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Key Points

The Air Force must ensure its force design and operational concepts can compete with and overcome the forces of near-peer adversaries like the People's Republic of China (PRC). Crucially, U.S. penetrating strike capabilities must enable decisive combat operations against near-peer forces in the event U.S. deterrence fails.

Prevailing U.S. military concepts like pulsed airpower and expanded maneuver to facilitate long-range kill chains presume a level of communication, networking, and connectivity that PRC military information dominance capabilities are specifically designed to counter and defeat.

Disaggregated collaborative air operations (DCAO) is a proposed operational concept that uses a penetrating stand-in force of fifth-generation and beyond aircraft as core elements in independently operating force packages that defeat near-peer strategies and capabilities.

DCAO leverages the advanced information collection and processing capabilities of fifth- and next-generation aircraft to significantly reduce dependencies on centralized command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR). These aircraft can operate with fourth-generation and uninhabited aircraft in formations that are disconnected from long-range networks but locally networked to collaborate in ways that counter PRC attacks.

This proposed operational concept will not solve the U.S. Air Force's ongoing modernization crisis or the alarming erosion of the capability and capacity of its current fighter and bomber force. While the Air Force must carefully consider how to apply the forces it has in near-term contingencies, the service must also rapidly modernize and grow its fighter and bomber aircraft inventories.

Uninhabited systems like CCA promise additive capabilities that increase the lethality, survivability, and capacity of Air Force operations, especially in highly contested environments. However, uninhabited aircraft cannot currently replace the decision-making and combat management capabilities of crewed aircraft, especially in operational concepts like DCAO that emphasize disconnected, disaggregated forces.

Disconnected by Design: 5th- & 6th-Gen Aircraft in Disaggregated Collaborative Air Operations

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Abstract

Facing increasingly grave threats, U.S. Air Force strike capabilities must enable decisive combat operations against adversary forces in the event U.S. deterrence fails. The service's force design and operational concepts need to compete with and overcome near-peer adversaries like the People's Republic of China (PRC). However, existing Air Force operational concepts for long-range kill chains and penetrating strikes into contested areas assume forces will have highly networked connectivity and reach-back to data and command centers. The PRC's informationized warfighting strategies are specifically designed to counter the networked U.S. approach. In a conflict, China's People's Liberation Army (PLA) will launch overwhelming attacks against U.S. military information links and nodes to cut off and isolate U.S. airpower force packages from these networks and then pick off the disconnected elements.

Given the vulnerabilities inherent in beyond line-of-sight (BLOS) datalinks and other long-range communications, disaggregated collaborative air operations (DCAO) is an operational concept that sidesteps these adversary strategies to dominate the battlespace information environment. DCAO combat air forces are locally networked formations that can operate even when disconnected from broader networks. The concept relies upon a force of fifth- and next-generation aircraft that can penetrate adversary air defenses, independently sensing, coordinating, and executing individual actions at the tactical edge of the battlespace. The DCAO operational concept builds upon the proven U.S. Air Force employment of effects-based operations (EBO) and parallel warfare. Just as precision weapons and stealth aircraft enabled effects-based operations in numerous conflicts following the Cold War, fifth-generation and beyond aircraft provide battlespace information dominance capabilities to enable new warfighting concepts that can achieve decisive effects forward in highly contested areas.

To make this operational concept viable in near-peer threat environments, the Air Force requires more advanced capabilities and greater capacities than its current fighter and bomber inventories can deliver. DCAO leverages forces and technologies that are available now to address the significant near-term threats facing the United States. In the near term, the Air Force should combine fifth- and fourth-generation aircraft as well as collaborative combat aircraft (CCA) to offer a range of force employment options. Fifth-generation aircraft currently in production should be supplemented by next-generation aircraft like the B-21 bomber and the F-47 Next-Generation Air Dominance penetrating counter-air (NGAD PCA) aircraft. The U.S. Air Force should aggressively field these newer aircraft to bring even more advanced capabilities to the DCAO concept.

Resetting Air Force Operational Concepts & Force Design

The United States military today faces tumultuous internal changes at a time when foreign threats are expanding and the character of modern warfare is rapidly evolving. The U.S. Air Force must ensure it pursues a force design and associated operational concepts that are capable of deterring a near-peer adversary like the People's Republic of China (PRC) from challenging U.S. and allied interests. Should deterrence fail, the Air Force must be capable of conducting decisive combat air operations from both inside and outside the theater of operations.

The Air Force, Navy, Marine Corps, and U.S. allies have made heavy investments in fourth-generation, fifth-generation, and next-generation combat aircraft, as well as in uninhabited systems. These shorter-range forces give U.S. and allied air forces capabilities to fight as an "inside force" and generate meaningful combat mass against potential PRC targets. An inside force design wielding these assets in the right mix with sufficient capacity, supported by a well-considered operating concept, can better deter near-peer adversaries than a purely "outside force." Retreating to an outside force may message an inability or unwillingness to fight alongside U.S. allies inside of threat envelopes. Conversely, inside forces, especially fifth-generation "stand-in forces" that can penetrate highly contested airspace, can generate more sorties to deliver sustained effects. Disaggregated collaborative air operations (DCAO) is a proposed operational concept that leverages inside, stand-in forces of fifth-generation and beyond aircraft that can enable the U.S. Air Force to deter and, if necessary, defeat near-peer challengers.

The current Air Force Future Operating Concept (AFFOC) prescribes "pulsed airpower" to conduct strikes and other missions in a campaign to counter aggression by near-peer forces such as China's increasingly capable People's Liberation Army (PLA). The current concept synchronizes and aggregates airpower in space and time to create massed effects and generate the temporary, episodic air superiority required for joint force operations. The AFFOC approach aligns with the Joint Warfighting Concept (JWC), which revolves around concepts of "expanded maneuver" and "pulsed operations."[1] However, even these novel ways of generating combat effects, like pulsed airpower, are *still largely symmetric* with the PLA's current warfighting counterstrategies and countermeasures. As such, there is every reason to expect that pulsed airpower and other such frontal assaults on the PLA will simply devolve into a mass-on-mass attrition conflict that the U.S. military lacks the forces and resources to win.

Unproven concepts like pulsed airpower and expanded maneuver to facilitate long-range kill chains appear to presume a level of communications, networking, and connectivity

Inside, Outside, Stand-in, Stand-off

Inside force: A force composed of shorter-range aircraft that are based relatively close to areas of combat operations within adversary direct attack ranges.

Outside force: A force composed of longer-range aircraft that are based outside of adversary direct attack ranges.[55]

Stand-in force: Stand-in forces are capabilities like low-observable aircraft that can penetrate enemy defenses and release munitions in close proximity to targets to conduct "stand-in" or "penetrating" strikes.

Stand-off force: Stand-off forces are capabilities that attack targets from a distance, generally outside of adversary threat ranges, by launching long-range weapons into contested airspace.[56]

that China's counter-information strategy, *informationized warfare*, will not allow. For a quarter century, the PLA has committed itself to developing capabilities that are purpose-built to delay, degrade, disrupt, and defeat the U.S. military by focusing on defeating U.S. battlespace information networks. China's military specifically designed its informationized warfare strategy, its increasingly dense anti-access/area denial (A2/AD) defenses, and its offensive strike capabilities to defeat U.S. military attempts at generating combat mass and massed effects using traditional operating concepts. **The AFFOC and JWC concepts and current approaches to closing long-range kill chains play directly into China's now well-established battlespace information dominance counterstrategy.**

Thinking Asymmetrically: Disaggregated Collaborative Air Operations (DCAO)

The U.S. Air Force should pivot away from traditional warfighting approaches based on generating temporal mass toward innovative, adaptive operating concepts that take full advantage of fifth-generation and beyond aircraft and the effects they can independently achieve. The DCAO concept represents this kind of shift. Rather than large formations in strike packages attacking episodically, DCAO envisions numerous small force packages—comprising advanced crewed aircraft with uninhabited systems—working collaboratively to gather intelligence, assess battlespaces, and execute precision attacks simultaneously while disconnected from broader networks. In contrast to pulsed operations, DCAO keeps the pressure on the enemy force around the clock, increasing their defensive challenges. This approach will increase the battlespace information dominance of U.S. forces while reducing their reliance on centralized command, control, and communications, which may be compromised in contested environments.

Understanding the Difference Between Operational Concepts and CONOPS

An operational concept is a *method* for employing military capabilities. Operational concepts informally reflect the assumptions and intent of military leadership and form the basis for operational planning or military force design. This term is distinct from a "concept of operations," or CONOPS, which describes specifically how resources will be used to accomplish a particular mission or operation in a given area of operations.

DCAO is an operational concept, not a specific "concept of operations" for a China contingency. DCAO assumes that, while the PLA is the U.S. military's pacing challenge, the strategies and capabilities that the PLA developed to counter the U.S. military will likely proliferate and manifest in other theaters.

