-tb-2-drone-shoot-down/>.

19 See 93-тя ОМБр Холодний Яр [93rd Mechanized Brigade], "Західна зброя в дії!" [Western weapons in action!], Facebook video, 28 July 2022, <https://www.facebook.com/93OMBr/videos/1396244900896667>. Today, the IAEA Mission Arrived at Zaporizhzhia NPP. Address by the President, 1.09.2022, YouTube, posted by "Office of the President of Ukraine," 1 September 2022, 7:45, <https://www.youtube.com/watch?v=Fx3YvAmCkU>.

increasingly fascinated with unmanned operations in conflict and associate UAS/C-UAS success with success in the overall war effort. This will apply to information consumers domestically, in allied nations, in a potential adversary's nation, and worldwide.²⁰ Finally, as unmanned ground and naval vehicles become increasingly capable and autonomous, there is little reason not to expect those platforms to impact the information domain as armed groups and state militaries begin employing them in combat.

在未來衝突中，美軍應預期無人機攻擊與擊落無人機事件的真實性，將成為資訊宣傳行動中的日益重要的層面，也就是說成功運用無人機不僅會帶來戰術作戰效益，也會在手機等移動裝置與社群媒體平臺發揮影響力。隨著大眾日益關注無人機在衝突中的表現，以及將無人機與反無人機成功與否視為影響整體戰爭成功的因素，這種影響力無疑將擴及於國內資訊受眾、盟國、潛在敵國及全球各地。²⁰最後，隨著陸用與海用無人載具愈來愈有能力與自主性，武裝團體與國家軍隊也逐漸在戰鬥中使用，可預期的是這些載具將影響資訊宣傳領域。

表 1 拜拉克塔爾 TB-2 無人機簡介

	
系 統 簡 介	1.TB-2 無人機由土耳其拜克塔科技公司 (Baykar Tech) 生產製造，為中高度長續航力 (MALE) 無人機 (歸為第四或五類)，能提供情監偵和武裝攻擊任務。 2.每套 TB2 系統包括 6 架無人機、2 個地面控制站、3 套資料終端機、2 套遙控影像終端機，以及其他地面支援裝備，無人機單價介於 100 至 200 萬美元。 3.地面控制站是北約規格的防護型車廂，配備多重空調與核生化過濾器，具備交叉多重的指揮管制系統，操作組員分別為飛行員、酬載操作員和任務指揮官等 3 員。 4.配備光學攝影機、熱影像儀、雷射測距儀、雷射指示器；結合慣性導航／全球定位系統為基礎的飛控系統，失去全球定位訊號，可自動導航與返航降落。

20 Theodore W. Kleisner and Trevor T. Garmey, "Tactical TikTok for Great Power Competition: Applying the Lessons of Ukraine's IO Campaign to Future Large-Scale Conventional Operations," *Military Review* 102, no. 4 (July-August 2022): 23-43; Field Manual 3-13, Information Operations (Washington, DC: U.S. GPO, 6 December 2016).

性能諸元	長 6.5 公尺、翼展 12 公尺、高 2.2 公尺、油量 300 公升、105 匹內燃機、通信距離約 300 公里、巡航速度 70-120 節、續航力 27 小時、作戰高度 1 萬 8,000 呎、最高升限 2 萬 5,000 呎、載重 150 公斤、最大起飛重量 700 公斤。
武裝承載	TB-2 無人機可以攜帶雷射導引智慧微型彈藥系統 (MAM)，包含 2 枚熱壓爆彈式 (MAM-L) 或是多枚高爆彈式 (MAM-C) 飛彈；長程空對地反裝甲飛彈 (射後不理紅外線導引飛彈) 攜行量為 1 枚；希瑞特 (CIRIT) 70 公釐雷射導引飛彈可掛載 4 至 6 枚。
戰史	1.2020 年第二次利比亞內戰期間，使用 TB2 無人機的政府軍曾造成國民軍大量損失，短時間內曾一度橫行天空。 2.2020 年納卡衝突期間，亞塞拜然在 2020 年 6 月使用 TB-2 無人機摧毀多個亞美尼亞移動防空系統、戰車和其他車輛。 3.2022 年烏俄戰爭，烏軍使用 TB-2 無人機搭載 MAM-L 與 MAM-C 飛彈摧毀大量俄軍裝備，烏軍還用於為空襲和其他遠程火力打擊提供觀察射效及戰果確認。

資料來源：寧博，〈納卡衝突一戰成名，拜拉克塔爾 TB-2 無人機〉《青年日報》，2021 年 5 月 31 日，<https://www.ydn.com.tw/news/newsInsidePage?chapterID=1374331&type=military>；Bayraktar TB2, Wikipedia, <https://zh.wikipedia.org/zh-tw/%E6%8B%9C%E6%8B%89%E5%85%8B%E5%A1%94%E5%B0%94TB2>；〈無人機篇 Bayraktar TB2〉，臺北論壇，https://www.taipeiforum.org.tw/article_d.php?lang=tw&tb=3&cid=184&id=9814，由譯者彙整製表。說明：美國國防部將無人機由小至大區分為第一至五類(Group1-5)。

