The Need for Collaborative Combat Aircraft for Disruptive Air Warfare

By Col Mark A. Gunzinger, USAF (Ret.)
with Maj Gen Lawrence A. Stutzriem, USAF (Ret.)
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About the Mitchell Institute for Aerospace Studies

The Mitchell Institute for Aerospace Studies is an independent, nonpartisan policy research institute established to promote understanding of the national security advantages of exploiting the domains of air, space, and cyberspace. The Mitchell Institute goals are: 1) to educate the public about the advantages of aerospace power in achieving America's global interests; 2) to inform key decision makers about the policy options created by exploiting the domains of air, space, and cyberspace, and the importance of necessary investment to keep America the world's premier aerospace nation; and 3) to cultivate future policy leaders who understand the advantages of operating in air, space, and cyberspace. Mitchell Institute maintains a policy not to advocate for specific proprietary systems or specific companies in its research and study efforts.

About the Authors

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Bill Sweetman has 50 years of experience in aerospace. An award-winning journalist, he has written for national news media, the popular press, and leading aerospace and defense trade publications, spending a decade at Aviation Week & Space Technology as an editor and columnist. He is known for incisive analytical skills and his work has been cited by the CIA and GRU, and he has addressed many professional conferences on unmanned air systems and other related topics. Bill joined Northrop Grumman's corporate strategy team in 2016 and spent time with the company's Advanced Programs unit, supporting technical and operational analysis of advanced air vehicles, before leaving to found Valkyrie Strategic Solutions LLC in 2023.

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Foreword

Today, the United States Air Force operates a force that is the oldest, smallest, and least ready in its history. At the same time, U.S. command of the air in the Western Pacific faces an unprecedented threat by China's modernized military. Addressing this and other challenges will require innovative approaches to air warfare that fully leverage the potential of autonomous uninhabited aircraft. This is why the Mitchell Institute created its Center for Uninhabited Aerial Vehicles and Autonomy Studies in 2022—to inform the American public, Congress, the Department of Defense, and industry on emerging opportunities to develop these critical aerospace capabilities.

Mitchell Institute's latest flagship report on collaborative combat aircraft (CCA) is based on varied perspectives from Air Force and industry operators, planners, and technologists. This report highlights a key finding from a 2023 Mitchell Institute wargame: CCAs operating collaboratively with 5th and future 6th generation combat aircraft promise to be essential force multipliers capable of disrupting and imposing costs on a peer adversary's air defenses. Other key findings include the importance of using a CCA "family of systems" to amplify combat effectiveness and the need to invest in logistics infrastructure suitable to conduct distributed CCA operations at scale in the Pacific theater.

CCAs are a unique opportunity for the Air Force to create a force design to achieve the degree of air superiority in contested environments required for joint force operations to succeed. The report's authors have produced an exceptional product that advances the conceptual thinking on CCA operating concepts and the need to balance their design attributes and costs with mission requirements. Now is the time to capitalize on innovative CCA capabilities and associated concepts to bolster deterrence and add the capacity to win against peer aggression if necessary. This is why the Mitchell Institute remains committed to bringing together the best military and civilian minds to explore innovative solutions for uninhabited aircraft.

Lt Gen David A. Deptula, USAF (Ret.)
Dean, The Mitchell Institute for Aerospace Studies

Executive Summary

"Neither air superiority nor victory are American birthrights…both are at significant risk."

-Gen Mark D. Kelly, Commander Air Combat Command[1]

Projecting decisive military power to distant theaters has long relied on the Air Force's ability to achieve air superiority by conducting offensive and defensive counterair missions to defeat an adversary's fighters, surface-to-air missiles, battle managers, and other air defense threats. Today and in the future, an effective air superiority force is an essential baseline requirement for any joint operation to defeat China's aggression in the Pacific, the pacing challenge for sizing and shaping the U.S. military.[2] The Air Force's ability to provide this core warfighting requirement is now at risk. This report assesses the potential for a family of uncrewed collaborative combat aircraft (CCA) to reduce this risk by increasing the lethality, survivability, and capacity of the Air Force's air superiority operations in highly contested environments.[3]

Over the last 30 years, Department of Defense (DOD) leaders repeatedly directed the Air Force to reduce its fighter inventories, cap its acquisition of stealthy F-22 air superiority fighters short of requirements, and delay other needed modernization programs. Congress acquiesced to these actions even as China matured its anti-access/area-denial (A2/AD) weapons complex to defeat the U.S. military's preferred way of war and legacy forces. This complex now includes stealthy fighters, some of the world's most advanced air-to-air and surface-to-air missiles (SAM), and multi-spectral sensors to track airborne targets.

More than three decades after the Cold War, the Air Force's air superiority force still includes aging F-15C fighters designed in the 1970s, the newest of which still in service today was delivered in 1989; less than half its stated requirement of F-22s; and 44-year-old E-3 airborne warning and control systems (AWACS).[4] This force lacks the lethality, survivability, and capacity to achieve the degree of air superiority required to deter and, if necessary, defeat Chinese aggression. Independent analyses indicate that counterair requirements in a defense of Taiwan scenario in the next ten years could exceed the Air Force's F-15C and F-22 inventories by at least half.[5] Other fighters capable of counterair operations include the Air Force's 5th generation F-35s, but they will be in high demand for multiple missions during a peer conflict, and non-stealthy F-16s, which are not designed for highly contested environments. The Navy and Marine Corps also have inventories of 4th and 5th generation fighters, but these forces are organized, trained, and equipped primarily to support their service-specific missions instead of achieving air superiority for joint force operations. Failing to achieve air superiority in a conflict with China would greatly increase the risk of a costly defeat that has existential, long-term impacts on the security of the United States and its allies.

The prescription for preventing this failure is not a secret—the DOD and Congress must provide the Air Force with additional resources to properly size and shape its air superiority forces for peer conflicts. This cannot be realized by continuing to rely on inadequate budgets, old technologies, and legacy operating concepts. Part of the solution is to accelerate production of Air Force F-35As and field its Next Generation

Key Terminology: CCA

This report uses the term collaborative combat aircraft to describe uncrewed aerial vehicles (UAV) that can operate with other aircraft in contested environments. CCA are distinct from earlier generation ISR-oriented UAVs because the Air Force envisions using them in conjunction with other aircraft to employ "a distributed, mission-tailorable mix of sensors, weapons, and other mission equipment" in contested environments. According to the USAF Scientific Advisory Board, CCA should be semi-autonomous, capable of "taking high level direction" from a pilot, and then "autonomously implementing this direction." CCA may also be "significantly less expensive" than crewed aircraft, which would allow warfighters to use them as expendable or recoverable/attritable assets. CCA variants could cost single digit millions to tens of millions of dollars each depending on their designs and mission systems.

Source: DAF Scientific Advisory Board FY 2022 Study on Collaborative Combat Aircraft for Next Generation Air Dominance.

Air Dominance (NGAD) family of systems. NGAD will include at least one 6th generation stealthy aircraft with longer ranges and larger payloads compared to current generation fighters, advanced weapons, and uncrewed CCA with autonomy and artificial intelligence/machine learning (AI/ML) technologies.[6] 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 that are designed to disrupt and defeat China's counterair operations. The Air Force could begin to acquire CCA at scale to reduce risk and deter China this decade. This stands in contrast to other, more exquisite solutions that are necessary to keep pace with China but may not be available in numbers for years—a major risk given the People Liberation Army's (PLA) rapid modernization and aggressive tendencies.

Insights from the Experts

During a July 2023 wargame, the Mitchell Institute tasked experienced operators, technologists, and engineers from the Air Force and defense industry to assess how a mix of uncrewed CCA and crewed combat aircraft could achieve the degree of air superiority required to defeat peer aggression. Organized into three "blue" U.S. air campaign planning teams, these experts selected notional CCA designs developed during a previous Mitchell Institute workshop and proposed concepts for using these CCA with 4th and 5th generation fighters to achieve air superiority during a notional defense of Taiwan campaign.

Insights, observations, and operating concepts in the report are based on the choices made by these wargame planning teams. One of the most important insights is the potential to **use CCA as lead forces to help disrupt and suppress** China's advanced integrated air defense system (IADS), improve the lethality and survivability of the Air Force's counterair forces, and magnify the service's capacity to project combat mass into highly contested battlespaces. Experts agreed it will not be feasible to match China fighter for fighter and missile for missile in today's battlespace, given the Air Force's fighter force is now less than half the size it was in 1991. Accordingly, all three wargame teams proposed CONOPS that initially used CCA at scale to disrupt China's IADS and level the playing field against the PLAAF. This mirrors the logic behind DOD's Assault Breaker initiative in the 1980s and its 2014–2018 Third Offset Strategy that sought to develop asymmetric capabilities to offset a peer adversary's superior combat mass and proximity to the battlespace.

All three wargame teams also chose to use a mix of CCA variants designed as airborne sensors, decoys, jammers, or weapon launchers to disrupt and stimulate the PLA's IADS, locate its critical nodes, and begin to attrit threats to support crewed aircraft operations. Dispersing these functions across a mix of CCA would improve the Air Force's operational resiliency and increase the number of airborne targets an adversary's forces must attack. By design, lower-cost CCA may lack the mission systems and full functionalities of 5th generation fighters. However, an adversary has no reliable way of differentiating between how CCA are equipped and must address them all as threats. The key is understanding that CCA—in the same way remotely piloted aircraft (RPA) sensor-shooters pioneered a new way of conducting precision strikes—will be more than intelligence, surveillance, and reconnaissance (ISR) information gatherers.

Another insight is that **CCA could increase the Air Force's capacity to generate lethal mass for counterair operations**. Appropriately equipped CCA can perform as force multipliers that increase the number of sensors and weapons the Air Force can project into contested battlespaces. CCA could also extend the sensor and weapon ranges of stealthy crewed aircraft they team with, increasing their lethality and survivability. This will require **designing CCA with enough survivability to ensure they can reach their air-to-air weapons launch points in contested environments**. Using CCA to reduce attrition of Air Force fighters and their crews would also have a major force multiplying effect over the course of a campaign—a key consideration given that DOD-mandated force cuts over the last 30 years caused the Air Force to divest its combat attrition reserves. This divestment has created an Air Force that now lacks the numerical capacity and resiliency to conduct extended combat operations in highly contested environments.[7]

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CCA could multiply the Air Force's diminished combat inventory in another way: **by enabling some of its non-stealthy combat aircraft to engage in the fight for air superiority in highly contested environments**. For instance, notional CCA designs available to Mitchell Institute's wargame experts included a long-range, air-launched design that carried two air-to-air weapons or four 250-pound class Small Diameter Bombs (SDBs). The experts used 4th generation F-15EXs and B-52 bombers operating outside the range of China's IADS to launch these counterair CCA into contested areas.

Experts participating in Mitchell's wargame **also preferred to use a mix of lower-cost CCA they classified as expendable systems and more capable, moderate-cost CCA that can be recovered and regenerated for additional sorties or attritted if mission needs require** in highly contested battlespaces. Experts chose to use expendable CCA in significant numbers during the first few days of their campaigns as airborne decoys, jammers, active emitters, and other ways that risked their loss in highly contested environments. And since these notional CCA could be ground-launched by rockets without the need to use runways, wargame experts chose to pre-position them at dispersed locations in the Philippines and Ryukyu Islands to improve the resiliency of the Air Force's combat sortie generation operations. As their campaigns progressed, experts shifted toward using a larger number of moderate-cost recoverable/attritable CCA that carried larger payloads of weapons and could return to their forward operating locations to regenerate for additional sorties.

Finally, wargame experts suggested **there is a need to develop concepts for operating CCA with other uncrewed aerial vehicles** for counterair missions rather than solely using them as adjuncts for crewed aircraft. Of note, operating CCA in this way would require providing them with more advanced autonomy and other technologies that add to their cost. Militaries have a long history of attempting to use emerging technologies to marginally improve the performance of their existing systems. This was the case at the dawn of U.S. military aviation when the Army initially believed aircraft could best serve as artillery spotters—like better high ground—dedicated to supporting ground operations instead of taking full advantage of their ability to perform a broader range of combat missions. Constraining CCA to supporting crewed aircraft operations would likewise artificially limit their potential to increase pressure on an adversary and complicate their threat calculus. This said, experts unanimously agreed that **CCA are complementary and additive capabilities that will not reduce the Air Force's 5th generation fighter requirements**. Both are needed to prevail over peer aggression, especially in extremely large theaters such as the Pacific.

Recommendations for the Air Force

Warfighting and technology experts from the Air Force and defense industry community agreed the service should field a family of CCA for offensive and defensive counterair operations and do so as rapidly as possible. The ability to achieve air superiority in a conflict with China is at risk today, and the threat will continue to grow as the PLA fields its next generation of counterair sensors, combat aircraft, and very long-range air-to-air and surface-to-air missiles. Developing CCA as part of the Air Force's force design is a once-in-a-generation opportunity to enhance its near-term capability and capacity to deter peer aggression. Getting an initial tranche of CCA into the hands of Air Force warfighters and sustainers as soon as possible would permit them to conduct exercises, experiments, and other operations that help inform iterative CCA design changes and acquisition decisions. Rapidly fielding these aircraft will require coordinated and concerted support from lawmakers, DOD leadership, and industry because of the scale of changes necessary to integrate them into operational units. This support must include additional resources to develop, acquire, operate, and sustain a mix of CCA.

Developing CCA as part of the Air Force's force design is a once-in-a-generation opportunity to enhance its near-term capability and capacity to deter peer aggression.

To this end, the Mitchell Institute offers the following recommendations that are based on insights from its wargames and related studies:

- **The Air Force should conduct tradeoff analyses to determine an optimal mix of CCA in its future force design.** These analyses should seek to create an inventory of CCA that balances individual design attributes such as size, low observability, range, mission systems, and unit cost with their mission requirements. Determining the right tradeoffs between these attributes will inform the development of a CCA force design that maximizes the Air Force's combat effectiveness and return on investment. Importantly, CCA will be complementary and additive capabilities that will not reduce the Air Force's requirements for 5th generation fighters and other advanced crewed systems.

- **The Air Force should create operating concepts for using expendable CCA to disrupt China's counterair and other A2/AD operations.** These concepts should address how lower-cost, expendable CCA could perform as lead forces to complicate the PLA's counterair targeting, identify its high-value air defense nodes, and cause PLA defenses to partially deplete their air-to-air and surface-to-air weapons on lower-cost uncrewed systems. This could include CCA with long ranges that can be ground-launched or launched from non-stealthy bombers and fighters. Uncrewed systems, combined with new, disruptive, cost-imposing concepts for their use, would create an asymmetric capability that will be difficult for the PLA to counter. This is a very different approach to relying on CCA to increase the Air Force's capacity to fight attrition-based warfare.

- **The Air Force should acquire CCA at scale to increase its capacity to project affordable counterair mass at range into highly contested areas.** CCA can be force multipliers in the sense that they can collaborate with other aircraft or operate nearly independently to increase the weapons and sensors the Air Force can project over long ranges into highly contested environments. For example, CCA designs capable of performing as penetrating "weapon trucks" would help offset the PLA's growing counterair forces, improve the survivability of the Air Force's 5th and 6th generation fighters, and multiply the number of weapons crewed fighters can bring to the fight. A critical recommendation made by experts participating in Mitchell Institute's wargame was that **CCA weapons trucks should have enough range and survivability to ensure they will reach their weapon launch points** in highly contested environments.