Fifth-generation and beyond aircraft like the F-22 Raptor, F-35 Lightning II, F-47 Next-generation Air Dominance penetrating counter-air aircraft (NGAD PCA), and B-21 Raider serve as central components of the DCAO warfighting concept in which dozens, if not hundreds, of small force packages probe and assess the battlespace and simultaneously deliver decisive effects. Within these disaggregated force packages, these advanced aircraft can orchestrate operations with fourth-generation aircraft, uninhabited aircraft, and other military capabilities. The information collection, processing, battle management, and communications capabilities of advanced fifth-generation and beyond combat aircraft serve as force multipliers—central elements in a disaggregated, effects-based family of combat systems.

The DCAO operational concept builds on proven U.S. Air Force approaches to conducting effects-based operations and parallel warfare. Just as precision weapons and stealthy aircraft enabled effects-based

operations, fifth-generation and beyond aircraft provide battlespace information dominance capabilities to enable collaborative warfighting concepts that can achieve decisive effects across contested battlespaces without relying on large strike packages and beyond-line-of-sight support for each mission.

DCAO also focuses on using battlespace information dominance to fracture adversary offensive operations and create effects that cascade through an enemy force. The ability of advanced aircraft to organically gather data, process it into actionable information, and close kill chains in real time is an important advantage. While capacity is still crucial, this concept does not rely on using either physically concentrated mass or distributed mass. Current concepts focusing on mass generally require highly centralized planning, coordination, and always-connected network communication. They also rely on quantities of aircraft that the United States does not and likely will not possess in the next decade. Instead, DCAO pushes information collection, processing, and battle management to the tactical edge of the battlespace. This is important because weapon systems will not be able to broadcast, network, or "reach back" for data in highly contested environments for fear of transmissions being detected, geolocated, and targeted. Data distribution will likely flow one-way—broadcast into the battlespace and received passively. In this way, a central command and control authority may shape military actions and communicate desired effects with a one-way push of data into the battlespace. Minimizing their emissions, fifth-generation and beyond aircraft can then leverage their advanced onboard processing capabilities to fuse onboard and off-board information, allowing their pilots to make informed decisions on the most effective way to engage adversary forces.

There are a few caveats. Uninhabited systems, like collaborative combat aircraft (CCA), will provide complementary and additive capabilities that promise to increase the lethality, survivability, and capacity of Air Force operations in highly contested environments. However, given the current state of autonomous technologies, CCA and other uninhabited aircraft will remain dependent on connectivity and real-time collaboration. Current CCA technology cannot replace the decision-making and other combat management capabilities of crewed aircraft, especially in a disconnected, disaggregated operational concept like DCAO.

Additionally, this new DCAO operational concept alone will not solve the U.S. Air Force's ongoing modernization crisis or check the alarming erosion of its fighter and bomber force. While the Air Force must carefully consider how to apply the air forces it has in the near term, the service must also rapidly modernize its fighter and bomber aircraft inventories and grow its capacity to deter and, if necessary, defeat a growing array of pacing threats.[2]

The Challenge: The Chinese Student Becomes the Master

To be successful, the DCAO operational concept must counter PLA informationized warfighting strategies and capabilities that challenge U.S. assumptions about network connectivity and communications. These informationized warfighting strategies are specifically designed to deny the U.S. military opportunities to connect its distributed forces and effectively generate mass and massed effects. Many of these PLA concepts are carbon copies of U.S. military concepts from the past three decades. The PLA has long modeled itself after the U.S. military, striving to become a "world-class" force by mid-century. Over the past 25 years, China's PLA studied, adopted, and evolved U.S. concepts related

to effects-based operations, parallel warfare, and system-of-systems confrontation—all linchpins of success in America's last major conventional conflict, the 1991 Gulf War. China's military also optimized its offensive and defensive capabilities to target and counter what the PLA sees as the U.S. military's critical operational center of gravity: its sprawling command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) system-of-systems.[3] For the first decade of this century, U.S. military assessments described the PLA's military strategy as "asymmetric."[4] Today, however, there is an extraordinary amount of symmetry between the PLA and U.S. military. For virtually every U.S. military capability, a PLA countermeasure has emerged. More concerning, in the capabilities-countermeasure development cycle, the PLA appears to be out-cycling U.S. technology development and acquisitions, resulting in an erosion of U.S. military advantage.

The PLA's overarching approach to operational-level warfare is based largely on U.S. military concepts borne out of the Cold War's Second Offset Strategy. As was the case in U.S. acquisition strategies of the 1970s and 1980s, China invested in stealth technology, precision guided munitions (PGMs), and networked C4ISR. These capabilities now provide the foundations for a PLA warfighting strategy that is, at its core, a simple two-step process. First, disaggregate an enemy force by attacking its C4ISR system-of-systems, and then target and strike the isolated and disconnected enemy force with long-range precision fires.

To counter the PLA's warfighting approach, DCAO leverages the advanced information collection and processing capabilities of fifth-generation and beyond aircraft to break dependencies from centralized C4ISR and operate with forces that are disconnected by design. This approach renders the impending onslaught of PLA attacks on U.S. C4ISR irrelevant. It is important to remember that the development of fifth-generation and beyond aircraft is rooted in the final days of the Cold War, when commanders anticipated aircraft would have to operate independently and in isolation, incapable of teaming in the face of advanced threats. The Air Force is now in a "back to the future" moment. There are operating environments in which collaboration could yield outsized results, but the U.S. Air Force cannot build its future force around an assumption of robust connectivity. The type of ubiquitous data exchange enjoyed anytime, anywhere during decades of conflict in Southwest Asia will not exist in a fight against a capable adversary that can detect and target almost any transmission in contested battle spaces.

The PLA Approach to Informationized Warfare & System-of-Systems Confrontation

U.S. ideas about modern warfare in the 1990s had a profound impact on the PLA's thinking about system-of-systems confrontation and informationized warfare over the past three decades. Chinese military thought leaders seized upon U.S. military concepts and force design and evolved them as their own, while the U.S. military turned its attention to very different types of warfighting in its Global War on Terrorism. As the United States now returns its focus to near-peer competition, the PLA's institutional thinking on the central role of battlespace information in modern warfare is now probably more developed than current conceptualizations within the U.S. Air Force or the U.S. military writ large.

In the 1990s, Major General Wang Pufeng was one of the leading Chinese thinkers on information warfare at the influential PLA Academy of Military Sciences (AMS). He observed that the United States employed what he

called "extensive information warfare capabilities" in airstrikes on Libya in the 1980s.[5] These "information offensive" capabilities, according to Wang, included reconnaissance, electronic attack against communications and air defense networks, anti-radiation missiles, and precision-guided munitions. Wang noted that information capabilities were even more significant in the 1991 Gulf War, adding computer virus attacks against Iraq's air defense network, strikes on communications, and the use of stealth aircraft in combat.[6] These observations revealed that China's military held a much more expansive view of "information warfare" than their U.S. counterparts. The PLA included elements such as kinetic strikes on information-related systems, C4ISR networks, precision-guided munitions, and stealth technology. Wang and his AMS colleagues began to develop ideas about informationized warfare—that is, warfare transformed by information in much the same way machines facilitated the transformation to mechanized warfare.

Beyond the PLA's observations of real-world operations, the U.S. military placed a tremendous emphasis on network-centric warfare and the role of information superiority in its military operations at the turn of the century. The Chairman of the Joint Chiefs of Staff's doctrine, *Joint Vision 2020*, published in 2000, stated:

> *"Throughout history, military leaders have regarded information superiority as a key enabler of victory. However, the ongoing information revolution is creating not only a quantitative, but a qualitative change in the information environment that by 2020 will result in profound changes in the conduct of military operations."*[7]

The Building Blocks of Informationized Warfare

While not entirely derivative of U.S. military doctrine, China's leading military thinkers seized on U.S. ideas to formulate their own concepts for informationized warfare and system-of-systems confrontation. These concepts, presented in China's Central Military Commission's military strategic guidelines, have clear roots in U.S. system-of-systems warfare doctrine. These guidelines explore the **form of war**, the **means of generating combat power**, the **basic form of operations**, and **basic guiding thought for operations**, all of which inform the development of PLA strategies, operational concepts, and force design. The guidelines also include an assessment of the strategic environment and identify China's strategic opponent, which is currently the United States.[8]

- **The objective form of war** (战争形态). The **form of war** is part of the PLA's basis for preparations for military struggle (军事斗争准备的基点). The U.S. military might refer to the "form of war" as the "character of war." That is, it describes *how* militaries fight wars, given the technology, politics, and collective experiences of the time. The PLA identifies the objective form of war as "informationized local wars."[9] The PLA believes that modern warfare is transformed by the ubiquitous availability, exponential growth in volume, and velocity of information, such that information now plays a leading role in combat operations.

- **Means of generating combat power** (战斗力生成模式). "Systems confrontation" (体系对抗) and "systems destruction warfare" (体系破击战) are two **means of generating combat power** in Chinese doctrine that specifically focus on the destruction of adversary information

systems. System-of-systems confrontation deemphasizes the operational performance of individual platforms such as tanks, airplanes, or warships. Instead, combat power is derived from the overall effectiveness of a system-of-systems that is bound together by battlespace information and data flows.

- **Basic form of operations** (基本作战形式). China's current **basic form of operations** is multi-domain integrated joint operations (多域一体联合作战). This form of operations defines how the PLA should organize for successful modern combat operations.

