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Key Points

US airpower operates most directly in conjunction with ground forces through close air support (CAS). Today's low threat CAS scenarios will persist, but other future conflicts will be highly contested, subjecting US and allied forces to unprecedented enemy threats.

Although aircraft optimized for low threat CAS environments will have ongoing value, providing desired effects at lower operating costs, a full-spectrum approach to CAS will also require the capability to engage in high threat scenarios.

Producing the desired CAS effects in high threat environments calls for aircraft with the highest levels of survivability and combat capability. Leveraging decentralized execution enabled by a jam-proof network—a combat cloud—these aircraft will integrate capabilities from all services and across all domains to maximize operations in highly contested scenarios.

Full Spectrum Close Air Support for the 21st Century: Leveraging Air Operations with Ground Forces

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Abstract

A new, full spectrum approach to close air support (CAS) must be developed in order for US forces to optimally operate with ground forces across all levels of conflict. Counterinsurgency and irregular warfare operations in low threat environments will persist for the foreseeable future. Legacy aircraft will be effective in those scenarios, but other future conflicts will take place in highly contested anti-access/area denial (A2/AD) environments. These will contain lethal anti-aircraft threats to which less advanced, non-stealthy aircraft are intrinsically vulnerable.

Fifth generation aircraft afford survivability in A2/AD environments via stealth. Their sensors collect enormous amounts of data, which they fuse into a picture of the tactical situation. These "sensor-effector" aircraft will share this information with joint forces across all domains—land, sea, space, and cyberspace—as part of a jam-proof construct known as the "combat cloud." This common detailed picture of an entire battlespace will enable US and allied joint forces to integrate and coordinate their various capabilities to produce desired tactical effects.

This cross-domain approach will be most effective when these sensor-effector aircraft are free to act quickly in response to evolving tactical scenarios. New methods of command and control (C2) that capitalize on the situational awareness (SA) created in the combat cloud will permit efficient, decentralized execution at the tactical level. To optimize ground force effectiveness, sensor-effector aircraft will act as "quarterbacks," making on-the-spot decisions and rapidly coordinating the weapons effects of "players" across all domains to target enemy forces before they can target our own.

Introduction

Since 2001, US forces have been engaged in near-continuous counterinsurgency and irregular warfare operations. These low intensity missions are expected to continue for the foreseeable future, and rely heavily on close air support (CAS) provided by a variety of aircraft, such as remotely piloted MQ-1 Predators and MQ-9 Reapers, B-1B and B-52 bombers, and F-15E, F-16, F/A-18, and F-22 fighter aircraft. The A-10, an aircraft optimized for the close air support mission, has also provided excellent combat effects.

Looking to the future, it is important to balance two competing dynamics: a requirement to provide CAS in low threat environments in a mission effective, cost efficient fashion, and preparing for an increasingly dangerous operating environment where CAS will be employed against highly capable, advanced adversaries. This latter type of operation will call for a fully integrated joint approach to combat that leverages capabilities across the air, land, sea, space and cyber domains. Assets from these domains must act collectively, by quickly coordinating their efforts through shared situational awareness (SA) and via timely operational and tactical decisions. The ability of these systems to survive and operate in these harsh environments will be imperative to maximize their combat effectiveness. It is particularly important to note that the advancing rate of technology proliferation will mean that conflicts once deemed "low threat" for aircraft will increasingly be populated by higher end, anti-access/area denial (A2/AD) weaponry.

A carefully balanced inventory of airpower assets and capabilities will be required for effective joint force employment across the full spectrum of conflict.

This reality will demand a new "full spectrum" approach to CAS to ensure friendly ground forces can effectively operate in conjunction with air forces in these scenarios. Meeting the challenge of A2/AD threats will require both survivability and the ability to harness available information to employ the proper force at the right time and place. The F-35 and B-21 will prove essential in filling such requirements, but many aircraft that perform well in uncontested environments will be at great risk in high threat scenarios and will have limited utility in those conflicts. In future low threat environments, concepts such as the US Air Force's proposed light attack fighter aircraft (OA-X) will be able to perform CAS effectively, while also generating savings due to its comparatively low hourly operating cost (an OA-X type aircraft could cost as low as one-sixtieth of a frontline fighter's hourly cost).[1]

Many different types of aircraft have racked up thousands of flight hours performing CAS in recent counterinsurgency operations; use of the OA-X will reduce the wear and tear on fourth and fifth generation aircraft, freeing them to train for combat in higher threat scenarios. A carefully balanced inventory of airpower assets and capabilities will be required for effective joint force employment across the full spectrum of conflict. The ability to perform CAS in threat-permissive conflicts is well established, and can be preserved by retaining the A-10 and other legacy aircraft that can effectively perform the CAS mission. The pressing need is to create the necessary capabilities to effectively operate in conjunction with ground forces in highly contested environments.

The Close Air Support Mission

The beginnings of the CAS mission date to the advent of combat aviation in the First World War. Then as now, aircraft employed gun and bomb attacks to defeat enemy ground forces attacking friendly ground units. Throughout the Second World War, the Korean War, and the Vietnam War, CAS continued to develop in complexity while retaining the same fundamental characteristics — using the speed, flexibility, and vantage of the air domain to defeat frontline enemy ground forces.

