



## CONTESTING THE AIR LITTORAL

*KELLY A. GRIECO*  
*MAXIMILIAN K. BREMER*

The diffusion of small uncrewed aerial systems, mobile air defense systems, and one-way attack drones is rapidly changing the character of war, with US adversaries gaining new ways to contest the air domain. The traditional notion that air superiority is won or lost in the “blue skies”—the medium and higher altitudes where fighters and bombers typically operate—is outmoded. Even if an air force manages to gain blue-skies air superiority, the airspace below these altitudes—called the air littoral—remains contested. Absent a significant revision in US Air Force thinking and operations, the service risks ceding control of the air littoral to the adversary as well as other services. Instead, the US Air Force should drive a reinvention of airpower concepts, including that of air superiority, as well as the close air mission, to fulfill its purpose and role as experts of the air domain.

**A**s the character of war rapidly evolves, driven by new technologies from artificial intelligence and additive manufacturing to small uncrewed aerial systems and one-way attack drones, the Air Force must change with it. Chief of Staff of the Air Force General David W. Allvin has said that nothing less than a “reinvention of our Air Force and airpower into the future” is required, including rethinking the concept of air superiority itself.<sup>1</sup> “Our traditional conception of what things like air superiority mean has changed,” Vice Chief of Staff General James C. Slife confirmed, observing that “quadcopters with a hand grenade can kill an American just as easily as a MiG or Su[khoi] can.”<sup>2</sup>

---

*Dr. Kelly A. Grieco is a senior fellow for the Reimagining US Grand Strategy Program at the Stimson Center and an adjunct professor of security studies at Georgetown University.*

*Colonel Maximilian K. Bremer, USAF, serves as senior adviser, Mobility Crosscutting Operational Enabler, and chief, Special Programs Division, at Air Mobility Command. He holds a master of airpower art and science from the School of Advanced Air and Space Studies, and a master in public policy, international security, from the Harvard Kennedy School.*

---

---

1. Chris Gordon, “Allvin: Drones, New Technology Driving ‘Reinvention’ of Airpower and USAF,” *Air & Space Forces Magazine*, February 13, 2024, <https://www.airandspaceforces.com/>.

2. James C. Slife, “The Future of Warfare: Preparing the US Military Forces for Competition and Contestation” (panel discussion, Global Security Forum 2024: Gathering Strength in a Gathering Storm, Center for Strategic & International Studies, Washington, DC, April 24, 2024), transcript available at <https://csis-website-prod.s3.amazonaws.com/>.

Three years ago, the authors warned about the need for new thinking in the pages of *Parameters*, writing at the time, “The airspace between ground forces and high-end fighters and bombers is quickly emerging as the more challenging and important contest for air control.” The article further noted that “addressing this threat demands more than technological solutions; it requires a paradigm change in American military thinking about verticality.” The authors termed this airspace the *air littoral*, defining it as “the area from the Coordinating Altitude to the Earth’s surface, which must be controlled to support land and maritime operations and can be supported and defended from the air and/or surface,” and proposing a volumetric concept of air control, localized in time, planar distance, and altitude.<sup>3</sup>

The war in Ukraine—where mobile ground-based air defenses and small drones of various types, from commercial quadcopters and first-person view racing drones to military-grade systems, crowded the skies—has offered grim confirmation of the critical importance of this airspace.<sup>4</sup> As defense analysts and practitioners have struggled to make sense of these developments, the term *air littoral* has entered the airpower lexicon.<sup>5</sup>

Building on this earlier work, this article argues a new way of thinking about the air domain is broadly relevant to future fights, especially the defense of the status quo in a Taiwan contingency. Absent a significant revision in thinking and operations, the US Air Force risks ceding control of the *air littoral* to the adversary as well as other services. The US Air Force has long extolled the virtues of offense. The belief that the “best defense is a good offense” is so powerful and so pervasive that some even say the service suffers from a “cult of the offensive.”<sup>6</sup> But there is a notable exception: current thinking about the *air littoral*.

To the extent the Air Force is at all concerned with the *air littoral*, it has focused more narrowly on tactical defense—that is, countering the threat from small drones. That is unfortunate, because as much as air warfare favors tactical defense over offense in the blue skies, the reverse is true in the *air littoral*—where tactical offense has the advantage while strengthening the operational defense, also known as *air denial*. By failing to address the implications of these changes, the Air Force is missing an opportunity to strengthen both deterrence and warfighting capability against great power challengers such as China and Russia.

---

3. Maximilian K. Bremer and Kelly A. Grieco, “The Air Littoral: Another Look,” *Parameters* 51, no. 4 (Winter 2021–22): 68, <https://press.armywarcollege.edu/>.

4. Maximilian K. Bremer and Kelly A. Grieco, “In Denial about Denial: Why Ukraine’s Air Success Should Worry the West,” *War on the Rocks*, June 15, 2022, <https://warontherocks.com/>.

5. See, for example, David Barno and Nora Bensahel, “Drones, the Air Littoral, and the Looming Irrelevance of the US Air Force,” *War on the Rocks*, March 7, 2024, <https://warontherocks.com/>; and Zachary Kallenborn, “Information Warfare in the Air Littoral: Talking with the World,” *Airpower after Ukraine*, Atlantic Council, August 30, 2022, <https://www.atlanticcouncil.org/>.

