U.S. Air Dominance in a Fiscally Constrained Environment: Defining Paths to the Future

Global Precision Strike

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Executive Summary

The first conflict dominated by precision strike capabilities, Desert Storm, occurred more than two decades ago. Since then, all conflicts in which the United States has engaged have been marked by the extensive, even overwhelming, application of precision strike capabilities. In fact, the U.S. military worked for decades to achieve its current level of capability which can be described simply as “one aircraft, one weapon, one target”.

A central strategic issue for the future is whether the United States military can maintain its dominant position in the face of three challenges to the current U.S. dominance in global precision strike. The first challenge is the proliferation of so-called anti-access/area denial (A2/AD) capabilities designed specifically to counter the U.S. dominance of the air. The second is the shift in the focus of political-military interests to the Asia-Pacific. The third challenge is the ability of precision strike forces to address an evolving target set.

There are five critical steps to preserving U.S. dominant precision strike in the first half of the 21st century. They are:

- **A More Rapid Transition to a Fifth-Generation Tactical Fighter Fleet.** The case for investing in fifth-generation platforms is unassailable. A sensible strategy would be one that reduces expenditures on legacy platforms in order to increase the number of F-35s acquired each year so that the total reaches approximately 1,000 by 2024.

- **Develop and Deploy A Robust Complement of Precision Deep Strike Capabilities.** Both the Air Force and the Navy need to invest in new capabilities to see and strike deep in the face of advanced air defenses. The critical steps are development and procurement of a large fleet of next-generation bombers, investment in sea-based cruise missiles and deployment of a highly capable Unmanned Carrier Launched Airborne Surveillance and Strike system.

- **Invest in a Family of Advanced Weapons.** New and modernized platforms are not enough to maintain U.S. dominance in air-based precision strike. Continuing preeminence will require investments in extremely precise, long-range, high speed and stealthy weapons to ensure the ability of U.S. forces to hold at risk the full range of targets in the face of the A2/AD threat.

- **Connect Air, Sea and Ground Platforms and Systems.** Advanced networks will be required to support distributed operations, the “combat cloud,” and near real-time sensor-shooter collaboration. The military services need to devote the required resources to achieving connectivity.

- **Enhance Base Defense and Prepare for Proliferated Basing.** Airbase resilience, particularly in the Asia-Pacific region, is vitally important politically as well as militarily. Such resilience will be a function of increased investment in a combination of active defense, passive defense, attack operations and proliferated basing.

The Path to U.S. Strike Dominance

Nothing has so altered the character of military conflict over the last century than the ability to find and strike targets from the air. For the millennia that preceded the invention of the airplane, the scope and scale of military operations increased only slowly. Armies could move perhaps 10 or 15 miles a day on foot or several times that distance on horseback. Even the advent of the motor vehicle only increased ground forces mobility by a factor of two or, rarely, three. Strategic offensive operations were further limited by an army's need to assure the availability of supplies and friendly bases as it penetrated hostile territory. Able to operate in only two dimensions, armies frequently found themselves stymied for weeks and even months by natural and man-made barriers and defenses. Navies could bombard ports and shore targets but were unable to project their power inland.

Similarly, for most of human history, the ability to strike at an individual adversary or unit was limited to ranges of a few hundred feet or less. Even the invention of gunpowder only extended the reach of military forces by a few miles at best. The industrial revolution and mass mobilization enabled the creation of large armies, the conduct of operations on a continental scale and the pursuit of a strategy of attrition warfare. Neither of these changes did much to alter the distances at which adversaries could be engaged. Hence, for more than three centuries, even as weapons technologies improved, tactical combat generally occurred at extremely short ranges and casualty rates skyrocketed.

Yet, within a few decades of the invention of the airplane and its first use in war, all this had changed. Distance as a factor in military strategy took on an entirely new meaning. As a consequence, the distinction between "front "and "rear" was blurred. Armies, fleets, cities, even entire countries could be devastated without opposing soldiers and sailors ever setting sight on one another or a single foot of foreign territory being occupied. Strategic operations conducted from the air could ignore geographic obstacles, bypass intervening hostile land forces and deliver powerful blows against political, economic, military and industrial targets deep in an adversary's homeland. The English Channel, Britain's first line of defense against an invasion from the Continent for eight centuries, became almost as irrelevant as a medieval castle's moat. The success or failure of major land campaigns could be decided by air wars fought hundreds of miles away and even over entirely different countries.

The impact of being able to operate against the surface of the Earth from the air profoundly influenced the conduct of military activities on both land and sea. Military forces were required to think in three dimensions and to adjust their behavior and character so as to reduce vulnerability to air attack. Offensive air power allowed a military to leapfrog the front lines, provided the means to conduct intensive, inherently mobile and highly concentrated strikes in support of ground forces and created the opportunity to conduct truly strategic operations into the depth of the enemy's interior. Operationally, air power not only provided massive and often decisive supporting fire for ground forces but also altered conditions in theaters of war to the advantage of the joint force. As General Dwight D. Eisenhower opined in his memoirs about his experiences in World War II, "foremost among the military lessons was the extraordinary and growing influence of the airplane in the waging of war."[1]

Naval warfare also underwent a revolution due to the advent of land- and carrier-based aviation. Aircraft launched from ships and land bases were able to attack opposing fleets and facilities hundreds of miles beyond the range of the largest naval guns. The strategy for naval warfare evolved based on the requirement to seize land bases for aviation assets and the creation of powerful carrier aviation strike capabilities with which to engage opposing carrier forces.

To the power of manned aircraft to deliver destruction on land and sea targets was soon added the capability to employ unmanned, electronically guided systems, specifically cruise and ballistic missiles. From the extremely simple V-1 rockets, the array of cruise and ballistic missiles has expanded to include a wide variety of land-, air- and sea/subsurface-launched systems. A specific subset of this category became the primary delivery means for nuclear weapons.

Strategically, the threat of long-range bombardment of critical national command and control systems, economic assets and military assets served as a deterrent. Where deterrence failed, strategic bombardment became a means of engaging adversaries at long-range and, in some significant instances, profoundly affected the course and outcome of major conflicts.

The impact of the ability to strike from the air on the conduct of military operations has been somewhat obscured by the dissonance between the promises made for this form of warfare and the ability of air forces to achieve decisive strategic ends. Air power advocates searched long and hard for a doctrine that would exploit the new capabilities to shape the character of warfare itself. Numerous military campaigns have been built around various theories about ways of achieving operational and strategic results from the employment of both massive and precise air power. Too often, such theories rested on an intellectually inadequate or even factually incorrect base. It turned out that the bomber wouldn't always get through, precision daylight bombardment was much more difficult than advocates had assumed and urban bombing, in the main, failed to produce the predicted effects on civilian morale and industrial production.[2]

Nevertheless, from the very beginning of offensive aerial operations, two trends have been evident. The first is the growing importance of air strikes to the operation of land and sea forces. Where air superiority has been available to one side, terrestrially based forces of the other have been increasingly constrained in their ability to move, operate and even survive. This reality was acknowledged as early as 1943 by then-Army Chief of Staff, General George C. Marshall. Field Manual (FM) 110-20, *Command and Employment of Air Power,* published under Marshall's leadership, declared that "land power and air power are co-equal and interdependent." The document made clear the U.S. Army's doctrinal view that "the gaining of air superiority is the first requirement for the success of any major land operation." After gaining air superiority, the first priority of tactical air forces was to "prevent the movement of hostile troops and supplies into the theater of operations or within the theater."[3]

Moreover, joint campaigns are increasingly shaped by the ability to deliver strikes from the air. A clear example of the use of air power in this manner is the operation of Allied tactical air forces against German logistics and transportation networks in France both prior to and after the Normandy invasion. As General Eisenhower made clear in post-war testimony before Congress, the invasion of Europe was predicated on a belief in the power of air forces. He declared that "without that air force, without the aid of its power, entirely aside from its ability to sweep the enemy air force out of the sky, without its ability to intervene in the land battle, that invasion would have been fantastic."[4] It is interesting that this view was shared by Eisenhower's opponent, Field Marshal Erwin Rommel, who declared that fighting an adversary with air superiority was like "being nailed to the ground."[5]

Ironically, while air power had a profound, even decisive impact on the conduct of land operations on the European continent, its strategic impact, as reflected in the effects of the bombing of German industry and urban centers, has been judged by virtually all post-war observers to have been a failure.[6]

Historically, two factors limited the operational and strategic impact of aerial bombardment. One was the difficulty of finding targets -- even large facilities and cities -- and the imprecision with which ordnance could be delivered. The second was the problem of effectively engaging air defenses at acceptable cost. In World War II, the combination of these two problems forced air forces to mass ever larger air armadas for each target in order to have the prospect of inflicting even minimal damage. In addition, when opposed by effective air defenses, these massed attacks suffered unacceptable losses.[7]

As the ability to attack both fixed and mobile targets in the field improved, the ability of air power to shape the course and outcome of conventional conflicts became even more pronounced. In the Korean War, even with strike technologies that differed very little from that employed during World War II, dominance of the airspace over the Korean peninsula allowed U.N. forces to interdict North Korean and Chinese supply lines as well as provide overwhelming firepower in support of ground forces.

The Vietnam War continued the air power dichotomy: tactical/operational success and strategic failure. Air power provided mobile firepower that repeatedly countered Viet Cong and North Vietnamese advantages in surprise and the ability to concentrate forces. But inadequacies in intelligence, surveillance and reconnaissance (ISR) and weapons targeting meant that air power still had to be massed to be effective. In the 1972 battle of An Loc, South Vietnamese forces and a small number of American advisors successfully held out against superior North Vietnamese Army forces. Thousands of strikes by tactical aircraft as well as heavy bombers forced the enemy to break up his ground elements into small units and which were difficult to mass forces for an attack. When the enemy did mass, he suffered terrible casualties." [8] U.S. air power was equally effective in the famous battle of Khe Sanh. Only at the end of the war were the first guided weapons introduced; they proved extremely effective and heralded a radical change in the ability of air power to strike terrestrial targets.[9]

At the same time, air power failed utterly to achieve the strategic objectives set for it. By Hanoi's own estimates, bombing destroyed almost all the country's industrial, transportation and communication facilities, wrecked three major cities and 12 of 29 provincial capitals, blockaded the country's major ports and, along with the war in the South, set the economy of the country back 10 or 15 years.[10] Nevertheless, the massive application of air power -- nearly 8 million tons of bombs on North and South Vietnam, four times the amount dropped in World War II and 17 times the amount dropped in the Korean War -- was unable to halt the flow of men and supplies into the South or, more important from a strategic perspective, to force North Vietnam to halt its aggression. The eventual fall of South Vietnam in 1975 only reinforced the longstanding view that air power lacked the technologies and techniques to achieve decisive strategic results. At best, it could provide substantial support to combined forces but only when subordinated to the needs of land and sea forces and employed en masse.