CAS missions range from "high threat," in which the aircraft performing CAS are faced with significant ground and airborne threats, to "low threat," where aircraft can operate with impunity due to the absence of such threats. The need for CAS arises when friendly ground forces encounter capable enemy ground forces that threaten to destroy or impede them. Examples include unplanned contact with previously undetected enemy forces, or an expected encounter that did not unfold as planned. These events might take place because friendly ground forces did not account for enemy actions; enemy ground forces were not defeated while still distant with organic ground, or joint force operations; because friendly forces advanced more rapidly into enemy territory than expected; or because friendly forces were outmaneuvered, outgunned, or surprised by the enemy. In any case, CAS may be required to neutralize the adversary quickly, without endangering friendly units. Failure to do so may result in the destruction of the engaged friendly forces, perhaps allowing enemy forces to break through the friendly lines to advance and threaten other forces in retreat, or attack the flanks of other friendly units.

CAS-Optimized Aircraft: Well-Suited—But Vulnerable

"While sustaining the A-10 fighter fleet for close air support, the Air Force should procure 300 low-cost, light-attack fighters that would require minimal work to develop. These aircraft could conduct counterterrorism operations, perform close air support and other missions in permissive environments."

Sen John McCain (R-AZ), chairman, Senate Armed Services Committee[2]

To continue to provide CAS in conjunction with US ground forces, the USAF has decided to retain the A-10 "Warthog" attack aircraft in its inventory until at least 2021.[3] It is also currently exploring the feasibility of SASC Chairman McCain's suggestion to acquire hundreds of light attack aircraft for CAS in permissive threat environments, where the A-10 and other multi-mission aircraft have been successfully operating. Counterinsurgency and irregular warfare operations promise to be a large part of US military actions for the foreseeable future. Aircraft optimized for low threat CAS, such as the A-10, the OA-X, and remotely piloted aircraft (RPAs) like the MQ-9 Reaper will continue to be valuable in those operations. Further, performing low threat CAS with an OA-X type of aircraft offers advantages in the forms of much lower operating costs and the opportunity to reduce wear and tear on frontline aircraft. For instance, the A-29 Super Tucano turboprop aircraft has an historical operating cost of $1,000 per hour, which is less than 1/20th that of the F-16 and 1/60th that of the F-22.[4,5]

In practice, aircraft development has always been an exercise in tradeoffs and compromises that reflect specific mission needs.

The use of frontline aircraft to perform low threat CAS during the years-long stabilization phase of Operation Iraqi Freedom (OIF) aged those aircraft considerably. A 2013 RAND Corporation study showed that between 2006 and 2010 F-16s assigned to active duty USAF units flew an average of 316 hours per year, while the average annual flight hours for a reserve component F-16 was 218.[6] In contrast, an F-16 unit deployed to OIF in 2007 logged an average of 487 hours per aircraft in just 9 months, at an annualized rate of 650 hours per year.[7] Despite the benefits of using CAS-optimized aircraft in low threat scenarios, key attributes of these aircraft make them unsuitable for use in high threat conflicts.

In practice, aircraft development has always been an exercise in tradeoffs and compromises that reflect specific mission needs. A 2005 RAND Corporation study identified the following attributes it judged would be desirable in an aircraft optimized for CAS, with the first two being the most important:[8]

- High airspeed
- Large weapons load
- Day and night, adverse-weather operations
- Long loiter time
- Situational awareness
- Quick turn (revisit) rate
- Mixed weapons load
- Accurate weapons delivery
- Survivability against air defense
- Flexibility to operate from unimproved bases

Several of these attributes conflict strongly with the others. Aircraft that are optimized for CAS invariably exhibit traits that make them less useful in other airpower applications. For instance, the A-10 was designed for long loiter times and a tight turning radius to permit multiple, rapid re-attacks against ground targets. These attributes enhanced its CAS capabilities, but at a cost; long loiter times and a tight turn radius each require a relatively slow airspeed operating envelope, effectively excluding the A-10 from offensive strike packages made up of much faster aircraft. CAS-optimization also resulted in the A-10 having no air-to-air radar, which greatly limits its capability against enemy fighter aircraft. These shortcomings make the A-10 highly vulnerable to modern air defense systems, greatly impairing its survivability.

When considering operations in conjunction with ground troops in conflicts where modern air defense systems may oppose our forces, however, we must recognize that the A-10 was not designed for such opposition, and the US has not yet had to pay the price for the vulnerabilities inherent in non-stealthy, lower-tech platforms like the A-10 or OA-X. Such limitations demand that we seek alternative means to ensure that we can provide essential mission capabilities when operating in conjunction with ground forces in highly contested combat environments.

Airpower Tenets and the Limitations of CAS-Aircraft

A brief overview of key airpower concepts will help to underscore the built-in shortcomings of aircraft designed solely for CAS.

Airpower theory has been continuously developed, tested in combat, and refined over the past 100 years. Airpower is most effective when it is applied with seven fundamental tenets in mind:[9]

Aircraft optimized for CAS have limited flexibility and versatility, greatly reducing their capability to shift to other missions…

1. Centralized Control and Decentralized Execution
2. Flexibility and Versatility
3. Synergistic Effects
4. Persistence
5. Concentration
6. Priority
7. Balance

An air component commander employs centralized control to optimize tasks of a limited number of air, space, and cyber assets. Decentralized execution provides airborne assets the freedom to quickly respond to changes in the immediate tactical situation to ensure that the overall objectives are met.

Aircraft optimized for CAS have limited flexibility and versatility, greatly reducing their capability to shift to other missions, operationally or tactically. Whereas a multi-role fighter has the flexibility to be diverted from a planned strike mission to an unexpected call for CAS, a CAS-optimized aircraft cannot quickly be tasked to join other fighters en route to strike an enemy target. CAS-optimized aircraft likewise do not possess the versatility required to be effective in the wide variety of missions that are flown in an air campaign—for example, as part of a strategic attack carried out against an adversary's centers of gravity, deep inside enemy territory. The limited utility of a CAS-optimized aircraft thus impairs its ability to contribute to the synergistic effects that can be obtained across all domains by aircraft comprising a flexible, coordinated force.