- **The Air Force should field CCA that will help reduce its dependence on large, fixed airbases in the Pacific.** Reducing the Air Force's current reliance on main operating bases with long runways in the Pacific theater could improve its ability to generate combat sorties while under attack, as envisioned in its Agile Combat Employment concept. CCA that can operate from short runways or launch without runways would help create a more dispersed, resilient forward posture. A network of distributed CCA operating locations would also complicate the PLA's ability to find, fix, and attack the Air Force's counterair forces when they are most vulnerable: on the ground and preparing for combat sorties.

- **The Air Force should seek to increase the lethality of its weaponized CCA over time by developing or adapting munitions to take advantage of their more limited payload capacities.** Wargame experts used AIM-120 missiles for multiple CCA air superiority missions. They also acknowledged that designing CCA to carry weapons originally created for aircraft with larger weapons bays would risk increasing the size, weight, and unit cost of some CCA variants. As the Air Force iterates its future CCA designs, it should take advantage of technologies like compact rocket motors and miniaturized components to design smaller weapons that would increase the number of targets CCA can attack per sortie, a factor that is critical to rapidly halting a Chinese offensive.

- **DOD should work with Congress to increase Air Force funding to create a force design that combines CCA and 5th and 6th generation combat aircraft for decisive counterair operations.** Decades of insufficient budgets have created a high-risk Air Force that lacks the force capacity, modernized capabilities, and readiness required to succeed in a conflict with China and meet other *U.S. National*

Defense Strategy priorities.[8] Reversing this decline requires growing the service's annual budget by 3 to 5 percent each year for a decade or more. These funds should be used in part to acquire CCA, increase F-35A acquisition, acquire other new weapon systems like advanced air-to-air munitions and B-21s capable of launching some CCA variants, and improve airbase defenses for peer conflicts.

- **Analyses are needed to determine logistics capabilities and operating concepts needed to support and sustain a high tempo of CCA operations in forward theaters.** These analyses should address requirements to pre-position CCA and their logistics in the Indo-Pacific, appropriate dispersal locations for CCA launch and recovery operations, and materiel and personnel requirements to sustain CCA combat operations at scale during a peer conflict. Developing an understanding of CCA theater logistics requirements will be a critical step toward determining future CCA designs.

In summary, the Mitchell Institute's wargames and related research strongly support the proposition that CCA will help mitigate the Air Force's growing capability and capacity gaps that threaten its ability to achieve air superiority. CCA combined with crewed 5th and future 6th generation fighters have the potential to disrupt China's A2/AD operations and then deny and impose costs, as called for by the *National Defense Strategy*. The stakes for creating this new hybrid force design have never been higher, given China's unchecked campaign to field new A2/AD weapon systems and proliferate them to other actors that threaten the security of the United States and its allies and partners.

Introduction

Report Methodology and Organization

This report assesses the potential for lower-cost CCA to increase the Air Force's lethality, survivability, and capacity to conduct decisive counterair operations in highly contested environments. Such operations include offensive missions to defeat adversary fighters and airborne battle managers, as well as defensive missions to suppress threats like long-range SAM systems. An effective counterair campaign to achieve air superiority is an essential baseline requirement for any joint force operation, which is why it is an enduring core mission of the U.S. Air Force. However, due to previous DOD decisions to cap F-22 acquisition at 187 fighters—far short of requirements—and delay other modernization programs, the Air Force's air superiority forces now lack the sortie generation capacity, survivability, and lethality needed for a peer conflict. Requirements for air superiority forces in a defense of Taiwan scenario or other Indo-Pacific conflict with China in the next ten years could exceed the Air Force's current F-15C and F-22 combat-capable inventories by at least half.[9]

Study methodology. Insights and recommendations in this report are based on wargames led by the Mitchell Institute in 2022 and 2023, plus other analyses that explored the warfighting potential of CCA in a future campaign to defeat Chinese aggression. The purpose of the Mitchell wargame was to explore how large numbers of CCA operating with 5th and 6th generation crewed combat aircraft could increase the Air Force's counterair effectiveness and reduce risk to all U.S. forces in contested environments. The Air Force already recognizes the potential of this capability and has prioritized developing CCA as part of its Operational Imperative #4 Tactical Air Dominance initiative.[10] Informing Congress, defense industry, and the American public on the warfighting potential of CCA and the need to rapidly acquire them is another necessary step toward creating this innovative force design.

To this end, the Mitchell Institute led its second in a series of wargames that tasked Air Force and defense industry experts, scientists, and engineers to assess CCA operating concepts and capabilities for counterair missions during the first two weeks of a notional conflict with China. The wargame included China experts acting as an opposing red team to challenge the assumptions and priorities of U.S. blue teams acting as air operations planning cells. Three overarching insights from these teams help clarify how CCA could contribute to the Air Force's future force design:

- First, wargame experts agreed that **CCA should be additive and complimentary** to the service's next-generation crewed combat aircraft, not replace them. Both will be needed at scale in a peer conflict, given their respective attributes.

- Second, **new concepts are needed to operate CCA** with crewed and other uncrewed aircraft for counterair missions. Constraining CCA to only performing as adjuncts to crewed aircraft could limit their combat potential.

- And third, **CCA carrying air-to-air weapons should be designed with at least enough survivability and mission systems to ensure they will be able to complete their kill chains** in highly contested environments.

Other insights from this wargame are presented throughout this report to substantiate its recommendations for developing a CCA force that will disrupt and defeat Chinese operations to control the air. The report begins by characterizing the Air Force's current combat forces and why air superiority remains critical to the success of all joint force operations. It then describes how the PLA is preparing to challenge the entire cycle—from sortie generation to air engagements—of the Air Force's counterair operations. The next section addresses how CCA could help create a force design that can disrupt China's A2/AD operations and gain the air superiority needed to defeat a PLA offensive. Follow-on sections cover other wargame insights into how CCA could help mitigate U.S. counterair shortfalls by:

- Increasing the Air Force's capacity to project counterair "mass" over long ranges into highly contested environments.

- Improving the lethality of Air Force counterair aircraft and weapons at the campaign and engagement levels of operation.

- Enhancing the survivability of Air Force counterair forces in the air and on the ground to reduce attrition and increase risk tolerance and operational resiliency.

A final section addresses other force design considerations, such as the need to understand capability and cost tradeoffs that will maximize the effectiveness of a high-low mix of CCA, the need for innovative concepts for operating CCA with crewed and other uncrewed aircraft, and the potential to develop CCA with "just enough" autonomy to accomplish their missions. Designing CCA with sufficient range, payload, sensors, survivability, and autonomy to operate as uncrewed collaborative teams or as independent unmanned combat air vehicles (UCAVs) will drive their fundamental design requirements and unit costs. Many of these insights are suitable subjects for follow-on analyses.

Background: Years of Neglect Created a High-Risk Air Superiority Force

The U.S. Air Force is tasked to establish air superiority that allows all services the freedom of action to perform their roles and missions unimpeded by attacks from the air. Today, this hallmark of national power is at risk because of a failure to modernize the Air Force's air superiority forces to keep pace with China's rapid military build-up over the past 20 years. While other service branches like the Navy and Marine Corps operate fighters, they are allocated first and foremost to support the service's organic missions like fleet defense and Marine Air Ground Task Force operations. Their forces are not sized at a scale necessary to meet combatant command air superiority requirements. DOD defines air superiority as "that degree of dominance in the air battle by one force that permits the conduct of its operations at a given time and place without prohibitive interference from air and missile threats."[11] A military that can establish and maintain command of the air can operate at sea, on land, and in the air with far greater freedom of action and effectiveness than a military whose forces are constantly at risk of exposure, harassment, and destruction from air attacks.

The ability to achieve air superiority has long been the difference between success and failure in warfare. In 1940, Germany's Luftwaffe was directed to destroy the Royal Air Force's fighter forces and establish air superiority to pave the way for a potential invasion of England. The Luftwaffe's failure to achieve these objectives caused Germany to abandon its invasion plan. Contrast that with the early hours of the 1967 Six-Day War, when Israel's ability to achieve air superiority allowed its military to inflict chaos, paralysis, and heavy losses on the air forces arrayed against it. Nearly unopposed in the air, Israeli attack aircraft armed with cannons and rockets supported Israel's numerically inferior land forces to route the enemy's ground offensive. These lessons are not relegated to distant military history. Today, neither Ukraine nor Russia has air superiority in the skies over eastern Ukraine, and the predictable result is a slow and costly campaign of attrition.

Throughout its history, the Air Force constantly worked to develop new air superiority capabilities that would maintain its combat edge over emerging threats. In the late 1960s and early 1970s, the Air Force designed the F-15 fighter to counter the Soviet Union's air superiority forces. Work on the stealthy F-117 fighter-bomber also began in the 1970s, and while they were not dedicated air superiority assets, they were capable of offensive counterair operations, including strikes on C2 centers and other air defense sites. E-3 Sentry AWACS, equipped with a long-range radar and powerful communications suite, joined the active inventory in the 1970s. The Air Force also upgraded its RC-135 Rivet Joint aircraft to allow its onboard analysts to intercept hostile radar and communications signals, identify and exploit those signals on the fly, and then feed information to AWACS and other operations centers. In the early 1980s, the Air Force began to take delivery of its EC-130H Compass Call aircraft, an upgraded system to carry operators and equipment to jam enemy communications. These systems quickly proved that, operating in concert, they could provide a decisive air superiority advantage.

In the months before the 1991 Operation Desert Storm air campaign, some defense analysts predicted coalition air forces would suffer major losses from Iraqi defenses that included air interceptor aircraft and surface-to-air missiles provided by Russia. However, instead of suffering high attrition levels, the coalition air campaign achieved an overwhelming victory that is studied to this day by the world's air forces. This success was largely due to the Air Force's use of the advanced sensors, guided munitions, 4th generation fighters, and other cutting-edge systems it developed through the 1970s and 1980s. Although stealth technology grabbed the headlines, it was this combination of capabilities that proved pre-war attrition estimates wrong and limited U.S. air losses to a handful of aircraft. Coalition pilots and their controllers were aware of the locations and activities of Iraq's air forces, while Iraqi operators had no such information on their adversaries. The Air Force took advantage of its information dominance to disrupt and destroy Iraq's air forces with an unprecedented degree of precision. After Desert Storm, the Air Force intended to continue to modernize its air superiority force by developing the 5th generation F-22 air dominance fighter and new air-to-air weapons.[12]

The Air Force's Diminished Air Superiority Force

Despite the success of this technological offset, force structure and modernization program cuts after the Cold War rapidly eroded the Air Force's ability to dominate the air domain. Decisions made by DOD beginning in the early 1990s nearly froze the USAF's force modernization. In stark contrast, China created what is now the world's most sophisticated IADS. Thirty-three years after Desert Storm, the Air Force's dedicated air superiority forces still predominately consist of the same—albeit upgraded—fighters, mission systems, and weapons that first joined the force during the Cold War. This aging and undersized force will struggle to operate effectively in the highly contested environments that will exist during a conflict with China.

The aging and undersized U.S. force will struggle to operate effectively in the highly contested environments that will exist during a conflict with China.

Consider basic combat aircraft mission rotation math—one-third of a deployed inventory of a combat aircraft will be executing missions; another third is returning to their airbases; the remainder is getting ready to launch on their next missions. Applying those numbers to the Air Force's F-22 inventory illustrates how a U.S. combatant commander could have only a handful of these stealthy fighters ready for missions at any given time—assuming the entire F-22 force is deployed to the fight, none are down for maintenance, and there is no combat attrition. With about 100 combat-coded F-22s in the force, those numbers would work out to about 30 F-22s on station in the battlespace at any given point in time. Attempting to stretch 30 F-22s across a region as vast as the Western Pacific makes it clear that capping F-22 acquisition well short of requirements was a radical decision.[13]

Breaking the force. The Soviet Union's dissolution and economic implosion removed the pacing threat the U.S. military used during the Cold War to size and shape its forces. During its 1993 Bottom-Up Review, the DOD determined its new pacing challenge should be preparing to defeat two lower-tier regional adversaries nearly simultaneously by operating much as it had during Operation Desert Storm.

One of DOD's first actions to match its forces with this reduced challenge was to divest a significant percentage of its existing forces, including the Air Force's fighters—first by accelerating the retirement of Vietnam-era capabilities like F-4s and then early model F-16s. DOD also directed the Air Force to reduce its acquisition of the stealthy F-22, the foundation of its future air superiority force. The Air Force originally planned to buy 750 F-22s, which was close to a one-for-one replacement of its F-15A/B/C/D inventory. The Bottom-Up Review reduced this target to 442 F-22s, and the 1997 Quadrennial Defense Review further cut it to 339 fighters (later changed to 381 aircraft). These cuts were driven by DOD's overly optimistic projections for a far narrower scope of missions and its desire to achieve a post-Cold War defense budget peace dividend by reducing spending.

Post-9/11: A hollow defense build-up. DOD again shifted its force design priorities in response to the 2001 terrorist attacks on the United States. Increases in defense spending in the 2000s and much of the 2010s were mostly allocated toward acquiring capabilities to sustain the Army's counterinsurgency/counterterrorism operations, not acquiring new capabilities for peer conflict. DOD directed the other services to invest their smaller budget plus-ups in capabilities like remotely piloted aircraft (RPA) to support these ongoing operations.

The F-22 fell victim once again to these changing priorities. In 2008, Secretary of Defense Robert Gates decided to end the F-22 program after the Air Force acquired only 187 total tails. This was based on his reasoning that F-22s were not needed for current operations, and F-35s then in development would provide sufficient overmatch in the future.[14] Gates also stated his belief that China would not have a single stealth fighter before 2020, by which time, according to contemporary plans, the Air Force would have taken delivery of 400 F-35s and would be buying 80 more per year.[15] Other new air superiority systems, including an improved version of AIM-9X, a comprehensive refit for F-16s, and a replacement for aging E-3 AWACS, were also washed out of DOD's budgets.

These decisions were made despite contemporary warnings of their impact on the force. "We have a geriatric Air Force," remarked Lt Gen Dave Deptula, USAF (Ret.), in early 2012. "Our fighters are falling out of the sky because we're putting more hours and years on them than they were designed for."[16] Resources needed to reverse this trend were simply not provided to the Air Force. According to independent defense industry analyst Richard Aboulafia, "The military had this tremendous increase in defense spending, but it all went to body armor and [mine-resistant ambush-protected vehicles]. It was all Iraq and Afghanistan, rather than actual technology."[17]

The Air Force's current air superiority force. The Air Force's dedicated air superiority fighter inventory now consists primarily of 179 aging 4th generation F-15C/Ds and 185 5th generation F-22s. Roughly 20 percent of these F-22s are training, test, or backup inventory aircraft that are not combat-coded and assigned to combat-ready squadrons. The service's slowly expanding F-35 force is also capable of offensive and defensive counterair operations, including airborne electronic attacks and air-to-air engagements. The Air Force had only 272 F-35As in its inventory by 2020, and in calendar year 2023, it received about half of the 80 F-35As it had originally planned to acquire annually—again, in large part due to inadequate

budgets.[18] These forces are supported by E-3B/G AWACS that are in their 4th decade of service. In early 2023, the Air Force awarded a contract for an AWACS replacement that is based on the E-7 "Wedgetail" aircraft acquired by Australia and the United Kingdom.[19]

Overall, the Air Force's dedicated air superiority force has long surpassed the brink of inadequacy. The bulk of this force consists of fighters designed and fielded decades ago that must soon be retired because of their age and history of high sustained use rates. As Gen Mark Kelly explained in mid-2023, "We literally ate the muscle tissue of the Air Force in the form of reduced fighter capacity, reduced readiness, putting hard miles on older aircraft, driving more extensive sustainment efforts."[20] The lack of fighter capacity due to aging aircraft and other factors is why the Air Force was forced to withdraw F-15C/Ds from the strategically vital Kadena Air Base in Okinawa in late 2022 without direct, permanently assigned backfill aircraft.

