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Key Points

The majority of the Air Force's air superiority aircraft were designed at the conclusion of the Vietnam War, produced in the 1980s, and are increasingly ill-suited to meet future threats. Worse, aircraft such as the F-15C Eagle face basic structural integrity limits that will see its airworthiness end by the mid-2020s.

The Air Force currently has 186 F-22s and approximately 175 F-35s—an inadequate inventory to meet a moderate combat demand, let alone meeting the challenge of a potential North Korean conflict, along with checking Russian aggression in Europe, or Chinese hostility in East Asia.

The Fiscal 2020 Air Force budget reveals the service plans to buy new-build F-15EXes, a design that does not align with modern operational demands. The imperative for fifth generation fighter aircraft is not an academic debate, it is driven by real-world threats and potential adversaries. As budget deficits, interest rates, and pressure from federal spending accounts grow, it will prove more difficult to sustain larger defense budgets. Less spending risks spurring a decrease in the F-35 buy rate and imperiling the next generation air dominance program.

Ensuring the Common Defense:
The Case for Fifth Generation Airpower

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Abstract

The United States Air Force today is operating a fighter aircraft inventory on the brink of disaster. These fighters, most designed at the conclusion of the Vietnam War and produced in the 1980s, are increasingly ill-suited to meet future threats. Worse, aircraft like the F-15C Eagle face structural integrity limits that will see this fighter retired by the early 2020s. An immediate change in policy and resourcing is required to restore vital U.S. military fighter aircraft capability and capacity.

The Air Force was not expecting to find itself on the edge of an air superiority capability collapse. Plans dating back to the 1980s declared the service would acquire more than 700 F-22 Raptors—later resized to a buy of 381—and 1,763 F-35 Lightning IIs to replace aging F-15s and F-16s. These fifth generation aircraft were designed to address future challenges in a complementary fashion—the F-22 optimized to meet air-to-air challenges and the F-35 providing multi-role flexibility.

However, after budget cuts, program delays, and a host of other challenges, Air Force plans failed to unfold as projected. F-22 production was capped in 2009 with just 187 aircraft produced, and F-35 numbers have not materialized as fast as originally programmed. Now, the Air Force only has 186 F-22s and approximately 175 F-35s to defend US security interests around the globe—an inventory woefully inadequate to meet a moderate combat demand. The answer to this problem set is clear: The United States must increase F-35 procurement and add resources to the next generation air dominance (NGAD) program to supplement a dangerously undersized F-22 fleet and rebalance today's fighter force structure mix.

Introduction

The United States Air Force today is operating a fighter aircraft inventory on the brink of disaster. The vast majority of the service's air superiority aircraft were designed at the conclusion of the Vietnam War, were produced in the 1980s, and are increasingly ill-suited to meet future threats. Making the situation worse, aircraft like the F-15C Eagle face basic structural integrity limits that will see that fighter's airworthiness come to an end in the mid 2020s. An immediate change in defense policy and resourcing is required to restore this critical component of U.S. military capability and capacity, made even more urgent given the objectives of the *2018 National Defense Strategy of the United States of America* and pragmatic real-world security challenges.

The United States Air Force today is operating a fighter aircraft inventory on the brink of disaster. The vast majority of the service's air superiority aircraft were designed at the conclusion of the Vietnam War, were produced in the 1980s, and are increasingly ill-suited to meet future threats.

Teetering on the edge of an Air Force air superiority capability collapse was not a situation in which the service was supposed to find itself. Plans laid out in the late 1980s and early 1990s declared the Air Force would acquire more than 700 F-22 Raptors—later resized to a buy of 381—and 1,763 F-35 Lightning IIs to replace aging F-15s and F-16s respectively. These replacement aircraft were designed to address future challenges in a complementary fashion—with the F-22 optimized primarily to meet air-to-air challenges and the F-35 providing multi-role flexibility for both air-to-air and air-to-ground applications. Both were designed to include stealth technology and advanced fifth generation sensors, computing power, and secure communications tools to collaborate across areas of operation.

The Air Force plan to meet future threats was derailed in 2009, however, when then-Secretary of Defense Robert Gates prematurely cancelled the F-22 purchase at less than half the Air Force's stated requirement to free up funds for wars in Afghanistan and Iraq. Adding to this, the F-35's programmed production ramp rate has continually been delayed. The Air Force presently has only 186 F-22s and approximately 175 F-35s to defend the United States—an inventory woefully inadequate to meet a moderate combat demand, let alone meeting the challenge of a potential North Korean conflict occurring side by side with a requirement to check Russian aggression in Europe or Chinese hostility in East Asia. What was once "tomorrow's threat" is now today's reality. Deterring the ambitions of modern adversaries demands a fighter inventory properly sized and infused with advanced capabilities.

To this end, instead of increasing the buy rate for more F-35s to support the goals of the new defense strategy, decisions in the Pentagon resulted in the Fiscal Year 2020 budget request including new-build F-15EX fighters—an aircraft design whose roots extend back to the late 1960s. Seemingly oblivious to its own defense strategy and reorientation to great-power contests, the Office of the Secretary of Defense (OSD) is reportedly driving this policy shift.[1] This is an incongruous approach given the burgeoning threat environment and the associated need to bring fifth generation fighter aircraft inventories onboard as fast as possible. While these "modernized" legacy fighters afford upgraded capabilities from their Nixon Administration-era F-15 model counterparts, they lack necessary attributes such as low observability (better known as stealth) and "combat cloud" functionality found in their fifth generation successors. These are not bolt-on capabilities. They must be designed into an aircraft from day one.[2]

While some defense observers suggest these F-15EXes are being purchased with additive funds, such arguments will be difficult to maintain over the long term if future defense budgets take a downturn in out years, when this acquisition effort will be most active. Given current federal budget deficits, rising interest rates, and mounting pressure from mandatory federal spending accounts, it will be increasingly difficult to sustain high defense budgets. Less funding will no doubt create a competition for dollars between the F-35 and F-15EX, leading to a decrease in the F-35 buy rate. Ultimately, if funds are actually appropriated for F-15EX production, the F-35 program would likely enter a death spiral—with the production rate cut resulting in higher unit prices, creating doubts about the program viability, and inducing further program cuts.

The answer to the Air Force's fighter modernization challenge is clear. Fifth generation fighter aircraft—not a new production version of fourth generation aircraft—are specifically designed, and required, to meet future combat requirements.

The Air Force has been here before—these are the same circumstances that undermined completing production of the military requirement for F-22s. Only this time, changes to the F-35 program would also impact the U.S. Navy, the U.S. Marine Corps, and the militaries of allies and partners buying the F-35. Given the large number of Air Force procurement efforts underway—F-35, B-21, KC-46, T-X, UH-1 recapitalization, ground based strategic deterrent modernization, space initiatives, and cyber priorities—there is little room for new programs. After three decades' worth of deferred recapitalization, canceling, curtailing, or delaying any of these efforts would imperil core missions. Vietnam War-era T-38s will not be viable forever. Nor will Eisenhower-era KC-135s. Even President Donald Trump has signaled that 2020 may be the high-water mark of the defense budget, and leaders like House Armed Services Committee Chairman Rep. Adam Smith are advocating for lower defense spending.

The answer to the Air Force's fighter modernization challenge is clear. Fifth generation fighter aircraft—not a new production version of fourth generation aircraft—are specifically designed, and required, to meet future combat requirements. The United States must increase F-35 procurement rates and add resources to the next-generation air dominance (NGAD) program to supplement a dangerously undersized F-22 fleet, and to redress an imbalance in today's fighter force structure mix that is currently 80 percent fourth generation and only 20 percent fifth generation.[3]

The Threat Environment Demands Fifth Generation Solutions

The imperative for fifth generation fighter aircraft is not an academic debate about a theoretical set of threats and requirements. It is driven by real-world demands. When the National Defense Strategy Commission released its assessment of the Trump Administration's defense strategy, their findings were both scathing and stark:

> *America's military superiority – the hard-power backbone of its global influence and national security – has eroded to a dangerous degree… America's ability to defend its allies, its partners, and its own vital interests is increasingly in doubt. If the nation does not act promptly to remedy these circumstances, the consequences will be grave and lasting.*[4]

In other words, America's military dominance is waning—especially given the reemergence of great power competition.

The United States faces a strategic challenge it has not confronted since the end of the Cold War, and one for which the U.S. military is not trained, organized, or equipped to handle.

The hostile intent of competing potential adversary nations is clear. China is aggressively and illegally expanding its territorial claims through the South China Sea by militarizing man-made islands. Russia is illegally annexing areas like the Crimean Peninsula by subversion and force. Both of these nations are pairing their hostile actions with aggressive military modernization programs. On top of this, the security of the United States is further complicated by North Korea's nuclear weapons and Iran's nuclear aspirations, the continued threat posed by violent extremism, and ongoing instability in Africa and the Middle East. The characteristics of these military and security challenges and their concurrency raise serious questions about U.S. Air Force capabilities and capacity.

While any threat to the United States must be taken seriously, this reenergized era of high-end peer conflict is the challenge that poses the greatest danger to America's national interests and fundamental security.

While any threat to the United States must be taken seriously, this reenergized era of high-end peer conflict is the challenge that poses the greatest danger to America's national interests and fundamental security. Said more directly, this challenge is existential and is one for which America is significantly underprepared.

Three decades have passed since the fall of the Soviet Union—the last peer competitor to significantly challenge the United States. In the interim, low-intensity conflicts and counterinsurgency operations have created a strategic amnesia regarding what is necessary to prevail in high-end combat. Some defense leaders over the past two decades would often deride strategies and technology focused on high-end warfare, calling air superiority fighters "gold-plated" Cold War relics. Therefore, it is not surprising the Air Force lost more aircraft due to other Congressional priorities, budget cuts, and OSD programmatic decisions than to any adversary during this time period. From 1990 to 2016, the Air Force total aircraft inventory shrank from 9,907 aircraft to 5,369 aircraft, a drop of over 45 percent. The air superiority component was similarly chopped from 3,206 F-4D/Es, F-15A/Cs, and F-16A/Cs in 1990 to a mere 1,753 F-15Cs, F-15Es, F-16s, F-22s, and F-35s today.[5]

Civilian national security leaders have come to assume dramatic success—as witnessed in campaigns like Operation Desert Storm over Iraq and Operation Allied Force over Serbia and Kosovo—is assured in the future, even as they cut Air Force capacity and modernization accounts. These decision makers incorrectly extrapolate that fighters purchased during the Reagan Administration are viable against well-equipped adversaries in future conflicts, based on how older Air Force aircraft excelled against insurgents and terrorists in Afghanistan and Iraq. Analysis from the respected Congressional Budget Office (CBO) appears to treat fourth and fifth generation aircraft as if they are interchangeable. One recently-released CBO report presented startling options to offset a hypothetical cancelation of the F-35 program by purchasing legacy fighters like the F-16 and F/A-18. The same report also floated the idea of divesting the entire F-22 fleet without suggesting how to regenerate a comparable capability.[6] Such poorly-reasoned options represent a dangerous disconnect between what is clearly understood about rising threats in today's security environment and necessary modernization choices.

U.S. military dominance today is not assured, and it must not be assumed.

Without the contributions of the Air Force in areas like air superiority, other military services' capabilities cannot be realized. Ships at sea, forces on land, space and cyber facilities, logistics infrastructure, and support aircraft are exceedingly vulnerable to attack from modern weapons and threats. Failure to modernize with relevant, capable, and survivable aircraft will result in crippling losses in a conflict with China or Russia—or countries using the advanced military equipment they produce. Waning U.S. military dominance is well understood by America's peer competitors, such that U.S. conventional deterrence has eroded. The disconnect between modern threats and the restoration of America's air superiority advantage is growing and must be corrected. The path forward is clear—responding to the new threat environment requires accelerating fifth generation aircraft solutions. The recapitalization of the Air Force fighter force with fifth generation aircraft is a pre-requisite to fielding viable U.S. military power around the globe able to deter and, if necessary, defeat peer adversaries.

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The F-22: A Cautionary Case Study

This policymaking disconnect between modern threats and the need for fifth generation capabilities is well illustrated by looking at how the F-22 Raptor program was brought to an early end. In 2009, then-Secretary of Defense Robert Gates criticized the F-22 for being a "niche, silver-bullet solution for one or two potential scenarios," while stating that the real and growing threat was from "rogue states or from short-to-medium range ballistic missiles…."[7] Since aircraft were not getting shot down and adversary air forces were considered less capable, Gates initiated the closure of the F-22 program at less than half the 381 F-22 aircraft required by the Air Force.