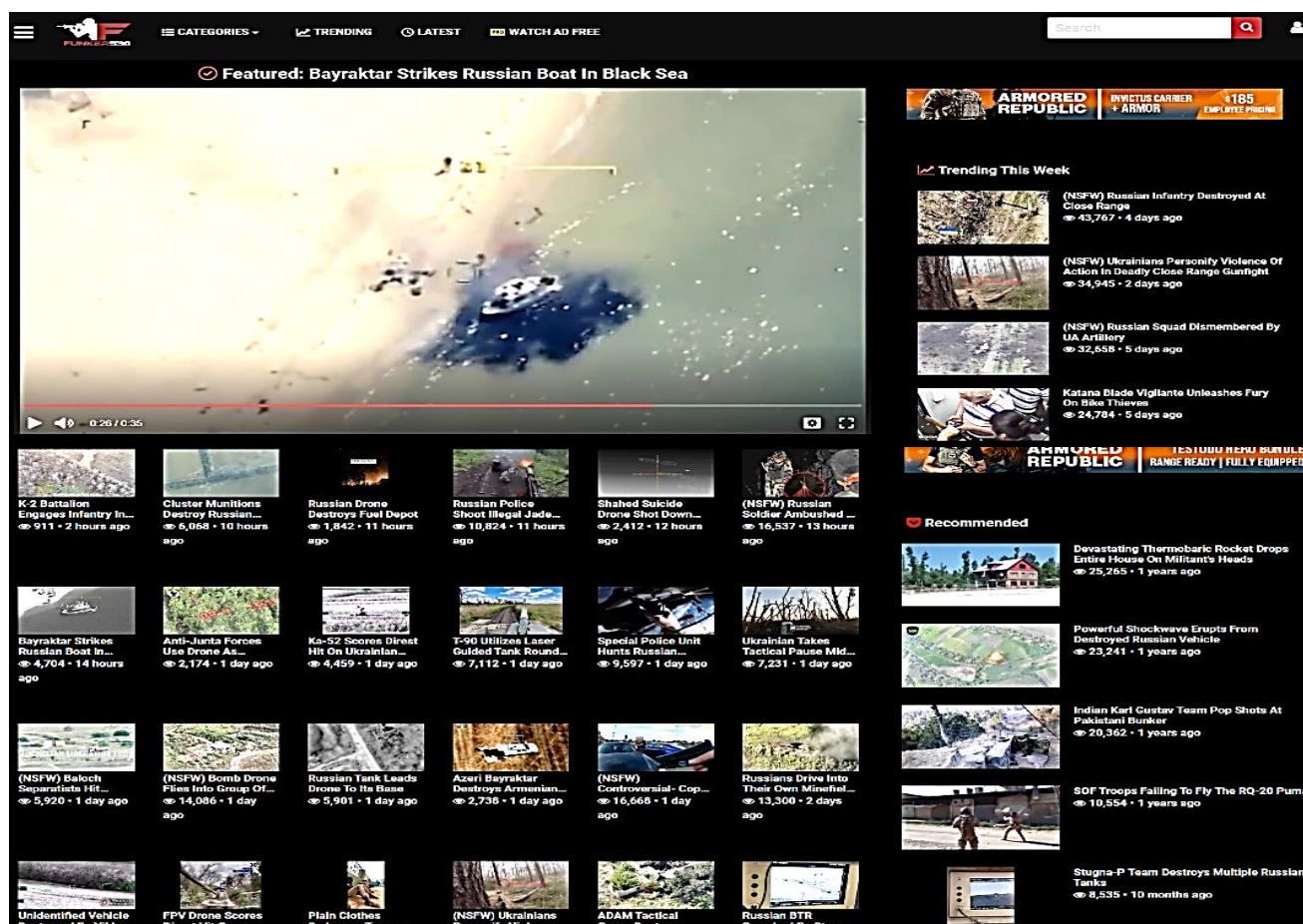


圖 1 Funker530 軍事新聞網

資料來源：<https://funker530.com/> 說明：Funker530 為專門提供戰場實況短片的國外軍事新聞網站，可供人檢
索眾多無人機執行打擊任務的影片。

Group 1–3 sUAS in Ukraine

While the Nagorno-Karabakh conflict lasted six weeks, the full-scale Russian invasion of Ukraine has continued for a year and a half. Further, the war in Ukraine has resulted in mass mobilization within Ukraine, resulting in hastily organized units such as the Territorial Defense Force and the Ukrainian International Legion for foreign volunteers.²¹ As the war continued, both the newly organized units and firmly established units began employing smaller, cheaper, Group 1–3 sUAS extensively. Ukrainian forces (and, to a lesser extent, at least in Western media, Russian forces) have purchased or received donations of commercial drones for their use. While not as large, capable, or long-range as standard military designed UAS, these drones can still provide an essential RISTA and BDA capability. Frontline personnel, such as at the platoon or squad level, can employ their own UAS rather than relying on UAS held as intelligence assets at the battalion-or-above level. This permits them and their leaders to see the battlefield in real time, make immediate adjustments, and better avoid ambushes or prepared enemy positions.²²

烏克蘭的第一至三類無人機

納卡衝突只維持六個禮拜就結束，但烏俄戰爭迄今為止已持續一年半以上仍未停歇，烏國因為戰事而發動國內大規模動員，出現一些如國土防衛隊和烏克蘭國際志願軍等暫時性單位。²¹隨著烏俄戰事持續進行，無論是新的或原有建制單位都開始廣泛運用更小型、更低廉的第一至三類無人機。烏軍（西方媒體或多或少認為俄軍也同樣）已採購或接受捐贈的商用無人機，雖然這些比不上軍規無人機系統的機型、能力及長續航力，但仍能提供重要的情、監、偵、獲和戰損評估能力，這讓前線的班、排級官兵可以使用自己的無人機，而不必依賴營級或營級以上作為情蒐功能的無人機。因此，班、排長就能靠無人機實地觀察戰場、進行即時調整，以及避免遭伏擊或知悉敵預備陣地。²²

Video footage from Ukraine also shows that Ukrainian forces modified

21 Maksym Butchenko, "Ukraine's Territorial Defence on a War Footing," International Centre for Defence and Security, 13 April 2022, <https://icds.ee/en/ukraines-territorial-defence-on-a-war-footing/>; Isaac Tang, "The Latest in a Long Line: Ukraine's International Legion and a History of Foreign Fighters," Harvard International Review, 2 September 2022, <https://hir.harvard.edu/the-latest-in-a-long-line-ukraines-international-legion-and-a-history-of-foreign-fighters/>.