Persistence in modern airpower does not necessarily require that an asset remain in the vicinity of potential targets; rather, the speed and range of air assets permits them to flow quickly to targets as needed to provide persistent effects. CAS optimized aircraft possess range and endurance, but their slower speeds, combined with other limitations, make them less able to provide persistence across the air component's area of responsibility.

From an air component commander's view, these characteristics of CAS-optimized aircraft effectively exclude them from contributing to any concentration of air assets that may be required during an evolving operational scenario, where rapid transitions to different roles may become necessary. While CAS may become a high priority during certain phases of an operation, having a CAS-optimized platform represents the permanent establishment of CAS as a high priority for the duration of the conflict. Much as firefighters sitting at a fire station cannot easily be used for other purposes, a CAS-optimized aircraft will see little application during large portions of an offensive operation. This limitation makes it difficult for the air component commander to quickly respond to changing threats and to maintain an effective balance in applying finite assets in support of the joint force commander's overall objectives across all domains and at all levels of war.

Yesterday's Aircraft: Tailored to Yesterday's Conflicts

The Cold War pitted NATO forces against the numerically superior forces of the Soviet Union. Planners sought to blunt that numerical advantage by targeting rear echelon Soviet forces before they could engage NATO forces, bringing a rapid end to a theoretical Soviet advance. The US Air Force was tasked with conducting strategic attack against distant Soviet command and control (C2) elements, as well as air interdiction strikes to target enemy forces before they could engage friendly forces. CAS would be performed as needed to defeat enemy forces and meet joint force objectives in conjunction with ground forces. Strategic attack and air interdiction were to be carried out by "strike packages" comprised of a large number of aircraft of varying types. It was assumed that the enemy would detect the attacking aircraft by radar and attempt to destroy them with its integrated air defense system (IADS), a combination of air-to-air fighters, surface-to-air missiles (SAMs), and anti-aircraft artillery (AAA) which received their cuing and guidance from centralized controllers.

Strike packages were designed to punch through the enemy's IADS in one location, briefly overwhelming the IADS' capabilities at that spot. Air superiority fighters, operating in front of the rest of the package, trained to conduct offensive counter air (OCA) "sweeps" designed to destroy and disrupt the enemy fighters. Electronic attack aircraft would follow, jamming enemy radar systems. Other aircraft were tasked with suppression of enemy air defenses (SEAD) by attacking enemy SAM systems with bombs and missiles. These actions would allow multi-role fighter "striker" aircraft to penetrate enemy airspace to attack their assigned targets with unguided bombs. The strikers would make their ingress runs at low altitude and high speeds to deny or delay acquisition by enemy SAM systems and the radars of enemy air-to-air fighters. They would fly in close formations of four aircraft to provide mutual support through visual lookout for SAM launches and to defeat any enemy fighters that survived the OCA sweep. Multiple "four-ship" formations were involved, each separated by minimum spacing that permitted some defensive maneuvering on the part of each, while not stretching out the "train" so much that the enemy forces had a chance to engage the strikers easily, nor prolonging the package's exposure to enemy threats longer than necessary.

The use of these strike packages concentrated airpower in both time and space, slightly impairing the attribute of flexibility that has long been the hallmark of airpower.

The use of these strike packages concentrated airpower in both time and space, slightly impairing the attribute of flexibility that has long been the hallmark of airpower. The need to mass forces in this manner for self-defense, and the limited amount of time that the package spent in enemy airspace, meant that any aircraft providing air attack in conjunction with friendly ground forces could not be part of a strike package. Aircraft that provided CAS would need to be continuously "on call" whenever friendly ground forces found themselves in close contact with opposing ground forces. The slower, CAS-optimized A-10, unable to keep up with the strike packages, was assigned to that role.

The strike package tactics developed for the Cold War were applied with tremendous success against the Iraqi military in Operations Desert Storm and Iraqi Freedom. However, the overarching strategy of the Desert Storm air campaign signaled a radical departure in how war was conducted. Technological advances, in conjunction with an effects-based approach to planning and execution, introduced a new concept of operations that has been described as "parallel" war—the simultaneous application of force across the totality of the enemy system to paralyze its ability to operate at the strategic and operational levels.[10]

Two significant operational level modifications were made in response to the specific capabilities of the Iraqi IADS. First, each campaign was preceded by an extensive air offensive that effectively eliminated the Iraqi IADS' capabilities. The success of the air campaign was a result of the advent of stealth technology, precision-guided weapons, and an effects-based approach to planning the air operations against the Iraqi government and military systems. Second, instead of flying at low altitude, strikers attacked from a relatively high altitude to avoid the extensive IADS threats in the well protected areas of Iraq.

While A-10 operations in heavily defended areas was precluded by the threat, even in areas of lesser defenses, such as Iraqi Republican Guard units in the desert, the vulnerabilities of the CAS-optimized A-10 were apparent. During Operation Desert Storm, multi-role F-16s executed nearly 32 percent of all air strikes, losing three aircraft to enemy fire and having three others damaged. The A-10, by comparison, flew 23 percent of all coalition strikes. Despite the Iraqi IADS being severely degraded, A-10s suffered the highest rate of aircraft losses, accounting for half of USAF tactical aircraft lost with six A-10s destroyed and fourteen damaged, with a loss-per-strike rate four times higher than that of the F-16. Notably, the stealthy F-117 accounted for 5 percent of all strikes (striking 40 percent of the fixed target base), with zero losses.[11] Although A-10 pilots performed valiantly and effectively, the A-10's disproportionately high loss rate in Desert Storm serves as graphic evidence of the vulnerability of CAS-optimized aircraft.