Gates badly misjudged the "real and growing threat," believing the future would simply be a linear extrapolation of the low-intensity conflicts experienced in Iraq and Afghanistan. Not only did he cut F-22 production well short of the combat requirement, but basic elements of the F-22 inventory, like attrition and reserve aircraft, were never purchased. This left no margin for F-22s lost in peace or war, nor did it provide any surge capacity. This latter point portends major problems when it comes to growing an experienced pilot force in the event of a spike in demand—either precipitated by wartime need, or events like the current fighter pilot shortfall. Gates' decision also meant that the much smaller F-22 inventory would be subject to high levels of wear and tear as it would be stretched too thin trying to meet burgeoning mission needs in the years after the program's cancellation. This is a situation where a military asset becomes a "low density, high demand" capability.

Gates also cancelled the F-22 as the most complete and highest-performing aircraft were coming off the production line. These jets were equipped with the most advanced processing capabilities and structural updates, and were routinely certified by the Defense Contacting Management Agency (DCMA) with "zero defects." These later model F-22s were the product of what industry calls the production "learning curve." Improvements derived from operational experience were incorporated into the production line, and as the workforce became more skilled at production, the quality of the jets improved. Production also matured and grew more efficient. In short, just as the least expensive and most refined F-22s were being delivered, Gates terminated the program—a

strategically thoughtless and economically irresponsible decision.

The decision has aged poorly over the past decade. Today, with China and Russia posing significant military threats, the capabilities of the F-22 are badly needed, and the Air Force's available supply is stretched thin. In a perfect world, the Air Force could simply redress the mistake by buying more F-22s. However, restarting an aircraft production line after shutdown is not an inconsequential effort. The cost of F-22 restart would require significant stand-up capital. The year the F-22 was cancelled, unit recurring "fly-away" costs were projected to be lower than $120 million per aircraft. Although the production line tooling still exists in storage, a 2017 Air Force study estimated the non-recurring costs for restarting this line could reach $9.9 billion.[8] Parts that are no longer in production would also require redesign. New suppliers would need to be found and recertified by the DCMA. Production facilities would need to be secured, engineering support and a skilled workforce recruited and trained, and a raw material supply would need to be reserved. Thus, any program restart would not be as simple as turning on a light switch.

As with any form of production, low rates drive higher costs because the fixed production line expenses are not shared across a broad base. This should stand as an ominous warning to those contemplating action that could send the F-35 into a similar death spiral.

The F-22 program originally called for 750 aircraft, with the ultimate production number of 187 aircraft the end result of a dynamic known as an acquisition "death spiral." Inventing new technology is very difficult and comes with challenges. In the case of the F-22, a revolutionary aircraft program literally invented, developed, and matured cutting-edge technology. As commitment to the program sagged and defense officials reduced the production rate, the $32 billion of development cost was amortized across a diminishing base of production aircraft. This saw individual aircraft costs spike, which precipitated further cuts. The original F-22 program of record was cut from 750 to 442, then to 381. Instead of being produced at 80 airframes per year, the annual production rate only reached 24 at its peak and declined to just 20 by the end of the program. As with any form of production, low rates drive higher costs because the fixed production line expenses are not shared across a broad base. This should stand as an ominous warning to those contemplating action that could send the F-35 into a similar death spiral.

Because the F-22 was not produced in sufficient numbers to replace the F-15, and the air superiority mission still demanded a certain volume of capacity, the Air Force had to retain older fourth generation F-15s much longer than planned. This presented a major challenge when it came to basic physics. Fighter aircraft do not really feel much difference between flying peacetime training and actual combat missions. The G-forces, speeds, and overarching wear and tear are roughly the same. There is only so long that an aircraft's structure can bear such stress. While service life upgrades and modernization efforts helped extend the F-15's viability, the reality still exists today that these legacy aircraft cannot operate in the threat environment in which the F-22 was designed to fly. The fourth generation F-15s are also going to hit a hard stop due to structural exhaustion, a time that is now drawing nearer. This drove the Air Force to initiate the NGAD program long before they had planned, before any significant technological advances have been realized, and at a time when other aircraft recapitalization is also needed—presenting affordability challenges in the broader aircraft portfolio acquisition schedule.

Such an approach drives tremendous inefficiency—with sunk investment in research, development, and production not effectively amortized—and then a repeat set of new costs driven by a quick-turn new development effort to backfill unmet requirements. Programs can come and go at the whim of politics and priorities, but real world-driven requirements generally remain fixed. The end result imposes tremendous cost on the nation with far too little to show in terms of operational combat capacity.

In contrast to the fate of the F-22, the F-16 is an example of a successful aircraft production and recapitalization strategy. The early block F-16s were replaced by far more "mature" later blocks—but this took time, a higher production rate, and larger quantities to get there.

The small fleet of F-22s resulting from the Gates decision also drove increased life cycle costs. In nearly every successful, large-scale aircraft acquisition effort, the military services seek to divert early-build aircraft to non-combat roles, like training and test, or retire them all together. Every new production line has teething problems, eventually maturing both the program and its production processes to build the most capable aircraft. It is the reason why many consumers are hesitant to adopt the first model year of any product—from cars to a smart phone. Instead of replacing the less capable early production F-22 Raptors as others came off the line, the Air Force was left with Block 10 jets the service had to make use of to their fullest. These were the earliest, least reliable, and least capable of the F-22s. This spiked program modernization and sustainment costs overall, as early-build aircraft became a larger, unplanned proportion of the final inventory that required higher support requirements. Budget analysts in Washington, DC often fail to factor into consideration these larger programmatic realities, and as a result draw up faulty projections for new aircraft fleets. Today, this reality can be seen playing out in some OSD Office of Cost Assessment and Program Evaluation (CAPE) analyses of the F-35's total life cycle costs.[9]

In contrast to the fate of the F-22, the F-16 is an example of a successful aircraft production and recapitalization strategy. The early block F-16s were replaced by far more "mature" later blocks—but this took time, a higher production rate, and larger quantities to get there. Over 603 Block 1, 5, and 10 F-16A/B's were built for the U.S. Air Force and other nations, with the U.S. Air Force taking delivery of 500 F-16A/B's (including Block 15 and 20 models). These early F-16s were relatively simple aircraft with a short-range radar, a gun, and AIM-9 heat-seeking air-to-air missiles.

Today, the Air Force F-16 force is wholly made of the F-16C/D series, which did not enter production until 1985. Today's F-16s are all-weather day and night multirole fighters with advanced radars, missiles, precision weapons, electronics, and sensors. Had the Air Force terminated production at the same number of F-16s as was done to the F-22—187—then the F-16 force today would be F-16A block 10s. These aircraft had little central processing, were subject to what maintainers call "infant mortality" (where parts break far earlier than anticipated), and had so many engine failures that one Air Force pilot who flew the first blocks of the F-16 recalled bluntly that early F-16s kept crashing. "We lost four aircraft in my first 44 days at Nellis. Wing commanders were lucky to last a month. In fact, there was a macabre joke circulating that if you wanted one of the new jets, just buy an acre of land off the end of the runway and wait," recalled veteran F-16 pilot Pete Gavares of the program's early years.[10]

However, the F-16 program was not halted after 187 aircraft were built. Leaders supported high production rates, unit

procurement costs were consequently low, and enough were produced to retire the early versions from the inventory and provide the Air Force a highly capable fleet of later block F-16s. At its height, the service had over 1,800 F-16s, allowing for amortization of maintenance, sustainment, and modernization costs.

If a military requirement remains valid, the most effective, prudent option is to amortize sunk development cost and purchase a full allotment. This, in turn, will yield a far more sustainable, viable inventory for the life of the aircraft.

The F-22 followed a wholly different course. With only 187 manufactured, there are simply not enough jets to meet operational demand while allowing for robust test, training, backup, or attrition reserve aircraft. As a result, training, test and maintenance requirements erode operationally available numbers. Of the 187 F-22s procured, only around 120 are available for operations at any one time. This drives up deployment rates, which wears out both crews and planes. Keeping the Raptor force in service is always a challenge because spares and other sustainment equipment cost more due to the small inventory and lack of high-volume pricing. Flying the smaller force more often than what was planned for a larger force structure consumes the aircraft's service life faster. This dynamic will eventually require either an expensive service life extension program (SLEP) or a replacement effort sooner than anticipated. The shortsighted termination of the F-22 by Gates was not only an economic and strategic military mistake, it created a costly spiral in sustainment costs, unplanned replacement or life-extension requirements, and very limited availability to counter the threat for which it was designed, and that are the primary concerns in the national defense strategy.

These "small fleet dynamics" are the very reasons why the CBO is proposing divesting the F-22 fleet. Limited inventories are more costly, difficult to manage, and pose readiness challenges. But these problems are not related to the F-22 itself, which despite these limitations, remains the most capable fighter aircraft in the world. These difficulties are fundamentally related to the scale and scope of a drastically reduced procurement. Analysts need to be aware of these negative outcomes of small fleet dynamics and take caution in extrapolating F-22 data to the F-35 aircraft inventory.

The most important lesson leaders should take away from the F-22 debacle is that it was wholly self-induced. If a military requirement remains valid, the most effective, prudent option is to amortize sunk development cost and purchase a full allotment. This, in turn, will yield a far more sustainable, viable inventory for the life of the aircraft. The F-22's military capabilities continue to be in high demand by combatant commanders because it is so effective across the spectrum of the most demanding threat and mission environments. The added lesson here is not that the F-22 should be divested. Instead, it is that national leadership should have remained committed to the program to achieve the economic, strategic, and sustainment advantages commensurate with production of its entire military requirement. If a military requirement exists, the most effective and efficient way of meeting it is to procure the full buy of the aircraft in question.

Today and tomorrow's threat environment is far different than what Secretary Gates projected a decade ago. It is in fact far more dangerous. Great power competition means the real possibility of high-end peer conflict breaking out, and that means fifth generation aircraft are essential to successful military operations. The United States must scale its fifth generation capabilities to meet modern adversaries and

prevail in tomorrow's conflicts. The United States and its allies cannot allow the F-35 program to be stretched out or delayed, curtailed to small fleet quantities, or fall victim to an F-22-style death spiral. Nor are these fighter-specific lessons. The same story could be told for the development and purchase of the B-2 bomber, and the lessons learned of the F-22 program certainly inform the imperative to carefully protect the B-21 program.

Anti-Access/Area-Denial: China and Russia's Strategy to Check America's Military

China and Russia have watched U.S. military operations for decades and have applied lessons from their observations when building their respective defense capabilities. The Defense Intelligence Agency's assessment of Russian military capabilities, *Russia Military Power: Building a Military to Support Great Power Aspirations,* states that:

> *…planners have analyzed U.S. operations such as DESERT STORM, NOBLE ANVIL, and IRAQI FREEDOM for insight, observing military art at the strategic, operational, and tactical levels in campaigns that displayed U.S. aerospace capabilities and underscored the importance of developing comparable indigenous capabilities that can be employed…*[11]

Both Russia and China have enjoyed observing the "American way of war" from afar for the last 30 years. They have analyzed how U.S. forces employ airpower using aircraft like the F-15, F-16, and F/A-18. They have deliberately designed their defenses to erode traditional U.S. airpower advantages. China and Russia also observed the void America left on the world stage while preoccupied with Afghanistan and Iraq, using this time to advance their own interests and develop high-end technologies—including fifth generation aircraft and anti-access/area-denial (A2/AD) capabilities.

Chinese and Russian strategists seek to deny U.S. and allied forces the ability to enter and maneuver freely in regions of interest.[12] As one Department of Defense (DOD) report explains, China calls this "active defense," a concept the Chinese describe as "strategically defensive, but operationally offensive."[13] The use of A2/AD weapons and capabilities is a long-term national strategy to secure regional influence and power for both rivals. Chinese and Russian surface-to-air missile (SAM) arsenals, fifth generation aircraft, and advanced weapons are key elements of this approach.

China, in particular, is aggressively pursuing improved SAM systems, investing in both research and procurement. The DOD's *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2018* explains, "The PLAAF [People's Liberation Army Air Force] possesses one of the largest forces of advanced long-range SAM systems in the world," which includes Russian designs like the SA-20 and SA-21 as well as indigenous types such as the HQ-9.[14] All are highly lethal to legacy aircraft. Russia also remains at the forefront of SAM technology as both a user and exporter of highly advanced systems. Recent sales of its highly-lethal SA-21 speak to this point. By making entry and maneuver inside the A2/AD environment costly in terms of both equipment and lives, both Russia and China seek to ensure that U.S. military operations are unsuccessful and politically untenable. Gaining air superiority is the first step in addressing this threat environment. If U.S. forces cannot secure control of the sky, no other forms of power projection are viable. Ships

at sea, soldiers on land, space downlink stations, and cyber nodes will not survive against such adversaries. Continued reliance on fourth generation fighters in the face of these improving capabilities portend major challenges.