- **Basic guiding thought for operations.** China's **basic guiding thought** is about how the PLA should approach joint operations to achieve its objectives. Its current design for combat operations pursues three objectives in priority order: information dominance, precision strikes on critical nodes, and joint operations (信息主导, 精打要害, 联合制胜).

These guidelines have been remarkably consistent over the past decade. China's 2015 military strategy effectively synthesized operational guidance into a single sentence: "Integrated combat forces will be employed to prevail in *system-of-systems operations*, featuring *information dominance*, *precision strikes on critical nodes*, and *joint operations*."[10]

The PLA's informationized warfare doctrine holds C4ISR systems-of-systems as critical centers of gravity in friendly and enemy forces.[11] As described, the PLA's designs to defeat a "strong enemy" like the U.S. military are, explicitly, attacking the key links and nodes of U.S. and allied C4ISR systems-of-systems to achieve battlespace information dominance. The PLA's belief that it must achieve and sustain battlespace information dominance at the tactical, operational, and strategic levels cannot be overstated. Any force that engages in a conflict with China's military and fails to recognize and understand the central role of battlespace information dominance in the PLA's operational design risks a potentially disastrous outcome.[12]

How We Got Here: "The Stupidest Thing This Country Ever Did"

The Chinese government's application of system-of-systems approaches extends well beyond military theory to how the government handles economic and social issues. Scholars credit Dr. Qian Xuesen with establishing the Chinese school of systems engineering and advancing the Chinese government's thinking on complex systems. Qian is also the "Father of Chinese Rocketry," revered as the founder of China's nuclear, ballistic missile, and space programs.[57] The origins of many of the most potent PLA systems threatening U.S. and allied militaries can be traced directly back to Qian Xuesen.

Qian Xuesen immigrated to the United States in 1935 and received a master's in aeronautical engineering from MIT and a doctorate from Cal Tech. During World War II, Qian held the rank of colonel in the U.S. Army as an expert consultant.[58] In 1943, Qian co-founded the Jet Propulsion Laboratory (JPL) to develop U.S. missile technology.[59] However, during the Red Scare and shortly after China's communists came to power in 1949, the U.S. government accused Qian of communist sympathies. For five years, the U.S. government prevented him from working on missile programs and placed Qian and his family under surveillance and then house arrest. In 1955, Qian returned to China disillusioned and angry. China's budding aerospace industry eagerly recruited him. Secretary of the Navy Dan Kimball, who had fought to keep Qian Xuesen working in the United States, remarked on his deportation, "It was the stupidest thing this country ever did. He was no more a communist than I was, and we forced him to go."[60]

Therefore, the PLA's priority operational objective in any conflict with the U.S. military and its allies will be deceiving, disrupting, and defeating the U.S. and coalition C4ISR system-of-systems. Informationized warfare, however, does not exclude contests of materiel power to diminish and destroy warfighting capacity. Once the PLA has achieved information dominance and rendered an enemy force "deaf, dumb, and blind," it will then pick off the disconnected and disoriented elements of the enemy force, leaving them unable to coordinate their defense or a counter-offensive.

Proven Operational Concepts to Counter Advanced Threats

The DCAO concept proposes disrupting complex enemy systems and countermeasures using myriad effects created by fifth-generation and beyond aircraft, fourth-generation aircraft, uninhabited systems, and long-range weapons. The concept is based on an evolution of the proven concepts of effects-based operations (EBO) and parallel warfare, which were both developed decades ago and used as the basis of the 1991 Gulf War air campaign.[13] EBO is a process for obtaining a desired effect on an enemy through the synergistic application of the full range of military and nonmilitary capabilities at all levels of conflict. Parallel warfare is an approach that targets multiple critical systems simultaneously, including leadership, communication, and military infrastructure, to paralyze the enemy's operational capabilities.[14]

DCAO differs from traditional approaches to EBO and parallel warfare by replacing EBO's highly centralized advanced planning and operational synchronization with the considerable data-processing, data-exchange, and decision-making capabilities of fifth-generation and beyond aircraft operating at the tactical edge. Fifth-generation and beyond aircraft are key battlefront elements in this construct, given their organic ability to sense the battlespace, process data into actionable information, and team with other platforms as circumstances allow, doing so with the protection afforded by stealth and advanced electronic warfare capabilities.

Evolving Effects-Based Operations & Parallel Warfare to DCAO

Substantial force-on-force engagements in Europe and the Middle East throughout the 1990s proved the unprecedented effectiveness of EBO and parallel warfare. These concepts sought to achieve strategic effects with an economy of force rather than the large-scale destruction and attrition of enemy forces characteristic of warfare throughout the Cold War. The U.S. military first demonstrated EBO and parallel warfare at scale during the 1991 Gulf War and Operation Desert Storm.

In the Desert Storm air campaign, new operational technologies like stealth and precision-guided munitions (PGMs) were pivotal in maximizing results in effects-based and parallel operations using comparatively few aircraft.[15] F-117 stealth fighters unaccompanied by large force packages allowed deep penetration behind enemy lines, while PGMs ensured a high-impact strike for each sortie. F-117s accounted for less than 2 percent of sorties during the Gulf War but hit over 40 percent of strategic targets in the conflict.[16] The use of stealth, precision strike, electronic warfare, and nascent cyber capabilities redefined the concept of combat mass, prioritizing combat effectiveness over using large numbers of aircraft and other forces to achieve similar results.

Instead of overcoming enemy forces through attrition alone, EBO sought to neutralize an adversary's ability to function effectively by targeting critical subsystems within broader networks. For instance, selective targeting that disabled Iraq's electric grid during the Gulf War disrupted and

neutralized Iraqi air defenses. Precision strikes rendered large-scale attacks on or the widespread destruction of defensive command and control systems or the country's electrical infrastructure unnecessary.[17] EBO allowed for an economy of force and reduced collateral damage, all while exacting the desired operational and strategic outcomes.

The lessons of EBO extended beyond the Gulf War to Operation Allied Force, the NATO air campaign against Yugoslavia. U.S. and NATO forces were largely unprepared for the operation that began on March 24, 1999, in response to Yugoslav forces conducting ethnic cleansing of Albanians from the Kosovo region.[18] The air campaign initially defaulted to a classic attrition-based warfighting strategy featuring high-technology aircraft, including the B-2 stealth bomber. NATO planners mistakenly believed that simply rolling back Yugoslav air defenses and targeting fielded military forces would force Yugoslavian leader Slobodan Milosevic to capitulate after the first week of air operations. Two months into the unsuccessful air campaign, the United States and its NATO partners switched to an effects-based strategy to strike infrastructure and economic targets with a special emphasis on the business interests of Milosevic's cronies and political allies.[19] The commitment to and effectiveness of those targeting efforts led to the withdrawal of Russian political support for Milosevic and his military. Ultimately, it was a successful effects-based operation that combined relatively limited bombing and non-kinetic attacks with a targeted strategic communications campaign that compelled Yugoslavian leaders to sue for peace.

The results of EBO and parallel warfare in Yugoslavia reflected ideas advanced by USAF Colonel John A. Warden III in the mid-1990s. Warden presented a conceptual framework for understanding warfare through a lens of systems theory. He argued that traditional tactical warfighting approaches, which focused on individual military forces or battles, were insufficient for modern warfare. Instead, Warden suggested the U.S. military should view an enemy as a complex *system* with interdependent components or subsystems that each played a crucial role in an enemy's ability to function and resist. Warden introduced a model that categorized a state's or organization's vital components into five rings: leadership, organic essentials (critical resources such as energy), infrastructure (transportation and communication systems), population, and fielded military forces. He asserted that the core strategic objective of a military campaign should be to disrupt or incapacitate these subsystems, particularly focusing on an adversary's leadership and organic essentials, to force the adversary to capitulate to the attacker's objectives. This is exactly what happened in Operation Allied Force. According to Warden, exploiting a systems approach drives an enemy to a state of strategic paralysis and minimizes the need to engage in direct force-on-force clashes.[20]

Critiques of Warden's strategy suggest that the five-ring model overestimates airpower's ability to cause rapid enemy collapse and deliver quick, decisive victories. According to some, Warden's focus on leadership decapitation and achieving strategic paralysis may ignore the simple and effective, yet less glamorous, strategy of air interdiction that uses mass to attack an adversary's logistics, supply chains, and fielded forces.[21] Historical examples, like World War II strategic bombing campaigns, reflect the huge investment of time, materiel, and lives that were necessary to drive an enemy to its breaking point. However, considering the outsized dependence on advanced information technology by some of the largest countries' militaries and economies, precision strikes may be able to paralyze even the most complex system-of-systems with an economy of force.

Executing effective attacks that apply Warden's five-ring model at the strategic level (i.e., the national level) may indeed prove problematic, but the concept of attacking systems and subsystems is eminently scalable. Lower-echelon organizations and units—an air force, air defense forces, or regional air operations command—rely on their own rings. The "shooters" in the outer ring—aircraft and missiles, for example—rely on inner rings that include people like pilots and maintenance personnel, infrastructure such as airfields and communications systems, organic essentials like fuel and spare parts, and leadership to direct the fight. Applying EBO and parallel warfare principles, these lower-echelon complex systems can be disrupted and rendered ineffective by conducting attacks on critical subsystems that ultimately paralyze the complex system. This can help avoid or reduce the need for major force-on-force engagements.

