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Jointness and the Norwegian Campaign, 1940

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The Norwegian Campaign in the spring of 1940 was the first major joint and combined operation of World War II in the European theater. Not only did the British and French work together to attack the German occupiers in the far north but also the military forces of all the participants included land, air, and sea elements. Though this campaign—seen from both the Allied and Axis sides—included major joint and combined elements, it was also marked by major errors. In truth, the services on both sides had yet to develop a joint perspective on war—their centuries-old tradition of working alone and only grudgingly succumbing to cooperation with each other would be very hard to break. Joint training and doctrine had not yet been sufficiently developed to allow diverse elements to work together effectively.

Moreover, in Germany, the unique power of Reichsmarschall Hermann Göring, head of the Luftwaffe, added even further to the poisonous effects of service parochialism. Göring would not allow his air forces, whatever the importance or necessity, to be subservient to the commander from another arm.

The Campaign

Although Britain and France declared war on Germany in September 1939 due to the Nazi invasion of Poland, they were loath to strike the enemy head-on along the western front. The French had seemingly learned from the Great War that the defense had become supreme; they therefore intended to sit behind their impregnable Maginot Line and allow the Germans to bleed themselves white in fruitless attacks. This passive inactivity, while Germany was occupied in the east devouring Poland, was scathingly referred to by some as "sitzkrieg" to distinguish it from the German blitzkrieg. Instead, the Allies looked for a less risky venue to strike Germany, and Norway came to mind.

Germany was heavily dependent on the high-quality iron ore of Sweden that came from the northern area of the country. This ore was usually shipped by rail through Norway to the ice-free port of Narvik on the Norwegian Sea and from there traveled south by freighter to Germany.[1] Although Sweden and Norway were declared neutrals, the Allies nonetheless considered denying this resource to Germany—by force if necessary. Two weeks after the outbreak of war, the First Lord of the Admiralty, Sir Winston Churchill, suggested mining Norwegian territorial waters to force German ore freighters into the open sea where they could be destroyed by the Royal Navy.[2]

As the months passed, this option and even that of occupying Norway were increasingly considered and then planned. Particularly, it was feared that Germany might act first and simply invade Sweden and Norway to ensure access to the iron ore and to protect the supply lines for its transshipment. On 8 April 1940, the Royal Navy began laying mines in Norwegian territorial waters. Despite the action being against international law by violating the rights of a neutral country, it was deemed essential to British security.[3]

The Germans *were* in fact concerned about their access to Swedish ore and the safe access to Norwegian ports. The Allied starvation blockade of World War I, coupled with numerous violations of neutral shipping rights during the first year of the current conflict, taught them that international law provided flimsy protection in a total war. Also, German planners thought that Norway could serve as a valuable submarine basing site and provide air bases for bomber aircraft that would outflank the Allies and allow powerful strikes on Britain's industry and lines of communication.[4] On 3 March 1940, Nazi Germany dictator Adolph Hitler ordered plans drawn up to occupy Denmark and Norway to protect German access to the Baltic Sea and to ensure that the ore supply lines along the Norwegian coast remained intact. The invasion of Denmark and Norway was set for 9 April—coincidentally, the day before this assault was to take place, the Allies began their mining operations.[5]

The German plan called for a series of quick, powerful, and wide-ranging attacks. Denmark would be seized, and the Luftwaffe would use the two airfields at Aalborg for ferrying troops and supplies into Norway and as a base for long-range strike aircraft. (30,000 German troops were airlifted into Norway by the Luftwaffe—the first major airlift of the war.) A simultaneous attack would be launched against the five major port cities of Norway—Oslo, Bergen, Trondheim, Kristians and Narvik—along with the major airfield at Stavanger. These attacks would employ most of the German surface fleet, six army divisions, a paratroop battalion, and approximately 1,000 aircraft.[6]

The plan went off well despite bad weather and the determined resistance of Norwegian units. But by the end of the first day, the Germans had the situation under control. Denmark surrendered in a nearly bloodless assault, and the five major Norwegian cities fell, as did the main airfields near Oslo and Stavanger. (The first major combat paratroop drop in history secured the airfield at Stavanger.)[7] The next day Allied help arrived, but it would prove to be too little and too late.

Allied plans were deeply flawed and took little account of the role airpower would play in such a major campaign. Historian John Terraine later wrote that the joint planning staff "displayed an amateurishness and feebleness which to this day can make the reader alternatively blush and shiver."[8] Like the Germans, the Allies did not institute a joint command for Norway; instead, each service maintained control over its own forces. In the Narvik area, for example, Adm Lord Cork commanded naval forces and Maj Gen P. J. Mackesy headed the ground troops. However, both received orders from London—sometimes contradictory. For example, Admiral Cork thought the army should assault Narvik forthwith, but General Mackesy considered that "sheer bloody murder" and refused. He had been told unequivocally by his army superiors not to land on an opposed shore. Admiral Cork had not been told of these orders.[9] So instead, General Mackesy landed 45 miles away on an undefended island and approached Narvik in a systematic land operation, all the while Admiral Cork chaffing at the "delay."[10] Such problems were aggravated when General Mackesy established his headquarters on land while the admiral remained afloat. Close coordination was impossible. The general was eventually relieved in the hope that joint cooperation would improve, but by then the campaign was virtually over.

The other Allied task force was directed to liberate Trondheim. However, this port was well within range of Luftwaffe aircraft, and Allied operations there were a disaster. The Royal Navy cruiser *Suffolk* was so badly mauled by German bombers, it barely limped back to port. The Admiralty was therefore convinced that a direct assault on Trondheim was impossible in the face of enemy air superiority. Instead, landings were made north and south of the city, and it was hoped that these two independent pincers would be able to march on Trondheim and retake it by land assault.[11] This ambition was soon seen to be impossible, again due to the Luftwaffe controlling the skies. Maj Gen Carton de Wiart, commander of the northern pincer, signaled London the day following his landing: "I see little chance of carrying out decisive, or indeed, any operations unless enemy air activity is considerably restricted."[12] The following day, 21 April, he was even more emphatic: there was "no alternative to evacuation" unless he could gain air superiority.[13] With its nearest air base more than 600 miles distant, the Royal Air Force (RAF) could not intervene, and the Fleet Air Arm (FAA) was simply outmatched—its aircraft, neglected during the interwar years, were obsolescent in comparison to those of the Luftwaffe. On 1 May the Royal Navy moved two aircraft carriers—the *Ark Royal* and *Glorious*—toward the area in an attempt to gain local air superiority over the landing areas, but the Luftwaffe drove off these ships. Because the Germans controlled the sky over the littoral, the ground forces were soon evacuated.

The situation at Narvik was not quite as dismal for the Allies—despite the disagreements between Admiral Cork and General Mackesy—simply because it was so far north the Luftwaffe had difficulty covering the area. The RAF, through Herculean efforts, carved three airstrips out of the snow and ice and deployed some Gladiator and Hurricane aircraft that had been transported by aircraft carrier. The German garrison had been resupplied by seaplane and flying boat, but the RAF quickly neutralized these reinforcements.

As a result, Allied ground forces were able to make some headway.[14] Unfortunately, on 11 May the Battle of France began, and Norway became a sideshow. Before the Allies had even retaken Narvik, they were planning its evacuation. It fell on 25 May, but the Allies returned to their ships and departed two weeks later. The Germans quickly moved back in, and the campaign was over. Norway would remain in Nazi hands until the end of the war.

Observations

- Germany's strategic plan was logical and achievable. Swedish iron ore, which comprised 40 percent of the German supply, was an essential war resource that needed to be assured.[15] This plan was a worthy goal that justified Germany's campaign to seize Denmark and Norway. On Hitler's part, the strategy was a necessary prelude to further operations—Germany was securing its resources for an extended war. Similarly, the plan to use Norway for submarine bases was wise; the U-boat pens at Trondheim became essential to the German navy and were a thorn in the Allied side for the rest of war. On the other hand, the plan to use Norway for Luftwaffe bases from which to bomb Britain proved to be a chimera—the bases were too distant from Britain to be useful.[16] The strategic concept of the Allies also made some sense. Opening a second front in Norway and avoiding the main enemy deployed opposite France—which was believed to be very powerful—was logical. For the same reasons that Norway was valuable to Germany, so too was its denial to the Nazi regime of great import to the Allies. Without Swedish iron ore, Germany would have serious difficulties attempting to manufacture the armaments it needed to sustain a total war. The problem for the Allies was in the execution.
- Although the Germans were no more experienced in joint planning than the Allies, they had greater foresight in their net assessment. Airpower was realized as essential, as were the innovative tactics of airlifting troops and supplies and employing vertical attack using paratroops. Both air missions were pioneered during this campaign. The Allies failed to appreciate the fundamental

change that airpower had made to the conduct of modern war. RAF aircraft lacked the range to operate effectively over Norway from their bases in Britain, and the aircraft of the Royal Navy's FAA were obsolescent and no match for the first-rate Luftwaffe fighters they would encounter.[17] This campaign would open British eyes to the need for more air assets more creatively used.

- British planning was poor. One observer noted that "the British had only the vaguest ideas as to those two most important elements in coming up with a workable operational plan: the enemy and the terrain." Troops departing for Norway were told that there was little snow in the Narvik area. Upon arrival they found several feet of it piled up all the way to the water's edge! General Mackesy's orders from his superior were not shared with the navy or air force. One observer, Gen Hastings Ismay, summarized the problem clearly: "The Chief of the Naval Staff and the Chief of the Imperial General Staff acted with sturdy independence. They appointed their respective commanders without consultations with each other; and worse still, they gave directives to those commanders without harmonizing them. Thereafter they continued to issue separate orders to them. Thus was confusion worse confounded."[18]
- Unity of command is a recognized principle of war and is especially necessary in the case of an amphibious assault against a defended shore. There must be a single commander in charge at all times, and all components must recognize that authority. During the Norwegian Campaign, both sides were deficient in this area. At times, component commanders received conflicting orders from their respective services back home. Also, there must be no conflict between sea and land commanders during such hazardous operations—which again was the case in Norway. Today, US joint doctrine insists on such unity, embodied in a "joint force commander" to whom all the other components—air, land, sea, space, and special forces—are explicitly subordinate at all times.[19]
- Although the German forces found a Norwegian population hostile to their presence, the typically rigorous and no-nonsense approach that the Wehrmacht traditionally took to such occupations ensured that there were no serious problems. On the one hand, this passive situation allowed the Germans to establish a solid base for extended operations within the country. On the other hand, the Allies were successful only in the far north at Narvik, where they could build rudimentary airfields from which to base aircraft and establish a supply and staging area. The intent was to use Narvik as a stepping-off point to attack German forces to the south. This plan, which would have been difficult to implement in any event, was never attempted due to the invasion of France and subsequent Allied withdrawal from Narvik.
- It is extremely difficult for any invader to launch an amphibious operation against a defended enemy shore. In the Norwegian Campaign, the British field commanders flatly refused to land at Trondheim or Narvik for this very reason—and they were supported in these decisions by superiors in London. When a vigorous enemy defense is expected, the attacker must take great pains to soften up enemy positions through a prolonged and heavy artillery

bombardment from sea, aerial bombing operations, or both. The alternative is to achieve near total tactical surprise—a rare occurrence.

- Similarly, the Allied forces that attempted to liberate Norway in 1940 were inadequate for the task. Not only were the participating ground troops insufficient to dislodge the Germans from their entrenched positions but also the air forces—both land- and sea-based—were likewise too sparse, and, as noted, in the case of the FAA were of inadequate capability. The importance of airpower in military operations during World War II will be discussed more fully, but in Norway, Luftwaffe superiority at the point of attack was a critical factor in Allied failure.
- Joint military leadership underwent a transformation due to this campaign. The addition of airpower to the equation made joint planning and command essential. Previously, a grudging cooperation between sailors and soldiers might have been sufficient, but the advent of airpower—necessary for the successful conduct of both land and sea operations—made joint coordination essential. Aircraft from land and sea bases operated in the same airspace—a danger unless those air arms closely coordinated their efforts. Simple factors of efficiency and effectiveness were also apparent. There was no unity of command in Norway—on either side—and as has been noted, conflicting orders were often sent to the component commanders, who maintained separate headquarters. Unity of command was ignored. From this point on, a joint commander, responsible for all forces within his theater, would be a sine qua non of effective military operations. What today is termed jointness was barely present in this campaign. As the war progressed, it became apparent that the Allies learned more quickly than did the Germans. The German official history ruefully admits this situation: "The successful conclusion of Weserübung [the German code word for the Norwegian/Danish invasion] did not encourage critical analysis; rather, it tended to divert attention from the shortcomings of the German command organization and the weaknesses of the Wehrmacht."[20]
- Doctrines among the services were seldom compatible, and the lack of joint exercises during peacetime became painfully obvious. These deficits were especially apparent in the poor results by naval gunfire in support of troops ashore and in the inadequacy of close air support. Such myopia now had to be cured by the harsh teacher of combat.
- This campaign demonstrated that intelligence was vitally important for success. The Allies had superior intelligence-gathering assets and also enjoyed the supreme advantage of having broken the German codes—the Enigma machine that transmitted Ultra intelligence. Yet because intelligence was poorly shared among the services and even within each service, the numbers, quality, and location of enemy aircraft, vessels, and shore batteries were often unknown to the key parties.[21]

- The notion of sea superiority underwent a fundamental and irreversible change because of the Norwegian Campaign. It was now realized that command of the air was essential to ensure command of the sea. The Luftwaffe controlled the air, and the Royal Navy could not maintain a presence in the face of that control. The Royal Navy's official historian later concluded that "if effective air cover was lacking, warships could not be maintained overseas."[22] This admission was startling. Gen Alan Brooke, later chief of the Imperial General Staff, concurred with this assessment, writing at the conclusion of the campaign that Norway demonstrated "the undermining of sea power by air power."[23] The sole bright spot for the Allies during the campaign was at Narvik, but this was so only because the Luftwaffe was unable to intervene effectively. Therefore, the RAF was able to gain localized air superiority.

A major tenet of naval theorists had been that one of sea power's great strengths was its ability to prevent an enemy from conducting a major amphibious operation. If such an operation were initiated, a navy could strangle it by preventing resupply to the troops ashore—a major lesson demonstrated in Napoleon Bonaparte's Egyptian Campaign of 1798 when his entire fleet was destroyed by Adm Horatio Nelson at Aboukir Bay. But this Mahanian concept of neutralizing an enemy fleet to gain sea control was a serious miscalculation that did not take into account the emerging importance of airpower. The British Cabinet initially believed that sea power would dispose of German forces in Norway in "a week or two."[24] Instead, the tone of the campaign was set on the first day when the Luftwaffe intercepted a portion of the British fleet at sea. Without air cover, one destroyer was sunk, and the battleship *Rodney* was damaged. In response, the fleet moved north out of range of German aircraft.[25] The Royal Navy was thus unable to lend effective support to the troops landing on the coast. The Luftwaffe had achieved air superiority over the littoral, and control of the air determined control of the surface below.

The Major Lesson of the Campaign

World War II demonstrated almost from its outset that control of the sea was difficult if not impossible to maintain if the air above the sea was not controlled as well. This had been the belief of many airmen between the wars, but they had no historical precedents to back it up. However, soon after World War II began, the truth of this new proposition was made apparent. During the Norwegian Campaign of 1940, the Royal Navy realized on the first day of operations that its ships were extremely vulnerable to the Luftwaffe—and throughout the campaign, air superiority had a critical impact on military operations. The RAF's aircraft, based in England and Scotland, didn't have the range to extend an air control bubble over the landing areas. While the FAA's aircraft had reasonable range—given that the Royal Navy's carriers were in Norwegian waters—they were substantially underpowered and obsolescent compared to the Luftwaffe's aircraft. Only in the far north, at Narvik, was the RAF able to scrape out rudimentary airfields for its use and thus contest command of the air with the Germans. Unfortunately, it was for naught because the Allies almost immediately evacuated Narvik after the Germans invaded France, and Norway soon returned to Nazi hands.

The need for air superiority over the littoral was repeatedly shown during the war. In May 1941 at Crete, more than 23,000 German invaders—transported mostly by air—landed on the island, which was defended by more than 42,000 British, Commonwealth, and Greek troops. Remarkably, the Germans were successful in less than a week, largely because the Luftwaffe had command of the air. The Royal Navy aircraft carrier *Formidable* was driven off with heavy damage, thereby eliminating its group of aircraft from use.

As in Norway, the RAF's aircraft lacked the range to cover the island from RAF bases in Egypt, and the result for the Royal Navy was catastrophic. The Luftwaffe sank three cruisers and six destroyers while heavily damaging an aircraft carrier, three battleships, and 15 other major ships. Counting smaller ships in the harbor at Suda Bay, a total of 42 vessels were sunk or damaged with a loss of more than 2,000 lives due to German air attacks.[26] The words of the British land and sea commanders are compelling. Maj Gen Bernard Freyberg cabled his superior during the battle that "a small, ill-equipped and immobile force such as ours cannot stand up against the concentrated bombing that we have been faced with during the last seven days."[27] The Royal Navy commander in the Mediterranean, Adm Andrew Cunningham, wrote at the time of the debacle, "As I have always feared, enemy command of the air, unchallenged by our own Air Force, and in these restricted waters, with Mediterranean weather, is too great odds for us to take on except by seizing opportunities of surprise and using the utmost circumspection—it is perhaps fortunate that HMS *Formidable* was immobilized, as I doubt if she would now be afloat."[28]

In one of the greatest shocks in the war to Churchill, Japanese land-based aircraft sank the battleship *Prince of Wales* and battle cruiser *Repulse* on 9 December 1941 off the coast of Malaya—those were the Royal Navy's only two capital ships in the Pacific. Adm Tom Phillips, the task force commander, had not commanded operationally since the Great War, and clearly the revolution in air warfare had passed him by. He did not wait for air cover, and when Japanese aircraft were first sighted, he also refused to break radio silence to call for help from RAF airfields within range. It was a fatal mistake.[29]

The eminent historian Michael Howard observed this shift in war, writing that the Second World War in Europe involved the transportation and then continued supply of massive armies from seemingly small and fragile port facilities. As a result, the defender moving up his reserves by road and rail enjoyed the customary flexibility of internal lines of supply, but "it was the new weapon of air-power, rather than the traditional one of sea-power, that had to be called upon to counter it."[30]

The specific impact on amphibious operations was also first revealed in Norway. For the rest of the war, commanders realized that amphibious operations could not succeed if the enemy controlled the air—regardless of the size of the flotilla supporting the landings. American amphibious assaults in the Pacific were dependent on air superiority. Indeed, it was not a coincidence that Gen Douglas MacArthur's "island-hopping" campaign consisted of jumps of around 300 miles—the radius of most US fighter aircraft at the time. Also, the islands chosen for assault either already had a runway in operation or the terrain allowed one to be rapidly built. In the central Pacific, the invading forces of Adm Chester Nimitz were always accompanied by multiple aircraft carriers to ensure air control over the beaches. The aircraft carrier replaced the battleship as the center of the US fleet. Air superiority was no less crucial in Europe. It was an integral part of the Allied landings in North Africa, Sicily, and Italy. In June 1944, the Allies landed on the coast of France. Air superiority was considered a prerequisite by Gen Dwight Eisenhower. Later he would testify before Congress regarding the importance of air superiority for the Normandy invasion:

> The Normandy invasion was based on a deep-seated faith in the power of the air forces, in overwhelming numbers, to intervene in the land battle. That is, a faith that the air forces, by their action, could have the effect on the ground of making it possible for a small force of land troops to invade a continent. . . .Without that air force, without the aid of its power, entirely aside from its anticipated ability to sweep the enemy air forces out of the sky, without its power to intervene in the land battle, that invasion would have been fantastic. . . . It would have been more than fantastic, it would have been criminal.[31]

Field Marshal Erwin Rommel, General Eisenhower's opponent in Normandy, admitted the accuracy of the above statement, acknowledging that "anyone who has to fight, even with the most modern weapons, against an enemy in complete command of the air, fights like a savage against modern European troops, under the same handicaps and with the same chances of success."[32] The noted historian Paul Kennedy summed up this new fact of war succinctly: "Airpower in the Second World War created winners and losers; either they had it or they didn't."[33]

Lt Gen Claude Auchinleck, who succeeded General Mackesy in command of the Narvik operation in 1940, wrote in his report of the campaign about the value of airpower in all its forms: "He [the enemy] used it first, to support his troops by low-flying attacks, by bombing [in the latter stages by dive-bombing], by surprise landing of combat troops by parachute, and from seaplanes. The enemy advanced detachments were supplied by air. And secondly, [airpower was used] to deny us the use of sea communications in the narrow coastal waters in the theatre of operations."[34] He concluded that "to commit troops to a campaign in which they cannot be provided with adequate air support is to court disaster."[35]

Air superiority allowed the Luftwaffe to conduct interdiction, close air support, reconnaissance, resupply, and reinforcement with little interference—almost 30,000 German troops were moved into Norway by air. Also of consequence, the psychological impact of having enemy aircraft continually overhead was a severe blow: "in some cases, frustration built up to a sense of hopelessness and a serious lowering of morale."[36] In short, the psychological impact of air attack was often as great as its physical impact. Germany's campaign in Norway proved to be highly successful at a relatively low cost; for the British and French, the opposite was the case. One other, and vitally important, result of this failed Allied campaign was the government fall of Neville Chamberlain. The new prime minister was Winston Churchill. ✪

Notes

1. J. R. M. Butler, *History of the Second World War: Grand Strategy*, vol. 2, *September 1939–June 1941* (London: Her Majesty's Stationery Office [HMSO], 1957), 119–23. Iron ore was also shipped from Swedish ports through the Baltic Sea to Germany (ibid., 121–22).
2. Klaus A. Maier et al., eds., *Germany and the Second World War*, vol. 2, *Germany's Initial Conquests in Europe* (Oxford, UK: Clarendon, 1991), 184–85.
3. Adam R. A. Claasen, *Hitler's Northern War: The Luftwaffe's Ill-Fated Campaign, 1940–1945* (Lawrence: University Press of Kansas, 2001), 58.
4. Ibid., 3, 5, 11.
5. Maier et al., *Germany and the Second World War*, 192.
6. Claasen, *Hitler's Northern War*, 41, 44.
7. Ibid., 49, 62, 69.
8. John Terraine, *A Time for Courage: The Royal Air Force in the European War, 1939–1945* (New York: Macmillan, 1985), 115.
9. Jack Adams, *The Doomed Expedition: The Norwegian Campaign of 1940* (London: Leo Cooper, 1989), 93.
10. Butler, *History of the Second World War*, 132–34, 141. Cork received orders direct from the Admiralty, even bypassing the commander-in-chief, Home Fleet, his nominal naval superior, 132.
11. Claasen, *Hitler's Northern War*, 103–5.
12. Denis Richards, *Royal Air Force 1939–1945*, vol. 1, *The Fight at Odds* (London: Her Majesty's Stationery Office, 1974), 86.
13. Ibid.
14. Claasen, *Hitler's Northern War*, 111–15.
15. Ibid., 9.
16. Ibid., 90. Germany never fielded a long-range bomber in any quantity during the war, and its medium bombers simply did not have the range to span the distance from Norway to industrial targets in Britain.
17. The Fleet Air Arm was part of the RAF until 1937, when it was turned over to the Royal Navy. It was not given a high priority by either service, so upon entering World War II its aircraft were definitely substandard. See Phillip S. Meilinger, "Between the Devil and the Deep Blue Sea: The Fleet Air Arm before World War II," *Royal United Services Institute Journal* 144, no. 5 (October 1999): 73–78.
18. Henrik O. Lunde, *Hitler's Pre-Emptive War: The Battle for Norway, 1940* (Philadelphia: Casemate, 2009), 245.
19. Joint Publication 3-02, *Amphibious Operations*, 18 July 2014, chap. 2, "Command and Control."
20. Maier et al., *Germany and the Second World War*, 219.
21. F. H. Hinsley et al., *British Intelligence in the Second World War*, 5 vols. (London: Her Majesty's Stationery Office, 1979–90), vol. 1, 136–43.
22. Claasen, *Hitler's Northern War*, 118.
23. Ibid.
24. Butler, *History of the Second World War*, 128.
25. Geoffrey Till, *Air Power and the Royal Navy, 1914–1945: A Historical Survey* (London: Jane's, 1979), 15.
26. Gerhard L. Weinberg, *A World at Arms: A Global History of World War II* (New York: Cambridge University Press, 2005), 229; and George Forty, *Battle of Crete* (Surrey, UK: Ian Allen, 2001), 162–71. Forty notes that a total of 23,464 German troops were moved into Crete by air (ibid., 162).
27. Alan Clark, *The Fall of Crete* (New York: William Morrow, 1962), 162.
28. Ibid., 120.
29. John Prados, *Combined Fleet Decoded: The Secret History of American Intelligence and the Japanese Navy in World War II* (New York: Random House, 1995), 215–22; and David Hein, "Vulnerable: HMSO Prince of Wales in 1941," *Journal of Military History* 77, no. 3 (July 2013): 955–89. Not just capital ships at sea were vulnerable: four US Navy battleships were sunk by Japanese aircraft in port at Pearl Harbor, with four others damaged. In addition, aircraft sank or damaged three cruisers, three destroyers, and two other ships.

30. Michael Howard, *The Mediterranean Strategy in the Second World War* (London: Greenhill Books, 1968), 4.
31. Testimony of Gen Dwight D. Eisenhower to Senate, Department of Armed Forces, *Department of Military Security: Hearings before the Committee on Military Affairs on S. 84 and S. 1482*, 79th Cong., 1st sess., 1945, 360.
32. B. H. Liddell Hart, ed., *The Rommel Papers* (London: Collins, 1953), 285.
33. Paul Kennedy, *Engineers of Victory: The Problem Solvers Who Turned the Tide in the Second World War* (New York: Random House, 2013), 226.
34. Adams, *Doomed Expedition*, 172.
35. Lunde, *Hitler's Pre-Emptive War*, 547.
36. Adams, *Doomed Expedition*, 173.

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Defeating the Threat of Small Unmanned Aerial Systems

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Unmanned aerial systems (UAS) offer new or improved military capability in many airpower applications. Contemporary UASs range in size from aircraft with wingspans exceeding 150 feet to vehicles that fit into the palm of an operator's hand. Medium-sized unmanned aircraft such as the MQ-1B Predator have become icons of American counterterrorism warfare, but small unmanned aerial systems (SUAS) have performed significant roles in militaries around the globe as well. SUASs provide game-changing potential for small militaries and nonstate actors by enabling airpower capability that may have been previously out of reach. More advanced militaries can also leverage SUAS capability to enhance existing combat systems.

Innovative applications of SUASs by adversaries create new threats to US joint forces. Defeating the threat posed by SUASs will require commanders to combine new technology and doctrine along with appropriate planning and policy to protect the joint force. Examining the proliferation, arming, and unique tactical advantages of SUASs is necessary to demonstrate the threat against a joint force. With the threat to the force understood, methods for countering it can be identified and conclusions drawn to ensure joint force mission success.