6. John R. Carter Jr., “Airpower and the Cult of the Offensive” (master’s thesis, School of Advanced Air and Space Studies, Maxwell AFB, AL, April 1998), 5, <https://apps.dtic.mil/>.

## A Blue Skies Tradition

The US Air Force has a proud tradition of air superiority, if not air supremacy, in most of its past military conflicts. Joint Publication (JP) 3-01, *Countering Air and Missile Threats*, defines air superiority as “that degree of control of the air by one force that permits the conduct of its operations at a given time and place without *prohibitive* interference from air and missile threats.”<sup>7</sup> The highest level of control is air supremacy, wherein the enemy is “incapable of *effective* interference within the operational area using air and missile threats” (emphasis added).<sup>8</sup>

For much of the last century, control of the air was seemingly won or lost in the blue skies—that is, the medium- and higher-altitude airspace where high-end fighters and bombers typically operate—whether that battle was fought between attacking formations and defending fighters or between attacking aircraft and surface-to-air missiles (SAM).

The contest for air superiority over Western Europe between 1942 and 1944, for example, saw Luftwaffe fighters fly high-altitude interception operations over the North Sea and northern Germany against the US Army Air Forces’ Eighth Air Force.<sup>9</sup> A similar story repeated itself in the skies over North Vietnam almost three decades later, but this time the decisive contest was waged between US warplanes and North Vietnamese ground-based air defenses. For the first time, the United States confronted a fully integrated air defense system of Soviet-built SA-2 Guideline SAMs and anti-aircraft guns linked to fire-control radars. The SAM added a new and lethal menace to aerial warfare.<sup>10</sup>

This blue-skies air superiority contest has grown ever more challenging, however, particularly with the introduction of phased-array radars and mobile long-range SAMs in the late 1970s.<sup>11</sup> The Air Force invested heavily in stealth and precision munitions to try to regain an advantage in the blue skies.<sup>12</sup> Yet in the years since, China has developed more advanced radar systems, including VHF- and UHF-band radars, and now possesses one of the largest advanced long-range SAM arsenals in the world, with sufficient reach to deny US aircraft the benefit of a high-altitude sanctuary.<sup>13</sup>

---

7. *Countering Air and Missile Threats*, Joint Publication (JP) 3-01 (Washington, DC: Chairman of the Joint Chiefs of Staff [CJCS], 2024), I-5.

8. JP 3-01, I-5.

9. Donald Caldwell and Richard Muller, *The Luftwaffe over Germany: Defense of the Reich* (Barnsley, UK: Pen & Sword Books Ltd., 2014).

10. David Hampton, *The Hunter Killers: The Extraordinary Story of the First Wild Weasels, The Band of Mavericks who Flew the Most Dangerous Missions of the Vietnam War* (New York: Harper Collins, 2015).

11. Marshall L. Michel III, *The Eleven Days of Christmas: America’s Last Vietnam Battle* (New York: Encounter Books, 2002), 239.

12. Benjamin S. Lambeth, *The Transformation of American Air Power* (Ithaca, NY: Cornell University Press, 2000).

13. *Military and Security Developments involving the People’s Republic of China 2023* (Washington, DC: Department of Defense, 2023), <https://media.defense.gov/>.

Airpower traditionalists, however, see a future that looks like the past. They prioritize countering these high-end threats on the assumption that US air control turns mainly, if not exclusively, on the contest in the blue skies. To them, the answer is simple: sustained and expensive investments in next-generation aircraft technology will be enough to recapture America's airpower advantage. "Advances in autonomy and other uncrewed systems technologies have created a unique opportunity to combine the lethality of 5th and 6th generation fighters with CCA [collaborative combat aircraft] that are designed to disrupt and defeat China's counterair operations," argues a report from the Mitchell Institute for Aerospace Studies.<sup>14</sup> Simply put, changing technology has not changed thinking.

Similarly, in 2021, then-Commander of the Pacific Air Force General Kenneth Wilsbach, who currently leads Air Combat Command, referred to fielding more technologically advanced air superiority capabilities in the Indo-Pacific as an "urgent operational need," stating, "I am advocating for NGAD [Next Generation Air Dominance], and the weapons that go with NGAD are also important so we can stay relevant as our adversaries continue to advance."<sup>15</sup> In short, the most discussed threats to US air superiority are those aimed at restricting the Air Force's ability to access and exploit the blue skies, its historically prized altitudes.

But this blue-skies bias misses the broader point: air control is no longer exclusively contingent on the outcome of the contest in the blue skies, and solely prioritizing winning this fight will not deliver air superiority to the United States. Air Force operators need to be masters of the air, of the whole domain, not specialists only in one part.