The next major American military conflict, Operation Desert Storm in 1991, overturned the conventional wisdom with respect to air power. In a reversal from the traditional paradigm, Desert Storm was a 43-day air war that was capped by a 100-hour land campaign. The air war employed a host of new capabilities, most particularly so-called “smart bombs” that allowed a single strike sortie to accomplish missions that had in the past required dozens and even hundreds of aircraft and upwards of thousands of weapons. Coupled to advanced ISR systems that included two developmental versions of the Joint Surveillance and Target Attack Radar System (JSTARS), the Coalition’s air forces achieved results that were an order of magnitude better than what had been possible in prior conflicts.

In addition, Desert Storm saw the use of specialized platforms and capabilities such as the F-117 Nighthawk stealth fighter, tactical land-attack cruise missiles and advanced means for suppressing enemy air defenses that obviated the need for air forces to fight through defenses to their targets. The Air Force’s official study of the air campaign concluded that while "in the past, air forces fought through elaborate defenses and accepted losses on their way to the target or rolled those defenses back, in the Gulf War, the Coalition could strike Iraqi air defenses immediately, and they never recovered from these initial, stunning blows."[11] The combination of high quality ISR, stealth aircraft and precision weapons allowed air planners to radically reduce the number of platforms and weapons required to conduct a mission, thereby expanding both the breadth and scope of the operations that a given force could conduct.

> The combination of the stealthy F-117 *Nighthawk* aircraft and PGMs *[precision guided missiles]* gave U.S. forces extremely high effectiveness. A typical non-stealth strike formation in the Gulf War required thirty-eight aircraft, including electronic warfare and defense suppression aircraft, to allow eight planes to deliver bombs on three targets. By contrast, only twenty F-117s armed with 2,000-lbs bombs were able simultaneously to attack thirty-seven targets in the face of more challenging defenses. As a result, although F-117s flew only 2 percent of the total attack sorties in the war, they struck nearly 40 percent of strategic targets, such as leadership and command and control facilities.[12]

Because of the relative scarcity of stealthy platforms and precision weapons, Coalition forces were still required to rollback hostile air defenses in order to establish air superiority so that non-stealthy aircraft could operate in Iraqi airspace. However, as a consequence of the ability to both find targets and precisely deliver weapons and to defeat or negate hostile air defenses, air power could now exercise a decisive influence over the course and outcome of conventional conflicts. Even a small number of advanced, stealthy aircraft armed with precision munitions were able to affect not merely the initial period of the conflict but its course and outcome as well.

Saudi General Khaled bin Sultan commanded joint forces during the 1991 Gulf War and made clear the effect of the Coalition air campaign on Iraqi ground forces:

> Both psychologically and physically, it must have been terrible to be on the receiving end of Coalition air power. From the start of the war the dilemma facing Iraqi troops was acute: they got hit if they stayed in their fortifications, they got hit if they fired their heavy guns, they got hit if they moved, and they got hit by Iraqi execution squads if they tried to cross over to us. . . . It was clear that the 38-day air campaign had done far more damage than we had imagined. There was little fight left in the Iraqi divisions facing our troops. Indeed, they must have realized the war was over.[13]

Based on the experience of Desert Storm, a number of subsequent analyses concluded that changes in air and space technologies, organization and operation were on the verge of empowering a revolution in air power. As the result of investments in a series of technologies (stealth, precision navigation and guidance, airborne surveillance, space sensor support to combat operations, computer-based command, control and communications) the potential existed for a new kind of air operation, one that could exercise a decisive influence on the course and outcome of conventional conflict at the theater level.[14] In the view of one well-respected analyst, these capabilities, together with new concepts for employing integrated air operations, allowed air forces for the first time to achieve strategic objectives.

> As a result of these three developments, air power has now arrived at a point where it has become truly strategic in its potential effects. That was not the case before the advent of stealth, highly accurate target engagement capability, and substantially improved battlefield information availability. Earlier air campaigns were of limited effectiveness at the operational and strategic levels because it simply took too many aircraft and too high a loss rate to achieve too few results. Today, in contrast, air power can make its presence felt quickly and can impose effects on an enemy from the outset of combat that can have a governing influence on the subsequent course and outcome of a joint campaign.[15]

The conflicts of the 1990s and early 21st century in which the United States military has been engaged would appear to validate the idea that modern air power enables a "new way of warfare." In the 1995 Operation Deliberate Force in the Balkans, the NATO coalition conducted the first precision strike campaign in which 70 percent of the weapons employed were guided (708 guided bombs plus 23 cruise missiles out of a total of 1,049 weapons employed). The 1998 Operation Allied Force was essentially conducted entirely from the air. Allied planes employed more than 7,000 precision weapons out of a total of 23,000 bombs delivered, including 329 cruise missiles. This was also the first time that the B-2 bomber was used, flying missions from the continental United States to Serbia, where it delivered the Joint Direct Attack Munitions (JDAMs) with remarkable precision.[16]

The U.S.-involved conflicts of the 21st century -- Operations Enduring Freedom, Iraqi Freedom and Odyssey Dawn -- were shaped to an unprecedented degree by the ability of U.S. and coalition forces to exploit air superiority and the elements of precision strike -- high-quality ISR, large inventories of precision munitions and cruise missiles and stealthy aircraft -- in order to seize the initiative from the outset of the operation and dominate its course and outcome. In each conflict, hostile air defenses proved ineffective, the adversaries' entire target set could be attacked from the opening moments of the conflict, fewer aircraft were needed to conduct these missions and more targets were accurately engaged with a reduced number of weapons.

In Operation Enduring Freedom (OEF), the decisive force in the initial campaign against Al Qaeda and to overthrow the Taliban was air power. Once Taliban air defenses and strategic targets were eliminated, in the first week of hostilities, air power was able to focus on close air support and battlefield interdiction. Improvements in precision targeting, weapons delivery command and control created unprecedented conditions in which more than 80 percent of targets were provided to fighters and bombers en-route.[17] One of the most valuable aircraft in the fleet turned out to be the B-1 bomber, which had been upgraded to carry a range of conventional precision munitions and could loiter for hours, providing on-call fire support to ground forces. Naval aviation demonstrated the ability to provide near-continuous strike capabilities over Afghanistan from aircraft carriers located some 400 nautical miles distant in the Arabian Sea.[18]

> The war saw a further improvement of some important trends that began during the Gulf War a decade earlier. Precision weapons accounted for only 9 percent of the munitions expended during Desert Storm but nearly 70 percent in Operation Enduring Freedom. The war saw the first combat use of the new Global Hawk high-altitude, unmanned aerial vehicle (UAV), the first operational use of Predator UAVs armed with Hellfire missiles, and the first combat use of the highly accurate, all-weather Joint Direct Attack Munition (JDAM) by the B-1 and B-52. For the first time in modern warfare, airborne and space-based sensors provided a constant flow of information about enemy force dispositions and activity.[19]

Operation Iraqi Freedom (OIF) was unique in a number of respects, most notably that the coalition had acquired air superiority over Iraq in Desert Storm and maintained it for more than a decade through Operations Northern and Southern Watch. In OIF, coalition air superiority was such a given that Saddam Hussein ordered his air force to bury their surviving aircraft. Nevertheless, OIF also demonstrated the tremendous growth that had taken place in the years that separated the two Gulf conflicts with respect to U.S. capabilities to conduct the core missions of precision strike. Moreover, the percentage of ordnance delivered that consisted of so-called "smart bombs" increased from around 6 percent to nearly 70 percent. The Navy launched some 288 Tomahawk cruise missiles in 1991 and more than 700 in OIF. In addition, OIF marked the large-scale, successful combat debut of the F/A-18E/F Super Hornet with its enhanced range, weapons carriage and avionics.[20] Equally important to the expanded targeting capability of modern precision weapons was the ability to command and control air forces in a way that allowed them to be employed to strategic effect.

> The opening rounds of Operation Iraqi Freedom proved that 21st century strategic airpower was no longer tied to traditional timetables. Strategic forces did not mount a parallel attack in isolation. Rather, strategic airpower bent and flexed to fit an array of campaign objectives, ranging from suppressing enemy communications to pursuing time critical targets. Strategic airpower could operate anywhere, anytime, and commanders varied the phasing of strategic attacks with other jobs of the air and land campaign.[21]

Despite the popular image that OEF and OIF have been ground conflicts, air power has been a key operational advantage in offensive combat operations. Systems such as the Apache helicopters, AC-130 gunships, tactical fighters with guided bomb units and B-1s have performed excellently in the close air support role. In a recent *New York Times* article on the role of air power in Afghanistan, the author recounts how an F/A-18E/F operating from an aircraft carrier in the Arabian Sea provided fire support to an Army convoy that drove to a Taliban ambush. The author concludes that "in its way, this strike was a model of what air power can do. It was timely, precise and effective, and it neatly integrated communications, logistics, tactics and firepower, freeing American troops from danger in a remote canyon halfway around the world."[22] In the view of one eminent strategic scholar, the attributes of modern precision strike are as relevant at the lower end of the conflict spectrum as they are in high-intensity conventional conflict:

> Ever since the U.S. Strategic Bombing Survey cast doubt on the efficacy of aerial bombardment in World War II, and particularly after its failure to bring victory in the Vietnam War, air power has acquired a bad reputation. Nowadays, killing enemies from the skies is widely considered useless, while its polar opposite, counterinsurgency by nation-building, is the U.S. government's official policy. But it's not yet time to junk our planes. Air power still has a lot to offer, even in a world of scattered insurgencies.[23]

The Chief of Naval Operations, Admiral Jonathan Greenert, described the impact of the precision weapons revolution on precision strike operations and collateral damage this way:

> Our commanders exploit this precision by using the smallest number and size of weapons possible. In addition to improving efficiency, this minimizes collateral damage -- which can have a significant strategic impact in modern counterinsurgency operations. From World War II to the Gulf War, the number of bombs used to hit a fixed target decreased by a factor of 300, the number of aircraft assigned decreased by a factor of almost 400, and bombing accuracy improved by a factor of 17. Instead of sorties per aimpoint, we now commonly speak in terms of aimpoints per sortie.[24]

Progressively over the past 75 years, the ability to conduct operational and strategic strikes from a base of operations in the third dimension has exerted an ever more powerful effect on the course and outcome of military campaigns. The power resident in U.S. air and naval forces has only increased. The United States now has some 200 stealthy aircraft that could operate from day one in contested airspace. The entire U.S. strategic bomber fleet of more than 100 aircraft, can deliver a range of conventional standoff precision munitions. The U.S. Air Force, Navy and Marine Corps fleets of F-15, F-16 and F/A-18E/F tactical aircraft can deliver a similar suite of munitions. U.S. airborne electronic warfare capabilities have been enhanced by the addition of the EA-18G Growler. Also, the U.S. Navy deploys many hundred Tomahawk cruise missiles, including the new, longer range Block IV, aboard virtually all its surface combatants and attack submarines.

The strategic and operational value of U.S. precision strike capabilities continues to grow. In essence, U.S. air power is capable of conducting near-zero circular error probable (CEP) strike missions. Precision strike forces, when properly supported by high-fidelity ISR, real-time command and control and electronic warfare systems, can hold at risk an adversary's strategic targets, provide a massive, rapid response force to counter aggression, shape the battlefield in a manner conducive to the conduct of joint operations in a manner which advantages joint and combined forces and provide a tool with which to hammer opposing ground formations against the anvil of Army and Marine Corps maneuver forces.