These shortfalls cannot be fixed by reverting to the same half-measures the Air Force has relied on since Operation Desert Storm: funding modifications to further extend the lives of its aging aircraft. In 2023, Air Force leaders testified, "The 179 F-15C/Ds in the Air Force's inventory will reach the end of their design service life in the next five to seven years, and our analysis shows additional service life extension programs are not cost-effective."[21] The Air Force's NGAD family of systems will be critical to maintaining its combat edge over China, but the crewed component of NGAD may not be available in significant numbers until the 2030s.[22]

There are additional options. Provided with adequate resources, the Air Force could begin fielding another part of the NGAD family of systems—AI-enabled CCA—and maximize F-35A acquisition in the next Future Years Defense Program (FYDP). Both actions would reduce risk this decade. General Kelly has noted there is no time to waste since "extensive analysis unambiguously shows that the current fighter fleet will not succeed," and the Air Force "must change now to provide the capability and capacity in the most affordable way in tightly constrained budgets to meet the peer threat"—a threat that is evolving far too swiftly for comfort.[23]

The Rise of China's Air Superiority Forces

China's Asymmetric Strategy for Success

Lessons learned from successful coalition operations against Iraq in 1991 did not go unnoticed by America's strategic competitors. The Defense Intelligence Agency has reported that Operation Desert Storm clearly demonstrated the "lethal effectiveness of information-enabled weapons and forces, particularly mobility and precision-strike capabilities."[24] This effectiveness caused China to initiate a rapid military modernization program that was fueled by its growing economy. Aware of its military's shortcomings, China funded technological investments to create "a leaner, more mobile force" to take advantage of the U.S. military's weaknesses and "deny U.S. forces access and freedom of action" in the Western Pacific.[25]

Whereas the U.S. Air Force's investments in advanced technologies during the 1970s and 1980s produced new aircraft, guided munitions, and other combat systems that proved highly effective in Operation Desert Storm, China is fully aware that many of those same capabilities are still in active service today. They also understand that those systems have exceeded their planned operational lives, and their inventories are too small and lack attrition reserves. The Air Force's combat aircraft inventories are so limited that the service may have to operate them in "pulses" once or twice a day instead of maintaining constant pressure on PLA forces assaulting Taiwan. This can create opportunities in space and time that advantage China. These are critical shortfalls, especially since it would take years or even decades to regenerate our force of sophisticated aircraft and their experienced crews should they be lost in combat.

Moreover, the Air Force's fighter forces also require the support of extensive C3ISR networks, aerial refueling to extend their ranges, and access to bases in the Western Pacific. These requirements are critical to overcoming the tyranny of distance in the vast Indo-Pacific theater. China understands the U.S. military's limitations and has tailored its warfighting strategy and counter-intervention system of systems to take advantage of them by:

- Quickly achieving a dominant position in the battlespace before U.S. and allied military reinforcements can deploy from their homelands and other locations to engage in combat.

- Inflicting loss rates on U.S. air forces that are unacceptable: in the air by using advanced forces such as long-range J-20 counterair fighters carrying advanced air-to-air missiles and on the ground by directly attacking U.S. and allied theater airbases.

- Focusing attacks on the lowest number, hardest-to-replace U.S. air assets. This can be seen in the PLA's investments in weapons designed to attack U.S. aircraft carriers and high-value airborne assets (HVAA) like AWACS.

- Degrading U.S. airborne battle management and command and control networks and other means to gain information dominance.

- Degrading U.S. sortie generation operations by striking U.S. theater airbases and ground support capabilities. Another PLA airbase attack objective is to compel opposing air forces to reposition their high-value assets from the Pacific's First Island Chain to more distant bases, increasing the ranges they must fly to the battlespace and reducing their sortie rates.

- Taking full advantage of China's "interior lines" to make the PLA's own high-value assets high-risk targets for U.S. forces. For example, the PLAAF's KJ-500 radar systems provide threat warnings and target cues to long-range air defenses on the PLA Navy's surface action groups (SAG). In turn, these SAGs provide an outer layer of defenses for PLA forces operating in the Taiwan Strait.

In short, China has long recognized the decisive nature of airpower and the need to achieve air superiority.

China's Air Superiority Forces

China's fighter force. A vital element of China's military modernization was its development of new air superiority capabilities like the 4th generation J-16, 5th generation J-20 Mighty Dragon stealthy fighter, and advanced air-to-air missiles. The Shenyang J-16 is a derivative of Russia's Su-30 upgraded with an active electronically scanned array (AESA) radar, composite materials for reduced weight, and the ability to carry indigenous Chinese PGMs.[26] The J-20 serves as a long-range stealth interceptor designed to keep U.S. 5th generation fighters at bay. As a Royal United Services Institute (RUSI) report explains, the J-20's "combination of passive sensors, AESA radar, [low observable] features, range on internal fuel, and long-range missiles make the J-20 a qualitatively greater threat than any previous non-Western combat aircraft."[27]

The PLA also operates older combat aircraft designs like the J-6 fighter. China has equipped some of its J-6swith automatic guidance and control systems so they can be used as decoys to draw fire from other Chinese aircraft that can be detected.

China's air-breathing long-range kill chain capabilities. China developed the KJ-500 AEW&C aircraft to maximize the lethality of its fighter fleet. Based on a distant derivative of the Ukraine-built Antonov An-12, China is acquiring KJ-500s in far greater numbers than its previous AEW&C designs. Like the E-7 Wedgetail, KJ-500s have an AESA that is more capable than the E-3's radar. This allows KJ-500s to act as a targeting system for long-range air-to-air missile engagements. General Kenneth Wilsbach, Commander of the U.S. Pacific Air Forces (PACAF), noted, "The KJ-500... plays a significant role in some of [China's] capability for long-range fires," which is why interrupting that kill chain is a high priority for PACAF.[28]

The tip of the spear in China's long-range kill chain is a new generation of air-to-air missiles that are among the most lethal in the world. According to RUSI, "China has approached parity with Western equivalents [of air-to-air missiles], even exceeding parity in some areas."[29] These missiles include the PL-15, an active radar-guided missile with a range comparable to or greater than the AIM-120D, which is the standard air superiority munition across the U.S. military.[30] Notably, PL-15s were designed to be carried internally by the J-20, a prerequisite for stealthy aircraft to maintain their low observability. The PLA developed its PL-17

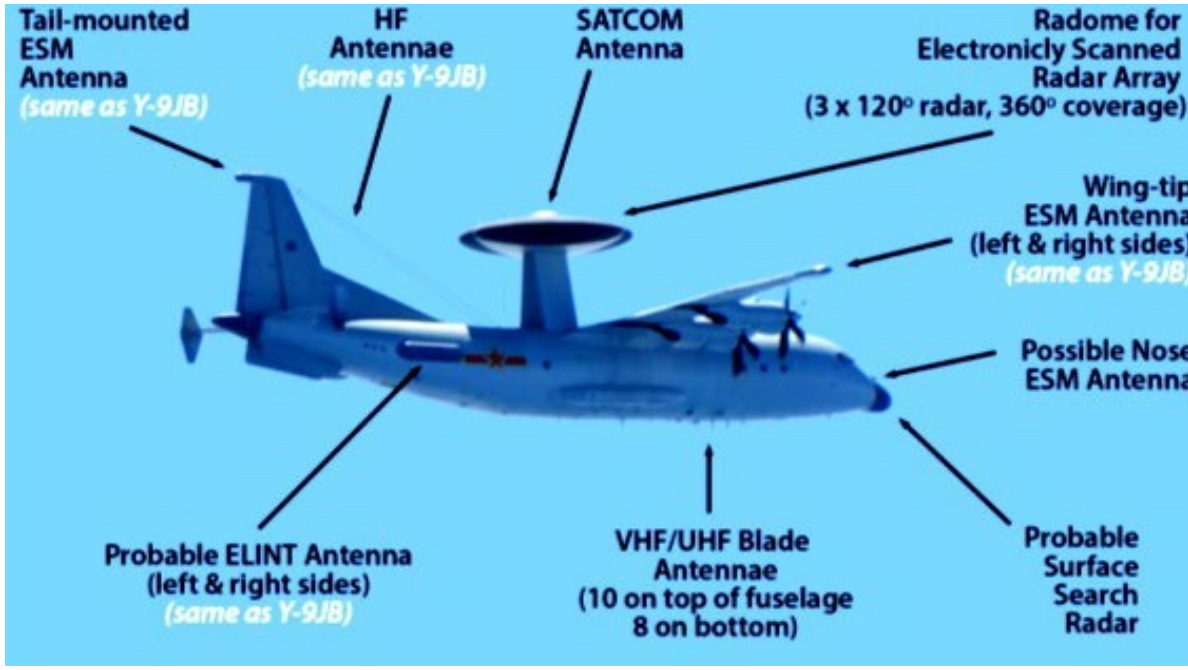

Figure 1: KJ-500 airborne early warning and control aircraft.

Source: J. Michael Dahm, Special Mission Aircraft and Unmanned Systems (Laurel, MD: Johns Hopkins University Applied Physics Laboratory, 2020), p. 9.

air-to-air missile specifically for long-range intercepts of HVAA. Far larger than the PL-15, this missile has an estimated range of215 nm.[31] J-16s carrying PL-15s and PL-17s are prepared to attack Air Force HVAA, including the aerial refueling tankers U.S. fighters depend on to increase their range.

China's land- and sea-based counterair capabilities. In 2015, President Xi Jinping directed reforms that accelerated China's military modernization. Although these reforms favored the PLA Rocket Forces and PLAN over the PLA Air Force, much of the subsequent investments focused on capabilities to defeat enemy air forces. U.S. defense analysts have rightly expressed concern over the rapid expansion and modernization of the PLAN's surface combatant fleet, but they often overlook that many of its modern warships are primarily poised as anti-air warfare (AAW) weapons. The largest and most costly sensors on these ships, around which the vessels are designed, are dedicated to anti-air and anti-missile warfare (see Figure 2).

The firepower of modern warships is also measured in the capacity of their missile launch system and weapons magazine. While the PLAN has fielded VLS-launched YJ-18A anti-ship cruise missiles (ASCM), most VLS tubes on its surface combatants are now loaded with SAMs. Since 2020, the PLA Navy has commissioned new Type 055 *Renhai*-class guided missile ships that are 75 percent larger than Type 052D destroyers and have 112 vertical launch system (VLS) tubes. Eight out of the PLAN's planned sixteen Type 055 heavy destroyers are in service, and its 27th and 28th Type 052D destroyers launched in March 2023. These capabilities present a formidable threat to non-stealthy combat aircraft.

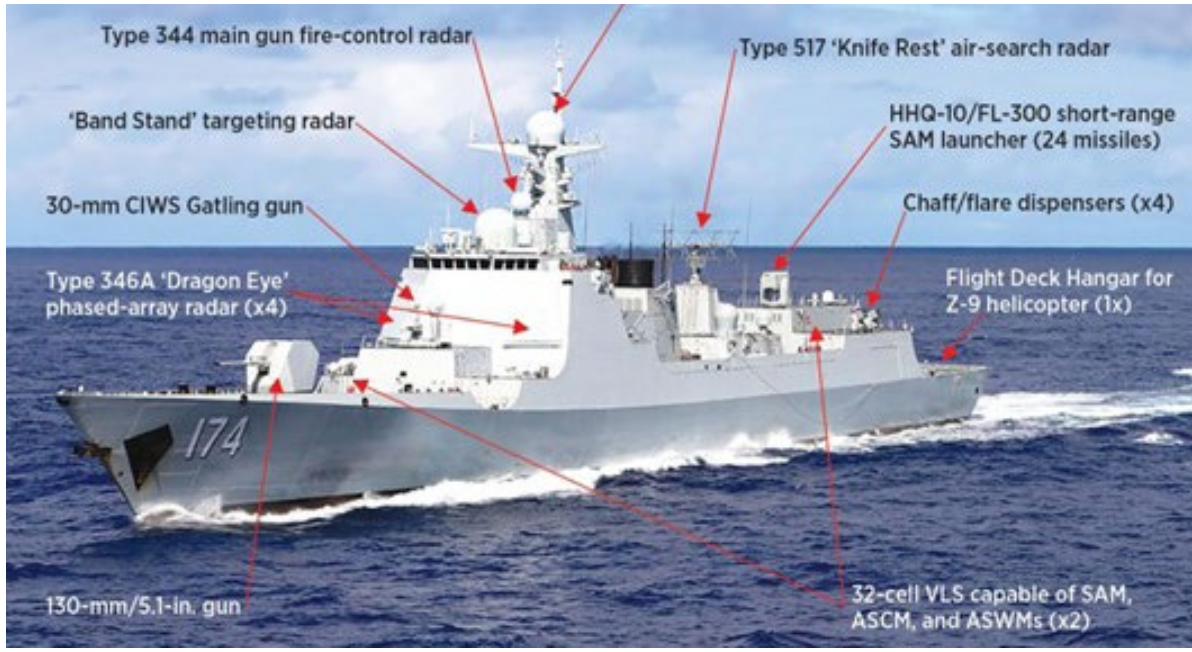

Figure 2: Type 052D *Luyang* III class destroyer. The PLAN's primary AAW sensor is the Type 346 radar—known to NATO as the Dragon Eye—which is installed on its Type 052C *Luyang* II-class destroyers. These destroyers are also armed with long-range HHQ-9 SAMs that are variants of the Russian Almaz-Antey S-300. A larger, follow-on Type 052D *Luyang* III-class of destroyers have upgraded Type 346A Dragon Eye radars and are equipped with 64 rather than 48 VLS tubes.

Source: PRC Ministry of National Defense, as cited by Eric Wertheim, "China's *Luyang* III/Type 052D Destroyer Is a Potent Adversary," *Proceedings*, January 2020.

Airbase attacks. China is preparing to use its growing bomber and missile forces to launch offensive counterair strikes against U.S. and Allied theater airbases—a key reason behind the Air Force's decision to develop uncrewed aircraft capable of operating without runways. China's Xian company continues to produce its H-6 series of bombers, which are derived from the Russian Tu-16—a contemporary of the U.S. B-52 bomber—and have more efficient engines and a new forward fuselage. H-6s can launch up to six long-range land-attack cruise missiles per sortie. The PLA also relies heavily on ballistic and cruise missiles supported by a network of reconnaissance satellites to locate and target U.S. bases and forces on the ground and at sea out to the Pacific's Second Island Chain.

The U.S. Air Force has the Responsibility

Under the Title X statute, the task of providing air superiority for *all* joint force operations within the U.S. military falls to the Air Force. While the Navy and Marine Corps also operate counterair forces, their primary assignment is to support their service-specific missions. This will be a high-risk endeavor for the Air Force during a conflict with China, given the inadequate size of the service's air superiority forces and related operational limitations. Increasing the Air Force's force capacity is part of the answer, but another part is to take a page out of China's playbook and develop capabilities and operational concepts that will disrupt China's counterair operations. This is the promise of a force of CCA that is capable of collaboratively operating with 5th and future 6th generation combat aircraft.

Throwing China Off Its Gameplan

The Need to Disrupt China's Counterair Operations

China's modernized IADS present an unprecedented challenge to the U.S. military's ability to maintain its freedom of access and exploit the air to defend America's vital interests in the Indo-Pacific. Even more troubling, the PLA will soon field additional advanced capabilities, such as stealthy J-31 fighters and its next generation of surface-to-air and air-to-air missiles that will further extend the ranges at which it can attack U.S. aircraft. This heightens the need for the Air Force to find ways to defeat China's efforts to control the air.

