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## Key Points

Air superiority and unity of command in its employment will remain critical to the success of future joint operations.

Achieving air superiority in the future requires realizing the ascent of information as a dominant factor in warfare. Building an architecture that integrates data to create decision-quality knowledge is key, and the ability to share it with sensor-shooters in every domain.

The Department of Defense must change its acquisition approach, or adversaries will outpace our air superiority capability development.

# An Operational Imperative: The Future of Air Superiority

By Brig Gen Alex Grynkewich, USAF

### Foreword: Preserving 21st Century Air Superiority

A prerequisite for effective military operations in all domains for all service components—the US Army, Navy, Air Force, and Marines—air superiority is the sine qua non for successful coalition and joint force operations. Since the end of Operation Desert Storm in 1991, US and coalition military operations have enjoyed the advantage of going into combat against adversaries that possessed little to no capability to deny US operations in the air above them. Military operations for over 25 years in permissive airspace has led US national security leadership to become accustomed to operating with unchallenged air superiority. As a result of the condition of continuous air superiority for over a quarter of a century, a presumption of sufficiency in air superiority force structure has built up. This has led to investment priorities dominated by near-term conflict and wishful thinking about potential future threats, along with reductions in planned defense resources in deference to other discretionary spending. Over the last decade the US Department of Defense leadership has truncated investment in air superiority. Correspondingly, capacity of this critical capability has atrophied and is no longer sufficient to meet the needs of the current National Security Strategy. This condition may prove calamitous to US military operations in future conflict. Beyond the elective, low intensity contingencies of the past 25 years, major regional conflict that can dramatically affect critical US national interests are likely to occur. The question is not if, but when. In this paper, Brig Gen Alex Grynkewich clearly and concisely illustrates how he and his team of US Air Force professionals worked for over a year providing a way ahead to address this most critical conventional warfighting mission area.

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## Introduction: Controlling the Air in the 21st Century

While the American ability to control the air is often taken for granted, we risk losing this advantage over the next decade and a half. Budget pressures and near-term priorities in lieu of long-term threats terminated key investment in America's air superiority capability at the same time other nations were developing advanced technologies in this critical mission area.[1] Russia and China will surpass our necessary air superiority capacity if we fail to correct the erosion of America's ability to control the air.

Sensing this challenge, from the middle of 2015 to mid-2016, the US Air Force afforded me the privilege of leading a team of experts studying how the Air Force could provide air superiority for the US military in 2030 and beyond.[2] Air superiority, often thought of as a mission, is more correctly conceived of as a condition. At its most basic, that condition is achieved when a force possesses the degree of control of the air required for military operations to succeed. Air superiority not only allows coalition and joint force operations to exploit the air domain, but also grants those friendly force operations freedom from attack on the surface. Without air superiority, results can be devastating—witness the rout of the Iraqi Republican Guard as it tried to escape from Kuwait along the so-called "highway of death" in 1991, or the losses suffered by the Taliban in late 2001 on the Shomali Plain in Afghanistan during the opening phase of Operation Enduring Freedom. With this in mind, the team I led—composed of air, space, cyber, logistics, and support experts—challenged every assumption and conducted an exhaustive review of options to facilitate continued control of the air by US and allied air forces.

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Many national security and military personnel can no longer conceive of a world in which US air superiority is not a given, or where we must fight for it. After all, no American ground forces have suffered enemy attack from aircraft since April 15, 1953.[3] Unfortunately, the world has changed. Middle-sized powers now possess the resources, technology, and know-how to challenge control of the air, and by 2030, many of those capabilities will have proliferated around the globe. As a result, although theater air superiority provides important strategic, operational, and tactical advantages, it may be extremely difficult to obtain. While many view air superiority as a theater-wide condition, reminiscent of Army Gen. Norman Schwarzkopf's dramatic declarations during the First Gulf War, we may no longer be able to prevent adversaries from operating within their own integrated air defenses, or contesting US and allied airspace. Instead, we will control their airspace for a discrete time and over a limited area, as needed by joint or coalition forces. This context is important: control of the air is not an end in and of itself—the US and its allies set the air superiority conditions only so we may then exploit the air domain to maximum effect and preclude an adversary from doing the same.

Attaining air superiority when and where we need it in 2030 will not be easy. The Air Force must develop capabilities that not only target and engage air and missile threats, as doctrine has long suggested, but also counter threats to the space assets we depend on in the air battle. Likewise, adversary use of cyberspace to deliver effects against our air, space, and logistics assets could prevent joint and combined forces from controlling air and space. Air superiority in 2030 must account for a multi-domain battlespace where air, space, and cyberspace converge. The USAF must ensure the service invests not only in necessary advances in raw combat power across those domains, but also in equally critical basing and logistics, intelligence, surveillance, and reconnaissance (ISR), and command and control (C2) capabilities. We must exploit "third offset" technologies to provide an information, knowledge, and decision advantage, and then use that advantage to gain control of the air at a time and place of our choosing.[4]

After more than a year of exhaustive study and rigorous analysis our team concluded that achieving air superiority in 2030 would require an integrated and networked family of both penetrating and standoff capabilities, operating not just in the air but across space and cyberspace as well. To explore how we reached our conclusions, the next section of this paper will discuss how the team defined the air superiority problem and how that led us to our overall recommendations. This paper will also show how the Air Superiority 2030 family of capabilities counters the anti-access/area denial (A2/AD) strategy of our potential adversaries, and how it exploits third offset technologies and ideas. The final section will then highlight some of the key attributes of the Air Superiority 2030 family of capabilities, including the imperative to adjust our acquisition paradigm, if we are to succeed.

## The Air Superiority Problem

In early 2015, the US Air Force began to work on its next-generation air-to-air fighter, commonly known as F-X.[5] When beginning such a program, military services usually start with an "analysis of alternatives" to help them define the desired attributes of new systems. The objective of this analysis is to determine the most rational investment decisions prior to committing taxpayer dollars. Key funding decisions typically follow shortly on the heels of this analytic effort. As the Air Force approached these decisions, it had to decide how much of its topline budget authority it was willing to allocate to the emerging F-X program. Out of this came a cost estimate for the F-X program based on trends from similar programs in the past. The result was not pretty.

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The two most recent examples analysts had available were the F-22 Raptor and F-35 Lightning II. As has been written extensively elsewhere, both programs experienced cost issues throughout development.[6] Resource constraints and the prioritization of then-current combat operations in Iraq and Afghanistan—to the exclusion of potentially more demanding conflicts in the future—led Secretary of Defense Robert Gates to truncate the F-22 program at 187 aircraft and to restructure the F-35 program in 2010. Comparing the expense of these fifth-generation aircraft programs to fourth-generation F-16 and F-15 programs, experts predicted F-X would cost substantially more than any prior fighter program in history. Additionally, Air Force planners evaluated the development timelines experienced during fifth-generation aircraft development.[7]

The combination of historically poor schedule performance with historically high costs led planners to conclude the earliest the Air Force could expect to field F-X would be around the year 2040. Many Air Force leaders felt 2040 would be too late to field the next tranche of air superiority capability. The F-22 reached initial operational capability (IOC) in 2005. While the F-35 recently entered initial operational service in August 2016, it is optimized for air-to-ground employment rather than air superiority. This means the USAF is facing a 35-year gap between fielding air superiority platforms if forced to wait until 2040. This would be an eternity during industrial-age aircraft development; it's even worse for the fast-paced world of aircraft development in the information age.