Key Principles of Effects-Based Operations and Parallel Warfare

EBO and parallel warfare provide flexible, integrated, and outcome-focused frameworks for planning and executing military operations while balancing effectiveness with efficiency in complex, unpredictable environments. Effects-based operations and parallel warfare offer six foundational principles that inform the DCAO concept and ensure it focuses on creating meaningful effects and an economy of force:

- **Focus on objectives.** The central principle of EBO is to achieve specific strategic, operational, or tactical objectives through measurable effects. Rather than concentrating on tasks or creating damage, EBO prioritizes operations focused on inducing a desired change in the target's behavior or capabilities. DCAO emphasizes overall battlefield outcomes and deemphasizes attrition for the sake of imposing costs or grinding down an adversary.

- **Conduct simultaneous operations.** Like EBO and parallel warfare, DCAO seeks to simultaneously apply forces across different domains and geographic areas, creating multifaceted challenges for the adversary. The goal is to create concurrent dilemmas for the enemy through the rapid and flexible application of air forces. Forcing the enemy to respond to threats on several fronts prevents them from focusing defensive efforts on a single threat axis and results in a fragmented, ineffectual enemy response.

- **Target multiple vulnerabilities.** Parallel warfare seeks to exploit multiple weaknesses in an adversary's strategy, logistics, or infrastructure. This could include targeting communication networks, transportation nodes, supply chains, and decision-making structures simultaneously. DCAO similarly seeks to target multiple vulnerabilities in an enemy system and adjust attacks in real time as those systems "heal," adjust, and adapt.

- **Decentralize command and control.** A key aspect of parallel warfare is decentralizing command and control to allow for rapid decision-making and execution at lower levels of command to respond to dynamic battlespace conditions. This is a foundational principle of DCAO. This flexibility allows military forces to adapt to changing circumstances on the battlefield and exploit opportunities as they arise.

- **Synchronize and integrate activities.** Ideally, forces should conduct effects-based and parallel operations simultaneously. Therefore, individual activities should be synchronized to ensure they support one another and do not operate at cross purposes. Conventional approaches

to parallel warfare require extensive planning and coordination in advance or connected command and control systems in real-time to guarantee the orchestration of different air combat forces. DCAO achieves this objective by broadcasting mission orders to the tactical edge of the battlespace, where fifth-generation and beyond aircraft synchronize and coordinate actions among other elements of independently operating force packages.

- **Utilize constant assessment and feedback.** Like EBO, DCAO will require continuous assessment and real-time feedback to ensure its operations are effective and achieving the desired effects.

Over thirty years ago, EBO and parallel warfare represented a paradigm shift in warfare in which emphasis moved away from traditional force-on-force attrition and toward strategic and operational impacts as a metric of success. DCAO builds on these cornerstones by integrating advanced technology and rethinking traditional network organizational structures to secure decisive outcomes with efficiency and economy of force.

However, current U.S. warfighting concepts such as Joint All-Domain Operations and the Joint Warfighting Concept seek to enable EBO and parallel warfare approaches by connecting commanders to shooters, sensors to shooters, and shooters to shooters, fostering collaboration, synchronization, and integration among U.S. and allied forces throughout the battlespace. In the face of PLA battlespace information dominance warfighting strategies discussed above, a force design relying too much on a highly networked, broad area C4ISR architecture with a large attack surface may be a significant vulnerability.

DCAO, An Asymmetric Operational Concept

Given the PLA strategy to target, disrupt, and destroy U.S. C4ISR networks and capabilities, the U.S. Air Force must have a *strategy* to fight the PRC's *strategy*—a way to secure battlespace information dominance when—not if—the PLA significantly degrades or destroys critical U.S. information links and nodes. The Air Force should pivot away from operational concepts that rely on a force that is networked across the entire area of operations and instead leverage the superior information capabilities of fifth-generation and beyond aircraft. Adopting a concept like DCAO would empower those forces operating autonomously at the forward edge of the battlespace. However, the U.S. Air Force's thinking on how to achieve air superiority and the future use of airpower in general appears to be retrograding to 1980s or earlier concepts that focus on attrition warfare and massed effects. These concepts have little hope of surviving first contact with what is known about PLA strategies and capabilities.

DOD's recently promulgated Joint Warfighting Concept is an example of this thinking. In mid-2023, the Department of Defense and the Joint Staff introduced the JWC, presumably in response to DOD's "pacing challenge"—countering Chinese aggression. The tenets of the JWC include:

- An **integrated, combined joint force** built around seamless integration, synchronized planning, and shared situational awareness across all U.S. and allied services.

- **Expanded maneuver**, an approach in which military forces are able to operate across a broader spectrum of the battlespace than expected, encompassing both traditional and non-traditional domains (e.g., the air domain and the cognitive domain).

- **Pulsed operations** characterized by the coordinated application of force in space and time to generate or exploit advantages over an adversary.

- **Integrated command and agile control**, which includes integrated command and control (C2) across all domains, interconnecting sensors, platforms, and decision-making processes.

- **Global fires** integrating kinetic and non-kinetic fires to deliver precise, synchronized effects across all domains.

- **Information advantage** involves the rapid collection, analysis, and dissemination of information using advanced technologies to enable decision-making superiority.

- **Resilient logistics** that enable the rapid movement of personnel, materiel, and equipment.[22]

The JWC appears to rest on an unproven assumption that larger U.S. force packages can and will be integrated, coordinated, and synchronized, and have shared situational awareness and interconnected decision-making processes that enable them to deliver effects across all domains seamlessly. The impactful advantages, synergies, and efficiencies afforded by such a highly networked force have not been lost on PLA planners. That is why China's military has dedicated itself to using overwhelming kinetic and non-kinetic strikes against the very information capabilities that link and bind U.S. forces—and the high level of connectivity that underpins it.

This report's proposed DCAO concept seeks to enable effects-based operations by pushing data-processing and decision-making to fifth-generation and beyond aircraft operating and coordinating actions

To Link or not to Link: The Limits of LPI/LPD Datalinks

U.S. forces that must operate in highly contested airspace are equipped with low-probability-of-intercept/low-probability-of-detection (LPI/LPD) datalinks or other LPI/LPD communications. The frequency hopping Link-16 datalink—the common U.S. and allied datalink for decades—broadcasts omnidirectionally and may be readily detected and geolocated by advanced electronic sensors. The F-35 datalink, the multifunction advanced data link (MADL), fuses frequency agility with a highly directional antenna to beam information between aircraft. Advanced datalinks transmitted through the space-layer may also be effective in preventing enemy interception or detection.

Proponents of new LPI/LPD communications datalink technology may assert it is nearly invulnerable to detection or attack and will continuously provide long-range, two-way communication among different groups of aircraft. However, rapid advances in countermeasures suggest that what may be LPI/LPD today will likely be subject to detection and interdiction in the future. It would be unwise to adopt a force design and operational concepts based on an assumption of constant long-range connectivity.

Leveraging the laws of physics is a better hedge against future enemy countermeasures. Long-range two-way links are generally fragile and may be subject to detection, geolocation, and disruption. One-way broadcasts into the battlespace are difficult for adversaries to disrupt because of the geometry of the transmission—only receivers and not broadcast sources are vulnerable to jamming. Meanwhile, within a force package, transmitting LPI/LPD waveforms at extremely low power at relatively close ranges with directional antennas may allow aircraft to communicate and exchange data without revealing their location to enemy ISR capabilities.

at the forward edge of the battlespace. In a shooting war with China's military, the PLA will mercilessly target any relatively long-range military communications that might otherwise facilitate reach-back and battlespace data exchange. The U.S. Air Force must pivot from operational concepts that rely on vulnerable networked data exchanged across the battlespace and use fifth-generation and beyond aircraft in discrete formations to achieve EBO and parallel warfare effects in disaggregated operations.

The DCAO concept applies key principles for an effects-based approach to operations (EBAO) outlined in contemporary U.S. Air Force doctrine. Per Air Force Doctrine Publication 3-0, *Operations and Planning*, both EBAO and DCAO capitalize on:

- **A focus on outcomes**—achieves specific end states and objectives with precision instead of mass.

- **Complex problem-solving**—recognizes that operations involve an interactivity achieved through the exploitation of complex systems that cannot be solved with deterministic or checklist approaches.

- **The human element**—acknowledges the unpredictability, friction, and "fog of war."

- **Nonlinear approach**—encourages decision-makers to anticipate unpredictable enemy responses and prioritize the adaptability of friendly forces.[23]

DCAO C2 & Synchronization

The proposed DCAO concept rests on a communications and battlespace data distribution architecture modified from JWC architectures like Joint All-Domain Command and Control (JADC2) that might otherwise support U.S. joint force operations in highly contested environments. Essentially, a DCAO communications architecture pushes coordinating commands and battlespace data far forward into areas where fifth-generation and beyond aircraft cannot transmit for fear of enemy detection. Fifth-generation aircraft operating in a "receive-only" mode can still process broadcasted information at the tactical edge of the battlespace and then synchronize and direct other force elements like fourth-generation aircraft or uninhabited systems, including CCA. One might characterize this mode of operation as "broadcast mission orders" and "broadcast ISR."