22 93-тя ОМБр Холодний Яр [93rd Mechanized Brigade], "Нічого особливого, просто точна робота холодоярських артилеристів по позиціях росіян" [Nothing special, just the precise work of the Holodoyarsk artillerymen on the positions of the Russians], Facebook video, 18 October 2022, <https://www.facebook.com/93OMBr/videos/639599104225843>; Sam Skove, "Near the Front, Ukraine's Drone Pilots Wage a Modern War on a Shoestring Budget," Radio Free Europe/Radio Liberty, 31 October 2022, <https://www.rferl.org/a/ukraine-drone-pilots-modern-war-shoestring-budget/32108994.html>.

such Group 1–3 sUAS to carry and drop munitions—often antitank rounds, grenades, or mortar rounds—onto enemy positions, vehicles, and personnel.²³ This is far from the first time we have seen commercial drones fitted to carry and drop such munitions; in Syria, militant groups like the Islamic State pioneered this technique as early as 2015.²⁴ However, Ukrainian forces appear to use them in large numbers and outside of formal military acquisition and development channels. Their effectiveness can be seen plainly in the published video footage. Furthermore, Ukraine has acquired purpose-built munitions-dropping sUAS. A Taiwanese-based producer, DronesVision, sent eight hundred purpose-built munitions-dropping UAS to Ukraine via Poland. The Revolver 860 system can carry eight 60 mm mortars to drop directly onto targets below.²⁵

來自烏克蘭的影片顯示，烏軍運用經改裝的第一至三類無人機，用以攜行如反戰車、手榴彈及迫砲等彈藥，向敵人陣地、車輛及人員進行攻擊，²³不過，這早就不是第一次看到商用無人機被改裝用於攜帶並投放彈藥，像是在敘利亞類似於伊斯蘭國的激進團體，早在 2015 年時就採取這種作法。²⁴烏軍顯然大量使用這類型無人機，相關採購與發展管道也不僅限於軍方體系，從網路上的影片可以看出這類型無人機的作戰效益，不僅如此，烏克蘭還獲得專門用於投放彈藥的無人機系統，如波蘭買家先向臺灣無人機製造商橙森國際購買 800 架「左輪 860」無人機（圖 2）後，輾轉交給烏克蘭，其能攜行 8 枚 60 公釐迫砲彈藥並對著底下目標物投擲彈藥。²⁵

Whether purely commercial sUAS conducting surveillance, jerry-rigged commercial drones carrying whatever munitions available, or purpose-built munitions-dropping sUAS, the United States must expect to face an ever-increasing quantity and variety of Group 1–3 sUAS on today's battlefield, no

23 "Lessons from Use of Drones in the Ukraine War," DroneShield, 13 July 2022, <https://www.droneshield.com/blog-posts/lessons-from-drones-in-ukraine-war/>; "Ukrainians Are Bombing Russians with Custom Drones," Vice News, 17 June 2022, https://video.vice.com/en_uk/video/ukrainians-are-bombing-russians-with-custom-drones/6267c399f85e1243221cd521?fbclid=IwAR3mY1U5MjrhYxToxGjUXzGTPVdA8vOI153tqxNczi98aliWIY5okl2xm8&latest=1.

24 Nick Waters, "Death from Above: The Drone Bombs of the Caliphate," Bellingcat, 10 February 2017, <https://www.bellingcat.com/news/mena/2017/02/10/death-drone-bombs-caliphate/>; Reuben Dass, "Militants and Drones: A Trend That Is Here to Stay," Royal United Services Institute, 6 September 2022, <https://rusi.org/explore-our-research/publications/commentary/militants-and-drones-trend-here-stay>.

25 "Revolver 860," DronesVision, <https://dronesvision.com/mortar-revolver-bomber-drone/>; Ashish Dangwal, "Ukraine Gets 800 Taiwan-Made 'Carpet Bomber' Revolver 860 Combat Drones to Thwart Russian Aggression," EurAsian Times, 29 August 2022, <https://eurasianimes.com/ukraine-gets-800-taiwan-revolver-860-drones/>; Keoni Everington, "Taiwan's Revolver 860 Combat Drones Being Used by Ukrainians on Battlefield," Taiwan News, 18 August 2022, <https://www.taiwannews.com.tw/en/news/4630475>.

matter the adversary.²⁶ Ukraine's rapid acquisition, proliferation, and employment of commercial sUAS shows that any potential adversary can exploit current technology similarly. Taiwan's Revolver 860 UAS is an example of one of the first, but certainly not the last, of a small munitions carrying UAS.

無論是單純用於監視的商用無人機，還是應急改裝後用以攜帶彈藥的商用無人機，抑或是專門用於投放彈藥的無人機，不管美國將面對的敵人是誰，都必須做好準備在戰場將須因應愈來愈多這種第一至三類小型無人機。²⁶烏克蘭既然有能力迅速獲得、擴大運用與部署小型無人機，想必敵方也可能在做同樣的事，前述「左輪 860」小型武裝無人機的購買只是其中案例之一，當然也不可能是最後一個案例。

These Group 1–3 sUAS have such a low radar cross-section that they can avoid detection by most modern U.S. Army air and missile defense (AMD) radars and are usually too small to counter with current U.S. Army SHORAD systems like the FIM-92 Stinger missile, whether fired in a Man-Portable Air Defense System (MANPADS) configuration or from the legacy Avenger or new Maneuver-SHORAD (M-SHORAD) platforms. While the United States has developed and acquired a litany of C-sUAS systems (e.g., Fixed Site-Low, Slow, Small Unmanned Aerial Vehicle Integrated Defeat System [FS-LIDS]; Mobile Low, Vehicle Integrated Defense System [M-LIDS]; and Mobile Air Defense Integrated System [MADIS]), they are not currently fielded to trained personnel across the force, especially our maneuver forces, in sufficient numbers to counter this exponentially growing threat. There is also an immediate need for highly mobile C-sUAS systems to accompany friendly forces that must remain agile to avoid detection and targeting by those same sUAS and other enemy collection techniques. If Ukraine and Russia are rushing “drone busters” to their forces, why aren't we?

第一至三類無人機具有低雷達截面積，可以躲避大多數現代美陸軍防空飛彈防禦雷達系統之偵測，由於體型較小，像是美陸軍 FIM-92 刺針飛彈（如人攜肩射式構型、或傳統復仇飛彈車、或新式機動型短程防空系統）之類的短程防空系統並無法有效因應。雖然美國已發展並獲得眾多反無人機系統（如定點的低空、慢速、小型無人空中載具整體打擊系統，低機動型載具整體防禦系統，機動

26 Andrew E. Kramer, “Homemade, Cheap and Lethal, Attack Drones Are Vital to Ukraine,” New York Times, 8 May 2023, <https://www.nytimes.com/2023/05/08/world/europe/ukraine-russia-attack-drones.html>.