Proliferation of Small Unmanned Aerial Systems

UASs have historically been the privilege of few nations as technology limited to large aerospace companies was required to conduct remote or autonomous flight. Recent engineering achievement has led to commercially available unmanned flight control systems enabling the development or acquisition of UASs by much smaller entities, including individuals. Oxford University doctoral candidate Ulrike Esther Franke focused much of her research on the implications of increased military use of unmanned systems. Ms. Franke reported that in 2000 only 17 countries possessed UASs for military application; by 2015 that number had risen to more than 75.[1]

The spectrum of UAS military users spans the globe and has not been limited to sovereign countries. Nonstate actors are operating UASs for military purposes, such as the terrorist group Hezbollah that has flown unarmed Iranian-built UASs over Lebanon and Syria.[2] As the development and export of UASs expand, the number of UAS users will no doubt increase to include more unstable or hostile governments as well as violent extremist organizations.

Smaller UASs present a substantial potential for armed groups that cannot afford or gain access to larger, more complex systems. For advanced militaries, SUASs provide a new opportunity to increase the quantity of military assets and introduce a new capability at significantly reduced cost compared to that of larger systems. The number of countries currently employing SUASs far exceeds those with medium and large systems. Ms. Franke's research notes that a multitude of European militaries have domestically developed SUAS programs. Additionally, many non-European countries are creating their SUAS systems.[3] It is hard to imagine a potential adversary, whether a state or nonstate actor, that will not employ a form of SUASs during future armed conflict.

State-funded defense programs are not the only source of unmanned aircraft. Commercial production has exploded in recent years with low-cost aircraft offering advanced autonomy and sensor features. Dà–Jiāng Innovation (DJI) Technology Company's Phantom 4 is an example of a SUAS available for purchase over the Internet. The Chinese-manufactured aircraft are capable of flight for almost 30 minutes, can reach altitudes over 18,000 feet, and come equipped with data-linked, high-definition cameras. The cost for this capability is a meager $1,400.[4]

In addition to cost savings and sensor capability, SUASs permit flexibility in employment. The systems are portable and do not require airfields or other support networks. Many small air vehicles are hand-launched or use some type of catapult for takeoff. Recovery is also relatively simple since most vehicles either land on short surfaces or employ a capture device to retrieve the aircraft in flight. Transportability allows SUASs to be used during maneuver warfare when operating in remote areas or where air cover and intelligence assets are otherwise unattainable. As identified in Ms. Franke's research, the proliferation of SUASs is proceeding at an alarming rate and will likely continue in the quantity of assets available and the armed groups that employ them. Combat capabilities will also expand through advancements in flight duration and autonomy, further enabling intelligence collection, communications, and strike missions.

Arming Small Unarmed Aerial Systems

Although many nations are rapidly acquiring UASs for military application, the ability to arm these aircraft has remained limited until recently. As of 2013, only the United States, United Kingdom, and Israel operated armed UASs; by 2015 both China and Iran possessed domestically developed armed UAS programs.[5] It is expected that armed UAS exports will grow swiftly to meet international market demand.

Evidence of armed UAS proliferation was provided in a January 2016 news story about Iraq operating armed unmanned aircraft manufactured in China. A deeper examination of Chinese exports showed that Saudi Arabia, the United Arab Emirates, and Egypt have also procured armed UASs from China. With more than 75 corporate and state organizations developing products for the UAS industry, China is postured to become a major supplier.[6] The appeal of China as an armed UAS supplier comes from its export policy founded on "price, privacy, and product."[7] China provides products at prices small governments can afford. Further, China's approach to privacy is highly attractive to many consumers who desire limited attention when procuring advanced weapons.[8]

Regardless of availability, the cost of medium to large aircraft can prohibit organizations from attaining armed UAS capability. The significantly lower cost of procurement and operation of SUASs has generated a new armed aircraft market. Although the current supply of armed SUASs is limited, the field is fast expanding. US-based Textron Systems, which produces the RQ-7 Shadow that is fielded by the US Army for intelligence collection, is one example of a new armed SUAS project. Bill Irby, senior vice president and general manager for Textron's unmanned systems, stated that Textron has successfully tested the RQ-7 with its lightweight, precision-guided weapons. Another example is the Chinese CH-3A.[9]

One challenge to armed SUAS development has been attaining weapons small enough to be employed from the air vehicles. Weapons like the AGM-114 Hellfire, carried on the MQ-1, weigh about 100 pounds. Newer designs such as the AGM-176 Griffin missile are significantly smaller yet still too heavy for many air vehicles in development. To solve this problem, in 2010 the US military released a request for proposals to develop precision weapons that weigh less than 11.3 kilograms (kg) (25 pounds).[10]

The industry responded to this request by designing a multitude of lightweight precision weapons. The Raytheon Pyros glide bomb weighs only 6 kg (13.2 pounds), while Lockheed-Martin's Shadow Hawk weapon weighs only 5 kg (11 pounds).[11] Although attaining information on China's developments in small precision weapons is difficult, it is not a stretch to imagine that its corporations are steadfastly working on SUASs and their accompanying weapons for the Chinese military and the international marketplace.

Along with arming SUASs to provide strike capability, expendable miniature aircraft designed to be munitions in themselves are available. Small aircraft that have integrated sensor-warhead payloads offer an even lower cost and a highly flexible option to militaries of all sizes. AeroVironment's Switchblade SUAS is an example of a single-use vehicle with integrated warhead and sensors. Switchblade comes in a portable package weighing just 2.5 kg (5.5 pounds), including the weight of the vehicle and launcher. With a 10-minute flight time and a top speed of more than 85 miles per hour (mph), Switchblade offers individual warriors a weapon that can fly up to altitude, spot an enemy, and rapidly engage with precision, yielding lethal effects with limited collateral damage.[12]

Armed SUAS acquisition is not limited to organizations with access to defense contractors that might be subject to some degree of government oversight. For groups without a benefactor with access to military hardware, weapons may be attained through another method. Advanced SUASs for commercial purposes can be readily adapted for armed missions. By removing cameras or other commercial payloads on small air vehicles purchased through the Internet, small improvised explosive devices (IED) can be added, creating makeshift guided missiles. As an example, the DJI S1000 aircraft features a payload dock on the bottom of the vehicle. The system was designed to allow users to attach different camera equipment based on the mission. In the hands of an innovative user, the S1000 is a highly capable SUAS that can fly a 9.5 kg (20 pound) payload for 15 minutes. This capability can enable a lone-wolf actor to perform precise kinetic strikes against targets in protected areas for less than $5,000.[13]

Whether purchasing SUASs that can carry precision-guided weapons, using aircraft that are weapons in themselves, or adapting drones ordered online to carry IEDs, the options for armed groups are rapidly expanding. The cost ranges from well above $500,000 to only a few thousand dollars, providing air-attack capability and quantity options never previously available.

Tactical Advantages of Small Unmanned Aerial Systems

The tactical applications of SUASs are numerous. Attempting to identify every potential military option would be virtually impossible, so it is perhaps more beneficial to focus on the tactical advantages unique to SUASs. These advantages can be understood by examining three properties of SUASs: size, speed, and swarm. Each of these properties provides a benefit in armed conflict. Combined, the properties generate combat potential that presents a significant threat to US military forces.

The small size and relative speeds of the air vehicles create substantial defensive difficulties. Joint Publication (JP) 3-0, *Joint Operations*, states: "Unmanned aircraft are a new challenge to US air defenses, as many systems have smaller radar cross sections and fly at much slower speeds than manned aircraft making them much harder to detect."[14] This doctrinally stated weakness was demonstrated in January 2015 when a DJI Phantom—flown by an amateur operator in the Washington, DC, area—crashed on the lawn of the White House. While the event was an accident and had no apparent malicious intent, it highlighted how small, slow air vehicles could exploit a seam between robust air and ground defenses.[15] A few months later on 22 April 2015, security personnel discovered another DJI Phantom on the roof of Japanese prime minister Shinzo Abe's office. Security personnel did not know when the aircraft landed on the building since the roof had not been accessed for a month and the approach and landing were not detected.[16]

SUASs have additional advantages beyond electronic and visual detection avoidance. Their small size make them easily transportable; they can be moved with small vehicles and, in some instances, carried in a backpack. An adversary can move equipment and operators near joint force basing areas before deploying the air vehicle. Instead of trying to penetrate US air defenses with fighter aircraft, adversaries could use passive detection measures to conceal the presence of armed SUASs and then launch them from a position inside US fortifications.

Although slow moving compared to most aircraft, their mere ability to fly generates a speed advantage in bypassing obstacles from launch to engagement. With an operating speed of up to 100 mph in some systems, small air vehicles can close employment range very quickly. When combined with small size, the speed of SUASs can create attack options where the first sign of an enemy presence would be weapon detonation. A profound benefit of speed and size is also the ability to operate inside the commander's decision loop. With the potential to attack repeatedly and to do so undetected, SUASs present a potentially devastating threat by creating a confusing environment for the unprepared operational commander.

One's aircraft fleet size must be considered when analyzing the impact of SUASs. The rapid growth of SUAS capability has led to a new reality in the application of airpower. Former secretary of defense Chuck Hagel alluded to this reality in a keynote speech to the Southeastern New England Defense Industry Alliance in September 2014 when he stated, "Disruptive technologies and destructive weapons, once solely possessed by only advanced nations, have proliferated widely and are being sought or acquired by unsophisticated militaries and terrorist groups."[17] SUAS proliferation is adjusting the balance of airpower, which has for decades been dominated by a select few nations.

With the advent of armed SUASs, US forces must change the way they have historically defended against enemy airpower. JP 3-0 identifies air and missile defense (AMD) as a key task of joint forces.[18] Historical assumptions in planning for AMD may no longer be valid due to the SUAS threat. A joint base in a theater without a significant enemy air force may have few assets allocated for AMD. Through the employment of SUASs, an enemy could exploit this US defense weakness or at least force operational commanders to allocate resources to air defense against the SUAS threat, removing offensive potential.

Defense analyst Paul Scharre calls attention to the change in relative airpower capability created by SUASs. In a 2014 report, Scharre notes, "Overwhelming adversaries through greater numbers is a viable strategy for technology competition, and was used successfully by the United States in World War II. One of the chief advantages of this strategy is that it can be used to *impose costs* on adversaries because it forces one's adversary to counter large numbers of systems (emphasis in original)."[19]

SUASs can impose air defense costs where none were previously necessary or drastically increase AMD costs against enemies with marginal air attack capabilities.

The ability to acquire large quantities of SUASs further affects relative airpower by allowing an enemy the opportunity to mass tens or even hundreds of air assets in a coordinated attack instead of employing a few legacy aircraft. By attacking with overwhelming numbers, SUASs could require US joint forces to engage numerous targets, imposing a significantly higher cost of defense compared to legacy airpower means. Although US joint forces may enjoy a significant technology advantage, their defenses may not be sufficient against a swarm of small air vehicles.

In a separate 2014 report, Scharre evaluates superior quality against large quantities in military engagements using a principal called Lanchester's Law. Scharre concludes, "A numerically inferior force can compensate with greater qualitative superiority, but a force that is outnumbered by its opponent 2-to-1 must, therefore, be *four times better* in quality in order to simply match its opponent. There is, in essence, a limit to how much qualitative superiority can compensate for smaller numbers" (emphasis in original).[20] The low cost of SUASs creates a possibility for a savvy adversary to simply overwhelm joint air defenses, adjusting the relative airpower for the attacker.

Combining the advantages of size and speed of SUASs with the quantities available due to low cost magnifies the change in the balance of airpower. Armed groups that previously had no option for successfully employing airpower can now challenge US joint forces. By employing SUASs in swarms, an adversary can further tip the scale in their favor.

As defined by Scharre, "a swarm consists of disparate elements that coordinate and adapt their movements in order to give rise to an emergent, coherent whole."[21] Swarming is much more than just coordinating an action with large masses. In a massed attack, the individual members use coordinated fire and maneuver to achieve a coherent objective. In swarming, coherency is within the mass itself. Scharre clarifies this distinction in noting that "a wolf pack is something quite different from a group of wolves."[22]

The ability to swarm SUASs is restricted with current technology. Operators have limited capabilities to link SUASs together or, by using autonomy, to react in harmony to changes in the battle situation and within the swarm itself. However, with proper planning and coordination, an adversary can take advantage of some SUAS swarm capabilities. "Centralized coordination" is a basic model of swarm command and control that uses a designated leader to orchestrate mission plans and maneuvers and to assign tasks during the mission.[23] A team operating SUASs under a centralized coordination construct can impose greater levels of damage than can masses of SUASs operating alone. The combination of speed, size, scale, and swarming allows SUAS tactical actions to extract operational gains. SUASs open a door for adversaries to counter joint force strengths through enabling their attack of critical vulnerabilities previously out of their reach.

An example of an opportunity afforded through swarming is demonstrated by the role of mining in warfare. Dr. Milan Vego, a US Naval War College professor of operations, suggests that mining is "in some cases almost the only means available to a weaker opponent at sea to challenge the control of a stronger navy." Dr. Vego adds that mines could be used to shape the battlespace by denying the free use of space and by forcing vessels out of protected waters where they may be vulnerable to attack by other means.[24] Similar to mines at sea or IEDs on land, large quantities of low-cost SUASs can be employed in a manner to mine airspace in locations of high-density air traffic.[25]

Airspace mining is just one illustration of how the unique advantages of SUASs can be used to challenge maneuver, sustainment, or protection measures. The threat posed by SUASs extends far beyond simple tactics. Adversary forces can use SUASs to impose costs on operational commanders by attacking personnel, infrastructure, and support systems. Delaying preparations to defend against the threat could end in disaster.

Defeating the Threat Created by Small Unmanned Aerial Systems

Averting disaster in joint operations will require commanders to address the SUAS threat. To be successful, commanders cannot wait and react to their enemy; rather, they must proactively work to achieve victory. Defeating the threat created by SUASs will require a combination of new technical solutions, updates to doctrine, incorporation of counter-SUAS efforts in planning for operations, and a new policy for fighting a new kind of enemy.

Technical solutions are intended to solve the problem of SUAS detection and provide an ability to destroy, disable, or neutralize the enemy aircraft. Leading the effort toward SUAS detection and defeat is the Joint Integrated Air and Missile Defense Organization (JIAMDO). JIAMDO is charged to plan, coordinate, and oversee AMD and associated joint concepts, according to a defense budget justification report.[26] One of JIAMDO's efforts at technical solutions to counter the SUAS threat is the annual Black Dart exercise.

In 2015 JIAMDO executed a $4.2 million budget for Black Dart. The event comprised a multiday series of experiments aimed at testing the detection and defeat of SUASs. Results from experiments at Black Dart revealed that a "system of systems" is necessary to identify and defend against SUASs. Detection involves a combination of radar, electro-optical, infrared, and acoustic technologies. Destruction or neutralization of the air vehicle requires a combination of kinetic and electronic solutions.[27]

Attempting to counter the threat of SUAS by defending with technical solutions alone will not suffice. A solely technical effort applied to current force protection constructs may lead to unacceptable costs of defense at the expense of mission capability. Doctrine must be updated to consider the capabilities unique to SUASs. Although many sources of doctrine can be considered, *Countering Air and Missile Threats* (JP 3-01) offers a logically sound point of origin to assess current doctrinal suitability for defeating this new threat.

Counter-AMD is typically led by the joint force air component commander. The counter-AMD construct is broken into two primary areas: offensive counterair (OCA) and defensive counterair (DCA). Each area must address the unique capabilities of SUASs.[28]

OCA is defined as "offensive operations to destroy, disrupt, or neutralize enemy aircraft, missiles, launch platforms, and their supporting structures and systems both before and after launch, and as close to their source as possible."[29] Attack operations, as part of OCA, are aimed at striking these components of enemy airpower before they can be employed against friendly forces. Airpower enablers, such as fuel storage and repair facilities, can also be targeted.[30]

The size and available quantity of SUASs make OCA missions against this threat difficult at best. Targeting the aircraft themselves can be an expensive and futile effort. Likewise, launch and support systems are easily concealable, transportable, and numerous. Because some SUASs use conventional fuel types, attacking fuel storage may yield some positive results. However, the low fuel volumes required enable adversaries to store sufficient quantities of fuel in small containers that are mobile and concealable. Also, many SUASs are electrically powered and can be charged from civil infrastructure that may be off limits to attack. The unique characteristics of these systems reveal that current OCA doctrine is insufficient to provide an effective plan to counter enemy SUAS employment potential.

Deficiencies also exist in current DCA literature. The DCA mission is defined by JP 3-01 as "all defensive measures designed to detect, identify, intercept, and neutralize or destroy enemy forces attempting to penetrate or attack through friendly airspace."[31] Executing this role requires utilizing a wide range of sensors and weapons based on land, sea, and air. The goal for DCA is to generate "defense in depth," allowing defensive systems an opportunity for multiple engagements against incoming air threats.[32]

The unique attributes of SUASs allow for evasion of detection with current air defense technology, while developing adequate sensors to detect the full range of SUASs can be prohibitively expensive. The transportability of SUASs allows for penetration of outer defense layers on land and sea, so employment can be initiated from close-in ranges that prohibit multiple engagements. When properly massed, swarms of SUASs can overwhelm inner defenses and create gaps for follow-on attacks to exploit.

Both OCA and DCA missions require significant study to generate doctrinal guidance to defeat the SUAS threat. However, a vector for solving this problem may come from the current doctrine itself: JP 3-01 identifies special operations forces (SOF) as a method of aiding the counterair mission. SOF units can be used to locate and eliminate air and missile facilities, support systems, and command nodes.[33]

Hunting enemy air systems that are mobile can be difficult. The size of SUASs makes this mission more difficult than for legacy missile systems by orders of magnitude because systems can be hidden virtually anywhere with ease. Although employing SOF units per current doctrine will likely yield insufficient results to counter the SUAS threat, it does illuminate a potential counter-SUAS technique.

The attributes of the SUAS that afford an advantage in attack can also be used against it. Installation commanders may seek to clear larger perimeters around joint force facilities than are historically maintained. Eliminating havens from which to launch SUASs close-in against friendly operating areas could force enemy attacks from distances that enable detection and elimination and challenge the range of systems too small to detect. Using ground forces to clear and hold a perimeter can be viewed as a new means of OCA.

JP 3-01 states that ballistic missile defense is a different mission, unique from defense against aircraft and cruise missiles.[34] Countering the SUAS threat will also require a different emphasis from current air and missile defense literature. By providing adequate doctrine, commanders will be able to incorporate technical solutions within joint forces during the planning process to help defeat the SUAS threat.

Planning for this threat is essential in the current battlespace. The low cost of SUASs enables adversaries to increase their relative airpower in their favor. Intelligence assessments on the ability of an adversary to obtain and operate large masses of SUASs must be accounted for in a planner's time-space-force estimation. SUAS analysis must consider an adversary's increased force size, space covered by the air assets, and the short reaction times commanders may have when SUASs are discovered. In examining the force-time factor, planners must also determine how to replace their systems rapidly.

When assessing how to protect one's center of gravity, a planner must weigh SUAS capabilities. In developing an operation idea, a planner must consider the SUAS's potential to disrupt, disable, or neutralize critical capabilities. The ability to collect intelligence and attack speedily against joint critical vulnerabilities must be evaluated.

Plans for sustaining forces and maintaining lines of communication (LOC) need to be developed with the SUAS threat in mind. Long unprotected LOCs make ideal targets for highly mobile SUAS operations aimed at degrading resupply to forces in the field. As an operational axis is determined and operations are phased, planning for sustainment can be difficult against a capable adversary with masses of SUASs.

In addition to having a well-constructed plan that incorporates effective technological solutions and doctrinal practices, operational commanders must also enact appropriate policy. The most highly trained force operating under a perfect structure cannot be successful without adequate guidance, such as clearly delineated rules of engagement (ROE). Applying a sound policy to the operating environment is a must if victory is to be achieved.

Since many operational bases, both land and maritime, exist in areas with significant populations, the use of SUASs for civil purposes can add a degree of complexity to the commander's mission. Maj Scott Gregg, USAF, director of Black Dart, noticed this difficulty at the 2015 exercise. During an interview regarding the difficulty of detecting SUASs, Major Gregg questioned, "How do you differentiate between a 10-year-old kid who just doesn't know any better and is flying something from a hobby shop and somebody who's flying that identical something from a hobby shop but has nefarious intent? You can't tell that with a radar or an infrared sensor."[35] As technology and doctrine are developed to parry the threat generated by SUASs, a necessary policy such as ROEs must be identified during operational planning and enacted.

Policy updates are needed not only in the operational sphere but also in the acquisition arena. SUAS advancements are largely driven by computer technology gains, so capabilities will likely continue to increase. The US defense acquisition process is unfortunately at odds with this reality. New defense equipment takes years to design, test, and field. Under this framework, necessary hardware identified through Black Dart or other methods may be irrelevant by the time it is fielded if adversaries simply outpace US technical solutions. A revised acquisition policy will facilitate timely technical solutions, allowing commanders to respond to the SUAS threat.

Conclusion

SUASs furnish an innovative adversary with new weapons that have substantial potential. The unique capabilities of small unarmed aerial systems—combined with their potentially large quantities—create the possibility of a completely new battlespace. Defense analyst Robert Martinage has studied the impending changes to battle brought on by advancements in technology. In *Toward a New Offset Strategy: Exploiting US Long-Term Advantages to Restore US Global Power Projection Capability*, Martinage observes that "the United States cannot afford to simply scale up the mix of joint power projection capabilities."[36] New systems with advanced technology are proliferating to enemies of the United States at an astounding pace. SUASs represent just one piece of the shift; the problem is a current and not solely a future threat.

Scharre argues that "the history of revolutions in warfare has shown they are won by those who uncover the most effective ways of using new technologies, not necessarily those who invent the technology first or even have the best technology."[37] The views of Martinage and Scharre reveal the need to act on the threat of SUASs now. The technological advantage in unmanned systems, once wielded by an elite few, is disappearing rapidly. The gap is being filled in a manner that gives US adversaries high-tech, effective means to attack joint forces worldwide. Successfully defeating groups armed with SUASs will require innovative solutions in technology, doctrine, planning, and policy. ✪

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Air Mines

Countering the Drone Threat to Aircraft

Lt Col Leslie F. Hauck III, USAF
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Moore's Law states that the processing power of electronic devices doubles every 18 months. This doubling has improved the capability of friendly military systems and those of our adversaries. Extrapolating this trend and other expected technological advancements suggests that by 2025 the currently widely proliferated "quadcopter" drones and their successors will have the capability to fly autonomously—at much higher altitudes, with longer flights—and be capable of complex formation maneuvers. These advances may happen soon since drones are already making strides in these areas. Additionally, drones will likely be produced with additive manufacturing printing machines at a low cost and may soon have weapons.[1]

Scenario: 12 October 2025, Kunsan Air Base, Republic of Korea

Tower: "Juvat 01, flight of two manned, two unmanned, line up and wait runway 3-6; Cyclops depredation in progress."

Juvat 01: "Juvats, line up and wait 3-6."

Tower: "Juvat 01, cleared takeoff runway 3-6; six Cyclops defeated."

Juvat 01: "Juvats cleared takeoff runway 3-6; check auto detect/fire, crush 'em!"

The Juvat flight of two manned F-16Vs and two drone wingmen "headhunters" (HH) take the runway for its close air support mission against the hostile Kim Jong Deux regime. Crew members arm their directed energy (DE) systems that will—with pilot consent—shoot swarm drones using their active electronically scanned array (AESA) with integrated infrared search and track (IRST) detect systems. Though the departing pilots and their drone wingmen have confidence in their onboard defensive systems, they are hopeful that the high-power electronic microwave (HPEM) beams fired by the tower have already dazzled or destroyed any threats. As the flight gets airborne, the pilots do not encounter additional "Cyclops" (drones) until they reach their area of responsibility (AOR). As the Juvat flight scans the AOR, the AESA/IRST sensors determine multiple small, near-stationary tracks swarming overhead friendly forces at 10,000 feet. With the help of data link systems providing fused additional surveillance data that include acoustic detection from other friendly remotely piloted aircraft (RPA), the pilots' systems triangulate and identify the threats and Juvat lead coordinates for an HPEM beam attack. The lead pilot considers a "hard kill" technique (shooting one of his air-to-air weapons that would yield a kinetic effect and destroy any hazardous material the drones may be carrying). However, intelligence assessed that the North Korean drones were not carrying weapons of mass destruction (WMD), and he elects to conserve his nonreplenishable missiles in accordance with his shot hierarchy. Unfortunately, as the attack commences, the unmanned HH02 wingman turns away from the formation, and the flight gets the text message "JL, HH02, MOTOR S2 FAIL, R2B, EMERG," indicating that there is an unknown problem in the drone's engine—possibly damage from foreign object debris ingestion from an enemy drone—and the drone immediately returns to base. HH02 is done for the day—if not a week or month.

This article assesses drones as a realistic airborne threat and reviews possible methods to counter this burgeoning technology. It begins by discussing the future drone threat and examines possible countermeasures to mitigate drone attacks against airborne assets, including DE and kinetic options. This research suggests that additional investment is needed today to counter the use of drone swarms that may be soon used as flak or as kamikazes against friendly aircraft.

The Threat

In 1921 Giulio Douhet argued in *The Command of the Air* that airplanes should be used as offensive weapons. He determined that if one desired to defeat his adversary, he should aggressively attack his opponent's air force in the air and—even more importantly—on the ground. Douhet was skeptical of air defenses like antiaircraft artillery (AAA) or "Triple-A," largely due to the low probability of hit (PH), which he compared to "a man trying to catch a homing pigeon by following him on a bicycle."[2] Much has changed since Douhet's writing, but the control of the air is still essential for effective friendly air and ground operations. What has changed, however, with regard to Douhet's theories, is the opportunity to attack enemy airplanes before they become a threat, a concept articulated by Winston Churchill in 1914: "the great defense against aerial menace is to attack the enemy's aircraft as near as possible to their point of departure."[3]

The idea of drones swarming and occluding the skies—waiting for aircraft to collide with them or even the concept of drones homing in on aircraft and scoring a kamikaze-like kill—seems analogous to the way hydrogen balloons were employed in World War II when belligerents used them as obstacles.[4] The idea may also be related to AAA capabilities and tactics proliferated against aircraft today.

In World War II, friend and foe alike used balloons that dangled thick, impenetrable wires to "area deny" low-level flying aircraft.[5] This tactic is known today in doctrinal terms as a "barrage defense;" it extends beyond balloons to AAA and drones that defend assets from airborne attack. Actors today fire artillery in specific areas hoping to hit approaching adversary aircraft, causing aircraft damage and preventing a successful strike. While these tactics in World War II were imprecise, with terms like *barrage defense* and *curtain fire*, modern technology allows more precision in targeting inbound aircraft. Today, radar-tracking systems allow for aimed-fire AAA, with an increased PH.