Current DOD cross-cutting initiatives, like JADC2, are focused on preserving connectivity across the network. JADC2 seeks to enhance the U.S. military's ability to operate cohesively across domains, connecting all joint force elements together with supposedly resilient networks. The goal of JADC2 is to bring together Army, Navy, Air Force, Marine Corps, and Space Force data and communications frameworks to achieve seamless integration and rapid decision-making in complex operational environments.

JADC2 will no doubt generate efficiencies and outsized effects in benign electromagnetic environments, such as those that have characterized wars in Southwest Asia over the past twenty-five years. However, force designs and concepts that assume a highly connected force have little chance of surviving first contact with an adversary like the PLA. Network-dependent forces are at the center of the U.S. military's existing operational concept, which promises to achieve efficiencies, synergies, and concentration of mass. But the level of connectivity it requires is also its greatest vulnerability—a clearly identified center-of-gravity that the PLA will target and strike with overwhelming kinetic and non-kinetic effects.

DCAO's command and control architecture, conversely, seeks to avoid the vulnerabilities inherent in the kind of network architecture that the PLA intends to attack. DCAO pushes responsibility for battlespace perception, data processing, and decision-making to the tactical edge. DCAO trades efficiency, synergy, and concentration of mass for survivability while still maintaining effectiveness.

DCAO Communications: Operating in Silence, Not in the Blind

In modern high-intensity threat environments, combat aircraft operating at the forward edge of highly contested airspace will likely be unable to maintain two-way beyond-line-of-sight links, transmit replies, or reach back to request specific data for fear of being located and targeted. The PLA has a longstanding saying: "The discovery of a target means that it will be annihilated (目标被发现就意味被消灭)." In the context of PLA informationized warfare and long-range weapons capabilities, an aircraft's ability to remain undetected is a key variable in determining combat outcomes.

That said, DCAO does not leave aircraft and their pilots operating blind in highly contested environments in a conflagration of isolated and disconnected elements. A central organizing authority, an air operations center, for example, might broadcast orders to aircraft operating forward. Such orders might include desired objectives, specific targets, or mission orders that communicate the commander's intent for different airborne formations assigned to different areas of the battlespace. In addition to monitoring enemy activity, a coordinating authority might also collect ISR of friendly forces to silently monitor friendly losses, aircraft and base status, and availability for tasking.

More significantly, an air operations center could broadcast intelligence and operational information into the battlespace. This may include information about the weather, enemy activity, and friendly activity for a particular area of operations. The advanced information processing capabilities of fifth-generation and beyond aircraft can process and parse out extraneous information and then fuse relevant data for onboard use and dissemination to other, less-capable forces. This might include communicating situational awareness and orders to fourth-generation aircraft and uninhabited CCA.

DCAO recognizes the complexity of the modern battlespace and acknowledges the limits of a static understanding of complex, interactive systems. That is, a force package's understanding of a complex enemy system-of-systems upon entering the battlespace is only a point of departure.[24] Given the current state of technology, autonomous systems cannot independently execute a concept like DCAO. Only crewed fifth-generation and beyond combat aircraft operating disconnected from battle networks can act on mission orders, engage in complex problem-solving to target adaptive enemy systems, and deal with the unexpected situations of a dynamic battlespace.

Asymmetric Capabilities: Fifth-Generation Aircraft Technologies

The capabilities at the center of the DCAO concept are precisely those capabilities that fifth-generation and beyond aircraft have to conduct operations at the forward edge of contested battlespaces. Yet, previous assessments related to fifth-generation aircraft have concentrated on capabilities more central to current modes of combat and underplayed the advanced sensing and information processing of these platforms. For instance, many reports on fifth-generation aircraft focused on their aerodynamic and other physical attributes like stealth, maneuverability, and speed. An excerpt from a recent Congressional Research Service (CRS)

report illustrates this type of assessment: "Fifth-generation technologies include stealth coatings and shaping, an internal weapons bay, composite materials, advanced radar and sensors, integrated avionics, and the ability to supercruise (i.e., fly at supersonic speeds without the use of an afterburner)."[25] While the physical and aerodynamic attributes of fifth-generation aircraft increase their survivability in high-threat environments, these aircraft also represent *the* quintessential informationized weapons system—an aircraft transformed by information—in the context of China's informationized warfare strategy.

Aircraft like the F-22 and F-35 are informationized juggernauts, with advanced sensors, datalinks, and communications as well as considerable onboard data processing capabilities and multi-source information fusion in the cockpit. For as much as the PLA Air Force's J-20 and J-35 fighters may appear physically similar to the F-22 and F-35, there is no publicly available evidence to suggest that these Chinese copies feature the computer hardware and data processing power and capacities that give U.S. fifth-generation aircraft their unparalleled advantages in highly contested battlespaces.

Fifth-generation and beyond aircraft are also central to empowering uninhabited aircraft like CCA. CCA are intended and designed to afford important combat capabilities at scale, but given the state of current and near-term artificial intelligence technology, it is both impractical and cost-prohibitive to replace crewed fifth-generation aircraft technology and their suite of capabilities in CCA. If fifth-generation and beyond aircraft are not present in the battlespace to manage CCA and other uninhabited systems, they will likely need their own sensing and processing capabilities, which will raise costs and reduce quantity buys. Fifth-generation and beyond aircraft are the linchpins of modern air combat, guiding other platforms in the force package.

Applying the Legacy of Forward Air Controllers to DCAO

In many ways, the DCAO concept is similar to U.S. military doctrine on close air support (CAS). CAS is air action by aircraft against hostile targets that are in close proximity to friendly forces. Integrating and synchronizing CAS action in time, space, and purpose, as well as with supported ground forces, is among the most complex tasks performed by the U.S. Air Force. Joint terminal air controllers (JTACs) on the groundwork with forward air controllers (airborne) (FAC[A]) to control the maneuver of and grant weapons release clearance to attacking aircraft.[61]

During the Vietnam War, the OV-10 Bronco light attack aircraft served primarily as an observation and FAC(A) platform to coordinate CAS from the air in real time. The OV-10 had multiple radios to act as a communications hub, a large greenhouse canopy for enhanced visibility, and a long on-station time to provide persistent overwatch. OV-10's real-time intelligence gathering, target marking, and flexibility made it a crucial asset to direct other strike aircraft that would roll in from longer ranges and higher altitudes in a fast-moving, highly complex battlefield.

DCAO applies these ideas in a much broader way. Even though the DCAO concept does not necessarily involve friendly troops in contact with enemy forces on the ground, DCAO puts fifth generation aircraft in a similar FAC[A] role. Pilots flying fifth generation aircraft with their advanced information collection and communications capabilities are at the center of the DCAO fight, sensing the battlespace, making decisions, and directing other aircraft, uninhabited systems, and long-range weapons onto targets in highly contested battlespaces.

Game-Changing Fifth-Generation Capabilities

As the only operational fifth-generation aircraft in production, the F-35 stands as an important means to immediately boost important U.S. warfighting capabilities and capacity. Recent upgrades to F-35s have realized massive increases in airborne data collection and information processing capabilities that provide a strong foundation to build out a DCAO operational concept. The F-35 represents, quite literally, a generational leap in technology, replacing decades-old fourth-generation fighter aircraft.[26]

Since entering service in the mid-2010s, F-35-associated technologies have continued to evolve and improve. The latest iteration is a major upgrade program known as Technology Refresh 3 (TR-3), Block 4. TR-3 consists of significant hardware upgrades to the F-35 that enable Block 4 improvements, including a new integrated core processor that is 25 times more powerful than its predecessor and a larger memory unit. The core upgrade to the F-35's F135 engine also provides increased durability and capabilities to facilitate next-generation weapons, sensors, and jammers. F-35 Block 4 upgrades focus on software and capability upgrades for the aircraft. These include improvements in target recognition and electronic warfare capabilities and support for an expanded arsenal of weapons. Most significantly, TR-3 Block 4 has adopted an open mission systems architecture, which will allow for rolling improvements to F-35 capabilities without major system redesigns.[27]

Building off lessons learned from F-22 and F-35, the B-21 is designed with powerful attributes to penetrate contested airspace and understand *where* and *how* to employ airpower in real time. Similarly, the F-47 represents key advancements in the penetrating counterair mission set, as described by Air Force Chief of Staff Gen Dave Allvin: "The F-47 will have significantly longer range, more advanced stealth, be more sustainable, supportable, and have higher availability than our 5th-generation fighters… [It will have] next-generation stealth, sensor fusion, and long-range strike capabilities to counter the most sophisticated adversaries in contested environments."[28] While China and Russia are making progress with their advanced aircraft, the B-21 and F-47 will likely remain unmatched capabilities for the foreseeable future. The United States must not squander this advantage. Procurement of these aircraft should be done rapidly alongside sustained fifth-generation aircraft and CCA production (if warranted after proof-of-concept testing) if the U.S. Air Force wants to compete and win in the modern battlespace.