In addition to exploiting U.S. military vulnerabilities, China and Russia are emulating American airpower strengths. They understand the asymmetric advantages afforded by fifth generation aircraft like the F-22 and F-35, which has motivated both countries to design and produce their own advanced fighters. For Russia, this comes in the form of the Su-57, an F-22-like stealth fighter. Similarly, China has developed the J-20, another F-22-class air superiority fighter, and the J-31, an F-35 look-alike—and very likely based on stolen F-35 data and intellectual property as a result of Chinese cyber operations. Still, there are those who argue that Chinese or Russian designed fifth generation aircraft are not as good as American F-22s and F-35s. While a definitive comparison is elusive and the debate remains open, it is important to remember the Air Force only has 186 operational F-22s and under 200 F-35s. The vast majority (approximately 80 percent) of the U.S. military's fighter force is still comprised of fourth generation airframes built decades ago.

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The real question is whether these new adversary aircraft are better than American fighters whose designs date back to the Nixon Administration. For example, the Air Force awarded the F-15 Advanced Tactical Fighter contract to McDonnell Aircraft in December 1969, with the first test flight of the F-15 Eagle occurring on July 27, 1972 at Edwards AFB, California.[15] That is why pressing forward with aggressive F-35 and NGAD procurement is so important. Su-57 production in Russia is still in an early, limited stage, but China is charging forward with its advanced fighters.[16] Experts have noted that the J-20 should now be ready for mass production, and that China sees a need for "at least 200," if not more of these fifth generation air superiority fighters.[17] The J-31 is also likely to undergo modification to enable it to fly from Chinese aircraft carriers. This would enable a kind of power projection into the Western Pacific that China had not previously possessed.

Nor has China's pursuit of power projection weapons and development of fifth generation technologies stopped with fighter aircraft. The Chinese have also embarked on efforts to develop medium and long-range next-generation bombers to extend their military's reach. The JH-XX, a medium bomber, is estimated to have a range of 1,000 to 2,000 nautical miles (nm), which means this aircraft could easily hold regions in the Pacific Ocean's first island chain, such as Japan and the Philippines, at risk. China's heavy bomber, the Xian H-20, which experts predict may share design similar facets with the B-2 and B-21, is expected to be able to fly at ranges upwards of 5,000 nm while carrying a payload of 20 tons and may also be nuclear-capable.[18] With this kind of stealth and range, Chinese bombers could easily target Guam—a key U.S. power projection base—without aerial refueling.

While the Chinese and Russians have spent decades studying and learning how the U.S. Air Force employs its forces around the world, relative American airpower readiness and advantages are eroding. Focused investments by these potential adversaries on highly advanced, long-range integrated air defenses like the SA-21, electronic warfare tools, hypersonic weapons, and indigenous fifth generation aircraft are

yielding game-changing advantages over U.S. forces.[19,20] If fifth generation aircraft becomes the technology of equals over the next few years, then legacy U.S. aircraft, no matter how advanced their avionics, will not survive in contested combat. A sizable fleet of fifth generation aircraft will be necessary to prevail.

Air Force on the Brink

Despite clear trends in advancing threat systems and global rivalry, individuals in the DOD, Congress, and the broader policy and budget community continue to attack U.S. fifth generation aircraft modernization efforts. Skeptics fail to appreciate the capability these aircraft bring to the challenging fights of the future, and the cost imposed by cheap alternatives. These critics often treat legacy aircraft and fifth generation airplanes in an interchangeable fashion.

In an A2/AD threat environment, against adversaries equipped with fifth generation aircraft, even more aircraft, support assets, and stealthy aircraft will be required to enable fourth generation aircraft to operate—but with uncertain mission success.

With capability differences removed from the debate, the aircraft modernization discussion most often focuses on unit cost. This drives highly inaccurate conclusions, since fifth generation aircraft cannot be exchanged in war plans on a one-for-one basis with fourth generation aircraft. Those seeking budget efficiencies by buying older non-stealthy aircraft designs fail to understand that when these assets are employed they need additional aircraft to accomplish mission objectives in a modern threat environment. Fourth generation aircraft require increased protection that stealthy assets don't require, for example. These large aircraft force packages are comprised of specialized support aircraft to jam radars, defeat enemy fighters, and negate SAM systems. These additional aircraft then drive higher requirements for more pilots, more support personnel, and more support aircraft like air-to-air refueling tankers, expansive basing requirements, and a proportionate boost in logistics support. Against peer threats, the number of additional support aircraft required to protect a force of fourth generation aircraft to get to its targets dramatically increases the total cost to achieve the same desired effect relative to a fifth generation aircraft. During Operation Desert Storm, for example, a single stealthy F-117 could accomplish what it took 19 non-stealth aircraft to accomplish.[21]

In an A2/AD threat environment, against adversaries equipped with fifth generation aircraft, even more aircraft, support assets, and stealthy aircraft will be required to enable fourth generation aircraft to operate—but with uncertain mission success. Without large support packages, fourth generation aircraft may not be able to execute missions in a challenged, heavily defended environment. Which begs some important questions: How can legacy aircraft be cheaper for the enterprise if they require such large support packages for employment? And if those support aircraft are no longer in the inventory, can legacy aircraft even be employed in challenging scenarios against capable opponents?

Much current analysis that informs defense choices in the Congress and in the DOD is premised on the experiences of aircraft operating in the environment enjoyed in the skies of Afghanistan and Iraq for nearly 20 years. Looking to the future, the Air Force does not even possess many of the capabilities required to employ fourth generation aircraft in A2/AD airspace that will likely be where future wars are fought. Ironically, key units were stood down and aircraft retired based on the assumption that the Air Force fighter force was going to be entirely fifth generation in

its composition. This original vector was indeed accurate when leaders envisioned it three decades ago, and it remains all the more important today given the return of peer great power competition. However, given the current fighter force composition (approximately 82 percent fourth generation and 18 percent fifth generation) and current F-35 production rates now hovering at less than half of what was originally envisioned, it will be decades before the Air Force achieves a 50-50 ratio of fourth generation to fifth generation fighters, much less a 100 percent fifth generation force.

Defense leaders today would do well to heed the wisdom of Sir Frederick Handley Page, a British aviation pioneer: "Nobody has ever won a war by trying to run it on the cheap. Nothing is so expensive as losing a war by saving money. If you want the cheapest possible Air Force today, it is very easy to standardize on a whole lot of aircraft that will be of no use when the war comes."[22] Yet, that appears exactly what the Air Force is about to do. Cost is cited as a reason the service is looking at the proposed F-15EX fighter.[23] Comparing unit acquisition and sustainment costs against the F-35, Chief of Staff of the Air Force Gen David Goldfein stated that if the service had the money "those would be 72 F-35s. But we've [got to] look at this from a cost/business case."[24] The argument suggests the Air Force can get more F-15EXes than F-35s for equivalent dollars, but it ignores all the other aircraft needed for force protection to enable F-15EXes to accomplish an equivalent mission. An F-15EX drives much more cost than an F-35 to achieve a similar effect in a high-threat environment, and ignores actual mission cost—the far bigger driver of real expense and combat value.

While the F-15 has certainly evolved significantly and is now equipped with very sophisticated avionics, nothing can change the fact that it lacks the stealth technology necessary to survive in today's contested environments. Though not as capable as fifth generation aircraft, existing Air Force combat aircraft can be deployed in a nuanced fashion while the service acquires new fifth generation capability as fast as the United States can afford and production variables allow. For example, air base defense tasks in the Asia-Pacific could be facilitated through a mix of F-15Es, F-16s, and MQ-9s. B-1Bs with upgraded radars could even serve as large missile trucks. While such an approach involves risk, it is far less risky than being saddled with an increasingly non-survivable "new" legacy aircraft for the next 30 years, the acquisition of which would risk sending the F-35 into an acquisition death spiral.

Cost assessments and business cases routinely fail to acknowledge the vast capability differences between legacy and fifth generation aircraft—and more than this, the drastic difference in their use in joint combat operations. In other words, fourth and fifth generation aircraft cannot be swapped one-for-one to accomplish the mission requirements dictated in U.S. war plans. Proof of this lies with the perspective of airmen who are tasked with flying these missions. As one fighter pilot, who originally flew the F-15 and now flies the F-35, explained in a recent conversation:

> *Five to eight years ago, we would plan an entire force package comprised of legacy aircraft, about 20 to 30 planes in total, all to maybe have a slim hope of taking down a modern surface-to-air threat. Just one. Now, we train to accomplish the same mission with only four F-35s. What was once nearly impossible has become commonplace with the advantages brought by fifth generation aircraft, like the F-35.*[25]

This operational perspective is not one influenced by "Washington, DC spin" or business development marketing—but by the reality of flying in today's Air Force.[26] Older aircraft are more expensive when considering the greater enterprise they require in order to operate effectively. Over a dozen legacy aircraft in a mission package versus a handful of fifth generation aircraft types provides some basic comparative cost perspective. Individual aircraft expenses, personnel requirements, logistics demands, and the high probability of casualties associated with a fourth generation strike package drives force structure requirements that are more expensive in total than fifth generation alternatives.[27]

From a macro perspective, the advantages afforded by fifth generation technology, are why Air Force leaders have held a unified line for over two decades championing the need to invest in advanced aircraft like the F-22, F-35, B-21, and now the NGAD. They have also held unilateral opposition to buying any more legacy aircraft designs like the F-15 and F-16. In late 2018, Air Force Secretary Heather Wilson reiterated that the Air Force was not interested in procuring new-build legacy aircraft, opting instead to continue to invest in a fifth generation force.

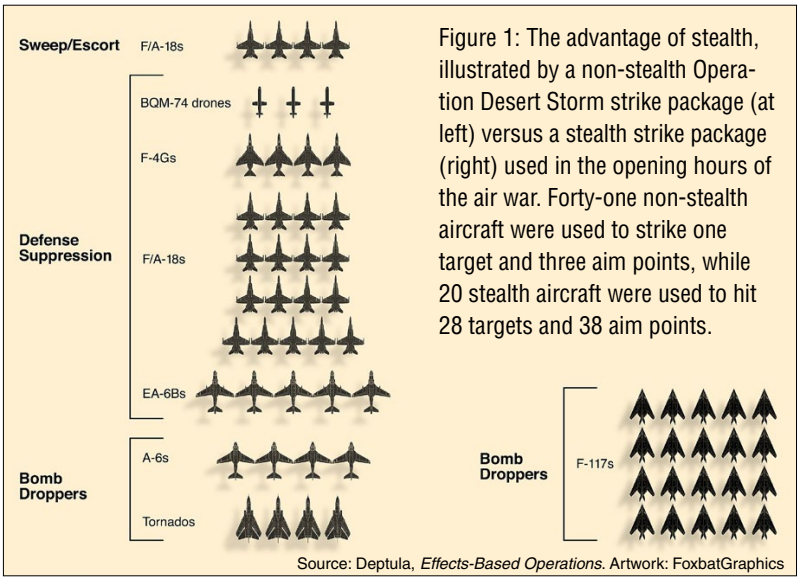

Figure 1: The advantage of stealth, illustrated by a non-stealth Operation Desert Storm strike package (at left) versus a stealth strike package (right) used in the opening hours of the air war. Forty-one non-stealth aircraft were used to strike one target and three aim points, while 20 stealth aircraft were used to hit 28 targets and 38 aim points.

Source: Deptula, *Effects-Based Operations*. Artwork: FoxbatGraphics

Since then, media reports suggest the Air Force's budget has been influenced by guidance from OSD, and with it, the line is now shifting. What is not changing is the basic reality of the security challenge facing the United States. Russia and China having spent the last few decades investing in air defense specifically designed to destroy fourth generation aircraft, and these technologies will proliferate to clients around the globe eventually. Even fifth generation technology will be pressed to succeed in some combat scenarios, which extend to areas of the globe where Russia and China choose to concentrate their advanced systems.

The Air Force must not waste finite resources building an inventory that was by and large designed to defeat the Soviet Union 30 years ago. Today's resources need to be focused on today's threats and those that will emerge in the future. The Air Force desperately needs to recapitalize its inventory, both in quality and quantity, as today it is flying the smallest and oldest inventory since its founding as an independent armed service in 1947. There is no extra capacity to allow for a tiered-capability force structure. All combat aircraft need to be ready to fly and fight in multiple regions around the world on a moment's notice. This includes the aircraft of the Air National Guard and Air Force Reserve, whose inventories are now counted as part of core warfighting capacity requirements across the force. There is no strategic reserve any longer: every combat aircraft must be able to deploy to meet the needs of the U.S. national defense strategy.