> . . . [T]he maturation of air power has enabled the maintenance of constant pressure on an enemy from a safe distance, increased kills per sortie, selective targeting with near-zero unintended damage, substantially reduced reaction time, and, at least potentially, the complete shutdown of an enemy's ability to control his forces.[25]

Precision strike at global range must remain a core competence of U.S forces, but particularly for the Air Force.

> Global strike, a significant portion of America's deterrence capability, means that the Nation can project military power more rapidly, more flexibly, and with a lighter footprint than other military options. . . . the Air Force's nuclear and conventional precision strike forces can credibly threaten and effectively conduct global strike by holding any target on the planet at risk and, if necessary, disabling or destroying it promptly -- even from bases in the continental United States. These forces possess the unique ability to achieve tactical, operational, and strategic effects all in the course of a single combat mission. . . . Whether employed from forward bases or enabled by in-flight refueling, global strike derives from a wide-range of systems that include bombers, missiles, special operations platforms, fighters, and other Air Force aircraft.[26]

The Elements of Dominant Strike

The first precision strike-dominated conflict, Operation Desert Storm, occurred more than two decades ago. Since then, all conflicts in which the United States has engaged and those of other advanced military nations such as Israel have been marked by the extensive, even overwhelming, application of precision strike capabilities. In fact, the U.S. military worked for decades to achieve its current level of capability, which can be described simply as "one aircraft, one weapon, one target." This condition is true regardless of type of platform or target. Whether it was the F-117 Nighthawk going "downtown" on the first night of Desert Storm, B-1 bombers providing close air support for special operations forces in Afghanistan, sea-launched cruise missiles targeting Libyan air defense centers or, in the near-future, F-35s operating against advanced air defenses, precision strike now characterizes an essential competence of the U.S. military. All other nations that seek to develop their air forces are following in a similar path.

In reality, precision strike is not based on a single technology, system or capability. Rather it reflects a number of key attributes. Advances in each of these capabilities have raised precision strike from the tactical level of one plane/one weapon to the operational and even strategic levels of war. This is a primary reason why the Air Force, in particular, refers to global precision strike as one of its core functions.[27]

What are the key elements of today's U.S. successful precision strike formula? They include the following:

Extremely Accurate Navigation and Near-Perfect Weapons Delivery

Even before the introduction of precision weapons, the ability of military aircraft to reliably find their way to the target constituted a significant step forward in the ability to conduct strike operations. Additionally, modern precision strike operations still can be very complex affairs, requiring the coordination of a host of enablers including ISR platforms, electronic warfare and air defense suppression assets as well as strike aircraft and aerial refueling tankers. Knowing with precision the location and flight paths of all aircraft involved in a mission has been an important feature of modern strike operations.

Improvements to onboard guidance and targeting systems, including targeting pods, have allowed for substantially improved delivery accuracy for relatively imprecise weapons. In addition, as demonstrated in Iraq and Afghanistan, these pods can be employed to provide high-fidelity real-time ISR in support of the joint force.

Accurate weapons delivery has been the Holy Grail of offensive air operations for many decades. Indeed, some analysts have suggested that fully realized -- that is, supported by the appropriate ISR and networking -- precision strike would constitute a revolution in military affairs.[28] Today, precision weapons delivery means essentially zero CEP. Initially, precision weapons required visual tracking to the target using either an electro-optical or laser designator/sensor. Before the introduction of GPS-based guidance, cruise missiles initially used a special terrain mapping system called TERCOM. In particular, the use of GPS-guidance and multi-mode seekers now enable day/night, all-weather weapons employment.

Over the past several decades, weapons guidance technology has evolved to reduce CEPs and allow for the employment of smaller, lower-weight weapons with equal or greater lethality. The development of both onboard precision targeting systems and the Sniper and Litening targeting pods allow the accurate delivery of even so-called dumb munitions.

The availability of smaller yield weapons is significant both in terms of limiting collateral damage as well as enhancing the capability of individual platforms to service a large number of individual targets. The B-2 has been configured to carry up to 80 individually targetable 500-pound JDAMs. In the near-future, virtually all U.S. bombers and tactical aircraft including the F-16, F-18, F-22 and F-35 will be configured to carry multiple 250-pound Small Diameter Bombs, each with a range, depending on the version, of up to 40 miles.

Although improvement in weapons guidance has reduced the number of weapons required to strike individual targets, the overall requirements for precision weapons as a fraction of the inventory of all air-delivered weapons has increased.

SEAD and Stealth

One of the distinctive features of the current revolution in precision strike is the ability to circumvent or, as necessary defeat, hostile air defenses and surveillance systems. Suppression of Enemy Air Defenses (SEAD) is defined as "that activity that neutralizes, destroys, or temporarily degrades surface-based enemy air defenses by destructive and/or disruptive means."[29] It is noteworthy that since World War II the number of U.S. combat air casualties has declined steadily but not coincidentally as the percentage of all sorties devoted to SEAD has increased sharply.[30]

The Navy and Air Force have long employed a combination of electronic warfare and kinetic means to conduct SEAD missions. Today, the U.S. Navy and Marine Corps maintain a dedicated fleet of electronic warfare aircraft based on the EF-18G Growler. U.S. strike campaigns as far back as Operation Desert Storm have generally begun with large-scale cruise missile strikes intended to destroy critical air defense sensors and command and control systems. A portion of the tactical fighter fleet -- F-15Es, F-16s and F/A-18s -- some equipped with the High Speed Anti-Radiation Missile (HARM), can conduct SEAD missions. In addition, both tactical and strategic platforms are equipped with passive measures including chaff and decoys with which to confuse surface-based air defenses.

Another approach to countering air defenses, generally employed in combination with SEAD activities, is stealth. While not rendering an aircraft "invisible," stealth signature reduction has allowed the U.S. military to conduct a single, integrated air campaign rather than sequential operations that require suppression of hostile air defenses prior to strike on other targets. The presence of even a handful of stealth aircraft has had an effect on operations that far exceeds their numbers. The results have been: a significant reduction in the number of aircraft sorties needed to support critical strike missions in the presence of air defenses; a greater ability to conduct strikes even in the presence of air defenses; and a marked reduction in casualties during air operations.

Today, the United States deploys a very small number of stealth aircraft. The current program for the F-35 Joint Strike Fighter will increase the presence of U.S. combat aircraft fleet with significant stealth features to nearly 70 percent by 2035. The percentage may be even higher if force structure reductions result in a smaller but "all stealth" tactical fighter force. Moreover, with the deployment of the Marine Corps' short-takeoff and vertical landing (STOVL) F-35B and the Navy's F-35C both the Sea Services will for the first time deploy stealth aircraft.

Intelligence, Surveillance and Reconnaissance

Precision weapons lose their utility in the absence of high-quality target information. Advances in ISR, intelligence processing, exploitation and dissemination and dynamic data sharing have proven a major contributor to the revolution in precision strike. So too has the ability of intelligence assets to accurately identify a target and characterize its location in three dimensions (what is termed "mensuration"). In addition, the miniaturization of sensors now enables single platforms to perform the entire kill chain process. The current ISR challenge is to find, fix and track mobile targets.

The evolution of the modern precision strike regime has been driven by a dynamic relationship between the increasing precision of modern weapons and improvements in the character and quality of ISR. More precise weapons require more accurate ISR and the ability of ISR assets to find, fix, characterize and track even small and highly mobile targets has enabled the development of even more precise weapons.

To date, the interplay of increased precision and more accurate ISR has taken place in relatively benign air defense environments. This will not be the case in the future. Moreover, a greater percentage of target identification and tracking will be required in a dynamic planning environment not only en-route but during combat.

Networking

A central feature of the ongoing revolution in precision strike is the explosion in the application of networks and networking solutions to tactical, operational and even strategic problems. The clearest examples of how the ability to connect sensors to shooters to command and control platforms have been in the ongoing conflicts in Iraq and Afghanistan. The ability to pass data from Special Forces on the ground to overhead air assets that could retarget weapons in flight allowed the U.S. Air Force and Navy to apply its overwhelming long-range precision strike capability to the close air support mission.

These same networks and connectors have also enabled the expanded use of unmanned aerial systems both for force protection and offensive missions. The power of the network motivated at least one reputable think tank to conclude that a military revolution may be in the offing.

> Global communications connectivity and the common operating picture that was made possible by linking the inputs of UAVs and other sensors enabled a close partnership between airmen and SOF *[special operations forces]* units and shortened the time from identification to successful target attacks. Such networked operations are now the cutting edge of an ongoing shift in American combat style that may be of greater revolutionary potential than was the introduction of the tank at the beginning of the 20th century.[31]

It is somewhat ironic that the effort to make each sortie -- each weapon launch -- precise and effective has now led to the growing requirement to network and coordinate actions on the ground, at sea and in the air. The greatest impact of smaller weapons results from their precise placement. As the number of tactical and strategic platforms declines due to inexorable budget pressures, it will become all the more important to ensure that each weapon is delivered precisely for maximum effect.

Network-empowered strike platforms such as the F-35 and new bomber will be equipped with sophisticated sensor and communications suites that will enable them to share data during the course of a mission. This will not only allow them to better counteradvance air defense threats but to dynamically retarget weapons based on a continually changing common operating picture. As a result, the need for restrikes is likely to be significantly reduced. Similar capabilities are being backfitted to current platforms, including both the F-22 and older strategic bombers.[32]

Accurate ISR and extremely precise weapons delivery have resulted in reduced collateral damage. This condition has gone from a secondary consideration to a primary targeting requirement in the limited conflicts of the past two decades. In the future, the ability to conduct precision strikes while avoiding collateral damage will require continuous coordination among platforms and even weapons.

The network is also empowering another form of collaboration; that between defensive systems. The U.S. Navy's Integrated Fire Control-Counter Air (NIFC-CA) is designed to integrate both dedicated sensor platforms such as the E-2D Advanced Hawkeye and Aegis air defense system with Army and Air Force sensors and weapons to enhance defenses against both ballistic missiles and air-breathing threats. The Army's JLENS tethered aerostat surveillance system has demonstrated the ability to support both air and missile defense launches. The Aegis ballistic missile defense system has successfully fired a Standard Missile 3 based on remote data from forward-deployed radar. The goal is eventually to be able to employ high quality data from dispersed sensors to conduct the actual engagement remotely, without additional guidance data from the system that launches the missile.

Reach

The United States, alone among the nations of the world, is able to conduct global precision strike. This is a result of both the Air Force's fleet of long-range bombers and the Navy's combination of carrier-based aviation and sea-based cruise missiles. In addition to guided bombs such as the JDAMs and Small Diameter Bomb capable of ranges up to approximately 50 nautical miles, both tactical and strategic platforms now are capable of carrying an array of longer-range munitions such as the air-launched cruise missiles, the Joint Standoff Weapon and the Joint Air-to-Surface Standoff Munition.