## Decoupling the Air Littoral from the Blue Skies

The notion that control of the air is won or lost in the blue skies was always a bit of a romanticized ideal. To be sure, if an air force achieved air superiority, it also gained a measure of control extending to the ground. But air control was never absolute. For example, when General Norman H. Schwarzkopf, the US and Allied commander, proclaimed "air supremacy" over the Iraqi air force on the tenth day of the Gulf War in 1991, the Iraqi air force had ceased all fixed-wing operations, and any Iraqi helicopters that still dared to fly were shot down. Yet Iraqi flak and short-range, mobile infrared anti-air missiles remained a serious threat, accounting for 71 percent of all coalition aircraft losses in the war.<sup>16</sup>

A similar story repeated itself in Kosovo a few years later. General John Jumper, commander of US Air Forces Europe, was able to declare air superiority, triumphantly

---

14. Mark A. Gunzinger, Lawrence A. Stutzriem, and Bill Sweetman, *The Need for Collaborative Combat Aircraft for Disruptive Air Warfare* (Arlington, VA: Mitchell Institute for Aerospace Studies, 2024), 4, <https://mitchellaerospacepower.org/>.

15. Kris Obsorn, "The US Air Force Is Going All In on 6th Generation Fighters," *National Interest*, May 17, 2021, <https://nationalinterest.org/>.

16. Lambeth, *Transformation*, 120.

claiming Allied warplanes could “go anywhere we want in the country, any time.”<sup>17</sup> But this declaration was only strictly true above 15,000 feet. The skies were not clear at lower altitudes, where Yugoslavia’s anti-aircraft artillery (AAA) and shoulder-fired, man-portable air defense systems (MANPADS) remained ever-present threats.<sup>18</sup> In the early years of the twenty-first century, the United States flew unimpeded in the blue skies over Iraq, Afghanistan, and elsewhere, but that success belied growing threats in and through the airspace closer to the surface.

The difference today is that the blue skies no longer offer the sanctuary they once did to US aircraft, but they also no longer confer the same operational and tactical advantages to the side in control of them. Air superiority in the blue skies was once a prerequisite for an air force to be able to freely operate specialized aircraft for other aerial missions—including battlefield interdiction and close air support; intelligence, surveillance, and reconnaissance (ISR); airlift; and medical evacuation—without incurring serious losses.

Today, however, air forces increasingly bypass the blue skies and instead access and exploit the air littoral—that is, the airspace between the Earth’s surface and blue skies—to conduct many of these missions, especially ISR and direct attack. Simply put, what was once a nuisance and sideshow to the main contest in the blue skies is now critically important for air control.

## **Air Littoral**

Three trends have converged to make the air littoral central to the contest for air control. First, the so-called Fourth Industrial Revolution continues to usher in technological breakthroughs in robotics, artificial intelligence, microelectronics, and additive manufacturing, among others. It is now possible to employ large numbers of small and cheap but lethal systems in the air littoral. In addition to numerous radar-guided AAA guns and MANPADS, small drones, loitering munitions, and cruise missiles offer new opportunities to access and exploit the air littoral.

Second, unlike previous high-tech revolutions in military affairs (RMA), today’s technological breakthroughs are occurring in an era of open innovation. As one political scientist argues, these earlier RMAs occurred in a closed context, when government-funded programs underwrote the technological development of new weapon systems.<sup>19</sup> The technologies that drove past RMAs—nuclear weapons, stealth aircraft, and precision-guided munitions—had few commercial applications, allowing governments to limit access through secret programs, security classifications, and restrictive copyrights. In this context, the barriers of entry were high, with only the

---

17. Robert Hewson, “Allied Force, Part II: Overwhelming Air Power,” *World Air Power Journal* (Winter 1999/2000): 110, qtd. in Benjamin S. Lambeth, *NATO’s Air War for Kosovo: A Strategic and Operational Assessment* (Santa Monica, CA: RAND Corporation, 2001), 50, <https://doi.org/>.

18. Lambeth, *NATO’s Air War*, 21–22.

19. Audrey Kurth Cronin, *Power to the People: How Open Technological Innovation Is Arming Tomorrow’s Terrorists* (New York: Oxford University Press, 2020).

major powers possessing the financial, organizational, technological, and scientific resources required to build effective air forces.<sup>20</sup>

Closed innovation also made it possible for air forces with the most advanced aircraft and weapon systems to prevent—or at least delay—the transfer and proliferation of these military technologies and associated concepts of operation. Indeed, the US stealth and precision-guided munition advantages endured for nearly three decades before US adversaries, including Russia and China, closed the gap.<sup>21</sup>

Today, however, the commercial sector—rather than state-funded laboratories and weapons programs—are driving technological progress. Because these technologies—robotics, artificial intelligence, big data analytics, and 3D printing—are inherently dual-use, cheap, and easy to operate, they diffuse globally in short order. For example, Houthi rebels employ a mix of military- and commercial-grade drones, laden with explosives, for precision strikes. They also now field their own homegrown designs, obtaining easily accessible off-the-shelf engines, servo actuators, and electronics through a network of intermediaries and using 3D printers to create other components for their missiles and drones.<sup>22</sup> Open innovation thus levels the playing field, empowering a wide range of actors to contest and exploit the air littoral.