A key objective of the *U.S. National Defense Strategy* is to deter China by creating a force capable of denying the PLA the ability to achieve its campaign objectives rapidly. The United States cannot afford to adopt a warfighting strategy and force design that seek to match China aircraft for aircraft, missile for missile, or ship for ship. Even if it were a desirable approach, DOD will not have the resources—budget and personnel—or the time to do so. Enabling U.S. forces to gain and maintain air superiority in the Western Pacific when and where needed will require employing novel, asymmetric capabilities to disrupt, degrade, and suppress China's IADS.

Assault Breaker, a Cold War precedent. The Defense Advanced Research Projects Agency (DARPA) Assault Breaker initiative of the late 1970s and 1980s is a historic parallel. Net assessments of the time indicated the U.S. military could not match the Warsaw Pact's massive advantage in heavy artillery and armored forces postured within easy reach of the border between West and East Germany. This advantage threatened to give the Warsaw Pact the ability to attack Central Europe with little warning and gain the upper hand against NATO's forces.

DARPA launched its Assault Breaker initiative to develop a reconnaissance-strike complex based on precision-guided weapons, stealth aircraft technologies, powerful airborne radars and other ISR systems, and a battle management and control network.[32] The principal targets for this reconnaissance-strike complex were logistics support for the Warsaw Pact's first echelon forces, followed by second-echelon armored forces moving forward in dense convoys to exploit the first echelon's advance. Assault Breaker envisioned using long-range radars to detect and track these targets and then attack them with guided missiles and rockets capable of dispensing showers of submunitions. These attacks would disrupt a Warsaw Pact assault and use its mass and momentum against it. A first echelon of Warsaw Pact forces would have no alternative but to continue to move forward as Assault Breaker capabilities attacked its follow-on forces and logistics "before they could reinforce the first wave of any Soviet attack."[33]

Assault Breaker achieved its objective of developing capabilities that weakened Soviet confidence in its ability to achieve a quick and decisive victory in Central Europe.[34] In a series of essays in *Red Star* and other official Soviet journals, Marshal Nikolai Ogarkov, who was appointed chief of the Red Army general staff in 1977, bluntly warned that the development of NATO non-nuclear weapons capable of inflicting mass destruction at long ranges threatened to undermine long-standing Soviet warfighting doctrine and plans.

Why Denial?

For the purposes of this report, a Chinese *fait accompli* refers to a successful PLA campaign to rapidly seize territory along the periphery of China before the U.S. military can effectively intervene. A successful *fait accompli* invasion of Taiwan would leave the United States with the choice of either acquiescing to the new status quo or launching a counteroffensive to evict occupying forces that would be so massive it risks escalating the conflict to an unacceptable level. Both choices would result in devastating long-term consequences for U.S. security.

The Third Offset Strategy. Developing disruptive, game-changing capabilities was also an objective of the Third Offset Strategy initiated by DOD during the Obama administration. A driver behind this strategy was the threat from emerging A2/AD threats that included extensive, multi-layer surveillance systems and long-range anti-ship, anti-air, and land attack weapons. DOD envisioned a Third Offset force that would rely heavily on new systems to defeat a peer adversary's campaign plan like long-range weapons to strike moving targets, next-generation uncrewed capabilities, and a new penetrating bomber now known as the B-21 Raider.[35]

A new U.S. theory of victory: Denying a Chinese *fait accompli*. In 2018, DOD released a revised *National Defense Strategy* that established "defeating a Chinese *fait accompli* military campaign to seize Taiwan or another area in the Indo-Pacific" as its new pacing threat for sizing and shaping the U.S. military.[36] According to Elbridge A. Colby, lead architect of the strategy, "wars with China or Russia must remain limited because the alternative is apocalypse, which neither side wants—thus we must plan and prepare for them as limited wars. Above all, this requires focusing on defeating the other side's theory of victory, and particularly the *fait accompli* strategy."[37] This will require a force that is "exceptionally lethal and capable, optimized to defeat China or Russia."[38]

This theory of victory mirrors the logic behind Assault Breaker and the Third Offset Strategy: A U.S. military that has the capability to deny an adversary the confidence that its campaign plan will be successful will pose a credible deterrent.

China may be susceptible to this deterrence by denial approach. One of China's highest priorities is to "reunify" the Chinese nation by annexing or invading its so-called province of Taiwan. Doing so by military means will require a massive operation to land, expand, and sustain forces in Taiwan by sea and by air in the face of resistance. China's leaders will not seriously contemplate this action unless they are convinced it will be successful. However, a major amphibious invasion of Taiwan cannot be launched with any degree of surprise. A military with a competent ISR network covering the region will have an idea of when a PLA amphibious force is marshaling for action, where it will come from, and where it will land. Concealing amphibious forces marshaling at a limited number of ports and enroute to a landing is impossible, and these forces must land on large, unobstructed beaches that have vehicular access to a road system—all of which a defender will have identified in advance. Plus, landing craft, amphibious vehicles, and slow-moving docking ships are not agile and easy to conceal, and they cannot be made so.[39]

This means Chinese forces assaulting Taiwan will be vulnerable to precision airstrikes. It also means the Air Force must be prepared to respond within hours to prevent PLA forces from achieving a lodgment in Taiwan. Only Air Force bombers and stealthy fighters will have the range, persistence, and survivability to find and attack large numbers of amphibious ships, surface action groups, mobile SAMs, and other PLA assault forces.

Other strike platforms, like the Navy's aircraft carriers, may have to stand off up to 1,500 nm from the Taiwan Strait to reduce the threat of Chinese anti-ship missile attacks. These distances significantly exceed the combat radius of their embarked fighters, and this would reduce the potential for carriers to attack targets in the Taiwan Strait. Moreover, many carrier fighters will be dedicated to the "outer air battle" to defend their carriers against PLAAF bombers carrying anti-ship cruise missiles.[40] Navy surface ships and attack submarines will also have a role to play, but their limited onboard weapons magazines could be depleted after a few days of high-intensity conflict. In the case of ships, a good part of their magazines consists of purely defensive weapons to counter missile attacks. Both must return to secure ports to replenish their magazines since they cannot do this at sea, and suitable ports in the Pacific theater will be threatened by Chinese air and missile attacks. This means ships and submarines could be out of the fight for weeks at a time, unlike Air Force fighters and bombers that can regenerate and fly their next sorties within hours of returning to their airbases.

High demand for Air Force strike forces in a defense of Taiwan scenario will place a massive premium on its ability to achieve air superiority in the conflict's opening days and through its conclusion. Like the Air Force's other combat forces, its air superiority aircraft must have the range, sortie generation capacity, lethality, and survivability to prevail against China's counterair system of systems. These are keystone requirements. Without air superiority, other essential components of the joint force employed by a combatant commander will not be viable. To develop this air superiority force, the Air Force should take a page out of Assault Breaker's book and prioritize asymmetric capabilities that will disrupt China's campaign and forces instead of attempting to out-build the PLA. For air superiority, these asymmetric capabilities include 5th and 6th generation aircraft complemented by a family of uncrewed CCA.

The rapid maturation of CCA technologies has created an opportunity for the Air Force to develop a new force design that disrupts China's way of war and do so quicker and for a lower cost than trying to symmetrically match China's forces.

CCA Can Help the Air Force to Create a Disruptive Force Design

The rapid maturation of CCA technologies has created an opportunity for the Air Force to develop a new force design that disrupts China's way of war and does so quicker and for a lower cost than trying to match China's forces symmetrically.

Understanding what is meant by "collaborative" is important to fully appreciate the potential of CCA. AI-enabled CCA should be capable of collaboratively operating with other crewed *and uncrewed* aircraft to share threat information, their own locations, and fuel and weapons status across a force package. Future

CCA could even be designed to autonomously assign targets to aircraft within a mission package to achieve the best weapons-to-target pairings. This means a CCA might detect and identify a target but determine it is not best positioned or best equipped to attack. In this case, it could pass off information to an uncrewed airborne mission manager, which then assigns the target to another CCA in the flight.[41]

Mitchell Institute's 2023 wargame and related assessments indicate there is significant potential for a CCA-enabled force to flip the PLA's warfighting approach against itself. The wargame's three teams of experts anticipated that aircraft attacking China's undegraded IADS would suffer severe loss rates. Rather than responding with caution and reserve, the teams employed large numbers of CCA as lead forces at the start of operations to counter the PLA's air defenses. Although many of these CCA would be expended, they could force the adversary to contend with a more complex, diverse threat and to react in ways that expose them to attacks.

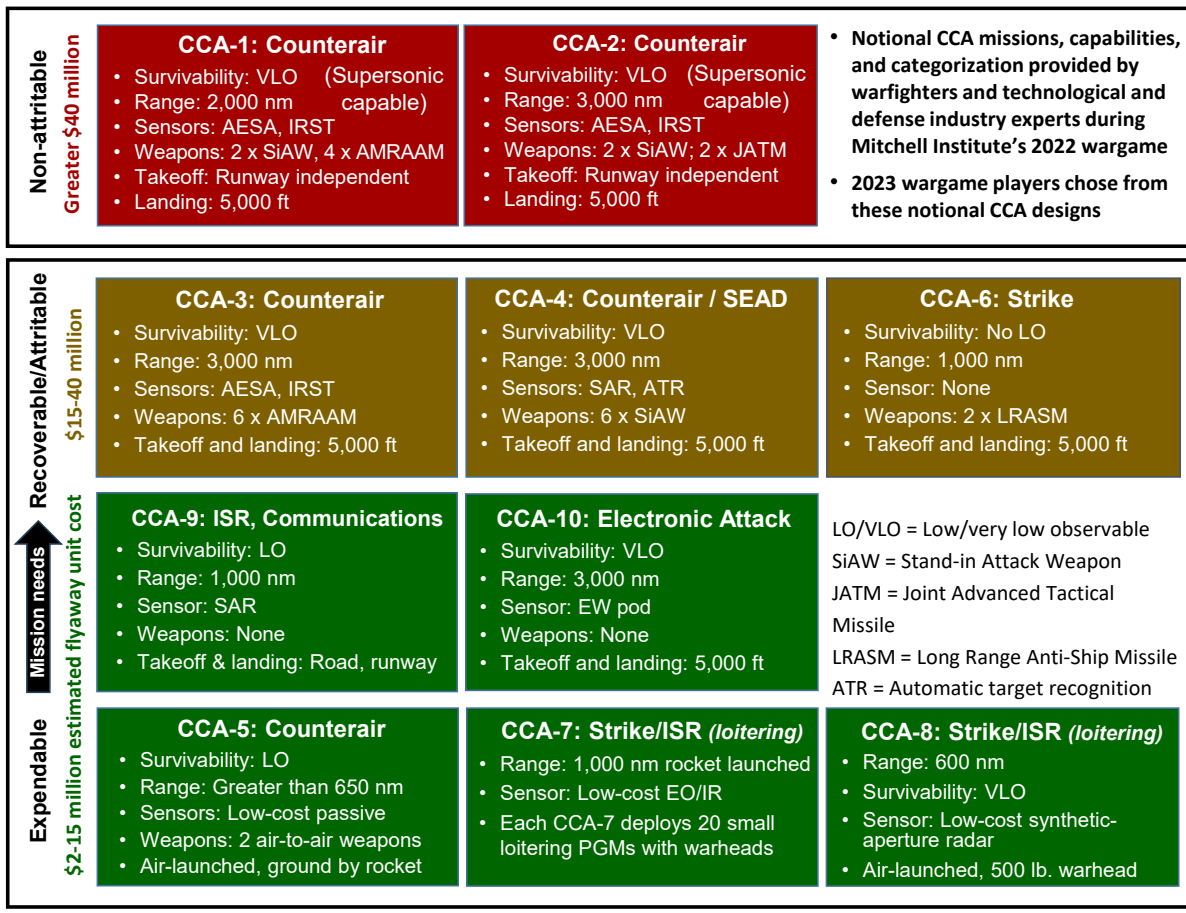

Figure 3: Operators, scientists, and engineers playing Mitchell Institute's 2023 wargame could choose from ten notional CCA to plan counterair missions for a 2030 China-Taiwan conflict scenario. It was necessary to bound the CCA design space for wargame players for a practical reason: they did not have time to create their own designs. "Sensors" in Figure 3 include AESA, infrared search and track (IRST) systems, and electro-optical/infrared systems (EO/IR). These and other systems are included in rough order of magnitude CCA flyaway costs developed during Mitchell Institute's 2022 wargame.[50]

Source: Mitchell Institute graphic.

Within limitations imposed by Mitchell, each wargame blue team was asked to choose from a mix of 4th and 5th generation fighters, MQ-9 RPAs, and ten notional CCA types derived from Mitchell Institute's 2022 CCA wargame to plan their assigned counterair missions (see Figure 3).

These notional designs include familiar types of uncrewed aircraft as well as more radical concepts, such as air-launched rockets that can fly long ranges before dispensing small, electrically powered loitering munitions on targets. Another takeaway is the potential to design CCA with lower unit costs than crewed aircraft for several reasons:

- The mass, volume, support systems, and other design requirements created by the need for a cockpit and pilot are eliminated in CCA. Cockpits impose a minimum cross-section size near the front of an aircraft's fuselage, in turn setting a minimum length, size, and mass for a vehicle capable of flight at transonic speeds.

- Flight at supersonic speeds and high-energy maneuverability required for modern fighters are not needed for CCA unless they are designed for close-in air-to-air combat. Supersonic speed increases fuel consumption, and the ability to sustain turns at 7–9Gs requires a much heavier structure and a larger wing. A design rule-of-thumb is that a subsonic, low-G aircraft can match the combat weapon loads and mission radius of a supersonic fighter at half the operational empty weight and engine thrust.

- CCA can be designed to be replaced quickly as technology evolves. They also do not need to fly frequently to maintain pilot proficiency—the reason for most crewed aircraft flight hours. Many design features of crewed combat aircraft, such as specialized surface treatments and engine components, are driven by the requirement to endure decades of service life and thousands of flight cycles.

Although the CCA force mixes chosen by the wargame blue teams varied due to their different counterair missions, they all reflected an overarching desire to use CCA in ways that would first disrupt and then suppress the PLA's air defenses. This was the single most important insight from the wargame.

Wargame Example 1: Using CCA for Disruptive Counterair "Sweep" Operations

One blue team played a counterair planning cell tasked to suppress PLA fighters and KJ-500s in advance of a pulse of U.S. penetrating aircraft attacking maritime and coastal ground targets. The team's theory of success for their first few days of "sweep" operations relied on first using large numbers of expendable and recoverable/attritable CCA variants as lead forces to **overwhelm, disorient, and disrupt the PLA's air defenses**, followed by a second wave of F-22s and F-35s operating collaboratively with CCA to attack airborne threats. In other words, the sweep team's overarching objective was to first disrupt and then attrit the PLA's air defenses using CCA as a lead force before employing crewed combat aircraft at scale. Based on their threat assessment, the team's first order of battle was "attacking the KJ-500s—peeling back the enemy's long-range kill chain" to reduce risk to E-7As and follow-on crewed fighters penetrating contested areas. The sweep team also used CCA to suppress high-powered, long-range (but horizon-limited) Dragon Eye radars on PLAN destroyers screening the Taiwan Strait.

The sweep team based this plan on their assessment of the Air Force's geographic, operational, and logistical disadvantages in a fight with China. U.S. air assets are expeditionary and must operate over long ranges from their Pacific airbases, while the PLAAF can stage from airbases adjacent to the Taiwan Strait. This range disparity creates multiple advantages for the PLAAF, including advantages in commanding and controlling its forces, projecting superior combat mass into the battlespace, and reducing the time needed to recover and regenerate aircraft for their next sortie. Moreover, U.S. E-7s and other HVAA that must operate 600–800 nm from the Taiwan Strait to avoid Chinese threats will be dependent on data transmitted over datalinks by penetrating aircraft and overhead sensors. The PLA will attempt to jam these datalinks and use its long-range air-to-air missiles cued by KJ-500s to attack the Air Force's airborne battle managers. On the other hand, the team assessed the PLA's command and control operations would be inflexible and constrain their echelon forces from exercising initiative.