Analogous to aimed-fire AAA, drones will soon have a hunt-and-destroy capability. Algorithms exist today to program a drone with "see-and-avoid" ability as demonstrated at the Massachusetts Institute of Technology (MIT) with proven autonomous software logic. In the MIT study, a graduate student in the school's artificial intelligence lab used an open-source stereovision algorithm that enables a "drone to detect objects and build a full map of its surroundings in real time . . . at 120 frames per second."[6] One can infer that this algorithm can be reversed to see and *not* avoid.

These technological developments will enable drone employment with an offensive mind-set, not just as a defensive barrier as suggested in the MIT study. These drones are becoming more capable and cheaper. The table below shows a list of the top commercial drones available as of December 2016. Even as this article goes to press, the prices listed in the table are falling—some by more than 50 percent since 2015.[7]

Drones will also likely soon have significantly longer loiter time. Electric storage battery technology is advancing at a rapid rate. At the University of Cambridge, for example, "very high energy density, [and] more than 90 percent [efficient]" lithium-air batteries are showing promise to deliver a 10-fold increase in power and endurance, and these will likely be commercially attainable within the next decade.[8] This technology does not even account for other developments yet to be seen, like more efficient aerodynamics and lighter components. A 10-fold increase in battery power would yield a flight duration of more than three hours for several of the drones listed in the table.

While birds usually attempt a last-ditch maneuver to avoid approaching airplanes, such is not the case with a killer drone. Attack drones will have a high PH. By regulation, USAF pilots must terminate training missions if there is an actual or suspected bird strike; clearly, they would also need to terminate for a drone strike. For example, a recent RQ-7 impact with a C-130 in Afghanistan not only ruptured a fuel tank but also damaged a wing spar and the wing box.[9]

Collisions between aircraft and drones will be much more destructive than collisions with birds due to the material composition of the drone and the potential for higher relative airspeed of impact.[10] Alexander Radi, a researcher for the Australian Commercial Aircraft Safety Authority, notes that birds "behave like fluids" at impact, with "the disintegration and the flowing of the bird absorb[ing] energy, which decreases the impact forces."[11] Drones are different. A "non-deformable impactor . . . creates a localized strain field in the target material with high peak forces, which supports . . . material failure."[12] Such an impact, particularly near an engine, could result in engine failure that could be catastrophic—especially to single-engine aircraft such as the F-16 or F-35. Further, just as bird strikes force mission termination, an impact with a hard metal object would decrease mission success and increase aircraft downtime.

Table. December 2016 drone sampling

	Model Name	Price (USD)	Flight Time	Other	Altitude (feet) / Speed (knots)	Size (mm) LxWxH
Camera Drones	DJI Inspire 1[a]	$2,899	> 30 min.	obstacle avoidance	* / 40	~450 x 450 x 300
	DJI Phantom 4[b]	$1,399	18 min.	solid hover accuracy	19,685 MSL** / 38	350 mm diagonal
	Yuneec Typhoon H 4k[c]	$1,199	25 min.	transmission up to 1.6 km	* / 40	520 x 457 x 310
	3DR Solo[d]	$999	20 min.	15 min. battery with payload	* / 48	250 x 460 x 460
	Yuneec Q500 4K[e]	$929	25 min.	watch me and follow me flight modes	* / 15.5	420 x 420 x 210
	DJI Phantom 3[f]	$499	23 min.	16 feet per second climb rate	19,685 MSL / 31	350 mm diagonal
	Parrot Bebop[g]	$199	unknown	lightweight fiberglass (400 g)	unknown / 25	280 x 320 x 36
Racing Drones (carbon fiber) 250 mm-class FPV	TBS Vendetta[h]	$499	5 min.	3 km range	4265 AGL / unknown	230 x 220 x 50
	Lumenier QAV250[i]	$539	FPV (first person view) customizable airframe for 250 mm drones; specs depend on build options			
	IRC Vortex 250 Pro[j]	$499	Also depends on customization		unknown / > 60	250 mm class
	Eachine Racer 250 RTF[k]	$359	10–14 min.	30 m operating range	unknown	220 x 233 x 50
	IRC Vortex 285[l]	$329	Also FPV with OSD (on-screen display), having similar characteristics as other racing drones			
Toy Drones	Parrot AR Drone 2[m]	$250	12 min.		328 AGL / 22	517 x 517 x 127
	LaTrax Alias[n]	$97	15 min.		unknown / 15	166 x 166 x 43
	Blade Nano QX[o]	$74	8 min.	very little payload capacity	not specified	182 x 160 x 63.5
	Syma X5C[p]	$44	7 min.	30 m operating range	not specified	310 x 310 x 80
	Hubsan X4[q]	$34	13 min.	300 m operating range	not specified	76 x 25 x 10
	Proto X[r]	$30	unknown	weighs only .4 oz.	not specified	50 mm diagonal

(*Source*: Ranking, pricing, and type information are derived from http://myfirstdrone.com/tutorials/buying-guides/best-drones-for-sale/. Additional specification information is found on the websites referenced below.)

[a]http://www.dji.com/inspire-1/info#specs
[b]http://www.dji.com/inspire-1/info#specs
[c]https://www.yuneec.com/en_US/products/typhoon/h/specs.html
[d]https://3dr.com/solo-drone/specs/
[e]https://www.yuneec.com/en_US/products/typhoon/q500-4k/specs.html
[f]http://www.dji.com/phantom-3-pro/info
[g]https://www.parrot.com/us/drones/parrot-bebop-drone#technicals
[h]http://www.team-blacksheep.com/tbs-vendetta-manual.pdf
[i]http://www.lumenier.com/products/multirotors/qav250
[j]http://www.immersionrc.com/fpv-products/vortex-250-pro/
[k]http://drones.specout.com/l/396/Eachine-Racer-250#Specs
[l]http://www.immersionrc.com/fpv-products/vortex-racing-quad/
[m]http://drones.specout.com/l/93/Parrot-AR-Drone-2-0#Flight&s=2Av3Rl
[n]http://drones.specout.com/l/90/LaTrax-Alias-6608#Specs&s=1I04SX
[o]http://drones.specout.com/l/40/Blade-Nano-QX#Specs&s=1I04SX
[p]http://www.symatoys.com/goodshow/x5c-syma-x5c-explorers.html
[q]http://quadcopterhq.com/hubsan-x4-h107c-review/
[r]http://www.protoquad.com/protox.html

* Many drone specifications put 400′ AGL (above ground level) as max height, which is the Federal Aviation Administration height restriction. However, drones are usually capable of reaching heights up to 20,000′, provided the distance is within transmitter reception.

** Mean sea level

A common assumption in drone collision articles comparing damage from drone strikes to bird strikes is that drones will not be in flocks and thus have a lower PH than a flock of birds. This assumption is wrong if an adversary uses swarming tactics. While the technology is in its infancy, the Naval Postgraduate School (NPS) demonstrated swarming technology in August 2015, manually controlling 50 drones with a single controller.[13] The NPS used Wi-Fi and algorithms in its test, and it will soon add greater autonomy.[14] This capability is rapidly growing. Last year, the Intel Corporation built a holiday light show for Disney Springs near Orlando, Florida, with 300 drones in complex changing formations, also with a single controller.[15] Drones will also one day fly with payloads of bombs or WMDs, DE weapons such as lasers and high-power microwaves (HPM), and other miniaturized weapons. Yet even with just their nonorganic material and with a hunt-and-kill programming, swarming logic, and automation, drones will soon pose a substantial threat to aircraft and our combat readiness.

Countertactics

Enemy flak was a greater concern than barrage balloons in WWII, and many of the 22,951 US operational losses in WWII were attributed to it.[16] To improve the odds for survival, fighter and bomber pilots increased their altitudes and altered their courses.

With drones, countermeasures are not yet fully developed, but DE and kinetic kill devices have the potential to dazzle or destroy drones. While it is possible to "fire" DE ahead of a flight path to clear threats, collateral damage concerns make this option problematic. Minimizing collateral damage would require identifying a specific threat and selecting the right weapon to defeat it.

Detection options that can locate and identify drone threats include audio (hearing rotors), electronic emission, optical (visual tracking), radar, light detection and ranging (LIDAR), and infrared (IR). The challenge with all these sensing types is that they are only marginally effective in detecting stealth aircraft, such as the very large B-2 bomber with dimensions of 69 x 172 x 17 feet.[17] Detecting 40 x 40 millimeter drones will be much more difficult.

Current procedures for finding birds and other small hazards around airfields may help but will not solve the problems that already exist with the drone threat, as when a drone collided with a British Airways 727 on 17 April 2016. Tower controllers use binoculars to locate raptors and other smaller birds flying near arrival and departure corridors, and pilots make radio calls warning other pilots of bird threats. These procedures may be less effective with drones, considering their evasive ability and smaller-than-bird size. A swarm of 100 drones—that may in the future cost about $1,000 for the *entire* swarm—would be more visible than a single drone. However, an adversary's ability to decrease the swarm density by increasing the spacing between drones would decrease visual detectability. A belligerent may space drones in a pattern that optimizes PH based on the airframe size of the expected adversary aircraft, which may make visual detection difficult.

Quadcopters have a distinct high-pitch whine from their propeller blades and motors, and such acoustic signature presents one type of drone detection option. An acoustic detection system simply records the detected sound and compares it to known acoustic signatures in a database for identification using multiple sources for geolocation.[18] However, Zain Naboulsi, chief executive officer of Drone Labs, mentioned that while acoustic detection does add value to a multisource drone detection system—relatively easy to design, use, and purchase—it is not nearly as effective as other drone detection options, largely due to environmental noise and range limitations.[19]

Electro-optical (EO), commonly thought of as television systems, is used today as detect-and-track enablers in many weapons systems. Examples include advanced targeting pods flown on fighter aircraft to deliver bombs, like Northrop Grumman's LITENING "Gen 4" advanced targeting pod; air-to-surface missiles like in Raytheon's air-to-ground tactical missile AGM-65H/K Maverick; and in drone killer detection systems like Boeing's Compact Laser Weapons System (CLWS).[20] These weapons systems integrate charge-coupled devices (CCD) to produce high-resolution digital imagery. Many of the systems that use EO for detect also have an IR track capability that augments the EO sensor.

An IR mode could also help detect and track drones, although a drone's heat source is much smaller than a typical aircraft, requiring the system to have different operating parameters than those used in standard IRST systems. Still, IR detection should not be discounted for drone detection. For example, Figure 1 shows Boeing's CLWS using EO/IR to track a drone in a nonadverse weather setting.

One serious limitation of using EO/IR to detect and track drones is that adverse environmental conditions significantly degrade its capabilities. While technological advances like CCDs make electronic detection superior to the capability of the human eye, they are still affected by clouds, fog, and smoke. Drones and airplanes can still operate in clouds.

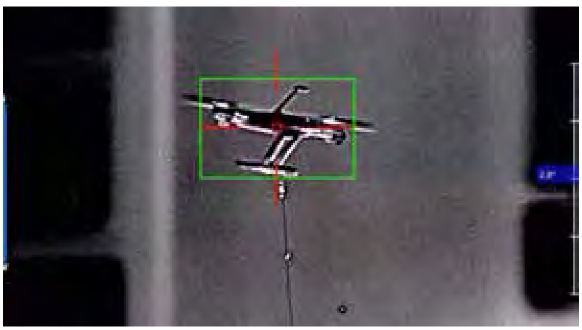

Photo courtesy of Boeing

Figure 1. EO/IR track on drone by Boeing's Compact Laser Weapons System

As a sensor, radar can detect drones, but legacy radars like the AN/APG-68 in most F-16s today would require upgrades in software coding and processing power. Even then, these older radars would have limited success in detecting the drones due to their small radar cross section and very small Doppler return, especially if the drone were nearly stationary and waiting for an approaching target.[21] Furthermore, the APG-68 would have problems distinguishing a target from ground clutter or birds, meaning there would be many false returns that were not drones. If F-16s were upgraded with a radar like the proposed APG-83 scalable agile beam radar (SABR)—an AESA radar mentioned in the opening combat scenario—legacy fighters might at least have a chance at detecting the drones.[22] Radars like SABR would have much higher success since they would have greater resolution and frequency agility.

Another advancement that could aid in drone detection is LIDAR or laser radar. Essential technological breakthroughs are still needed for it to succeed in detecting airborne objects, but there is potential.[23] LIDAR can detect a jet's "exhaust trail [that] will contain concentrations of hydrocarbons on the order of parts per million, which can be 100 or more times the background atmospheric concentration."[24] The new Air Force Research Laboratory (AFRL) program named Vibration Interrogation for Battlefield Exploitation seeks to use laser vibrometer technology to detect engine vibration or other disruptions for identification.[25] Although drones may not have nearly as large an exhaust plume as a fixed-wing or larger RPA, LIDAR technology may still benefit drone detection. LIDAR still faces environmental constraints discussed above for EO/IR as its wavelengths have difficulty penetrating foggy or cloudy conditions. However, LIDAR can "see" through light haze—provided the obscurant is not so opaque that no photons return to the sensing source.[26] Many people today are becoming familiar with LIDAR, even if they don't know it, with self-driving cars and adaptive cruise control.

Any system communicating—whether from drone to drone with Wi-Fi, as was used in the NPS project, or with radio-frequency control like the many drone systems listed in the table above—emits signals that are detectable. A passive sensing-detecting system might also work to search for drone emissions, but the shortcoming of this detection tactic is that nonemitting drones will not be found. Locating such drones is very possible in the near future with autonomous drones that find their own targets without emitting or requiring any outside input.

Considering the systems discussed—their strengths and weaknesses—a system that integrates all of these resources for targeting would be greatly desired. On adverse weather days, radar and acoustic systems could still provide input, and on clear days all systems could work together to identify the targets, track them, and enable the kill via ground or airborne defense systems.[27] The engagement of a drone, once detected, still requires a kill mechanism. DE and kinetic drone defeat options are explored next.

The AFRL leads research for the Hybrid Defense of Restricted Airspace (HyDRA) study, looking specifically at DE defeat options (laser and HPM) that might augment kinetic alternatives for integrated air defense.[28] Depending on the lasing medium, lasers span wavelengths from the IR to the ultraviolet.[29] According to Dr. William Cooper at AFRL's DE Directorate, "A lot more has been developed with DE to high TRL [technology readiness level] than most people know."[30] This is good news because the USAF may need this technology soon. HyDRA is one of the ongoing AFRL DE programs that look specifically at DE options to augment kinetic defenses. The AFRL anticipates that these systems will provide near-term options to National Capitol Region defenses and then extend to meet the needs of combatant commanders. United States Pacific Command plans to use the technology on drones and potentially also against cruise missiles.[31] Dr. Cooper notes that even a low-kilowatt (kW) laser system "could likely easily neutralize" a drone at close range, adding that DE both minimizes collateral damage and ensures proportional lethality for Law of Armed Conflict legalities.[32] The AFRL has already demonstrated DE systems successfully against Group 1-2 Unmanned Aircraft Systems at Black Dart with MATRIX and MEGA HPEM systems (fig. 2).[33] Dr. Cooper, however, emphasizes that the "timeline [for development and fielding] really has a lot more to do with our corporate willingness to acquire, integrate and utilize the technology."[34] DE experimentation tests were conducted successfully in the summer of 2016 of 150 kW-class systems at the White Sands Missile Test Range (with detailed results classified). The AFRL also has an Advanced Technology Demonstration (ATD) project under way, known as the Self-Protect High Energy Laser Demonstration (SHiELD). The former is a General Atomics program using the High Energy Liquid Laser Area Defense System laser, and the latter is a $500 million ATD with AFRL and the Defense Advanced Research Projects Agency (DARPA).[35] According to Dr. Cooper, the future three-phase implementation plan for SHiELD will hopefully demonstrate its tactical usefulness and spur doctrinal change. However, he notes that not all phases are funded. Specifically, "Phase I implements a low-power pointing laser to demonstrate the ability to lock on and track targets. Phase II increases the power level. Phase III, if funded, would demonstrate a full-power system that could have podded residuals."[36]

Photos courtesy of Boeing

Photo courtesy of Orbital ATK

Figure 2. (*Left*) **Boeing Compact Laser Weapons System and** (*right*) **AUDS HPEM System**

Another system using laser defeat is Boeing's CLWS that needs only single-digit kW power to destroy its target in seconds.[37] Boeing touts its easy operation and portability, and technology experts equate the controller for the system that links the laptop to the controller of an X-Box 360 video game system.[38] According to Boeing, the CLWS will have relatively minimal cost and a range in the "tens of kilometers," requiring just a 220-volt outlet.[39] Boeing's program director stated the obvious benefit of not needing to replenish the armament: "The cost of the shot is basically the electricity to drive the laser. You're not firing a missile with all the cost of the logistical trail or cost of the missile or firing bullets where you have to worry about where they fall."[40] Stability and power requirements will continue as limiting factors in the near future of having an air-to-air laser kill, but the low kW demand potential, the future of battery advancements, and the minimal lasing time to affect a drone's destruction demonstrate definite potential.

Dazzle by definition is to "cause someone to be unable to see for a short time."[41] Laser beams can dazzle something (like a drone's optical sensor), but they are more likely to be used to destroy a target, like the design of the CLWS. An HPEM dazzle technique may destroy a drone, disable the drone temporarily, or "cook" key electronic components and render the drone ineffective.

The Anti-Unarmed Aircraft Vehicle Defense System (AUDS) was developed by three technology companies to dazzle drones and potentially take control of their navigation and control systems. Such a system could be very important if a hostile actor attaches WMDs or other ordnance to a drone, where free fall after engagement might generate casualties. The AUDS system purportedly can detect a drone at a range of five miles using EO/IR sensors, and then uses radio-frequency interference against the radio signals sent to the drone coming from the remote operator. When the drone picks up the AUDS signals, it "freezes, unsure of where to fly." What happens next is up to the new operator.[42]

As was the case for drone detection, multisystem queuing enhances DE attack capabilities, but even with it, there are still targeting limitations for both lasers and HPMs. The major weakness for laser technology is that foul weather can prevent or significantly degrade its success. On the other hand, while HPMs can engage through clouds, an enemy can counter HPMs with DE hardening. Conductive Composites Company, for example, recently layered nickel on carbon within a plastic-like material that can mold to other structures, like drone surfaces. This process mitigates HPM attacks by directing the energy around and away from the target—a concept similar to the idea of placing a Faraday cage around the drone.[43]

While DE is a choice weapon against drones due to its scalable and multiple-use capabilities, aircraft must still have kinetic kill options should they face a reduced visibility situation (lasers and IR) or an adversary having DE-hardened components. This article has focused mainly on fixed-wing aircraft that fly at fast airspeeds and higher altitudes—characteristics that add destruction to collisions—but many more aircraft are threatened by drones. Helicopters, for example, are also at risk to drones, considering that their operation is mostly in today's drone-prone, lower-altitude environment. Helicopter pilots today worry about other threats like man-portable air defenses (ManPAD) and rocket-propelled grenades (RPG), but increasingly pilots' combat sorties will also need airborne scan for drones. The RPG and ManPAD threats have the US Navy's (USN) attention, and the USN is quickly developing countermeasures that could also be useful for drone defeat.

The Helicopter Active RPG Protection (HARP, previously known as HAPS) is a product under development by the USN, with the objective of RPG detection and defeat. This concept can extend to killing threatening drones.[44] The HARP concept could also provide a kinetic kill option that could be developed for USAF aircraft.[45] A key interoperability of HARP is that the friendly-launched kill vehicle is designed to fire from an existing chaff and flare dispenser (integrated in the AN/ALE-47). Notably, the aircraft employing HARP would still have the ability to carry chaff and flare countermeasures, albeit in reduced amounts.[46] According to an Orbital ATK press release in February 2015, the HAPS vehicle "was able to launch, perform pitch maneuvers, and fly to a detonation point that simulated the location of an incoming rocket-propelled grenade" (fig. 3).[47] Optimizing the amount of blast and frag to kill an RPG or a drone is important. Jay Rodgers, the USN's HARP principal investor, states that "even blast alone is a tough kill mechanism for achieving effectiveness given kill vehicle warhead size constraints and how close to the aircraft the intercept is likely to occur." Thus, he continues, "enhanced blast and frag have better RPG [and drone] defeat potential. The enhanced blast is particularly attractive as it has greater effect than unaugmented blast but doesn't have the same lethal radius as fragmentation, a fratricide issue."[48]

Another USN program, Standoff Weapon Defeat (SOWD), which has similar RPG defeat concepts as the HARP program, touts being "useful as a drone countermeasure."[49] Users and investors in SOWD range from DARPA to the Secret Service, and over 10 Army agencies are involved in the program. However, only one USAF agency—the Air Force Security Forces Center—is involved in SOWD support.[50] This disparity is understandable based on the current base-defense-doctrine construct placing the majority of base kinetic defenses under an Army lead. But the USAF has to consider the utility of SOWD not only for air base defense but also for air-to-air engagements.[51] Further, as threats loom for flight departure and recovery corridors, the Air Force might have more of a doctrinal interest in those area defenses than does the Army, inviting application of more USAF resources.

Photo courtesy of Orbital ATK

Figure 3. Orbital ATK's HAPS kill vehicle

The USAF would also benefit from investing in a new kinetic weapon designed to kill drones—one that could cost less than the $1.55 million AIM-120D AMRAAM.[52] A cost reduction would be possible because the concept weapon would destroy smaller targets (less warhead required) and not travel as far (less propellant, etc.). The system could even be a friendly-launched drone that simply hunts enemy drones and kills them through impact or explosion. In summary, there needs to be multiple layers and options in the kill chain for destroying enemy attack drones. The sensors used for detection must fuse data from all sources mentioned above, and the war fighter should have both DE and kinetic options available for the kill.

Recommendations

Drones must first be detected before they can be killed, and doing so requires USAF investment in upgrades like an AESA radar for the F-16 and continued advancement of data fusion systems across all platforms. Air base security requires detection of drones before they fly overhead. While base defense is doctrinally an Army mission, the Air Force has a vested interest in protecting its aircraft. In the air, the USAF needs to invest in systems that enable detection of threats to aircraft thus allowing control of that particular air domain. The current drone threat suggests that we should pay close attention to aircraft departure and arrival corridors, in addition to clearing mission routes. In the end, these objectives necessitate having detect and shoot capability on USAF aircraft. For defeat, the USAF should not pick just one capability but should acquire multiple dazzle and/or destroy options, including DE and kinetic weapons. The DE research of the AFRL should be considered for air-to-air engagements, meaning that HyDRA needs funding and TRL advancement. Additionally, the USAF should develop a system similar to HARP for all aircraft that have countermeasure dispense systems. Finally, as drone proliferation threatens to overwhelm the combatant commander's base defense resources, all the services must work jointly to field and operate integrated, fused systems that protect war fighters.

Conclusion

In 1921 no individual, including Air Marshal Douhet, could have had the prescience to know the implications of Moore's Law or envisage the complexity of aerial systems in existence today. However, if Douhet were alive today, he could still repeat his time-tested words: "victory smiles upon those who anticipate the changes in the character of war, not upon those that adapt themselves after the changes occur."[53] He would also emphasize that winning air forces must immediately consider how drone warfare might change the character of war—a reflection that could reveal a need for prompt development of drone detect and defeat systems.

While some areas of technological advancement might slow, others are primed for a vertical launch trajectory. Even without the inevitable innovations in electronic components, swarm drone and/or singular kamikaze-like drone attacks on friendly aircraft are possible in the very near future. This eventuality demands a significant change to counterair doctrine and enlarges the concepts of detecting and defeating our adversaries. While there is no single panacea for defeating enemy drones, many options exist that provide increased success of operations in contested environments. Thinking of Douhet one final time, drone detect and defeat options should *absolutely not* be related to the improbability of a person catching a homing pigeon on a bicycle. ✪

Notes

1. This article uses the term *drone* to describe a class of small (Group 1) unmanned aerial systems that may be remotely piloted or, in the future—and more in line with the content of this paper—has autonomy (i.e., they could be not "remotely piloted" at all). This term is chosen also since it is widely used in the commercial industry, which sells drones like quadcopters, as referenced in this article. The Department of Defense (DOD) has a formal lexicon separate from the "drone" labeling in this article. For more information on what the DOD calls "unmanned aircraft systems," see UAS Task Force, Airspace Integration Integrated Product Team, *Unmanned Aircraft System* [*UAS, now remotely piloted aircraft, RPA*] *Airspace Integration Plan*, ver. 2.0 (Washington, DC: DOD, March 2011), http://www.acq.osd.mil/sts/docs/DoD_UAS_Airspace_Integ_Plan_v2_(signed).pdf.

2. Giulio Douhet, *The Command of the Air*, trans. Dino Ferrari (1942; new imprint, Washington, DC: Air Force History and Museums Program, 1998), 18, http://permanent.access.gpo.gov/airforcehistory/www.airforcehistory.hq.af.mil/Publications/fulltext/command_of_the_air.pdf.

3. Joint Publication 3-01, *Countering Air and Missile Threats*, 23 March 2012, IV-1, http://www.dtic.mil/doctrine/new_pubs/jp3_01.pdf.

4. Persons new to drone technology may not realize their current high proliferation or low-cost specifics; for detailed information and background on existing commercial drones, see the table in this article.

5. Maj Franklin J. Hillson, "Barrage Balloons for Low-Level Air Defense," *Airpower Journal* 3, no. 2 (Summer 1989): 41.

6. Mary Grady, "MIT Drone Avoids Obstacles Autonomously," *AV Web*, 4 November 2015, http://www.avweb.com/avwebflash/news/MIT-Drone-Avoids-Obstacles-Autonomously-225143-1.html," 1.

7. For example DJI's Phantom 3, which cost $1,299 in March 2016, had fallen to $799 by October based on pricing found on Amazon.com.

8. David Nield, "Researchers Create Lithium-Air Battery That Could Be 10x More Powerful than Lithium-Ion," *Science Alert*, 3 November 2015, http://www.sciencealert.com/researchers-have-created-the-ultimate-lithium-air-battery-with-super-storage-and-efficiency.

9. "C-130 Mishap Photos," *C-130.net*, http://www.c-130.net/g3/c-130-photos/Mishaps/Herkcollision, accessed 2 November 2016.

10. Such collisions do not even consider the possibility of a drone carrying impact-fused explosives.

11. Alexander Radi, *Potential Damage Assessment of a Mid-Air Collision with a Small UAV* (Monash University, Australia: Civil Aviation Safety Authority, 6 December 2013), 10.

12. Ibid., 3. Radi found that at collision velocities above 200 knots, the drone would likely "penetrate the fuselage skin, with potential of damaging internal systems" (ibid.). Most USAF aircraft will be flying well above this speed.