Today's Reality: Anti-Access/Area Denial Strategies

ANTI-ACCESS

"Action intended to slow deployment of friendly forces into a theater or cause forces to operate from distances farther from the locus of conflict than they would otherwise prefer. A2 affects movement to a theater."

AREA DENIAL

"Action intended to impede friendly operations within areas where an adversary cannot or will not prevent access. AD affects maneuver within a theater."

AirSea Battle Concept Implementation Summary, May 2013[12]

As great a threat as A2/AD strategies pose, stealth technology, advanced datalink systems, and modern sensors offer a means to effectively counter those threats.

The world of air combat has changed radically since the 1980s. The rise of "double digit" SAMs such as the SA-20 has placed the survivability of large, dense strike packages in doubt. These modern SAMs have the ability to track and reach targets at all altitudes, at great distances, and with sufficient maneuverability that legacy fighter aircraft will not be able to evade these missiles, even with a maximum performance turn. Adversaries with such weapons are able to employ anti-access (A2) and area denial (AD) strategies designed to control large areas of strategic interest to the US.

IADS equipped with these modern systems will place US forces at higher levels of risk and force them to operate at greater distances from areas of interest. A renewed focus on US interests in the Asia-Pacific region, coupled with the recognition of the challenges posed by an A2/AD environment led to the development of the AirSea Battle (ASB) concept in 2009. ASB featured the principle of attack-in-depth, and expanded its perspective to include integrated operations across the air, land, sea, space, and cyberspace domains. Such cross-domain integration will be applied not only to offensive operations, but also to counter the increased threats posed by A2/AD systems, including the threats to friendly ground forces. In 2015 the ASB concept was expanded to formally include all services and domains, and it was renamed the "Joint Concept for Access and Maneuver in the Global Commons," or "JAM-GC."[13] The Army's contributions to JAM-GC include its missile and air defense capabilities, augmentation of communications, and providing forced entry to strategic locations.

Modern Aircraft: Designed for A2/AD Environments

As great a threat as A2/AD strategies pose, stealth technology, advanced datalink systems, and modern sensors offer a means to effectively counter those threats. Rather than a starting position of knowing that friendly aircraft will be seen and targeted by enemy systems, stealth aircraft are able to enter and operate in enemy airspace undetected, and hence, untargeted. Modern datalink systems allow the F-22 and the F-35 to maintain awareness of the positions and actions of wingmen, enemy aircraft, and other friendly forces. More accurately described as "sensor-effectors" than "fighters," these fifth generation aircraft employ a wide variety of sensors to find, fix, track, target, and engage enemy forces applying force when required to create desired operational effects. The F-35 in particular is designed around a sensor "fusion engine" a mathematical algorithm through which all available information is combined, correlated, and presented to the pilot in a single, fused display of the battlespace.[14] This enables the pilot to focus on tactics, rather than sensor management. The B-21 will harness similar capabilities.

Stealth, datalinks, and sensors are the core attributes that define fifth generation technology. These capabilities offer entirely new possibilities in offensive air combat, allowing all of airpower's attributes to be used fully and effectively. The F-22, F-35, and the B-21 Raider will rely on stealth to avoid detection by the enemy; they do not need to fly at low altitude to enter contested airspace. High altitude operations provide for better communications, greater flexibility, higher speed, and longer ranges for weapons and sensors. Gone too is the need to fly in the defensive crouch of a visual formation to provide lookout for enemy aircraft and missiles; stealthy fighter aircraft are free to fly in widely spread formations, beyond visual range, while still retaining the ability to support others in their formation for both offensive and defensive purposes. This "detached mutual support" gives modern aircraft the flexibility to cover much larger swaths of the sky while performing their missions.

In contrast to the almost total reliance on unguided bombs during the 1980s, precision laser-guided and GPS guided munitions now enable the destruction of targets with only a fraction of the bombs previously required. With far fewer aircraft required per target, the F-35 will supply versatility in smaller numbers than with non-stealthy legacy aircraft, while being even more effective. Technological advances have also yielded a broad array of options for force application that go beyond simply destroying targets with bombs. In addition to traditional "kinetic" weapons that rely on explosives to destroy targets, "non-kinetic" means such as directed energy weapons already exist or are within reach.[15] Non-kinetic weapons can even be non-destructive. On May 2, 1999, the BLU-114/B "graphite bomb" submunition was employed by NATO forces against a Yugoslav electrical plant during Operation Allied Force, spraying carbon filaments over power lines that caused short-circuits—disabling 70 percent of the country's power grid for seven hours.[16] This created an operational effect that was the same as if the power plant had been destroyed.

The goal of CAS is to neutralize the threat to ground forces posed by proximate enemy forces. Ground commanders will not care how that result is achieved, as long as it is timely and effective.

Rather than an assault concentrated in time and space, the enemy will have to contend with precision attacks from all points of the compass by aircraft that cannot be detected or tracked by radar. The F-35 will swarm and disperse at will, greatly complicating the enemy's defensive problem by providing concentration of effects when needed, but also retaining overall flexibility to create synergistic effects across the battlespace. Add the now routine capability of conducting air combat operations at night, and the persistence of these effects will be multiplied greatly by round-the-clock attack.

Against the backdrop of this modern tactical scenario, new options for the protection of friendly ground forces become available. The goal of CAS is to neutralize the threat to ground forces posed by proximate enemy forces. Ground commanders will not care how that result is achieved, as long as it is timely and effective. It can be accomplished by any capable aircraft, system, or combinations of aircraft and systems, whichever can produce the desired effect in a timely fashion. In fact, in the nine years from 2006 to 2105, over 80 percent of CAS conducted in Iraq and Afghanistan was conducted by aircraft other than the A-10.[17]

Ideally, the need for CAS will be prevented by finding, fixing, tracking, targeting, and engaging enemy forces before they make contact with friendly forces. Air Force doctrine already contains missions intended to produce that effect; strategic attack and air interdiction. CAS is a last resort, emergency mission to be executed only if these other efforts do not prevent enemy forces from threatening our ground forces, or if the enemy outmaneuvers friendly ground forces.