This acute challenge led Air Force leadership to look for a different approach to the F-X problem. They decided the time had come to reexamine their assumptions and reframe the Air Force's approach to air superiority. The team I led for slightly more than a year, the Air Superiority 2030 Enterprise Capability Collaboration Team (ECCT), was the result of this decision. Crucially, the Air Force chief of staff tasked the team with taking a "multi-domain approach" to air superiority, meaning we were to consider solutions that might not necessarily come only from the air. Perhaps, the thinking went, cyberspace or space-based capabilities would be able to produce contributing effects to achieving air superiority and move the Air Force to an entirely new cost curve. The Air Force had done this before during the 1950s when a fundamental reframing of how to provide nuclear combat power led to the advent of the intercontinental ballistic missile (ICBM), which moved the Air Force off a bomber-only cost and capability model.

Air Force leaders were equally concerned with cost and the team's intellectual approach to capability development. To some, F-X looked like a standard recapitalization program to replace an aging aircraft with a newer, more capable aircraft. While this approach sometimes works, leaders were concerned that Air Force processes were not built to ask whether an aircraft was the right solution or not—they simply assumed it was. A similar assumption had been made by the Polish military between the two world wars. On the eve of World War II, they had refitted their cavalry units with entirely new equipment. Based on the lessons of World War I, they not only procured new weapons for their cavalrymen, but also gas masks for both men and horses. In effect, they had recapitalized their cavalry without ever challenging the assumption that such cavalry was relevant in modern warfare.[8]

To help ensure the Air Force did not make that same mistake the ECCT adopted a comprehensive analytical framework. As all military planners appreciate, the first step in solving a complex problem is to make sure they truly understand it. Therefore, our team dedicated the first 90 days of our effort not only to outlining our methodology, but also to deconstructing the air superiority problem from every angle. We started with ensuring our intellectual understanding of air superiority was correct. Our team knew control of the air was needed not as an end in and of itself, but so friendly forces could exploit that control for ISR, strike, mobility, or even space launch—and to preclude the enemy from doing the same. Thus, we developed an appreciation for the time and geographical requirements for air superiority in various scenarios. Additionally, as we examined Air Force, joint, and combined counter-air thinking, we expanded on the doctrinal definition of air superiority. Traditionally, air superiority doctrine focuses on neutralizing air and missile threats.[9] Our team added other threats that might preclude our control of the air, including cyberspace-based attacks and other non-traditional and unconventional threats.

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The next step in our process was to examine the 2030 timeframe and the expected operational environment. Leveraging a vast array of intelligence and analysis, our team developed as much understanding as possible about the future environment, dividing expected threats into two categories. The first category contained evolutionary and traditional threat capabilities, such as airplanes, air-to-air missiles, and surface-to-air weapons systems. For the most part, we think we have a reasonable idea how these technologies will evolve and proliferate over the next 15 years, as these technological cycles are relatively well understood. The second category, however, contained a more revolutionary set of comprehensive threats, including advanced and highly accurate ballistic missiles, cyberspace threats, and threats to our space assets. While we know these threats will exist—many already do—it is more difficult to predict how they will evolve and proliferate. In the end, what we do know is that in 2030 our forces will face a combination of threats from both categories in a variety of places around the world.

It is worth noting that our effort was not about preparing for conflict against so-called near-peer adversaries. Rather, it was about being prepared to face the technologies we see spreading around the world and the expected operational environments created by such technological advancements and proliferation. Indeed, such proliferation of advanced technology is already occurring, as evidenced by the advanced missile systems deployed in Syria, or the weapons recently acquired by Iran.[10]

The next step for our team was to assess our planned force structure against the backdrop of the expected threat environment. Air Force analysis over the past several years suggested numerous capability gaps existed, and we were able to validate many of these. In the end, however, only one gap mattered to our team: the Air Force's lack of ability to gain and maintain air superiority in 2030. This gap was rooted in a number of critical shortfalls across both the proficiency and sufficiency of our planned forces. In terms of proficiency, the team assessed that we would not only lack many of the raw capabilities needed in the expected threat environment, but that we would also lack trained and ready Airmen to maintain and operate these capabilities. We also assessed a lack of quantitative sufficiency. This meant that even in areas where our capability was technologically adequate and proficient, the planned quantity of those capabilities in the 2030 inventory would be insufficient in many scenarios to attain operational- and strategic-level effects and outcomes.

Our team found two main causes of this expected gap. First, the Air Force broadly—but not entirely— failed to rapidly develop and field capabilities over the last two decades. Second, even with programs the Air Force had fielded, many were focused on operations in a single function or domain without enough forethought given to interactions with other functions and domains. As an example, even the F-22—the most advanced air superiority aircraft on the planet—stills fail to meet its full potential owing to its communications limitations. This gap limits the speed at which F-22 pilots can pass data from their fifth-generation sensors to other elements in a joint military operation or to our intelligence enterprise. The Air Force recognized this long before our team's effort, and it is working on enhancements to magnify the impact of F-22s, by increasing the effectiveness of other forces through improved connectivity.[11]

**A concept based on tactics or technology can be interesting, but becomes more compelling when integrated with an entire concept of operations.**

Having deconstructed doctrine, threats, and the problem, we turned our attention to solutions. We reached into every corner of the Air Force, across the other military services, into agencies such as the Defense Advanced Research Projects Agency (DARPA), our national laboratories, and across academia and industry. We wanted to leave no stone unturned in our search for creative ideas to address the air superiority capability gap. This effort led to the submission of over 1,500 different ideas, both materiel (e.g., modernization, acquisition programs) and non-materiel (e.g., improved tactics or training). We assessed each of these ideas against four criteria: effectiveness, technological maturity, expected cost, and the number and complexity of any dependencies required for the idea to be effective.

The knowledge generated from this assessment proved foundational to the remainder of our effort. We learned many ideas that sounded promising up front were in reality ineffective, technologically immature, too expensive, or highly dependent on consecutive miracles to succeed. As just one example, at one of our analytical events we evaluated a recommendation for a hypersonic, highly maneuverable, optionally manned aircraft with intercontinental range and equipped with exquisite sensors and directed-energy weapons. Unfortunately, while such a platform would be highly effective, the technologies required to actually create such a capability simply will not exist by 2030.