13. Rollin Bishop, "Record-Breaking Drone Swarm Sees 50 UAVs Controlled by a Single Person," *Popular Mechanics*, 16 September 2015, http://www.popularmechanics.com/flight/drones/news/a17371/record-breaking-drone-swarm/.

14. Ibid.

15. "Intel, Disney Light Up the Sky over Walt Disney World Resort with New 'Starbright Holidays' Drone Show," Intel news release, 16 November 2016, https://newsroom.intel.com/news-releases/intel-disney-starbright-holidays-drone-show/.

16. John Ellis, *World War II: A Statistical Survey: The Essential Facts and Figures for All the Combatants* (New York: Facts on File, 1993), 258–59. Mr. Ellis is clear that the 22,951 number is not perfectly accurate, and it is difficult to determine what a belligerent determined as a "loss." Researchers will find some variation in this figure. Ellis is able to conclude that flak was a major contributor to operational losses in WWII and thus uses the term "a large number."

17. USAF fact sheet, "B-2 Spirit," 16 December 2015, http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104482/b-2-spirit.aspx.

18. Mark Pomerleau, "Drones: Findable, but Not Stoppable," *GCN*, 3 June 2015, https://gcn.com/articles/2015/06/03/drone-detection.aspx.

19. Zain Naboulsi (CEO, Drone Labs), teleconference with Lt Col Leslie F. Hauck III, 14 December 2015. Mr. Naboulsi emphasized that we are currently seeing an exponential increase in drone proliferation and capability, especially considering the new infusion of money from prominent technology companies like Intel to the Yuneec Company. He noted that "detection is hard" but possible and should not be left to just audible detection, which is easy but not optimal. For countermeasures, he stated that jamming is easy and is the "sledgehammer" against drones, as you can point and confuse them, and that "barrage noise is not elegant, but it is efficient." Naboulsi argued that electronic warfare is currently the most effective way to defeat drones but that in three to five years, encryption will make such technology much more challenging.

20. Andreas Parsch, "Designations of U.S. Military Electronic and Communications Equipment," 2000–2008, accessed 22 November 2015, http://www.designation-systems.net/usmilav/electronics.html.

21. From Colonel Hauck's experience.

22. Ibid.

23. Carlo Kopp, "Laser Remote Sensing—A New Tool for Warfare," Royal Australian Air Force Air Power Studies Center, 1995, http://www.ausairpower.net/ASPC-LIDAR-Mirror.html.

24. Ibid.

25. Graham Warwick, "Laser to ID Targets by Their Vibration," *Aviation Week and Space Technology*, 23 November 2015, http://aviationweek.com/technology/week-technology-nov-23-27-2015.

26. National Oceanic and Atmospheric Administration Costal Services Center, "Lidar 101: An Introduction to Lidar Technology, Data, and Applications," November 2012, https://coast.noaa.gov/digitalcoast/_/pdf/lidar101.pdf3.

27. Of course, adverse weather subjects the drone to similar difficulties in detecting its target, but the detection problem is made simpler by the relative size difference (the larger and noisier target is easier to detect) and at the same time more difficult (there is limited volume and power available in the drone to house more sophisticated detection equipment).

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32. Ibid.

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34. Cooper to Hauck, e-mail. What this statement does not fully consider are the implications of the potential for collateral lasing damage beyond the target to friendly forces or the possibility that further range targets might not even have enough laser energy for destruction or dazzle at all; see the kinetic kill information in this article for other defeat options.

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Putting the Right Man in the Loop

Intelligence, Surveillance, and Reconnaissance Tactical Controllers

Maj Jaylan M. Haley, USAF

Today, Department of Defense (DOD) investments in airborne intelligence, surveillance, and reconnaissance (ISR) assets made during the early 2000s pay dividends for varied requirements. The DOD ISR Task Force and uniformed services must continue to reform intelligence operations, but it must rise above reliance on hardware purchases to solve its problems. Innovation, particularly at the tactical level, must extend to organizational and process remodeling. Rather than relying on gadget solutions alone, the DOD can achieve a greater return on investment by enacting changes to its intelligence organizations' behaviors and processes. Solutions to the conceptual problems can lead to better use of scarce ISR assets as well as reapplication of existing theory, military philosophies, and doctrine. People are the key to this type of reform, and a methodical investment must be made in the right people across the DOD but particularly in the United States Air Force (USAF).

The right people can tailor technological innovation, update doctrine, and create effective tactics, techniques, and procedures (TTP). The joint community needs intelligence professionals who are positioned, skilled, and empowered at the tactical level to make what we have count most. The same vigor applied to hardware acquisitions should apply to recruiting people who can make our billion-dollar hardware investments make sense. The special operations community started down this road at least five years ago through their institutionalized use of what they call ISR tactical controllers (ITC). Fortunately, efforts are under way to bring these tactical, joint information collection professionals to bear for conventional military forces. However, service headquarters staffs and collection tacticians must solidify mechanisms that train individuals to be the operations professionals that joint communities can request and use.[1]

An Intelligence Operation's People Problem

In its simplest form, the airborne intelligence collection cycle consists of three components: planning, execution, and assessment. Each is made of complicated and linked subprocesses. After 9/11, stale doctrine, unimaginative TTPs, and a rush to field technologies made initial hardware investments ineffective, leading to battlefield inconsistencies, inefficiencies, and failure. A large part of these problems stems from the absence of the right people at the tactical level with the skill set to decipher and employ sunk costs. In other words, the DOD made better instruments for the intelligence symphony, but today, the propensity for members of the intelligence community to play well together is complicated by a variety of factors that few understand.

In a 2014 *Joint Force Quarterly* article, Col Jason M. Brown, USAF, echoes the 2008 comments of Lt Gen Michael Flynn, US Army, about a requirement for intelligence personnel who create the right effects.[2] Colonel Brown highlights the use of USAF ISR liaison officers (ISRLO). He demonstrates that a small group of personnel can effectively weave together airborne intelligence collection efforts with the appropriate placement, skills, and authorities. But there are not enough ISRLOs to go around nor should there necessarily be.

Each service explored ways to identify, train, and employ better tactical ISR experts, but all are inadequate.[3] For instance, those designated to integrate airborne collection to a supported commander's scheme of maneuver receive service-centric training of the supported command. Today, supported commanders have access to a variety of joint capabilities. At the tactical level, the supported commanders' ISR professionals must be able to understand and help employ the *full scope* of joint capabilities. While service-centric training is inadequate to this task, "joint" training, sadly, is far worse. It often consists of either PowerPoint slides which outline collection platforms' capabilities or a "how-to" pamphlet. Slides and pamphlets are poor substitutes for rigorous training programs that emphasize the practical application of combat ISR capabilities.

When it comes to planning, execution, and initial assessment of joint airborne ISR operations, many personnel tasked to do so are hardly prepared. It is most unfortunate for those individuals placed in collection management and ISR operations positions without any training at all. For a variety of reasons, the ones lucky enough to receive joint training are often *not* the ones who run the airborne intelligence collection process. This does not mean that those who, ultimately, help execute collections on behalf of the supported commander are incapable of doing so; it means they may not have the training, proximity to command, and delegated execution authorities to accomplish their mission effectively.

Independently, aircraft crews for tasked collection assets conduct all mission-related tasks. What is missing is a cadre of workers within the supported commands—regardless of service—that can reliably coordinate and integrate *planning, execution, and assessment* of tasked airborne ISR assets with the tactical supported commander's scheme of maneuver regardless of service lead. Tasked assets rely on these individuals to clarify the supported commander's initial guidance, refine collection plans and requirements, leverage all available intelligence community resources against a problem, and integrate with nonintelligence team members, as necessary, to achieve the supported commander's intent. This is the DOD's intelligence operation's people problem.

A Case for Conventional ISR Tactical Controllers

During Operations Iraqi Freedom (OIF) and Enduring Freedom (OEF), air and ground component commanders emphasized the importance of collocating intelligence airpower professionals with primarily land–supported commanders. Air component ISRLOs were introduced to the land component in 2006. Initially, ISRLOs were collocated with higher headquarters (HHQ) land component commanders, two or three echelons above the tactical fight. Over time, ISRLOs deployed to lower echelons because they were needed there. But, as previously mentioned, there are too few ISRLOs to fulfill requirements at the lower echelons, even for relatively limited contingencies such as Operation Inherent Resolve (OIR). Recently, land-supported commanders expanded ISRLO capabilities by adding ITCs to teams led by ISRLOs. For OIR, these teams consisted of an ISRLO lead with multiple joint ITCs. These teams reflect a concept mentioned by Lt Col Michael Grunwald in a 2009 paper that he termed "ISR Liaison Teams."[4] While these teams are primarily Air Force persons, importantly for OIR, the ITCs can come from *all* services. These joint ITCs executed their functions with limited training. The ITC training focused on surgical ISR collections while leaving a wider breadth of ISR competencies to ISRLOs.

ITCs are a small cadre of primarily intelligence operations personnel who are trained specifically to integrate and coordinate tactical airborne intelligence collection. To be clear, this training is provided above and beyond the person's baseline intelligence duties. ITCs train to synthesize planning, execution and initial assessments for near real-time, tactical integration of airborne collection assets into the supported commander's scheme of maneuver. Sometimes these effects are for a narrowly defined objective, while at other times their operations span broader objectives. ITCs are effective because they (1) are almost always collocated with or highly connected to the most tactical supported commander, (2) have a deft knowledge of ISR capabilities *and how to use them*, and (3) have sensor tasking authority (STA) that allows them to simultaneously coordinate and control multiple intelligence sensors, creating the effect that their supported organization requires. ITCs do not perform intelligence support functions; they coordinate intelligence sensor placement. A misapplication of intelligence support and intelligence operations personnel was a critical component of past intelligence collection failures.

Professionals who conduct intelligence *support* missions absorb every bit of classified and unclassified information about a problem set to analyze a situation. Then, they propose likely courses of actions by the adversary force so friendly forces can determine the best course of action. Intelligence support personnel produce intelligence via analysis of available information and ask questions to generate collection requirements to answer those questions. In military jargon, these individuals are often referenced as "analysts" though it is important to note that not all analysts are intelligence support personnel. The reverse is true that not all intelligence support personnel are analysts. There are a variety of other functions provided by intelligence support personnel such as information processing, briefing support, and information management.

On the other hand, operations personnel consume actionable intelligence provided by intelligence support professionals. For instance, fighter or bomber pilots may choose to alter their flight paths, an infantry company may choose to maneuver differently to seize its objective, or a ship commander may bypass certain littoral areas. Likewise, an intelligence operations professional may plan or execute a different orbit for aircraft collection, choose a different time of day for collection, or select a completely different collection target to achieve desired effects.

Commanders and staff members *must* acknowledge the distinct functions of intelligence support and operations professionals before further progress can be made with information collection. Why? Because being good at one necessarily means that you will not be good at the other. For an individual, intelligence support and intelligence operations *are* a zero-sum game. The intelligence community needs more individuals like ITCs, bred as intelligence operations personnel who focus on making recommendations and decisions that help commanders and fellow operations personnel use our sometimes scarce resources to better effect. With a modest investment of time, money, and effort, joint ITCs can continue to fulfill conventional requirements as they have done for OIR.

Too often, circumstance forces tactical leaders to resort to better joint intelligence operations solutions. This scenario contrasts with one in which a deliberate process is used to facilitate effective intelligence operations. When the right person is collocated with the supported commander at the most appropriate level, that person has a deep understanding of a small plate of asset capabilities and limitations, is aware of effective TTPs, and is given STA. Perhaps the most important aspect of ITCs is their connection to the supported commander.

What Do ISR Tactical Controllers Look Like?

Airmen in proximity to the supported commander have the advantages of increased power and understanding in carrying out the commander's objectives. Clearly, the joint community demonstrated this lesson during the Vietnam conflict when tactical air control parties (TACP) established standards for the employment of munitions close to friendly forces. Airmen fused the ground commander's intent with an unparalleled ability to deliver fairly precise ordinance for devastating effect against the adversary. A 1967 *Air and Space Power Journal* article, "Tactical Air Employment: Current Status and Future Objectives," recounted this contribution by telling the story of the US experience in Ia Drang Valley during the Vietnam War.[5] The lesson is that operations professionals collocated with the supported commander understand the supported commander's specific intelligence needs and can tailor collection to meet the commander's requirements. In addition to placement, training is an important aspect of being an ITC.

The DOD cannot give ITCs a cursory understanding of ISR operations and capabilities, then put them in the driver's seat of a multibillion-dollar enterprise. Ideally, ITCs would attend the short training courses already in existence held by the special operations community. Albeit ideal, the special operations trainers probably could not accommodate the volume of potential ITCs needed by conventional forces. Consequently, the conventional uniformed services should consider sponsoring their own school. Potentially, the school could be jointly managed and instructed at the Air Force's ISRLO training hub and home of the USAF Warfare Center at Nellis Air Force Base, Nevada. Another alternative would be the Army's intelligence training center at Fort Huachuca, Arizona. Again, preferably, all ITC training would happen before deployment.

Sometimes it is not feasible to provide ITCs predeployment training, which is a unique benefit of the ISRLOs. For OIR and prior to ITCs showing up on the joint manning document (JMD) for key OIR locations, ISRLOs developed, staffed, and executed an ITC training program. By June 2015, the ISRLOs trained 10 USA and United States Marine Corps (USMC) ITCs. The joint ITCs went through a weeklong, intensive program that coupled academics and real-time operations to provide the ISR operations novices with necessary qualifications to perform as ITCs. Stateside ISR operations professionals highlighted the stark difference in forward-deployed ITCs for OIR compared with other contingencies, noting that the OIR ITCs were competent and comfortable with the full spectrum of planning, execution, and assessment of ISR operations. Most importantly, strong partnership between ITCs and other members of the TACP—like the joint terminal attack controller (JTAC)—enabled surgical strike operations in support of Iraqis on the ground. Assuming a pipeline to organize and train joint ITCs can be created, one final piece of the puzzle must be inherent to ITCs, and that is the supported commander's authority to task intelligence collection sensors once allocated from HHQ. This concept was recently introduced in a multiservice TTP known as the sensor tasking authority.[6]

A commander's ability to affect the battlespace is directly proportional to the appropriate delegation of authorities to appropriate personnel, which applies to the tasking of intelligence sensors. For instance, in planning for close air support (CAS), supported commanders establish target priorities, effects, and timing for CAS integration. Air liaison officers and JTACs subsequently plan and control CAS operations to meet those requirements. The same can be said for the conduct of electronic attack by electronic warfare officers. Manning, training, and doctrine precede CAS and electronic warfare at the tactical level. However, such is not necessarily the case for ISR operations. ITCs are the intelligence operations manifestation of planning and sensor tasking to meet the commander's requirements.

For intelligence sensors, STA is the authority to tactically task a sensor to achieve efficient effects on a specific target. In the context of an ITC, STA usually involves the fusion of multiple sensors toward various objectives. It is different from sensor control where, usually, a sensor operator manually actuates a mechanism to control a specific sensor. Think of STA as a music conductor's baton, dictating the rise, fall, and tempo of the music.

STA is a complex, inherent aspect of asset allocation. It involves the responsibility to plan, execute, and assess the initial effectiveness of allocated assets. A unit *must* plan specific, tactical use of sensors to ensure the commander's objectives are met. Planning involves coordinating with supporting intelligence units, such as flying squadrons and the Distributed Common Ground System (DCGS), and for the Air Force, securing MQ-1 Predator and MQ-9 Reaper assets. For instance, OIR ITCs provide tailored ISR plans, collection maximization documents, and updated collection priorities for tasked assets up to on-station time. Once on station, ITCs furnish specific sensor direction to ensure that tasked intelligence units remain on the precise and, sometimes, developing targets of the supported commander. A fully trained

ITC is in communication with aircraft crews from wheels-up to wheels-down, providing tailored, tactical direction. Once a mission is complete, the ITCs give and receive crew feedback for the front- and back-ends of the platform. They articulate how well or poorly the crew performed to achieve desired objectives. Further, the ITCs work with pilots, sensor operators, and other intelligence operations crew members to ensure feedback is incorporated into the next mission, which may be just a few hours away. STA exercised by an active and competent ITC is the full-spectrum mission piece that is a missing link to effective ISR operations.

What Does the DOD Get by Investing in This People Problem?

ITCs are more than well-positioned, well-trained, authority-bound intelligence operators; they are resource multipliers trained, certified, and qualified to perform their very specific functions. For airborne operations, they are the people who clearly understand *all* the facets involved with tactical information collection. The DOD spent billions to field hundreds of Predator-class and larger unmanned aerial vehicles among other intelligence assets for the varied requirements of supported commanders around the world. These hardware investments speak nothing of the tens of thousands of Soldiers, Sailors, Airmen, Marines, and Coast Guard members who make the entire front and back ends of the intelligence collection system work. ITCs recognize this complexity and maximize planning, execution, and assessment for the supported commander.

ITCs conduct detailed premission planning to clearly understand the commander's intent for available assets, deconflict capabilities to address multiple commanders' priorities, plan to fill gaps in intelligence as identified by intelligence support personnel, and maintain situational awareness of other operations for the supported commander. Also, while much of the supported commander's intent is captured in vetted and validated collection requirements, ITCs address the inherent latency in the three- to four-day intelligence tasking process and the tactical surprises that almost always occur in the lead-up to mission execution. The ITC plans with and provides premission materials to supporting intelligence organizations such as remotely piloted aircraft units, the Air Force DCGS, HHQ organizations, and other vested parties. It is the one person or group that supporting intelligence organizations can rely upon to be their link into the supported commander's operations—the ITC is always there.

During execution, ITCs ensure that all apportioned and tasked intelligence assets remain on the appropriate commander priorities. Then, ITCs retask assets within a predefined construct. Inside a tactical operations area, ITCs have an incredible amount of flexibility to collect on targets that support the commander's intent. For OEF, OIF, and OIR, when ITCs were used, they tasked and retasked assets in real time based on developing intelligence collection, worked to get the residual collection from other assets in the area not tasked to their specific mission, and used that information to enhance collection with assets tasked to their mission. When it comes to information collection, ITCs care little for where the information comes from; they care about collecting what is needed to accomplish the supported commander's requirements.

Furthermore, ITCs work with JTACs to deconflict intelligence sensors against multiple targets so that various aspects of an intelligence situation can be addressed by a variety of available sensors. Sometimes ITCs may only be tasked one sensor, but when they can work with the JTAC, they can utilize a flight of F-16s or F-18s with targeting pods and the pilots' eyes to collect on other targets for development or potential prosecution. With a clear understanding of the intelligence battlespace provided by intelligence support professionals and an even better grasp of how to properly task sensors, ITCs execute intelligence collection efficiently and effectively. Further, ITCs train to be sensitive to the improper and inefficient use of sensors.

As with ISRLOs, ITCs debrief intelligence operations crew members on tactical scenarios and give direct input into improving intelligence operations. A properly trained ITC can identify points and periods in time where intelligence collection is not efficient or effective and provides direct feedback to a variety of entities—such as the DCGS that houses the back end of intelligence operations, the ground control element where pilots and sensor operators reside, real-time weather organizations, and collection management nodes. This function does not negate the need for ISRLOs. Rather, it sharpens the feedback from ISRLOs, who can also aggregate ITC input to ensure that many problems are fixed.

A variety of organizations during OEF, OIF, and previous operations complained that there was not enough feedback about intelligence collection operations. In part, individuals tasking the sensors could not provide feedback because they did not know what feedback to present. While ISRLOs are meant to fill this gap, they cannot be the ITCs for every aircraft. ITCs provided ample feedback during OIR, driving requirements to correct issues such as links with intelligence collection assets and to integrate CAS with sensor collection and deconfliction in real time. ISRLOs used tactical feedback from ITCs to fulfill their role of giving HHQ organizational-level feedback, sharing an understanding of tactical situations with the persons tasking ISR assets. The recipe of training ITCs to plan, execute, and assess ISR operations works.

Where Do We Go from Here?

During OIR a cooperative effort between the supported commander, Combined Joint Forces Land Component Command–Iraq (CJFLCC-I), and the US Central Command (CENTCOM) Combined Forces Air Component Command (CFACC) birthed the beginning of a conventional, joint training, certification, and fielding of ITCs. USAF-provided ISRLOs from the division-aligned air support operations squadron (ASOS) trained USAF, USA, and USMC ITCs on the specific aspects of ISR operations mentioned above. While none of the ISRLOs attended the only formal, special operations ITC training, all ISRLOs worked with ITCs and other tactical tasking authorities using their experiences to guide the creation of the training program. CJFLCC–I, through their intelligence chief, certified the trained ITCs as ready for information collection operations on behalf of the supported command. The certified ITCs executed functions alongside ISRLOs, who provided tactical direction based on inputs from the supported commander, the intelligence chief, the collection manager, and lower echelon units. While this program was a gap-filler for OIR, it leaves several unresolved issues that the headquarters staffs of uniformed services must address to ensure that the benefits of this partnership are not lost.

In the spring and summer of 2015, CENTCOM, CFACC, and CJFLCC–I personnel built a framework outlining requirements, manning, and a command structure for joint ITCs. The framework empowered Air Force ISRLOs as leads for joint ITCs to meet the supported commander's intent for tactical information collection operations. The framework stipulates that all services provide ITCs and that ITCs could include coalition partners. Ideally, an intelligence operations team would consist of one or two Air Force ISRLOs and two to four joint ITCs, depending on the echelon and tempo of operations. The ITCs may be trained from within the organization that they are requested by. For instance, for a USA brigade, a USMC battalion, or a US Navy fleet, one ISRLO and three or four joint ITCs may be appropriate for sustained 24-hour operations. Less important than numbers is that ITCs were positioned at the most tactical level of the organization. It was unnecessary to have ITCs at all levels of the supported command. Hence, the command and control of ITCs present a unique challenge to traditional command structures.

ITC is both a function and a position. For instance, a USA brigade intelligence person can execute the ITC function but not be in an ITC position or billet, as was the case during OIR. When a function, the ITC should fall under the guidelines of airpower execution through the ISRLO. In this case, through the ISRLO, the ASOS exercises tactical control (TACON) of the ITC; however, administrative control (ADCON) and operational control (OPCON) remain within USA channels. Conversely, if a person is billeted as an intelligence, surveillance, and reconnaissance controller, TACON, ADCON, and OPCON should fall within the air support operational squadrons. Optimally, ITCs should be deployed in that position to achieve their specific function even though this is not always feasible.

The proposed framework mirrors an existing agreement between the USA and USAF that creates joint fires observers (JFO). JFOs are USA personnel who enhance JTAC capabilities by providing individuals with JTAC-lite training without terminal guidance authorities. Terminal guidance for munitions requires that a person is certified and qualified as a JTAC or forward air controller (airborne). While the JFO program has its drawbacks, such as JFO training not always executed as intended, it is an excellent construct for ITC training and certification.

If a conventional ITC program is to exist, its execution must be joint because all services have something to lose if it does not come to fruition. The special operations community already has a well-developed training and certification program for ITCs. Conventional forces can replicate the special operations community's best practices. Invariably, each service will be driven to develop its standards and certify its ITCs. If that should happen, the standards upon which that certification is based should be joint and integrate some of the lessons learned from existing ISRLOs and ITCs. For instance, an ITC should do the following:

- Hold an intelligence operations military occupational specialty or Air Force specialty code for at least three years.

- Presently, take a direct part in intelligence operations for at least one year (e.g., USAF DCGS operations, Shadow/Gray Eagle platoon operations, collection management, ISRLO, etc.).
- Complete an ITC curriculum managed by the Directorate of Command, Control, and Communications (J-6), which is similar to the JFO program.

Likely, Headquarters Air Force intelligence and Air Combat Command intelligence would be the lead for Air Force contributions to a joint curriculum. Once these prerequisites are met, a joint certification should be conferred for presentation to the requesting combatant command. Again, mirroring the JFO program, the Joint Staff J-6 could manage ITC administration. The standards need not be overly laborious, but they must be clearly defined and agreed to by all the uniformed services before any training or certification programs are initiated within each service.

Finally, combatant and combatant component commanders must ensure that ITCs continue to appear on JMDs that drive in-theater requirements. Service staffs should coordinate to validate the ITC requirement and define it. When validated, combatant commands should request ITCs as a part of a baseline package for any contingency that involves airborne information collection. Most importantly, ITCs cannot be seen as a Band-Aid for all intelligence problems. They cannot be used as intelligence support personnel or collection managers because each of these personnel has very specific roles and functions to affect the battlespace for the supported commander. If they are to be effective, ITCs must be ITCs—certified, qualified, and empowered to perform their function. Also, while ISRLOs can be ITCs if the situation dictates, they must not be relied upon as the sole source of ITCs.

Conclusion

ITCs are a critical, missing link for effective, tactical ISR operations processes. Intelligence collection operations have benefited from a decade of debate and movement in the realm of doctrine and technology. The DOD must now address a specific intelligence people problem: recruiting, certifying, and properly deploying enough ITCs to integrate with ISRLOs within the joint tactical air control system. Modern ISR operations require the tactical edge of effectively placed, well-trained, and empowered operators. While it makes the most sense to have Airmen fill these roles, the problem is joint, requiring a joint solution. The USAF has taken the lead to develop the structures needed to support a joint ITC endeavor. These efforts include developing the initial training plan and sending in-garrison ISRLOs to special operations ITC training courses. However, all the services must come together to determine the most appropriate joint solution. Time is of the essence.

Future US military strategy depends heavily on airborne reconnaissance and surveillance operations. Large, global footprints will no longer be acceptable or affordable to the American people and supported commanders. Thus, the ways in which the military addresses surgical problems must be constructed surgically. ITCs enhance the small-team concept that equips supported commanders with the expertise needed as a part of a functioning, effective, and efficient team. ✪

Notes

1. Adam Young, "Employing Intelligence, Surveillance, and Reconnaissance: Organizing, Training, and Equipping to Get It Right," *Air and Space Power Journal* 28, no. 1 (January–February 2014): 26–44, http://www.au.af.mil/au/afri/aspj/digital/pdf/issues/2014/ASPJ-Jan-Feb-2014.pdf; and Mike Snelgrove and Jaylan Haley, "Ricochets and Replies: Employing Intelligence, Surveillance, and Reconnaissance: Organizing, Training, and Equipping to Get It Right," *Air and Space Power Journal* 29, no. 2 (March–April 2015): 166–70, http://www.au.af.mil/au/afri/aspj/digital/pdf/issues/2015/ASPJ-Mar-Apr-2015.pdf.

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3. Maj George Lewis III, "Transforming Army Intelligence Analysis Training and Doctrine to Serve the Reasonable Expectations and Needs of Echelons Corps and Below Commanders, Consumers, and Customers" (monograph, School of Advanced Military Studies, USA Command and General Staff College, 2005), http://www.au.af.mil/au/awc/awcgate/sam/transforming_intell_analysis.pdf; Michael T. Flynn, Matt Pottinger, and Paul D. Batchelor, *Fixing Intel: A Blueprint for Making Intelligence Relevant in Afghanistan* (Washington, DC: Center for a New American Security, 2010), https://s3.amazonaws.com/files.cnas.org/documents/AfghanIntel_Flynn_Jan2010_code507_voices.pdf, http://www.cnas.org/files/documents/publications/AfghanIntel_Flynn_Jan2010_code507_voices.pdf; and Matthew Reiley, "Transforming USMC Intelligence to Address Irregular Warfare" (master's thesis, USMC Command and Staff College, 2008), http://www.dtic.mil/dtic/tr/fulltext/u2/a490714.pdf.