Fifth-Generation Aircraft in DCAO

The unique information-related attributes of advanced combat aircraft like the F-22, F-35, and B-21 will allow them to conduct disaggregated and collaborative operations with other fifth-generation fighters, fourth-generation aircraft, and uninhabited aircraft. These capabilities will enable DCAO when U.S. air forces are disconnected from broader battle networks or are in a "receive only" data environment. The capabilities summarized below focus principally on the latest iteration of the F-35. Classification issues tied to the B-21 and F-47 aircraft prevent an open discussion of those aircraft and their capabilities, but similarities in the features and attributes of those aircraft are likely quite strong. The Air Force is also considering upgrades to the F-22 with the intent of extending that aircraft's service life beyond 2030. The F-22 improvements reportedly include classified sensor systems associated with the Air Force's Next-Generation Air Dominance family of systems that includes an even more advanced F-47.[29]

Stealth. Fifth-generation stealth technology goes beyond the shape and design of the aircraft

and coatings that prevent adversaries from seeing the aircraft on radar. They do not render fifth-generation aircraft "invisible." Those capabilities effectively shrink an adversary's detection range, often significantly. Aircraft stealth inhibits every element of an adversary's kill chain—detection, tracking, track transfer to weapons employment, weapon tracking, and fusing. It includes preventing an adversary from determining an aircraft's altitude, range, speed, and direction of flight with sufficient accuracy to launch weapons against it. Beyond stealth, the advanced sensing and battlespace awareness capabilities of fifth-generation and beyond aircraft allow them to identify and map adversary air defense emitters and then maneuver to further avoid detection.[30]

Passive sensing. Fifth-generation aircraft have significant capabilities to passively collect threat radar and other electronic emissions. Passive sensors allow combat aircraft to detect targets and potential threats without using active radar or other emissions that could be detected by an adversary. The F-35's Distributed Aperture System (DAS) consists of six infrared cameras that look in all directions around the aircraft. DAS provides the pilot with unparalleled situational awareness without having to emit any signal that might give away the aircraft's position.[31]

Advanced radar. The F-35's AN/APG-81 active electronically scanned array (AESA) radar was an improvement on the F-22's AN/APG-77 AESA radar that significantly increased the detection range and volume of airspace the F-35 can scan.[32] The F-35's AN/APG-81 is now being replaced by the AN/APG-85, which will reportedly double the capabilities of its predecessor.[33] While many details surrounding the APG-85 are classified, the radar will incorporate some of the latest technologies available, contributing to the F-35's unparalleled battlespace situational awareness.[34]

Electronic warfare. The F-35 TR-3/Block 4 reportedly includes significant upgrades to the aircraft's already substantial electronic sensing, protection, and attack capabilities.[35] The F-35's electronic sensing capabilities rival those of older, big-wing reconnaissance aircraft. The F-35's APG-81 and APG-85 multi-function radars are so powerful that they can be used to jam or spoof enemy radars.[36]

Target tracking. In addition to advanced radar and passive sensing capabilities, the F-35 has an upgraded Electro-Optical Targeting System (EOTS) that provides super high-definition video and precise laser designation capabilities. EOTS combines both forward-looking infrared (FLIR) and infrared search and track (IRST) capabilities, allowing pilots to passively detect and track targets or potential threats at long ranges without emitting any detectable signals.

Computing power. The F-35 TR-3 upgrade includes an improved integrated core processor (ICP) that offers 25 times more processing power that will allow the system to continue to scale up capabilities well into the future.[37] The ICP incorporates over half-a-gigabyte of dynamic random access memory (DRAM) to operate various systems.[38] Onboard computer data storage figures are classified, but they must be in the range of multiple terabytes to hold the amount of data the F-35 collects and processes. Other processing power improvements include enhanced mission data file (MDF) capabilities and an improved Communication, Navigation, and Identification (CNI) processor.[39]

Information fusion. The F-35's advanced processing capabilities can fuse information from multiple onboard and off-board sources into a cohesive picture of the battlespace and provide pilots with recommendations and target solutions on a single display. The TR-3 improved panoramic cockpit display features a higher-fidelity touch-sensitive screen for better information management capabilities.

These sensor fusion features allow pilots to allocate their cognitive capacity to flying and engagement management rather than sensor management.[40] In other words, pilots can focus on combat functions and less on the mechanics of operating the aircraft and its systems.

Propulsion. Propulsion is a key driver of capability for any advanced combat aircraft, enabling speed, maneuver capability, electrical power, and survivability. Fifth-generation and beyond propulsion features the most advanced low-observable technologies and coatings, which enable stealth operations in non-permissive environments. Other advanced propulsion technologies, such as adaptive architectures, also promise to improve range.

Non-Fifth-generation Aircraft in DCAO

The DCAO concept recognizes the challenges created by a near-peer adversary's integrated air defense systems and effectively combines the advanced technology of fifth-generation and beyond aircraft with the force-multiplying capabilities of fourth-generation and penetrating uninhabited systems to achieve war-winning effects in highly contested environments. Fifth-generation and beyond aircraft can act as information hubs and coordinators for multiple types of aircraft in DCAO.

The wider inventory of U.S. fourth-generation and future uncrewed aircraft can play many different positions on a team with a fifth-generation aircraft quarterback. The computing power and information fusion capabilities of fifth-generation and beyond aircraft can help enhance target management and mission coordination, directing the actions of fourth-generation combat aircraft and uninhabited systems such as CCA. By receiving either pre-flight or in-flight mission orders, fifth-generation and beyond aircraft can assign specific targets, tasks, or objectives to these older and/or less survivable aircraft. For example, an F-35 or B-21 could use its stealth capabilities to penetrate enemy air defenses undetected, relay critical targeting data to fourth-generation jets equipped with long-range stand-off munitions, and guide uninhabited systems to perform electronic warfare actions on threats or complete

Maintaining Propulsion Advantage

No matter how capable an airframe or the associated mission systems, their attributes are of little benefit without the performance advantages afforded by a capable jet engine. As the United States looks to sustain its fifth-generation air combat advantage and innovate next-generation capabilities, defense leaders should not take the historic U.S. advantage in propulsion technology for granted. Many of the Air Force and other services' aircraft are flying with engines designed in the Cold War. Newer engine types designed in the 1990s and 2000s are now decades old. Sustaining and upgrading existing designs is different from developing, fielding, and producing new engine technology. That is why the Air Force and other services have invested in multiple programs to pursue new engines that deliver the enhanced performance, reliability, and efficiency necessary to meet current and future mission requirements. Better thrust, increased efficiency to boost range, and greater reliability are all fundamental attributes of advanced aircraft. Beyond propelling the airframe through the atmosphere, cutting-edge sensing, data processing, and electronic warfare capabilities require significant electricity generation, which, in turn, produces substantial amounts of heat that drive design considerations like size, weight, power, and cooling (SWAP-C). The U.S. defense industry is in a race with potential adversaries to develop new propulsion technologies to overcome the engineering and physics that limited the performance of engines conceived in the last century. Beyond the weapons and sensors featured prominently when discussing advanced combat aircraft, the underlying propulsion provides the essential foundation for the combat advantages these aircraft provide.

reconnaissance tasks. This distributed approach to achieving mission tasks helps reduce risk to vulnerable assets while maximizing the overall effectiveness of DCAO force packages. This force-multiplying effect is critically important, especially given the diminished state of the Air Force's combat air inventory.

Enduring Requirements for "Stand-In" Air Forces

DCAO leverages stealthy fighters, bombers, and potentially uninhabited systems like CCA to comprise a stand-in force. The terms "stand-in force" and "stand-off force" have gained popularity among airpower strategists, even though U.S. Air Force doctrine has not formally defined the terms. The distinction between the two types of forces lies in where and how each force completes its respective kill-chains and other actions. Stand-in forces can operate both outside and inside contested airspace, whereas stand-off forces generally operate only outside contested airspace. Another key difference is that stand-in forces rely more on their organic capabilities to complete their find, fix, target, track, engage, and assess (F2T2EA) kill chains. Stand-off forces usually operate outside the lethal range of enemy threats and rely on off-board, non-organic sensors and communication networks to complete their kill chains to employ long-range weapons.[41] Stand-in aircraft like F-35, F-22, F-47, and B-21 can penetrate high-threat areas, generate their own targeting information, and then allocate weapons to strike targets.

Examples of Real-World Successes in Mixed-Generation Ops

Fifth-generation aircraft have already used their sensors to collect battlespace data, process it into actionable information, and then team with other force elements in real-world operations. These examples demonstrate the potential for operating in highly contested environments in which threats effectively cut off force packages from two-way communications and force them to operate independently.