Threat systems are not devolving in the meantime. A legacy force structure simply cannot survive in a contested environment like those being built by China or Russia. Recapitalizing America's Air Force with new-build fourth generation aircraft would jeopardize the U.S. military's ability to

underwrite our nation's diplomacy, protect our national interests, and fulfill our promises to our allies. Additional purchases of legacy aircraft also risk the moral obligation to equip America's airmen with the aircraft they need to go into hostile airspace, accomplish their mission, and come home safely.

Requirements must be matched by resources, and this means both quality and quantity. This requires investment in fifth generation fighters and bombers, not in small numbers of "hedge force" advanced aircraft. Military dominance—in particular, the ability of the U.S. Air Force to ensure air superiority and hold any target on the globe at risk—can no longer be taken for granted. The National Defense Strategy Commission concluded that, based on the United States' lack of investment to be prepared for a high-end fight:

> *The U.S. military could suffer unacceptably high casualties and loss of major capital assets in its next conflict. It might struggle to win, or perhaps lose, a war against China or Russia. … U.S. military superiority is no longer assured and the implications for American interests and American security are severe.*[28]

This is a dire warning that demands action. The United States cannot pursue a course of action that, as one experienced Air Force pilot explained, "…amount to an expensive way of getting shot down."[29]

Understanding the Fifth Generation Aircraft Imperative

Why, then, if the U.S. military is facing a critical military capability and credibility gap, is there a consistent assault on fifth generation airpower? How can it be that even rational senior leaders in the defense establishment can consider procuring fourth generation inventories as a viable solution for strengthening U.S. military posture when these legacy aircraft cannot survive modern threat systems? What is driving the notion that 20th century platforms can prevail in 21st century warfare?

One reason for believing that legacy aircraft are "good enough" is that for the last 30 years these aircraft have indeed been good enough—for the mission set assigned to them. After the spectacular performance of fourth generation aircraft in Operation Desert Storm, there has not been any serious military challenge to U.S. Air Force airpower. One F-16 was shot down in 1995 by an SA-6 SAM during Operation Deny Flight over Bosnia, one F-16 and an F-117 were shot down by SAMs in 1999 during Operation Allied Force, and the last aircraft shot down by enemy SAMs was an A-10 in 2003, during the opening phase of Operation Iraqi Freedom.[30] In contrast to even the Air Force experiences over the Balkans in the 1990s, airspace over Iraq and Afghanistan since 2003 has been an overwhelmingly permissive threat environment during the last 18 years of counterinsurgency operations.

A sense of complacency regarding any challenge to U.S. military power has developed since the end of the Cold War, when the B-2 was cancelled. Of the 132 stealth bombers planned, only 21 were procured and 20 remain in the inventory. Despite a tremendous investment in research and development, the unipolar decade of the 1990s created a belief that advanced technologies and airpower were no longer necessary in an era where America's great power adversary—the former Soviet Union—no longer existed. However, military commanders understood the circumstances were far more complex and that the United States still needed to maintain advanced capabilities. The lengths to which the U.S. military had to go to sustain core capacity since then have bordered on the incredible.

For example, when a B-2 experienced a catastrophic engine fire in 2010, the Air Force spent four years and over $105 million to rebuild it. This resulted in a basic reconstruction of major sections of the jet by hand. However, Air Force leaders had no choice. Then-Chief of Staff of the Air Force Gen Norton Schwartz explained, "With only 20 B-2s—as precious as those aircraft are—no one questioned whether or not we'd make the investment."[31]

Because fourth generation aircraft have been dubbed "good enough" for the last 30 years of conflict, many individuals failed to understand and appreciate the vast difference between fourth and fifth generation technology. Even U.S. government agencies, such as the CBO and OSD, treat fourth and fifth generation technology the same, as if they were interchangeable numbers on a ledger that have no specific impact on military outcomes. That a fourth generation aircraft, even a new one like the F-15EX, could have advanced avionics, but still be non-survivable further confuses the issue.

Fifth generation aircraft tout an enormous information advantage provided by sophisticated sensors and fused processing, so it would seem reasonable to think that with similar avionics, a new legacy platform would be good enough. But what is left is stealth. This is the most notable feature of fifth generation technology. Modernization programs have continued to incrementally increase the capabilities of fourth generation aircraft through sensors, displays, pods, and sometimes increased processing. As a result, stealth—or perhaps more significantly, the cost associated with it—is typically understood to be the only differentiator between the two. Nothing could be further than the truth.

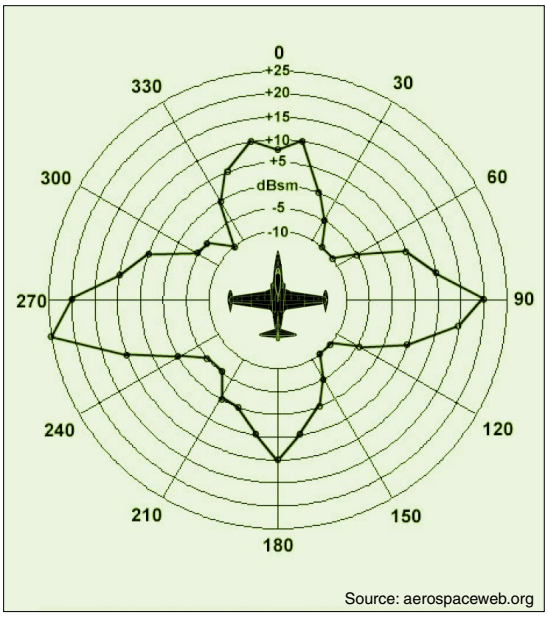

Figure 2: The simulated radar cross section (RCS) of a T-33 first generation jet trainer. To minimize vulnerability to radar, aircraft attempt to present their smallest reflection to adversary radars. Here, the smallest reflection would be between 30 and 60 or 120 to 150 degrees.

Understanding the Attributes of Fifth Generation

Fifth generation aircraft share three basic categories of common attributes: all-aspect stealth and superior aerodynamic performance, advanced automated sensors, and information fusion. The key to the capability leap over previous aircraft designs is synergizing all these attributes in order to present an asymmetric advantage over any adversary. It is this synergy that gives fifth generation aircraft vastly increased lethality and survivability that cannot be matched by any fourth generation aircraft.

Advanced Shaping, Aerodynamics, and Low Observability: Stealth and Survivability in Advanced Threat Environments

Stealth is the attribute for which fifth generation aircraft are best known. Radar-foiling stealth designs are visually striking, such as the strange facets of the F-117; the smooth, blended flying wing appearance of the B-2; and the canted angles of the F-22 and F-35. Without stealth, no other fifth generation attributes would matter because the aircraft would lack its fundamental survivability. Stealth is the cost of entry into A2/AD threat environments; without it, fourth generation aircraft cannot get to their

targets and will likely be shot down. Equating legacy aircraft with fifth generation aircraft is illogical—stealth definitively changes operational outcomes and will do so well into the future. In a simple cost analysis, the return on investment is substantially more with fifth generation aircraft than with legacy fighters regardless of their lower individual unit cost.

The advanced maneuverability of both the F-22 and F-35 is quite impressive given the context of older stealth designs. Unlike past stealth platforms, both of these fifth generation fighters do not compromise performance to have a radar cross section termed "very low observable (VLO)."

Understanding how radar interacts with aircraft is critical to appreciating the value of stealth in war. The radar cross section (RCS) of an aircraft is the magnitude of radar energy from a threat system that reflects off an aircraft. It is not uniform. As radar energy bounces off the surface of the aircraft it may return straight back to the radar receiver, reflect on an axis different than the original energy source, or scatter in a variety of directions. Evidence of an object reflecting energy in the radar field of view is termed a "radar or target return." It can "bloom" or "fade" as energy reflects more or less in strength from various viewing angles off the aircraft. The challenge facing aircraft designers is to create a low-observable (stealthy) signature that does not increase in strength or "bloom" dramatically from any viewing angle horizontally or vertically. This is particularly important when a SAM threat looks up, or when an adversary aircraft looks down using radar to try to find, fix, track, or engage a target aircraft. In addition to the geometry of aircraft surface areas, some materials can absorb radar energy while others reflect it like a mirror. Reducing reflected radar energy requires all sensors and weapons to be housed internally on an aircraft. Any external store is a major radar reflector, even when shaped and coated for a reduced radar signature.[32]

In the past, designers had to make compromises between aerodynamic performance and stealth. The multi-faceted shape required to redirect radar energy away from a radar receiver could not support advanced aerodynamic maneuverability. The experimental "Have Blue" aircraft and its successor, the F-117, are dramatic examples of how radically the design demands of stealth changed an airframe and its flyability—since such designs did not resemble a classic non-stealth airplane. However, the shape of a stealthy airframe was so aerodynamically unstable that it required a digital flight control computer to enable basic aircraft control. The F-117 design literally could not have flown without it.

The B-2 design benefitted from advances in computational power that occurred after the F-117 was developed. Long-range strike is about range and payload—the requirement to hold any target anywhere on the globe at risk. The flexibility of a manned platform in a given target area enables real-time decision making, and the payload and number of missions a bomber can execute provides a low "cost-per-effect." Increased computational power allowed aircraft designers to do away with the F-117-type facets and replace them with the smooth lines of the bomber. The clean, stealthy lines of the flying wing means that the B-2 has a low drag index, assisting in its fuel efficiency and long range (a B-2 can fly 6,000 nm unrefueled). The stealth bomber's robust bomb bay can also carry over 20 tons of conventional or nuclear weapons. The Air Force's planned B-21 will also benefit from these design features.

The advanced maneuverability of both the F-22 and F-35 is quite impressive given the context of older stealth designs. Unlike past stealth platforms, both of these fifth generation fighters do not compromise performance to have a radar cross section

termed "very low observable (VLO)." Because of the computational power of today's advanced processors, combined with the deep knowledge and experience with stealth designs and innovative materials, fifth generation aircraft are "all-aspect stealth," and are on par with—or even exceed—the air combat maneuverability of fourth generation fighters. Both the F-22 and F-35 retain controllability past their critical angle of attack, are supersonic with afterburners engaged, are high-G airframes, and boast competitive roll and pitch rates in any dogfight. All of this maneuverability means that neither the F-22 nor F-35 have to be predictable in their flight path maneuvering. In a dense and highly dynamic threat environment, they can aggressively react to threats both offensively and defensively.

Despite the efforts of competitors like China and Russia to counter the advantages of low observability, stealth continues to confer a competitive operational advantage, providing access to adversary airspace and targets—and therefore the initiative.

While the angles, shapes, and textures necessary to minimize RCS make fifth generation aircraft distinctly recognizable, stealth is much more than minimizing the RCS of an aircraft. Stealth is a holistic design approach that goes beyond shaping the airframe or applying specialized coatings. In order to delay or deny detection by an adversary's threat systems, designers must manage multiple signatures and emissions across the spectrum of electromagnetic energy. These energy signatures encompass elements from radar and radio, to electronic warfare systems and data links. Even thermal or infrared emissions are controlled. To an adversary's infrared sensor, aircraft appear hot against a cold sky, making them easy to detect. Thus, minimizing thermal signature is also a key design factor. Passive sensors have improved in sensitivity and capability over the years, making traditional omni-directional radios a major vulnerability. Fifth generation aircraft must have low probability of detection (LPD) and low probability of intercept (LPI) radios and data links. Directionally focused with low power and narrow beam width, LPD and LPI transmissions make it extremely difficult for adversaries to use passive detection to exploit fifth generation aircraft radios and data links for targeting or even early warning. Fifth generation aircraft automatically manage the power and direction of their own sensors and rely upon passive sensors as well. All of this comes together to create stealth aircraft technology.