4. Michael Grunwald, *Transforming Air Force ISR for the Long War and Beyond*, Wright Flyer Paper no. 36 (Maxwell AFB, AL: Air University Press, 2009), http://www.au.af.mil/au/aupress/digital/pdf/paper/wf_0036_grunwald_tranforming_isr.pdf.

5. This battle was popularized by Lt Gen Harold G. Moore, USA, retired, and Joseph Galloway in their book *We Were Soldiers Once . . . and Young*. Their book formed the basis of *We Were Soldiers*, a 2002 motion picture directed by Randall Wallace, starring Mel Gibson as General Moore.

6. Air Force Tactics, Techniques, and Procedures (AFTTP) 3-2.88, *ISR Optimization: Multi-Service Tactics, Techniques and Procedures for Intelligence, Surveillance and Reconnaissance Optimization*, April 2015, 21, http://www.alsa.mil/mttps/isr/.

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Airpower and Irregular War

A Battle of Ideas

Dr. John T. Farquhar

In a recent *Wall Street Journal* article, "Why Air Power Alone Won't Beat ISIS [Islamic State Iraq and Syria]," military historian and foreign-policy analyst Max Boot presents a clear thesis expressed in his title: anti-ISIS coalition airpower efforts will fail if not combined with ground forces.[1] His article describes early airpower theories and their limitations confronting irregular warfare (IW).[2] He looks at the airpower doctrine devoted to strategic air warfare for an industrial age but neglects more contemporary thinking. His critique appears to be on the mark and is largely unchallenged by many contemporary Airmen, but Boot's article misses an even more important question given public opposition to committing ground forces in Syria and Iraq: what can airpower do to confront the Islamic State? Or stated more generally, what can air forces do to counter IW?

A survey of the relatively limited contemporary literature devoted to airpower and IW reveals a focus on kinetic effects, such as bombing and targets, and overlooks the political nature of irregular war. For contemporary Airmen confronting IW, three ideas expressed by Prussian theorist Carl von Clausewitz set the stage: (1) War is an instrument of politics, (2) "The first, the supreme, [and] the most far-reaching act of judgment that the statesman and commander" have to discern and agree upon is the kind of war they are facing, and (3) Everything in strategy is very simple, but that does not mean that everything is very easy. Great strength of character, clarity, and firmness of mind are needed to follow through and not be distracted by thousands of diversions.[3]

With these thoughts in mind, Airmen should consider the following thesis: In irregular war, first and foremost, airpower is an instrument of politics. No matter how spectacular its technological potential in air, space, and cyberspace domains, Airmen must remember that airpower is simply a means to achieve a political end. Good, effective ideas exist on how to use airpower's flexibility and many attributes that enable other instruments of power, but Airmen must remember that airpower has to be used within a comprehensive political strategy; airpower alone, especially kinetic air strikes, cannot substitute for sound policy.

At its core IW is conceptual—a battle of ideas. Considering the Arab Revolt from 1916–1918, T. E. Lawrence observed the difficulty posed for a conventional army confronting an idea: “How would the Turks defend . . . [against] an influence, a thing invulnerable, intangible, without front or back, drifting about like a gas?”[4] Writing of the Chinese Revolution, Mao Zedong talked of winning the hearts and minds of the people and described a process of using an ideologically trained army not only to fight but also to persuade the people through word (propaganda, education, and indoctrination) and deed (moral example, civic actions, and coercion). Along the same lines, contemporary Australian counterinsurgency (COIN) expert David Kilcullen defines COIN as “a competition with the insurgent for the right and the ability to win the hearts, minds and acquiescence of the population.”[5] He notes that for success, the counterinsurgent must use combat power carefully, indeed even sparingly, because misapplied firepower “creates blood feuds, homeless people and societal disruption that fuels and perpetuates the insurgency.” He adds, “The most beneficial actions are often local politics, civic action, and beat-cop behaviors. For your side to win, the people do not have to like you but they must respect you, accept that your actions benefit them, and trust your integrity and ability to deliver on promises, particularly regarding their security.” “In this battlefield,” he observes, “popular perceptions and rumor are more influential than the facts and more powerful than a hundred tanks.”[6]

The difficulty of IW lies not in theory but in practice. “Winning hearts and minds” seems intuitively obvious but proves exceedingly hard to do. How do you convince a population of your righteous view when you are an outsider and don’t speak the language or know the culture? Irregular war theory evokes Sun Tzu’s famous line, “Know the enemy and know yourself; in a hundred battles, you will never be defeated.”[7] This certainly is a wise observation, but how can you “know your enemy” in a single short deployment? Thus, the Airman’s conundrum is to use airpower as an instrument to advance the overall political objective without damaging the cause through excessive force.

IW poses a particularly tough challenge for airpower and Airmen. Fortunately, two excellent sources influence current doctrinal thinking: “Air Theory, Air Force, and Low Intensity Conflict: A Short Journey to Confusion” by Col Dennis M. Drew, USAF, retired, and *Airpower in Small Wars: Fighting Insurgents and Terrorists* by James S. Corum and Wray R. Johnson.[8] Colonel Drew ably critiques the shortcomings of the first 50 years of US Air Force doctrinal thinking (or lack thereof) regarding irregular war, while Corum and Johnson present a history of airpower in small wars through a series of twentieth-century case studies. Both sources link classic IW theory with useful ideas made possible by airpower.

In his article, Colonel Drew asserts that the Air Force “has not effectively accounted for the realities” of irregular war in its theory of airpower and, instead, preferred to think of it as “little more than a small version of conventional war.”[9] He succinctly presents five differences between insurgencies and conventional wars that proved vexing to airpower’s application:

1. Time–classic insurgencies were protracted struggles intended to frustrate the Western concept of short, decisive wars.

2. Dual military and political strategy—IW featured both a military and a civilian political strategy intended to harass and frustrate a government by showing its inability to cope. After wearing down the government's resources and morale, the insurgents harnessed the masses to overwhelm government forces in a conventional campaign. In other words, Airmen can't directly influence a government's policies, and when airpower is called for in direct combat, it's too late.
3. Insurgents used guerrilla tactics to negate superior government firepower by blending insurgents into the civilian population and deny airpower targets.
4. Insurgent/guerrilla logistics were largely immune from classic airpower interdiction and strategic attack, being too small, too dispersed, and too blended into the populace for attack.
5. The center of gravity was the same for the government and the insurgents: the people. "Putting fire and steel on target" may backfire by alienating this center of gravity.[10]

Drew cautioned that US Airmen tend to be "doers" rather than "thinkers" and value technology and mental toughness more than devotion to academic study and conceptual inquiry. During the first five decades of Air Force doctrinal development, well-reasoned thinking on the application of airpower appeared occasionally, but basic Air Force doctrine was "unaffected at best and contradictory at worst" in its treatment of irregular war.[11] In essence, Drew's article challenged a generation of Air Force leaders to do better.

Seeking to fill an intellectual void and create a textbook for teaching airpower's role in irregular war, Corum and Johnson argue that airpower is an "indispensable tool" for militaries confronting terrorists, guerrillas, insurgents, or other irregular forces. They emphasize that all forms of aviation comprised airpower to include army, navy, and air force aircraft, plus civilian, police, remotely piloted aircraft (RPA), space, and other nontraditional aviation sources. Presenting a series of in-depth airpower case studies ranging from the 1916 Mexican punitive expedition against Pancho Villa to Israeli air strikes against Hezbollah in the early 2000s, Corum and Johnson conclude with 11 general lessons:

1. A comprehensive strategy is essential. Military, political, economic, social, and other resources must be coordinated to attain a political goal.
2. The support role of airpower, as in intelligence, surveillance, and reconnaissance (ISR), transport, medical evacuation, supply, etc., is usually the most important and effective mission in a guerrilla war.
3. The ground attack role of airpower becomes more important when the war becomes conventional.
4. Bombing civilians is ineffective and counterproductive. Campaigns to punish backfire.
5. There is an important role for the high-tech aspect of airpower in small wars, as in smart bombs, space, cyber, and RPAs).

6. There is an important role for the low-tech aspect of airpower in small wars. Simple, old aircraft can still do the job and may be more cost-effective.
7. Effective joint operations are essential for the efficient use of airpower.
8. Small wars are intelligence intensive.
9. Airpower provides the flexibility and initiative that is normally the advantage of the guerrilla.
10. Small wars are long wars.
11. The United States and its allies must put more effort into small wars training. Small or irregular wars are not simply smaller versions of conventional war. Similarly, building host nation (HN) airpower capacity is an effective force multiplier.[12]

The airpower-oriented writings of Drew, Corum, and Johnson complement the important 2006 *Counterinsurgency* manual (Army FM 3-24/Marine Corps Warfighting Publication [MCWP] 3-33.5)—signed by then Lt Gens David H. Petraeus, USA, retired, and James N. Mattis, USMC, retired. In this first new counterinsurgency (COIN) manual in 20 years, a celebrated writing team captures classic ideas of how to defeat insurgency through protecting the population: "The government normally has an initial advantage in resources; however, that edge is counterbalanced by the requirement to maintain order and protect the population and critical resources. Insurgents succeed by sowing chaos and disorder anywhere; the government fails unless it maintains a degree of order everywhere."[13]

Counterinsurgency's "Appendix E: Airpower in Counterinsurgency" recognizes airpower's asymmetric advantage and echoes the ideas of Drew, Corum, and Johnson. The appendix emphasizes airpower's supporting role in most COINs. It acknowledges airpower's importance in direct strike, intelligence collection, transport, helicopter troop lift, close air support, reconnaissance, surveillance, and the need to develop a HN's airpower capability. Still, with the manual's population protection emphasis, the appendix cautions that "precision air attacks can be of enormous value in COIN operations: however, commanders [must] exercise exceptional care. Bombing, even with the most precise weapons, can cause unintended civilian casualties. Effective leaders weigh the benefits of every air strike against its risks. An air strike can cause collateral damage that turns the people against the host-nation (HN) government and provides insurgents with a major propaganda victory."[14]

Succinct, insightful, and conceptually sound, FM 3-24's airpower annex represents an important step forward in doctrinal thinking regarding airpower and irregular war. Furthermore, it demonstrates the value of applying academic thought to warfighting challenges.[15]

Despite the doctrinal advance, Air Force Maj Gen Charles J. Dunlap, Jr. claims the acclaimed Army-Marine COIN manual failed to go far enough. In *Shortchanging the Joint Fight: An Airman's Assessment of FM 3-24 and the Case for Developing Truly Joint Doctrine,* General Dunlap acknowledges the manual's skillful statement of classic, population-centric COIN doctrine, but points out the document's failure to exploit contemporary airpower's potential made possible by advanced technology.

More importantly, the general argues, "the value of an Airman's contribution to the COIN . . . is not limited to airpower capabilities," but, "equally or more important is the Airman's unique way of thinking." A joint doctrine, including an air-minded perspective, must emerge to fight unconventional war.[16]

In a cogent argument, General Dunlap proposes change to FM 3-24's troop-heavy, close-engagement approach. Airpower represents an asymmetric advantage for the United States. Thus, he wants to replace American boots on the ground, more likely to stir local resentment of foreign occupiers, with technology-enhanced capabilities of air, space, and cyberspace.[17] He reasons that under present conditions, "masses of ground forces, especially American troops, simply is not sustainable strategy."[18] Public aversion to US casualties and long-term, costly employment of American ground troops weakens FM 3-24's case. Instead of "clear-hold-build," airpower could provide an alternative "hold-build-populate," where airpower could help create safe havens . . . abandoned areas that could be rehabilitated, protected, and repopulated.[19] In essence, General Dunlap fuses FM 3-24 COIN theories with contemporary precision, high-technology capabilities and thinking. In his view, "the challenge for military strategists is to devise pragmatic options within the resources realistically available to political leaders."[20]

Appearing at roughly the same time as General Dunlap's study, a critique by noted airpower theorist Phillip S. Meilinger addresses the boots-on-the-ground approach of American COIN doctrine. Even with the relative success of the 2007–8 surge in Iraq, Meilinger considers the presence of thousands of American ground troops dangerous and deadly for US forces and Iraq's civilian population. Instead, he suggests that the United States objectively study the Royal Air Force's "air-control" operations in the Middle East during the 1920s and 1930s and the airpower, special operations forces (SOF), and indigenous ground forces that succeeded in Bosnia, Kosovo, Afghanistan in 2001–2, and Iraq in 2003.[21] In essence, Meilinger reinforces General Dunlap's argument and calls for a joint, air-centric COIN to build on American strengths and avoid political weaknesses. In other words, precision airpower—plus SOF, ISR, and indigenous troops—is the key.[22]

In "Preparing for Irregular Warfare: The Future Ain't What It Used to Be," Col John Jogerst, USAF, retired, lauds the Air Force's superb tactical capabilities but proclaims these skills "irrelevant" strategically. He states that in COIN, "the critical capability involves building the partner nation's airpower—an essential distinction."[23] In a war for political legitimacy, the USAF must understand the difference between "doing COIN (the job of the local authorities) and enabling COIN (the role of external actors)," including the United States.[24] Agreeing with FM 3-24, Colonel Jogerst emphasizes assisting the HN by enhancing its local presence and enabling small unit tactical prowess through "immediate, precise, and scalable firepower."[25] But unlike General Dunlap or Meilinger, he emphasizes foreign internal defense (FID), building partner capability, and training HN air forces to do the job themselves.[26]

Colonel Jogerst proposes creating a permanent USAF IW wing staffed by COIN experts to avoid the usual American tendency to provide overwhelming force independent of local control. Since IW and COIN are inherently political wars, HNs must be trained to function independently and reinforce the government's legitimacy.[27] Hence, a USAF IW wing would provide a long-term, sustainable organization with a

COIN group to teach airpower employment and provide initial capability and an FID group to develop HN capability. Additionally, Colonel Jogerst stresses that the wing must prepare a small number of personnel with intensive cultural and language skills to build useful personal relationships with the partner nations.[28]

Although not specifically oriented for IW, another work from a different source exemplifies General Dunlap's argument for novel, "air-minded" thinking. Dr. Sanu Kainikara's *The Bolt from the Blue: Air Power in the Cycle of Strategies* (2013) presents broad, fresh, air-minded perspectives useful for IW at the conceptual, strategic level. A former Indian air force wing commander and current air theorist at Australia's Air Power Development Centre, Dr. Kainikara argues that airpower planners must reject the concept of a linear end state.[29] Instead, airpower represents an instrument in a cycle of strategies that include influence and shape, deterrence, coercion, and punishment. In other words, the spectrum of violence is not a line—as often depicted with humanitarian assistance on one end and total war on the other—but a circle or cycle with war termination immediately linked to postconflict stabilization. In this, Dr. Kainikara evokes Clausewitz's famous aphorism, "In war the result is never final."[30] Just as classic insurgency theory often talked of stages of guerrilla or irregular war, Dr. Kainikara suggests applying COIN air strategies as a cyclical process.

Dr. Kainikara emphasizes the correct calculation of ends and means and airpower's inherent flexibility. For example, in the strategy of influence and shape, he describes distinct airpower contributions to monitor, assist, intervene, police, and stabilize in an effort to avoid conflict.[31] Highlighting airpower's strategic contribution, Dr. Kainikara explores its ability to apply nonlethal force by monitoring, providing physical assistance and intervention through airlift, and active policing and stabilization through ISR. Like General Dunlap, Dr. Kainikara articulates four airpower advantages applicable to irregular war:

1. It carries a comparatively low operational risk with respect to one's own casualties.
2. Since operational risk is low, it is easier to obtain political support for action.
3. Airpower is scalable in that it is relatively easy to ramp up or down the intensity and tempo of operations.
4. Air responds rapidly to evolving threats.[32]

Consequently, Western policy makers may be unable to resist applying limited airpower even when airpower alone may not win an irregular war. The need to "do something" will trump military planners' understanding of airpower's limits in fighting insurgencies.

Recently, retired Air Force lieutenant general David A. Deptula provided another air-minded way of thinking, but instead of Dr. Kainikara's strategic focus, the general advocates an operational approach to exploit emerging technologies. In a series of wide-ranging, insightful articles, speeches, and testimony before the Senate Armed Services Committee, General Deptula stresses the synergies possible by RPA and fifth-generation aircraft currently labeled as "fighters" but are more accurately "sensor-shooters" that will permit information age warfare. By combining the attributes of traditional ISR on one stealthy, data-linked aerial platform armed with advanced precision weapons, information-age airpower will breach sophisticated air defenses to achieve desired effects on the battlefield. Although his remarks are primarily aimed at streamlining joint organizations, improving command and control, and harnessing possibilities for information-age warfare, General Deptula's ideas show promise for IW, particularly those conflicts that escalate toward conventional operations. As technology proliferates, even future irregular threats will feature enhanced information and antiair capabilities. In short, air planners must be open to harnessing new capabilities made possible by cutting-edge technology.[33]

In sum, challenged by Colonel Drew and historically analyzed by Corum and Johnson, thinking on airpower's role in IW significantly advanced during the past decade. Dunlap, Meilinger, Jogerst, and Kainikara conceptualize the air instrument as a tool in the fight against contemporary, irregular wars. Moreover, airpower theory, as shown by General Deptula, suggests the importance of advanced technology as a force multiplier. As Meilinger and others articulate, airpower combined with advanced ISR and SOFs generates unparalleled precision strike and greatly enhances local forces. Likewise, Colonel Jogerst gets it right with his emphasis on FID—the need to build HN capacity. More recently, operations in Afghanistan, Iraq, and Syria demonstrate the value of airborne ISR in providing persistent overwatch for ground operations and convoy protection and in guarding forward outposts. Despite airpower's important technological contribution, Airmen must resist the lure of technological determinism. Technology is vital and should not be minimized, but it does not provide a silver bullet.

Context matters, history matters, and the political ends must be understood and acceptable to the populations involved. Airmen must not forget that COIN and IW are inherently political. As such, outsiders will inevitably face frustration when local domestic politics and internal dysfunction take their toll. Airpower may provide enhanced capabilities to a HN but cannot substitute for competent government. Therefore, two additional observations from T. E. Lawrence, quoted below, complement the ideas of air theorists and should not be ignored:

1. Rebellion must have an unassailable base, something guarded not merely from attack, but from the fear of it. . . . It must have a sophisticated alien enemy, in the form of a disciplined army of occupation too small [for the territory]. It must have a friendly population, not actively friendly, but sympathetic to the point of not betraying the rebel movements to the enemy. Rebellions can be made by 2% active in a striking force, and 98% passively sympathetic.
2. In 50 words: Granted mobility, security (in the form of denying targets to the enemy), time, and doctrine (the idea to convert every subject to friendliness), victory will rest with the insurgents, for the algebraic factors are in the end decisive, and against them perfections of means and spirit struggle quite in vain.[34]

Lawrence's ideas provide a blueprint not only to the insurgent—in the achievement of mobility, security, time, and doctrine and the creation of an unassailable base—but also to the counterinsurgent to deny these elements to the enemy. Airmen must contribute in the battle for ideas for irregular war through creative thinking—how to employ the many unique, force-multiplying attributes of airpower in the comprehensive political strategy. As examined, contemporary air theorists offer many of the tactical, operational, and strategic ideas needed to enhance local forces and avoid large numbers of American boots on the ground. Still, Airmen must recognize a caution: used in political isolation or without strategic thought, airpower simply illustrates the truth of Lawrence's 50 words: "for the algebraic factors are in the end decisive, and against them perfections of means and spirit struggle quite in vain." ✪

Notes

1. Max Boot, "Why Air Power Alone Won't Beat ISIS," *Wall Street Journal,* 9 December 2015, A15. The author thanks Phillip S. Meilinger, Jim Titus, Wray Johnson, and two anonymous *Air and Space Power Journal* (*ASPJ*) referees for insightful comments that improved this work.

2. Although specialists will debate the nuances and differences between terms, this article will use *irregular warfare*, *small wars*, *guerrilla war*, and *counterinsurgency* interchangeably. Additionally, it substitutes *irregular warfare* (IW) for *low-intensity conflict* (LIC) for Dr. Dennis Drew's observations. For astute commentary on the problem of terminology in irregular warfare/counterinsurgency/small wars, see Colin S. Gray, "Irregular Warfare: One Nature, Many Characters," *Strategic Studies Quarterly* 1, no. 2 (Winter 2007): 37.

3. These famous passages have been paraphrased. Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1984), 87, 88, 178.

4. Better known as Lawrence of Arabia, Lawrence produced a number of insightful writings on guerrilla warfare of which *The Seven Pillars of Wisdom* is the most famous, but his short "On Guerrilla Warfare" and "27 Articles" are valuable for succinct insights. T. E. Lawrence, "T. E. Lawrence on Guerilla Warfare," *Encyclopedia Britannica*, 6 November 2014 (originally published in the 14th ed., 1929), https://www.britannica.com/topic/T-E-Lawrence-on-guerrilla-warfare-1984900. See also T. E. Lawrence, "The 27 Articles of T. E. Lawrence," from *The Arab Bulletin*, 20 August 1917, http://wwi.lib.byu.edu/index.php/The_27_Articles_of_T.E._Lawrence.

5. David Kilcullen, "Twenty-Eight Articles: Fundamentals of Company-Level Counterinsurgency," *IO Sphere,* Summer 2006, 29, www.au.af.mil/info-ops/iosphere/iosphere_summer06_kilcullen.pdf.

6. Ibid.

7. As famous as this line is, consider carefully the rest of the quote: "When you are ignorant of the enemy but know yourself, your chances of winning or losing are equal. If ignorant both of your enemy and of yourself, you are sure to be defeated in every battle." Gen Tao Hanzhang, *Sun Tzu's Art of War: The Modern Chinese Interpretation* (New York: Sterling Innovation, 2007), 36.

8. Dennis M. Drew, "Air Theory, Air Force, and Low Intensity Conflict: A Short Journey to Confusion," in *The Paths of Heaven: The Evolution of Airpower Theory*, ed. Phillip S. Meilinger (Maxwell AFB, AL: Air University Press, 1997), 321–47; and James S. Corum and Wray R. Johnson, *Airpower in Small Wars: Fighting Insurgents and Terrorists* (Lawrence, University of Kansas Press, 2003).

9. Drew, "Air Theory," 321.

10. Paraphrased from ibid., 323–25.

11. Ibid., 347.

12. Corum and Johnson, *Airpower in Small Wars,* 425–37. The 11 points are quoted verbatim from Corum and Johnson while Dr. Farquhar has added additional comments based on the book's commentary.

13. Headquarters (HQ) Department of the Army and HQ Marine Corps Combat Development Command, Department of the Navy, HQ US Marine Corps, Field Manual (FM) 3-24 and Marine Corps Warfighting Publication (MCWP) No. 3-30.5, *Counterinsurgency*, 15 December 2006, 1-2. Although the manual has both Army and Marine Corps numerical designations, this article will simply refer to it as FM 3-24. In *The Gamble: General Petraeus and the American Military Adventure in Iraq* (New York: Penguin Press, 2009), Thomas E. Ricks describes the writing of FM 3-24 as an intellectual, policy, and leadership tour de force. Ricks details General Petraeus's role in assembling a diverse team of practitio-

ners and academics, both military and civilian, to develop a groundbreaking, discerning, focused work challenging past approaches to counterinsurgency and prescribing a way forward. FM 3-24 features the writings of David Galula, Charles Calwell, David Kilcullen, Roger Trinquier, and others in addition to famed guerrilla-warfare classics, including Sun Tzu, T. E. Lawrence, and Mao Zedong. The field manual's annotated bibliography is impressive and worth professional study.

14. FM 3-24/MCWP No. 3-30.5, *Counterinsurgency*, E-1. The similarities between FM 3-24's airpower annex and Corum and Johnson are intentional: Dr. Jim Corum largely authored the document with coordination in the early stage with Dr. Conrad Crane and Dr. Wray R. Johnson. Wray Johnson, telephone call with author, 18 November 2016.

15. The author thanks an unnamed referee for this article in pointing out a RAND Project Air Force monograph that provides a valuable primer on airpower's role in counterinsurgency and advocates for expanding the resources and scope of Air Force Special Operations Command's 6th Special Operations Squadron. In a thorough, perceptive analysis, the RAND team ably articulates four COIN principles: (1) understand the adversary, (2) build state capacity and presence, (3) control the population, and (4) keep the use of force to a minimum. The RAND study reinforces the ideas of Drew, Corum, Johnson, and others expressed in this article that airpower provides a vital, cost-effective COIN enabler for a host nation's political strategy. Alan J. Vick, et al., *Air Power in the New Counterinsurgency Era: The Strategic Importance of USAF Advisory and Assistance Missions* (Santa Monica, CA: RAND Project Air Force, 2006).

16. Maj Gen Charles J. Dunlap, Jr., *Shortchanging the Joint Fight: An Airman's Assessment of FM 3-24 and the Case for Developing Truly Joint Doctrine* (Maxwell AFB, AL: Air University Press, 2008), 7–8. Note: General Dunlap's observations made an impact; the current counterinsurgency manual is now a joint publication (JP): JP 3-24, *Counterinsurgency*, 22 November 2013, http://www.dtic.mil/doctrine/new_pubs/jp3_24.pdf.

17. Dunlap, *Shortchanging the Joint Fight*, 13.

18. Ibid., 33.

19. Ibid., 43.

20. Ibid., 64.

21. Phillip S. Meilinger, "Counterinsurgency from Above," *Air Force Magazine* 91, no. 7 (July 2008): 39, http://www.airforce-magazine.com/MagazineArchive/Documents/2008/July%202008/0708COIN.pdf. Another well-written article reinforcing the precision airpower plus SOF theme is John James Patterson VI, "A Long-Term Counterinsurgency Strategy," *Parameters* 40, no. 3 (Autumn 2010): 118–31.

22. Phillip S. Meilinger, e-mail to author, 12 May 2016.

23. John D. Jogerst, "Preparing for Irregular Warfare: The Future Ain't What It Used to Be," *Air and Space Power Journal* 23, no. 4 (Winter 2009): 68.

24. Ibid.

25. Ibid., 72.

26. Ibid., 75.

27. Ibid., 74.

28. Ibid., 76. Complementing Colonel Jogerst's work, a 2010 RAND study, *Courses of Action for Enhancing US Air Force "Irregular Warfare" Capabilities*, systematically articulates four courses of action to build an IW mind-set and build capacity within the institutional Air Force. It reinforces Jogerst's emphasis on building partner capacity through foreign internal defense and insists that many essential COIN tasks could not be done without the Air Force. Richard Mesic et al., *Courses of Action for Enhancing US Air Force "Irregular Warfare" Capabilities: A Functional Solutions Analysis* (Santa Monica, CA: RAND Project Air Force, 2010), xi, xix.