型防空整體系統)，但這些系統目前尚未部署至相關單位，尤其是戰鬥部隊，這類能量尚不足以因應這種不斷增長之威脅，而且當前立即性需求為讓友軍配備高機動型反小型無人機系統，還須夠靈活運用才能避免被同類型小型無人機系統鎖定及被其他敵偵蒐科技偵測。若說烏克蘭與俄羅斯正在為其部隊提供「無人機剋星」干擾槍（圖 3），那為何美軍沒有呢？

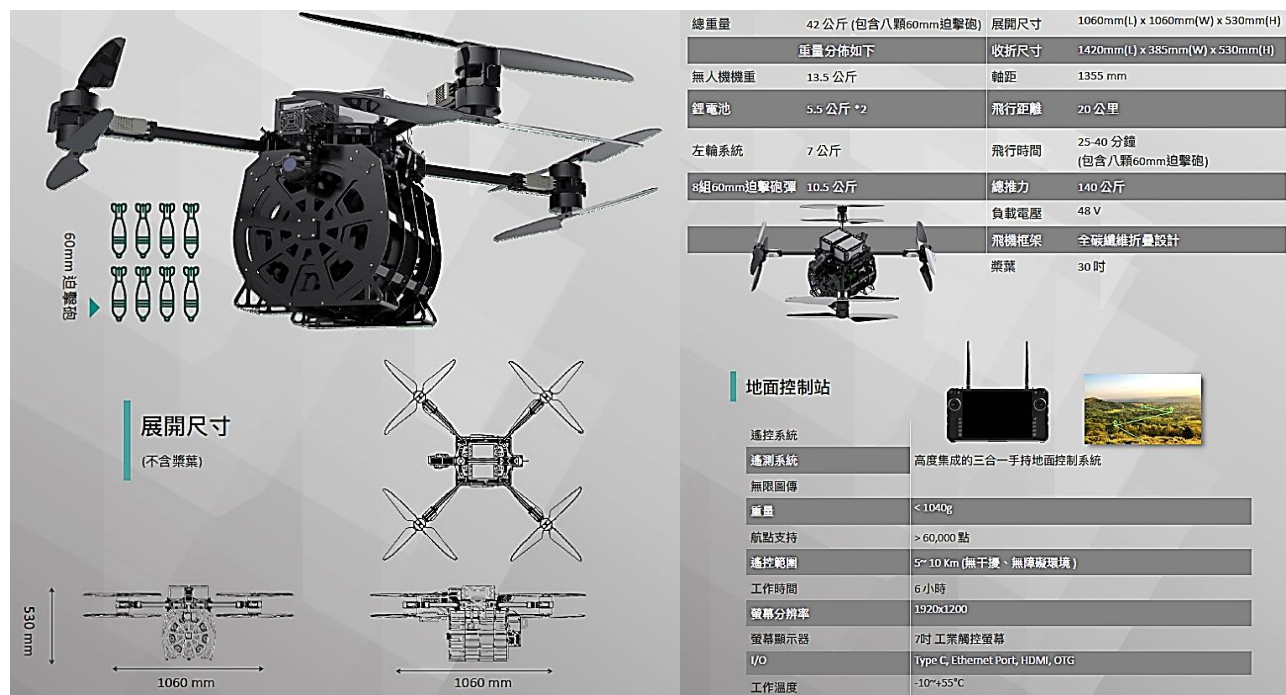


圖 2 左輪 860 無人機

資料來源：DronesVision, <https://dronesvision.com/download/tw/dronesvision-revolver-tw.pdf> 說明：Revolver 是一種軍用戰鬥四旋翼無人機，旨在通過投擲炸彈攻擊敵對的地面部隊，武器艙設計可容納多達 8 枚 60 公釐迫砲彈藥，另可為客戶量身訂制來滿足不同類型的戰爭需求。



圖 3 無人機剋星干擾槍

資料來源：Todd South, "The Army Is Adding the 'Dronebuster' to Its Set of Anti-drone Tools," *Army Times*, April 23, 2017, <https://www.armytimes.com/news/your-army/2017/04/23/the-army-is-adding-the-dronebuster-to-its-set-of-anti-drone-tools/> 說明：長寬高為 53x27x16 公分，重量 2.2 公斤，持續干擾時間為 3 小時，有效距離為 750 至 1,000 公尺，主要干擾機種為第一、二類無人機。

Providing Friendly sUAS Capabilities in the Tactical Fight

The lessons of Ukraine and Nagorno-Karabakh are not limited to C-UAS. They also reveal the necessity of all tactical units having a sUAS RISTA capability. In Ukraine, sUAS have become so essential to the battlefield that Ukrainian forces have sent sUAS on sUAS-recovery missions behind enemy lines—a drone rescuing a drone.²⁷ Maneuver platoons can employ sUAS to surveil an objective before occupying, conducting movement, or attacking. RISTA/BDA sUAS are clearly essential for correcting indirect fire of all types, whether used by forward observers or any frontline soldier.

提供友軍小型無人機戰術飛行能力

納卡衝突與烏俄戰爭的經驗教訓不是只有如何反無人機，也凸顯各個戰術單位都應具備小型無人機的情、監、偵、獲能力。在烏克蘭方面，小型無人機系統已變得如此重要，以至於烏軍甚至派遣小型無人機至敵後方進行搶救無人機任務，也就是用一架無人機救援另一架無人機。²⁷戰鬥排可以在佔領、行動或進攻前運用小型無人機來監視目標，而具備情、監、偵、獲和戰損評估能力的小型無人機，無論是由前方觀察員或前線士兵使用，它們對於修正各種間接火力至關重要。

sUAS benefits should not be limited to maneuver units only, however. The ability for real-time, on-demand aerial reconnaissance or surveillance is essential for all units. For example, a battery—whether air defense or field artillery—conducting a Reconnaissance, Selection, and Occupation of Position performs a ground reconnaissance of a potential new site and the routes there.²⁸ A sUAS would allow them to add a real-time air reconnaissance capability, protecting the ground element until they have surveilled the site and route. Any unit—logistics, medical, engineer, etc.—conducting a road march or occupying a new position can use a Group 1–3 sUAS to conduct an air reconnaissance of the route ahead of them, doing so even as they move. A sUAS RISTA capability at echelons lower than brigade combat teams will also reduce the number of priority intelligence requirements submitted to higher headquarters, thereby freeing up brigade-and-above intelligence assets.

小型無人機系統的好處不僅止於戰鬥部隊而已，還可以為所有部隊提供即時、備便的空軍偵察或監視能力，例如，不管是防空或是野戰砲兵營，當在執行

²⁷ “Ukrainian Drone Recovers Another Crashed Drone,” Funker530, 30 December 2022, <https://funker530.com/video/ukrainian-drone-recovers-another-crashed-drone/>.