Strategic attack, air interdiction, and close air support are best viewed as simply three points along a continuum of required responses to an enemy threat. The point on that continuum where the threat lies should determine the required response—ranging from an immediate, emergency response (CAS), to postponing dealing with certain threats to allow limited assets to execute higher priority missions. New methods of command and control (C2) will be required to achieve such timely and precise response to threats.

Command and Control of Aircraft Operating with Ground Forces

Currently it falls to the engaged ground commander to recognize the need for CAS and to request it from a higher echelon. The request passes through a service-specific pipeline to intermediate level centers tasked with coordinating air support for ground forces. There the urgency, type, and quantity of the needed CAS effect are analyzed, and the threats to the CAS asset posed by other operations in that airspace are considered. The request for CAS is sent further up channel, to a USAF combined air and space operations center (CAOC), or a Marine Corps tactical air command center (Marine TACC), or the fleet command center (FCC) of a Navy maritime operations center (MOC). It is at this operational level where scarce, dedicated CAS assets are allocated and ordered to the scene. After the CAS assets arrive on scene, a joint tactical air controller (JTAC) with the engaged ground forces communicates with the CAS aircraft via a standard format message called a "nine-line" to update the situation, identify the location of targets and friendly forces, and then request the desired attack. The nine-line process takes considerable time, and works far better in permissive threat environments than it would in an A2/AD scenario where the CAS aircraft would be continually reacting to enemy threats. The cumulative delays created by these chains of events slows the response to requests for CAS, potentially increasing the risk to our ground forces.

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While it is important to exercise centralized control and planning over forces, the advantages offered by the airpower tenet of decentralized execution are not optimized through current C2 systems. The complicated, centralized processes in place today increases the time of response, and places a great deal of the decision making regarding tactical actions at the operational level. In addition, the huge quantities of information gathered by intelligence, surveillance, and reconnaissance (ISR) assets, plus the battlespace situational awareness derived from airborne and ground-based radar systems are also consolidated at the operational level—not with the airmen in their cockpits. CAOC personnel integrate this information to create a well-detailed picture of the battlespace.

The centralization of situational awareness increases the tendency to centralize tactical decision making at the operational level. Because of this dynamic, CAOC commanders use their situational awareness to direct the actions of assets throughout the theater. Decades of experience in using this method of C2 have refined these processes, and they have worked fairly well in operations against less capable adversaries in small regional conflicts, with modest numbers of assets and sorties involved. There is an enormous difference between an air campaign that averages 3,000 sorties a day, and the routine air operations that Americans have become used to over Iraq and Syria of one or two hundred a day.

The previously mentioned RAND Corporation study notes that the shift of Army doctrine toward greater emphasis on maneuver warfare would require faster decision cycles for air operations.[18] Such faster decision cycles will require a new approach to the C2 of air assets. In addition to the US Army's more fluid tactical approach, the advanced threats, rapid pacing, and the complexities inherent in operations in A2/AD environments anticipated in future conflicts all combine to quickly overwhelm any process reliant on centralized execution. Simply adding more CAOC personnel to process the data does not solve this problem. In fact, it can actually slow the decision cycle as was demonstrated in a 2016 Red Flag exercise.[19]

Centralized control and execution also creates a center of gravity that could be targeted by more capable adversaries. If a CAOC were destroyed, or even simply cut off from ongoing operations, the engaged forces would be largely deprived of direction and adequate situational awareness. Combat would degenerate into uncoordinated, localized battles. Assets would not be used effectively, and their synergistic effects would be lost. This could cripple the operation, resulting in a decisive loss. In many ways, this is precisely the tactic the US and its allies used against Saddam Hussein's forces in 1991 during Operation Desert Storm. The US must ensure we are not similarly vulnerable to such an attack.

A better approach to battle management, one that capitalizes on the efficiencies inherent in decentralized execution, is a must for future combat operations. Decentralized execution will empower the tactically engaged forces to rapidly respond to threats and opportunities. This new degree of flexibility will be made possible by a robust, self-establishing, self-repairing information network known as the "combat cloud."

The Combat Cloud and Decentralized Execution: An Analogy

"Desired military effects will increasingly be generated by the interaction of systems that share information and empower one another. This phenomenon is not restricted to an individual technology, nor is it isolated to a specific service, domain or task. This concept can be envisioned as a "combat cloud". The combat cloud treats every platform as a sensor, as well as an "effector," and will require a C2 paradigm enabling automatic linking, seamless data transfer capabilities, while being reliable, secure, and jam proof."

Lt Gen David Deptula, USAF (Ret.) [20]

It is useful to think of the combined forces air and space component commander (CFACC) as the "coach" of the air and space combat team. A football coach assembles a team of players with different roles and abilities, sees that the players are trained individually, and then together, until they function as a team. The coach provides the team with a detailed game plan, briefs the players about the other team's strengths and how to counter them, and also how to capitalize on their weaknesses. Similarly, the CFACC assembles and trains the air and space team, providing them with objectives, intelligence, and a game plan.

It is useful to think of the combined forces air and space component commander (CFACC) as the "coach" of the air and space combat team. A football coach assembles a team of players with different roles and abilities, sees that the players are trained individually, and then together, until they function as a team.