Other concepts submitted to our team included words and phrases such as "3D printing," "hypersonic," "swarming," or "autonomous." Many concepts showed promise, such as 3D printing, which could revolutionize logistics.[12] Hypersonics could enable rapid long-range strike in the future, and swarming has been a favored tactic of fighter pilots for a century. Autonomy could drastically reduce human workload when executing complex tasks in future operations as well. Consequently, our team recommended pursing these technological and tactical innovations. At the same time, we caution those who would consider any one or two such concepts "silver bullets" that would by themselves solve the air superiority problem. Furthermore, such innovations must be paired with valid concepts of operation to make them effective in the expected operational environment. A concept based on tactics or technology can be interesting, but becomes more compelling when integrated with an entire concept of operations.

In order to evaluate various innovations in an operational context, our team organized viable concepts into several conceptual frameworks for further analysis. The first conceptual framework included robust modernization of the planned force of 2030, but had few additional capabilities put in to the mix. This provided a base case for our analysis, showing the maximum amount of capability we could extract from the force without starting major new acquisition programs. The force in this conceptual framework achieved control of the air the traditional way, by rolling back an adversary's integrated air defense system over time from the outside in until air superiority was attained over a desired geographical area.

Our second and third conceptual frameworks were a standoff force and a force that could take attrition, respectively.[13] The standoff force broadly consisted of non-penetrating platforms delivering large volumes of weapons (including non-kinetic effects) from beyond the lethal range of threat systems. The attritable force consisted of a large number of platforms with modular payloads (either kinetic or non-kinetic) that could be reused multiple times, but that were also inexpensive enough that losing some in a high-threat environment was acceptable. Importantly, the attritable force we assessed in this conceptual framework did not just exist in the air domain, but in cyberspace and space as well.

Broadly speaking, we expected both the standoff and attritable forces to achieve air superiority through a high volume of weapons, effects, or attritable platforms swarming and converging in a desired space and time to overwhelm enemy defenses. Yet deeper analysis revealed that neither force was able to generate enough knowledge of targets much beyond the edge of an adversary's defenses. Each could only achieve air superiority on the outskirts of an integrated air defense system. Over time, air superiority could extend deeper into the adversary system—but to get to that point the scheme of maneuver ended up resembling yet another traditional roll-back operation, albeit with cyberspace and space capabilities in play as well.

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Our fourth conceptual framework centered on what many would describe as a sixth-generation fighter: a highly survivable, highly lethal aircraft supported by cyberspace and space capabilities. While our analysis showed this conceptual framework would be highly effective at the tactical level, it was hobbled at the operational level by an insufficient quantity of capability due to the high cost of the aircraft. Additionally, to achieve the effectiveness needed, the development program postulated for this program would carry a significant degree of technical risk, creating a very real possibility that this sixth-generation fighter would not field until well past 2030. We concluded that the exquisite capabilities in this framework would cost too much and arrive late to need.

At this point in the team's study, the problem seemed intractable: we could not modernize our way out of the problem, multi-domain standoff weapons and attritable forces failed to achieve air superiority, and our only successful operational capability was unrealistic both in terms of cost and timeline. As we reviewed the analysis conducted on the conceptual frameworks in greater detail, however, several important insights came to light that would guide us as we developed courses of action.

First, we learned that modernization of some current platforms would allow them to better perform some aspects of the counter-air mission, including as defensive counter-air over friendly forces and suppression of enemy air defenses on the edge of an integrated air defense system. Second, we determined we could launch standoff weapons over long distances—if we could provide enough information for them to hit a target. We learned that while we do not have access to all information necessary to provide targeting information today, we could significantly improve our ability in this area by fusing cyberspace intelligence with new space-based capabilities, and close this gap. This could include using cubesat or nanosat miniaturized satellite technology to blanket an area of interest with overhead coverage, for example.

If we could develop these capabilities and pair them with new and existing air-domain data sources, we would significantly improve the effectiveness of standoff weapons. Doing this, however, would require getting the right sensors in the right places, meaning they would have to reach deep in adversary territory sometimes. Attritable assets with the right sensor payloads provided one option, as did networking together current or upgraded airborne sensors, including fifth-generation aircraft and dedicated ISR platforms. Still, attritable assets could lack persistence, and fifth-generation assets could not go everywhere we needed them to go. We still would need a capability to penetrate and persist in an adversary air defense system. Such a capability would not only employ weapons or project effects, but just as importantly it would serve as a key node in what was emerging from our analysis as a new conceptual multi-domain battle network—a "combat cloud."[14]

As we continued our work, these lessons led us to develop a vision for an integrated and networked family of air superiority capabilities comprised of both standoff and "stand-in" assets.[15] Stand-in assets are those that seek to operate inside the threat range of enemy defenses, such as penetrating bombers or fighters equipped with short-range weapons. By contrast, standoff assets remain outside those defenses—sending only longer-range weapons like missiles or other effects (such as jammers or even cyber effects) into the most contested areas. The pairing of both stand-in and standoff capabilities, according to many analyses, is critical to defeating a future adversary's anti-access/area denial (A2/AD) strategy.[16]

## Defeating the A2/AD Strategy

Over the last decade, would-be adversaries have been acquiring and fielding capabilities to preclude US and allied forces from freely operating around the world. This buildup of military capabilities in the Asia-Pacific, Europe, and even in the Middle East, poses a complex operational problem for America and its allies across a range of missions, including in the fight for control of the air. Many of our would-be adversaries have adopted A2/AD as a means to counter US and allied conventional superiority. Anti-access capabilities are those that threaten bases and logistical lines into a theater, denying access to basing or to the theater. Area denial capabilities aim to create an impenetrable bubble over key assets, denying a force the ability to operate in the protected area once it gains access to the theater. A key feature of the A2/AD strategy is the defense of high-value anti-access capabilities under the protective bubble provided by area denial assets. This puts attacking forces on the horns of a dilemma. They cannot attack an adversary's area denial threats because anti-access capabilities prevent them from projecting power into a theater. They cannot attack the anti-access threats because they are heavily protected by area denial capabilities.

**In today's context, anti-access threats aim to force our capabilities to operate from beyond their effective range—whether in air, space, cyberspace, on land, or at sea.**

As the chief of naval operations recently pointed out, there is nothing new about A2/AD as a strategic approach.[17] It is merely an extension of the long battle for supremacy between offense and defense over the course of military history. In today's context, anti-access threats aim to force our capabilities to operate from beyond their effective range—whether in air, space, cyberspace, on land, or at sea. These threats include long-range aviation assets with long-range weapons, such as bombers with advanced air-launched cruise missiles. They might also include short or intermediate range ballistic missiles. Together, these weapons increase the risk to friendly forces operating across a wide swath of geography and could even prevent combined US and allied operations for at least a period of time.