偵察、選定及目標佔領任務時，都可以運用無人機對可能新陣地及前進路線進行地面偵察。²⁸小型無人機作為地面部隊的即時空中偵察，可以讓單位在對目標點與路線做偵察時避免遭受攻擊，所以不管是後勤、衛生、工兵等單位都可以在排除前進道路障礙或佔領新陣地時，運用無人機的空中能力對前方進行偵察。美軍旅級戰鬥隊以下各層級部隊若能具備小型無人機的情、監、偵、獲能力，不僅有助於提交給高層總部的優先情報需求（情報蒐集要項）工作，而且也能強化底下各層級部隊的情蒐能力。

Equipping units with Group 1–3 sUAS—ideally government-developed but, if necessary, commercial off-the-shelf as Ukraine has done—will also benefit the defense of fixed sites from ground attack. This includes command posts at all echelons, forward arming and refueling points, tactical assembly areas, communications relay sites, and many more. sUAS can monitor the site perimeter, entry control points, and routes in and out of the area with a live feed direct to the element tasked with site security or the local command post.

為部隊配備第一至三類無人機（理想是採用國產或是必要時像烏克蘭一樣採用商規現貨），將有助於防衛諸如各層級部隊指揮所、前方械彈油料補給點、戰術集結區及通信中繼站等固定設施避免遭地面攻擊。小型無人機不僅可以監控目標區四周、入口控制點及區域進出通道，而且還能將實況影像直接傳送給負責地點安全的部隊或當地指揮所。

Of course, the internal proliferation of sUAS would necessitate training in discretion; if I fly a small quadcopter over the brigade command post twenty-four hours a day, it will be quite easy for an enemy force to determine where we are and target us, both visually and based on electromagnetic emissions. But the benefits of having the capability of a sUAS for monitoring relatively fixed sites and conducting reconnaissance of new sites and routes, employed with proper discretion, far outweigh the risks, especially since the adversary is very likely to be using comparable sUAS to try to find our positions anyway. If Ukraine and Russia are rushing Group 1–3 sUAS to their forces, why aren't we?

當然，小型無人機要在單位內達成普及化，將需要進行審慎的培訓作業，像是一架小型四旋翼無人機每天 24 小時都可能不停飛越旅指揮所，則敵軍很容易透過目視或電磁輻射偵測就能發現並鎖定我方位置，至於擁有小型無人機之好

28 ATP 3-01.87, Patriot Battery Techniques (Washington, DC: U.S. GPO, August 2018), para. D-23–D-24.

處是可以監控相對固定的地點，並執行新陣地或路線的偵察任務，若能謹慎運用，好處將大過於風險，尤其是我們也要考慮敵人也可能同樣運用小型無人機來找出我方位置。烏克蘭和俄羅斯都不遺餘力為部隊配備第一至三類無人機，那為何美軍不這樣做呢？

Current AMD and C-sUAS Shortcomings

Both Nagorno-Karabakh and Ukraine show the inability of current AMD systems to defend friendly forces against new UAS like the Bayraktar TB-2 and Group 1–3 commercial sUAS adapted for military use. A number of videos released by both Azerbaijan and Ukraine during their respective conflicts show the TB-2 striking Soviet-era AMD platforms, still in use by a number of countries—including NATO countries—like the SA-8 “Gecko” or the Buk M-1/2 (SA-17 “Grizzly”), and others.²⁹ Russia also recently shared video of a Lancet one-way attack UAS striking and destroying an American-made Avenger system.³⁰ Ukraine and Russia’s use of commercial Group 1–3 sUAS demonstrates the requirement for a vast expansion in C-sUAS coverage, and combatants there have scrambled to rapidly equip their forces with C-sUAS weapons.³¹ Even if current AMD platforms could adequately intercept such sUAS (which they cannot), their high quantity, cheapness, ease of use, and proliferation among tactical-level units means modern militaries need a C-sUAS capability interspersed throughout their forces. From a warfighting function perspective, this is both a fires and a protection issue.³²

當前防空飛彈防禦與反無人機系統缺陷

從納卡衝突與烏俄戰爭兩場戰事顯示，當前防空飛彈系統並無法有效防禦友軍，以避免像 TB-2 無人機和專門用於軍事用途的第一至三類商用無人機之攻擊。根據許多公布的影片顯示，TB-2 無人機有效攻擊一些蘇聯時代的防空飛彈系統，諸如 SA-81 壁虎、山毛櫸-M1/2（北約代號 SA-17 灰熊）等，而這些系統仍在包含北約在內的許多國家中使用。²⁹俄羅斯近期還分享一段影片，顯示柳葉刀無人機在自殺式攻擊中摧毀美製的復仇者飛彈車。³⁰從烏俄雙方爭相使用第

29 In Ukraine: “Russian BUK-M2 Air Defense System Obliterated by Bayraktar TB2 Drone,” Funker530, March 2022, <https://funker530.com/video/russian-buk-m2-air-defense-system-obliterated-by-bayraktar-tb2-drone/>. In Nagorno-Karabakh: Azerbaijan Ministry of Defense (@wwwmodgovaz), “#Enemy’s combat ready anti-#aircraft #missile systems were destroyed,” Twitter, 10 October 2020, 10:07 a. m., <https://twitter.com/wwwmodgovaz/status/1314945583870816257>.

30 “Российский дрон «Ланцет» уничтожил в зоне спецоперации американский ЗПК Avenger” [Russian drone “Lancet” destroyed the American Avenger air defense system in the special operation zone], RT, 7 May 2023, <https://russian.rt.com/ussr/news/1145579-lancet-zrk-avenger>; “Lancet Kamikaze Drone Hits Ukrainian AN/TWQ-1 Avenger,” Funker530, 7 May 2023, <https://funker530.com/video/lancet-kamikaze-drone-hits-ukrainian-antwq-1-avenger/>.