Phase 1, a "Brawler Pulse" of counterair forces. The sweep mission team called their first phase of counterair operations a Brawler Pulse (see Figure 4). The team planned to use 110 CCA-5s and 30 CCA-10s as lead forces during this pulse to achieve a kill shot advantage over PLA air superiority aircraft and create multiple airborne tracks to sow confusion and dilute the PLA's defensive responses.

Notional CCA-5 class aircraft employed by the sweep team are air-launched, about the size of long-range cruise missiles, fly at subsonic speeds, and carry two air-to-air missiles each. While the notional CCA-5 had a range greater than 650 nm after launch, wargame teams discussed the value of extending its range to 1,000 nm to increase stand-off distances for its non-stealthy launching aircraft or increase the CCA's loiter time in engagement areas. Since CCA-5s lack landing gear, the sweep team launched them from B-52 bombers and F-15EX fighters. The team also planned to use C-130s to emplace CCA-5 ground-launched variants at sites in the Southern Philippines, Palau, and Japan, reasoning this dispersed posture would reduce strains on U.S. main operating bases and increase locations the PLA would have to attack to suppress Air Force combat sortie generation. The sweep team assumed Brawler Pulse CCA-5s operating in highly contested airspace would be expended on targets or attritted by enemy defenses.

The team planned to program some of their Brawler Pulse CCA to collaboratively perform as a multi-static network of passive sensors that would detect and identify targets and then share their data with other mission aircraft. Other Brawler Pulse CCA would create persistent "aerial minefields" for KJ-500s or operate as four-ship decoys resembling crewed aircraft formations to stimulate PLA air defenses, cause them to reveal their locations, and then waste their weapons. If required, CCA that had expended their weapons or had insufficient fuel to recover could be used as guided projectiles to strike targets. The team also planned to follow their CCA pulses by launching AGM-158C Long Range Anti-Ship Missiles (LRASMs) from B-52s and other aircraft against high-value SAG targets located by CCA.

The sweep team's Brawler Pulse command and control concept centered on using unarmed long-endurance CCA-10 class UAVs and MQ-9 Reapers as relays to pass data between E-7A Wedgetails operating outside contested airspace and penetrating crewed and uncrewed mission aircraft. CCA in the Brawler Pulse were also expected to seek and attack targets with human-on-the-loop supervision. This means the CCA would be cleared to attack targets after their human controllers reviewed their sensor data, which is why the

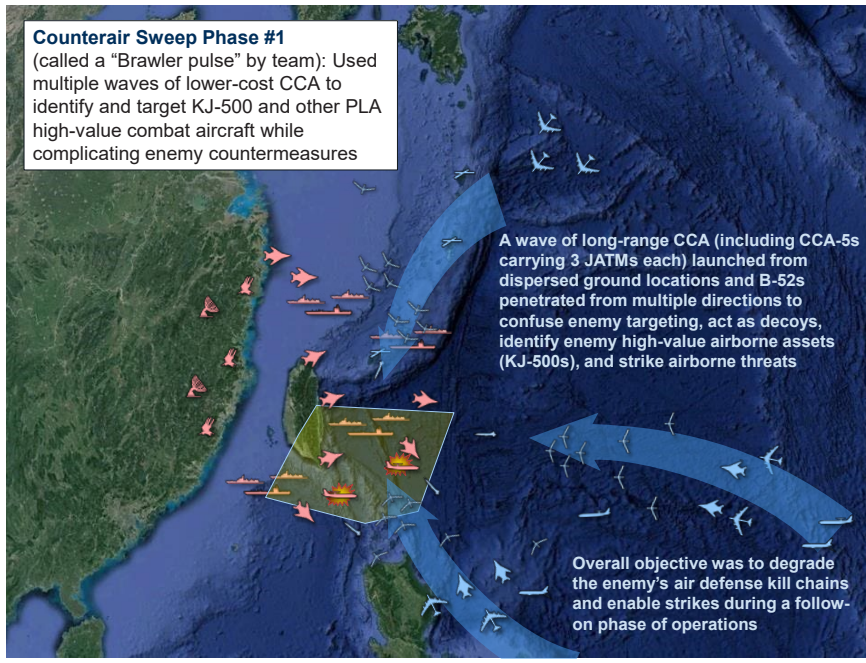

Figure 4: Sweep Phase 1 "Brawler Pulse" CONOPS. To gain the degree of air superiority needed to support follow-on Allied strike operations, the sweep mission team used large numbers of expendable CCA to disrupt, confuse, and overwhelm the PLA's air defenses; stimulate threats; soak up enemy shots; and identify targets for follow-on 5th generation fighter and CCA attacks.

Source: Mitchell Institute graphic.

team dubbed these CCA as "Brawlers." The team also engaged in considerable discussion on if, and when, future counterair CCA should be allowed to go autonomous, a decision they likened to "launching an AMRAAM with a booster" toward a beyond visual range target. In this mode, CCA could continue to operate in an engagement area until they found a target or were attritted.

Phase 2, an "Exquisite Pulse" of counterair forces. In the second, "Exquisite Pulse" phase of operations, the sweep team shifted toward using notional uncrewed CCA-3s, which are subsonic, stealthy, have a range of about 3,000 nm, and can be runway launched and recovered. Notional CCA-3s could each carry six AMRAAMs—as many as an F-22 or F-35—and have AESA radar and infrared search and track sensors. The team planned to program these CCA to perform as pickets and air patrols in advance of stealthy fighters during attacks on KJ-500s, SAGs, and opposing fighters. This would compel threats to react and direct their shots at CCA instead of crewed aircraft. Given their long range and mission persistence, CCA-3s could also be used to maintain constant pressure on the PLA's air defenses between U.S. strike pulses.

The sweep team organized these forces into multiple lines of attack that penetrated the operating area. A four-ship of F-22s and eight CCA-3s would fly one main line of attack, and an eight-ship of F-35s and 16 CCA-3s would fly a second line. These lines of attack would be supported by decoy CCA programmed to mimic the two main lines to complicate and disrupt the enemy's defensive operations. All attacking aircraft remained within line of sight of one another, making it difficult for adversary forces to jam their communications. E-7s, CCA-10s, and MQ-9s continued to provide sensing and C2 support to attacking forces.

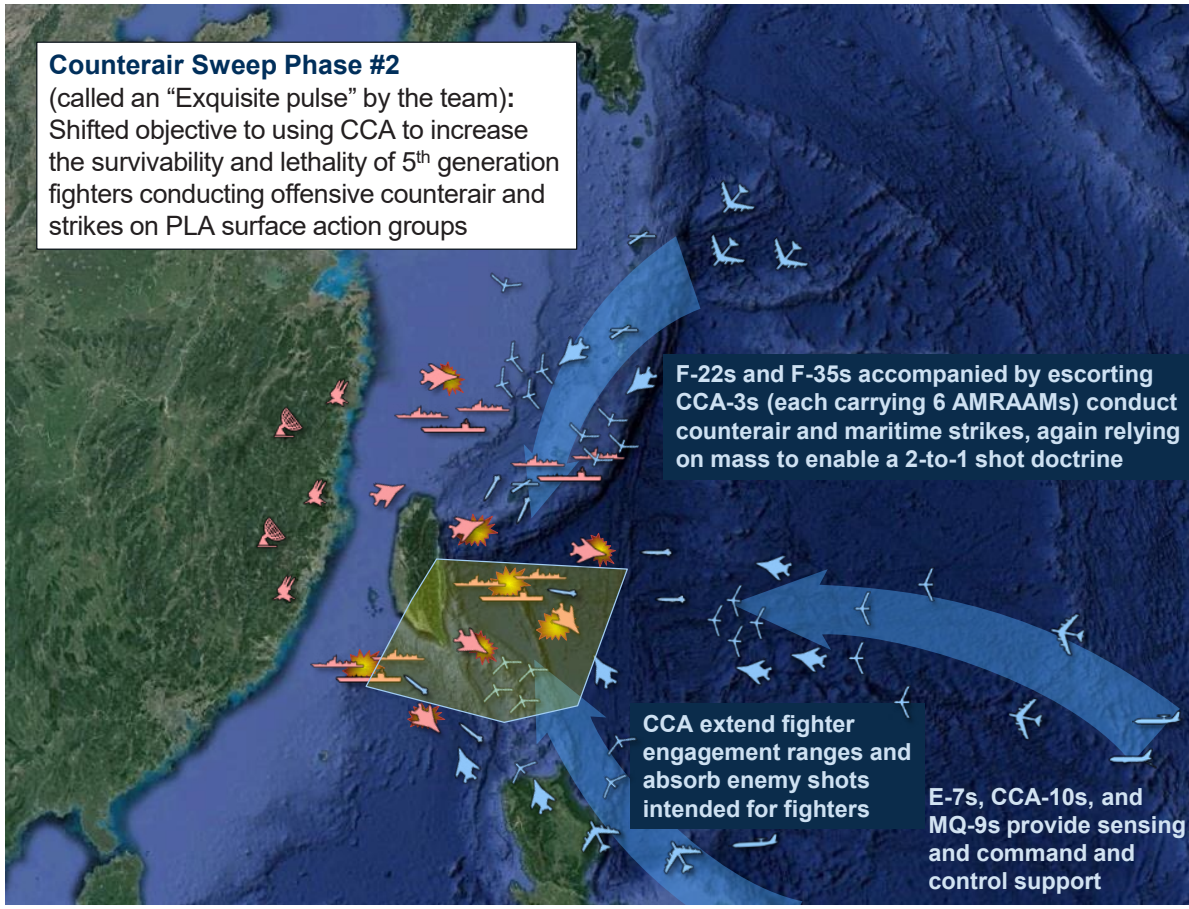

Figure 5: Sweep Phase 2 "Exquisite Pulse" CONOPS. The sweep mission team used CCA in their second pulse of counterair forces to extend the engagement ranges of 5th generation fighters and increase counterair combat mass projected into the operating area.

Source: Mitchell Institute graphic.

Wargame Example 2: Using CCA to Suppress Long-Range Kill Chains Targeting High Value Airborne Aircraft

A second blue planning team was tasked to suppress China's KJ-500s and other long-range airborne threats to U.S. HVAA, including E-7As and aerial refueling tankers supporting coalition air operations. This team also developed a two-phase plan that used CCA as a lead wave of forces to disrupt China's air defenses, followed by a mixed force of crewed and uncrewed aircraft.

Phase 1, a "Detonation Phase" of counterair forces. The HVAA defense team's first phase of operations, called a "Detonation Phase," used a combination of long-range CCA-9s and CCA-10s forward-deployed to the Ryukyus and B-52-launched CCA-5s to trigger Chinese air defense threats (see Figure 6). Their goal was to use these CCA to first elicit responses from China's defenses, pass threat information to E-7As to assess the most critical links and nodes in the PLA's air defenses, and then help enable targeting for the second wave of forces known as the "Uppercut Phase."

Why U.S. HVAAs Are High-Value Targets

Using HVAA like AWACS to gain and maintain information dominance has been a key to U.S. success in air warfare. To deny this advantage, the PLA developed long-range weapons to attack HVAAs and force them to stand off from battlespaces at distances that exceed their sensor ranges. HVAAs like E-7s are large aircraft that lack significant defenses, are expensive, and operate from long runways like the commercial aircraft they are derived from. Because of their distinctive shapes and airfield limitations, HVAAs are easy to identify and attack in the air and on the ground. Satellite imagery of a PLAAF airfield has shown an apparent AWACS mock-up, which could be a faux target to calibrate ground-attack missile seekers.

The team planned to disperse their CCA across multiple small installations in the Ryukyus and other areas close to the battlespace to counter China's airbase strikes and maintain a high sortie generation tempo. This posture would heavily depend on pre-positioning critical materials to support CCA operations since there would be little time and resources available at the start of a campaign to deploy and distribute additional assets to locations while under threat of attack. The team expected that aggregating these distributed CCA into integrated force packages after launch would be a significant command and control challenge.

Phase 2, an "Uppercut Phase" of counterair forces. The HVAA defense team timed their second wave of forces—called an Uppercut Phase—to engage in the battle after PLA aircraft reacting to the first CCA wave would be low on fuel. Uppercut used even larger numbers of CCA, again principally from operating locations in the Ryukyus and Philippines, to attack the most critical air defense communication links, nodes, and threats identified during the Detonation Phase. These uncrewed aircraft included long-range CCA-3s modified to operate independent of runways. The HVAA defense team planned to evolve their CONOPS over the course of the conflict to adjust to attrition, but their priority remained on sustaining intense attacks to degrade PLA air defenses and other A2/AD threats to enable other joint force operations.

The red team planned to counter these strikes by launching massive attacks against the HVAA defense team's operating locations to degrade their sortie generation rates. The HVAA defense team responded by taking maximum advantage of camouflage, concealment, and deception (CCD); mobile non-kinetic and kinetic missile defenses; and other capabilities such as mobile shelters that could be quickly relocated. The team also emphasized the need to disperse and periodically relocate their CCA operations to complicate the PLA's targeting challenge. On balance, the team believed incorporating CCA into the Air Force's future force design could help reduce the impact of Chinese attacks on coalition airbases.

These CONOPS would require a major logistics operation to sustain since the HVAA defense team relied on forward CCA arming and refueling locations that would have to be periodically resupplied by air. The team observed, "The logistics tail drives CONOPS," and noted there would be a need to minimize the number of personnel deployed to their distributed operating locations. At the same time, the team understood that distributed operations would require more personnel and logistics than a force that is concentrated at a few main operating bases.

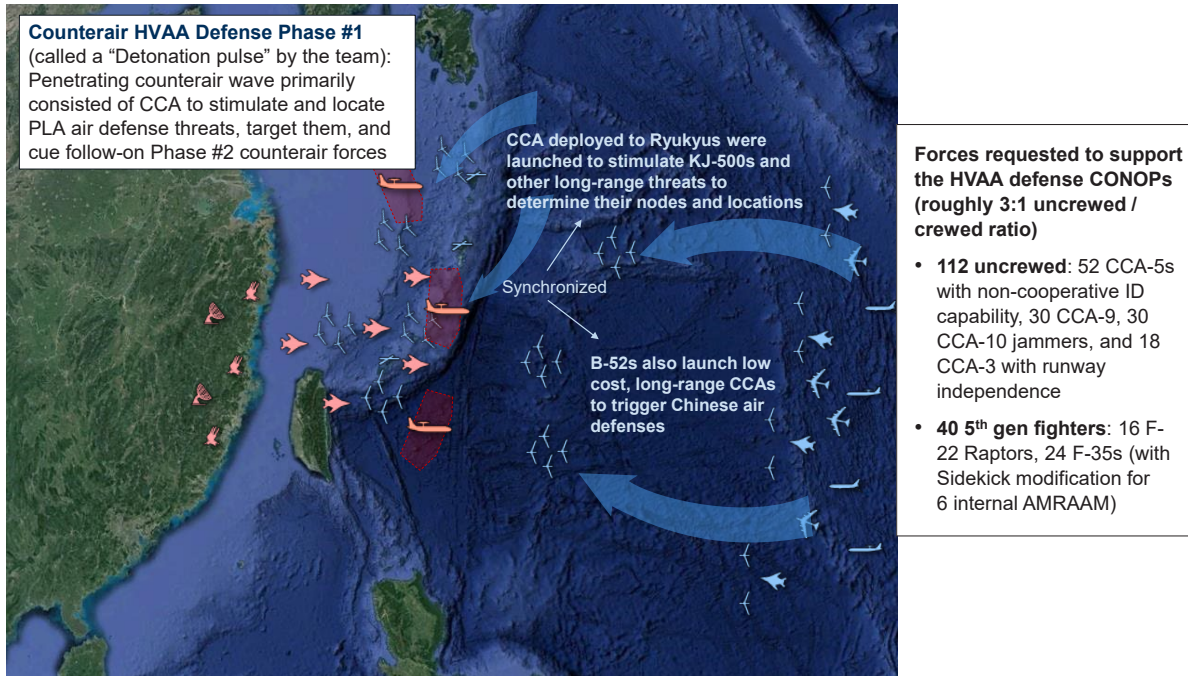

Figure 6: HVAA defend Phase 1 "Detonation Pulse" of CCA as lead forces CONOPS. The HVAA defense planning team used air-launched and ground-launched (by special operations forces) CCA as lead forces to locate and suppress air defense threats. Source: Mitchell Institute graphic.