Some 200 U.S. Navy ships and submarines have the capacity to carry thousands of Tomahawk cruise missiles in several variants with ranges approaching 1,000 nautical miles. The four *Ohio*-class submarines can carry up to 154 cruise missiles each. Since first introduced into the fleet and provided to a select number of allies, more than 2,000 Tomahawk missiles have been launched. The upgraded version of this weapons system, the Tactical Tomahawk Block IV, can loiter for hours exploiting existing networks to transmit real-time pictures to controllers and respond to instructions to shift course or change targets. The Tomahawk can be launched with multiple targets stored in its guidance system or dynamically reprogrammed in flight.[33]

These numbers belie the reality that the U.S. military possesses only a handful of platforms capable of reaching targets deep in enemy territory, particularly if in the presence of heavy and advanced air defenses. The problem is even more challenging if the targets are hardened requiring the employment of very large, deep-penetration weapons or are mobile.[34]

Numbers

The evolution of U.S. precision strike capabilities over the past twenty-odd years has seen a significant reduction in numbers of Air Force and Navy/Marine Corps platforms even as the overall ability of this smaller fleet to service targets has expanded. Over the past decade, armed unmanned aerial systems (UASs) have further enhanced the ability to conduct precision strikes, particularly against individual vehicles and small groups with little collateral damage.

Nevertheless, if the size of the fleet continues to shrink, the time will soon come when the number of tactical fighters and strategic bombers is simply insufficient to meet current demand. The quantitative adequacy of U.S air forces must be judged based on their ability to meet three basic requirements: a rotational base; surge capacity; and ongoing operational, training and maintenance activities. Surge capacity can be further defined based on the number of conflicts for which the U.S. military is required to be able to fight. Historically, the requirement to conduct two conflicts in widely separated theaters at approximately the same time, the canonical "Two Major Theater Conflicts" standard, required a force of approximately 200 strategic bombers, 20 tactical fighter wings and 11 aircraft carriers.[35] The requirement to rapidly halt aggression by two adversaries means the early deployment of substantial numbers of tactical aircraft and rapid initiation of large-scale strategic strikes. The projected force over the next decade is expected to fall well short of these levels.

Moreover, in the face of the proliferation of advanced anti-aircraft systems and the creation of integrated air defense systems by prospective adversaries, the requirement for stealthy aircraft and electronic warfare platforms is likely to rise substantially in the years to come. It is much more difficult to defeat an integrated air defense system if the number of stealth aircraft remains relatively small.[36] The present inventory of stealth aircraft is quite limited as is the number of electronic warfare aircraft.

Challenges to Dominant Strike

Without question, the United States military has set a standard for the conduct of aerial precision strike unrivaled in military history and unequalled in the modern world. This position has been reached as the result of decades of investment in a host of technologies, tactics and procedures.

> Over time, the United States has come to rely on some key elements in prosecuting its global responsibilities that are facilitated by its dominance in precision strike. The first is unfettered access in protecting the global commons. . . . A second key advantage stemming from U.S. success with precision strike is air superiority. Precision strike is not the only reason the United States has enjoyed air superiority over the years, but it does play a key role. . . . A final key element of the U.S. monopoly of precision strike ties in with the previous two. It is freedom of movement. Freedom of movement is an essential element to warfare, whether on the ground as the sweeping, famed "left hook" the XVIII Airborne Corps performed during the Gulf war showed, or on the sea as was demonstrated in 1996 when President Clinton ordered two U.S. aircraft carrier battle groups into the waters near Taiwan in response to aggressive actions by the Chinese.[37]

The central issue for the future is whether the United States can maintain its dominant position in the face of three basic challenges to the current U.S. dominance in global precision strike. The first challenge is the proliferation of so-called anti-access/area denial capabilities, which, appropriately networked and directed, create the prospect of a layered offense/defense regime designed specifically to counter the U.S. dominance of the air. The second challenge is the shift in the focus of political-military competition from the European side of the Eurasian landmass to the Western Pacific. The ability to deploy and employ air power will be affected by changes in distance, local geographies and alliance relationships in the Asian Pacific. The third challenge is to deploy a force appropriate to the changing nature of military operations based on unpredictability with respect to location, timing, adversaries, coalition partners, the difficulty of predicting the location of future conflicts, shifting coalitions of the willing and the need to achieve decisive results rapidly and with a minimum of collateral damage. More than 20 years ago, one air power advocate predicted many of the challenges today's military would face in its efforts to maintain dominant air power across the globe.

> The combination of continued and emerging threats to national security interests, proliferation of sophisticated weapons, and reduced numbers of overseas U.S. forces in an unstable world presents new challenges for U.S. military forces. The likelihood that U.S. military forces will be called upon to defend U.S. interests in a lethal environment is high, but the time and place are difficult to predict.[38]

The most immediate and obvious challenge is the anti-access/area denial threat. In particular, A2/AD relies on the proliferation of precision strike systems to counter adversaries' precision strike capabilities. This involves the employment of a range of measures some offensive, others defensive, but all intended, in particular, to deny the U.S. freedom of maneuver, prevent access to regions of conflict and counter the offensive threat posed by hostile air power. The new U.S. defense strategy defined the threat to core aspects of U.S. conventional deterrence thusly:

> In order to credibly deter potential adversaries and to prevent them from achieving their objectives, the United States must maintain its ability to project power in areas in which our access and freedom to operate are challenged. In these areas, sophisticated adversaries will use asymmetric capabilities, to include electronic and cyber warfare, ballistic and cruise missiles, advanced air defenses, mining, and other methods, to complicate our operational calculus. States such as China and Iran will continue to pursue asymmetric means to counter our power projection capabilities, while the proliferation of sophisticated weapons and technology will extend to non-state actors as well.[39]

According to the Air Force's *Global Horizons* study, and confirmed by other intelligence community reports, the majority of foreign combat air forces will be made up of modern fourth- or fifth-generation aircraft. Additionally, potential adversaries will gain greater access to advanced defensive systems and offensive munitions. They will also be able to contest the use of space and engage in sophisticated electronic warfare and cyber attacks on U.S. command, control and communications systems.[40]

As a consequence of the proliferation of advanced military technologies, the decades' long U.S. advantage in air power will be seriously challenged. The U.S. Air Force Chief Scientist, Dr. Mica Endsley, recently observed that "in air operations, I think over the past few decades, we've enjoyed pretty good air superiority in a lot of the theaters we operated in -- that's not necessarily going to be the case in the future."[41] Air Combat Command (ACC) Commander Lieutenant

General Gilmary M. Hostage III went even further in a public interview, stating that even today the majority of ACC's combat aircraft "do not have the ability to operate without significant risk in an advanced threat environment."[42]

China, more than any other nation, is pursuing a comprehensive A2/AD capability, one clearly designed to counter the dependence of the U.S. defense strategy on air and naval power. China's A2/AD posture includes conventional weapons systems that integrate assets from all domains: land, air, sea, space and cyberspace.[43] In August, 2013, it was reported that China had simultaneously launched three small anti-satellite weapons into orbit in what was a clear demonstration of a capability to threaten low-orbiting military satellite systems.[44]

Beijing is developing and deploying military systems in support of an A2/AD capability, providing China with the ability for longer-range strikes against U.S. carriers and bases in the region, with the goal of denying U.S. forces access to the region and disrupting operations of U.S. forces in the region. According to former Secretary of Defense Robert Gates, China's "investments in cyber and anti-satellite warfare, anti-air and anti-ship weaponry, submarines, and ballistic missiles could threaten America's primary means to project power and help allies in the Pacific" including U.S. bases, air and sea assets and the networks that support them.[45] A recent report by the National Air and Space Intelligence Center concluded that China "is developing and testing offensive missiles, forming additional missile units, qualitatively upgrading missile systems, and developing methods to counter ballistic missile defenses."[46] The most recent edition of the Department of Defense's *Military and Security Developments Involving the People's Republic of China* concluded that:

> As part of its planning for military contingencies, China continues to develop measures to deter or counter third-party intervention, particularly by the United States. China‘s approach to dealing with this challenge is manifested in a sustained effort to develop the capability to attack, at long ranges, military forces that might deploy or operate within the western Pacific, which the DoD *[Department of Defense*] characterizes as anti-access and area denial (A2/AD) capabilities. China is pursuing a variety of air, sea, undersea, space and counter-space, and information warfare systems and operational concepts to achieve this capability, moving toward an array of overlapping, multilayered offensive capabilities extending from China‘s coast into the western Pacific. China‘s *2008 Defense White Paper* asserts, for example, that one of the priorities for the development of China‘s armed forces is to increase the country‘s capabilities to maintain maritime, space, and electromagnetic space security.[47]

The People's Liberation Army's (PLA) growing arsenal of increasingly capable ballistic and cruise missiles poses a clear preemptive threat to U.S. and allied targets in the region. One recent analysis of a cross-strait conflict that modeled the extensive use by China of such weapons concluded that:

> The danger to both ROCAF *[Republic of China Air Force]* and USAF *[U.S. Air Force]* operations in the Taiwan Strait is sufficiently grave that a credible case can be made that the air war for Taiwan could essentially be over before much of the Blue air forces have even fired a shot. [48]

In addition to its expanding offensive capabilities designed to deny the United States and its allies the ability to operate military forces close to Chinese territory, the PLA is also building sophisticated area surveillance and air defense capabilities. To date, this air defense system relies heavily on advanced Russian interceptor aircraft and surface-to-air missile systems.[49] These defenses are heavily focused on the eastern approaches to that country and the Taiwan Straits, almost a Chinese Maginot Line. According to the Defense Department's *2013 Annual Report*:

> China has developed a national integrated air defense system (IADS) to defend key strategic cities and borders, territorial claims, and forces against threats from the air. Overall, China's IADS represents a multilayered defense consisting of weapons systems, radars and C4ISR *[command, control, communications, computers, intelligence, surveillance, reconnaissance]* platforms working together to counter multiple types of air threats at various ranges and altitudes. One of China's primary goals is to defend against precision strike munitions such as cruise and ballistic missiles, especially those launched from long distances. In order to counter precision strike munitions, China has developed advanced long-range SAM *[surface-to-air missile]* systems, airborne early warning platforms, and C2 *[command and control]* networks. Defense against stealth aircraft and unmanned aerial vehicles is also a growing priority.[50]

China is not the only nation to pursue an A2/AD strategy in the face of U.S. air and sea dominance. Russia, North Korea, Iran and Syria are all acquiring critical capabilities with which to support such a strategy, most notably ballistic missiles and integrated air defenses. Russia is investing heavily in advanced air defenses, which they have also made available for export.[51]

In all four cases, the strategy these countries could be expected to employ would be similar to that of the PLA: an initial rapid, intense strike by air and ballistic missile forces against U.S. and coalition partners' airfields, command, control and communication nodes and logistics centers, followed by a limited offensive or even just a protracted defense relying primarily on an integrated IADS but also the dispersal, movement and hardening of high value targets. Additonally, North Korea possesses a nuclear weapons capability, and Iran and Syria are seeking to acquire one. Russia has made the first use of nuclear weapons as a means of de-escalating a conventional conflict an explicit element of its military doctrine.