一至三類商用無人機顯示，反小型無人機的需求不斷攀升，而參戰雙方更加緊為部隊配備反小型無人機的武器。³¹即使目前防空飛彈系統可有效攔截小型無人機（事實並非如此），但由於數量眾多、造價低廉、易於使用，以及在戰術層級日益普及，這意味著軍方須在單位內廣泛部署反小型無人機之能力。從作戰功能的觀點而言，這將涉及火力與防護兩項議題。³²

What does this mean for air defense and protection against sUAS? First, there is little doubt that modern militaries will require more air defense. As Group 4 and 5 UAS like the TB-2 increase in quantity and capability, militaries will need more C-UAS AMD systems to deny those systems airspace and, ideally, intercept and destroy them. AMD and the fires warfighting function, including incorporating nonlethal fires via electronic warfare capabilities, are best suited to counter Group 4 and 5 UAS. Indeed, Russia has reportedly vastly improved its ability to counter Ukraine's TB-2s, incorporating electronic warfare capabilities alongside traditional air defense systems to relegate the TB-2s to reconnaissance duties safely away from potential intercept.³³

這對反小型無人機的防空與防護系統具有何意義？第一，毫無疑問的是，現代軍隊將需要更多的防空系統，像是 **TB-2** 這種第四至五類無人機不斷在數量上增加與能力上強化，這意味著軍方將需要更多反無人機防空系統，以阻止無人機進入領空，並在理想情況下進行攔截和摧毀。防空飛彈系統與火力打擊功能，包含納入電子戰的非致命火力能力，這些最適合用來反制第四至五類無人機，誠如報導指出，俄羅斯已大幅提升反制烏克蘭 **TB-2** 無人機的能力，將傳統防空系統與電子戰能力相結合，讓 **TB-2** 無人機僅能在遠離攔截區之外的地方執行偵察任務。³³

Second, there is also an urgent need for a robust C-sUAS capability that can detect, identify, respond to (including engagement), and report the enemy sUAS, with the aim of negating the effects of the enemy's sUAS.³⁴ The current radars and weapon systems that most militaries, including the United States, rely upon were designed and maintained with a counter-aircraft mission, adept at detecting and destroying fighters, bombers, and helicopters, not small, slow

31 "Ukraine's Anti-Drone Rifle Takes Aim at Russian UAVs," Radio Free Europe/Radio Liberty, 23 June 2022, <https://www.rferl.org/a/ukraine-anti-drone-gun-russia-war/31912255.html>.

32 Glenn A. Henke, "Once More Unto the Breach: Air Defense Artillery Support to Maneuver Forces in Large-Scale Combat Operations," *Military Review* 103, no. 2 (March-April 2023): 74–75.

33 Alia Shoaib, "Bayraktar TB2 Drones Were Hailed as Ukraine's Savior and the Future of Warfare. A Year Later, They've Practically Disappeared," *Insider*, 28 May 2023, <https://www.businessinsider.com/turkeys-bayraktar-tb2-drones-ineffective-ukraine-war-2023-5>.

UAS. While the United States and other modern militaries possess capable C-sUAS systems such as M-LIDS and various “drone buster” guns, these systems must be available organically—not as a just-before-deployment attachment or fielding—for maneuver and support units alike. Just as all units can receive and deploy with antiarmor systems like the AT-4, or formerly deployed to Iraq and Afghanistan with counter-improvised explosive device systems, all units require a short-range C-sUAS capability to at least defend against Group 1–3.³⁵ Most importantly, they need this capability *now*. The next fight, whoever it is against, will see widespread use of sUAS by our adversary.

第二，單位目前迫切需要一個健全的反小型無人機能力，用以偵測、識別、應變（包含接戰），以及報告敵小型無人機位置，以利抵銷敵小型無人機所帶來的影響。³⁴當前包含美國在內的大多數軍隊，所使用雷達與武器系統之設計與運作，主要是針對飛機這種目標物，擅長偵測並摧毀戰機、轟炸機及直升機，而不是小型、慢速的無人機。雖然美國和其他現代國家軍隊擁有反小型無人機能力，諸如低機動型載具整體防禦系統及像「無人機剋星」一樣的各式干擾槍，但這些系統必須為建制部隊所運用（不是只作為部署前的展示裝備），尤其是戰鬥部隊與支援單位更應如此。誠如所有單位都配備 **AT-4** 反戰車火箭筒這種武器裝備，或是先前在伊拉克與阿富汗戰場普遍使用的反應急爆炸裝置，同樣道理，可以用來反制第一至三類無人機的短程反小型無人機武器，也應配備至各單位。³⁵重要的是，部隊「現在」就需要這種能力，無論下一場戰爭面對的是誰，敵人都將大量使用小型無人機系統。

Third, units must train with UAS, including Group 1–3, in mind. Tactics thought to be left to the history books—air guards, react-to-air attack, using small arms to fire at aircraft—need to return and adapt to the C-UAS fight.³⁶ Even if units cannot train with an air defense unit directly, trainers can provide their opposing forces with sUAS to conduct RISTA operations against the training audience. They can even rig them to drop foam Nerf footballs or tennis balls to mimic current battlefield tactics. And while these changes will come at a financial cost, they cannot exist solely at combat training centers.³⁷ Adversary UAS need to be incorporated into regular field training exercises, combined live-fire exercises, command post exercises, convoy

34 ATP 3-01.81, Counter-Unmanned Aircraft Systems Techniques, para. 1-11.

35 Kyle Rempfer, “Drones Are Biggest Tactical Concern Since the Rise of IEDs in Iraq, CENTCOM Boss Says,” Army Times, 8 February 2021, <https://www.armytimes.com/news/your-army/2021/02/08/drones-are-biggest-tactical-concern-since-ieds-rose-in-iraq-four-star-says/>.

training, small-unit training, and more.

第三，單位須將第一至三類無人機系統納入訓練科目，而且曾被認為已是歷史的戰術，諸如空中護衛、空中攻擊反應及使用輕兵器對飛行器射擊等都應重新回歸至反無人機作戰的計畫作為。³⁶雖然部隊無法直接與防空單位共同訓練，但可以在訓練科目中納入假想敵無人機從事情、監、偵、獲活動，讓受訓人員體驗可能的戰場情景，甚或將無人機偽裝成橄欖球或網球外型，以模擬當前戰場的敵戰術行為，這些作為不能僅由戰鬥訓練中心來做，各單位都應付出這種訓練經費的成本。³⁷敵無人機想定也應納入常規野戰訓練演習中，如聯合實彈演習、指揮所演習、護衛訓練及小部隊訓練等。

The question quickly arises: How best to address these shortcomings? There are a variety of options available to policymakers and planners. The Army's current approach to counter armored threats provides a possible framework with multiple options. Ground forces could field C-sUAS weapons systems directly to lower-echelon units, just as we currently do with AT-4s and did for counter-improvised explosive devices in Iraq and Afghanistan. After Russia's illegal annexation of Crimea and support for separatists in eastern Ukraine in 2014, the Army began the Additional Skill Identifier A5 program, training infantry soldiers on the Stinger platform. One option is to expand this program or make such training standard, just like AT-4s, or supplement the current Additional Skill Identifier A5 program with additional C-UAS training and equipment.