During a game, the coach exercises overall control by substituting players, assessing the execution of the game plan, and making adjustments to the plan based on what the other team actually does. During offensive combat operations, the CFACC employs centralized control, adjusting to significant events in order to guide the air component towards realizing the joint force commander's objectives.

When plays are executed, a football coach cannot make decisions for the players, but must rely on the players' abilities, judgment, and training. Similarly, despite the high level of situational awareness the CFACC possesses, tactical decisions are best made in real time by the air component's "players," the engaged forces. Attempting to direct the tactical actions of all forces from the CAOC is an adaptation of the old Soviet model of centralized command and control—a failed model.

A coach relies on the quarterback to make real time decisions for the offense. The coach may send in a play, but if the quarterback sees that the play is doomed to failure because of an adjustment made by the opposing defense, that play must be discarded and replaced by an "audible" play that can be successful. The quarterback has the best information available, the knowledge to quickly decide on a course of action, and the ability to coordinate the actions of the team. In an A2/AD combat scenario, the sheer number of tactical decisions that must be rapidly made would easily overwhelm a CAOC. Lani Kass, a lead developer of concepts that underpin US Cyber Command operations, asserts that the air component's key contribution is its tremendous "ability to quarterback a battle that takes place cross-domain—land, air, sea, space, cyber, and under the sea simultaneously."[21]

A combat "quarterback" at the tactical level, armed with the situational awareness and judgment to see what needs to be done, plus the authority and ability to coordinate the resources with which to do it, will be indispensable. The combat cloud will empower numerous quarterbacks across the entire battlespace each one an information node in a grand sensor-effector network to simultaneously make the timely audibles required to ensure success. The cloud will integrate real-time battlespace information and present it immediately to the tactically engaged forces, providing them with a degree of situational awareness that is currently available only at the CAOC level. It will also enable them to act by tasking applicable effectors directly and immediately, eliminating the lengthy, multilayered chain of events currently required to generate air operations in conjunction with ground force operations.

Shifting the locus of effort from the "centralized control" airpower tenet to the "decentralized execution," tenet of airpower, these audibles will be made by the airmen actually executing the mission. They alone are uniquely suited to make adjustments in response to an evolving tactical situation. They will know the commander's intent, mission objectives, stated acceptable levels of risk (ALR), and the rules of engagement (ROE). They will be supplied with real time awareness of threats, friendly forces, and the number and capabilities of available assets. This will greatly reduce reliance on decision makers at the CAOC, thereby decreasing the response time in applying the desired effect. It will also permit much greater flexibility in the tactical application of airpower assets, vastly increasing combat efficiency through timely concentration of effector assets, and providing for better persistence of the effect. At the same time the "coach" of the air team, the CFACC will retain the ability at the operational level to modify the game plan as required.

Victory on the Ground in an A2/AD Environment: A Glimpse Into the Future

"Look, I don't care how you do it, or what you do it with - I just need you to find the bad guys that are shooting at me, kill them quickly, don't hurt or kill me, and help me find more bad guys before they shoot at me!"

Unnamed US Army infantry officer[22]

Imagine a future conflict played out in an A2/AD environment in which the air component is tasked with operating in conjunction with deployed friendly ground forces. The joint force commander's objectives, supplemented by the stated mission priorities, are known to all tactically engaged forces. Suppose that the sensor-effector network detects a previously unknown threat, or recognizes that a known threat has not been neutralized as planned. Through the combat cloud, decentralized execution by tactical forces can efficiently and rapidly reassign air, land, and sea assets from lower priority tasks in order to prevent a CAS scenario, or to perform CAS if required, without reliance on the CAOC for coordination. The pilot of a sensor/effector aircraft such as an F-35 will be able to act as a quarterback, tasking available assets to attack hostile ground forces in lieu of expending his own ordnance. This will free the F-35 to monitor for enemy air threats, and to continue to coordinate the ground support effort. The F-35's fusion engine accelerates the "observe, orient, decide, and act" process by performing the bulk of the observing and orienting, allowing the pilot to decide and act faster and more effectively.[23, 24]

In the event that CAS is required, the combat cloud will greatly enhance the situational awareness of the responding assets, reducing or eliminating the need for a lengthy situation report from a JTAC, and allowing for safer and more rapid employment of weapons.

For air interdiction, synergistic effects can be achieved by attacking with multiple assets simultaneously, matching weapons to targets. Remotely piloted aircraft (RPAs) from any service could be tasked by the F-35 pilot; RPAs equipped with solid state lasers (SSLs) could target enemy aircraft and ground vehicles, while other RPAs could employ cluster bomb units, precision-guided munitions, missiles, and guns. If the enemy force is sufficiently large, the F-35 pilot may call upon a larger stealth aircraft, such as the B-21, to precisely employ numerous heavy munitions over a large area. As the reassigned air assets proceed to the location of enemy ground forces, they could be preceded and/or supplemented by rockets launched by the Army's High Mobility Artillery Rocket System (HIMARS), an Army Tactical Missile System (ATACMS) missile, or by precision-guided hyper velocity projectiles (HVPs) now under development by the US Navy. HVPs could be fired by Army howitzers, or by the electromagnetic rail guns (EMRGs) soon to be mounted on Navy ships. The EMRGs will be able to deliver HVPs as far as 200 nautical miles in just 6 minutes.[25] Cruise missiles launched from air, sea, or land can be tasked to interdict enemy forces far from friendly ground forces, with the aim of preventing the need for CAS entirely.