The HVAA defense team also agreed that CCA command and control, autonomy, and rules of engagement (ROE) were interdependent factors. The team debated linkages between autonomy and rules of engagement (ROE) for using CCA as lead forces without crewed aircraft. Requirements to constantly maintain humans in decision loops could constrain the warfighting potential of CCA in highly contested environments where an enemy is capable of degrading or temporarily denying beyond line-of-sight communications. With software to share situational awareness within CCA force packages and appropriate ROE parameters, the CCA could autonomously perform an expanded set of mission actions without continuously available long-distance links to E-7s or other command and control centers.

While some wargame participants took the view that it would be too expensive to equip every CCA to perform as a node in a self-forming C2 network or to make it highly autonomous, others pointed out that software-defined radio (SDR) technology is mature and affordable. The latter group also cautioned against assuming C2 for CCA will be prohibitively challenging in contested areas since reliable 50-mile line-of-sight communications would likely be adequate for most CCA in a force package as long as one or two of them carried longer-range communication systems to connect with other force packages and E-7s. An important observation was that adding autonomous upgrades to CCA should be quick and inexpensive since it is a matter of computer memory, processing power, and software. One team commented, "A high level of autonomy can be employed on any CCA at roughly a fixed rate."[42]

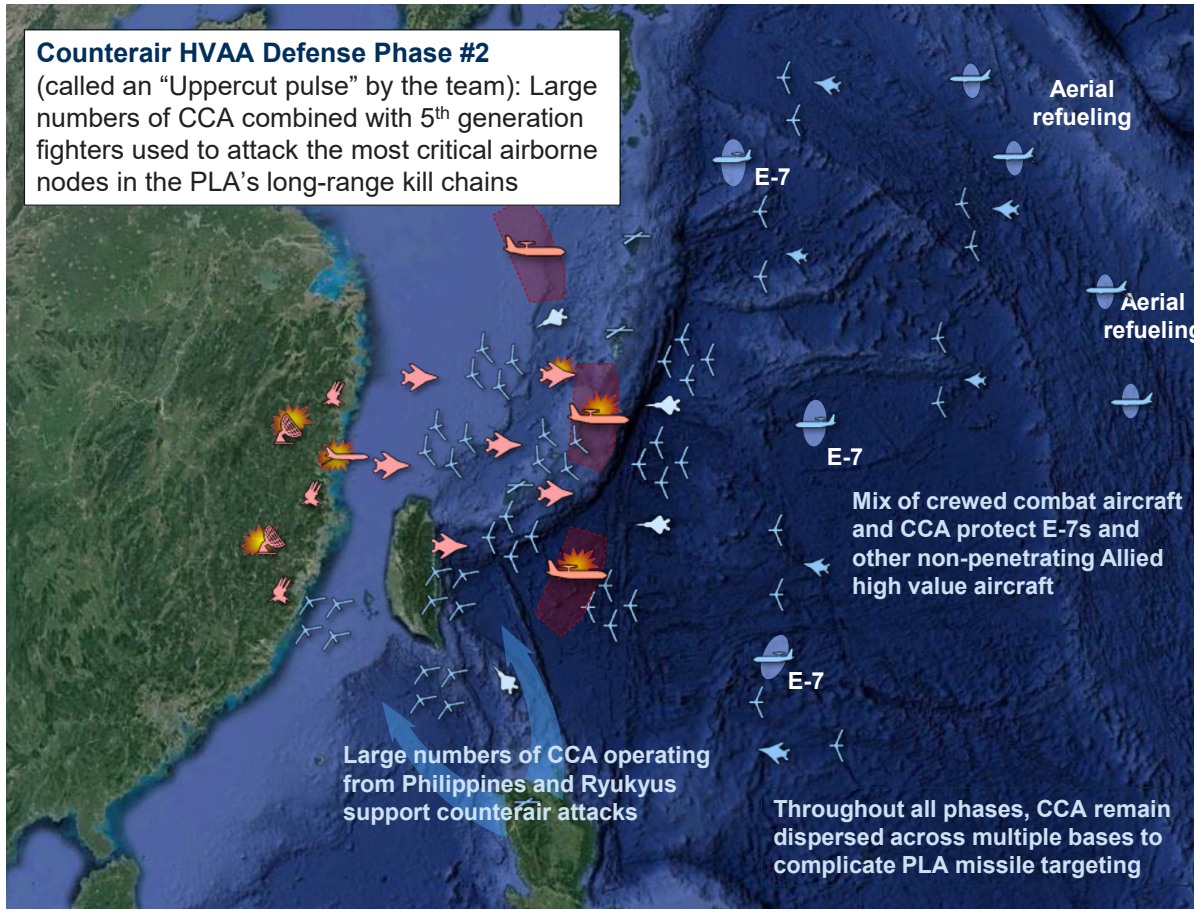

Figure 7: HVAA defense Phase 2 "Uppercut Pulse" of counterair forces CONOPS.

Source: Mitchell Institute graphic.

Wargame Example 3: Using CCA to Disrupt and Suppress Air Defenses

The Mitchell Institute tasked a third blue team to develop an operating concept and request forces to conduct suppression of enemy air defenses/destruction of enemy air defenses (SEAD/DEAD) missions against three PLA SAGs operating northeast of the Taiwan Strait. The wargame scenario assumed the PLAN would deploy SAGs in combination with KJ-500 aircraft to extend China's A2/AD umbrella into the East China Sea. Because surface-based radars are range-limited against low-flying targets, the PLA will use KJ-500s to provide its SAGs with long-range threat warnings and enable them to use their HHQ-9 surface-to-air missiles out to their maximum range of about 135 nm.

Like the other blue teams, the SEAD/DEAD team also proposed CONOPS that relied on using expendable and recoverable/attritable CCA alongside a smaller number of 5th generation fighters to disrupt, suppress, and destroy Chinese Dragon Eye radars and other emitting SAG sensors. These CONOPS reflected the maxim, "Quantity has a quality all its own," which is particularly valid against ship-based air defenses that cannot be repaired, replaced, or rearmed without returning to port.

The team kicked off their first pulse of forces by using MQ-9 Reapers equipped with multi-mode maritime radar to detect and track SAGs while remaining outside the effective range of their surface-to-air missiles. The team then used CCA-10s carrying sensors and electronic warfare systems to stimulate SAG defenses to react and then locate and track their emissions. Cued by these CCA, CCA-6s carrying LRASMs and F-35s conducted distributed strikes from multiple directions to suppress SAG long-range radar arrays and other vulnerable targets. As with the other teams, the SEAD/DEAD planners accepted that communications in highly contested areas could be compromised and addressed this problem by using CCA to create a self-forming line-of-sight communications network connected to airborne relays.

The SEAD/DEAD team pre-positioned some CCA in Taiwan, central Japan, and the Philippines and generated crewed fighter sorties from airbases in Iwo Jima and elsewhere in Japan to ensure they would have enough range after launch to accomplish their missions. The team modeled this posture on the Swedish force dispersal approach that uses multiple satellite "road bases" located close to major airbases so that the road sites can be resupplied by ground vehicles. The team also planned to use aircraft shelters, decoys, mobile missile defenses, and rapid runway reconstitution to increase the resiliency of their force posture, noting that CCA capable of short or vertical take-off and landings would also reduce the impact of PLA airbase attacks.

CCA Can Help Fill Air Superiority Capability and Capacity Gaps

Mitchell Institute's wargame illustrated how the Air Force could use a mix of lower-cost and moderate-cost CCA to disrupt a peer adversary's A2/AD operations and enable crewed and uncrewed aircraft to perform counterair missions over long ranges with reduced attrition. CCA capable of operating from small, dispersed runways or without runways could help sustain the Air Force's combat sortie generation rates while under attack and reduce the risk of aircraft attrition on the ground. Launching some CCA variants from mobile ramps or catapults and recovering them with parachutes and airbags may be feasible for smaller designs and appropriate when a less than 100 percent recovery rate is acceptable. Alternatively, smaller aircraft could be designed for short takeoffs and landings using portable arresting gear, allowing them to operate independent of long runways that can be located and targeted. Additionally, because uncrewed CCA may not need to fly as frequently as crewed aircraft, they could be postured in forward locations along the Pacific's First Island Chain like other pre-positioned materiel. Forward posturing CCA in this way could help the Air Force sustain its initial combat pulses to defeat Chinese aggression and reduce reliance on long-range supply chains that will be at risk of attack.

CCA Can Increase the Air Force's Ability to Project Air Superiority "Mass" at Range

As noted earlier in this report, the Air Force's air superiority capacity and capabilities have eroded over three decades, even as China invested steadily in modernizing and expanding its forces. This has created a reality where the Air Force's remaining F-22s and F-15Cs cannot generate enough combat mass in a conflict with China. The PLA's ability to operate from airbases that are closer to the battlespace, shorter flight times to and from engagement areas, and other home team advantages have the effect of increasing its sortie generation rates. Given these disparities, China's air forces can now "out-mass" the Air Force's diminished air superiority force in the Taiwan Strait battlespace—and the Air Force cannot redress this unfavorable balance in the near term by attempting to accelerate NGAD development.

The Mitchell Institute's wargames suggest there is another option: rapidly field CCA and develop operating concepts to use them in asymmetric ways the PLA will find it difficult to counter. For example, CCA designed as expendable or recoverable/attritable systems could increase the Air Force's capacity to disrupt and degrade the most lethal air defenses at the start of a campaign. Air Force and defense industry experts playing Mitchell Institute's wargame created these and other concepts to use CCA to simultaneously attack ship-based and airborne defenses that the PLA could not quickly replace. The wargame teams also used CCA as airborne screens to stimulate air defenses and absorb air-to-air and surface-to-air missile shots to open the door for follow-on heavy strikes. These airborne screens increased the probability that crewed aircraft would accomplish their missions and return to their bases to regenerate for their next sortie. Using CCA at scale in these ways could help shift the burden of countering superior mass to China's forces.

CCA as Force Multipliers

Force multiplier for 5th and 6th generation combat aircraft. CCA can multiply the combat utility and cost-effectiveness of the Air Force's F-35s, F-22s, and future NGAD in contested battlespaces. From a lethality perspective, teaming several CCA carrying weapons for air-to-air or SEAD/DEAD engagements with fighter aircraft could "multiply" their combined target kill potential. Using CCA as sensors and shooters could also reduce the need for crewed fighters to activate their radar, open their weapons bay doors, or perform other actions that would temporarily reduce their stealthy signature. This would help reduce crewed aircraft attrition rates, which has a force-multiplying effect over the course of an air campaign.

Using CCA as sensors and shooters could reduce the need for crewed fighters to activate their radar, open their weapons bay doors, or perform other actions that would temporarily reduce their stealthy signature.

Another multiplier: Getting 4th generation combat aircraft back in the fight for air superiority. Air Force and defense industry experts playing Mitchell Institute's 2023 wargame proposed innovative ways of using CCA that would help the Air Force to use its non-stealthy aircraft for counterair missions. This would have a major force multiplying effect since non-stealthy fighters and bombers still comprise most of the Air Force's combat air forces.[43]

Today, the Air Force's non-stealthy combat aircraft may have to stand-off from Chinese air defenses at distances that are outside the range of current U.S. counterair weapons—possibly 800 nm or more. Stand-off bombers and fighters with the capacity to launch long-range CCA armed with air-to-air missiles and other counterair mission systems could directly contribute to the fight for air superiority. During Mitchell Institute's wargame, players used B-52 and F-15EX-launched CCA to cause PLA air defenses to react in ways that would reveal their locations and allow U.S. forces to target them. The teams complemented these "ring the fire alarm" operations by using weaponized air-launched CCAs as long-range munitions dispensers for air-to-air engagements cued by E-7As, F-22s, F-35s, or even other CCA. Air-launching CCA also had the benefit of extending their effective ranges since the CCA did not need to use their own fuel to takeoff, climb to operational altitudes, and then fly long distances to engagement areas.

CCA Can Expand the Air Force's Counterair Operating Concepts

Another insight from Mitchell Institute's wargame is CCA can expand options for Air Force warfighters to create diverse combinations of crewed and uncrewed force packages for counterair missions. Less homogenous force packages would complicate the ability of an adversary to understand the nature of the threat it is facing and rapidly determine the most effective countermeasures. Depending on their operational priorities, wargame players either deployed groups of CCA as a primary attacking force supported by crewed aircraft or as jammers, decoys, sensors, and weapon launchers primarily supporting crewed aircraft. This insight is accompanied by a major caveat. CCA capable of collaboratively operating with other CCA as a primary force will likely require more capable—and more costly—autonomous technologies and mission systems than CCA designed to perform as "loyal wingmen" to crewed fighters. The Air Force should carefully assess these capability and cost tradeoffs as it develops its CCA requirements and concepts for their operation.

The wargame teams also used CCA in ways that would help expand the Air Force's operating concepts for generating counterair combat sorties along the First Island Chain. All blue planning teams considered how they could pre-position CCA—possibly containerized—at forward operating locations that lacked runways and other facilities required by fighters and then disperse and sustain them by airlift or by road. One blue team dispersed CCA-5s on C-130 cargo aircraft to remote operating locations across the Ryukyu Islands and the Philippines. The team's operating concept used SOF forces deployed by the C-130s to launch these CCA to maintain pressure on China's air defenses and cause them to expend resources between strike pulses. The wargame teams agreed that, if feasible, launching some CCA from mobile ground ramps and recovering them using parachutes or airbag systems would expand options for their use and reduce the Air Force's reliance on runways. The teams also considered the potential to operate CCA from Swedish-style road-base dispersed operating locations.

Less homogenous force packages would complicate the ability of an adversary to understand the nature of the threat it is facing and rapidly determine the most effective countermeasures.

Defending these pre-positioned CCA assets and their dispersed locations remained a blue team concern throughout Mitchell's wargame, as did challenges associated with sustaining sortie generation operations while under attack and with airlift assets that would be heavily over-subscribed in a time of war. These issues require additional analysis to determine CCA logistics and personnel requirements.

CCA Can Increase the Survivability of Counterair Operations

Enhance the lethality of 5th generation fighters. Using stealthy aircraft for counterair operations in highly contested environments will not be risk-free. Most contemporary stealthy fighters are optimized to reduce their frontal signatures against sensor arrays that would be found in many theaters. In peer conflict scenarios like the kind used for Mitchell Institute's wargames, combat aircraft will have to operate through and in parallel to adversary surveillance networks that are designed to detect them in a wide band of frequencies and from all aspects. These 360-degree threat environments can increase a stealth aircraft's risk of detection.[44]

A crewed NGAD with an all-aspect stealth design and other technologies that reduce its signature in the electromagnetic spectrum will help address these vulnerabilities, but NGAD may not be available in significant numbers until well into the 2030s. In the near term and midterm, the Air Force could use CCA to create networked kill webs that extend sensing, communications, and weapons nodes 360 degrees around crewed stealth aircraft (see Figure 8). This can increase a pilot's awareness of the battlespace and expand options to avoid or counter threats before an enemy can react.