Importantly, anti-access threats are not limited to the air domain or even to the physical domains. Anti-satellite (ASAT) systems are one clear example. A ground-based ASAT capability typically has the range and power to wreak havoc above the atmosphere and deny the exploitation of the space domain for intelligence, surveillance, and reconnaissance (ISR), communications, or other purposes.[18] Similarly, cyberspace capabilities might be used against air or space capabilities or against friendly cyber forces. Such threats might preclude logistics in forward areas for aircraft or force cyber operators to shift to a defensive focus—the virtual equivalent of denied battlespace in the physical domains.

As noted above, an effective A2/AD strategy protects anti-access capabilities with area denial threats. In the air, area denial is accomplished using an integrated air defense system (IADS) comprised of radars, aircraft, and surface-to-air missile systems. In space, area denial might be accomplished by rendering an orbit unusable by spreading debris. In cyberspace, firewalls and other protective systems prevent friendly actions in a similar manner throughout the virtual battlespace. Collectively, these area denial capabilities present a robust defense across air, space, and cyberspace.

Many defense analysts have focused on ways to tackle anti-access systems. Their ideas include longer-range aircraft, missiles, and weapons that allow US forces to "stand off" beyond the range of threat systems. Others have discussed short-range defensive capabilities to provide the last line of defense at US forward bases, including both active measures (such as short-range missiles or gun systems) and passive measures (like camouflage and hardening).[19] Other useful proposals include advanced air refueling capabilities, robust theater and base level logistical systems, and new concepts for fighting from our bases.[20] Our team added a few other ideas as well. For example, instead of always trying to go through the anti-access environment, the US Air Force could and should improve our ability to go above the threat (in air or space) or below it (ground, sea, flying at low altitudes, or in cyberspace).

All of these ideas are a necessary part of the solution to the air superiority problem looming by 2030. Unfortunately, they are not sufficient. Paired with a sophisticated operational approach, these anti-access counters might be able to achieve limited effects over a short duration—a raid or reprisal action—but our analysis showed an adversary would still retain a significant advantage. In more complex scenarios, we found an adversary will likely still be able to mass decisive power at a time and place of its choosing. The reason for this shortfall is that the capabilities mentioned above only counter an adversary's anti-access capabilities. They ignore the second half of the problem—the bubble of area denial protection. Through war gaming, our team saw the impact this had on diplomacy, access to the global commons, and a host of other national-level issues. In effect, conventional deterrence failed in these simulations, increasing the danger that skirmishes or other minor conflicts would quickly escalate.[21]

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To regain the ability to deter and decisively win conventional conflicts, we must also build capabilities and concepts to counter the area denial side of the A2/AD strategy. The team found we needed a credible ability to attack the anti-access threats where they lived, rather than just protect ourselves against their effects. This concept is not a new one for Airmen. Airpower strategists have long known that gaining air superiority by destroying aircraft in the air is necessary, but not sufficient. It is much more efficient and effective to destroy those capabilities on the ground by striking airfields, aircraft, fuel farms, and other infrastructure.[22]

This logic still holds in a multi-domain environment. The adage that "sometimes offense is the best defense" unequivocally applies in the combined effects fights of the 21st century. For instance, making US on-orbit assets more resilient is again necessary, but not sufficient. The US must also protect our spacecraft by eliminating terrestrial threats to them. Just as it would be reasonable to strike airfields and aircraft before they leave the ground laden with cruise missiles (known as "offensive counter air" operations), it also makes sense to defend our space assets by striking (or threatening to strike) an adversary's ground-based ASAT capabilities before they launch (offensive counter space). These strikes need not be kinetic. Similarly, cyberspace anti-access capabilities striking US forces within cyberspace or elsewhere could be targeted either from cyberspace, from the air, or from space. Thus, the air superiority force necessary to defeat the A2/AD strategy in 2030 requires a combination of capabilities across the domains of air, space, and cyberspace. Our team's analysis revealed four main considerations for such a force.

First, this force must be able to operate over long distances. Operating from range allows friendly forces to base beyond the reach of most anti-access threats while still maintaining the ability to strike them where they live, under the area denial umbrella. If forces attempt to fight from close proximity to an adversary employing the A2/AD strategy, thousands of attacks on their position will quickly overwhelm base defenses.[23] These attacks might be ballistic or cruise missiles, ASAT weapons, or cyberspace-based attacks. Generating combat power becomes untenable under such persistent attack. If forces are instead able to operate from range—or from a different orbit, or behind a firewall—the number of threats able to reach their position is more manageable. Similarly, generating combat power becomes more realistic, whether by aircraft sortie generation, space-based effects, or employment of cyberspace weapons. Military history is replete with examples of the benefits of striking from increased range, including moving from lances to pistols, from smoothbore to rifled muskets, and from fighter guns to air-to-air missiles. The concept of operating at range from threats still applies in the multi-domain air superiority battle of 2030.

Second, our 2030 air superiority force requires a robust logistical backbone capable of delivering key commodities—fuel, spare parts, and weapons—even while under attack. Even if operating from range, hundreds of weapons could still harass friendly forces from the air or cyberspace domains. Mobility and logistics capabilities must be able to deliver and support the force in a world where deploying into theater is a movement to directly contact the enemy, and bases are no longer conceived of as sanctuaries, but as fighting positions. Concepts and capabilities critical to air superiority in 2030 include passive and active base defensives, logistical networks capable of supporting dispersed forces, and the ability to rapidly reconstitute, recover, and regenerate combat power after a successful adversary attack. The KC-46 tanker will be a critical backbone of this future force, along with follow-on advanced air refueling capabilities, and new tactics, techniques, and procedures appropriate for deploying and employing a long-range force.

Third, to defeat the A2/AD strategy, the 2030 force must include both standoff and stand-in capabilities. Stand-in capabilities include aircraft such as the B-21 Raider, a penetrating counter air (PCA) aircraft, as well as space and cyberspace capabilities able to operate in or over adversary systems. Long-range strike aircraft like the B-21 will provide the ability to neutralize airfields and logistics targets, while the PCA will maintain air superiority for other forces operating within an adversary's air defense system coverage. Space systems overhead will provide ISR, navigation, and communications support to penetrating capabilities, enabled by a space mission force ready and able to fight through any adversary actions. Outside the IADS, standoff forces will increase the tempo of friendly operations by providing the necessary volume of weapons and effects to keep the pressure on the adversary system. While able to affect targets at the outskirts of an IADS by themselves, standoff forces will receive guidance and cueing from stand-in forces on deeper targets. This significantly increases the effectiveness of the standoff force, improving its accuracy, and making it a more viable option for employment. This effectively increases the amount of ordnance and effects a commander can bring to bear. F-22s and F-35s will remain critical to the fight, providing air superiority for standoff forces and over friendly bases.