Multi-use technologies are not simply a “poor man’s air force,” however, as China is investing heavily in these areas to gain a military edge. Indeed, The People’s Liberation Army already makes extensive use of off-the-shelf drones—the Chinese company DJI is the world’s largest commercial drone manufacturer—and has accelerated efforts to build an “intelligitized” military and integrate them into operational concepts, including autonomous swarms for attritional warfare.<sup>23</sup> In 2023, for example, China’s National University of Defense Technology tested a drone swarm capable of “self-repair,” which overcame test jamming signals, restored communications links, and went on to find and destroy a target with loitering munitions—all without the help of a human operator.<sup>24</sup>

China also recently unveiled ASN-301 loitering munition similar to the Iranian Shahed-136 and Israeli Harpy and announced plans to develop what it termed a “new-type

---

20. Sebastian Ritchie, *Industry and Air Power: The Expansion of British Aircraft Production, 1935–41* (London: Routledge, 1997); and Ferenc Vajda and Peter Dancey, *German Aircraft Industry and Production, 1933–1945* (Warrendale, PA: SAE International, 1998).

21. Thomas G. Mahnken, “Weapons: The Growth & Spread of the Precision-Strike Regime,” *Daedalus* 140, no. 3 (2011).

22. Max Mutschler and Marius Bales, “Liquid or Solid Warfare? Autocratic States, Non-State Armed Groups and the Socio-Spatial Dimension of Warfare in Yemen,” *Geopolitics* 29, no. 1 (2024).

23. *In Their Own Words: The Science of Military Strategy 2020* (Maxwell AFB, AL: China Aerospace Studies Institute, 2022), <https://www.airuniversity.af.edu/>.

24. Alistair Gale, “China, US Test Intelligent-Drone Swarms in Race for Military AI Dominance,” *Wall Street Journal*, August 19, 2023, <https://www.wsj.com/>.

loitering munition with super long-range.”<sup>25</sup> The People’s Liberation Army, like other militaries, intends to access and exploit the air littoral at scale to battlefield advantage.

Finally, these technological advances have opened new possibilities for broad occupation and persistence in the air domain. Since its inception, military aviation has demonstrated unique strengths and limitations. The medium of the air offers few obstacles, allowing aircraft and other airborne systems to achieve unmatched maneuverability, speed, and range to rapidly concentrate firepower where and when it is most needed. Air forces, unlike armies, however, cannot live in their primary domain—the effects of gravity and human endurance limit flight times.<sup>26</sup> Additionally, from the start, aircraft have been expensive systems, requiring highly trained pilots and massive supporting infrastructure to fly them. This reality inevitably limits the size of traditional air forces, even for the wealthiest of nations.

As a result of both limited flight times and aircraft numbers, the occupation of airspace could occur for a time, but it was ultimately ephemeral. Once friendly aircraft left the airspace, surviving adversary aircraft could return to access and exploit it. During the race for Tunis in November 1942, for example, the Allies flew nearly twice as many sorties as the enemy, but operating from more distant airfields, they could rarely loiter more than 10 minutes over the battlefield.<sup>27</sup> When Allied fighters were in the air, German Stukas returned to their nearby bases and waited for them to leave, returning unopposed to bomb and strafe Allied ground forces.<sup>28</sup> In short, it was impossible to persistently possess the air domain.

This paradigm—contesting and occupying the airspace temporarily via small numbers of expensive, crewed aircraft, and then leaving—has become increasingly outmoded. But large numbers of drones can achieve persistence indirectly, by continually rotating in and out of the air littoral.<sup>29</sup> Because they are so cheap and quick to build compared to traditional platforms, air forces might deploy, lose, and replace them in large numbers.

Consistent with this vision, the Pentagon’s Replicator initiative aims to rapidly scale and deploy “multiple thousands” of autonomous drones with a per-unit cost ranging from tens of thousands to hundreds of thousands of dollars—not millions.<sup>30</sup> “Replicator is meant to help us overcome the PRC’s [People’s Republic of China’s] biggest advantage,

---

25. Akhil Kadidal and Rahul Udoshi, “China Developing Long-Range Loitering Munition,” *Janes*, July 26, 2023, <https://www.janes.com/>.

26. Phillip S. Meilinger, *Ten Propositions regarding Airpower* (Washington, DC: US Air Force Office of History, 1995), 2.

27. Rick Atkinson, *An Army at Dawn: The War in North Africa, 1942–43* (New York: Henry Holt, 2002), 184.

28. Daniel R. Mortensen, *A Pattern for Joint Operations: World War II Close Air Support, North Africa* (Washington, DC: Office of Air Force History and US Army Center of Military History, 2005), 61.

29. Maximilian K. Bremer and Kelly A. Grieco, “To Reinvent Itself, the US Air Force Must Go Big on Small Drones,” *Defense News*, April 2, 20024, <https://www.defensenews.com/>.

30. Jim Garamone, “Hicks Discusses Replicator Initiative,” Department of Defense (DoD), September 7, 2023, <https://www.defense.gov/>.

which is mass: more ships, more missiles, more people,” Deputy Secretary of Defense Kathleen Hicks explained at the initiative’s launch. Hicks reasoned, “We’ll counter the PLA’s mass with our own, but ours will be harder to plan for, harder to hit, and harder to beat.”<sup>31</sup> For the first time in the history of aerial warfare, air forces can be built around cheap mass.