The challenge posed by today's Syrian air defenses is illustrative of the intensifying A2/AD threat the U.S. military confronts. The Assad regime has one of the more formidable air defense systems in the world, actually better than that which the United States faced in 1991 and 2003 in Iraq. Comparing the Syrian air defense challenge to others the United States has addressed, the Chairman of the Joint Chiefs of Staff, General Martin Dempsey, observed that:

> . . . they have approximately five times more sophisticated air defense systems than existed in Libya, covering one-fifth of the terrain. All of their air defenses are arrayed on their western border, which is their population center. So five times the air defense of Libya, covering one-fifth of the terrain, and that is about ten times more than we experienced in Serbia.[52]

The Syrian Air Defense Forces consist of some 25 air defense brigades, each with six surface-to-air (SAM) batteries. Overall it deploys some 650 fixed, long-range surface-to-air missile launchers (SA-2, SA-3 and SA-5), 250 mobile low-to-medium altitude SAM launchers (SA-6, SA-8, SA-10 and SA-11) and 4,000 pieces of anti-aircraft artillery. There are also 12 batteries of the advanced, mobile SA-22, the missile that shot down a Turkish reconnaissance jet over the Eastern Mediterranean. Additionally, the Syrian Air Force can put into the air about 400 interceptor aircraft.[53] On order, but yet to be delivered, is the Russian-built S-300, considered an extremely capable surface-to-air system close in capability to the U.S. Patriot.

There is some dispute as to how effective Syrian air defenses might be, particularly against U.S. stealth aircraft and long-range standoff weapons. One unclassified analysis concluded that a minimum of 300 aircraft conducting multiple sorties plus hundreds of Tomahawk cruise missiles would be required just to degrade Syrian air defenses.[54] This figure was given indirect confirmation by General Dempsey in a letter sent to the Chairman of the Armed Services Committee that outlined potential military options for dealing with Syria. In the letter, General Dempsey identified two options that focused on the use of air power alone: conduct limited standoff strikes and establish a no-fly zone. Execution of either of these options would require the employment of hundreds of aircraft, ships, submarines, intelligence and electronic warfare enablers and aerial refueling tankers in a campaign to attack hundreds of targets. As the Chairman noted in his description of military options, any decision involving the deployment of U.S. ground forces would also require implementation of one or the other air power option, if not both.[55]

Compounding the difficulty of addressing the technological and operational challenges posed by A2/AD threats to U.S. dominance in the air is that of a new strategic geography. Prospective regions of conflict, whether in Southwest or Northeast Asia, are 8,000 or more miles from the continental United States. As forward basing in other parts of the world is reduced, the effort to project power forward will inevitably become more difficult and expensive.

The new defense strategy with its emphasis on ensuring stability in and access to the Asia-Pacific region dictates consideration of new force structure options. Simply stated, the Asian mainland and Western Pacific are very far from the continental United States. It is also a very large region, extending from the tip of Siberia in the north to Australia, Singapore and the straits in the south. The movement of forces to and within this region will require time. Operations in the region will have to deal with long lines of support and communications even if forces themselves are based in friendly countries.

Conversely, prospective U.S. adversaries have a clear operational advantage in their proximity to potential areas of conflict. It is only 110 miles from the Chinese mainland across the Taiwan Strait. North Korean forces are poised on one side of the Demilitarized Zone some 30 miles from South Korea’s capital, Seoul. Iran occupies one side of the Strait of Hormuz, which itself is only 21 miles wide at its narrowest point. This means that prospective adversaries could mount a rapid two-part offense designed to first devastate U.S. forward deployed capabilities and regional basing infrastructure and, second or simultaneously, seize control of disputed territory before U.S. forces could surge into the region.

Access to forward bases is both more complex and more limited in the Asia-Pacific region, particularly in the central and northern portions of this region, than in either NATO or the Middle East. U.S. forward positioning of air assets is dependent on a handful of major facilities, notably those on Guam, Japan, South Korea and Okinawa. There are constraints on how much additional manpower and equipment can be deployed to these facilities. These facilities are at present relatively vulnerable to attack by existing air and ballistic missile forces in the region. Additional bases in Australia and Southwest Asia would certainly be beneficial and enhance operational flexibility but would not do much to alleviate wartime operational requirements for facilities in the more likely zones of conflict. Thus, in the face of these challenges, for both political and strategic regions, U.S. enduring interests demand the positioning of some forces in a manner that places them at increasing risk. A recent independent review of the U.S. military posture in the Pacific concluded that:

> More than ever, a robust forward U.S. military presence anchored in key alliances and partnerships is critical to advancing this enduring interest. . . . Forward-deployed U.S. forces in the Western Pacific face greater risks from advanced capabilities such as A2/AD and a broader array of demands, both geographic and across the spectrum of military operations.[56]

The intersection of the proliferation of A2/AD capabilities and strategies with evolving geo-strategic realities raise the very real possibility that the United States could see its 60-year dominance in the air undermined and, as a consequence, suffer defeat in a future conflict. A number of studies have warned that the combination of A2/AD systems, geographic asymmetries and sheer number of platforms and weapons could prove decisive, at least in the initial stages of a future conflict.[57] One analysis of the so-called Asia-Pacific pivot warned that even the least stressing of the commonly identified prospective regional conflicts, one involving North Korea, could absorb virtually the entire ready tactical fighter force.[58] A study by the RAND Corporation that examined major conventional operations involving China, Iran and North Korea concluded that:

> In all three plausible future MCO *[major combat operations]* cases, our assessment is that it is possible that the United States could lose the war, in terms of being unable either to achieve its own goals (e.g., regime change in North Korea) or to frustrate those of its adversary's (Chinese control of Taiwan). This is true not because the North Korean, Chinese, or Iranian militaries are fair matches for the United States in a stand-up fight -- far from it. This is true because future MCOs *will not be* stand-up fights.[59]

The third challenge to the future of precision strike is the increasing complexity and unpredictability of future target sets coupled with the expectation, if not the absolute requirement for very low collateral damage. Beginning with the air war in Kosovo, improvements in ISR, navigation and weapons has allowed targeters and aircraft crews to achieve increasing effects with reduced collateral damage. Indeed, by the time of OIF, control over attacks on fixed targets far exceeded anything seen in previous wars. As former Secretary of Defense Donald Rumsfeld noted in a press conference at the time, "The targeting capabilities and the care that goes into targeting, to see that the precise targets are struck and that other targets are not struck, is as impressive as anything anyone could see."[60] Similarly, the Commander of U.S. Central Command, General Tommy Franks, noted,"I think you have seen, time and time again, military targets fall while the civilian infrastructure remains in place. And it's the same with civilian lives."[61]

The avoidance of collateral damage has become a central concern in strike planning. According to one source, there are specific software programs now in use that allow targeters to carefully plan all aspects of a strike to ensure minimum chance of unintended damage.

> The drive to limit civilian casualties and collateral damage has generated great scrutiny among military planners. Since the air campaign in Kosovo, a special software program has been used, appropriately termed "Bugsplat," which predicts the amount of damage that could occur for a given airstrike. Planners examine a computer-generated map of the target area that contains detail regarding the size, construction materials, and function of surrounding buildings. Planners can specify the type of bomb used, warhead size, attack path, fuze setting, and other factors for a specific target. The computer program then estimates how much damage, if any, would occur to nearby buildings if munitions hit on target, or if they missed. Based on the results, planners can then modify the size of the warhead, weapon type, attack path, and other variables to drive the anticipated damage results lower. In some cases, the target might be avoided altogether if "Bugsplat" indicates that significant collateral damage would occur.[62]

Past and prospective adversaries of the United States have sought to limit the effectiveness of precision strikes by a variety of techniques, chief among them colocation, hardening and mobility. In the years leading up to the 2006 conflict with Israel, Hezbollah undertook a large-scale program to disperse its rocket inventory, collocating much of it with urban populations as well as creating a massive network of hardened and buried command and control facilities. As a result, Israel's operations were much less effective than had been anticipated. Three years later, during the operation against Hamas in Gaza, the Israeli Defense Forces successfully employed a joint force that capitalized on superb tactical ISR, targeted precision strikes and complex information operations. Israeli aircraft conducted strikes on targets in highly urbanized terrain with a better than 95 percent success rate and extraordinarily low collateral damage.[63]

North Korea and Iran have taken similar steps to disperse, harden and protect critical infrastructure and key military assets. In addition, both these countries have developed and deployed mobile ballistic missile launchers.

Mobile and so-called fleeting targets have always been more difficult to strike with the same assurance of low collateral damage as is now available with respect to fixed targets. At present, the U.S. military is not much better at finding and striking mobile targets than it was in the so-called "Scud Hunt" during Operation Desert Storm more than two decades ago. In addition, so-called triple-digit SAMs that are at the heart of evolving area denial threats are almost without exception mobile, which makes them more difficult to plan for as well as to successfully target.[64]

These three factors -- an emerging A2/AD environment, distance to likely theaters of conflict and more complicated target sets -- in themselves would be sufficient to challenge U.S. precision strike dominance in the decades to come. The Department of Defense's *Joint Operational Access Concept* (JOAC) framed the challenge for the future in a similar manner.

> The essential access challenge for future joint forces is to be able to project military force into an operational area and sustain it in the face of armed opposition by increasingly capable enemies when U.S. overseas defense posture is changing and space and cyberspace are becoming increasingly important and contested domains.[65]

The problem is made substantially more difficult by decisions on defense spending that look to either severely restrict the size of available strike assets and enablers or the ability to modernize existing fleets to address anticipated shortfalls. Indeed, it is even possible that in the foreseeable future the U.S. military will lack both the capacity and capability to ensure the dominance in aerial strike that it has enjoyed for more than two decades.

Capabilities Required for Precision Strike Dominance in the Future

The strengths of U.S. global strike forces rest in its inherent characteristics of speed, range, flexibility, precision and lethality. The value of these capabilities has been demonstrated in conflicts large and small for more than 20 years. If anything, the U.S. military has improved its performance in each of these areas since 1990. Moreover, the variety of platforms, basing modes, weapons payloads and response times allow U.S. global strike forces to employ a variety of strategies and operational concepts to defeat A2/AD challenges and ensure precise engagement of the desired targets.

It is clear that retaining the ability to hold any target on the planet at risk is becoming ever more difficult. There is no "silver bullet" solution to the complex problem posed by the emerging A2/AD threat, operational environments characterized by long distances and relatively few bases and changing target sets. The solution set certainly will include new technologies: platforms, weapons and electronic countermeasures (ECM). But it will equally involve new tactics, operational concepts and even air campaigns. Finally, but not last in the order of priority, there will need to be a holistic consideration of all the approaches available with which to pursue the goal of holding any target on the globe at risk.