接下來會浮現的一個問題是：如何有效解決防空系統在面對無人機時的缺陷？其實有各種不同選項供決策者或計畫人員採納。其中之一是讓地面基層部隊配備反小型無人機武器，這種作法類似於美陸軍在應對戰甲車威脅時所採取的眾多選項之一，讓基層配備 **AT-4** 反戰車火箭筒，也類似於先前在伊拉克與阿富汗戰場，部隊普遍使用的反應急爆炸裝置。在 2014 年俄羅斯非法併吞克里米亞並支持烏東分離主義者之後，美陸軍著手發展「附加技能識別項目 **A5**」計畫，旨在訓練步兵使用刺針飛彈，這個計畫擴大衍生之後也能成為解決缺陷的另一個選項，例如像 **AT-4** 作法一樣將反無人機的訓練標準化，或是在該計畫內額外增列反無人機系統的訓練與裝備等各項子計畫。

36 Ibid.; Andrew E. Kramer, "We Heard It, We Saw It, Then We Opened Fire," New York Times, 23 October 2022, <https://www.nytimes.com/2022/10/23/world/europe/ukraine-russia-drones-iran.html>; Henke, "Once More Unto the Breach," 74; ATP 3-01.81, Counter-Unmanned Aircraft Systems Techniques, Appendix A.

37 ATP 3-01.81, Counter-Unmanned Aircraft Systems Techniques, fig. A-1.

There is also an option to add a separate SHORAD/C-sUAS element to units organically. This would prevent haggling over command and support relationships and reduce demand for AMD/C-sUAS resources when, as is the current doctrine, U.S. SHORAD battalions are “potentially” distributed to Army divisions, not organically a part of the maneuver units.³⁸ An element organic to maneuver units could be a new type of SHORAD battery, minimally reliant on integration with other air defense sensors and shooters, in each brigade combat team, perhaps within the brigade engineer battalion. This battery might consist of a platoon of sensors, a C-sUAS platoon with electronic warfare weapons systems to counter Group 1–3, and a typical SHORAD platoon with weapons like the Stinger missile in MANPADS configuration to counter aircraft and Group 4 and 5 UAS.

為建制單位增設獨立的短程防空與反小型無人機系統也是一種可行選項，其好處不僅可以防止指揮與支援關係的爭論，而且也能減少對防空飛彈防禦與反小型無人機系統之需求，因為依現行美軍準則指導，美軍短程防空營可能會配屬至師底下，而不是成為戰鬥部隊的一個建制單位。³⁸若在戰鬥部隊增設一個新式的短程防空連，可以減少須依賴其他的防空偵打一體系統，或許可以考量在旅級戰鬥隊編制的旅工兵營內增設，這個連可以編制一個偵測排、一個反小型無人機排（配備電子戰武器系統來反制第一至三類無人機）、一個典型的短程防空排（配備如人攜肩射式構型的刺針飛彈，以反制飛行器或第四至五類無人機）。

Or, again looking to the example of antiarmor capabilities within maneuver units, every maneuver battalion could include a platoon within the battalion headquarters and headquarters company or weapons company dedicated to C-UAS, perhaps with two squads for C-sUAS and one squad of traditional SHORAD. After many decades of risk-averse air defense, the increased risk of decentralized air defense shooters is necessary in this emerging world of UAS. The Army could look to how Air Force tactical air control parties, embedded in Army maneuver forces, receive a tactical air picture as inspiration for how to integrate the necessary SHORAD/C-UAS capabilities in maneuver forces into the joint AMD fight. Whether this hypothetical C-UAS element resides organically at the battalion, brigade, or division level, with or without a C-UAS weapons system fielded directly to frontline personnel, or a mix of all of these, the key takeaway is that maneuver units need C-UAS organically and in

38 ATP 3-91, Division Operations (Washington, DC: U.S. GPO, October 2014), para. 1-11, 1-44, 1-52.

adequate numbers to defend their battlespace independent of external support. Better minds can determine the precise form of the solution—the *immediate* need, however, is all too apparent.

至於在戰鬥部隊的反裝甲能力運用方面，各個戰鬥營可以在營部、營部連或兵器連內增設一個排，用於執行反小型無人機任務，這個排的其中兩個班負責反小型無人機，另一個班負責傳統的短程防空防禦。美軍在數十年時間內防空系統都是處於低風險接戰模式，未來在面對新興無人機戰場時，分散式防空打擊的風險必然增加。美陸軍可以借鑑空軍戰術空中管制組編配於陸軍戰鬥部隊，從而獲得空中戰術圖像的作法，同樣道理，我們也可以將戰鬥部隊的短程防空與反無人機能力整合至聯合防空飛彈防禦的作戰計畫中。無論這個增設的反無人機單位是否能編制於營、旅或師，又是否能直接提供前線人員反無人機武器，還是兩者都能並行，其關鍵在於戰鬥部隊需要編制內的反無人機能力，以利在毋須靠外部支援下防衛自身作戰責任區。雖然反覆思考是為做出更佳解決方案，但這種「立即性」需求應無法再等待了。

Whatever the solutions, a few principles are evident, principles that the Joint Counter-Small Unmanned Aircraft Systems Office may consider in their strategies, particularly when updating the Department of Defense C-sUAS strategy that has not been updated since January 2021 despite the stream of lessons from Nagorno-Karabakh and Ukraine.³⁹ As mentioned, we need more air defense force protection assets, better equipped for C-UAS and specifically C-sUAS, dispersed to the lowest level, organic to maneuver and nonmaneuver units alike, and with more integrated and accountable training. The large-scale drone fight is already here; our ground forces need the equipment, knowledge, and training to counter and survive it.