29. His statement refers to JP 5-0 that outlines an operational design process envisioning an initial state and identifying friendly centers of gravity, tangible "lines of effort" for focus, intermediate objectives for measured progress, and enemy centers of gravity to achieve a desired end state linking military and political objectives. JP 5-0, *Joint Operation Planning*, 11 August 2011, http://www.dtic.mil/doctrine/new_pubs/jp5_0.pdf.

30. Carl von Clausewitz, *On War,* ed. and trans. Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1984), 80.

31. Sanu Kainikara, *The Bolt from the Blue: Air Power in the Cycle of Strategies* (Canberra, Australia: Air Power Development Centre, 2013), 35.

32. Paraphrased from ibid., 74–75.

33. Lt Gen David A. Deptula, *Beyond the "Bomber": The New Long-Range Sensor-Shooter Aircraft and United States National Security* (Arlington, VA: Air Force Association, 2015), http://media.wix.com/ugd/a2dd91_1633acd30231444796f217d0cc39af65.pdf; David A. Deptula, "The Combat Cloud: A Vision of 21st Century Warfare," keynote address, Association of Old Crows, Washington, DC, 1 December 2015, http://media.wix.com/ugd/a2dd91_1550c5f873934b068afa8be3ad4ddd54.pdf; and David A. Deptula, "Revisiting the Roles and Missions of the Armed Forces," Statement before the Senate Armed Services Committee, 5 November 2015, http://www.armed-services.senate.gov/imo/media/doc/Deptula_11-05-15.pdf.

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Dr. John T. Farquhar

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The Myth of Strategic and Tactical Airlift

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> *I don't understand tactical or strategic. The words have now become meaningless and dysfunctional. In fact, in modern military speech, they are more often used to divide people and frustrate efforts than to illuminate and facilitate.*
>
> —Gen Charles A. Horner

In the 21st century, our ability to quickly and decisively deliver combat forces and equipment is of the utmost importance in achieving our national security objectives. The swiftness and flexibility of the US Air Force's mobility airlift fleet is the key to executing a rapid global mobility strategy. The operational effectiveness and efficiency of military air transportation relies on the expertise and intuition of Air Mobility Command's (AMC) mobility planners. Working in coordination with the United States Transportation Command (USTRANSCOM) and geographic combatant commands (GCC), AMC is responsible for the tasking and tracking of almost 900 daily mobility sorties worldwide. Using a hub-and-spoke model, mobility planners conceptualize airlift requirements and routes as either tactical or strategic in nature. Airlift assets are also considered this way. Tactical aircraft (usually C-130 variants) are smaller and are used primarily for intratheater airlift within a defined area of responsibility (AOR). Strategic aircraft (C-5B/M, C-17A) have larger payload capacities and extended ranges, making them useful for intertheater transportation between two different AORs or GCCs. Similarly, Air Force doctrine describes air mobility operations as either "intertheater or intratheater in nature."[1]

Throughout the history of the mobility air forces, planners tried various initiatives to centralize control of both airlift types. Ultimately, though, the doctrinal tenet of centralized control and decentralized execution resulted in an airlift system in which tactical assets and operations are parceled out or chopped to regional commanders, while strategic assets remain under the control of AMC. Consequently, only a portion of the service's C-130 fleet is available to be tasked by planners as part of the global air mobility system under the operational control of USTRANSCOM/AMC. We argue that this asset categorization can inhibit the appropriate distribution of airlift and result in a less effective airlift system.

The Air Mobility Context

The distinction between strategic and tactical operations has endured since World War II, although the lines between the two are often blurred. After the initial drafting of Air Force Manual (AFMAN) 1-1, *United States Air Force Basic Doctrine*, in 1964, the Military Airlift Transportation Service (MATS) submitted a manual that attempted to outline a unified airlift system. It recognized that the differences between strategic and tactical airlift had become negligible with the advent of modern aircraft. Included with the submission were the ideas of Gen Howell Estes Jr., MATS commander, who discussed airlift unity based on 25 years of evolution in airlift thinking and capability. In his opinion, the dual airlift system approach "perpetuates post–World War II thinking and fails to acknowledge and exploit the full capability of the modern transport aircraft in its primary role." He further believed "that the full functional capability of airlift must be addressed as an entity in order to exploit the flexibility of airlift forces . . . [and that] such capability cannot in any way be considered divisible." However, senior leaders disagreed with this assessment and ordered the publishing of two separate manuals—one produced by MATS (AFMAN 2-21, *Strategic Airlift*) and a second produced by Tactical Air Command (AFMAN 2-4, *Tactical Airlift*).[2] While the basic idea of a segregated airlift system endures, its application in modern air warfare has periodically been challenged. General Horner, the coalition forces air component commander during Operation Desert Storm, argued in his book *Every Man a Tiger* that the strategic versus tactical planning model was obsolete. He felt that these terms are "a heritage" from previous wars where strategic attacks were directed at the enemy's heartland while tactical assaults were targeted at forces in the field. He viewed airpower as "essentially very simple: aircraft can range very quickly over very wide areas and accurately hit targets very close to home or very far away. Nothing more. Nothing less."[3]

The USAF's modern hub-and-spoke system—similar to the one employed in the commercial aviation industry—allows maximum opportunity for aggregation at major aerial port hubs and promotes increases in efficiency versus a simple point-to-point delivery method.[4] It also seemingly necessitates the segregation of Air Force mobility aircraft into strategic airlift for long-haul distances and tactical airlift for the "spoke" routes. However, while the planning model remains somewhat static, improvements in aircraft technology increase the flexibility, speed, and range of modern USAF airlifters and blur any tactical or strategic distinction. These advances present an opportunity to challenge the current model by using a holistic approach in the aircraft selection process.

Regardless of a route's or requirement's designation as strategic or tactical, all airlift fleet assets should be analyzed to maximize efficiency and minimize fuel consumption and cost while still meeting the overall objective of fulfilling the war fighter's requirement. Flexible aircraft like the C-17A, with its direct delivery capability and recent upgrades to the USAF's primary tactical airlifter, the C-130J, present the prospect of exploring and exploiting these aircraft beyond their simple application as inter- or intratheater assets.[5] Furthermore, empirical evidence suggests that increasing delivery method diversity will add efficiency and reduce operations costs. Studies examining airframe and route optimization indicate that costs and efficiency can improve with a more diverse airlift fleet.[6]

The Air Mobility Fleet and Evolution of the C-130

The Lockheed C-130 "Hercules" has been a staple of the USAF's air mobility fleet for nearly 60 years. The original C-130A entered the Air Force inventory in December 1956. Since then, this flexible platform has been periodically upgraded and improved and is still the most capable aircraft for its specific mission set. In 1999 the Air Force introduced the C-130J model, which incorporated state-of-the-art technology that significantly increased performance in range and fuel efficiency and reduced manpower requirements and operational and life-cycle costs. Also, Lockheed developed a stretch version of the aircraft, the C-130J-30, which added 15 feet to the fuselage and extended its payload capacity and range. The newest C-130J upgrades represent an evolution of the airframe with dramatic increases in fuel efficiency, extending the aircraft's range at 35,000 pounds (lb.) of payload to 2,100 nautical miles (nm)—an improvement of nearly 62 percent compared to the older C-130H.[7] Its new Rolls-Royce turboprop engines also markedly improved the aircraft's power and top speed—from 366 to 410 mph. Greater speed, capacity, and range allow the C-130J-30 to blur the capability distinction and give it greater parity with the larger, strategic mobility aircraft. Table 1 compares AMC's strategic airlift fleet with its newest tactical airlifter.

Table 1. USAF mobility aircraft comparison

	Tactical Airlift			*Strategic Airlift*		
	C-130H*	C130J*	C130J-30*	C17A*^	C-5A/B/C*	C-5M^
Speed	366 mph	417 mph	410 mph	450 mph	518 mph	586 mph
Max Payload	42,000 lb.	42,000 lb.	44,000 lb.	170,900 lb.	270,000 lb.	285,000 lb.
Range (Unrefueled)	1,300 nm	1,800 nm	2,100 nm	2,400 nm	4,350 nm	5,250 nm
Max Load (Pallet Positions)	6	6	8	18	36	36

*(*Source*: See the following fact sheets at http://www.af.mil/AboutUs/FactSheets.aspx: "C-130 Hercules," 1 September 2003; "C-17 Globemaster III," 1 October 2015; and "C-5 A/B/C Galaxy and C-5M Super Galaxy," 15 May 2006.)
^Manufacturer's specifications

While the C-17A and the C-5 clearly enjoy distinct advantages in speed, payload, and range over the C-130 in their application as long-range airlifters, the newest C-130J excels in its extremely low relative cost to operate. Per hour of flight and the cost metric analyzed, the C-130J is between 66 percent and 70 percent less expensive to operate than the C-17A and costs between 74 percent and 78 percent less than the C-5M.[8] Much of the variable cost savings results from superior fuel efficiency.

Depending on the length of the city pair—the combination of origin and destination airfields—the C-130J consumes only about a quarter of the C-17A's fuel per hour and less than one-fifth of the fuel consumed by the C-5M. Energy market volatility and disruptions in the energy supply chain can create substantial pressures on mobility aircraft fuel budgets. Within the Department of Defense (DOD), the USAF uses more than 60 percent of all fuel, and AMC consumes more than half of that.[9] Therefore, if the C-130J can adequately perform even a small part of the intertheater airlift missions currently flown almost exclusively by the C-17A and C-5B/M, the resulting impact could be significant.

Increased Fuel Efficiency through "Hopping"

A precondition for consideration of smaller aircraft into the strategic mobility mix is the reality that they have reduced ranges relative to their larger counterparts. When flying missions over great distances, smaller aircraft will likely need to stop more often to refuel. Extra stops often add both fuel and time penalties, although these can be offset by the increased fuel efficiency associated with flying smaller aircraft. When hopping from point to point, an inherent trade-off must be made between performance and number of stops. Table 2 illustrates this concept.

Table 2. Dover to Ramstein stop/performance trade-off

	C-130J-30		*C17A*		*C-5B*		*C-5M*	
Stops	Max Payload (klb)	Weight/ Pallet Allowed	Max Payload (klb)	Weight/ Pallet Allowed	Max Payload (klb)	Weight/ Pallet Allowed	Max Payload (klb)	Weight/ Pallet Allowed
0	Unable		85.38	4.74	123.41	3.43	179.19	4.98
1	42.96	5.37	142.36	7.91	177.88	4.94	232.04	6.45
2	53	6.63	156.71	8.71	234.47	6.51	270	7.5

*Klb represents thousands of pounds.

As Table 2 shows, making a stop en route to a final destination considerably increases the maximum allowable payload and weight per pallet allowed. These effects on overall efficiency and fuel consumption are not trivial. For example, a 230,000 lb. cargo requirement when flying from Dover AFB, Delaware, to Ramstein AB, Germany, without an en route stop would require two aircraft. However, a single C-5M (assuming the volume constraint is satisfied) making a single stop can execute this cargo requirement in one mission.

The focus of increasing cargo aircraft productivity historically emphasized improvements in payload capacity and speed. Accordingly, aircraft subsequently became larger and faster, adding the benefit of extending their operational range. This advantage has largely driven an upward trend of ever-increasing stage lengths, especially for passenger airlift. However, the trend of increasing cruise speeds for conventional aircraft designs is beginning to plateau and is unlikely to grow appreciably anytime soon. Therefore, designers now build larger aircraft with greater payload capacity to obtain productivity increases.[10] The unfortunate side effect of this approach is that large aircraft pay a stiff penalty in fuel consumption and efficiency. Analytical work by John Green and Raj Nangia shows that using today's technology, the most fuel-efficient passenger aircraft design is optimized at a range of approximately 3,000 nm.[11] They hypothesize that sizeable fuel savings could be realized by using either in-flight refueling or segregating long routes into a set of smaller legs with aircraft designed for shorter flights. Similar analysis by Andrew S. Hahn in 2007 shows that in a commercial passenger setting, a conservative estimate of fuel savings of approximately 29 percent is achievable. Realizing such efficiencies would require breaking up longer routes of 15,000 kilometers into three stages of 5,000 kilometers each and redesigning aircraft for this specific type of operation.[12] While these studies primarily apply to commercial passenger airlift, the principle of hopping with smaller, capable aircraft should be explored within the context of military cargo airlift operations.

Reducing Airlift Inefficiency through Aircraft Selection Modeling

To analyze the effects of an all-inclusive approach to airlift planning, we created a mathematical model called the Aircraft Selection Model (ASM). The ASM is a rule-based modeling tool developed to consider the broadest possible set of airlift alternatives—given a specific cargo requirement and desired city pair—to foster objective, data-driven aircraft selection decisions. While the ASM can be modified to model different objective functions, it was designed to minimize a scenario's fuel consumption. Using historical data collected from two AMC information systems, it was possible to compare historical aircraft selection decisions to ASM's ideal aircraft mixes. The ASM explicitly considers the C-130J-30 together with the C-17A and the C-5M as available aircraft in the strategic mix. This model assumes that aircraft are available as needed, which, in reality, is a constraint for air mobility planners.

The scope of analysis focused on one month of cargo movement data (July 2012) for four high-traffic, intertheater city pairs (fig. 1):

- Dover AFB, DE (KDOV), to Ramstein AB, Germany (ETAR)
- Dover AFB, DE (KDOV), to Rota Naval Station, Spain (LERT)
- Travis AFB, CA (KSUU), to Hickam Air Field, HI (PHIK)
- Travis AFB, CA (KSUU), to Joint Base Elmendorf, AK (PAED)

July 2012 was chosen because of the relatively large amount of cargo moving from stateside to overseas that month, which allows the ASM to come up with unique alternative solutions. Available data suggests that cargo movement is highly seasonal and tends to peak during the summer months.

Analysis of this month of airlift data showed several instances in which the ASM found ideal airlift choices that differed from the actual historical data and resulted in significant fuel and operational cost savings. The 8 July 2012 Dover-to-Ramstein city-pair scenario illustrates the ASM's potential use. On that day, 20 individual cargo items accounting for 20.2 pallet position equivalents and 125,500 pounds were transported between this city pair by two C-17As. Our model identified four viable aircraft mix alternatives that could conceivably fulfill this cargo lift requirement, as shown in Figure 2.

Figure 1. Strategic city pairs analyzed using the ASM

Figure 2. Aircraft mix alternative, KDOV-ETAR, 8 July 2012

The model shows a possible savings of 148,000 lb., 118,000 lb., or 94,000 lb. of fuel by respectively selecting three C-130J-30s, a single C-5M, or a C-17A and C-130J-30 for this particular cargo movement. Using the conversion rate of 6.7 lb./gallon and the fiscal year 2016 price of Defense Logistics Agency aviation fuel of $2.95, the variable cost savings is about $65,000, $52,000, and $41,000, respectively. We also analyzed the effect of this modeling approach for semivariable costs by including two Air Force cost metrics: Air Force total ownership cost (AFTOC) and logistics cost planning factors costs per flying hour (CPFH). These two comprehensive cost metrics incorporate fuel and contracted/organic maintenance, repair, personnel, and supply costs. By taking the total flight time for each aircraft type in the aircraft alternative and multiplying by its respective CPFH figures, we show that selecting figure 2's alternative 1, 3, or 4 would reduce semivariable flying hour costs by about $113,000, $72,000, or $83,000 (using logistics CPFH figures) or $39,000, $40,000, or $37,000 (using AFTOC CPFH figures), respectively.

This method was repeated for each day and each city pair during the July month of analysis with the following results (fig. 3):

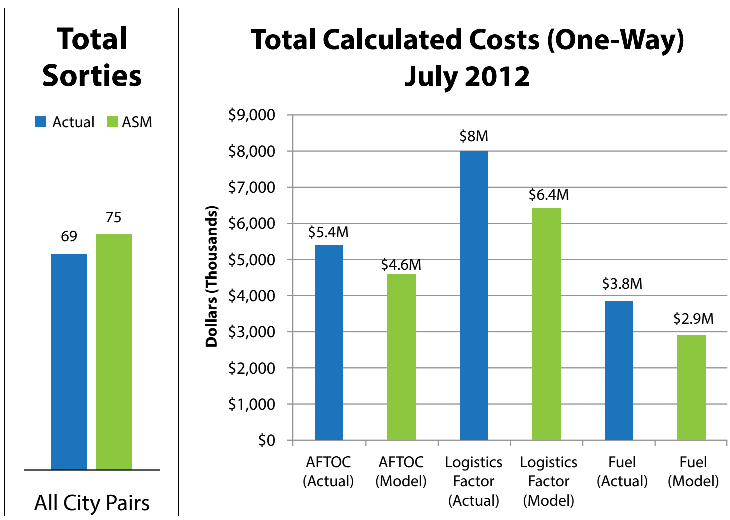

Figure 3. Actual versus ASM cost metric comparison

As figure 3 shows, meaningful fuel and operational cost savings can be achieved by using a holistic, fleet-based quantitative approach to select airlift aircraft. These results parallel a scheduling and delivery problem studied by Chinyao Low, Chien-Min Chang, Rong-Kwei Li, and Chia-Ling Huang demonstrating that total costs (defined as fixed vehicle costs and variable routing costs) gradually decrease as the vehicle types employed are increased. By expanding delivery fleet diversity, planners are more able to tailor airlift capacity to a specific demand. To illustrate this concept, our 8 July 2012 Dover-to-Ramstein city-pair scenario is again shown in figure 4. When considering only the traditional strategic airlift for aircraft selection, planners are limited to only two options for the cargo demand on that day: two C-17As or a single C-5M. In contrast, an all-inclusive approach that comprises all airlift assets identifies two additional viable options that outperform the actual aircraft selected on the day of analysis (two C-17As)—both in terms of fuel consumption and semivariable costs. Including smaller increments of airlift capability allows for aircraft mix alternatives with reduced excess capacities, leading to improvements in operational efficiency.

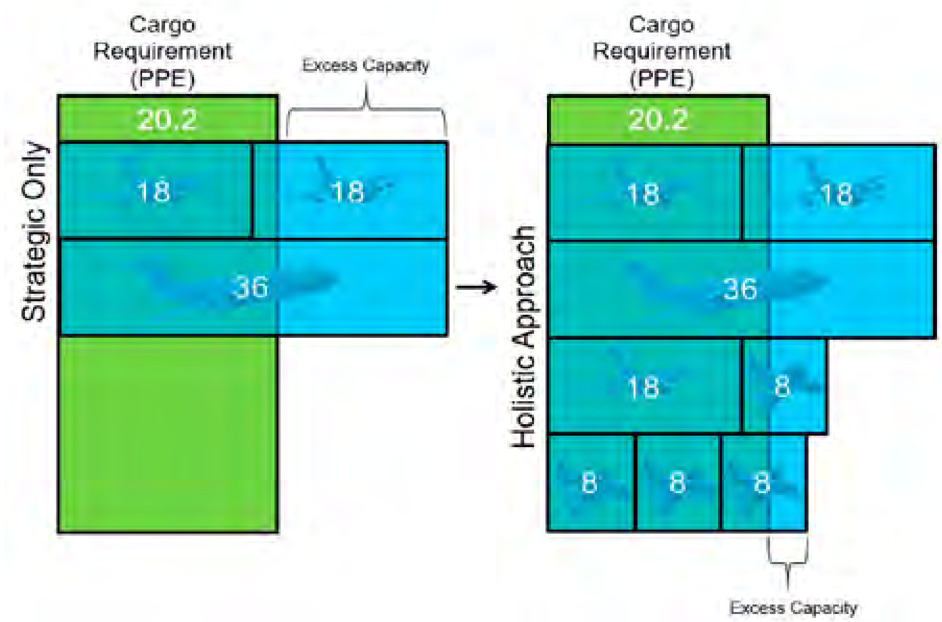

Figure 4. Strategic-only versus all-inclusive planning approach

Conclusion

Delivering combat capability effectively should be the primary goal of any military operation, but limited resources demand that military planners constantly search for new ways to operate to achieve this goal. Energy is one of the largest line items in the DOD's budget and therefore presents itself as a prime target for efficiency analysis. While necessary to curb growing demand, researching and developing new technologies aimed at reducing fuel consumption can be expensive and doesn't necessarily guarantee a return on investment. A smarter short-term approach is to analyze how we are using assets and to look for innovative ways to better use them. One should note that while the ASM's algorithm focuses on fuel efficiency, other variables determine in concert the overall efficiency—and importantly the effectiveness—of the system. The increased probability of maintenance actions, required additional en route support, and supplemental aircrews to support a revised airlift strategy would affect the overall efficiency of the airlift system. More research is needed to determine an aircraft mix that doesn't compromise the level of effectiveness our war fighters require.

For air mobility operations, a simple change in how assets are considered in the planning process may improve operating efficiency. As General Horner observed, constraining ourselves with arbitrary strategic or tactical labels can be "more often used to divide people and frustrate efforts than illuminate and facilitate."[13] In understanding mobility operations, the doctrinal tenet of centralized control and decentralized execution demands an appreciation for the differences between *strategic* and *tactical* in terms of mission planning and execution. However, we should recognize that while the present air mobility hub-and-spoke system requires an understanding of missions as being strategic or tactical in nature, any corresponding categorization of airlift assets is not necessary. It may, in fact, be counterintuitive to the efficient operation of the airlift system. By using a more holistic, deliberate approach to the mobility aircraft selection process, planners can more closely tailor capability to demand, resulting in less excess capacity and waste and a reduction in fuel consumption and operating costs. ✪

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The Doolittle Raid—75 Years Later

Dr. Robert B. Kane, Lieutenant Colonel, USAF, Retired

Two weeks after the 7 December 1941 Japanese attack on Hawaii, President Franklin D. Roosevelt informed the chiefs of the Army, Navy, and Army Air Forces (AAF) that he wanted to strike back at Japan to boost American morale—a request he repeated in the ensuing weeks.[1] Their problem was how to accomplish the president's objective since the heart of US naval power in the Pacific lay on the bottom of Pearl Harbor. The United States did not have an aircraft able to reach Japan from the closest American land base.

Two individuals independently came up with the ideas that produced the Doolittle Raid: Navy captain Francis Low and Lt Col James "Jimmy" Doolittle—a famous prewar military test pilot, civilian aviator, and aeronautical engineer and now special assistant for Lt Gen Henry "Hap" Arnold, AAF chief. Low was the assistant chief of staff for antisubmarine warfare for Adm Ernest J. King, chief of naval operations. His observation of Army pilots making bombing passes on an outline of a carrier deck painted on the airfield at Norfolk Naval Base, Virginia, on 10 January 1942, sparked the idea of launching Army bombers from an aircraft carrier.[2] On 3 February, Low had two B-25s—each with a pilot and copilot—loaded onto the Hornet, the Navy's newest carrier, at Norfolk. When the carrier was past the Virginia capes, the aircraft flew off of the carrier's deck without difficulty.[3]

Meanwhile, General Arnold had asked Colonel Doolittle to determine the best aircraft for such an attack. The aircraft required a 2,400-mile cruising range and a 2,000-pound bombload and yet needed to be small enough so that a "reasonable" number of them could fit on the back half of an aircraft carrier. Doolittle settled on the Army's newest aircraft, the B-25B. Since the B-25's range was only about 1,300 miles, the aircraft would require modifications to double its normal fuel capacity.[4] Also, the B-25 had minimum self-defense capability—two machine guns in a top turret, two in a belly turret, and one in the bombardier's nose—and fighters would be unable to accompany the bombers.[5] Doolittle would have to rely on the element of surprise to compensate for the aircraft's minimum protection.

The final plan envisioned a Navy task force of two aircraft carriers—one to carry the aircraft for the raid and one to protect the task force—as well as escort and support ships that would sail westward until the force was about 400 miles from Japan. The planes would launch at night, fly toward Japan, and arrive over their target cities right after sunrise. Then, after dropping their bombs, the aircraft would fly 1,200 miles from Japan across the East China Sea to China and land on airfields just inside Chinese-held territory before sundown.[6] The plan was bold and innovative with many risks but, if successful, could pay strategic dividends.

With the president's and service chiefs' approval of the raid's concept, Doolittle chose the 17th Bombardment Group (BG) (Medium) at Pendleton Field in northeast Oregon to provide the crews and aircraft for the raid. As the first group equipped with B-25s, it had the most experienced crews in flying the new aircraft. On 3 February, the War Department transferred the 17 BG to Columbia Army Air Base, near Columbia, South Carolina, to conduct antisubmarine patrols off the east coast of the United States, and Doolittle had 24 aircraft diverted to Mid-Continent Airlines in Minneapolis, Minnesota, to receive additional fuel tanks and other needed equipment.[7]

The group officially arrived at Columbia on 9 February. Around 16 February, Doolittle arrived at Columbia and informed only the group commander of the true nature of the mission. Doolittle then briefed the crews that he was looking for volunteers for a highly dangerous, secret mission that would contribute to America's war effort but provided no additional information. Because everyone volunteered, Doolittle and the group's three squadron commanders selected the best 24 crews for the mission.[8]

Those crews flew the modified bombers from Minneapolis to Eglin Field, Florida, and arrived between 27 February and 1 March 1942, along with 60 enlisted support personnel (fig. 1).[9] For the next three weeks, the crews trained in simulated carrier takeoffs, low-level and night flying, low-altitude bombing, and overwater navigation. Each morning, the crews readied their aircraft at Eglin's main airfield and conducted the day's training operations at various Eglin auxiliary fields or over the Gulf of Mexico. Navy lieutenant Henry Miller, a flight instructor from nearby Naval Air Station (NAS) Pensacola, supervised the short takeoff training and later accompanied the Raiders aboard the *Hornet*.[10]

Courtesy of Doolittle Raider Organization

Figure 1. Some of the Doolittle Raiders in the officer quarters on Eglin Field in March 1942. *Left to right*: 1st Lt Richard Joyce, 1st Lt Richard Cole (with dark necktie), 1st Lt Henry A. Potter, 1st Lt William Fitzhugh (with magazine), 1st Lt Carl Wildner (without hat), and officer with back to camera unknown

The 17 BG enlisted men and Eglin technicians also made additional modifications to the aircraft. These included the installation of a collapsible fuel tank and more fuel cells in the fuselage, removal of the belly turret and a heavy tactical radio, installation of deicers and anti-icers and steel blast plates around the upper turret, and installation of mock gun barrels in the tail.[11] They also fine-tuned new carburetors for the aircraft engines to obtain the best possible engine performance and fuel consumption rate for cruising at low altitudes.[12]

Doolittle had the top-secret Norden bombsights removed from the aircraft to prevent them from possibly falling into Japanese hands and—because of their relative inaccuracy at the medium altitudes—planned for the actual raid. Capt Charles Ross Greening, pilot and armament officer, created an aiming sight, dubbed the "Mark Twain," which Eglin's sheet-metal workshops manufactured for about 20 cents each. It proved to be relatively accurate in the actual attack.[13]

Early morning on 23 March, Doolittle received the word from General Arnold to leave Eglin Field and fly to the Sacramento Air Depot, McClellan Field, California. Although early-morning fog, rain, and the aircraft modifications had reduced the planned training time (about 50 hours total) by 50 percent, Doolittle in his postraid report to General Arnold noted the crews had reached a "safe operational" level.[14] McClellan Field technicians conducted last-minute inspections and made final modifications to the aircraft.[15] After arriving at NAS Alameda, California, on 31 March, the Navy squeezed 16 onto the rear of the *Hornet*'s flight deck, leaving about 450 feet for the aircraft's takeoff run.[16]

At 0848 on 2 April, the *Hornet* left San Francisco Bay with 71 AAF officers and 130 enlisted men aboard, her escort, and supply ships (fig. 2). A few days later, this task force rendezvoused with the USS *Enterprise*, commanded by Vice Adm William Halsey Jr., and her escort ships north of Hawaii. The *Enterprise*'s aircraft would protect the task force from a Japanese air attack as the *Hornet*'s aircraft were below on the hangar deck.[17] By early morning 18 April, the combined force had reached a point about 750 miles east of Japan.