As early as 2015, U.S. Air Force F-22s were used as "quarterbacks" to direct other aircraft in operations over Syria. F-22s deconflicted multiple assets using their superior sensing, processing, and information fusion capabilities. Serving as a force package mission commander, F-22 pilots would routinely direct aircraft such as F-15Es and B-52s where to attack and when.[62] In 2024, Israeli F-35s led a force package of as many as 100 aircraft, including fourth-generation F-15s and F-16s on a long-range strike against Iran.[63] In June 2025, Israeli F-35s again led a large mixed force package of over 200 aircraft and uninhabited systems such as radar-seeking attack drones into Iran to strike military leadership and nuclear-related targets.[64] The F-35s flew ahead of the main strike formation, penetrating heavily defended airspace and mapping hostile radars and SAM sites. Their data enabled rapid vectoring of Israeli F-15s and stand-off missiles from Israeli submarines and loitering munitions. Despite advanced Iranian air defense capabilities, the strikes achieved near-complete surprise and successfully degraded key military infrastructure with no reported Israeli losses.[65] The DCAO concept envisions standardizing and institutionalizing these types of operations at a larger, more complex scale.

As illustrated by these examples, the U.S. Air Force and allied air forces can leverage the stealth, sensor fusion, and precision capabilities of penetrating fifth-generation aircraft to effectively leverage the multirole capabilities of fourth-generation aircraft and uninhabited systems. As the Air Force continues to innovate and integrate emerging technologies and uninhabited systems, coordination using fifth-generation aircraft will be key to achieving air superiority and operational effectiveness in complex, contested environments.

The threat environments facing today's Air Force are substantially more complex than the relatively permissive environments that existed during decades of counterterrorism operations in Southwest Asia. Widely proliferated advanced integrated air defense systems (IADS) now pose an unacceptable threat to non-stealthy aircraft in multiple theaters. Non-stealth combat aircraft will certainly retain a role in operations against a near-peer adversary, but they must likely operate from stand-off ranges.

An over-reliance on these stand-off forces creates a force design with significant operational limitations in highly contested environments, including an increased reliance on off-board sensors, communication networks, and other capabilities required to complete long-range kill chains from stand-off distances.[42] This increased reliance on off-board systems and long-range data links is, again, a significant vulnerability against adversaries like the PLA that seek to disrupt U.S. operations through battlespace information dominance. The U.S. Air Force's operational history, especially over the past several decades, reveals that a combination of stand-in and stand-off capabilities offers unparalleled strategic and operational flexibility. This is especially true in an uncertain strategic environment in which the United States cannot anticipate where and when it will need to fight, much less who it may need to fight, with any degree of certainty.[43]

Others have correlated the two terms "inside force" and "outside force" with descriptions that differentiate between where forces are postured. In this sense, "inside" forces operate from bases that are located closer to the battlespace. In the case of a conflict involving the PRC, this would include the Pacific's First Island Chain. "Outside" forces would be postured along the Second Island Chain or even farther from adversary threats. Inside forces may be subject to a higher volume of enemy air and missile attacks compared to forces based outside the ranges of those missile threats.[44] U.S. Air Force inside forces have long been the core of its force design, which includes over 2,000 fighter aircraft in the service's active component, Air National Guard, and Air Force Reserve.[45] These shorter-range combat aircraft, including the A-10, F-16, F-15, F-22, and now the F-35, have deterred adversaries and conducted decisive air operations for decades. Operating from an inside force posture, these combat aircraft have consistently and reliably established air superiority and delivered mass, tempo, and precision effects against U.S. adversaries in real-world operations since the end of the Cold War.

An inside U.S. military presence also serves to increase the risk that an adversary might attack an area in question, including the Baltic states, Taiwan, a Philippine island, or Japan. Ambitious challengers like Russia and the PRC will need to carefully consider the geostrategic ramifications of engaging an inside U.S. force presence. A predominantly outside force that may or may not show up to a future fight to intervene may be little more than an abstraction to PRC and Russian leaders. It simply lacks the deterrent value of an inside force. Moreover, a forward presence of inside air forces demonstrates U.S. resolve to stand by allies and partners in times of crisis. Allies and partners, bolstered by a U.S. stand-in presence from well-defended forward air bases, are more likely to fight in a coalition, which further serves the cause of deterrence.

Reinforcing allies and partners is one of the three strategic priorities in the U.S. Pacific Air Force's *PACAF Strategy 2030*, which acknowledges that the Air Force and other services must fight as an allied team. Despite speculation that the Air Force might retrograde to more of an outside force posture, *PACAF Strategy 2030* requires it to remain prepared to conduct operations in the Indo-Pacific with inside forces operating from a more distributed regional posture.[46]

Toward a Balanced Force Mix

On a practical level, inside forces composed of both fifth- and fourth-generation strike fighters are what the U.S. Air Force has available in the greatest numbers in its present-day inventory to address near-term crises. The current U.S. bomber force does not have the sortie generation capacity when operating from an outside force posture, nor does it have enough very long-range—and typically more costly—weapons to generate enough stand-off strikes required for a large-scale operation against a near-peer adversary.

Critical penetrating, stand-in shortfalls will likely persist at least through the mid-2030s until sufficient numbers of next-generation B-21 bombers are available and the F-47 NGAD PCA can advance.[47] In the interim, the Air Force should substantially increase its acquisition of fifth-generation F-35s to raise the capacity of its stand-in forces. These aircraft, combined with the service's current inventory of fighter aircraft and weapons, are the only viable option to create effects across a large geographic battlespace like East Asia until more B-21s and the F-47 can join the force.

Basing these forces forward in the face of significant adversary strike threats in the Pacific and Europe is a serious concern. These challenges are significant, but not insurmountable—*if* the services invest in hardening, dispersal, deception, camouflage, and active defenses that include kinetic and non-kinetic effectors to counter missile attacks against their air bases.[48] In a conflict with a near-peer adversary, generating necessary combat sorties *only* from air bases located thousands of miles from the battlespace will be impractical if not impossible.

Dozens or hundreds of inside-based, stand-in formations led by fifth-generation and beyond aircraft working with CCA and fourth-generation aircraft will require new operational concepts to ensure they can deliver effects that will fracture and ultimately defeat adversary operations. Disaggregated collaborative air operations are designed to do just that.

The Value of an Inside Force Presence

Some U.S. military planners and leaders have concluded that inside forces postured at dispersed locations along the Pacific's First Island Chain may be too vulnerable and unable to survive PLA long-range missile strikes. Such operational conclusions ignore history and fail to value the geopolitical leverage and deterrence that inside forces provide. As strategist Michael Kofman observed, "Vladimir Putin and Xi Jinping are not military planners by training, nor do they stay up at night reading technical manuals on niche capabilities or wargaming with many-sided dice."[66] The very presence of U.S. air forces in Japan and elsewhere along the Pacific's First Island Chain *reduces* the potential for China to launch an act of aggression.

All the Wrong Lessons from All the Wrong Wars

Extraneous lessons from the conflict in Ukraine have dragged down the level of the U.S. debate surrounding the application of airpower in modern, high-end combat. Graphic battlefield videos on social media of small drones attacking tanks have understandably done more to shape misperceptions among the public and senior U.S. decision-makers than even the most persuasive policy papers. In a fundamental misunderstanding of how airpower is applied, the fact that neither Russia nor Ukraine has achieved air superiority has caused some to herald the demise of crewed aircraft, pointing to a fundamental change in the character of modern warfare. That is simply not true.

The conflict in Ukraine has demonstrated an evolution, not a revolution, in ground and maritime tactics.[49] Ground forces in Ukraine are using small drones for ISR and as what is best

characterized as precision artillery at relatively short ranges (about 10–20 km). Drones contest air superiority like a mortar round—they are certainly lethal and difficult to shoot down, but they are not a means to establish control of airspace for other military purposes. Uncrewed surface vessels (USVs) serve as remote-controlled torpedoes that similarly exercise no control over water space. More than that, longer-range drones fired at cities or military bases could be considered nothing more than slow-moving, propeller-driven cruise missiles. Most significantly, these so-called "revolutionary" military technologies have not delivered decisive victories to any military that has employed them. They may have increased casualties among infantry and armor, but drones have had no demonstrable impact on air operations.[50]

Small drones lack range and face debilitating challenges from electronic jamming, making them unsuitable for operations over great distances, like those in the Pacific theater. Similarly, slow-moving long-range drones may not survive in highly contested environments, like those created by PLA air defenses. Iran's use of longer-range drones to attack Israel has been an objective failure in the face of Western defense capabilities. The history of drones on the modern battlefield is still a work in progress, and the drone capabilities-countermeasures development competition is certainly accelerating.[51]

A revolution in uninhabited airborne capabilities is very likely on the horizon, but a significant shift in how air forces generate airpower and where they are based should not take the wrong cues from recent experiences in Ukraine or Southwest Asia. The coming revolution in air operations in high-intensity conflicts will more likely be the product of advanced battlespace information sensing, collection, and onboard processing from advanced fifth-generation and beyond aircraft, combined with the use of more advanced uninhabited aircraft like CCA.[52]

Other Challenges: An Easy War is Hard to Find

The DCAO operational concept offers an innovative and adaptive approach to outmaneuver near-peer adversaries' evolving strategies and capabilities designed to defeat current U.S. approaches to generating combat mass. Relative to a potential conflict with China's military, DCAO is an operational concept that outmaneuvers the PLA's warfighting strategy to disrupt and destroy the integrated networks upon which current U.S. operational concepts rely.