The contest for air control—particularly in the air littoral—thus increasingly favors the larger air force—the side with the advantage in sheer numbers of cheap, easy-to-produce systems and precision munitions. Air forces that remain wedded to costlier legacy systems—and legacy ideas about airpower and air control—will continue to build fewer but more expensive systems, risking irrelevancy. They will be limited in action and misaligned with future operational needs of the joint force.

## Exploiting the Air Littoral

The future of air warfare will see a growing contest to occupy the air littoral, where drones and missiles of various types will be employed in massive numbers to saturate the airspace and wreak havoc and confusion on an adversary. Air forces can exploit the air littoral to advantage across multiple mission sets, especially air denial and the close air mission: surveillance and reconnaissance, communication, direct attack, and mobility.

### *Air Denial*

The air littoral can support a strategy of blue-skies air denial, in which an air force aims to deny operational freedom to an adversary’s air force without necessarily being able to control that airspace.<sup>32</sup> Air denial draws upon the concepts of British naval theorist Julian Corbett, who argued total command of the seas was impracticable. No navy could be everywhere at once due to the sheer size of the maritime domain.

For Corbett, command consists of control and denial. Even if a navy could not exclude the enemy from the sea, he maintained, it could still limit or deny the other side’s ability to make effective use of the sea for its own purposes. “The most common situation in naval warfare,” Corbett observed, “is that neither side has the command”—that is, “command is normally in dispute.”<sup>33</sup> To deny command, he advised an active defense, in which a navy remained threatening as a “fleet in being” by staying active and mobile and conducted “harassing operations . . . to prevent the enemy from exercising control in spite of his superiority by continually occupying his attention.”<sup>34</sup>

The air domain is similarly vast, and the last 30 years notwithstanding, the history of aerial warfare suggests the default condition is for command of the air to be in

---

31. Kathleen Hicks, “The Urgency to Innovate” (keynote address), National Defense Industrial Association, Washington, DC, August 28, 2023, transcript, <https://www.defense.gov/>.

32. Maximilian K. Bremer and Kelly A. Grieco, *Assumption Testing: Airpower Is Inherently Offensive* (Washington, DC: Stimson Center, 2023), <https://www.stimson.org/>.

33. Julian S. Corbett, *Some Principles of Maritime Strategy* (New York: Longmans Green, 1918), 77.

34. Corbett, 190.



dispute. Air denial is analogous to Corbett's concept of sea denial, in that it focuses on limiting another air force's ability to gain and exploit air superiority in military operations. A strategy of air denial aligns well with US political and military objectives: to maintain the territorial status quo in Europe and the Indo-Pacific and prevent the emergence of China's regional hegemony.<sup>35</sup>

These objectives require an airpower strategy that would make it both difficult and costly for China or Russia to quickly seize territory and present their conquests as a *fait accompli*. A Russian land grab in the Baltics, much less a Chinese amphibious invasion of Taiwan, is not feasible without air superiority—including in the air littoral. Russian forces have learned this bloody lesson in Ukraine over the last two years, and Chinese military writings consistently make the point that offensive amphibious and maritime operations are unlikely to succeed absent air superiority.<sup>36</sup> They are not wrong: one study found modern amphibious operations have succeeded only 14 percent of the time without air superiority.<sup>37</sup>

Ultimately, neither Russia nor China wants to start a war that it cannot win. As such, US airpower strategy and doctrine should be oriented toward the goal of convincing their respective leaders that they cannot obtain the air superiority required to mount successful offensive operations.

While a strategy of air denial has been used successfully in past wars—most famously in the 1940 Battle of Britain—the difference today is that technological advancements have opened new and more effective ways for the defender to contest both the lateral and vertical airspace. Notably, the mobility, density, and expendability of air defense systems and drones allow a doctrine of volumetric defense.

This type of defense layers the effects of cyber disruptions, electromagnetic jamming, air-based air defenses, and ground-based air defenses in increasing degrees of strength, both horizontally, from deep-strike to close-in capabilities, and vertically, from the blue skies to the air littoral. The outer layer consists of a mix of sensors, platforms with air-to-air missiles, cyber, electromagnetic capabilities, and ground-mobile long- and medium-range SAMs to cover the approaches from the blue skies. The inner layer includes thousands of anti-aircraft guns, short-range and man-portable SAMs, rockets, drones, and loitering munitions to deny control of the air littoral.<sup>38</sup>

Specifically, saturating the air littoral over attacking surface forces—whether in defending against a Chinese amphibious invasion of Taiwan or a Russian attack on a NATO Ally in eastern Europe—would create numerous hard-to-solve and time-consuming

---

35. Joseph R. Biden Jr., *National Security Strategy* (Washington, DC: White House, October 2022), <https://www.whitehouse.gov/>.

36. Lyle Goldstein, "The Hard School of Amphibious Warfare: Examining the Lessons of the 20th Century's Major Amphibious Campaigns for Contemporary Chinese Strategy," *Asia Security* 19, no. 1 (2022).

37. Ian Speller and Christopher Tuck, *Amphibious Warfare: Strategy & Tactics from Gallipoli to Iraq* (London: Amber Books, 2014).