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Fully linking the capacity of the standoff force with the superior capability of the stand-in force requires new concepts for multi-domain command and control (C2) and new multi-domain tactics. Thus, the fourth requirement of the USAF's 2030 air superiority force is that it must become a truly networked and integrated combat cloud of capabilities. In this new concept of operations, aircraft, spacecraft, and weapon systems in every other domain no longer operate independently, but rather are integrated as sensor-effector nodes in a holistic ISR, strike, maneuver, sustainment complex that can achieve the condition of air superiority at the required time and place for the necessary duration.[24] This force must be able to take data from an array of available sources and sensors and rapidly turn it into decision-quality information. Such a decision might be at the operational level, allowing a commander to apportion forces for desired effects, or it might be at the tactical level, providing operators with multi-domain situational awareness and targeting solutions.

To achieve this level of integration and networking, the 2030 air superiority force will need to leverage several of the technologies championed by Deputy Secretary of Defense Robert Work as part of his notion of the so-called "third offset."[25] Work posits that the third offset will be enabled by technology and likely include some combination of autonomous systems along with human-machine teaming and collaboration, all brought together into a battle network.[26] In this battle network, he describes three layers, or grids: sensors, command and control, and effects. As our team looked into the multi-domain integration and networking requirements for air superiority in 2030, we independently came to many of the same conclusions Work articulated. Foremost, our team developed a concept we referred to as "data-to-decision" (or D2D).[27] This emerged as we realized that in 2030 we would have a robust family of sensors across a number of traditional and non-traditional platforms. We saw a need to build an architecture that would make the most of this data and create decision-quality knowledge.

In the D2D concept, the US Air Force's sensor grid is made up of a variety of assets. These include purpose-built airborne ISR aircraft, or airplanes built solely for the purpose of gathering intelligence such as the U-2, RC-135, or RQ-4. It also includes other aircraft that, while not strictly for ISR, nonetheless have advanced sensors able to collect valuable data, such as the F-22, F-35, B-21, the PCA, and others. As such, we echoed and reinforced the perspective retired Air Force Lt Gen David Deptula has advanced for many years that fifth generation aircraft are not just fighters, but rather "F-, A-, B-, E-, EA-, RC-22s," and -35s.[28] This concept also includes cyberspace-based ISR systems that gather data from the virtual world, as well numerous Air Force satellite constellations. D2D takes the data from all of these sensors and makes it accessible not only to the platform or sensor that collected it, but also to every other system in the family, creating a combat cloud.

To make this happen, the family of capabilities for D2D will need advanced communications architectures to tie this sensor grid together. Historically, the focus of such discussions has been on waveforms and datalinks. In the era of software definable radios, we will need instead to build self-healing networks that lean heavily on autonomous learning. Such an application of autonomy will allow the network to reconfigure on its own, in real time, in response to adversary jamming. Similar to how a smart phone can seamlessly transition from Wi-Fi to 4G or from 4G to 3G and down to analog operations, an autonomous, learning, self-healing network will ensure maximum performance of the combat cloud across a host of different operational environments.[29] This does not mean it will always work at maximum capacity, just as a smart phone on 3G lacks the speed and performance it has when on Wi-Fi. But it does mean that the network will be able to adapt and reconfigure to its environment quickly, adjusting to disruptions and uninhibited by the slower pace of human assessment and action.

**Initially operating from range, as the anti-access threat is reduced US and allied forces can move closer to the adversary, whether in physical or virtual space.**

As we move to build a combat cloud, the air superiority family of capabilities will rely on a series of applications that take the data from the sensor grid and turn it into meaningful information and knowledge.[30] This portion of the D2D concept is similar to Work's ideas on human-machine collaboration, in particular how machines can assist human decision-making. Machines will more rapidly turn the sensor data into information and knowledge to enable humans to make more and better decisions. This decision might be at a command and control center to reassign forces to new missions. For example, in a multi-domain combined effects fight, if an air commander loses a long-range strike mission due to weather or maintenance, she might reallocate that aircraft's targets to a cyberspace team. Conversely, if her cyberspace team runs into unexpected resistance due to a new software patch on an adversary system, she might reassign their target to an aircraft. Importantly, not all decisions supported by this grid will be at the operational or battle management levels. Applications resident on a B-21, PCA, or B-52 with standoff weapons could also access and fuse sensor grid data to provide precise targeting information for kinetic or non-kinetic employment. This is the essence of the combat cloud concept of operations.

The concepts underlying D2D and the combat cloud are foundational to the success of our air superiority 2030 family of capabilities. D2D is the connective tissue that ties our standoff and stand-in forces together. This linkage is what allows for the precise application of kinetic or non-kinetic fires against the adversary system in mass. This, in turn, begins a virtuous cycle for friendly forces. Initially operating from range, as the anti-access threat is reduced US and allied forces can move closer to the adversary, whether in physical or virtual space. This decrease in range translates into an increase in operational tempo, thereby facilitating the further dismantling of anti-access capabilities under the umbrella of area denial threats. This again allows forces to move closer to the adversary, allowing shorter-range and less-survivable capabilities to engage more effectively. Eventually, as tempo increases, the mass of effects brought to bear overwhelms the enemy force and defeats its A2/AD strategy. The adversary system is rendered ineffective, allowing the full range of joint operations.

Developing an air superiority force for 2030 capable of executing the concepts described above will require significant innovations in how the Air Force has traditionally developed and fielded systems. Not only must we link capabilities across functions (e.g., operations and logistics), but also across the domains of air, space, and cyber. The speed at which we adapt and field such capabilities must increase, as well. And we must develop Airmen-leaders who are not only experts at the employment in their particular aircraft, domain, or function, but who can move fluidly and fluently across some of the traditional boundaries that define Air Force experiences and careers.

To control the air in 2030 will require fresh thinking. Gaining and maintaining air superiority in 2030 will require new concepts of operation. It will require a rejection of platform-based thinking that yearns for a "silver bullet" solution, and will require Airmen and leaders in other domains to apply operational art across every domain. While these intellectual foundations are certainly the most critical aspects of success in 2030, it is also true that concepts of operation dependent on outdated technology or doctrine will fail. Any family of capabilities able to solve the "2030 problem" will ultimately be comprised of platforms across all domains and from all services. If Airmen and other component leaders in 2030 lack key capabilities, it will not matter how skilled they are in warfighting or operational art. The most brilliant commander today, equipped only with the technologies of yesterday, is doomed to fail in future combat. With that in mind, this paper expands on previous discussions regarding the key attributes of the air superiority 2030 family of capabilities, and lays out some of the recommendations our team made with respect to force development and acquisition methodologies.

**Any family of capabilities able to solve the "2030 problem" will ultimately be comprised of platforms across all domains and from all services.**

### Autonomy, Survivability, and Getting to 2030

One of the attributes highlighted in the third offset discussion is autonomy. Our team saw several uses for autonomous systems in assisting with data and network management. However, we remain agnostic on broader questions of autonomy, such as whether or not particular capabilities we proposed should be manned or unmanned. The reason for this is relatively simple: Whether something is manned or unmanned does not provide capability in and of itself. At times it makes sense to have a human present in an aircraft or vehicle, at others it does not. If having a human onboard a particular aircraft makes it more effective, it should have a human on board. If humans limit the capability of an aircraft, there may be advantages to engineering them out. Detailed analysis prior to and during the development of each particular capability within the air superiority family should determine the answer to the manned versus unmanned question. Nonetheless, some broad considerations and perspectives on this topic are worth discussing in slightly more detail to inform future assessments.