無論解決方案為何，但有一些原則是顯而易見，這些是「聯合反小型無人機系統辦公室」在擬定策略時應納入考量，尤其是應著手更新美國國防部反小型無人機策略，因為該策略自 2021 年 1 月頒布以來尚未更新，但此期間已出現來自納卡衝突與烏俄戰爭兩場戰事的諸多經驗教訓。³⁹如前文所述，我們需要更多的防空兵火力系統，也就是更適合用於反無人機（尤其是小型無人機）的裝備，並將之配備至各個基層單位，成為戰鬥與非戰鬥的編制武器，同時進行更多整體可靠性訓練。大規模無人機作戰時代已然來臨，地面部隊需要無人機裝備、知識和

39 U.S. Department of Defense, Counter-Small Unmanned Aircraft Systems Strategy (Washington, D C: U.S. Department of Defense, 7 January 2021), <https://media.defense.gov/2021/Jan/07/2002561080/-1/-1/1/DEPARTMENT-OF-DEFENSE-COUNTER-SMALL-UNMANNED-AIRCRAFT-SYSTEMS-STRATEGY.PDF>.

訓練，才能在這個戰場下生存並有效制敵。

Conclusion

The wars of Nagorno-Karabakh and Ukraine show us the present and the future of UAS warfare. Whether it is the employment of Group 4 and 5 UAS like the TB-2 Bayraktar or ingeniously adapting and rigging commercial off-the-shelf sUAS for RISTA and offensive capabilities, the wars show that any potential adversary, and the United States itself, can and should rapidly acquire and employ such UAS. These drones have reshaped the battlefield, reshaped the information fight, and obviated or revealed gaps in older air defense systems. It has ushered in new urgency to a latent shortcoming in the U.S. Army and Department of Defense-wide—its C-UAS capability.

結論

納卡衝突與烏俄戰爭兩場戰事向世人展示無人機戰爭之現在與未來。無論是像 TB-2 這種第四至五類的無人機運用，或是巧妙改裝商規現貨無人機並用於情、監、偵、獲及攻擊，戰爭都表明不管是美國或是任何潛在敵人，都可以也應該迅速獲得並部署無人機系統。無人機已重塑戰場型態、改變資訊戰的運用方式，以及暴露老舊防空系統的缺陷，這不僅為美陸軍也為整個美軍帶來新的急迫性，即反無人機當前的潛在缺陷。⁴⁰

Just as the United States and allied ground forces should seek to distribute the benefits of small RISTA UAS to all units at low-level echelons, they must also rapidly add, improve, and integrate C-UAS force protection capabilities with all units down to the tactical-unit level. Failure to do so before the next conflict, whomever it may be against, will lead to public embarrassment in the information domain, tactical losses of materiel and personnel, and lost opportunities in the offense. Domination of the skies will not just depend on advanced fifth-generation aircraft—it will require the Group 1–3 quadcopters and C-sUAS weapons we are seeing proven on the battlefield every day in Nagorno-Karabakh and Ukraine.

誠如美國和盟邦地面部隊不斷致力於將具情、監、偵、獲等優勢能力的小型無人機配屬至基層部隊，他們還必須不斷持續精進，將反無人機兵火力整合至戰術層級的各個單位。在下一場衝突來臨之前，無論是與誰作戰，如未能做到這點，將在資訊宣傳領域喪失公共形象、面臨人裝的戰術損失，以及在攻勢中喪失先

40 John R. Hoehn and Kelley M. Sayler, Department of Defense Counter-Unmanned Aircraft Systems (Washington, DC: U.S. Congressional Research Service, 17 April 2023), <https://crsreports.congress.gov/product/pdf/IF/IF11426>.

機。美軍不能僅依賴第五代戰機來確保制空權，還需要在納卡衝突與烏俄戰爭中所見漫天飛行的第一至三類小型無人機。

譯後語

無人機與反無人機已成為當代戰場不可或缺之作戰工具，近期納卡衝突與烏俄戰爭兩場戰事正是最佳例證，本文從組織編制、武器配屬、教育訓練及戰略文件修訂等面向提出精進無人機與反無人機建議，國軍相關單位應將這些建議列入參考。世界各國已對無人機系統運用投入更多投資與關注，因為其已在各場戰事上經證明為不對稱戰力之一，更是世界軍事發展的一股趨勢，我國有能力也應持續強化無人機系統的運用與部署，相關成果已有騰雲、劍翔、銳鳶 I 型等無人機系統，並於 2022 年起交付陸軍戰術型近程無人機。

該型無人機提供國軍地面部隊高空偵察能力、即時獲取戰場情資與偵蒐敵軍部署、觀測火力效果並做數據修正，更重要的是，還可將戰場資訊整合傳送至指揮所，作為指揮官即時下達與修正作戰決策的依據。至於在反無人機方面國防部已擬定「遙控無人機防禦系統計畫」，編列經費為三軍籌購無人機防禦系統和干擾槍，以因應營區上空來路不明或共軍在外離島的無人機襲擾。鑒此，部隊在接裝後應妥善規劃人員的教育訓練、裝備維保與妥善率及飛行操作證照取得，才能讓無人機與反無人機系統發揮最大效能。

值得注意的是，單靠無人機的作戰效能仍有其限度，無人機若能與其他作戰職能整合，如三軍短程防空系統、資通電軍偵蒐及干擾系統、雷達情資整合後的共同作戰圖像等，才能成為戰力倍增器。⁴¹此外，在烏俄戰爭最新無人機發展趨勢上，烏克蘭國家安全局指出，烏國已派出網路作戰人員，部署在戰區前線，整合駭客、無人機、人工智慧（AI），用以強化前線攻防能量來對抗俄軍威脅。⁴²由此可見，無人機與各個作戰職能的搭配將成為未來戰場趨勢，這種趨勢是國軍未來在規劃無人機中長期戰略時應列入考量。

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41 林俊賢，〈從一、二類無人機威脅談野戰防空之應處〉，《砲兵季刊》，第 197 期，2022 年 6 月，頁 62。

42 王光磊，〈烏整合駭客、無人機、AI 強化攻防〉，青年日報，2023 年 9 月 7 日，<https://www.ydn.com.tw/news/newsInsidePage?chapterID=1613318&type=universal>