38. Maximilian K. Bremer and Kelly A. Grieco, "In Defense of Denial: Why Deterring China Requires New Airpower Thinking," *War on the Rocks*, April 3, 2023, <https://warontherocks.com/>.

dilemmas for them before either could attain air superiority. Whereas the United States and its Allies and partners would have one problem to solve—how to parry the blow from attacking aircraft and missiles—attacking Russian or Chinese air forces would confront both air-to-air and ground-to-air threats in the fight to gain and maintain control of the air littoral.

Flying through a mostly open and featureless sky, larger crewed aircraft are inherently easier to locate and destroy than the mobile ground-based air defenses hunting them from terrain more favorable to cover and concealment. From the so-called “Scud hunt” in Iraq in 1991 to the current war in Ukraine, mobile air defenders, employing “shoot-and-scoot” tactics, in which they fire their missiles and quickly turn off their radars and move away, are challenging to find and eliminate.<sup>39</sup>

In addition to these SAM threats, continuous waves—and soon autonomous swarms—of small sensing, decoy, and weaponized drones could be used to mine the air littoral. In a twenty-first century version of the barrage balloon, large numbers of low-cost drones could both offer point defense and channel attacking aircraft into narrow flight corridors, forcing them to run a gauntlet of other air denial weapons.<sup>40</sup> Even if an attacking aircraft escapes a direct hit, it could still suffer mission kill from blast and fragment damage.

The attacker’s expensive crewed aircraft could avoid flying in the air littoral, taking their chances in the blue skies, where the threat from long-range air defenses awaits them, but that would do little to protect their surface forces from continued surveillance and attacks from the air littoral. The United States and its Iraqi partners learned this lesson in Mosul in 2016 and 2017. Even though the United States had air supremacy in the blue skies, the Islamic State was still able to access and exploit the air littoral, employing quadcopters loaded with explosives that killed or wounded dozens of Iraqi soldiers and nearly bringing Iraqi ground operations “to a screeching halt.”<sup>41</sup>

Enemy small drones create a difficult dilemma to solve—one that would put US adversaries on the losing end of the cost curve. Take ongoing US operations against Iranian-backed Houthis in the Red Sea: US Navy warships are using \$2.1 million anti-air missiles to intercept Houthi attack drones that cost as little as a few thousand dollars. As one DoD official stated, “The cost offset is not on our side.”<sup>42</sup>

Similarly, the United States alongside other partners shot down approximately 300 Iranian attack drones and missiles headed toward Israel in April 2024, employing F-15E

---

39. Thomas A. Keane and Eliot A. Cohen, *Gulf War Air Power Survey*, vol. 2 (Washington, DC: Office of the Secretary of the Air Force, 1993); and William Rosenau, *Special Operations Forces and Elusive Enemy Ground Targets: Lessons from Vietnam and the Persian Gulf War* (Web only: RAND Corporation, 2002), <https://doi.org/>.

40. Leslie F. Hauck III, and John P. Geis II, “Air Mines: Countering the Drone Threat to Aircraft,” *Air & Space Power Journal* 31, no. 1 (2017), <https://www.airuniversity.af.edu/>.

41. David Larter, “SOCOM Commander: Armed ISIS Drones Were 2016’s ‘Most Daunting Problem,’” *Defense News*, May 16, 2017, <https://www.defensenews.com/>.

42. Laura Seligman and Matt Berg, “A \$2M Missile vs. a \$2,000 Drone: Pentagon Worried over Cost of Houthi Attacks,” *Politico*, December 19, 2023, <https://www.politico.com/>.

fighters, destroyers, and Patriot missile systems. The operation was overwhelmingly successful, but it is reported to have cost at least 10 times as much to defend against the attack as it cost Iran to launch it.<sup>43</sup> This estimate may well be low, when accounting for fuel, maintenance costs, and staging support for high-end fighters.

This cost imbalance is driving the pursuit of cheaper countermeasures, including lasers and other directed-energy weapons, but the technological challenges remain daunting, as the director of the Navy Surface Warfare Division cautioned in early 2024.<sup>44</sup> For the foreseeable future, air denial will thus remain both easier and cheaper to achieve than trying to gain air superiority outright, including in the air littoral.

### ***Close Air Mission***

The US military today faces an acute dilemma: small numbers of larger, more expensive airframes and sensors are vulnerable and can expect high rates of attrition on the ground and in contested airspace while the growing reach of adversary long-range air-to-air and surface-to-air missiles risks pushing these assets back too far from the fight to be effective. As the *Air Superiority 2030 Flight Plan* concluded in 2016, “The increasing lethality and reach of adversary weapons will significantly increase the risk” to large surveillance platforms. It warns, “This will limit their ability to see and manage activities in the contested and highly contested environments.”<sup>45</sup>

The US Air Force should anticipate and prepare to succeed in an operating environment characterized by the mutual denial of air superiority, especially early in a conflict against a near-peer such as China. Above all, this operational reality requires reimagining the close air mission. Rotational occupation of the air littoral with large numbers of small drones would allow the US Air Force to continue to provide aerial surveillance and reconnaissance, communications, direct attack, and mobility within contested airspace.