War is fought in an environment beset by fog and friction. Because war is a contest of wills, a fighting force will do everything possible to impose more fog and friction on its enemies. For millennia, military forces have attacked adversary command and control networks to do just that. In ancient times, a command and control network consisted of military messengers either on foot or horseback. Later, Genghis Khan's homing pigeons passed information and orders across his empire. Later still, the complex ciphers and code breaking of World War II would play a decisive role.

What does this have to do with manned versus unmanned flight? We can be sure that adversaries will attempt to degrade or deny our communication networks, whether the network that we pass information on or the network through which we exert command and control. In the context of platforms used for air superiority, the types and resiliency of the networks we use varies significantly between manned, remotely manned (i.e., piloted from a ground station similar to an MQ-1 or MQ-9), or autonomous systems. Remotely manned systems present the biggest challenges, as they require a high bandwidth of secure and reliable global communications. This is likely an untenable option for loitering in highly contested space as, in many scenarios, we expect the electromagnetic spectrum to be highly contested. Even an agile, smart, and self-healing network will be challenged to maintain bandwidth and throughput in the face of high jamming power projected over short distances. This does not mean remotely manned aircraft will be irrelevant to future combat—far from it. The advantages remotely manned aircraft bring through long-range and endurance, paired with human control, are substantial. But how and when we leverage these capabilities will be determined largely by new operational environments.

Counter intuitively, autonomous and manned aircraft are similar in their bandwidth requirements. This makes sense when one considers that a manned aircraft is also autonomous—at least from the network's perspective. The commander must order it to do its mission, but once so ordered, the autonomous brains on the platform—whether artificial or human—execute the mission on their own without the need for an elaborate or robust communication network reaching back to a ground station. This simplifies the problem of determining whether and where a human should be in the loop. The key question becomes: Where does it make sense to add autonomy? In other words, at what point in the mission chain are we confident artificial intelligence or algorithms will allow the machine to do more effectively or efficiently what humans have done in the past?

**For nearly three decades, from the earliest days of the F-117 over Iraq to the most recent employment of F-22s over Syria, stealth provided the US Air Force a distinct operational advantage. As a result, many have come to regard survivability as synonymous with stealth.**

While this may seem a new question, it is not. For decades, fighter aviation has constantly adjusted the point of autonomy. As the fighter community moved from guns to missiles as the primary air-to-air weapon, what it really did was assign part of the mission chain (targeting and killing, in this case) to an autonomous (albeit one-way) "wingman" in the form of a missile. Early missiles were short range, but today medium- and long-range missiles fly autonomously well beyond visual range. Moving the point of autonomy using concepts such as an "arsenal plane," a longer-range air-to-air weapon, or an unmanned "loyal wingman" extends the logic fighter aviation followed since the advent of the missile age.[31] If an autonomous option for an aircraft or weapon fills a gap and provides capability, this should be considered along with cost and technical readiness as part of the detailed tradeoff analysis that occurs when planning for development of any complex weapons system.

Survivability is the second key attribute that must be evaluated as part of any capability development effort. For nearly three decades, from the earliest days of the F-117 over Iraq to the most recent employment of F-22s over Syria, stealth provided the US Air Force a distinct operational advantage. As a result, many have come to regard survivability as synonymous with stealth. Others have argued that stealth is an outdated technology the Air Force should abandon.[32] Neither perspective is correct; the truth lies somewhere in between.

Stealth is not dead.[33] It is also not the only attribute that contributes to the survivability of Air Force weapons and aircraft. Survivability should be the true focus of analysis and discussion. This is a complex discussion, as aircraft signature, redundancy of onboard systems, speed, maneuverability, and electronic attack capability all interact to contribute to survivability. How a particular design implements and optimizes the trade space between all of these depends on a host of factors, not least of which is the state of all the relevant technologies. Using the F-117 as an example, while the United States had made the critical breakthrough in technology needed to create a stealth fighter, the state of technology at the time was such that it was incompatible with supersonic speeds or high performance maneuverability.[34] Thus, engineers focused their efforts on optimizing the F-117's signature. It survived by being a very low observable aircraft in the radar portion of the electromagnetic spectrum, not by being faster or nimbler. Though the F-117 was nearly invisible to radar, it was restricted to flying only at night to avoid another key sensor in aerial combat—the human eye. Flying during the day could have resulted in the F-117 being spotted by an enemy fighter pilot. In that event, it would have been difficult for the F-117 to survive an air-to-air confrontation.

Fast-forward 20 years to the early 2000s, and the F-22 Raptor found a different balance of attributes to maximize survivability.[35] While stealthy, the F-22 is also fast and highly maneuverable. New technology resulted in a radically new design. Combining "supercruise" capability with high maneuverability, the F-22 can fight and survive in places the F-117 could not.

One other attribute affects survivability: lethality. To paraphrase the tactics manual from my days as a young F-16 pilot, the best way to ensure you survive is to make sure the enemy does not.

This remains true today, and it complicates any discussion of trades one must make when designing an aircraft. The capacity of weapons, the quality of sensors that allow more accurate targeting, and the effectiveness of weapons (kinetic or non-kinetic) are all factors which impact survivability. But one aircraft cannot have everything. Increase weapons capacity too much and the aircraft becomes too large to maneuver. Adding and operating too many sensors means the signature of the aircraft might be compromised. Optimizing these trades across the entire air superiority family of capabilities will require detailed analysis of all these attributes.

This need for detailed trade space analysis led our air superiority team to recommend to senior Air Force leaders we abandon talk of a "sixth generation" fighter.[36] Instead, we suggested the Air Force focus on defining the required attributes for a penetrating counter-air (PCA) capability.[37] We took this approach for several reasons.

**Only after building the F-22 Raptor and seeing the tremendous advantage it provided did the Air Force conceive of it as a generational leap from F-15s and F-16s.**

First, using the terminology of "sixth generation" risks getting into a discussion about what it means and how to define it. The barrage of questions that follow usually includes: Is it hypersonic? How stealthy is it? Does it carry directed energy weapons? How high can it fly? Is it manned? These may be valid questions, but not in the context of defining what sixth generation means. When the Air Force started the Advanced Tactical Fighter (ATF) program in the 1980s, it did not set out to create a "fifth-generation" capability. Rather, it set out to create an aircraft that could operate in the expected operational environment of the early 2000s. Only after building the F-22 Raptor and seeing the tremendous advantage it provided did the Air Force conceive of it as a generational leap from F-15s and F-16s. Then, using the fifth-generation F-22 as a baseline, the Air Force began retroactively classifying older fighters using this new terminology. As a young F-16 pilot, I was unaware that I was flying a fourth-generation aircraft at the time. The Air Force only defined the F-16 (and F-15) as such after the service adopted the fifth-generation terminology to describe the dramatic transformation of capabilities delivered by the F-22.