Courtesy of US Navy

Figure 2. Doolittle Raid aircraft on the rear flight deck of the USS Hornet in April 1942 somewhere in the Central Pacific

Unfortunately, at 0558 on 18 April, Navy scout planes discovered a Japanese picket boat, which the USS *Nashville* sank by gunfire. Not sure if the patrol boat had sent a message of the sighting—although it had but could not send a second, confirmatory message before it sank—Doolittle and *Hornet* skipper Capt Mark Mitscher decided to launch the B-25s immediately (fig. 3). The launch was 10 hours earlier and about 250 miles farther east of Japan than planned. All 16 aircraft had taken off safely between 0820–0919. One Sailor, however, lost an arm when a sudden movement of the carrier caused him to step back into the prop wash of aircraft 10.[18]

Courtesy of US Navy

Figure 3. Most of the Doolittle Raiders on the deck of the USS *Hornet* in April 1942 somewhere in the central Pacific. (*Left*) Lt Col James Doolittle and (*right*) Capt Marc Mitscher, USN, commander of the USS *Hornet*

Six hours after launch, now about noon Tokyo time, the B-25s arrived over Japan. They climbed to 1,500 feet and began their bombing runs on their designated targets in Tokyo, Yokohama, Yokosuka, Nagoya, Kobe, and Osaka. The B-25s encountered light antiaircraft fire and a few enemy fighters, but none were lost to enemy fire. The crews of two aircraft shot down three Japanese aircraft and strafed additional military targets. Doolittle later reported that the mock gun barrels in the aircraft tails apparently succeeded in warding off enemy fighters during the raid.[19]

After the attacks, 15 of the 16 aircraft headed southwesterly across the East China Sea toward eastern China for friendly airfields. However, the earlier-than-planned launch caused all 15 to run low on fuel as they approached the Chinese coast. Only a tailwind that increased the ground speed during their flight allowed them to get that far. Additionally, by then, night had closed in and forced all 15 crews to ditch along the China coast or bail out over eastern China around 2200.

Within hours of launching from the *Hornet*, the pilot of aircraft 16, Capt Edward York, realized that his engines were burning fuel at an unexpected high rate. Civilian technicians at McClellan Field had changed the settings of his aircraft's carburetors. Realizing that his aircraft would not reach China, York headed toward Vladivostok in the Soviet Far East.[20]

Although the Soviet Union was an ally of the United States in the war against Nazi Germany, it was not at war with Japan because of a prewar neutrality treaty and, as a result, interned the crew and confiscated the aircraft. After 13 months of internment, many US government attempts to repatriate the crew members and three moves that placed them at Ashgabat, 20 miles north of the Iranian border, the People's Commissariat for Internal Affairs (NKVD) or Soviet secret police arranged to smuggle the Americans into Iran, and they soon returned to the United States.[21]

During the next several days, Chinese soldiers and guerrillas scoured the countryside and rescued 69 of the Raiders from thousands of Japanese soldiers, also looking for them. Two crewmen drowned when their aircraft crashed off the Chinese coast, and one died after bailing out. The Japanese army captured eight and tried and executed three as war criminals, and one of the remaining five died while in prison. Office of Strategic Services agents rescued the remaining four from a Japanese prison in Shanghai in August 1945. Also, seven crew members sustained injuries serious enough to require medical treatment. The Chinese people paid dearly for helping the Americans to safety—the Japanese army destroyed many villages and murdered up to 250,000 Chinese.[22]

Initially, Doolittle felt that the raid had been a terrible failure: loss of all of his aircraft, the whereabouts of many of the crewmen unknown, and little actual damage to Japan's military capabilities. He fully expected to be court-martialed on his return to the United States. Instead, President Roosevelt awarded him the Congressional Medal of Honor and promoted him to brigadier general. All 80 Raiders received the Distinguished Flying Cross and decorations from the Chinese government, and those Raiders killed or wounded received the Purple Heart.[23]

Although Doolittle had such despondent thoughts right after the Raid, the effects of the attack had significant and long-ranging implications and, even today, provide those interested in studying the raid with some lessons learned. The most notable and immediate effect was the tremendous boost in national morale when Americans woke up the next day to newspaper headlines and radio journalists proclaiming "US Bombs Tokyo." This was the first good news after four months of doom and gloom, from the surprise attack on Hawaii on 7 December to the surrender of about 12,000 American and 65,000 Filipino soldiers in the Bataan Peninsula to the Japanese. The raid came less than 10 days after the worst defeat in American history.[24] It provided the first inkling of hope of eventual victory.

Additionally, Japan had not been attacked by outsiders since the thirteenth century when typhoons (the "divine wind" or kamikaze) had destroyed separate Mongol fleets in two attempts to invade Japan. Thus, Japanese leaders had encouraged a sense of invulnerability among the Japanese people. The Doolittle Raid shattered that perception, which continued to diminish as Allied victories across the southwest, central, and western Pacific accumulated after mid-1942. Also, Japanese leaders pulled back four frontline fighter squadrons to defend the home islands from another American attack, an attack that did not occur until late 1944.

The raid also confirmed the Japanese leaders' decision eight days earlier to halt their advance into the Indian Ocean and toward India for a naval operation to extend their eastern defense line further east toward Hawaii and seize Midway Island. Such an operation, they believed, would draw out the American carriers missed at Pearl Harbor—and America's only offensive military power in the Pacific at the time—into a battle where Japanese naval aircraft would destroy them. (President Roosevelt had told newspaper reporters that the Doolittle aircraft had come from Shangri-La, the fictional land of James Hilton's novel *Lost Horizon*, but the Japanese leadership reasoned that they had to come from an aircraft carrier.) That operation led to the resounding American naval victory at Midway, 5–7 June 1942. During the battle, the Japanese navy lost four fleet carriers, about 275 aircraft, and 2,400 men including experienced pilots and aircraft mechanics versus American losses of one carrier, 150 aircraft, and 307 men.[25] That victory stopped the Japanese advance eastward and, within months, placed them on the defensive.

There are other tactical defeats from history that eventually produced strategic results. For example, in seven years of war during the American Revolution, the Americans won only a handful of major battles but still won the war. From the autumn of 1780 to the summer of 1781, American guerrillas fought the Southern Campaign with only two major victories—King's Mountain and Cowpens—yet Lord Cornwallis abandoned South Carolina and marched his army north to Yorktown, Virginia, where he became trapped and eventually surrendered to Gen George Washington in October 1781. During the Southeast Asia War, the Viet Cong guerillas and North Vietnamese army won very few major battles but eventually won the war in April 1975.

The Doolittle Raid can also teach leaders—officers and enlisted—about decision making, innovative thinking, and risk taking. As previously noted, Captain Low and Colonel Doolittle independently put together an out-of-the-box, innovative plan to achieve the president's objective of a retaliatory attack on Japan. As they thought about how to carry out the idea, neither of them restrained their thinking to the standard, accepted contemporary ideas about the use of Army medium bombers and carriers. When Doolittle received the code phrase to leave Eglin Field for McClellan Field early on 23 March, the crews had completed only about 50 percent of his original training program. Nevertheless, he deemed what they had accomplished "operationally" sufficient—a partial solution instead of a 100 percent. The modifications to the raid bombers made by gunners, flight engineers, and ground crew were as audacious and successful as those made by the planners and aircrew.

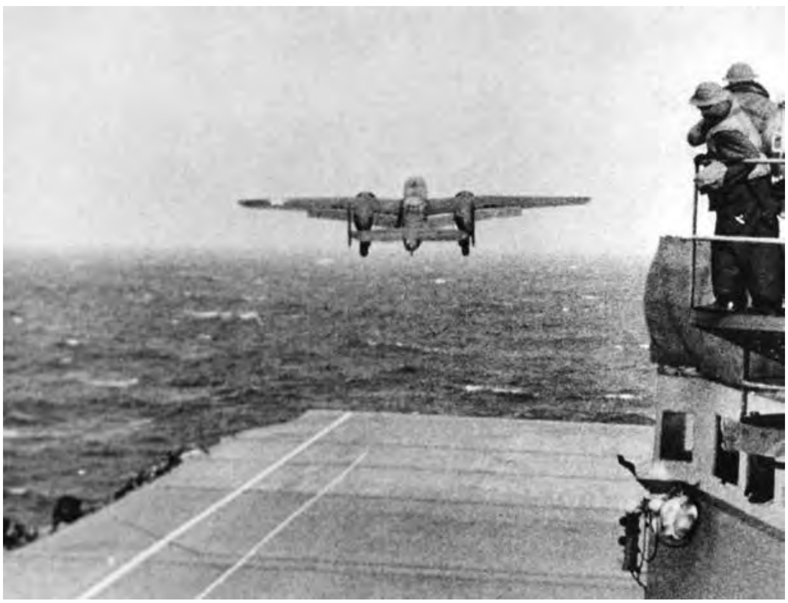
Both Doolittle and Mitscher knew that the earlier-than-planned launch on 18 April would place the aircraft at the end of their fuel reserves, but the two commanders, in weighing the options, risked launching early to carry out the mission. As a retired Air Force lieutenant colonel on active duty from 1976–2003, I served in a generally "no-mistake" Air Force. In many cases, members were fired or discharged for one mistake out of 99 successes. Such an atmosphere limited risk-taking and innovative thinking out of fear of punishment and possible forced departure from the service. Think back to Doolittle's thoughts right after landing in China and on the trip back to the United States.

As important as it is to have innovative thinkers who do not constrain themselves to standard operating procedures, it is equally important to have leaders, such as General Arnold, who are receptive to "outlandish" ideas. Imagine if Arnold had been a standard, conservative leader, like the British and French generals who—

time and again—ordered their soldiers into futile frontal attacks against the German trenches, barbed wire, and machine guns from October 1914 to early 1918, resulting in millions of casualties. Such a leader would have told Low and Doolittle to go back to the drawing board and develop "a more reasonable" idea. Instead, Arnold told them to test the idea; consequently, Doolittle got the go-ahead to plan the mission, train the crews, and carry out the mission.

Another example of innovative thinking is the Air Force's use of the B-52 Stratofortress and B-1B Lancer. These aircraft were designed to drop nuclear weapons in case of nuclear war. However, the Air Force has most successfully used these nuclear-capable strategic bombers—armed with 12 (B-52) or 24 (B-1B) Joint Direct Attack Munitions (warheads with a Navstar Global Positioning System tail kit for guidance)—for close air support in Operations Enduring Freedom and Iraqi Freedom, given the extreme accuracy of the weapon.

Finally, the raid known as Special Aviation Project No. 1 was the first big joint operation since the Union's siege of Vicksburg, Mississippi, 18 May–4 July 1863, commanded by Gen Ulysses S. Grant.[26] This successful operation involved major units of the Union Army and Navy and ended with the capture of Vicksburg, giving the Union complete control of the Mississippi River and splitting the Confederacy. From the development of the initial concepts by Navy captain Low and AAF colonel Doolittle in early January 1942 to the launch of the Raiders' aircraft off the *Hornet* on 18 April 1942, Navy and AAF members worked together to achieve the successful launch of Doolittle aircraft (fig. 4). Such collaboration serves as a model for joint operations during and since World War II.



Courtesy of US Navy

Figure 4. Aircraft no. 1, flown by Lt Col James A. Doolittle, right after its takeoff from the deck of the USS Hornet on the morning of 18 April 1942

Today's armed forces face numerous challenges—threats from peer states, rogue states, and nonstate actors; increasing numbers of cyber attacks and international and domestic terrorist attacks; diminished national defense budgets that have limited new weapon systems acquisition; reduced manning end strengths; and aging weapons systems. The days of unlimited budgets and standardized, conservative decision making are gone. Given the challenges of today's world and the foreseeable future, America's military forces need leaders willing to accept innovative, out-of-the-box solutions to problems and followers willing to provide them without fear of retribution if the solution fails—in other words, more Arnolds and Doolittles. Although the Doolittle Raid occurred 75 years ago, it still deserves study by the military leaders of today and tomorrow. ✪

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Ensuring Surety of Supply through Sustainable Aviation Fuels

Maj Marcus R. McWilliams, USAF

Background

In the last 15 years, there has been massive instability in the global petroleum market. In the last three years alone, US prices for commercial-grade Jet A fuel have risen to a high of $3.29 per gallon in 2013 and plummeted to a low of 80 cents per gallon in 2016.[1] In the wake of rapidly spiking crude oil prices in the early 2000s, Congress passed the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007. The legislation included tax incentives and funding for the research, development, and production of biomass-sourced fuels. While the legislation was largely aimed at diesel fuel production, the technologies and methods developed have had a direct impact on the production of alternative jet fuels.

As a result, the production of biodiesel has doubled in just five years, going from 678 million gallons in 2008 to 1,359 million gallons in 2013.[2] During this period, the US Air Force's Alternative Fuels Certification Office, working in conjunction with the Commercial Aviation Alternative Fuels Initiative—a consortium of airlines, manufacturers, and fuel producers—led the way in testing and certifying alternative jet fuels for use in military and commercial aircraft.[3]

While the Air Force certification program ended in 2012, the US Navy has continued participating with the commercial sector in the testing and development of aviation biofuels. Five different production methods have now been standardized and certified for commercial production of sustainable aviation fuels. Multiple airlines, both US and international, are pursuing the adoption of aviation biofuels into daily operations as a means of expanding their corporate environmental sustainability portfolios, meeting government-mandated emissions requirements, and taking advantage of tax incentives.

Meanwhile, as US foreign policy has shifted from a post–Cold War Eurocentric focus toward the Asian-Pacific region of the world, the Department of Defense has had to adjust, making plans for conducting military operations in an area of the world with comparably few established military bases. Utilizing existing facilities owned by allied and partner nations has become a planning reality, meaning the ability to use locally available fuel sources will have a direct impact on the flexibility of military air operations.[4]

Current State

In the last decade, biofuels have made significant strides in moving mainstream in the commercial aviation world. The American Society for Testing and Materials (ASTM) International, owner of the US jet fuel production standard, has approved blends of five biofuels as part of the Jet A standard.[5] These are (1) coal, biomass, or natural-gas-based jet fuel (Fischer-Tropsch Synthetic Paraffinic Kerosene, FT-SPK)—up to 50 percent; (2) Fischer-Tropsch fuels with added aromatic content (FT-SKA)—up to 50 percent; (3) plant, oil, and fat-based fuel or hydroprocessed esters and fatty acids (HEFA)—up to 50 percent; (4) sugar-based jet fuel or synthesized isoparaffins (SIP)—up to 10 percent; and (5) alcohol-based jet fuel or alcohol to jet (ATJ)—up to 30 percent.[6]

Because of their inclusion in the Jet A standard specification, these biofuels can be used in the approved blend ratios at any time with no warning or additional marking noting the biofuel content. This practice is similar to that for B5 biodiesel, which does not require markings on gas station dispensers. In contrast, biofuels that have warranty implications from manufacturers, such as E10/E15 gasoline and B20 biodiesel, are required to have warning labels.

However, despite the adoption of biofuels into the jet fuel standard, very few production operations have come online to make aviation biofuels. Economics is a major factor here. Producing aviation biofuels remains significantly more costly than refining crude oil. Depending on the production method, the extra costs stem either from the required feedstock or from the capital cost of building and running the facility. Current estimates suggest that the best possible production price comes from biomass feedstocks making HEFA fuels. The same reports indicate that prices are unlikely to go below $3 per gallon in the near term.[7]

Thanks to sustained efforts by Air Force Materiel Command (AFMC), the Air Force has certified all aircraft using JP-8 to fly on available biofuel blends except for the F-22 and F-35. The F119 and F135 engines in those aircraft have not been approved for ATJ blends by manufacturer Pratt and Whitney and would require an extensive testing effort lasting 12–24 months to be certified. At present, no funding is available to pursue ATJ certification for those engines from Air Force research and development channels. Not only would funds be required to obtain the fuel for testing but also the engine and flight tests must be built into AFMC's already busy testing and development curriculum. The Navy is currently testing ATJ in its aircraft and, as of May 2016, had not noted any serious setbacks.

Future State

Aviation biofuels face an uncertain future. In the United States, the tax incentives for using biofuels under the Environmental Protection Agency's Renewable Fuel Standard program are subject to change each federal budget cycle. Also at stake are the federal subsidies and loans given to renewable energy producers. Additionally, the availability of cheap oil—currently around $50 per barrel—reduces the incentive for commercial airlines to use biofuels beyond the level incentivized by tax relief. Internationally, agreements to reduce greenhouse gas emissions—such as the United Nations' 2015 Paris Agreement—have governments both incentivizing and directly sponsoring aviation biofuel programs.[8]

Aviation biofuel projects under way in the European and Pacific theaters represent an opportunity for the US Air Force to ensure unencumbered access to potential operating locations. In Norway, Oslo Airport has integrated a HEFA biofuel blend, produced by Air BP, into the airport's main fuel hydrant system.[9] In Japan, 46 companies and universities have teamed to create the Initiatives for Next Generation Aviation Fuels, an organization with the goal of mass-producing aviation biofuels in time to showcase them during the 2020 Tokyo Olympics.[10] In the South Pacific, Virgin Australian Airlines and Air New Zealand have teamed in an attempt to acquire 5 percent of their aviation fuel from local renewable sources by 2020.[11]

Implications

The *National Military Strategy of the United States of America 2015* lists "improving our global agility" as a means of effectively and efficiently executing integrated operations around the world. Doing so requires the US Air Force to rapidly position forces in areas of need to "seize opportunities, deter adversaries, and assure allies and partners" around the world.[12] Thus, our aircraft must be able to fly on whatever fuel is available.

In general, the Air Force is well positioned to do just that; most US Air Force aircraft have been authorized to use aviation biofuel blends as drop-in replacement fuels. As previously mentioned, the main holdouts are the F-22 and F-35, which have not been approved to use ATJ blends. However, with the F-35 expected to be the workhorse of combat airpower in the coming decades, the ability to operate at any suitable airfield around the world will become increasingly important. Likewise, the F-22 is now being regularly forward deployed to Europe, at times flying from allied-nation airfields rather than Air Force bases. The ability to operate from any suitable foreign commercial airports is a tactical advantage that should be maintained.

Finally, of a more immediate concern is the fact that the Air Force has converted from JP-8 to commercial Jet A at most continental US bases, having completed the changeover in 2014. As the commercial aviation fuel standards have continued to progress, adding more biofuel production pathways, the US Air Force has been unable to keep pace due to lack of funding for engine, fuel system, and flight testing. Currently, only a handshake agreement between the military services and commercial fuel producers and consumers is keeping aviation biofuel blends that are not approved for military engines from making their way to military bases. Without testing to ensure full operability with commercial fuel standards, the Air Force could soon face the uncomfortable reality of having to perform risk assessments—likely reducing flight performance envelopes on some aircraft—to accommodate unapproved aviation biofuel blends in commercial circulation.

Conclusion

The US Air Force must devote the appropriate resources to achieve and maintain certification for its aircraft to fly on all commercially available blends of sustainable aviation fuel. As sustainable aviation fuels proliferate across the globe, the US Air Force's ability to use these as drop-in replacements for military fuels will foster surety of supply and freedom of operation at airports worldwide. ✪

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Reconstructing a Shattered Egyptian Army: War Minister Gen. Mohamed Fawzi's Memoirs, 1967–1971 edited by Youssef H. Aboul-Enein. Naval Institute Press (http://www.nip.org), 291 Wood Road, Annapolis, Maryland 21402, 2014, 320 pages, $19.95 (hardcover), ISBN 978-1-61251-460-4.

In 1967 the Egyptian military was crushed during the Six-Day War, and Israel occupied the West Bank of the Suez Canal. It was left to Gen Mohamed Fawzi, the new Egyptian armed forces commander in chief and subsequently Egypt's war minister, to restructure the defeated military, both materially and intellectually, for the future effort to reoccupy the Sinai Desert. The story of this transformation from a shattered defensive military to a robust, offensively oriented force that pushed the Israeli Army to the maximum is presented in General Fawzi's memoirs, translated and edited by Cdr Youssef Aboul-Enein of the US Navy. Although the book was originally published in 1984, Aboul-Enein's work has made Fawzi's memoirs available in the English language. For this effort, Commander Aboul-Enein, a Middle East foreign area officer and instructor at the National Defense University, must be commended.

Fawzi's memoirs appear in three parts. The first part is a scathing critical analysis of the causes of the Egyptian defeat in 1967. In this reviewer's opinion, Fawzi's candid discussion is by far the most illuminating and valuable portion of the work. The first problem Fawzi notes is that the Egyptian Army's conventional war skills deteriorated while it fought a five-year counterinsurgency in Yemen. A similar problem confronted the US military after Vietnam and again may be an issue after American forces leave Iraq and Afghanistan. A second problem was a disconnect between policy goals of the Egyptian civilian leadership under President Gamal Abdel Nasser and military plans prepared under the leadership of Field Marshal Ali Amer. The relationship between Nasser and Amer undermined civilian control, distorted and created chaos in the Egyptian command structure, and eliminated independent analysis of the military situation prior the Six-Day War. Third, numerous operational and intelligence failures led to the almost total destruction of the Egyptian Air Force on the ground and the Army's lack of preparation in the Sinai. Finally, a dearth of organizational cohesion resulted in units failing to operate effectively and Israel's rout of the Egyptian Army.

Fawzi's desire to address these problems forms the basis of the second and third parts of the book: rebuilding the military to ensure operational effectiveness and organizational cohesion and developing a strategic approach to retake the Sinai. One of the more interesting portions of these discussions is Fawzi's efforts, in conjunction with both President Nasser and his successor Anwar Sadat, to realign the Egyptian political and military policy-making structure so that the one would always support the other.

As interesting and valuable as some portions of the book are, fundamental organizational problems permeate the entire work. The author originally published the individual chapters as a series of articles in *Infantry Magazine* during 2012 and 2013. Although he has added some new information to the book-length version, the chapters are for the most part presented as they appeared in serial form. The result is repetitious language that made sense when the chapters to some degree stood alone but should have been excised in the unified version. A second problem is a tendency for some chapters to be disjointed from the others and, at times, to lack contextualization. Again, that was not as much of an issue in the original serial publication as it is in the current work. Third, when the chapters were published in *Infantry Magazine*, each was separately introduced, but these introductions now add little to the substance of the text and in fact can be distracting. Finally, the footnotes are much too sparse. This reader had difficulty determining whether nonquoted factual material is derived from the original Fawzi memoirs or is the result of the editor's independent research. Certainly, Commander Aboul-Enein and the Naval Institute Press should be commended for bringing the ideas of an important Egyptian officer to the English-reading world, thereby giving insight into Middle Eastern military theory, but the final product needed a heavier editorial hand.

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Fallen Astronauts: Heroes Who Died Reaching for the Moon by Colin Burgess and Kate Doolan, with Bert Vis. University of Nebraska Press (http://www.nebraskapress.unl.edu/catalog/CategoryInfo.aspx?cid=152), 1111 Lincoln Mall, Lincoln, Nebraska 68588-0630, 2003, 272 pages, $40.00 (hardcover), ISBN 978-0-8032-1332-6; $25.00 (softcover), ISBN 978-0-8032-6212-6.

In the race for space, some individuals are associated with the first tentative steps into the vast reaches of the heavens. The National Aeronautics and Space Administration (NASA) has in its history men and women like John Glenn, Neil Armstrong, Charles Bolden, Mae Jamison, and Eileen Collins, who rode stacks of metal, tubes, liquid oxygen, and rocket fuel into the skies in the quest for exploration and knowledge of the unknown. We recall them with ease, secure in knowing that their achievements have increased our understanding of what was at one time inconceivable to most people. Another group, no less deserving of our respect, has paid the ultimate price in their efforts to go where no one has gone before.

Fallen Astronauts: Heroes Who Died Reaching for the Moon chronicles the story of people who were lost as they sought to fulfill their dreams of becoming part of the initial cadre of space travelers. These men (and they were mostly men at the time) perished in training, routine proficiency evolutions, or simply unfortunate traffic accidents. Their stories are not well known outside the small circle of astronauts, cosmonauts, and test personnel who worked, drank, and watched the skies with them. Authors Colin Burgess, Kate Doolan, and Bert Vis conducted extensive research into the unique and distinguished history of these men and were significantly aided by recollections of the families who have kept the memories of their sons, fathers, husbands, brothers, uncles, and cousins alive these many years. Retired astronaut Eugene Cernan, himself a distinguished member of that stellar group, adds in his foreword that he was amazed at the information the authors found with regard to his former compatriots—information that even he as a contemporary did not know.

The first chapter covers the story of Capt Theodore Cordy Freeman, USAF—graduate of the US Naval Academy's class of 1953 and a member of the third group of NASA astronauts in 1963. Finishing near the top of every training program, he was well regarded by colleagues, coworkers, family, and friends alike. His stature within the astronaut program led some to believe that he would plant the first footprints on the moon, an honor that we now bestow upon Neil Armstrong. Captain Freeman's career was on the fast track to allow him to reach goals he set for himself as a young boy in Lewes, Delaware. Sadly, his life was cut short when his T-38 training aircraft suffered a bird strike and twin-engine flameout on approach to Ellington Field in Houston. Unable to perform a dead-stick landing, he attempted to eject, but his aircraft was too low to the ground. Killed upon impact, Captain Freeman was the first US astronaut fatality. His wife, Faith, experienced his loss in a very public way because the astronauts were part of a high-profile publicity campaign to instill confidence about the space program in the American public and to show that we were actively competing against the Soviet Union in the space race.