In the event that CAS is required, the combat cloud will greatly enhance the situational awareness of the responding assets, reducing or eliminating the need for a lengthy situation report from a JTAC, and allowing for safer and more rapid employment of weapons. One can envision an "auto nine-line" (A9L), by which a responding pilot can examine all pertinent information while still en route to the location where the effect is needed. The auto nine-line will self-generate via the combat cloud when the need for CAS is identified, and can be modified, supplemented, and updated by all parties involved. Friendly positions, the locations of other assets involved, known enemy positions and the threats posed by enemy weapons will automatically be displayed and updated. It will be a dynamic, common reference for all parties threatened by, or engaged in neutralizing, enemy forces.

Via the combat cloud, the engaged ground commander can choose from the palette of available effects, considering both their effectiveness and their potential threat to friendly forces. Once the desired effect is chosen, any attack restrictions required to keep ground forces safe from the selected effects will automatically be displayed for the responding effectors.

The final authority to release weapons, or to employ other effects, will be determined by both the proximity of the enemy threats to friendly forces and the relative danger of the selected CAS effect. If tight control of the effect is required, a networked "cleared hot" authorization can be passed by the ground commander to the effector. In some cases, there may be no restrictions placed on the responding assets; for example, the use of a directed energy weapon that poses no threat to friendly forces will permit immediate, unrestricted weapons employment. If confidence is high among all involved that the effect's threat to friendly forces is nil, the effectors could employ at will unless trumped by an "abort" input.

The final authority to release weapons, or to employ other effects, will be determined by both the proximity of the enemy threats to friendly forces and the relative danger of the selected CAS effect.

An abort input can be made by any participant who determines that employment of the effect must not proceed. For example, an F-35 can call for an abort if the pilot detects enemy aircraft that threaten friendly forces and therefore must be dealt with first, in accordance with the "dynamic" acceptable level of risk. Unlike predetermined, fixed risk levels, a cloud-supported, dynamic ALR can rise and fall, depending upon the unfolding scenario and its impact on campaign objectives. Adjustments to the operational risk assessment can be made by higher level commanders, or they can occur automatically, based upon criteria previously supplied by those commanders.

Meanwhile, ground commanders, air commanders, and their staffs in the CAOC continue to monitor the ongoing mission reprioritizations and the reassignments of effectors as they occur. As adjustments ripple throughout the system as a result of the retasking of a given asset, air-to-air fighters, aerial tankers, ISR assets, rescue forces, and others may need to have their missions altered in response to operational audibles. Commanders at this level retain the ability to selectively exercise centralized control, if needed, to ensure that the allocation of combat assets remains in balance with respect to the joint force commander's objectives and reflect their priorities for asset employment. CAOC commanders may occasionally elect to modify the tactical level decisions being made by the combatants, but generally their attention will be focused on directing operational level activity. In the event that the CAOC is cut off from engaged forces, or even destroyed, the combat cloud offers the potential to continue these operational level functions via a combination of autonomic features and informed decisions made by the engaged forces. In any case, the flexibility, versatility, and survivability of the assets carrying out the mission remain critical to its success.

The Imperatives of Flexibility, Versatility, and Survivability

"The speed, range, persistence, and flexibility of air assets are their greatest advantages, and their employment location and purpose may change in minutes."

Joint Chiefs of Staff, Joint Publication 3-30, Command and Control of Joint Air Operations [26]

Making the above vision of future force protection a reality will require the right inventory of assets that can be integrated into a sensor/effector network. A stable of assets that are able to survive and operate in an A2/AD environment, and that possess sufficient flexibility and versatility will allow the CFACC to hold fewer assets in reserve for possible CAS missions, either airborne or as ground CAS alert. This will increase the effectiveness of applied airpower.

Assets already airborne with preplanned targets should have the flexibility to be reassigned to an emerging CAS mission, providing timely response. The decision to divert an asset to a developing enemy ground situation will hinge upon a number of considerations, including the priority of an aircraft's original mission and the versatility of that aircraft—its ability to provide the desired effect on enemy surface forces. Another factor in deciding whether an aircraft should be reassigned will be the availability of another aircraft to provide mission backfill for the diverted aircraft. Ideally, aircraft that may be on CAS standby will also have enough versatility that they may be immediately "re-roled" to provide mission backfill for that diverted aircraft to ensure that the originally planned mission effect is still achieved.

Managing a collection of force application assets requires a thorough awareness of the capabilities and limitations of available assets across all domains. These must be assessed, cataloged, and then thoughtfully integrated into the "quiver" of the sensor-effector network. Once the entire palette of available effects is known, deficiencies may be identified. These deficiencies may be either general in nature, applying to all scenarios, or may be campaign specific, driven by the CFACC's apportioned and allocated assets, the enemy's assessed capabilities, and the campaign plan. Theater and campaign-specific deficiencies may be addressed in the planning stages through the addition of assets that can meet the need, or in the execution phase, through the application of less capable assets in sufficient numbers to produce the desired effect. General deficiencies may identify the need for new assets to address those deficiencies, including the need to develop and acquire platforms that can provide CAS effects.

Flexibility, versatility, and the ability to survive and operate in an A2/AD environment are must-have traits for aircraft that will be part of a fully integrated, cross-domain approach to ground force protection.

A full spectrum approach to CAS will require the ability to operate in conjunction with ground forces in all combat environments, not all of which demand aircraft with the highest levels of combat capability. Based on the results of the 2013 "Combat Dragon" experiments designed to assess the utility of turboprop aircraft optimized for CAS, the USAF now plans to evaluate a number of commercially available aircraft which can be configured to perform integrated air and ground missions in uncontested environments.[27] While this is a worthy pursuit, it is vital to understand that such CAS-optimized aircraft will have little or no role in highly contested environments. Flexibility, versatility, and the ability to survive and operate in an A2/AD environment are must-have traits for aircraft that will be part of a fully integrated, cross-domain approach to ground force protection.