The other word we avoided in the discussion of penetrating counter-air capabilities was "fighter." While to some this is sacrilege, the rationale is sound. When we hear the word "car," most people envision a four-wheeled enclosed vehicle, typically propelled by an internal combustion engine with a range of 200 to 400 miles and top speeds of around 120 to 150 miles per hour. We all possess mental models that define a car in a similar way. The same is true of "fighter." In the modern context, most people have a mental model of a short-range, highly maneuverable, supersonic, manned aircraft, typically armed with a limited number of missiles and a gun. A future PCA may not fit this model. For example, this paper highlights the importance of increased range. Payload is also important, as increasing magazine depth allows for greater persistence and improved lethality. Maneuverability and speed will be important too, but may not fit our traditional definition of a fighter either. In the end, the expectations is any future PCA solution will be labeled a fighter and get an F-designation. But the Air Force needs to be willing to challenge its assumptions and expand its thinking about how to balance the trade space on every platform in the air superiority family of capabilities. As stated by Deptula, "In the second century of airpower, we must untether airpower from the confining categories of "B"…"A"…"F"… "MQ" or any other label. Constrained thinking, restrictive classification schemes, and anachronistic nomenclature are antithetical to innovation."[38]

Penetrating counter-air is only one part of the solution to the 2030 air superiority problem. Several other air, space, and cyberspace capabilities will be critical to control of the air. As mentioned previously, the front end of the kill chain—the ability to find, fix, and track—has proved the most difficult part to achieve. While space and cyberspace capabilities cannot support this part of the kill chain on their own without air domain contributions, the inverse is also true. For instance, the US military has become accustomed to finding, fixing, and targeting ground forces by placing a remotely piloted aircraft overhead with full motion video. That will not be possible in highly contested 2030 threat environments. We certainly will still use airborne sensors to search for targets, but we will also use space- and cyberspace-derived information in near-real time to aid the targeting process. Using cyberspace to degrade an enemy command and control network or disrupt key enemy infrastructure may also be possible, though the nature of the cyberspace environment 15 years from now is extremely difficult to predict.

Future commanders will need to understand each domain and the capabilities it brings to the table as they make decisions to apportion forces. How will the Air Force develop that future commander? What set of education and experiences do future commanders need to succeed in the 2030 operational environment, and how can the Air Force provide these? The answers to these questions could potentially affect tremendous change in professional military education, career paths, and leadership opportunities. We must start now to develop those Airmen. The majors and lieutenant colonels of today are the senior general officers of 2030, and they will need this knowledge and experience to effectively employ multi-domain capabilities in the field by then.

**...if the Department of Defense does not change its acquisition approach, others will outpace our capability development around the world.**

This leads to a final question—how do we get capabilities to the field by 2030? This date is only 13 years away. Under traditional acquisition approaches, most major defense programs take many more years to complete. Many other observers have noted some of the shortfalls with defense acquisition, and I will not repeat them here. Correcting these is an increasing area of focus for the Department of Defense, the military services, and Congress. Often the reason citied is a need to be better custodians of taxpayer dollars, or to eliminate waste. While I appreciate that rationale as a taxpayer, as an Airman I would add another. Namely, if the Department of Defense does not change its acquisition approach, others will outpace our capability development around the world. We are already behind in many areas, and we must act now or our remaining technological advantages will continue to erode. Thus, to the fiscal imperative we must add an operational imperative: we must improve our ability to develop and field capability quickly in the information age or we will lose future fights.[39]

Our team recommended four tenets to increase the speed of capability development. First, programs must maintain requirements discipline—the ability to know the basics of what you need and stick to them. Overly complex requirements or changing requirements create instability and start a cycle of delays and cost increases nearly impossible to break.[40] The initial change in requirements drives an increase to development and delivery timelines, as additional engineering and testing must now be built into the program. That change to delivery timelines delays the fielding of a capability. As that timeline extends, the projected threat environment changes, incentivizing additional requirements changes to meet the evolving threat. Over time, the cycle repeats itself.

A far better approach is to stick to a basic requirement up front while building into the design enough margin to modify and add capabilities over time.[41] A positive historical example in this regard is the F-16. Originally envisioned as a daytime visual flight rules (VFR)-only fighter, John Boyd held ruthlessly to this basic requirement at the time of the fighter's development. After fielding, however, the F-16 evolved from flying daytime VFR-only missions to low-altitude night missions with laser-guided bombs, and even suppression of enemy air defense missions as a SAM-killing Wild Weasel. As the world changed, so did the F-16.

Second, the Air Force should reinvigorate the concept of parallel development. This centers on the idea that there are various technological development cycles that are not naturally synchronized. There are industrial development cycles for components such as aircraft outer mold lines, space lift, and engines. These items sometimes take a decade to advance. There are also hardware development cycles, which generally follow Moore's Law, which stipulates that computer-processing power roughly doubles once every 18 to 24 months. This law tends to drive central processing units, sensor arrays, and other apertures in an extended adaptation—typically a two to five-year cycle. Finally, there are software development cycles that run from months down to minutes. The idea behind parallel development is to synchronize these cycles by maturing each of the components of a spacecraft, aircraft, or cyberspace tool in a separate line of development and outside a formal program. Once a technology reaches the appropriate level of maturity, it then can be ported out of that parallel line of development and integrated into a program. Meanwhile, the technology development line continues working the next iteration of capability to ready it for future use.

Done correctly with consistent funding and focus, parallel development can significantly reduce the technical risk found in any program. The F-117 is a good example of this technique in action. Effort on stealth technology had progressed in one line of development, advanced flight controls in another, and various other subcomponents came from yet others.[42] Once the technology was mature across all of the required systems, it was brought together into the F-117 program. This allowed the Air Force to more easily manage risk. As technical risk decreased outside the program, what remained was integration risk. While not trivial, the program brought no unnecessary risks into integration by using mature and in some cases fielded subcomponents. This enabled rapid development of the aircraft. The decision to produce the F-117 was made in November 1978, with the first flight accomplished in June 1981, and the first operational aircraft delivered in 1982.

**Done correctly with consistent funding and focus, parallel development can significantly reduce the technical risk found in any program. The F-117 is a good example of this technique in action.**

Third, the Air Force must manage integration risk. Again, this is not a trivial task on a complex weapons system. However, prototyping and experimentation provide an elegant solution. The F-117 did this correctly by building an essentially operations-ready prototype before entering its limited production run. More recently, the F-22 program began with a fly off competition between the YF-22 and YF-23 prototypes.[43] In truth, these aircraft were mere technology demonstrators rather than true prototypes, similar to the X-planes developed at the outset of the F-35 program. They did not contain all of the systems and subsystems the final versions of these planes would need. For prototyping to truly work, the Air Force must move beyond the technology demonstrators these programs used, and instead truly integrate the subsystems onto the capability we are trying to field. Only then can we evaluate whether or not these capabilities can complete their intended tasks.