First and foremost, large numbers of small drones can create an “unblinking eye” over the battlefield to conduct reconnaissance and surveillance for the Joint force.<sup>46</sup> Joint operations depend critically on the air component for surveillance and reconnaissance. Air surveillance offers wide-area coverage to the Joint force for airborne early warning, battle management, command and control, and target detection and tracking.<sup>47</sup>

---

43. Andrew Macaskill, “Israel’s Defenses Would Trump Iran’s in Any Air War, But at a High Cost,” Reuters, April 18, 2024, <https://www.reuters.com/>.

44. Justin Katz, “It’s Hard’: Navy Needs to Be Realistic about Laser Weapons, Admiral Says,” Breaking Defense, January 11, 2024, <https://breakingdefense.com/>.

45. Enterprise Capability Collaborative Team, *Air Superiority 2030 Flight Plan* (Washington, DC: Department of the Air Force, May 2016), 8, <https://www.af.mil/>.

46. Rebecca Grant, “Toward an Unblinking Eye,” *Air & Space Forces Magazine*, October 1, 2012, <https://www.airandspaceforces.com/>.

47. Troy McLain and Gerrit Dalman, “Seize the Highest Hill: A Call to Action for Space-Based Air Surveillance,” *Air & Space Power Journal* 32, no. 4 (2018): 32, <https://www.airuniversity.af.edu/>.

For the close air mission, the United States will need to complement existing capabilities with a mix of cheaper high-altitude surveillance platforms—balloons and drones—and numerous cheaper platforms operating in the air littoral. By rotating large numbers of small drones in and out of the air littoral, the US Air Force could achieve persistence indirectly over the theater of operations to close gaps in lower-altitude surveillance coverage and create a real-time surveillance picture.

In 2023, the deputy chief of staff for Air Force Futures proposed using small, inexpensive drones—estimated to cost around \$500,000 each—to monitor shipping traffic in the Taiwan Strait. Any attempt by China to invade or blockade Taiwan would involve large numbers of Chinese warships, but with large numbers of these low-cost drones operating over the Strait, the United States could readily spot those ships on the move.<sup>48</sup> Those small drones could also provide critical reconnaissance, sending targeting information back to aircraft, submarines, and surface vessels that have the weapons needed to sink those warships.

Small drones employed at scale can also create a meshed communication network, extending the communication range. The drones would form a chain of relays, in which one drone relays communication for another, to provide beyond-line-of-sight (BLOS) radio communications. They would also be robust against China's high-powered ground-based jammers, including in a Taiwan contingency, one RAND report concludes, by using high-frequencies, such as those in the tens of gigahertz.<sup>49</sup> Currently the Joint force primarily relies on satellites for BLOS communications, but in the event of a conflict with China or Russia such signals could be blocked by jammers or otherwise disrupted. In that situation, a drone mesh network would still offer a communication link, adding another layer of resiliency to military communications and enabling rapid decision-making.

The US Air Force could also use the air littoral to conduct direct attack, employing numerous small, cheap drones in support of Joint combined arms operations. For much of the Air Force's history, its leaders have argued that airpower is most effective when employed indirectly, whether in strategic bombing of an enemy's population, economy, or leadership or the interdiction of its war production and lines of communication. But the historical record of airpower over the last 70 years suggests otherwise. As one political scientist argues, airpower's "asymmetric advantage is its ability to locate and attack massed and maneuvering armies," because it places enemy ground forces on the "horns of a dilemma."<sup>50</sup>

If these forces concentrate and maneuver, they will face almost certain destruction from lethal air strikes, but if they disperse and hide, they cannot concentrate and maneuver to conduct the large-scale breakthrough and exploitation operations required

---

48. Andrew Hoehn and Thom Shanker, "Are Cheap Drones the Answer to the Tension in the Taiwan Strait?" *Defense News*, June 29, 2023, <https://www.defensenews.com/>.

49. Thomas Hamilton and David Ochmanek, *Operating Low-Cost, Reusable Unmanned Aerial Vehicles in Contested Environments* (Santa Monica, CA: RAND Corporation, 2020), <https://doi.org/>.

50. Phil Haun, *Tactical Air Power and the Vietnam War: Explaining Effectiveness in Modern Air Warfare* (New York: Cambridge University Press, 2024), 9, 14.

to seize territory.<sup>51</sup> In other words, airpower is most effective when it has no need to destroy armies, because it has already denied the enemy its preferred strategy of massing at the decisive point.

Air forces can now leverage this asymmetric airpower advantage by crowding the skies of the air littoral. In Ukraine, for example, the blue skies are mostly empty of warplanes, but the air littoral is congested. Drones in the air littoral are a persistent presence and threat over the front lines, making the movement and massing of troops and vehicles extremely dangerous. A Ukrainian drone operator fighting in the Kharkiv region observed, “Nobody really knows how to advance right now.” He concluded it was “almost impossible” to achieve a decisive breakthrough “in an era of cheap and lethally accurate drones.”<sup>52</sup>

The area between the opposing lines is known as “the death zone,” with another Ukrainian drone operator warning that those who dare to move—whether Ukrainian or Russian—are spotted by the other side’s drones and are “dead immediately.”<sup>53</sup> This drone-saturated airspace has delivered tactical airpower’s main advantage—denying an enemy the ability to concentrate and maneuver. The effect on the enemy army or navy is the same, whether it is achieved from the air littoral or the blue skies.