Despite the efforts of competitors like China and Russia to counter the advantages of low observability, stealth continues to confer a competitive operational advantage, providing access to adversary airspace and targets—and therefore the initiative. The VLO radar cross sections of modern fifth generation aircraft makes electronic attack (like jamming or deception techniques) much more effective at much lower power. This enables stealth aircraft to get further inside an area protected by A2/AD capabilities and closer to threats, even against technologies designed to counter stealth. Legacy aircraft—and this includes the proposed F-15EX—simply cannot penetrate and survive in this same highly defended airspace. Because of the F-15EX's much larger RCS, it requires greater volumes of electronic attack to allow the fighter to effectively penetrate defended airspace. Even by doing so, an F-15EX effectively turns itself into a homing beacon in this high-threat environment, highlighting its position for enemy attack. Even when using off-axis jamming to cover actual position, the effect of this approach is much like using a flashing neon advertising sign declaring to the enemy that something is coming. According to one Marine aviator who has experience flying the F/A-18, F-16, F-22, and F-35:

Stealth is absolutely an entry requirement. Of course, the adversary is attempting to take really aggressive steps to marginalize the utility of stealth; they will do everything they can to deny us that massive competitive advantage. This just means that anything does not have stealthy qualities is even more vulnerable, not less. Stealth is one of several [attributes] that are built into the platform in order to make the aircraft survivable and lethal.[33]

The additional attributes of fifth generation fighters also include advanced sensors and algorithms that fuse multiple data inputs, automatically process those inputs into decision quality information, and display that information to the pilot—another hallmark of fifth generation aircraft. All active sensors, like an electronically scanned array radar, must manage their emissions to avoid alerting the adversary. Too strong of a pulse, and threat sensors can home in on the source. Thus, fifth generation aircraft use a suite of active and passive modes and sensors that are automated and work together to create an integrated, highly accurate, and real-time picture of a given area of operations.

Battlespace Awareness and Decision Superiority in Fifth Generation Aircraft: Advanced Automated Sensors

Talk to any fifth generation pilot, and they will note how deeply they appreciate the survivability afforded by stealth. But it is the information and decision superiority provided by the integrated sensors and avionics on their aircraft that they emphasize when talking about their holistic capability. A fifth generation aircraft's game-changing attribute is indeed its power to gather, process, and harness information. While some fourth generation aircraft may feature elements of this technology, especially new-build models, the sheer volume and quality of information available to a fifth generation pilot dramatically increases combat mission effectiveness. Combining data from off-board sources and the aircraft's own array of multi-spectral active and passive sensors, a powerful central computer uses highly sophisticated algorithms to correlate, compare, evaluate, and ultimately fuse information to create a highly accurate, real-time situational awareness picture. The power of fifth generation aircraft to gather, process, exploit, and share information in effect "turns operators of these advanced aircraft into mission commanders, rather than having them focus on managing and operating subsystems," according to two experienced fifth generation Air Force pilots.[34]

The battlespace awareness provided to the fifth generation pilot through fusion of all information sources is significantly advanced compared to fourth generation aircraft. Fourth generation aircraft largely have loosely federated sensors, and their radar systems are separate from data link systems, which are also separate from electronic warfare systems, and other components. In a fourth generation aircraft, it is the responsibility of the pilot to not only manage each sensor and system individually, but also interpret the information gathered from each sensor and system, and make sense of that information in relation to the information from other sensors. Situational awareness—or battlespace awareness—is something that every fourth generation pilot must build individually, and is the result of personal experience, aptitude, and proficiency.

The advantage that sensor fusion provides the fifth generation pilot is dramatic. Sensors in a fifth generation aircraft are highly advanced, automated, and require

little to no active control from the pilot. Sensor data is shared with other aircraft via data link, allowing a collaborative approach where pilots can easily correlate, compare, and fill in the best information on hand with other aircraft in their flight automatically. The result is a robust common picture among all flight members.

Battlespace awareness is also presented to the fifth generation pilot on an intuitive, top-down range display. This includes a collaborative picture built from sensors and multiple off-board sources through data links. Known as a "tactical situation display" in the F-35, this fused battlespace picture essentially provides a map of all threats to the pilot: targets; friendly air, sea, and land systems; geographic and navigation points; and hostile tracks. Unencumbered by the burden of managing and interpreting a federated system of sensors and inputs, fifth generation pilots are presented actionable knowledge that has the effect of both time and range advantage against an adversary. It takes time to manually control and then interpret the many sensors on a legacy aircraft, and in aerial combat, time is range. The longer these tasks take, the less initiative, surprise, or maneuver is available to the pilot. Fourth generation pilots simply have fewer options. But because these tasks are automated in fifth generation aircraft, the information is of high quality, and knowledge is presented in an intuitive fashion. As a result, pilots can execute better threat avoidance, target detection, direction of forces, engagement decisions, and other command actions. In short, fifth generation aircraft provide superior information and decision advantage. As one F-22 pilot who flew sorties during Operation Inherent Resolve over Syria explained: "We have more information at our fingertips than other aircraft. We have an easier time making big decisions."[35] Unlike fourth generation pilots, fifth generation pilots share the same battlespace understanding, enabling more coordinated, efficient, and effective operations.

Although modernization has made legacy aircraft incredibly capable, it is doubtful that even the F-15EX could emulate fifth generation information fusion in a comparable fashion. This kind of information and sensor fusion must be built into the design of an aircraft from the beginning.

Although modernization has made legacy aircraft incredibly capable, it is doubtful that even the F-15EX could emulate fifth generation information fusion in a comparable fashion. This kind of information and sensor fusion must be built into the design of an aircraft from the beginning. Although legacy aircraft modernization programs have improved these airframes for operations in less demanding airspace, there is still a dramatic difference between their federated systems and the fusion that fifth generation capability provides. It is the difference between connecting and overlaying information, and truly correlating, comparing, evaluating, and fusing an integrated battlespace picture. For example, given the speed of combat aircraft, signal timing from sensors and off-board assets to fusion processors matters; it can make the difference between a positive enemy identification, precise coordinates for targeting, or knowing the exact disposition of an enemy aircraft formation—or not. And that can make the difference between a successful combat engagement and a defeat. All of this capability depends on how the sensors, fiber optics, and processors have been built into the aircraft, though. It cannot be retrofitted to yield the same optimized performance as a purpose-built fifth generation design.

This information and decision advantage is transforming how fifth generation aircraft operate in combat. Increasingly, fifth generation pilots are

taking on the role of battle managers. If traditional battle management wide-body aircraft are unable to loiter in high-threat environments, the ability of fifth generation pilots to assume the battle management role is vital to combat effectiveness. When deployed to Syria in Operation Inherent Resolve, an experienced F-22 pilot noted he and other pilots were serving as the "quarterbacks" of the campaign. As the forward-reaching eyes and ears of the Air Force, F-22s over Syria directed strikes, shepherded air packages away from danger, destroyed high-value ground targets, and vastly enhanced the situational awareness of the operation's whole enterprise.[36]

Long-range strike missions similarly benefit from such an advanced, shared battlespace picture. Fifth generation information systems make bomber crews more mission effective overall. Bomber missions, like those undertaken by the B-2 and the future B-21, penetrate deep into enemy battle space, and this means that their requirement for real-time situational awareness is even greater. Distance is time, which means the deeper these aircraft go into enemy territory, the older their mission intelligence becomes: the order of battle, location of targets and threat systems, and even mission prioritization may have changed just during the flight time to target. The information and sensor fusion built into fifth generation aircraft will increase effectiveness of long-range strike at a strategic level because of enhanced situational awareness. It will also allow effective partnering between elements of a given joint force operation. For example, a B-21 could relay sensor data to a submarine launching a missile against a target deep behind enemy lines and then provide rapid bomb damage assessment.

The Synergy of Stealth and Information: Fusion, Offensive Initiative, and Maneuver

The kind of information and decision superiority offered by fifth generation fighters simply cannot be achieved by fourth generation aircraft. Like stealth, highly integrated avionics cannot be retrofitted into a federated system, or be achieved through a piecemeal upgrade program. Fusion must be designed into a fighter aircraft from the beginning. New-build legacy aircraft could include integrated avionics and software systems, automating their sensors and fusing the data similar to fifth generation aircraft. Even so, fourth generation aircraft would be unable to translate such information advantage into combat advantage given their lack of stealth. With advanced A2/AD threat systems proliferating, fourth

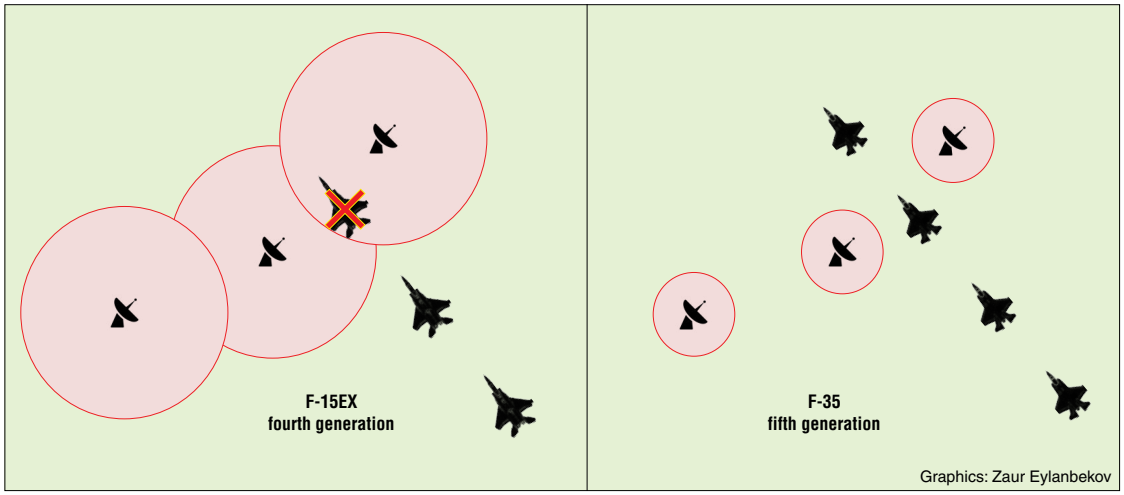

Figure 3: A notional air defense radar network arrayed against fourth generation (left) versus fifth generation aircraft (right).

generation aircraft cannot expect to get to the fight regardless of their avionics or information systems. Their airframes are simply not survivable in such a high threat environment. What is the point of investing tens of millions of dollars in a new aircraft like the F-15EX, if it is not able to meet the full spectrum mission demands of the U.S. national defense strategy? The unit cost of an F-35 and an F-15EX is virtually the same today—and as production of the F-35 increases, it will become less expensive than the F-15EX. With an order of magnitude greater combat effectiveness than the F-15EX, the rational choice between procuring one or the other is to accelerate F-35 production.

Anti-access and area-denial threats make stealth signatures mandatory for modern combat aircraft, and the cost of entry to 21st century fights.

Anti-access and area-denial threats make stealth signatures mandatory for modern combat aircraft, and the cost of entry to 21st century fights. However, stealth by itself is only a passive defense, one that is fixed and unchangeable in flight. Without the advanced sensors and fused avionics that give fifth generation technology the ability to understand the threat environment in a dynamic real-time fashion, mission planners must work closely with intelligence experts to develop a fixed flight path from which aircraft cannot deviate. Using an all-aspect RCS model, planners use complex programs to optimize how the aircraft will present itself to known, geolocated threat systems in order to minimize its radar return against those threats (never mind that those threats could move later, throwing this analysis into doubt). Without fifth generation designs, this brand of legacy stealth aircraft employment must stay on a flight path determined before takeoff, not deviate from planned flight routes, and cannot compensate for mobile threats that may have changed their positions. To maneuver away from the strict flight plan would trespass into the unknown, negate careful planning, and leave the pilot with no knowledge of how effective their aircraft's stealth was in denying or delaying detection by the adversary.

This concept of operations for early stealth aircraft was effective when threats were largely fixed and the order of battle relatively static. But the advent of highly lethal and increasingly mobile SAM systems, as well as the requirement for stealth to be effective against capable adversary aircraft, may decrease the survivability stealth provides when it is used only as a passive defense.

It is the synergy of stealth with information and decision superiority that transforms battlespace awareness into superior initiative and maneuver and provides a true asymmetric advantage relative to any other aircraft. Automated, multi-spectral sensors are able to build a highly accurate real-time threat picture for the pilot, who can then manage how he presents his RCS to a threat. This speaks to the reality that stealth is not a binary technology—either working, or not. Instead, it is an advantage that must be managed to increase or decrease an enemy's ability to find, fix, target, and strike the aircraft in question. Too often, stealth skeptics try to turn the debate about the attributes of stealth into an all-or-nothing equation. Nothing could be further from the truth. Stealth increases the probability of aircraft survival, while at the same time making defense much more difficult for the enemy. With fifth generation aircraft, a predetermined flight path (the so-called "black line") no longer matters for survivability. Modern fifth generation aircraft have freedom of maneuver because they are both stealthy and know where threats are located. Then-Maj Gen Jeffrey Harrigian, who flew both the F-15C and the

F-22 prior to heading the Air Force's F-35 integration office, and Col Max Marosko, also an F-15C and F-22 pilot, wrote in a July 2016 paper that:

> *Fifth generation aircrew and aircraft … [can] accurately identify friendly, neutral, and adversary systems. This data allows fifth generation pilots to enhance their stealth, or low observable (LO) signature management, enabling the aircraft to survive and maintain situational awareness of events in combat even when operating in close proximity to advanced threats.*[37]

Another F-22 pilot flying combat sorties over Syria in the early phase of Operation Inherent Resolve described what he experienced: "I see radars. I see airplanes. I see surface-to-air missiles, and the jet knows where those things are and tells me. So, I have a picture of the battlespace."[38] In modern high-end warfare, airmen flying into harm's way will either be empowered with those attributes, or they will be dead.