Once that evaluation of the prototype is complete, it will be time to decide whether to declare a program and invest in the long-lead items needed for production. In the event a production decision is made, program managers must hold fast to stable requirements. Parallel lines of technology development will progress, tempting operators and developers to adjust requirements. But managers and leaders should not succumb to this temptation. Maintain requirements stability and instead include newly developed technologies in later increments or blocks. Importing these into the baseline post-prototype aircraft will only delay and derail the fielding of capability. If, on the other hand, it is decided that the prototype does not provide enough of an increase in capability to warrant production, the lessons from prototyping should be applied to the next iteration of development.

Even in the first case, when a decision is made to enter production on the first prototype, continued technology development and planning for follow-on increments and blocks must continue. This was our team's fourth recommendation: take an incremental approach to capability development.[44] As technologies mature through parallel development, so should several different prototyping phases. These will likely result in multiple blocks or increments of capability within a single program. As new blocks or increments enter to forces, older ones must be repurposed or retired. As the pace of technological change increases, the Air Force should expect the pace of the change in the service's force structure to increase as well. Keeping capabilities of any kind in military inventories for decades invites irrelevance. Sustaining old capabilities also ties up significant resources as operating costs increase over time. We must develop, test, field, and eventually retire capabilities on a much faster cycler than has occurred over the last several decades. We must invest in the future rather than sustaining the past.

A similar pace of technological change to what we are experiencing today occurred in the 1950s and 1960s, leading to the fielding of the "century series" fighter aircraft.[45] During this time period, the pace of change was not driven by Moore's Law, but rather by Bernoulli's Law, a core tenet of fluid dynamics that states that an increase in the speed of a liquid or gas occurs simultaneously with a decrease in pressure, or potential energy. Aerodynamic engineers applied the Swiss mathematician's equations and rapidly learned how to build more effective and efficient airfoils, which allowed them to build aircraft capable of greater speed, range, and maneuverability. The rapid pace of advancement required the constant fielding of new aircraft to keep pace with technology. Every five to seven years, the United States fielded new military aircraft that could fly higher, faster, and further.

**...if ISR, airlift and strike missions are essential in gray zone conflicts, air superiority is doubly so. Simply put, you cannot fly ISR, airlift, or strike missions—or ensure the adversary does not fly them—without control of air and space.**

Development of a PCA aircraft and other air domain capabilities should adopt this mindset lest we continue to fall behind. But this is not just an air domain issue. Maintaining relevance in cyberspace absolutely will require rapid fielding in response to technological change. Furthermore, as the ability to launch cubesat and nanosat capabilities matures, we must look to emulate the "century series" fighter mentality in the fielding of space capabilities, as well. We cannot accept industrial-age acquisition timelines in an information-age world.

Building the force to achieve air superiority in 2030 will take time, effort, and sustained commitment. Even though technology and platform development are not a panacea, a focus on the fundamentals of capability development, maintaining requirements discipline, and using an acquisition game plan that leverages experimentation and prototyping are prerequisites to success. Pairing these acquisition and development techniques with new concepts of operation and development of Airmen and joint leaders with the ability to leverage the strengths across all the domains will get the Air Force to the goal of achieving air superiority for years to come.

## Conclusion

As I have briefed the results of the team's study to various groups, some critics challenged our most basic assertion that air superiority matters. Others even went so far as to say they did not think the United States would need air superiority in 2030. When confronted with these assertions, I asked how they predicted conflict would unfold in the future. Often they would reply that hybrid warfare would dominate, with irregular and regular forces operating in a "gray zone" between war and peace.[46] In this kind of warfare, attribution and intent are challenging, if not impossible, for friendly forces to ascertain. Because of this, some argue that ISR, short-range lift, and on-call strike are the most valuable airpower capabilities.

Hybrid war and gray zone conflict are likely forms of some types of future warfare. We have already seen examples of this, such as the ongoing conflict in eastern Ukraine.[47] I also contend that ISR, airlift, and persistent strike will remain essential in many conflicts, including those in the gray zone. However, these two points do not negate the need for air superiority. Indeed, if ISR, airlift and strike missions are essential in gray zone conflicts, air superiority is doubly so. Simply put, you cannot fly ISR, airlift, or strike missions—or ensure the adversary does not fly them—without control of air and space. Ukraine again provides an instructive example, as a lack of air superiority has resulted in multiple losses of Ukrainian Air Force Su-25 ground attack aircraft.[48]

Some have argued that attaining the vision the Air Force has outlined for air superiority is unobtainable. They charge that the service always talks about fielding a "family of systems," but then reverts to developing single aircraft types. This is simply not true. The Air Force always fields a family of capabilities—we go into combat today with fighters, bombers, remote piloted aircraft, and command and control platforms like the E-3 AWACS all integrated in the battlespace. Sometimes this family works well together, and sometimes there is friction. Different datalinks, communication nodes, and capabilities are cobbled together into a force package because they were all designed without the kind of integrated operating paradigm envisioned for the combat cloud. In the last century, military systems were designed in a segregated fashion, were not interoperable, and integration was an afterthought. That is no longer the case, and this paradigm will not work in the future. We can minimize the friction and cost of integrating a 2030 family of capabilities if we start thinking today about how it fits together. As Deptula recently testified before Congress, in the future the US "must possess an agile operational framework that enables the integrated employment of joint and allied military power." This will mean the Air Force and the other military services must take "the next step in shifting away from a structure of segregated land, air, and sea warfare approaches to truly integrated operations."[49]

Still others have argued that fielding new capabilities in a "family" will be prohibitively expensive. They argue we should simply buy more of what is available now rather than embark on expensive and risky development programs. This logic is flawed on two points. First and foremost, the capabilities available today are insufficient win the wars of the year 2030. Second, our team explicitly rejected exquisite solutions, replete with technical risk, and grounded ourselves in budget realities. Cost was a key concern for us—both in terms of development costs and operating costs. But with stable funding, requirements discipline, and a commitment to acquisition best practices, the Air Force can be good stewards of taxpayer dollars even as we increase the speed of our development cycles to keep ahead of evolving threats.

This does not mean air superiority in 2030 will be cheap or easy. Indeed, we are already lagging behind in several key investment areas across aircraft, weapons, and sensors. The devastating effects of the Budget Control Act of 2011, combined with the rapid technological advances by other nations, have produced this stagnation. However, with sustained commitment to revitalizing our air superiority capability and capacity needs, discipline in requirements, and a new acquisition approach that takes full advantage of experimentation and prototyping, the Air Force may recover. The Air Force and the military services must recover this vital capability, after all. Air superiority is not an optional capability. Without it, in any future conflict, we will lose. ✪

## Endnotes


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