The United States is taking steps to address the set of challenges to its dominance in precision strike. The most obvious of these is the long-term investment in fifth-generation aircraft with their combination of stealth, speed, connectivity and advanced ECM. According to the *Report of the 2010 Quadrennial Defense Review*:

> U.S. air forces will become more survivable as large numbers of fifth-generation fighters join the force. Advanced land-based and carrier-based aircraft will provide the greater average range, flexibility and multi-mission versatility required in order to deter and defeat adversaries that are fielding more potent anti-access capabilities.[66]

While a few critics have argued that the F-35 is less capable in certain ways than advertised, there is virtually no disagreement with the threat posed to fourth-generation systems by advanced air defenses. Fifth-generation aircraft provide the tactical and operational space that will permit operations to degrade advanced air defenses and to strike critical, time sensitive targets in contested airspace. Stealth also acts synergistically to multiply the effectiveness of the other capabilities available to counter integrated air defenses, such as longer-range weapons, advanced SEAD and ECM.[67]

Often misunderstood is the role that the integrated ISR and command, control and communications (C3) capabilities of fifth-generation platforms not only in addressing emerging threats to precision strike but in enhancing the capabilities of the entire joint force. Each platform becomes a node in a massive, integrated force. As ACC Commander Lieutenant General Hostage III noted:

> The fifth generation aircraft will enable the air combat cloud and allow me to use my legacy assets differently. Many of my fourth generation fighters can be used to extend the network of linked systems, providing reinforcing fires, and I can focus on the fifth-generation assets as the core nodes shaping distributed joint capabilities.[68]

There is a consensus among air power experts that maintaining U.S. dominance in the air and space will require the creation of “meta networks” and the close integration of sensors, platforms, intelligence fusion centers and even weapons both in joint and coalition forces. For example, a study of the U.S. Air Force’s strategic requirements for the period from 2020-2030 concluded that:

> To execute the situational awareness mission effectively, the Air Force’s intelligence community must globalize sensor systems through the integration of air, space, and cyber. This will enable the service to develop a comprehensive/integrated network of sensors and complete a metamorphosis of its assets into a tightly organized and dynamic force for global as well as regional coverage.[69]

It is important to bring all current platforms into an integrated C3 network that supports improved information sharing. However, as a solicitation for an advanced tactical data link system correctly points out, there are serious limitations to current systems.

> Current tactical communication capabilities have limited throughput and scalability, insufficient AJ (anti-jam) and LPE (low probability of exploitation) capability, and high latency and network join times. Link-16, the most widely used airborne tactical data link, provides C2 *[command and control]*, SA *[situational awareness],* weapons coordination, electronic warfare, and other capabilities, but does not meet emerging throughput, scalability, and latency requirements, especially in high electronic attack environments. Developed in the 1970's, Link-16 still meets the needs for a wide range of missions. Multifunction Advanced Data Link (MADL) and Cooperative Engagement Capability - Data Distribution System (CEC-DDS) use directional antennas to provide low probability of detection and a high degree of resistance against jamming respectively; however, they are limited in terms of interoperability, configurability, scalability and latency.[70]

There are additional operational considerations for continuing to invest in fifth-generation platforms. Stealth will allow strike platforms to operate close enough to their targets to permit the use of short-range, lower-cost precision weapons. This is a particularly important consideration in larger contingencies in which long-range advanced munitions will be at a premium. In addition, as demonstrated in conflicts from Operation Desert Storm through OIF, stealth allows the delivery of the appropriate weapon for hardened and buried targets even in a contested environment.

It is increasingly apparent that countering advanced A2/AD threats will require new operating concepts and more integrated use of available assets. The JOAC set basic guidance for the military services regarding addressing the problem of maintaining access including that necessary to maintain precision strike primacy. More detailed considerations have been developed as part of the Air Force's and Navy's new operational and planning construct called Air-Sea Battle. As described by the former Chief of Staff of the Air Force, General Norton Schwartz and the current Chief of Naval Operations, Admiral Jonathan Greenert:

> Air-Sea Battle provides the concepts, capabilities and investments needed to overcome the challenges posed by emerging threats to access like ballistic and cruise missiles, advanced submarines and fighters, electronic warfare and mines. By better countering these military threats, Air-Sea Battle will improve the credibility and effectiveness of the entire joint force as a key element of Joint Operational Access Concept implementation directed in the new defense guidance. Air-Sea Battle relies on highly integrated and tightly coordinated operations across warfighting domains -- for example, using cyber methodologies to defeat threats to aircraft, or using aircraft to defeat threats on and under the sea.[71]

A key to the success of efforts to counter the emerging A2/AD threat under the umbrella of the JOAC and Air-Sea battle is to "break the prospective adversary's kill chain."

> Air-Sea Battle defeats threats to access by, first, disrupting an adversary's command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) systems; second, destroying adversary weapons launchers (including aircraft, ships, and missile sites); and finally, defeating the weapons an adversary launches.[72]

Air-Sea battle envisions the employment of a combination of technologies, tactics, techniques and procedures to deal with an advanced IADS. According to Colonel Jordan Thomas, Air Force lead for Air-Sea Battle operations:

> The new reality requires the Air Force to return to the days of the "package," which would include not only suppression of enemy air defenses aircraft -- enabled "by national technical means" -- but also fighter sweepers, Rivet Joints, and other aircraft. It's going to take a lot more assets.[73]

It took heroic efforts during World War II to bring our air forces within reach of the adversaries' homelands. Without Great Britain as the unsinkable aircraft carrier would there even have been a strategic bombing campaign of Germany, much less the Normandy invasion? Unless we plan to fight our way across the Pacific, creating air and sea bases much in the same way we did during World War II, we will have to conduct future major campaigns from strategic ranges.

Another reality of future precision strike campaigns is the need to do more, perhaps most, operations from the homeland. For 60-plus years, the U.S. military has had the advantage of forward-deployed forces and basing infrastructure in friendly countries. Neither of these situations is certain to pertain for some, perhaps most, future high-intensity conflicts. Most U.S. forces will start from home stations, as countries may not be willing to allow access to their territory for U.S. forces or, most significantly, the bases we wish to use will be under threat from advanced, long-range strike systems deployed by our adversaries.

It is increasingly clear that the requirement to operate in an A2/AD environment, coupled with changing geo-strategic realities, will require inter alia, greater investments in long-range strike capabilities. Numerous studies have warned that the growing anti-access threat, particularly from long-range ballistic missiles and air-breathing systems, may limit the utility of forward bases and force U.S. aircraft carriers and surface ships to operate beyond the effective ranges of their missiles and aircraft. Arms control-imposed limitations on ballistic missiles and range limitations on cruise missiles will make it imperative to focus on the United States' portfolio of long-range air-breathing strike capabilities.[74] Moreover, effective long-range strike will require more than just standoff capabilities.

> Being able to safely penetrate to the vicinity of targets is crucial to deterrence and combat effectiveness. If the assets of highest value to an adversary cannot be held at risk, then that adversary is less likely to be deterred from aggression. Although it is feasible to attack many targets with standoff weapons such as the cruise missiles carried by B-52 bombers, that approach will not work with relocatable targets such as mobile missile launchers because they must be found before they can be destroyed. In addition, it is very expensive to wage large-scale air campaigns using standoff weapons exclusively -- so much so that the Air Force probably will not have enough cruise missiles on hand to get the job done. So the growing inability of bombers to safely transit defended air space is a serious problem.[75]

Long-range precision air-breathing strike systems provide two additional, albeit related, advantages. First, they will permit engagement with hostile forces, including strikes to strategic depth, from outside the range of hostile air defenses and from the opening moments of a future conflict. Second, long-range strike capabilities provide the flexibility to choose the avenue of attack. This allows U.S. joint precision strike forces to avoid the teeth of an adversary's A2/AD capabilities -- for example the PLA's "Maginot Line" opposite Taiwan -- and to maneuver strategically. The availability of robust long-range strike capabilities also serves to reduce the incentive of potential adversaries to launch a preemptive attack on forward bases in an effort to disarm the United States and its allies.

Future precision strike dominance will require an increased investment not only in long-range platforms but also in longer-range weapons. Such weapons would maintain the effectiveness of legacy platforms in the face of advanced IADS. The need to consider the next generation of long-range weapons was acknowledged by the current Under Secretary of Defense, Acquisitions, Technology and Logistics Frank Kendall:

> Right now we're taking some risks. We're tight on readiness and some R&D *[research and development]* and acquisition investments. We're being challenged in terms of technology development and U.S. military modernization programs. We've neglected electronic warfare and held off on some advancements in precision weapons systems. But we need to start thinking about the next generation of weapons.[76]

The emerging threat requires also that the requirements generation system break down the stovepipes between platforms, weapons systems and payloads. In the spirit of the integrated approach advocated by Air-Sea Battle, there have been proposals that the Air Force and Navy jointly develop a long-range precision strike family of systems that consists of ISR, airborne electronic attack, and strike assets.[77]

It will be insufficient for U.S. forces to operate only from beyond the range of A2/AD threats. The ability to project air power forward, whether to conduct air superiority or strike missions, will necessitate more robust air and missile defenses as well as approaches to ensure the ability to operate from air bases within range of such weapons. This will be particularly important in the Western Pacific in view of the dependence of the United States on a relatively small number of bases.[78] According to one study of potential conflict scenarios in this region:

> Thus, our analysis makes clear that developing ways to rapidly neutralize an opponent's arsenal of theater-range ballistic and cruise missiles will be critical to success in future MCOs (Major Contingency Operations). Some combination of offensive and, especially, effective *defensive* means will be needed.[79]

A 2006 study by the RAND Corporation on shaping the future Air Force considered a range of challenges to current U.S. air dominance including A2/AD, the changing operational environment and the emergence of new targeting requirements. This study is exemplary of the range of actions that should be taken in order to meet these critical challenges. The study proposed five new initiatives (not in priority order):

- New concepts for locating, identifying and tracking small mobile targets, especially missile launchers and individuals;
- Theater missile defense;
- Persistent and responsive fire support for U.S. and third-country ground forces across the full range of combat environments;
- Long-range surveillance and strike platforms; and
- Well-trained cadres of counterterrorism, counterinsurgency and nation-assistance finders, influencers and responders.[80]

The Five Steps to Continuing U.S. Precision Strike Dominance

If the United States is to remain capable of deploying dominant precision strike power in the next three or four decades, there is no alternative to investing in a set of modernized platforms, systems and networks. In the present budget environment, this can only be accomplished by reducing costs across the defense enterprise. Most of the savings could be achieved through a combination of base closures, reduction in administration personnel and functions and most significantly, reducing the costs of regulations and oversight in the acquisition system. However, given resistance in Congress and by some in government to such measures, cuts in current force structure appear inevitable. The Air Force is considering drastic cuts to legacy forces, including eliminating in their entirety the A-10, KC-10 and F-15C fleets.[81] The actions recommended below need to be considered in concert with steps to reduce other defense costs as well as the size and expenses associated with the legacy force structure.

1. A More Rapid Transition to a Fifth-Generation Tactical Fighter Fleet

The case for investing in fifth-generation platforms is unassailable. As discussed above, it is the consensus of experts that fourth-generation aircraft will not be effective against the emerging A2/AD threat.[82] A robust program to develop and deploy advanced airborne strike platforms and systems in order to provide both the capability and capacity to conduct precision strikes at all ranges is absolutely vital.[83]

An essential feature of a fifth-generation aircraft is low observability, primarily against radar. Stealth technology can decisively counter the threat posed by IADS, as well as allow a smaller aerial force to defeat a larger but less technologically sophisticated one, particularly when complemented by electronic warfare (EW) and electronic counter measures, standoff weapons and robust networking.

There are measures that can be taken to reduce the signatures and improve the survivability of fourth-generation aircraft. However, such measures cannot achieve nearly the effect of those designed into a platform from its inception. Conversely, the value of EW and other countermeasures is multiplied when deployed in support of a fully stealthy aircraft.