In addition to the right mix of assets, providing full spectrum CAS in various scenarios will rely heavily on the development of the combat cloud architecture and its associated C2 tools, as well as the lessons derived from carefully constructed exercises and wargames.

Cloud Flag: Making Cross-Domain Integration Work

Making the fully integrated, cross-domain approach to ground attack a reality will require considerable work, but certain pieces of this capability are already being developed. According to the USAF's chief of future operations, the US is "only a few policy decisions away" from treating the domains of space and cyber as operational domains, which will greatly enhance cross-domain collaboration.[28]

A good deal of work has been done in the area of digitally-assisted close air support (DACAS) which allows nine-lines to be transmitted from a JTAC's computer directly to aircraft performing CAS, though the pilot and the JTAC still communicate by voice to confirm information.[29] DARPA's persistent close air support (PCAS) program has demonstrated the ability to digitally link multiple aircraft with JTACs, sharing situational awareness, identifying multiple targets, and jointly selecting the best weapons for the situation. [30]

While these efforts promise to reduce the time between aircraft arriving on scene to perform CAS weapons employment, the same layered, cumbersome communication and decision chains still remain. Autonomic systems could further enhance ground attack by automatically responding and adapting to circumstances without initially requiring direct human involvement, offering the potential for earlier identification of threats and faster action to neutralize those threats. At the tactical level, a proposed "autonomic close air associate" would link and then aid ground forces, manned aircraft, RPAs, and information systems to create shared situational awareness, supplying information to an F-35's fusion engine. This would enable faster, more effective CAS operations with reduced risk of fratricide and collateral damage.[31]

At the operational level, there is also a growing reliance on cyber-physical systems whose scale and complexity make it both difficult and costly for humans to manage. Autonomic aids, still largely academic in terms of military application, will be key features of the future combat cloud system required for effective operations in A2/AD environments. The Space and Naval Warfare Systems Command is one of the organizations which has already begun to examine the use of autonomic functions to enhance the efficiency and resiliency of naval C2 systems.[32]

CAS-optimized aircraft will continue to be effective in permissive environments. Aircraft like the proposed OA-X can be operated at much lower cost than other combat aircraft, and their use in low threat scenarios will free up fifth generation aircraft to train for, and be used in, future conflicts that feature highly contested environments.

In addition, developing predictive and rapidly reactive analytic tools will be necessary for commanders at all levels to maximize the effectiveness of their capabilities by freeing assets to act with initiative in support of the commander's intent. New doctrine, war gaming, and large-scale exercises will be needed in order to validate and improve these tools. For example, when event "x" happens, how quickly and effectively does the response from available assets address that problem? What mission "holes" are created by the shifting of those assets? What adjustments are needed to offset those holes? What is the impact upon overall tactical and strategic objectives after such adjustments are made?

After the exercise ends, it will be critical to analyze the results and to capture the lessons learned. Should there have been more of a certain type of aircraft committed, or should different aircraft have been used? What about the objectives themselves? Were they realistic, or did the available aircraft call for somewhat lesser goals? Did faulty execution create the problem, or was the plan unrealistic in its expectations? If there were failures due to the problems with the cloud itself, how can those problems be corrected?

The first such "Cloud Flag" exercise should have limited numbers of players, employing live, virtual, and constructive elements. In the case of defense-in-depth of ground forces, one can limit the exercise to testing the ideas, assumptions, tactics, and procedures involved, as well as the functionality of the cloud itself. These exercises could gradually increase in both threat level and scenario complexity, while expanding the size of the exercise and replacing virtual and constructive elements with live systems. The results of such exercises, carefully planned, executed, and evaluated will be essential to prevailing in real world conflicts of the future.

Conclusion

"No legacy aircraft is suited to provide CAS in a contested environment that features widespread surface and air threats. Although the F-35 can survive in high threat environments, it cannot get the job done alone. The F-35 is central to the future of CAS, but not as a replacement to the A-10. Instead, the F-35 must be part of a system-wide transformation of the way that we do CAS—to provide support to ground forces far beyond what we've been able to achieve in the past, in all scenarios, including highly contested threat environments. We can be more lethal, we can be more precise, and we can strike down the enemy before he ever has a chance to harm our forces on the ground."

Lt Col Derek O'Malley,
USAF Weapons School instructor, F-16, and F-35 pilot [33]

A new, full spectrum approach to CAS must be developed in order to optimize the close integration of air and ground forces across all levels of conflict. Friendly ground forces engaged in ongoing counterinsurgency operations of recent years have been well served by the close air support provided not just by the A-10—an aircraft optimized for that mission—but by virtually every other combat aircraft participating in those operations. CAS-optimized aircraft will continue to be effective in permissive environments. Aircraft like the proposed OA-X can be operated at much lower cost than other combat aircraft, and their use in low threat scenarios will free up fifth generation aircraft to train for, and be used in, future conflicts that feature highly contested environments.

In those conflicts a joint, cross-domain approach to offensive and defensive operations will be required, employing fully integrated land, air, sea, space, and cyber systems able to prevail against the A2/AD strategies favored by potential adversaries. It is critical to recognize that A2/AD environments will render CAS-optimized aircraft less survivable, less flexible, and less versatile, and thus they will have very limited—if any—utility. When decisions are made regarding what types of aircraft to add or retain, their survivability in an A2/AD environment and their ability to counter A2/AD threat systems must be a significant consideration.

Modern sensor-shooter assets, acting collectively as part of a "combat cloud" will capitalize on the airpower tenet of decentralized execution to provide timely, superior integration with friendly ground forces operating in contested environments. Top priority should be given to developing and honing these capabilities, to ensure that CAS can be effective across the threat spectrum no matter what contingencies US forces and their allies may confront in the future. ✪

Endnotes

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