Fifth generation pilots can seize the initiative in combat with an accurate, real-time battlespace picture, optimizing and managing their RCS presentation, denying detection to the adversary, and maneuvering with initiative. Legacy aircraft could at best use that information defensively just trying to survive. A legacy aircraft such as the F-15EX would not be able to use that information superiority to drive the fight, because without stealth, they would constantly be forced to react defensively.

As F-22 Raptors demonstrated against Islamic State forces over Syria, fifth generation aircraft have the capability to go wherever they are needed. That operation, however, was not prosecuted against a high-end peer adversary. Flying in a combat scenario against Chinese forces or against Russian defensive systems drives the need for fifth generation technology even higher. Delaying or denying detection compresses the adversary's reaction time, and together with freedom of maneuver, gives truth to the F-22 pilot motto of "first look—first shot—first kill." The combination of information and decision superiority with stealth does not just enhance the survivability of the F-22 and other fifth generation aircraft in a dynamic battlespace, it also makes them more lethal.

Stealth is no longer merely a defensive survival attribute in combat. With fifth generation advanced avionics and information fusion, stealth is offensive, both in terms of yielding the advantage of surprise while simultaneously increasing lethality.

The Liability of a Mixed Fourth and Fifth Generation Force

A mixed technology aircraft inventory of fighter aircraft is a fact of life for the U.S. Air Force. Old aircraft are replaced with new airframes over a transitional period. A mixed generational inventory, however, should not be the end-state objective force. Although fifth generation fighters can make legacy fighters more effective, this is not the best answer for the future force structure. For example, the Air Force was not buying F-4s in the 1980s as it was modernizing with new F-15s and F-16s.

During this current transition, fifth generation aircraft have proven themselves to be force multipliers, making legacy aircraft far more effective. Veteran F-15C and F-22 pilot Harrigian, who went on to lead the Air Force's F-35 integration office, wrote in his paper with F-22 pilot Marosko that the Raptor "[had] the ability to make every asset it works with better, as it connects and leverages the entirety of a strike package in ways older aircraft [can] not do."[39] Fifth generation aircraft can

provide escort and act as forward battle managers, enhancing fourth generation survivability and the effectiveness of an entire package. For advanced-generation bombers, the intelligence, signals, and other data they can gather and share in real-time from deep in a battlespace means that campaign-level decisions can be made faster and with higher fidelity.

This kind of integration makes the most of existing force structure and capabilities as the Air Force transition its fighter force inventory from fourth to fifth generation aircraft. However, this kind of mixed fleet actually degrades the combat potential of fifth generation aircraft. Given the limited number of fifth generation aircraft in the Air Force inventory, sub optimizing their potential by deliberately spending resources on new-build old airframes is an unwise force-mix decision. This choice speaks to an Air Force that has grown too comfortable operating in permissive environments, not one where survival and mission success will push available crews and their aircraft to their limits.

Without any of the attributes necessary for low observability, the mere presence of fourth generation aircraft increases the vulnerability of the whole force—and the potential for serious losses and mission failure. With weapons and pods hanging from hardpoints under their wings and fuselages, powerful and active sensors, and no LPI/LPD radios or data links, fourth generation aircraft are noisy, attractive targets for advanced SAMs and threat systems. In dense and contested A2/AD battlespace, even fifth generation aircraft will be stressed to survive during the course of their missions. Fourth generation aircraft will be on the defensive the minute they enter the A2/AD arena. A liability for fifth generation aircraft in this kind of battlespace, fourth generation aircraft will require protection and could endanger the success of the mission. VLO stealth is crucial to survivability and offense in these advanced threat environments. Airmen need to fly and fight to win—not simply survive. The success of all joint force operations and the fundamental outcome of conflicts will depend on the effects they can achieve.

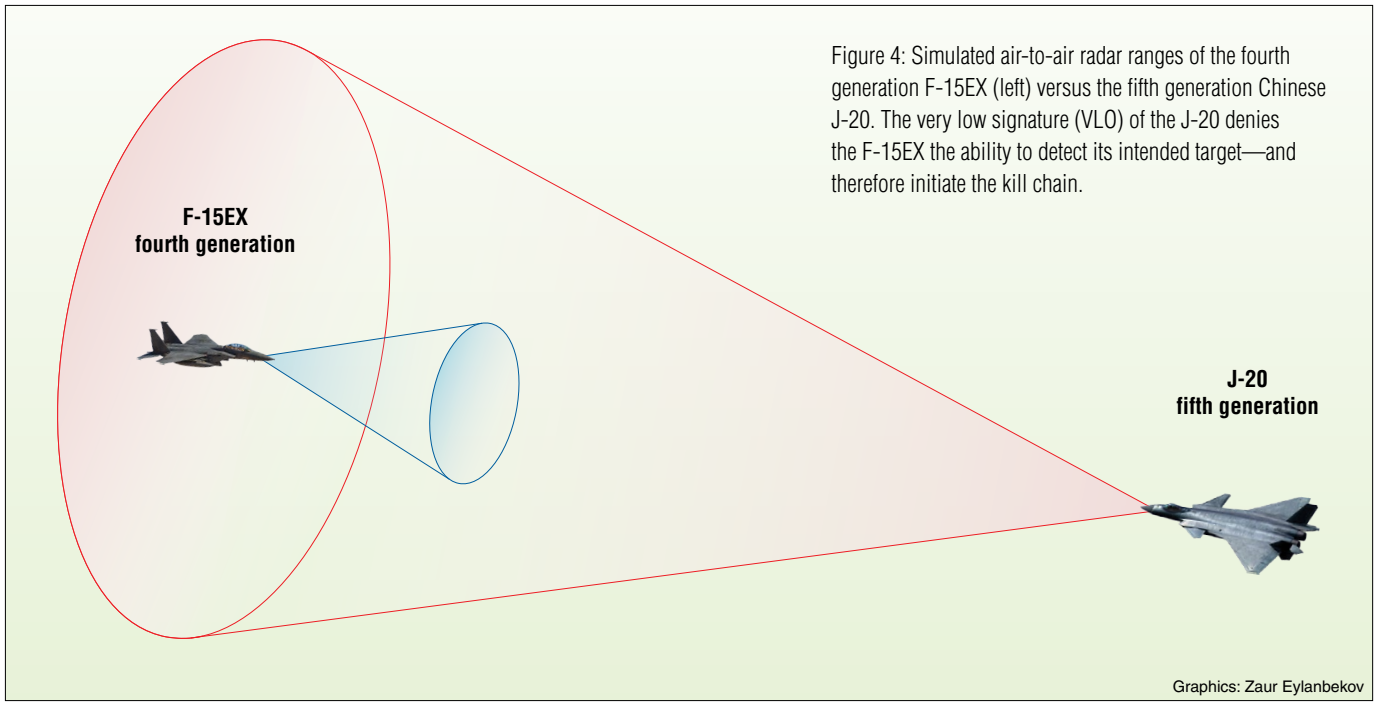

Figure 4: Simulated air-to-air radar ranges of the fourth generation F-15EX (left) versus the fifth generation Chinese J-20. The very low signature (VLO) of the J-20 denies the F-15EX the ability to detect its intended target—and therefore initiate the kill chain.

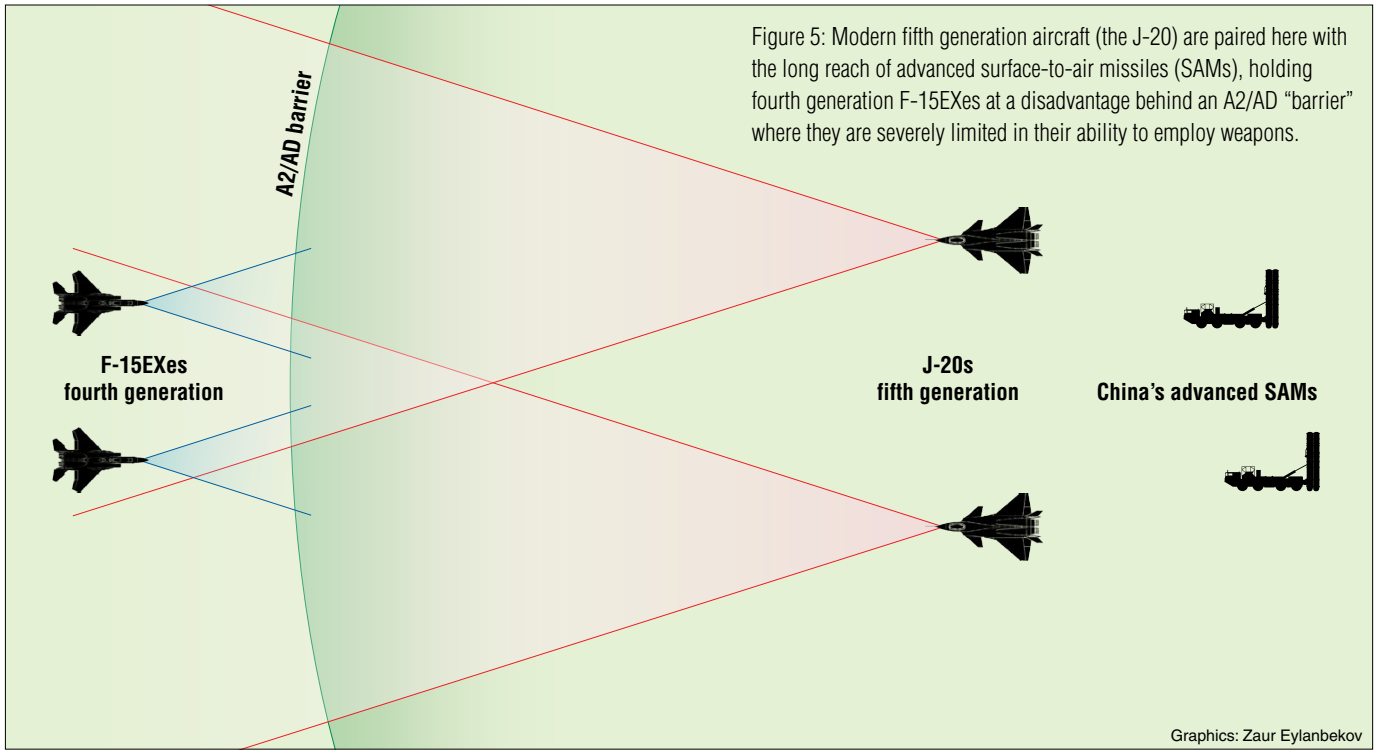

Figure 5: Modern fifth generation aircraft (the J-20) are paired here with the long reach of advanced surface-to-air missiles (SAMs), holding fourth generation F-15EXes at a disadvantage behind an A2/AD "barrier" where they are severely limited in their ability to employ weapons.

Some arguments for sustaining fourth generation force structure revolve around the utility of these aircraft in a standoff role. If a legacy aircraft like an F-15EX cannot penetrate an A2/AD threat, the argument goes, could it stand outside and contribute missiles and other long-range weapons to the fight? Unencumbered by the need for low observability because they are held off at range by the threat, is it possible that a legacy aircraft could offer magazine depth—more weapons—to an A2/AD fight? It's tempting to think so, but physics suggest otherwise.

Although fifth generation aircraft are criticized for the limited number of weapons they can carry internally, weapons load out does not matter if one cannot enter and fight inside an A2/AD battlespace. A combat aircraft must be able to carry out two tasks when engaging an adversary: it has to be able to see the adversary, and its missiles have to be able to reach them. In an A2/AD battlespace where the adversary also has fifth generation aircraft, it is unlikely an F-15EX would be able to detect stealthy enemy aircraft while positioned outside A2/AD defenses, making its missile range moot. Even if a legacy aircraft received targeting information from a fifth generation aircraft, all the adversary would have to do to defeat the incoming weapons is remain just out of reach inside the A2/AD zone. It is a safe assumption that if the adversary is within missile range, then the legacy aircraft is also within range of adversary missiles—with the fourth generation aircraft being a much more observable and easier to detect target. This is a scenario where the advantage of "first look—first shot—first kill" belongs to the adversary.