DCAO, like any operational concept, forms a basis for operational planning or military force design. It is a conceptual point from which to work backward toward other supporting requirements. It does not, in and of itself, solve many of the enduring challenges facing the U.S. Air Force, especially in the Indo-Pacific area of operations. Failure to invest in required communications systems, basing, and logistics may undermine, if not cripple, the employment of the DCAO concept. DCAO requires associated capability development of both technology and tactics, techniques, and procedures (TTPs) to support its disaggregated, collaborative operations.

DCAO highlights a number of potential challenges, dependencies, and vulnerabilities that the Air Force should address as the concept is developed and implemented. Several of the challenges facing DCAO are synonymous with those facing the Air Force's Agile Combat Employment (ACE) concept that disperses combat sortie generation operations across multiple operating locations. These challenges include:

- **Defending U.S. air bases against air and missile attacks.** Forward-based air forces are essential for DCAO. There is an acute threat of PLA long-range missile strikes against bases in the Indo-Pacific, but vulnerabilities to missile attacks also exist in other theaters of operation. Effective base

hardening, dispersal, active defenses, and offensive counterair operations to suppress enemy strikes are absolutely necessary to offset these threats.[53] No future adversary should be given a sanctuary from which to operate unhindered.

- **Conducting sustainment and logistics operations while under attack.** Distributed operations require a robust logistics system capable of withstanding disruptions and enemy attacks. Given the potential for enemy disruptions to communications outlined in this report, forces may not be able to reach back for logistics and maintenance data or to request resupply. A push-based logistics system, like the push-based data and communications system proposed for DCAO, may address those shortcomings. A hybrid push-pull system could address the U.S. military's reliance on real-time logistics demand signals.[54]

- **Decentralizing command and communications.** DCAO requires a significant shift toward decentralized operations, away from centralized C4ISR systems that will be explicitly targeted by advanced militaries like the PLA. This transition involves designing and deploying secure, reliable communication methods that work effectively in contested environments. DCAO's reliance on push or broadcast mission orders and intelligence data into the battlespace while limiting outbound communication creates operational constraints and potential coordination challenges. Advanced communication technologies for intra-force package communication, like LPI/LPD systems, may become vulnerable over time. These challenges must be addressed through TTP development to ensure DCAO operations remain effective as capabilities and countermeasures advance.

- **Integrating mixed air forces.** Forces will need to train to coordinate complex operations between fifth-generation and beyond aircraft, older fourth-generation aircraft, and uninhabited systems. The Air Force and other services will likely need to make investments in communications capabilities to ensure that fifth-generation and fourth-generation aircraft, as well as uninhabited systems and long-range weapons, can safely and effectively communicate in highly contested environments.

- **Increasing the capacity of the air force's fifth-generation and beyond aircraft inventories.** DCAO depends heavily on using fifth-generation and beyond aircraft for sensing, processing, and decision-making. Continued delays and shortfalls in production, upgrades, or deployment of these aircraft will undermine the core capabilities of the concept. Rapidly fielded upgrades to fifth-generation and fourth-generation aircraft will be necessary to maintain an edge over countermeasures developed by adversaries.

Balancing the funding and development of DCAO with other strategic priorities, such as long-range strike capabilities and other force modernization efforts, poses a resource allocation challenge. Funding fifth-generation and beyond aircraft acquisition alongside the requisite air base defense, logistics, communications capabilities, and training will be essential for the successful implementation of DCAO. All represent significant investments. However, these measures are needed to effectively deter and, if necessary, defeat near-peer adversaries in highly contested environments.

Conclusions & Recommendations

The U.S. Air Force must adapt its force design and operational concepts to counter near-peer adversaries like China. Given declining Air Force aircraft inventories, it should emphasize shifting from traditional mass-on-mass warfighting strategies to operational concepts like DCAO. DCAO leverages fifth-generation and beyond aircraft, such as the F-22, F-35, F-47, and B-21, as core components of a stand-in force capable of conducting disconnected and decentralized operations in contested environments. These advanced aircraft can collect, process, and disseminate critical battlespace information, and then orchestrate and control fourth-generation aircraft and uninhabited aircraft, including CCA.

Existing U.S. Air Force operational concepts using large force packages like "pulsed airpower" continue to assume its forces will have highly networked connectivity in contested environments, which China's military will ruthlessly target. China's military doctrine for informationized warfare and system-of-systems confrontation is clear about the PLA's intent to degrade, disrupt, and destroy U.S. C4ISR capabilities at all levels of warfare—tactical, operational, and strategic. DCAO sidesteps these adversary strategies by employing forces that are disaggregated by design.

The recent U.S. and Israeli operations in Southwest Asia demonstrated the efficacy of fifth-generation F-22s and F-35s leading and coordinating force packages, integrating data from multiple sources, and enhancing the capabilities of fourth-generation aircraft and uninhabited systems. By leveraging the advanced sensing, stealth, and onboard processing capabilities of fifth-generation and beyond combat aircraft, DCAO will improve the survivability and effectiveness of U.S. combat air forces without dependencies on vulnerable, centralized C4ISR networks. The concept design enables numerous smaller units of air forces operating independently to disrupt and defeat adversary operations.

While the F-35 remains a perennial punching bag for defense critics, the aircraft has been embraced by U.S. allies and is the envy of U.S. adversaries. Its capabilities are truly game-changing, especially given that the United States will likely be operating these aircraft in coalition operations alongside some of the twenty partner nations that have purchased the F-35. Its combat performance over Iran stands as a testament to the incredible effectiveness of the aircraft. Questioning the F-35's viability is regressive and must stop if the United States is to move forward. Officials should instead commit to meeting the buy rates originally established for fifth-generation aircraft. Newer, next-generation aircraft must be pursued, but not at the expense of the significant investment in fifth-generation aircraft necessary to replace hundreds of Cold War-era fighters that are at the end of their service lives.

Recommendations

This report proposes a new concept for conducting disaggregated collaborative air operations to effectively counter near-peer adversary warfighting strategies. The concept's core elements are based on fully exploiting the capability advantages of the Air Force's fifth-generation and beyond combat aircraft to achieve decisive effects in contested battlespaces. These capabilities will also help create new ways to employ fourth-generation crewed aircraft and uninhabited aircraft in conflicts against near-peer adversaries. To mature DCAO and ensure the Air Force's new force design delivers the capabilities U.S. warfighters require, the Mitchell Institute offers the following recommendations:

- **Reduce dependence on centralized C4ISR.** The Air Force should design operational concepts to ensure its combat forces will continue to function effectively without reliance on long-range, highly networked, or centralized command

systems that are vulnerable to PLA attacks. These concepts should include ways and means for "broadcast mission orders" and "broadcast ISR" that push data into contested battlespaces without relying on vulnerable two-way communications.

- **Adopt and develop Disaggregated Collaborative Air Operations as an operational concept.** Air Force operational concepts should employ fifth-generation and beyond aircraft as central components to lead decentralized and disaggregated operations. Leveraging fifth-generation aircraft's advanced sensing and data-processing capabilities to control and orchestrate formations of fifth- and fourth-generation aircraft, as well as uninhabited systems, will reduce their dependence on centralized C4ISR systems and increase their resiliency in the face of PLA informationized warfare attacks.

- **Modernize and scale fifth-generation and beyond forces.** The Air Force should rapidly scale up its inventory of fifth-generation aircraft to replace its geriatric fourth-generation combat aircraft. The Air Force should also develop and acquire CCA (if warranted after proof-of-concept testing), B-21, and F-47 NGAD PCA aircraft at scale to create a collaborative, disaggregated, effects-based family of combat systems that enhances the survivability and effectiveness of all joint forces in contested environments. Continued investment in future upgrades to sensor and computing technology should be a priority in addition to developing propulsion capabilities that current and future aircraft will require.

- **Balance stand-in and stand-off forces.** The Air Force should create a balanced mix of stand-in and stand-off combat air forces to provide theater commanders with the operational flexibility needed for conflict with near-peer adversaries. This balanced mix of stand-in and stand-off aircraft should create a more complex force composition that increases the Air Force's ability to create multiple dilemmas that adversary forces must address.

- **Expand forward base defense and hardening efforts to enable DCAO.** The Air Force should double down on its Agile Combat Employment concept to enable DCAO. Hardening, dispersal, deception, and deploying active defenses to the service's Pacific bases will increase their ability to generate combat sorties while under threat from episodic attacks by PLA strikes.

DCAO addresses some of the most sophisticated threats from some of the U.S. military's most challenging military competitors. The Air Force must always be prepared for an intense, large-scale, extended war with a near-peer adversary. That said, the Air Force must also prepare to address a wide range of possible contingencies in unforeseen circumstances and operational environments. DCAO is not a concept that seeks to "do more with less." The DCAO concept leverages forces and technologies that are available now or in the near future. Maintaining a substantial stand-in force of fifth-generation and beyond aircraft augmented by long-range stand-off forces and, potentially, uninhabited CCA offers U.S. leadership and warfighters the greatest possible strategic and operational flexibility in an uncertain world. ✪

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