Today, the United States deploys a very small number of truly stealthy aircraft. The existing fleet of F-22s is simply too small to be able defeat a large IADS system or overcome the numerical advantage of emerging regional powers. The decision to cut off the procurement of F-22s at 187 was based on the assumption that large numbers of carrier-based F-35Cs would be available from the opening moments of a future major regional contingency to “knock down the door” for legacy forces.[84]

The only way for the U.S. military and that of its major allies to transition to a fifth-generation force is by the acquisition of the F-35 Joint Strike Fighter. The current program for the F-35 will increase the presence of U.S. combat aircraft fleet with significant stealth features to nearly 70 percent when the Air Force, Navy and Marine Corps acquire the full complement of more than 2,400 aircraft. The effect of the F-35 will be even greater when planned procurements are completed to the eight international partners in the Joint Strike Fighter.

The Department of Defense needs to accelerate its acquisition of the F-35. On the original procurement plan, there would now be some 1,000 operational F-35s. Because of delays in the program, the Air Force faces a fighter shortfall of some 800 aircraft and the Navy/Marine Corps of around 100. A sensible strategy would be one that reduces expenditures on legacy platforms in order to increase the number of F-35s acquired each year so that the total reaches approximately 1,000 by 2020. An early "buy out" of portions of the F-35 program would also reduce the overall cost of the program by establishing an economical rate of production and would also free up resources post-2020 for the procurement of a new long-range bomber.[85]

A large force of F-35s for the Air Force, Navy and Marine Corps is significant for more reasons than just its inherent stealthiness. The F-35 sensor suite and networking capability will allow it to conduct new kinds of aerial operations based on "swarming" tactics as well as to ensure the most effective employment of aerial assets. The ability of the F-35 (and the F-22) to serve as a sensor and EW platform not only will make a stealthy force more effective but also multiple the effectiveness of legacy platforms.

A combination of stealthy aircraft, dedicated EW platforms and legacy aircraft with enhancements will be required to retain precision strike dominance over the next several decades. This will necessitate continuing investment in a robust fleet of EF-18 Growlers, the Next Generation Jammer and additional electronic countermeasure capabilities. In addition, the retention of some number of modernized F-15Es and F-16s will be necessary in order to provide sufficient capacity to address large contingencies.

2. Develop and Deploy A Robust Complement of Deep Precision Strike Capabilities

A robust U.S. long-range precision strike capability for the next two to three decades will likely rest on three pillars. One is a large inventory of sea-launched cruise missiles deployed on Navy surface ships and submarines. The second is a new Air Force strategic bomber. The third is a new long-range, carrier-based strike platform, probably unmanned.

The Air Force and the Navy need to invest in new capabilities to see and strike deep in the face of advanced air defenses. It might also be argued that to these requirements should be added promptness. The ability to deliver large volumes of weapons precisely and promptly against all but the most hardened targets would be a powerful deterrent of any prospective adversary. Should deterrence fail, such a capability would be able to meet the requirements in the current strategy to deny an aggressor the prospect of achieving his objectives or to impose unacceptable costs on the aggressor and to do so rapidly. Such capability could achieve the goals air power advocates set out nearly a century ago.

The Navy must go forward with the plan to add the Virginia Payload Module (VPM) to all *Virginia*-class boats procured from FY2019 onward. The Navy has long deployed surface- and subsurface-launched cruise missiles, including the new Tactical Tomahawk Block IV. This includes four converted *Ohio*-class nuclear powered ballistic missile submarines (SSGNs), each capable of launching 154 cruise missiles. In addition, the latest block of the *Virginia*-class includes the ability to carry more than 36 cruise missiles plus advanced payloads in a mid-body section, called VPM. The VPM will house four large-diameter, vertical launch tubes capable of holding seven additional Tomahawk cruise missiles or other payloads. The VPM would permit an increase in the total number of Tomahawk cruise missiles carried by the *Virginia*-class design from about 36 to about 65. The 22 *Virginia*-class boats planned to be built with VPMs could carry 616 Tomahawks in their VPMs, equaling the number of cruise missiles carried by the four SSGNs.[86]

The critical issue for the maintenance of U.S. precision strike dominance is the Air Force's ability to deploy a next-generation bomber, sometimes referred to as the Long-Range Strike family of systems (LRS). Without a new, stealthy, penetrating bomber, the only capability the United States will have for precision strike at ranges beyond 1,000 miles will be the fleet of 16 operational B-2s.

> Given the characteristics of the current bomber fleet, many analysts expect the Long Range Strike Bomber to have an unrefueled range of about 5,000 nautical miles and a payload similar to the B-2's 40,000 pounds -- with all munitions carried internally to minimize the plane's radar signature. Like the B-52 it may have the capability to launch standoff weapons of considerable range, which presumably would dictate development of a new munition. The airframe, sensors and engines of LRS-B probably will be stealthy across a broader range of frequencies than those of previous bombers, so that the plane can operate for prolonged periods in hostile airspace. Experts also expect a typical cruising speed in the high subsonic range, perhaps with supersonic "dash" capability.[87]

A new bomber must be able to penetrate robust IADS. Prospective adversaries are pursuing a variety of passive protective measures including hardening and mobility to secure high-value targets. A new strategic platform must be able both to hunt, find and attack mobile targets but also to carry very large weapons with which to penetrate extremely hard structures. Therefore, it must have advanced stealth features as well as EW and ECM capabilities.[88]

The current plan is to acquire between 80 and 100 new bombers. It is not clear why this will provide an adequate number. Properly sizing the bomber fleet should be based on several considerations. One is the number of operational platforms needed to address the high end of the A2/AD threat involving multiple layers of offensive and defensive capabilities as well as a very large potential set of critical targets. New operational concepts for dismantling A2/AD defenses from long range may require protracted strikes on multiple axes over a lengthy period of time.[89]

Additionally, strategic bombers have proven themselves in the close air support and interdiction missions once hostile air defenses have been neutralized. Because of its ability to loiter, high-speed dash capability and large payload, the B-1 has demonstrated its utility in support of ground forces in Afghanistan. Given the very high cost of long-range precision strike systems compared to relatively simple GPS-guided, unpowered weapons, the role of bombers in future low- and medium-intensity conventional conflicts is likely to be significant.

It is clear that even in an era of stealth aircraft and advanced EW, numbers will matter. The strategic bomber fleet cannot be a "silver bullet" force unable to absorb losses in the event of a major theater conflict. Moreover, in a protracted air campaign the cost of the necessary inventory of long-range precision munitions can exceed that of an equally effective bomber fleet.[90] Therefore, the Air Force should consider options for building a larger fleet of bombers, perhaps as many as 200, if, as is likely, the A2/AD threat continues to intensify and air power remains a key asymmetric U.S. advantage in low- and medium-intensity conflicts.[91]

As is the case with the transition from a fourth- to a fifth-generation tactical fighter force, the development and deployment of a new strategic bomber will take decades to complete. Over that time, improvements must be made in the legacy fleet to ensure its effectiveness even in the face of growing A2/AD challenges. Each of the three types of bombers in the current fleet requires upgrades to enhance connectivity, expand the range of munitions that can be delivered, and cope with the inevitable problems associated with aging.[92]

The third pillar is an extended range capability to complement the F-35C. The Navy is seeking to develop and deploy an initial Unmanned Carrier Launched Airborne Surveillance and Strike (UCLASS) system with limited capabilities to fill holes in the capabilities of the current carrier air wing (CVW), particularly for long-range, persistent ISR. The real increase in capability is likely to have to wait for the development of an as-yet undefined next-generation UCLASS drone. This system will need a range equal to that of the current proposed design, but it also will have to carry a significantly larger payload and have the ability to deploy long-range air-to-ground weapons. This would allow the carrier air group to engage targets at or beyond the range of current and projected anti-ship ballistic and cruise missiles. A large payload capacity could also allow the UCLASS to fill a yawning gap in current CVW capabilities -- air-to-air refueling of both manned and other unmanned platforms.[93]

Representative Randy Forbes provided a clear description of the characteristics required of UCLASS as well as its place in the future carrier air wing:

> Along with squadrons of F/A-18E/F Super Hornets and the F-35C, I believe the CVW of the future should include a detachment of 4-6 UCLASS so that it could have a larger strike radius. A UCLASS program with an endurance of greater than 12 hours (or roughly a 1,000 nm combat radius), that is moderately stealthy, and can carry as much or more payload than the F-35 carries internally would transform the CVW from a capability with short tactical reach to a global naval strike and reconnaissance platform. A UCLASS with 12-14 hour endurance would allow for 2 launch/recoveries each day to provide full 24-hour ISR coverage from each platform. More importantly, a UCLASS outfitted with JSOW *[joint standoff weapon]* could operate as a “missile truck,” to borrow the Chief of Naval Operations terminology, while freeing up high-end platforms like the F-35C to perform other missions. In short, a CVW with a detachment of UCLASS equipped with stand-off weapons would give the CVN *[aircraft carrier]* of the future the capacity and reach to hold targets at risk while operating outside the ASBM *[antiship ballistic missile]* envelope. This would help to reduce the operational advantage the ASBM offers while increasing the strategic and operational flexibility of American decision-makers.[94]

3. Develop and Deploy a Family of Advanced Weapons

New and modernized platforms are not enough to maintain U.S. dominance in air-based precision strike. Continuing preeminence will require investments in weapons/payloads as well. Simply extending the range of existing precision weapons can both expand the effectiveness of existing and planned platforms and help counter the danger posed by longer-range air defense systems. Investments in networks and joint fires can enable weapons engagement delivery without the need for active illumination of the target by either the delivery platform or even the weapon itself. Either passive detection systems or off-board assets can provide cueing.[95]

However, extremely precise, long-range, high speed and stealthy weapons will be required to ensure the ability of U.S forces to conduct future SEAD campaigns and simultaneously hold at risk the full range of targets. Additionally, such weapons will also serve to maintain the utility of legacy platforms in the face of the A2/AD threat.[96] The payloads carried by such weapons will need to be improved to counter evolving threats and adversary advances in countermeasures. Admiral Greenert identified a set of investment priorities for Navy weapons thusly:

> In particular, we need longer-range weapons to allow platforms to reach our foes despite their improvements in sensors. We need more capable and more numerous electronic-warfare and cyber payloads to thwart detection and targeting. We need unmanned payloads that expand the reach of today's platforms both for sensing and attack.[97]

In view of the reliance of U.S. precision strike campaigns on air- and sea-launched cruise missiles, particularly in the initial wave of strikes on hostile IADS and C3 targets, it is vital to ensure the effectiveness of this class of weapons. Consequently, the Air Force and Navy should explore development of stealthy long-range land-attack cruise missiles capable of carrying a wide variety of payloads to replace both the Tomahawk and Air-Launched Cruise Missile.[98]

Existing systems can also be made more effective with improved sensors, greater range and performance features, as was the case for the Joint Air-to-Surface Standoff Missile-Extended Range (JASSM-ER). The Defense Advanced Research Projects Agency is currently working to develop the Long Range Anti-Ship Missile (LRASM), and autonomous, precision-guided anti-ship standoff missile based on the JASSM-ER platform. LRASM will employ a multi-modal sensor, weapon data link and an enhanced digital anti-jam Global Positioning System.[99]

Currently, the United States will attack long-range air defense systems with the Advanced Anti-Radiation Guided Missiles (AARGM). AARGM employs a multi-sensor system that includes a Millimeter Wave terminal seeker, advanced Anti-Radiation Homing receiver and jam-resistant, advanced GPS to engage traditional and advanced enemy air defense threats even when they have ceased radiating. In the near-term, more capable, longer-range and higher speed variants of the AARGM will need to be developed.