This is no theoretical scenario. A Chinese A2/AD zone could potentially extend past the Pacific Ocean's "first island chain," which runs from the South China Sea up to Japan and as far as the Aleutian Islands. This calls into question whether there would even be basing capable of integrating a legacy fighter like the F-15EX. The situation looks even bleaker in Europe or the Middle East, where base proximity suggests an aircraft may very well be subject

to tracking and targeting the moment it takes off. The notion that a highly-observable legacy aircraft could lurk outside an A2/AD zone while lobbing long-range weapons to establish air superiority is not based on tactical reality. Similarly, it is unlikely that a legacy aircraft could detect mobile or fleeting ground targets and engage them with standoff weapons while remaining outside an A2/AD zone.

While there are niche missions, like cruise missile defense, where a fourth generation aircraft like an F-15EX may afford useful capability, existing assets can also be used for such missions. In the Pacific theater, it is doubtful these aircraft will be called upon in a high-threat scenario, because they lack needed survival attributes. However, F-15EXes could be used for base defense or "missile caddy" roles. Other aircraft, like the B-1B and the MQ-9 remote piloted aircraft (RPA) could also be repurposed to engage in these types of missions. In these roles the necessary capabilities are a radar, missile capacity, and endurance. Given the pressures already on the Air Force budget, a prudent option to accomplish the roles an F-15EX would be tapped for is to repurpose existing aircraft for such niche missions versus diluting available recapitalization funds away from priorities like the F-35, B-21, KC-46, T-X, UH-1 replacement, combat search and rescue helicopter, and the new ground based strategic deterrent (GBSD) enterprise. Most experts agree that the Air Force will be stretched trying to pay for all of these priorities to begin with. It makes little sense to add the F-15EX—whose combat utility against the highest priority threats is questionable at best—to the current list of acquisition efforts. It would be one thing if resources were abundant, but they are not. The E-8 JSTARS recapitalization deferment and the decision not to procure the light attack aircraft (LAA) unless the funds necessary to cover such a purchase are added to the Air Force total obligational authority (TOA), already point to a stretched Air Force acquisition budget. Adding a high cost, low-value mission aircraft to the current mix makes no sense.

It is the synergy of information and stealth that truly makes fifth generation aircraft revolutionary and has the potential to provide a significant asymmetric advantage.

It is the synergy of information and stealth that truly makes fifth generation aircraft revolutionary and has the potential to provide a significant asymmetric advantage. Fifth generation aircraft must be freed from the constraints of a mixed aircraft inventory so that aircrews and servicemembers can fully develop and mature operational concepts, tactics, and build the networked information enterprise of the future. Until a fully fifth generation force is fielded, the true transformative potential of fifth generation combat operations will not be realized.

Quality and Quantity: Achieving the Required Mix

Clearly, fifth generation airpower is a dramatic step in capability beyond fourth generation airpower. But this does not mean the Air Force can now do more with less, or be smaller but more lethal. The Air Force is smaller than ever before, and the peer threat environment is advancing to reduce and possibly reverse U.S. capability advantages. Making the Air Force smaller is not a feasible option.

The high demand on small fleets like the F-22 often lead pilots to comment that physics is an operational limitation—an aircraft can only be in one place at one time. This is certainly true, though not always obvious until thinking through the details of deploying and fighting across large regions like the Asia-Pacific. A single four-aircraft combat air patrol, for example,

requires at least 18 aircraft for support. This includes four aircraft on station, four returning to base, four readying to launch, four en route, and two in maintenance. Today only 186 total F-22 Raptors remain in the Air Force inventory, and approximately 120 are combat coded at any given time.[40] Assuming a mission capable rate of 80 percent (the current DOD goal) results in 96 aircraft available for tasking. Accordingly, only five four-ship combat air patrols could be provided worldwide at any one time without withholding a combat reserve. When considering total air superiority requirements, and other missions F-22s are designated for, a key insight emerges—there simply are not enough to meet mission requirements.

The notion that "less is more" can only be true when fifth generation aircraft are operating in a fourth generation threat environment. Given the dramatic pressures to cut budgets in the 1990s, permissive threat environments were used to justify cutting the F-22 requirement from 750 to 443 during the 1993 Bottom-Up Review, for example. F-15s were battle-proven and undefeated, so the logic went, and the F-22 was even better: thus, far fewer were required. Over time, budget pressures and the permissiveness of a unipolar world pushed those F-22 requirements down even further, from 443 to 381.[41] But that was for fifth generation aircraft operating in a legacy threat environment. When facing an A2/AD battlespace and other fifth generation adversaries, less means far less. Twenty B-2s are not enough to hold the tens of thousands of likely targets at risk necessary to win in an Asia-Pacific conflict, and 120 combat capable F-22s are not enough to meet the challenges outlined in the *2018 National Defense Strategy*. Cancellations of the B-2 and F-22 were extremely short-sighted. Without the critical mass required, some missions will simply be impossible to achieve, or will generate losses not experienced since the Vietnam War (where 40 percent of the F-105 force was lost in combat).[42] This realization is what is driving the Air Force's efforts to develop NGAD and why the B-21 need is so urgent. The United States cannot delay either program and the Air Force should increase its objective inventory of the B-21 to 180 aircraft.[43] In a peer conflict between great powers, quantity matters a great deal.

With the Air Force already ceding capacity as an advantage, quality is the service's only remaining potential war-winning attribute.

The True and Complete Cost of Plan B

The Air Force must remain committed to its fifth generation recapitalization plan. Anything less is a decision to go backwards while China and Russia advance their warfighting capability and capacity. With the Air Force already ceding capacity as an advantage, quality is the service's only remaining potential war-winning attribute. In looking to the future in a world where peer threats are more widespread, it is crucial to understand that vital interests are increasingly at risk. Realistically, America could win or lose battles against irregular forces in Afghanistan and Iraq and the overarching impact on core national interests would be nearly imperceptible. In contrast, Russia and China both have competing interests and potent military capabilities to advance those objectives. The United States must recognize these high stakes, and the price of failure in a conflict with these nations would prove catastrophic. American preeminence is not a guaranteed condition, it is something that must be deliberately prioritized and defended.

Procuring new inventories of legacy aircraft of any quantity will result in a long-term commitment to fourth generation

aircraft. The F-15EX is projected to have a 20,000-hour airframe life—nearly 80 years of service, which puts the fighter in the Air Force inventory up to the 22nd century.[44] Given the significantly diminished buy rates now programmed for the F-35, the Air Force is now faced with maintaining existing legacy aircraft as part of its force structure for many decades into the future. This presents significant operational challenges. Diluting fifth generation recapitalization efforts through further legacy acquisitions simply makes no sense in a future where these aircraft are overmatched against the advanced threats.

Once a procurement decision for the F-15EX is made, it is not easily reversible. Even a perceived middle ground, like continuing F-35 production while also buying F-15EX, would have pernicious, long-term consequences. New legacy aircraft buys do not relieve pressure on fifth generation aircraft. Rather, their combat vulnerabilities increase the demands on fifth generation aircraft in both the A2/AD battlespace and in DOD's budget space. Attempts to justify F-15EX buys to recapitalize Air National Guard units for the homeland defense mission also fall flat. The Air Force reserve component of today is an operational component, an integral partner in day one, front-line combat operations—no longer an operational reserve. In a great power conflict, all elements of the Air Force deploy and fight. Given the small size of the total force there is no other alternative. Recapitalizing the Air National Guard and Air Force Reserve with F-15EX invalidates the assumptions on which U.S. war planning is based. The Air Force's reserve components need fifth generation aircraft just as much as the active duty—anything less requires a substantial increase in the overall size of the Air Force.

Given how long DOD procurement, development, and acquisition processes take, the United States cannot afford to defer F-35 recapitalization, B-21 progress, or development of NGAD.

As described earlier, any comparative analysis of fourth and fifth generation lifecycle costs against an A2/AD-capable peer threat must add to the fourth generation side of the ledger the cost elements fifth generation weapon systems were designed to do without. These include more aircraft, numerous support aircraft, and a large attrition reserve to account for the certainty of heavy expected losses.

Additional combat equipment, force support, increased force size, and greater attrition reserves are not the only financial consequences of pursuing even a small legacy aircraft buy. There are political realities as well. Military service budgets are generally considered zero-sum balance sheets. The planned buy of F-15EX in the Fiscal 2020 Air Force budget would decrease the production rate and total quantity of fifth generation aircraft. Planning documents indicate this has already happened—the previous F-35 production rate of 56 per year in the out years of the FY 2020 DOD budget to just 48 aircraft a year.[45] Rate and quantity reductions in a procurement program increase the cost of each aircraft, as well as its total lifecycle cost, creating the vicious cost-escalation death spiral described earlier. What may appear to be a high-low compromise mix of aircraft could very quickly degenerate into a predominantly low mix with a small high-end force—not where the Air Force needs to be relative to the demands of the new national defense strategy.

Given how long DOD procurement, development, and acquisition processes take, the United States cannot afford to defer F-35 recapitalization, B-21 progress, or development of NGAD. Time matters a great deal—particularly since

modernization of Air Force fighter aircraft has been deferred over the last three decades. A quick review of the acquisition cycles for the F-22 and F-35 add urgency to modernization requirements. The Advanced Tactical Fighter (ATF) program began in 1986, with the contract awarded in 1991 for what would become the F-22. The Air Force declared initial operating capability (IOC) for the F-22 in 2005, 19 years after the ATF's start. The F-35 had a similar timeline. First conceived of as the Joint Advanced Strike Technologies (JAST) portfolio in 1994, the program became the Joint Strike Fighter (JSF) in 1996.[46] The contract for the F-35 was awarded in 2001, and the F-35A was declared IOC by the Air Force in 2016, 22 years after its inception. Both these programs took nearly two decades each to reach IOC. While invention and maturation of technology does take time, much of the delay is the result of DOD bureaucracy and Congressional oversight rules. Instead of delaying either program, the Air Force must accelerate new programs like the B-21 and NGAD and ensure a high annual rate of production to get these vital capabilities on the ramp as rapidly as possible. The rate of technological innovation and processing power is only accelerating; we cannot wait for the future or it will pass us by.

Accelerating production rates requires sophisticated coordination of the entire supply chain, production schedules, and may even require additional skilled labor, tooling, and manufacturing facilities.

An active production line takes roughly three to four years to produce an aircraft, from ordering raw materials to final acceptance. Accelerating production rates requires sophisticated coordination of the entire supply chain, production schedules, and may even require additional skilled labor, tooling, and manufacturing facilities.[47] This means that to prepare for any conflict, since the Air Force has no combat aircraft strategic reserve, at least three to four years are required to begin the build-up for an active production line. It is not clear, in the emerging competition with China and Russia, if the United States would have that much time. If any major combat operations were to erupt, it would likely already be too late to build the needed force structure. Like then-Secretary of Defense Donald Rumsfeld said, "You go to war with the Army you have … not the Army might want or wish to have."[48] In World War II, it took nearly five years—from 1938 to 1943—for production of existing aircraft designs to ramp to the levels needed to support the European bombing operations that made the D-Day invasion of Normandy possible. A fourth generation fleet will be wholly unable to cope with a fifth generation adversary or effectively operate in A2/AD battlespace. If America is challenged by a peer threat, it will be too late to ramp up aircraft production, much less develop the revolutionary game-changing technologies needed to prevail.

Conclusion

Last year, Goldfein and Wilson provided testimony to the Senate Armed Services Committee regarding the readiness of the Air Force to fulfill its security obligations across the globe:

> *Our military advantages and readiness [shrank] due to the longest continuous stretch of combat in our nation's history, coupled with years of inconsistent and insufficient funding. At the same time, our strategic competitors, notably China and Russia, have closed gaps in capability and capacity. The result is an overstretched and under resourced United States Air Force.*[49]

This should be no surprise. We are now facing the consequences of 30 years of underinvestment in airpower, and the consequences of that underinvestment are explicitly stated in the National Defense Strategy Commission's findings. Unfortunately, even though the national defense strategy acknowledges the strategic great power competition facing the United States, the Trump Administration's proposed budgets for Fiscal 2019 and beyond "do not fund a level of military capacity or capability adequate to defeat either adversary should war occur while deterring other enemies simultaneously."[50]

Across the past three decades of underinvestment, regular divestments piled up to the point that the Air Force now faces a recapitalization crisis—the Air Force is too small and only getting smaller as its aircraft age out of service. To stabilize the force and meet defense strategy objectives, the Air Force needs a replacement rate of at least 72 fighters a year, or it risks a decline to only 33 fighter squadrons in the total force.[51] Buying legacy aircraft is not the answer to this set of circumstances. The Air Force should return to its planned F-35 procurement rate of 80 aircraft per year both to prevent a collapsing inventory as old aircraft age out and to accelerate the delivery of fifth generation capability.