Maintain a first-shot, first-kill advantage. The ability to detect, track, and engage airborne targets earlier and at greater ranges than an adversary is a key to success in air-to-air combat. The PLAAF's advanced fighters can now employ very long-range air-to-air weapons that exceed the range of the AMRAAM, the Air Force's premier front-line air-to-air missile.[45] In battlespaces located close to China's mainland, PLA air forces will also operate

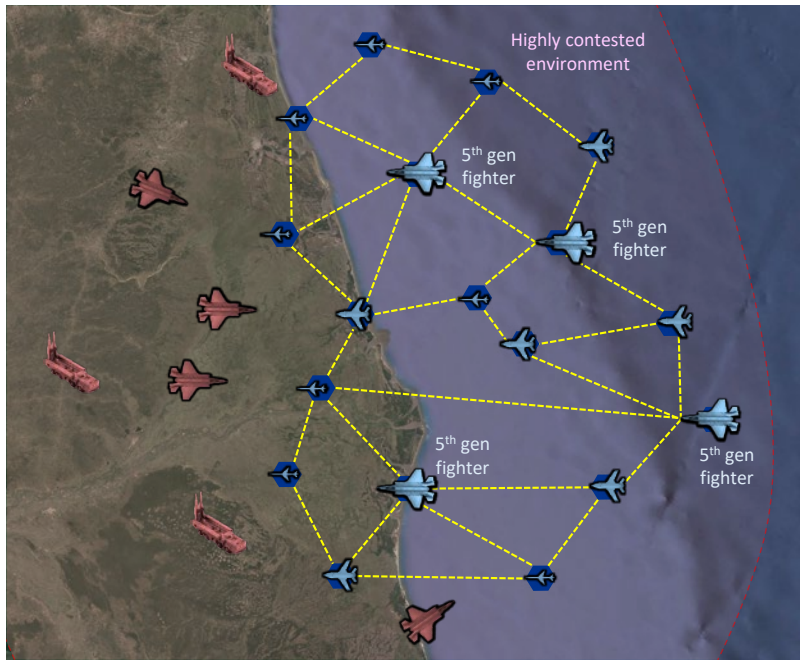

Figure 8: Illustration of a kill web that could extend a common operational picture and lethality 360 degrees around 5th generation fighters operating in highly contested airspace. Kill webs could increase a pilot's ability to detect threats and then take actions to avoid or counter them before an enemy can react.

Source: Mitchell Institute graphic.

under the umbrella of a network of long-range airborne sensors. These capabilities, combined with redundant communications networks to transmit threat data and create a common operational picture, can give PLAAF pilots a first-shot, first-kill advantage, as illustrated by the left panel of the illustration in Figure 9.

CCA could help close this capability gap and shift the advantage to the Air Force's warfighters. As illustrated in the right panel of Figure 9, a group of CCA forming an armed screen in front of crewed fighters could detect threats and pass information to their fighter teammates using secure line-of-sight datalinks that are difficult to detect. The fighters could then maneuver to avoid the threat or command their CCA mission partners to launch their air-to-air missiles before the adversary fighters are within range to employ their own weapons. The concept of employment in Figure 9 would require designing CCA with at least **enough survivability to reach AIM-120D launch points** and the capacity, power, and cooling to carry sensors sufficient to support an air-to-air kill chain. This is one of the most significant insights from Mitchell Institute's wargame.

Create a more resilient forward posture. The Air Force must increase the survivability of its air superiority forces while they are on the ground as well as in the air. During Mitchell Institute's 2023 wargame, a red team acting as an opposing PLA force launched large-scale ballistic missile and cruise missile attacks against the Air Force's main operating bases in the Pacific. Since these airbases now lack sufficient air and missile defenses, the red team reasoned their attacks could impose costs, suppress the Air Force's sortie generation tempo, and attrit significant numbers of Air Force aircraft. To counter this threat, the wargame's blue teams chose to posture their CCA at distributed locations in the Philippines, Ryukyu Islands, and other forward locations instead of co-locating them with crewed air superiority forces. The teams reasoned dispersing their CCA operations would help "dilute" China's airbase missile attacks instead of concentrating them at a handful of main operating bases. The teams also located their CCA as far forward as possible to reduce the time and distances they would need to fly to reach operating areas.

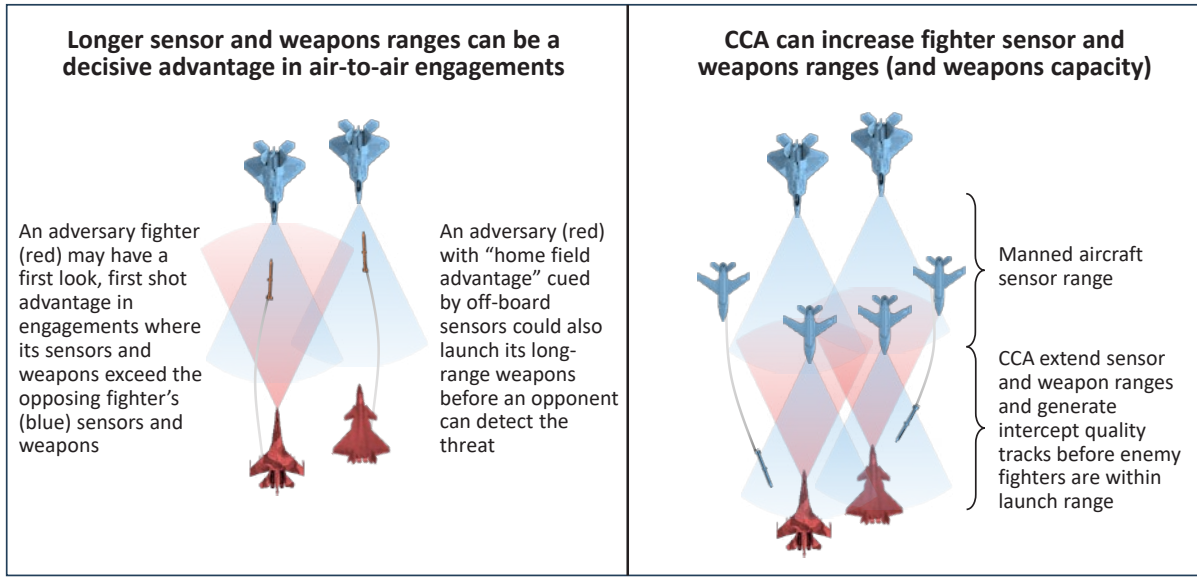

Figure 9: CCA teamed with 5th generation fighters could help pilots maintain a first-shot, first-kill advantage. Source: Mitchell Institute graphic.

Considerations for a Future CCA Force Design

Understand Tradeoffs That Will Help Maximize CCA Warfighting Potential

The Air Force and the U.S. defense industry are experienced in assessing tradeoffs between the attributes of potential new aircraft designs such as size, range, useful payload, mission systems, survivability, speed, and cost. Assessing these tradeoffs for CCA and understanding how to best integrate their operations with crewed aircraft is critical for maximizing their warfighting potential. Many CCA design requirements will be different than requirements that have existed for decades for high-performance crewed combat aircraft, such as the need to use 8,000-foot runways and endure thousands of flight hours over a 30-year lifespan. Moreover, the lack of a need for a crew cockpit, fuel-thirsty afterburning engines, and heavy 9G-tolerant airframes can reduce the size of CCA and make them easier to transport, store, and disperse than crewed aircraft. And as Mitchell Institute's wargames illustrated, some CCA may not need to carry more than a few weapons—or no weapons at all—to pose a threat that an adversary must honor.

Experts participating in Mitchell's 2022 and 2023 wargames discussed the need to assess CCA design requirements from an end-to-end perspective. Their basic assumption was the Air Force should balance attributes such as CCA size, low observability, range, and mission systems, as all of these influence unit cost. Making the right tradeoffs between these factors will increase the Air Force's potential to acquire different classes of CCA in significant numbers, a critical consideration given the service's budget constraints and other pressing force modernization needs.

Determining the "right" balance of attributes for CCA will heavily depend on the missions they must perform and the threat environments they must operate in. For instance, a CCA that is intended to be an expendable decoy or expendable stand-in airborne jammer may not require as much low observability as CCA that are designed to launch weapons at targets, survive to return their airbases, and then regenerate for their next sorties. CCA ranges also depend on operational factors like where they will be postured—close to engagement areas like in the Ryukyu Islands or more distant bases—and if they can be air-launched. As another example, giving each CCA a full suite of sensors would increase their cost, but in some cases, the same functionality could be achieved by distributing those capabilities across a package of lower-cost CCA—again, depending on mission needs.

Mission needs and risk drove CCA force mixes during the first two days of the campaign. Air Force and defense industry experts playing in Mitchell's 2023 wargame favored using lower-cost, less-capable, expendable CCA to disrupt China's air defenses and increase their potential for mission success during their first two days of operations. Notably, all three blue counterair planning teams chose to use expendable CCA-5s against China's undegraded IADS (see Figure 10). These and other expendable uncrewed systems increased the teams' loss tolerance for very high-risk missions to disrupt China's air defenses and suppress long-range sensors that were key nodes in the PLA's kill chains. It is important to stress that these expendable CCA did *not* have the same low observability, mission systems, and other capabilities as the wargame's higher-end CCA—nor were they needed since the teams' overarching priority was to transfer a significant degree of risk to uncrewed systems in an extremely challenging threat environment.

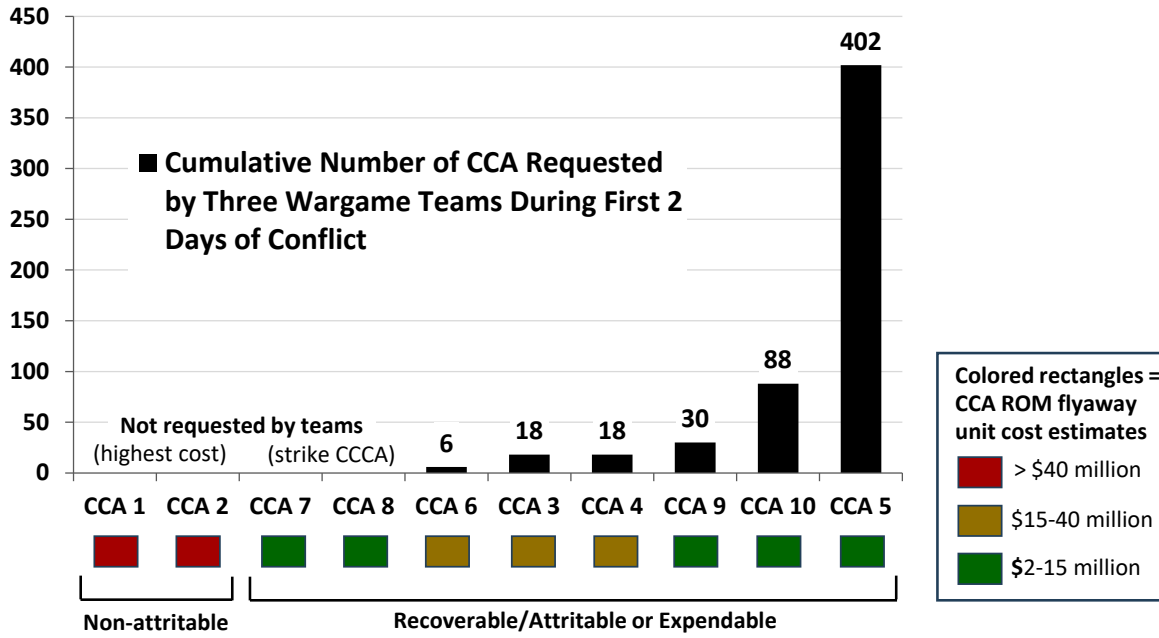

Figure 10: The bar chart shows the distribution of CCA selected by wargame teams for the first two days of the air campaign. Wargame teams favored CCA which could be used as decoys and expended or attritted during the first two days of the air campaign to compel an enemy to react in ways that increased their vulnerability to attacks. The red, gold, and green boxes along the bar chart's x-axis correspond to their rough order of magnitude flyaway cost categories. No teams selected CCA-1 and CCA-2, the highest cost notional designs, or CCA-7 and CCA-8, both of which were designed for precision strikes in Mitchell Institute's 2022 CCA wargame.

Source: Mitchell Institute graphic.

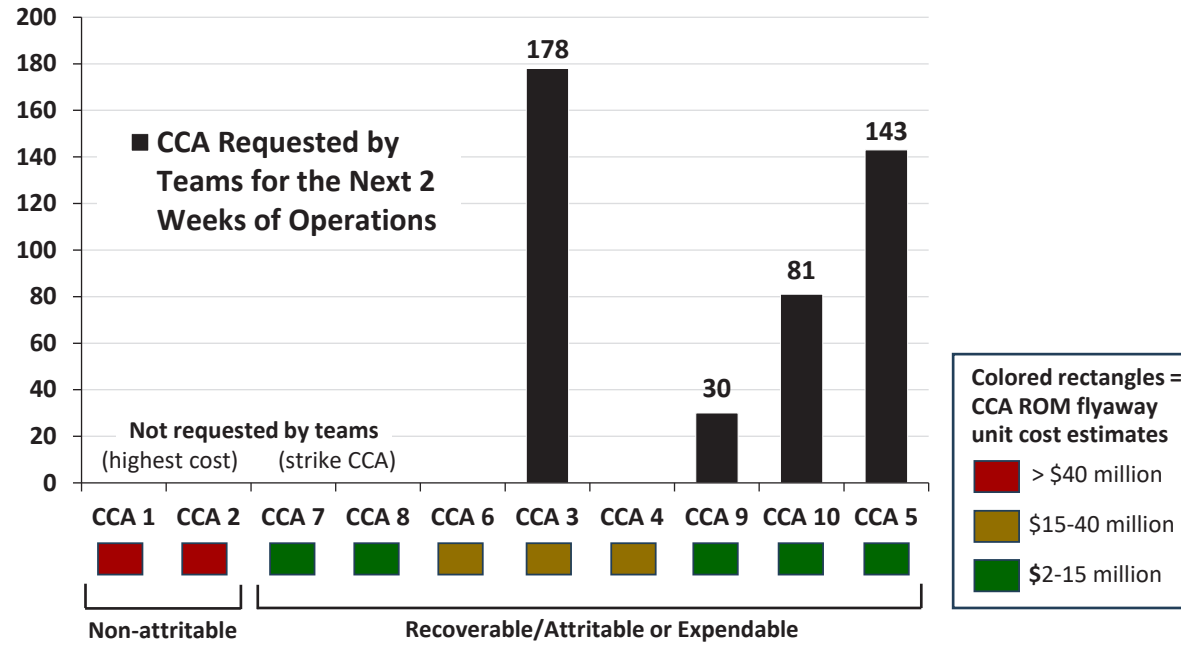

Figure 11: The bar chart shows wargame teams selected a larger number of more capable, moderate cost CCA to operate with F-35s, F-22s, and other CCA during the next two weeks of the air campaign.

Source: Mitchell Institute graphic.