Written in an easy-to-read style, the book fills in the empty places in the history of the space program that were occupied by these brave individuals. Personal memories by family members humanize their names, yielding a more robust portrait of each man. The following chapters continue to describe these early, would-be pioneers in detail, giving readers insight that would be lost to history, save for the recollections shared between family and friends. Each chapter begins with a recounting of events that led to the mishap—witness, for example, the fate of Maj Edward Galen Givens Jr. (chap. 5), in training to become a command module pilot for the Apollo program. He died after skidding off the road and crashing into an irrigation ditch just outside Houston. After setting the stage for the incident, each chapter then switches to a short account of its subject's life, detailing his birth, schooling, portions of his military career, selection for astronaut training, and the whirlwind events that quickly enveloped him. The chapters culminate with completion of the description of the accident and immediate aftermath as family and friends struggle to cope with the subsequent publicity. The authors devote significant space to the story of the wives and family who continue to experience the good and difficult memories of their moments in the spotlight and examine how those times continued to affect their lives.

A welcome inclusion is chapter 4, which details the lives of several Soviet cosmonauts, the most recognizable of whom is Yuri Gagarin. As the first human to fly in space, he was arguably the most famous individual in the entire book, and his death had a profound effect on the Soviet space program. A Hero of the Soviet Union, he was feted in many lands and throughout the world at large. Although the descriptions of the cosmonauts and their lives are at times slightly less detailed than those of the astronauts—probably due to the difficulty of penetrating the secrecy surrounding the Soviet Union's space program—they remain a vital element of the overall narrative. These accounts help the reader understand that beneath their space suits, these men—separated by geography and their countries' political philosophies during a time of strained relations between the world's superpowers—were essentially the same.

The select few people who have been granted the opportunity to journey into space are part of a rare group, but in some ways the passage of time has separated and dehumanized them—a disservice to us all. The authors seek to reverse that trend by filling in a noticeable gap in our knowledge concerning the early years of the space program. Their efforts at chronicling the inevitable cost of our quest to explore the heavens serve as a bittersweet reminder that these stellar individuals were people just like the rest of us, thus strengthening the very foundation from which we launch and continue to reach for the stars.

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Lavi: The United States, Israel, and a Controversial Fighter Jet by John W. Golan. Potomac Books (https://www.nebraskapress.unl.edu/pages/PotomacBooks.aspx), 1111 Lincoln Mall, Lincoln, Nebraska 68588-0630, 2016, 450 pages, $39.95 (hardcover), ISBN 978-1-61234-722-6.

Lavi: The United States, Israel, and a Controversial Fighter Jet, John W. Golan's engaging history of Israeli fighter aircraft design and acquisition, sheds new light on the strategic relationship between Israel and the United States while simultaneously underscoring the importance of airpower to the continued existence of the State of Israel. The author employs his aerospace engineering background to analyze technical aspects of the failed attempt to design and manufacture an Israeli close air support fighter aircraft called the Lavi. Meticulous research paints the backstory of the Lavi program as the history includes such topics as the aerial battles over the Sinai Peninsula during the Yom Kippur War in 1973 and the political intrigues within President Ronald Reagan's National Security Council.

Golan's main argument uncovers how individual personalities in the Israeli and US governments, complemented by repeated financial crises, ultimately doomed the cutting-edge Lavi program. The author supports this position with meticulous research and analysis, equally balancing Israeli and American perspectives. While the Lavi program never accomplished the desired output of close air support fighters, Golan successfully highlights the importance of modern Israeli aviation in galvanizing the strategic relationship between Israel and the United States. With an easily readable writing style and a thorough level of detail, the book presents an overarching history of Israeli aviation alongside an aerodynamic primer on fighter aircraft design and acquisition.

Although he effectively presents a holistic and an engaging history of the Lavi program, the author relies heavily on his technical background to offer a considerable amount of quantitative data. Additionally, appendices with aerodynamic specifications and cost breakdowns comprise nearly half of the 450 pages. This quantitative approach enables the reader to explore the data in-depth to understand concepts such as how the Lavi compares to the F-16 as well as the specific dollar amounts and capacity within Israel's acquisition programs. Ultimately, this technical approach effectively delivers a thorough understanding of Israeli and US interests while lamenting the failed Lavi program.

Lavi: The United States, Israel, and a Controversial Fighter Jet is an excellent read for Airmen. The themes of airpower dominance, technological innovation, and aviation acquisition provide critical lessons learned from the Lavi that readily translate to contemporary issues facing the United States Air Force. These lessons include the importance of rapid technological integration as well as the necessary unity of effort during the forging of a new aircraft. The Lavi never fully materialized, but this engaging account of modern airpower captures an essential chapter of US and Israeli air force history.

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The Global Village Myth: Distance, War, and the Limits of Power by Patrick Porter. Georgetown University Press (http://www.press.georgetown.edu), 3240 Prospect Street, NW, Suite 250, Washington, DC 20007, 2015, 240 pages, $49.95 (hardcover), ISBN 9781626161931; $29.95 (softcover), ISBN 9781626161924.

Many are the works, serious and not so, that attempt to explain why the United States rejected two centuries of near isolationism and continental defense and became the world's policeman after World War II. Generally, these works find the consequences dire, and *The Global Village Myth*, written by Patrick Porter, professor of military history at the University of Exeter, United Kingdom, is no exception.

The global village myth is that technology (military technology in particular) has changed the once vast planet wherein Geoffrey Blainey could decry the remoteness of Australia as the *Tyranny of Distance* (Macmillan, 1975) and replaced it with a world so small that there is no longer any possibility of isolation or any safe distance—not even an ocean apart. Logic says that the best way to counter the inescapable threat is to confront it from as far away as possible.

From at least World War II, mainstream thought has been that the globe is shrinking due to the inexorable march of technology. As the maps showed a shrinking globe, those who argued for containment and a smaller footprint in the world—George Kennan, Hans Morgenthau, and other strategy intellectuals of the fifties—lost the argument in an environment dominated by Joseph McCarthy, a Red scare, dominoes, and an overall feeling that safe space no longer existed, not since weapons acquired world reach. The climate of fear produced globalism, a strategic concept that demands massive and aggressive defense because short distances take so little time to cross. According to the author, it's not true.

If anything, Porter asserts that closeness makes for greater security, but before explaining how that is possible, he offers a lengthy introduction explaining what the myth is and how it arose. The author is not the first to note the importance of switching from the Mercator projection to the polar-view map during the war. Matthew Farish's *The Contours of America's Cold War* (University of Minnesota, 2010) did that some years ago. Although Porter does not reference Farish, he agrees about the significance of misreading the map, especially by the military, based on the wartime misconception of the fearsome menace of airpower and its ability to shrink distances, transforming the Atlantic and Pacific into wadeable streams.

Even after postwar studies indicated the ineffectiveness of large-scale bombing, already nervous strategists had nightmares of massive waves of unstoppable bombers wreaking havoc and bringing previously invulnerable nations (read America) to their knees. The current buzzword is *globalism*, a subset of the broader globalization that deals with trade, communications, and the like. Globalism deals with military strategy, the behavior of defense forces in a tighter battlefield with less room for false steps.

Potentially, globalism is dangerously wrong because it leads to ill-advised behaviors associated with imperial overreach as warned against by Paul Kennedy's *The Rise and Fall of the Great Powers* (Random House, 1987) back in the Cold War. Even the wealthiest and richest power in the world has finite capacity and eventually will overextend and enter a period of decline. In the meantime, as others note, imperial hubris will put the emperor's nose into other people's business and generate Chalmers Johnson's *Blowback* (Metropolitan Books, 2000), a retaliatory sneak attack for desecrating a holy land, for example. From there, events can spiral downhill—one little preventive war, one presidential usurpation of congressional prerogative after another—until the United States is fighting trigger-happy in accordance with Dick Cheney's One Percent Doctrine. If there's even a 1 percent chance—and there is always at least a 1 percent chance—then shoot first and ask questions later. Such doctrine is dangerous, destructive, and a distraction from the real world and its problems.

Furthermore, it is all unnecessary because the globalists misconstrue distance. By looking at the small stream where once was a mighty ocean, they fail to see that the stream is an alligator-infested moat supported by barbed wire, land mines, nuclear drones, and suicidal robot soldiers. They confuse geographic distance with strategic distance. Those who attempted to cross no-man's-land during World War I could have pointed out the difference, as could those who rode to certain death with Pickett and an endless assortment of foolhardy leaders over time.

One moat worthy of mention because the author uses it as a major component of his argument is the Formosa Strait, the narrow body of water between Taiwan and China. The strait is a globalist nightmare because it is nowhere near the distance that Taiwan would require for safety. At the snap of a finger, should China be so inclined, the Chinese flotilla of landing craft could cross it under air cover and land ground troops with virtual impunity. The globalists, however, fear wrongly. China has not attempted such an action, thus raising the question why? The author's answer is that the geographic distance is insignificant but that the strategic distance, the relevant measure, is vast. Taiwan has that alligator-filled moat and a sophisticated defense sufficient to make China think that perhaps the price of conquest might be too great. A small globe is not necessarily a more dangerous one, particularly when smallness allows concentration of defenses. Just ask the Luftwaffe about the Battle of Britain.

Another argument is that the globe isn't that small anyway, not for logisticians. The example—the long and deliberate move of an army to the Middle East to liberate Kuwait—illustrates the constraints of moving modern American armies, amenities and all, with a limited air cargo capability and a fleet restricted technologically to about 25 knots per hour. Geography in the old sense still matters. For materiel, the Atlantic is as vast now as it was for Britain in the American Revolution.

So globalists can relax. The old barriers still work, and new ones add to the difficulty of the offense. Rather than pre-positioning materiel and troops throughout the world just in case some small brushfire might flare up, a wiser use of resources is withdrawal from all of the bases that unnecessarily expose the face of the force to a terrorist-administered black eye that provokes overreaction.

Oddly enough, after his sustained argument against globalism, the author does note almost in passing that globalism is a theory that has largely passed its prime. If it is so discredited, then why does he spend so much time debunking it? And why doesn't he bother to explain why he thinks globalism is passé? Is globalism too tightly tied to neoconservatism? Have globalist ventures proved too expensive and painful, as in Iraq and Afghanistan? Possibly, but he doesn't say.

Another shortcoming is that the work is academic, not real world. In theory the world is safe enough for containment to be a viable option, particularly since no major foe threatens the continent. Nevertheless, lurking in the background is always the question of any untested theory. What if it's wrong?

The bookshelf of works seeking to explain how the United States has gone astray and become a military-driven wastrel is massive, but mostly the literature deals with the economic, political, social, and other damage that being the world's policeman has caused. The major strength of this work is that it is one of the best to explain how it happened and why it is so unnecessary. Realistically, Porter will join the others in the wilderness where their cries will remain unheard as Andrew Bacevich's *The New American Militarism* (Oxford, 2005) remains the American way.

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Forgotten Fifteenth: The Daring Airmen Who Crippled Hitler's War Machine by Barrett Tillman. Regnery History (http://www.RegneryHistory.com), 300 New Jersey Avenue NW, Washington, DC 20001, 2014, 338 pages, $29.99 (hardcover), ISBN 978-1-62157-208-4; $18.99 (softcover), ISBN 978-1-62157-404-0.

The history of the Fifteenth Air Force (AF) has always been overshadowed by that of the Eighth AF, and while a flood of books on the "Mighty Eighth's" experience is available, this is not the case for the Fifteenth. Since the nineties, a significant number of studies have examined this numbered air force's subordinate units at the group—and sometimes even the squadron—level. However, on a larger scale, very little has been published about the Fifteenth from a broader, strategic perspective.

To fill this gap, Barrett Tillman has written *Forgotten Fifteenth: The Daring Airmen Who Crippled Hitler's War Machine*. This well-known and respected author is a master storyteller who offers an authoritative and thoroughly researched survey of the role of the Fifteenth in World War II.

The book follows the unit's history from its formation in November 1943 until the end of the war in Europe in May 1945, presenting the main goals, challenges, and difficulties that it faced. *Forgotten Fifteenth* is written in an entertaining narrative style, not as a repetitive day-by-day chronology. It is an easily readable book with many first-person accounts.

One strength of the study is that the author highlights the value of both the engineers who built the airfields and the ground crewmen who maintained their aircraft at a high level, despite the frequently rudimentary conditions at many of the air bases. He also gives credit to lesser known formations such as photo and weather reconnaissance units.

Tillman avoids perpetuating unnecessary myths and points out some significant, albeit lesser known, facts related to the Fifteenth. It is worth mentioning, in general, that weather caused many unexpected problems in "sunny Italy" and seriously hampered the unit's activity. Many people know the importance of the oil-related targets. However, Fifteenth AF's most difficult and costly target was not the extremely heavily defended complex at Ploesti, Romania, but the industrial area around Vienna. A number of individuals appear in the book as well, from important commanders to aircrew members notable for their extraordinary achievements or exploits.

The author also mentions the opposing side. In this case, not only the Third Reich and its Luftwaffe but also some smaller Axis nations battled the American flyers. Of these opponents, Tillman fails to mention the Croatian fighters, who also engaged the Fifteenth several times (with limited results but significant losses).

It would have been useful had the *Forgotten Fifteenth* drawn on more native-language sources from the smaller Axis nations since, in most cases, only limited information about them is available in English. By utilizing these references, the book could have avoided errors such as the following:

- American flyers were never reported as "Italians" by their Hungarian opponents (p. 189). (Since the source was not mentioned, I have no idea where the author found this erroneous information.)
- Hungarian fighters were not withdrawn after 22 August 1944 because of their accumulated losses (p. 143) but because of the next day's events when Romania joined the Allies. Consequently, the strategic situation dramatically changed in that sector.
- In one case, both the cited source and the author confuse the Hungarian and Romanian capitals, referring to Bucharest instead of Budapest as Hungary's capital (p. 62). In another case, one finds a reference to "Herausschutz" (p. 45), presumably meaning "Herausschuss." (The latter term was used for a fighter claim if the attacker successfully separated a heavy bomber from the other aircraft, literally shooting it out of its formation.) In German, "Schuss" means "shot"; "Schutz" means "protection."

Overall, *Forgotten Fifteenth: The Daring Airmen Who Crippled Hitler's War Machine* is a valuable addition to our understanding of the air war over Europe in World War II, effectively covering the history and importance of Fifteenth Air Force. I highly recommend it.

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Historical Studies in the Societal Impact of Spaceflight edited by Steven J. Dick. National Aeronautics and Space Administration History Program Office (http://www.history.nasa.gov), 300 E Street SW, Washington, DC 20546, 2015, 664 pages, $35.00 (hardcover), ISBN 978-1-62683-026-4. Available as a free download from http://www.nasa.gov/sites/default/files/atoms/files/historical-studies-societal-impact-spaceflight-ebook_tagged.pdf.

The prospect and inherent awe of spaceflight have captivated society since the beginning of the twentieth century. Authors like H. G. Wells, writing of concepts before their time, exposed the common man to the possibility of space travel—well before Sputnik was even conceived. Sixty-three years after publication of *The War of the Worlds*, cosmonaut Yuri Gagarin became the first human being to enter outer space. From there, the spaceflight capability of various world powers' space programs has brought controversy and innovation, frustration and wonder. In *Historical Studies in the Societal Impact of Spaceflight*, historian and editor Dr. Steven J. Dick compiles the third volume in a NASA history series on the impact that spaceflight has had on the global population, both past and present. This volume is divided into three major parts: "Opinion," "Spinoff?," and "The World at Large."

In "Opinion," Dr. Dick presents a study by William Sims Bainbridge entitled "The Impact of Space Exploration on Public Opinions, Attitudes, and Beliefs" in which he asserts that public opinion can be, for the most part, quantified based on how the public understands the concept of space exploration. Bainbridge argues for the necessity of polling and gauging public opinion to determine the direction politicians must tread in developing space programs. He devotes a large portion of this study to the reliability—and flaws—in public opinion, presenting legitimate mathematical insights into the benefit of polling. Conversely, Bainbridge wisely concedes that "polls are not referendums, however much journalists and some politicians might want them to be" (p. 73). In acknowledging both the pros and cons of measuring public attitudes in regard to spaceflight, he develops a concrete argument concerning the necessity of the poll, finally determining that "the American public is willing to continue the voyage of discovery and achievement into outer space" (p. 74).

Part 2, "Spinoff?," includes three case studies that question the claims NASA often makes regarding technological "spinoffs" from its own scientific studies. The title of part 2 is posed in such a manner to reflect NASA's annual spinoff reports. It seeks to examine fully whether or not advancements can definitively be attributed to the original work of NASA scientists—or whether that organization is making a leap in assertion by claiming these spinoffs, which include NASA's effect on medical technology, integrated circuits, and microelectromechanical systems (MEMS). Part 2 delves into explaining what constitutes a spinoff, stating that it is "a kind of horizontal diffusion, in which an intact innovation moves from one application to another" (pp. 79–80). Once again, Bainbridge offers his expertise in examining the legitimacy of NASA's unintended, albeit beneficial, contributions to medicine. He considers, for example, bone density analysis, antishock garments, and pacemakers in determining his overall thesis: while actual spinoff status is debatable for some medical advancements, the overarching public curiosity derived from such claims far outweighs the semantics of what constitutes a spinoff. This study provides excellent insight into medical advancement resulting from NASA's work, but it would have been more beneficial had Bainbridge separated it into two different works: an explanation of spinoff criteria and a focused examination of NASA's medical spinoffs.

The next chapter in part 2 addresses the realm of integrated circuits—those "tiny electronic devices . . . that contain at least two electronic components . . . and the connections required to form a circuit" (p. 155). Author Andrew J. Butrica addresses NASA's role in these circuits' procurement and overall manufacture during the Apollo years. Though not blatantly stated, his work implies that NASA's use of integrated circuits, although still in their infancy, created a gateway for their mass production and procurement. Even though NASA was not the first entity to send integrated circuitry into outer space (that distinction belongs to the Goddard Interplanetary Monitoring Platform), Butrica's study suggests that NASA's work paved the way for using circuits in future space program endeavors, with the impact outside NASA open to debate. The author's follow-on study in chapter 4 on MEMS has a structure and conclusions similar to his work on integrated circuits. Butrica thoroughly examines NASA's role in MEMS development, determining that "NASA's investment was still insufficient to realize the full potential of the research" (p. 324). A decent comprehension of

MEMS and integrated circuits past and present is highly encouraged in order to fully grasp the concepts in Butrica's work.

Part 3 uses broad strokes to quantify what NASA has meant to the global "greater good," examining, for example, its impact on the advancement of nuclear power, humanity's effect on the environment, and satellite applications. Although this part of the book is worthwhile as a whole, for today's Air Force, Jim Pass's "An Astrosociological Perspective on the Societal Impact of Spaceflight" is its most relevant chapter (9). Pass concentrates more on how societies develop space travel policy and the inherent societal reactions—information that is valuable for present-day Air Force operations as we continue to expand our capabilities to include outer space. Civilian space travel is a possibility in the future—thanks to people like Sir Richard Branson—but arguably the US Air Force, working in concert with NASA, will take the greatest strides toward making space more accessible to humanity.

As a whole, *Historical Studies in the Societal Impact of Spaceflight* is well developed and thoughtfully presented. Steven Dick's editorial work is impeccable, ensuring that each study in this volume reflects the overall intent: to explain how spaceflight affects us all, even in ways we may not realize. The chapters offer a thorough background and develop the thesis in a manner that supports the anthology's overall purpose: providing a history of spaceflight. This book is recommended both for readers who desire graduate-level understanding of the effects of spaceflight and for Air Force personnel who wish to acquire a baseline of understanding for future air-space endeavors.

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Counter Jihad: America's Military Experience in Afghanistan, Iraq, and Syria by Brian Glyn Williams. University of Pennsylvania Press (http://www.upenn.edu/pennpress/), 3905 Spruce Street, Philadelphia, Pennsylvania 19104-4112, 2016, 400 pages, $39.95 (hardcover), ISBN 978-0-8122-4867-8.

Two images have been circulating together around the Internet in recent months. The first picture is of a young boy waving an American flag; the second, a young Soldier holding the same flag. Above the child are the words "We were just kids on 9/11." Those below the Solider read "We're not kids anymore." As time goes on, more and more military personnel are too young to remember or were too young at the time to understand this critical event. A 2014 demographic study of the military determined that almost 50 percent of enlisted members and 13 percent of officers were younger than 12 on 11 September 2001 (p. iv). This generation is in dire need of an honest history of the wars since 9/11 and of a detailed analysis of today's terror threats. Not only could they use this for their personal edification but also they deserve to know whom they are fighting and killing—and why. Prof. Brian Glyn Williams's *Counter Jihad* provides just the account they have been lacking.

A professor of Islamic history at the University of Massachusetts–Dartmouth, Williams offers a detailed view of a complex chronicle to which many millennials (and even some late Generation X individuals) may have never been exposed. In his words, "This history of counterterrorism and warfare in distant lands and tragedy in the United States is not intended for experts alone. It is meant to be a guide for all those who want to learn from the mistakes and successes of the wars in the Middle East and Central Asia and apply them to the future and present" (p. xii). Although Williams's target audience includes the undergraduate students he instructs daily, another group requires such an education: young military professionals. No other assemblage has a greater need for an account of the conditions and decisions that brought about these wars than today's junior combatants. These are the people who have been called upon to win this war and who may bear the burden of taking enemy lives in order to protect coalition and civilian lives. It is important that the average citizen understand these events, but it is paramount for our military members, especially those who are now coming of age to fight and lead. *Counter Jihad* will provide them a better understanding of the war their superiors have spent their careers fighting, thereby equipping our millennial warriors with comprehension of how the current state of affairs in Afghanistan, Iraq, and Syria came to be.

Williams's analysis includes a plethora of quotations from many senior government officials, highlighting what older Americans were hearing from their political and military leaders as they tried to transform their lives into a new normal after 9/11. The author also supplies information about misunderstandings in the American government and intelligence community; for example, Secretary of State Colin Powell once claimed that Saddam Hussein was working to build nuclear weapons, but none were ever found (p. 103). Although Williams presents the content with all of the rigor and discipline one would expect from an expert in this field, *Counter Jihad* explains this history in a way that is both interesting and understandable to someone with minimal knowledge about the Middle East. The result is an excellent resource for the junior Airman, Marine, Sailor, or Soldier desiring to learn more about the complex world in which he or she fights. From explanations of mid-twentieth-century conflicts around Israel to an analysis of the Islamic State of Iraq and Syria's (ISIS) strength in early 2016, this book offers the reader a thorough and balanced summary that is neither strictly pro-American nor pro–Middle East but pro-truth.

All armed forces members, active duty or otherwise, should have the kind of education about the Middle East and the United States' recent involvement that this study provides. Additionally, it gives the reader insights into ISIS, one of the foremost national security threats of our time. Williams writes that "until the Shiite-dominated governments in Baghdad and Damascus overcome years of mistrust and warfare and win the trust of the Sunnis in both Iraq and Syria, ISIS will be able to exploit a deep pool of support in both countries. This will make it incredibly difficult to defeat without U.S. troops on the ground" (p. 317). This fight against ISIS will not conclude in the foreseeable future, and its success will fall on the shoulders of those too young to remember the day that this struggle against terror began. It is critical that military leaders of tomorrow attempt to understand both the enemy of today and the lessons of yesterday. That journey of comprehension can begin in *Counter Jihad*, making this text a worthwhile—even necessary—addition to any professional warrior's bookshelf.

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Victor Alert: 15 Minutes to Armageddon; The Memoir of a Nuke Wild Weasel Pilot by Maj Gen Lee Downer, USAF, Retired. CreateSpace Independent Publishing Platform (https://www.createspace.com), 4900 Lacross Road, North Charleston, South Carolina 29406, 2016, 159 pages, $9.95 (softcover), ISBN 978-1-53346-339-5.

If you know what to look for, you can still see the bleached and rusting bones of Victor Alert areas scattered across Europe. The double fences and 40-foot towers are long gone, but somewhere within a quick taxi to the runways remain handfuls of hardened aircraft shelters on Christmas tree ramps and low-slung buildings with the distinctive NATO-hardened look. Walking around on a quiet day, perhaps you close your eyes and imagine you hear the sounds and voices and wonder what it was like to work here, day in and day out, waiting for the call to go to war and inflict nuclear violence against the Warsaw Pact. *Victor Alert: 15 Minutes to Armageddon* answers that question.

Maj Gen Lee Downer's personal memoir relates his experiences as a nuclear-certified pilot sitting Victor Alert during the Cold War. The primary arc of the story, written in a first-person conversational style, describes a singularly eventful night spent on alert with the surprise of an early morning scramble and subsequent hours of tension waiting in the cockpit for a launch order. As indicated by the title of the book, that order would have had the crew dropping a nuclear weapon within 15 minutes. Throughout this narrative, the author uses flashbacks to reflect on the training and preparation needed to pull nuclear alert, the activities and culture of the times, and the impact of the lifestyle on the aircrew's families.

That story of waiting is one of the book's best features; even knowing the ultimate outcome—that nuclear war never happened—the reader remains engaged, thanks to the narrative device. That engagement, coupled with the easy conversational style and length of only 159 pages, makes for a two-to-three-hour read. Unlike struggling through a dry academic work, reading *Victor Alert* is more like swapping war stories over drinks in a smoke-filled legion hall. This style makes the book suitable for anyone trying to capture the flavor of the era, but researchers trying to harvest technical details may be disappointed.

As a pilot with 4,000 hours and 14 of his 33 years in the Air Force served in Europe, Downer has firsthand knowledge of both the details and culture of the times that allows him to tell those stories. This perspective as a pilot, however, drives an aircrew-centric description of what, in fairness, was an aircrew-centric activity. Although several times he does acknowledge the contributions of the thousands of men and women at each base that made the mission possible, the author does not provide much detail on their perspectives. Interactions with maintenance and security personnel are described only from the surface level of a pilot's viewpoint even though they are equally essential to the weapons system.

A short vignette at the end about the perennial peace camp at Royal Air Force Upper Heyford seems disconnected at first. Upon reflection, however, one concludes that the empty stub of a road, now scoured of any evidence of the hundreds of protesters who cycled through over the years, is symbolic of the end of the era. As the author notes, there was no party, no celebration when Victor Alert stood down—just a few sighs of relief. While not exactly missed, its absence may have left a void among those like Downer who devoted their passion, dedicated their careers, and made family sacrifices.

At the end of the book, the author offers a few reflections and editorial comments about the current state of the nuclear enterprise, but he does not establish a clear thesis at the beginning and return to it with support as the narrative progresses. The stories are more of a pure ethnography, describing the nuclear-alert way of life. The book, however, does have an overriding theme: Victor Alert was all-consuming. Academic preparation was intense, mistakes were not tolerated, and the alert cycle was the pulse of the wing, setting the tempo for other activity. Perhaps, as Major General Downer briefly alludes, lapses in nuclear surety over the last two decades can be attributed in part to the loss of broad experience with nuclear weapons, learned as a lieutenant or captain sitting Victor Alert.

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