There is a limit to what can be done to make air-to-surface weapons stealthier. A new design approach will be required. One such approach that holds promise, although it is currently in early development, is hypervelocity. A weapon with multi-Mach speed would be capable of addressing all three challenges posed to precision strike dominance: A2/AD, distance and mobile or fleeting targets.[100] The Air Force has a plan to develop a hypersonic strike weapon by 2020.[101]

Hypervelocity weapons could also provide a means to conduct conventional prompt global strike (CPGS). In 2004, the Defense Science Board warned of the need to develop a conventional prompt global strike capability to address emerging A2/AD threats and the evolving character of high value targets. It proposed development of a range of such weapons, including 50 intercontinental ballistic missiles with an advanced conventional payload (such as a boost glide vehicle, a variant of the Trident D-5 with a non-nuclear warhead and a 5-meter CEP) and supersonic and hypersonic air-to-surface weapons.[102] Another concept is for a Forward-Based Global Strike system, a new conventionally armed intermediate-range ballistic missile, either land-based or submarine-deployed, deployed in the Western Pacific.[103] There is a consensus that any weapon designed for the CPGS mission will be in the nature of a "silver bullet," reserved for key elements of an advanced IADS or for extremely high-value mobile targets.[104]

4. Connect Air, Sea and Ground Platforms and Systems

Many experts believe that the key to preserving U.S. precision strike dominance in the near-term is the exploitation of information systems and networks to integrate both legacy and fifth-generation platforms. Advanced networks will be required to support distributed operations, "combat cloud," and near real-time sensor-shooter collaboration.

As discussed above, a key aspect of the success of U.S. global precision strike is due to the development of integrated communications and data sharing networks. In the future, the close integration of ISR systems, cyber capabilities, airborne platforms and even weapons will be required not only for the defeat of A2/AD threats, but also to the conduct of effective precision strike campaigns across the conflict spectrum.

> An essential prerequisite for cross-domain operations is communication and data links that connect sensors, decision-makers, and shooters armed with kinetic, electromagnetic, and cyber weapons. Our investments, guided by the Air-Sea Battle concept, are building increasingly robust networks able to communicate between each service's platforms, even in a contested electromagnetic environment. Part of this effort is focused on the systems and procedures for Joint Tactical Networking to connect today's aircraft and ships with new 5th generation aircraft, such as the F-35 and F-22.[105]

Beyond the deployment of Link-16 and the creation of the Joint Tactical network based on the F-35's Multifunction Advanced Data Link, there needs to be significant investment in future network capabilities. The Air Force has initiated a New Common Data Link capabilities program. The Navy is investigating an Advanced Tactical Data Link intended to overcome the inherent limitations in a Link-16-based system. The Navy also has begun the Integrated Targeting and Fire Control roadmap effort, which seeks to integrate current and planned platforms and sensors into "vertical" kill chains.

5. Enhance Base Defense and Prepare for Proliferated Basing

The Air Force's *Pacific Air Force Strategic Plan 2013* has identified airbase resilience as a key tenet of its strategy to counter the A2/AD threat. "As we face emerging, ambiguous threats from a near-peer competitor with high-end, growing A2/AD capabilities, PACAF's *[U.S. Pacific Air Force's]* integrated air and missile defense approach is designed to counter A2/AD capabilities through a smart mix of Active Defense, Passive Defense, and Attack Operations into a unique formula at each affected operational location."[106]

The Department of Defense recognizes the need to expand its deployments of air and missile defense capabilities in both the Middle East and Western Pacific. The Navy and Army both have effective air and missile defense systems. The Aegis ballistic missile defense system will be installed on some 100 cruisers and destroyers as well as in an ashore form currently planned for deployment in Europe. The Army operates the Patriot air and missile system as the Theater High Altitude Air Defense. The Army also has proposed deploying the Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System, a long-endurance, long-range surveillance system based on two large aerostats that carry radars, one for surveillance and the second to provide very precise intercept data. JLENS can look out to about 550 kilometers and track hundreds of targets at one time including ballistic and cruise missiles, low-flying aircraft and even ships at sea.

The U.S. Navy's Integrated Fire Control-Counter Air is designed to integrate both dedicated sensor platforms such as the E-2D Advanced Hawkeye and Aegis air defense system with Army and Air Force sensors and weapons to enhance defenses against both ballistic and air breathing threats. The Army's JLENS has demonstrated the ability to support both air and missile defense launches. The Aegis ballistic missile defense system has successfully fired a Standard Missile 3 based on remote data from forward-deployed radar. The Defense Department needs to invest in networking the full range of ISR capabilities in a theater so that all forces are empowered to employ high-quality data from dispersed sensors to conduct engagements remotely, without additional guidance data from the system that launches the missile.

Complementing the active defense of forward facilities should be programs to enhance base survivability as well as to develop alternative basing modes. Established bases such as Osan and Kusan in South Korea, Kadena in Japan and Guam could be hardened against conventional missile attack. The Air Force needs to prepare alternative airfields, perhaps on the U.S.-controlled islands of Tinian and Saipan, for use in the event of a regional conflict. Japan has offered to allow U.S. Air Force units to disperse on warning to a large number of auxiliary and civilian airfields, severely complicating an adversary's efforts to target those forces.[107] At these and other locations, the positioning of additional stockpiles of repair materials, spare parts, munitions and fuel would allow for continuing operation even when bases were under attack.[108]

Conclusion

Since the birth of military aviation, there have been two revolutions in air power. The first and most basic revolution occurred in the first half of the last century. It centered on the creation of platforms and organizations focused on seizing control of the air and striking targets on land and sea. Although even to the present day the first revolution is associated with strategic bombardment, this is not where it had significant effect. Despite the expenditure of nearly untold resources, material and lives in the pursuit of decisive strategic effects through massive, deep penetration raids on enemy homelands, the first revolution was largely successful at the tactical level. Limitations with respect to navigation, targeting and penetration of hostile air defenses prevented air forces from achieving the dreams (or in some cases fears) of air power theorists. Rather, air power was highly successful in its support of land and sea forces, striking enemy ground formations and fleets and interdicting transportation and logistics.

The second revolution was essentially operational in character. It was based on dramatic successes in solving the twin problems of navigation/precision targeting and penetration. First demonstrated at the end of the Vietnam War and improved upon in subsequent conflicts, the ability to precisely navigate and deliver ordnance on target coupled with techniques to manage the signatures of airborne systems, particularly through stealth technologies, dramatically changed the ability of air power-oriented forces to affect military campaigns. Air strikes became almost exponentially more effective due to the phenomenon of one weapon per target as well as the higher lethality achieved. The combination of low-flying air- and sea-launched cruise missiles and stealthy aircraft armed largely with precision-guided munitions enabled the rapid destruction of hostile air defenses, the establishment of air superiority and the near-paralysis of enemy command and control and military forces. This second revolution has been a key, if often unrecognized, factor in the current conflicts. Apache helicopters, AC-130 gunships, B-1 bombers, fighters with guided munitions and unmanned aerial systems with Hellfire missiles have proven decisive in countless engagements.

The next revolution could well be strategic in character. It will be based on ubiquitous ISR and cheap precision weapons. This third revolution is already being experienced at the tactical and operational levels as sensors and targeting systems become smaller, faster and more common and precision strike systems proliferate not only throughout the air services but to ground forces as well. Superb ISR coupled with advanced systems such as the Small Diameter Bomb, Advanced Precision Kill Weapons System, the Excalibur artillery projectile and even the Switchblade mini-UAS are today or will have soon a significant impact on the conduct of joint operations. Equally as important as their impact on the battlefield is the ability of advanced ISR and low-cost precision weapons to reduce the cost per strike, often by an order-of-magnitude or more.

The challenges for this third revolution will be, first, to scale up the gains being made in tactical ISR and precision strike and, second, to deal with the problem of advanced air defense systems. To date, this latest air power revolution has been conducted largely in a benign air environment, over relatively short ranges and against adversaries with limited target sets. U.S. fifth-generation aircraft, most particularly the F-35 Joint Strike Fighter, are intended to address many of the requirements for sophisticated ISR and precision strike in hostile airspace. But the United States at present must rely on a fleet of aging long-range bombers, only a handful of which are stealthy, and sea-launched cruise missiles for long-range strike. Although judged still to be effective against existing air defense threats, these systems and weapons will face difficulty in penetrating advanced defenses. In addition, in the event of conflict with a large, well-armed adversary, the number of potential targets is likely to exceed available inventories of weapons, which tend to be expensive, as are all current U.S. long-range ISR systems, be they airborne or space-based platforms.

For the long-run (post 2040), the challenge will be to accomplish the missions of global precision strike and local air dominance at lower cost. This means, ultimately, shifting the focus of development of next generation capabilities from relatively large, extremely capable, but very expensive multi-mission platforms and towards payloads and independent aerial "objects" that can be produced and deployed in large numbers.[109] Simply put, it appears impossible to bend the cost curve for large, complex aerial systems sufficiently to permit the necessary number of platforms to be acquired. Adversaries willing to spend more, build cheaper systems and accept much higher casualty rates can overwhelm even a fifth-generation U.S. force. Hence, the need to move to a different paradigm based on technological innovation that maintains overall mission performance goals but achieves them through the use of different systems.

Glossary of Acronyms

A2/AD	Anti-Access/Area Denial
AARGM	Advanced Anti-Radiation Guided Missiles
ACC	Air Combat Command
C3	Command, Control, and Communications
CEP	Circular Error Probable
CPGS	Conventional Prompt Global Strike
CVW	Carrier Air Wing
ECM	Electronic Countermeasures
EW	Electronic Warfare
GPS	Global Positioning Satellite
HARM	High Speed Anti-Radiation Missile
IADS	Integrated Air Defense System
ISR	Intelligence, Surveillance and Reconnaissance
JASSM-ER	Joint Air-to-Surface Standoff Missile-Extended Range
JDAM	Joint Direct Attack Munitions
JLENS	Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System
JOAC	Joint Operational Access Concept
JSTARS	Joint Surveillance and Target Attack Radar System
LRASM	Long Range Anti-Ship Missile
LRS	Long-Range Strike
MCO	Major Combat Operations
NATO	North Atlantic Treaty Organization
NIFC-CA	Naval Integrated Fire Control-Counter Air
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
PLA	People's Liberation Army
SAM	Surface-to-Air Missile
SEAD	Suppression of Enemy Air Defenses
SOF	Special Operations Forces
SSGN	Navy hull designation for nuclear powered ballistic missile submarines
STOVL	Short Take-Off Vertical Landing
TERCOM	Terrain Contour Matching
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
UCLASS	Unmanned Carrier Launched Airborne Surveillance and Strike
VPM	Virginia Payload Module

End Notes

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