CCA force mixes for the next two weeks of operations. In the wargame's second move, the blue teams modified their CCA force mixes for the next two weeks of counterair operations against the PLA. As Figure 11 illustrates, the teams chose to use a larger number of more capable, moderate-cost CCA-3 and CCA-4 in collaboration with F-22s and F-35s. To a significant extent, these choices were the result of the teams' desire to increase the density of the weapons and sensors they projected into the battlespace. The teams also wanted to use these mid-range CCA to create a more dispersed forward force posture to counter the red team's missile attacks on U.S. airbases.

Over both moves, the teams showed little enthusiasm for using higher-end CCA-1s and CCA-2s that could fly at supersonic speeds and sustain high-G maneuvers like advanced fighters. Supersonic speeds usually require higher fuel consumption rates that can reduce an aircraft's range and mission persistence, and high-G maneuvering can require designing aircraft with larger wings and heavier airframe structures. CCA-1s and CCA-2s also had notional flyaway unit costs that approached the cost of a highly capable crewed fighter. The teams reasoned that at these high price points, it would simply be better for the Air Force to buy additional F-35As.

Optimize Weapons for CCA

All blue counterair planning teams recommended the Air Force consider how it could maximize the lethality of its weaponized CCA by developing munitions that would increase the number of targets they could attack per sortie. The form factors of some current weapons—including the AMRAAM—were established in the early 1950s and require large weapons bays to accommodate them.[46] As one participant observed, the AMRAAM was designed for fighters in the 1970s to match the form factor of AIM-7 Sparrows, which entered service in

1954. Designing CCA around these legacy weapons could increase CCA sizes, weights, and costs. As the Air Force iterates its CCA designs over time, it should also take advantage of novel technologies—like smaller, less costly navigation and guidance systems and seekers—to develop weapons with small warheads that will increase CCA targets per sortie. Imagery from the war between Ukraine and Russia has shown it is possible to use small drones carrying grenade-sized warheads to destroy large aircraft and even armored vehicles.

Balance the Number of CCA Variants in the Force

Participants in Mitchell Institute's CCA wargame series addressed the potential advantages and disadvantages of acquiring multiple variants of these uncrewed aircraft for the future force. From an operational perspective, CCA capable of different missions and different launch and recovery methods would help increase the resiliency of the Air Force's operations in the Indo-Pacific theater. From a program perspective, a more diverse CCA force could encourage additional vendors to compete for their development contracts, create incentives to reduce program costs, and increase the potential to surge CCA production in a crisis. On the other hand, a future force design with too many CCA variants could reduce program savings from economies of scale and create multiple unique logistics requirements that increase the time, effort, and resources needed to sustain the force in peacetime as well as during operational surges.

The Air Force should seek to create a CCA force design that balances these advantages and disadvantages. Wargame participants suggested that creating common design standards and developing CCA with sufficient modularity and mission flexibility—like Swiss army knives—would help create a balanced, versatile, and economically sustainable force. With sufficient modularity and flexibility, CCA may be able to quickly change their roles between missions to perform as part of a lead CCA force, as wingmen to crewed aircraft, or even transition to other roles in flight in response to mission needs. Another approach would be to acquire CCA that the Air Force can replace as technology and designs improve, similar to many consumer devices. At the same time, an unlimited menu of different CCA types would work against realizing lower costs through economies of scale and create unique logistics support requirements.

The value of using secure datalinks to share information between airborne aircraft is another factor that should inform flexible, modular CCA force designs. It is unnecessary to design every CCA to carry a radar, IRST, electromagnetic warfare system, or beyond line-of-sight communications if the intent is to operate them as part of a group of uncrewed and crewed aircraft that can automatically share information. Designing a family of CCA systems as *interconnected* sensor, jamming, shooter, and communications nodes could reduce the time and cost of developing CCA. Moreover, short-range line-of-sight datalinks are inherently resistant to jamming, and widely available software-defined radio technology could create affordable self-forming networks with low latency and low probability of interception.

"Just Enough" Autonomy

The degree to which CCA can autonomously accomplish tasks such as navigating to avoid threats, identifying targets, distinguishing hostile from friendly or neutral forces, and, most importantly, being trusted to do so

in the face of jamming and deception will shape how they are used in combat. A significant degree of CCA autonomy may be vital to mission success in environments where an enemy's communications jamming is effective. Experts participating in Mitchell's wargames thought of CCA communications, autonomy, and rules of engagement as a tripod. CCA with persistent, high data rate beyond line-of-sight communications to human controllers—like RPAs with a dedicated satellite transponder conducting counterterrorist operations—can comply with complex rules of engagement with little autonomy. However, CCA force designers should not assume the same degree of assured connectivity will be possible in highly contested environments where communications jamming is expected. In these operational conditions, CCA with a higher degree of autonomy could still accomplish their missions, particularly if it is "collaborative autonomy" in which multiple CCA spread over space and time can combine their sensor information to form a shared picture of the battlespace.

The Mitchell Institute designed its 2022 and 2023 CCA wargame scenarios to reflect realistic operating environments, including the electromagnetic spectrum. Players in both games were told to plan their operations with the assumption that adversary jamming would significantly degrade their beyond line-of-sight (BLOS) radio frequency communications in locations close to the Taiwan Strait. In response, Air Force and defense industry experts playing the 2022 wargame defaulted to requiring their notional CCA designs to have the highest possible level of autonomy. However, a similar group of experts playing Mitchell's 2023 wargame recommended most CCA should have "just enough" autonomy to perform their missions. This shift could reflect progress in developing a better understanding of the role of autonomy and CCA requirements.

The cost of autonomy was raised as an issue during Mitchell Institute's wargames. Some wargame participants suggested a "just enough autonomy" approach could help reduce the time and cost needed to design and field operational CCA, and others noted the largest cost item in developing autonomous functionality is validating code, not the commercially derived hardware it runs on. Once the code is developed, it could be quickly proliferated across a CCA fleet with the option to select the level of autonomy needed for a given mission.

CCA Are More Than Adjuncts to Crewed Aircraft

Viewing CCA as limited capabilities that are best used to augment or enhance crewed aircraft could constrain the Air Force's iterative development of a more capable, adaptable, and diverse mix of CCA and innovative concepts for their use. The tendency to initially use emerging technologies to enhance existing approaches to warfare is not new. In the 1920s and 1930s, France and Germany both developed state-of-the-art tanks and other armored vehicles. By the start of the conflict in Europe in 1930, France had fielded about the same number of tanks as Germany but had developed different doctrines for their use. France chose to use armored forces as mobile artillery support for its infantry and to defend its Maginot Line instead of massing them as the point of a spear to defeat Germany's mechanized assaults. According to one military historian, "the Germans recognized the potential of massed armored forces in conducting rapid, mobile operations, [while] French armored units were committed to battle in a piecemeal fashion."[47]

Experts playing Mitchell Institute's wargames used their notional CCA to provide additional magazine depth for mixed formations of crewed and uncrewed aircraft, perform as "armed pickets" for 5th generation fighters, and attack the PLA's air defenses in collaboration with other CCA. These use cases were far from a narrow approach in which the primary purpose of CCA was to improve the effectiveness of crewed aircraft. The closest coupling in any of the proposed CONOPS was when groups of CCA were teamed with crewed aircraft, but even then, the CCA were usually physically separated from their crewed counterparts while in flight. As a group, wargame players recommended the Air Force develop similar innovative concepts that take maximum advantage of the capabilities CCA can bring to the battlespace.

The CCA use cases explored during Mitchell's wargames imply that future CCA could be designed to operate with minimal human guidance. This raises issues regarding maintaining humans in the loop during CCA operations, meaning crews or remote controllers must initiate critical actions like commanding CCA to employ weapons against a threat. The Air Force and DOD should expedite the development of policies that will allow CCA to employ weapons against some appropriate, validated targets without humans in the loop. Cruise missiles may be an apt analogy—DOD has fielded multiple cruise missile variants that can use automated seekers to locate and identify targets and then guide their weapons to their designated aimpoints.

Conclusion and Recommendations

Three decades of force cuts and deferred modernization have created an Air Force that is unprepared to gain the air superiority needed to prevail in a great power conflict. In 1991, the Air Force could call on 134 squadrons to defend the U.S. homeland and meet its global operational requirements. This has since dwindled to a total of 57 fighter squadrons, including a handful of units that are organized, trained, and equipped primarily for counterair operations.

Over the same period, China undertook a rapid military build-up that transformed it from a continental power to an adversary capable of coercing its neighbors and projecting forces to extend its dominance throughout the South China Sea. China's modernized military includes a formidable network of layered air and missile defenses that is designed to deny air superiority to foreign militaries attempting to intervene against PLA aggression.

Should these military modernization trends continue to diverge, the Air Force will not have the capability or capacity to gain the degree of air superiority required during a multi-domain operation to defeat Chinese aggression—DOD's pacing challenge. This cuts to the core of the viability of the U.S. national security enterprise; inaction increases the risk that China could achieve a military success that would have a devastating impact on stability across the Indo-Pacific and undermine the credibility of the United States as a security guarantor.

This does not have to be the case. Fully resourcing the Air Force's modernization programs, including its development of an NGAD family of systems, will be the foundation for a future air superiority force that wins. The service may begin to field a crewed NGAD aircraft to replace its aging F-22s before the end of this decade, but it will likely be well into the 2030s before they are available for combat in significant numbers. Furthermore, Air Force leaders have testified, "While the NGAD crewed fighter will give us an exquisite edge, **it will be unaffordable to purchase these in sufficient quantities to provide the necessary mass on a threat-relevant timeline.**"[48] This is why the Air Force also intends to acquire uncrewed CCA that will be capable of collaborative operations with its 5th generation F-35s and crewed NGAD systems. These CCA will be "a force multiplier that will allow us to achieve air superiority affordably and at scale."[49]

The maturation of uncrewed system technologies is on a path to support fielding a first generation of CCA this decade, when the threat of Chinese aggression may be most acute. Operational CCA will help transfer risk from crewed to uncrewed aircraft operating in highly contested environments and impose costs on adversary forces. This does not mean the Air Force should rely on CCA and other combat air investments to attempt to match China's air superiority forces one-for-one. Based on Mitchell Institute wargames and related studies, the Air Force should field a mix of CCA and use them as asymmetric capabilities to disrupt and degrade China's air and missile defenses. New CCA combined with novel, innovative operating concepts for their use could deliver significantly more combat power than simply throwing more mass at the problem.

Recommendations

Creating a future air superiority force design with a mix of 5th and 6th generation aircraft and cost-effective uncrewed CCA will require the support of DOD, Congress, and the American people. A narrative that explains the value of CCA and their potential to help offset the Air Force's air superiority shortfalls is a critical step toward this force design. For these reasons, the Mitchell Institute offers the following seven recommendations for the Air Force:

- **The Air Force should conduct tradeoff analyses to determine an optimal mix of CCA in its future force design.** These analyses should seek to balance CCA attributes such as their size, low observability, range, mission systems, and other features that determine their unit cost. This balance should be based on the missions CCA will perform and the degree of risk the Air Force desires to shift to uncrewed CCA. For instance, a CCA designed as an expendable decoy may not require as much payload capacity or the same degree of low observability as recoverable/attritable CCA that are designed to fly multiple sorties. Balancing CCA capabilities with their mission requirements and costs will be key to maximizing their combat utility and cost-effectiveness. These CCA will be complementary and additive capabilities that will not reduce the Air Force's requirements for 5th generation fighters and other advanced crewed systems.

- **The Air Force should create innovative operating concepts for using CCA to disrupt China's advanced IADS and other counter-intervention operations.** New technologies are insufficient by themselves to achieve major advances in a military's warfighting effectiveness. The history of warfare is replete with examples of how militaries limited the potential of novel technologies by using them in old ways. Transitioning to an effective crewed-uncrewed air superiority force mix will require innovative operating concepts for CCA, as well as the organizational structures that integrate them with the Air Force's other forces. These concepts should include approaches for using CCA to complicate the counterair targeting of an adversary, causing its forces to expend air defenses on lower-cost uncrewed systems.

- **The Air Force should acquire CCA at scale to increase its capacity to project counterair mass at range into highly contested areas.** CCA can be force multipliers in the sense that they can collaborate with 5th and 6th generation aircraft to increase the density of weapons and sensors the Air Force can project into highly contested environments. The Air Force should also acquire air-launched and ground-launched expendable CCA with long ranges and the capacity to carry weapons and other counterair mission packages. These CCA would permit the Air Force to use its stand-off fighters and bombers to create offensive and defensive counterair effects in contested environments. Weaponized CCA should have enough range and survivability to ensure they will reach their weapon launch points.

- **The Air Force should field CCA that will reduce the Air Force's dependence on large, fixed airbases in the Pacific.** CCA that can use shorter runways to launch and recover or launch independently of runways would help create a more resilient inside force that can generate combat sorties while under attack. Creating this dispersed force posture will also require additional logistics, mobility, and other resources to regenerate and sustain CCA operations at scale.

- **The Air Force should seek to increase the lethality of its weaponized CCA over time by developing or adapting munitions to take maximum advantage of CCA payload limitations.** Designing CCA around legacy weapons that were originally created for crewed aircraft—like the AMRAAM and JDAM family of munitions—could significantly increase the size, weight, and cost of some CCA variants. As the Air Force iterates its future CCA designs, it should also take advantage of technologies like smaller engines, compact lower-cost rocket motors, and miniaturized components to design smaller weapons that would increase the number of targets CCA can attack per sortie—a factor that is critical to rapidly halting a Chinese offensive.

- **DOD should work with Congress to increase Air Force funding to create a CCA force design for counterair operations.** Decades of insufficient budgets have created a high-risk Air Force that lacks the force capacity, modernized capabilities, and readiness to defend the U.S. homeland, defeat peer aggression, and deter in other theaters as called for by the *National Defense Strategy*. Reversing these shortfalls will require growing the Air Force's annual budget by 3 to 5 percent each year for a decade or more. Continuing the Air Force's current funding levels will threaten its plans to acquire CCA, new air-to-air and air-to-surface weapons, and other counterair capabilities before its aging systems reach the end of their design service lives.

- **Analyses are also needed to determine the capabilities and operating concepts needed to support a high tempo of CCA operations in forward theaters.** These analyses should address requirements to pre-position some CCA and their logistics in the Indo-Pacific, determine appropriate dispersal locations for CCA launch and recovery operations, and define materiel and personnel requirements to sustain CCA operations at scale during peer conflicts.

In conclusion, the U.S. Air Force is caught in a dilemma caused by a budget that is too small and the need to increase its readiness and force capacity for every mission the nation asks it to perform. Solving this dilemma will require new, cost-effective capabilities and operating concepts for projecting affordable mass into highly contested battlespaces. Developing smaller PGMs to increase the number of targets stealthy aircraft can strike per sortie is part of this affordable mass approach, as is acquiring a force of uncrewed CCA for offensive and defensive counterair missions. These CCA could be used in disruptive ways that will help offset the PLA's ability to project superior combat mass to control the air over the Taiwan Strait and other areas of the South China Sea.

Developing this affordable, uncrewed force will require balancing the ranges, survivability, degree of autonomy, and other attributes of CCA with the missions they must perform. And "affordable" means designing CCA to perform their intended missions for a low enough cost that they can be expended to reduce risks to crewed aircraft if necessary. It does *not* mean the Air Force can afford to buy combat-credible CCA without additional resources. The service cannot continue to cannibalize its existing capabilities to acquire new systems. That path would further expand the gap that already exists between the forces the Air Force can provide and its global operational requirements. The need is too great, and the risk is too high to forego taking full advantage of these and other game-changing capabilities. ✪

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7 See David A. Deptula and Mark A. Gunzinger, *Decades of Air Force Underfunding Threaten America's Ability to Win* (Arlington, VA: Mitchell Institute for Aerospace Studies, September 2022).

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