Similarly, drones cycled fast enough into the airspace could overwhelm China’s targeting process and in turn inflict significant losses should its forces attempt to invade Taiwan. Chinese commanders would have to decide how much “clearance” is needed in the air, and for how long, but trying to destroy large numbers of these systems would risk depleting their anti-air missiles in the process. Chinese military planners could opt instead to ignore these small, cheap drones, but they would leave their surface forces vulnerable to attacks in multiple directions, including drones maneuvering over the top of them to conduct vertical envelopment, subjecting attackers to continuous fires.<sup>54</sup>

A single small drone is unlikely to sink or even damage a ship. When used in large numbers, however, they could cooperatively attack from different directions to confuse and overwhelm a ship’s defenses and then disable the ship by targeting its critical sensors, communications, and engineering components.<sup>55</sup>

Finally, drones employed in the air littoral can carry cargo, sustaining forces distributed across the battlefield. Because these systems are uncrewed, they can assume greater risks in resupplying these forces than traditional crewed aircraft. The Marine Corps is leading the way in this effort, with its logistics battalions set to receive three to six Tactical Resupply Unmanned Aircraft System drones, which can carry

---

51. Haun, 13–34.

52. Luke Harding, “Cheap but Lethally Accurate: How Drones Froze Ukraine’s Frontlines,” *Guardian*, January 25, 2024, <https://www.theguardian.com/>.

53. Siobhan O’Grady and Kostiantyn Khudov, “Drones Are Crowding Ukraine’s Skies, Largely Paralyzing Battlefield,” *Washington Post*, April 14, 2024, <https://www.washingtonpost.com/>.

54. Jules Hurst, “Robotic Swarms in Offensive Maneuver,” *Joint Forces Quarterly* 87, 4th Quarter (2017).

55. Tyler Rogoway, “The Compelling Case for Arming US Navy Warships with Drone Swarms,” *War Zone*, April 4, 2024, <https://www.twz.com/>.

150 pounds up to nine miles, with the long-term goal to field cargo drones capable of handling “thousands of pounds.”<sup>56</sup>

This combination—a transparent battlefield, precision weapons en masse, and a faster kill web—make it very dangerous to move. That puts the attacker at a significant disadvantage because they must move forward to execute an offensive mission, leaving them exposed to the defender’s fire. In contrast, the defender can operate and re-supply themselves from a prepared position, where they conceal and protect themselves from an attacker’s fire. When leveraged appropriately, these developments favor the United States—and its Allies and partners—in preserving the territorial status quo against Chinese or Russian military aggression.

## Conclusion

The US Air Force should develop its strategy and doctrine not based on how it wishes it could fight air wars, or how it might relive past successes against nonpeer adversaries but rather on how it will be most effective in future combat. The challenge of the air littoral calls for a rapid and forceful look at doctrine, organization, training, materiel, leadership and education, personnel, and facilities.

Air Force and Joint doctrine should recognize and develop new tactics, techniques, and procedures for the air littoral and denial-based operations. This doctrinal and tactical innovation is more likely to come from its digitally native Airmen than today’s legacy pilot force, as the former are much more capable than senior pilots of understanding the nonlinear and one-to-many interactions of humans and machines. From basic training onward, Airmen should be as familiar with small drones as Marines are with their rifles. Airmen need to be airminded and bring that thinking to the Joint fight.

The changing character of war means that uncrewed systems, especially in the air littoral, are no longer the sole purview of intelligence agencies and special operations forces. Air littoral operations will be critical in all future fights, especially against near-peer adversaries. The Air Force, as the independent air component of the Department of Defense, should provide the organizational and intellectual leadership to develop and field new capabilities and concepts, including creating and incorporating high numbers of low-end, close-in air occupation elements and capability as it restructures for conflicts of the future.

Airmen should have not only the freedom to innovate and adapt but also the tools. China’s significant industrial lead in small drone production, combined with the increasing cooperation of Iran and Russia in development of military tactics and integration, means US adversaries now hold advantages in both technology and doctrinal innovation. The US and Allied industrial base will need to start producing at scale. The service’s thinking needs to expand beyond countering a threat to using new capabilities with the right facilities, including ranges where these concepts can

---

56. Sam Skove, “Marines See Progress with Drones, Despite Flat Budgets,” *Defense One*, March 19, 2024, <https://www.defenseone.com/>.

be tested and refined, and the right Airmen placed in positions to drive that development. Most important, the Air Force needs its leaders to advocate for these changes, so the service, charged with warfare in and control of the air domain, is able to regain its role as the leader of that domain. Æ

### **Disclaimer and Copyright**

The views and opinions in *Æther* are those of the authors and are not officially sanctioned by any agency or department of the US government. This document and trademark(s) contained herein are protected by law and provided for noncommercial use only. Any reproduction is subject to the Copyright Act of 1976 and applicable treaties of the United States. The authors retain all rights granted under 17 U.S.C. §106. Any reproduction requires author permission and a standard source credit line. Contact the *Æther* editor for assistance: [aether-journal@au.af.edu](mailto:aether-journal@au.af.edu).