New procurements of legacy aircraft are a tempting but deadly siren song. They are not fiscally or militarily prudent, and present a disastrous example of penny wise yet pound-foolish thinking.

New procurements of legacy aircraft are a tempting but deadly siren song. They are not fiscally or militarily prudent, and present a disastrous example of penny wise yet pound-foolish thinking. Additional fourth generation aircraft do not help the U.S. Air Force meet its long-term challenges. To buy new, legacy fighter aircraft like the F-15EX reflects uninformed analysis that backs the U.S. military further away from its ability to protect, assure, dissuade, and deter modern threats across the globe. The CBO, CAPE, and other analytical organizations must more accurately factor military considerations and consequences into their alternatives.

The United States is in a strategic contest with China and Russia. Deterring war and winning should war break out cannot be reduced to simple math equations or budget drills. War is the costliest of human endeavors and money spent to achieve an asymmetric advantage to deter it is money well spent. What may appear to be a rational cost-saving choice may prove far costlier, and ineffective when considering the outcome of employment against modern threats. It is the moral obligation of the U.S. government to ensure that our military is resourced to do what we ask of it. We must provide our airmen, soldiers, sailors, and marines with the equipment and capability necessary to succeed in their missions.

While each military service will need new capabilities and capacity to fulfill their obligations outlined in the *2018 National Defense Strategy*, none of those investments will matter if the Air Force is unable to provide the airpower foundation that joint combat operations depend upon. These missions have been taken for granted and largely neglected over the last 18 years of counterinsurgency operations in permissive airspace environments. New-build legacy aircraft will not rectify that capability gap. America must now have the resolve to rebuild its Air Force into one that can meet and defeat advanced adversaries in an A2/AD battlespace. To accomplish this, America's Air Force must be provided the resources to:

- Shift Fiscal Year 2020 DOD funds allocated for F-15EX to F-35A production.
- Increase F-35A production rate to 80 per year beginning in Fiscal Year 2021.
- Lower the fourth to fifth generation fighter force ratio from 82/18 to 50/50 as rapidly as possible.
- Encourage allies to buy fifth generation aircraft.
- Replace aircraft program expense assessments with a "cost-per-effect" model, and eliminate "aircraft unit cost" as a decision metric.

This will require significantly adjusting priorities from the Congress, given the magnitude of the investment – but the cost of choosing inaction will be much greater. ✪

Endnotes

1 Jared Keller, "The Pentagon is eyeing a dozen fighter jets the Air Force doesn't even want," *Business Insider,* December 24, 2018, https://www.businessinsider.com/pentagon-is-eyeing-new-F-15X-fighter-jets-the-air-force-doesnt-want-2018-12
(all links accessed in April 2019).

2 David A. Deptula, "Evolving Technologies and Warfare in the 21st Century: Introducing the Combat Cloud," *Mitchell Institute Policy Papers*, Volume 4 (Mitchell Institute for Aerospace Studies: Arlington, VA, September 2016), http://docs.wixstatic.com/ugd/a2d-d91_73faf7274e9c4e4ca605004dc6628a88.pdf.

3 Valerie Insinna, "Air Force Not Considering New F-15 or Hybrid F-22/F-35," *Defense News*, September 12, 2019, https://www.defense-news.com/digital-show-dailies/air-force-association/2018/09/12/air-force-not-considering-new-f-15-or-hybrid-f-22f-35-top-civilian-says/.

4 Eric Edelman, Gary Roughead, et. al., *Providing for the Common Defense: The Assessment and Recommendations of the National Defense Security Commission,* (Washington, DC: United States Institute of Peace, 2018), https://www.usip.org/sites/default/files/2018-11/providing-for-the-common-defense.pdf, v.

5 Christopher Bowie and James C. Ruehrmund, Jr., *Arsenal of Airpower: USAF Aircraft Inventory 1950-2016,* (Arlington, VA: Mitchell Institute for Aerospace Studies, 2018), 24-28.

6 Congressional Budget Office, *Options for Reducing the Deficit 2019 to 2028,* (Washington, DC: Government Printing Office, 2018), https://www.cbo.gov/system/files?file=2018-12/54667-budgetoptions.pdf, 132, 143, 148, 150.

7 Robert M. Gates, "Economic Club of Chicago," U.S. Department of Defense, July 16, 2009, http://archive.defense.gov/Speeches/Speech.aspx?SpeechID=1369.

8 Oriana Pawlyk, "The F-22 Fighter Jet Restart Is Dead: Study," *Military.com,* June 21, 2017, https://www.military.com/daily-news/2017/06/21/the-f22-fighter-jet-restart-dead-study.html.

9 Authors' note: Some historic CAPE assessments pegged the total cost of the F-35 program over several decades to be well north of one trillion dollars, figures that are disputed by many industry analysts as well as the F-35 joint program office. See: Andrea Shalal-Esa, "Exclusive: U.S. Sees Lifetime Cost of F-35 Fighter at $1.45 Trillion," Reuters, March 29, 2012, https://www.reuters.com/article/us-lockheed-fighter/exclusive-u-s-sees-lifetime-cost-of-f-35-fighter-at-1-45-trillion-idUSBRE82S03L20120329.

10 Pete Gavares, "Modernization or Death: Heed History's Lessons on the F-35," *Defense News*, September 16, 2018, https://www.defensenews.com/digital-show-dailies/air-force-association/2018/09/16/modernization-or-death-heed-historys-lessons-on-the-f-35/.

11 Defense Intelligence Agency, *Russia Military Power: Building a Military to Support Great Power Aspirations* (Washington, DC: Government Printing Office: 2017), http://www.dia.mil/Portals/27/Documents/News/Military%20Power%20Publications/Russia%20Military%20Power%20Report%202017.pdf, 33.

12 Ionut Alin Cirdei, "A2AD Concept in the Modern Security Environment," in *International Conference Knowledge-Based Organization,* Vol. 24: Issue 1 (July 2018), https://content.sciendo.com/view/journals/kbo/24/1/article-p50.xml.

13 Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2018* (Arlington, VA: Department of Defense, May 2018), https://media.defense.gov/2018/Aug/16/2001955282/-1/-1/1/2018-CHINA-MILITARY-POWER-REPORT.PDF, 46.

14 Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2018* (Arlington, VA: Department of Defense, May 2018), https://media.defense.gov/2018/Aug/16/2001955282/-1/-1/1/2018-CHINA-MILITARY-POWER-REPORT.PDF, 34.

15 "Historical Snapshot: F-15 Eagle," Boeing product profile website, https://www.boeing.com/history/products/f-15-eagle.page.

16 Joseph Trevithick and Tyler Rogoway, "No, Russia's Su-57 Stealth Fighter Program Isn't Dead, At Least Not Yet," *The Warzone,* July 18, 2018, http://www.thedrive.com/the-warzone/22234/no-russias-su-57-stealth-fighter-program-isnt-dead-at-least-not-yet.

17 Minnie Chan, "China 'Nearing Mass Production' Of J-20 Stealth Fighter After Engine Problems Ironed Out," *South China Morning Post,* September 5, 2018, https://www.scmp.com/news/china/military/article/2162765/china-nearing-mass-production-j-20-stealth-fighter-after-engine.

18 Jon Lake, "China Developing Fifth-Gen Stealth Fighter-Bomber, Says DIA," *AINonline.com*, January 21, 2019, https://www.ainonline.com/aviation-news/defense/2019-01-21/china-developing-fifth-gen-stealth-fighter-bomber-says-dia.

19 Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2018* (Arlington, VA: Department of Defense, May 2018), https://media.defense.gov/2018/Aug/16/2001955282/-1/-1/1/2018-CHINA-MILITARY-POWER-REPORT.PDF, 34.

20 Minnie Chan, "China 'Nearing Mass Production' of J-20 Stealth Fighter After Engine Problems Ironed Out," *South China Morning Post,* September 5, 2018, https://www.scmp.com/news/china/military/article/2162765/china-nearing-mass-production-j-20-stealth-fighter-after-engine.

21 David A. Deptula, *Effects-Based Operations: Change in the Nature of Warfare* (Arlington, VA: Aerospace Education Foundation, Defense and Airpower Series, 2001), 10-11.

22 "V-Force: Battle for the Skies – Vulcan, Valiant, Victor," Amazon Prime video, 1:03:19, February 5, 2019, https://www.amazon.com/V-Force-Battle-Vulcan-Valiant-Victor/dp/B07B4FQLSK/ref=sr_1_1?s=movies-tv&ie=UTF8&qid=1549893675&sr=1-1&keywords=victor+valiant+vulcan.

23 Tyler Rogoway, "F-15X Will Come In Two Variants, And No, It Won't Cost $100 Million Per Copy," *The Warzone,* February 4, 2019, http://www.thedrive.com/the-war-zone/26305/F-15X-will-come-in-two-variants-and-no-it-wont-cost-100m-per-copy.

24 Jeff Martin, "If the money is there, new and improved F-15s could be coming soon to the Air Force," *Defense News,* January 26, 2019, https://www.defensenews.com/newsletters/2019/01/26/if-the-money-is-there-new-and-improved-f-15s-could-be-coming-soon-to-the-air-force/.

25 Authors' note: This observation is from an email conversation with several Air Force F-35 pilots, Eglin AFB, FL, January 2019.

26 Authors' note: Sadly, fifth generation insight is often lacking in key corridors of Capitol Hill, the Pentagon, and various analytical centers throughout the policy and budget community of the U.S. government. Given the pilot shortfall demands most of these airmen remain assigned to their cockpits in operational units, too often the unique inputs and perspectives of pilots are not brought to the table at meetings in places like the Air Staff, CAPE offices, and on Capitol Hill. As a result, faulty assumptions and inaccurate understanding regarding fifth generation concepts of operation continue to handicap modernization discussions.

27 Authors' note: Desert Storm air campaign Master Attack Plan: First 24 Hours, 2121, January 16, 1991.

28 Eric Edelman, Gary Roughead, et. al., *Providing for the Common Defense: The Assessment and Recommendations of the National Defense Security Commission* (Washington, DC: United States Institute of Peace, 2018), https://www.usip.org/sites/default/files/2018-11/providing-for-the-common-defense.pdf, vi.

29 Authors' note: This observation was made by co-author Lawrence Stutzriem, in a discussion with the authors, January 2, 2019.

30 Authors' note: In contrast to fixed wing aircraft, helicopters are far more vulnerable to small arms fire and the man-portable missile threat. In Operation Iraqi Freedom alone, 38 U.S.-flagged helicopters (both military and contractor) were shot down by enemy fire. See: Wikipedia, s.v. "List of aviation shootdowns and accidents during the Iraq War," last modified March 26, 2019, https://en.wikipedia.org/wiki/List_of_aviation_shootdowns_and_accidents_during_the_Iraq_War.

31 Norton A. Schwartz quoted in W.J. Hennigan, "Resurrecting a Stealthy Giant," *Los Angeles Times,* March 20, 2014, https://www.latimes.com/business/la-fi-c1-rebuilding-billion-dollar-bomber-20140320-m-story.html.

32 Authors' note: For more information on low observability and stealth see, Maj Gen Mark Barrett, USAF (Ret.) with Col Mace Carpenter, USAF (Ret.), *Survivability in the Digital Age: The Imperative for Stealth* (Mitchell Institute for Aerospace Studies: Arlington, VA, July 2017) http://docs.wixstatic.com/ugd/a2dd91_cd5494417b644d1fa7d7aacb9295324d.pdf.

33 Authors' note: These observations were gathered from a conversation between the authors and a veteran retired Marine Corps aviator, January 3, 2019.

34 Jeff Harrigian and Max Marosko, "Fifth Generation Air Combat: Maintaining the Joint Force Advantage," *The Mitchell Forum*, No. 6 (Arlington, VA: Mitchell Institute for Aerospace Studies, July 2016), http://docs.wixstatic.com/ugd/a2dd91_bd906e69631146079c4d082d0eda1d68.pdf, 3.

35 Brian Everstine, "The F-22's Undetected, Indispensable Role Over Syria," *Air Force Magazine,* May 2017, http://www.airforcemag.com/Features/Pages/2017/May%202017/The-F-22s-Undetected-Indispensable-Role-Over-Syria.aspx.

36 John A. Tirpak, "Critical Ingredient in Short Supply," *Air Force Magazine*, March 2016, http://www.airforcemag.com/MagazineArchive/Pages/2016/March%202016/Critical-Ingredient-in-Short-Supply.aspx.

37 Harrigian and Marosko, "Fifth Generation Air Combat," 4.

38 James R. Chiles, "Raptors Uncaged: An F-22 Pilot Opens Up About the Fighter's First Combat," *Air and Space,* February 1, 2016, https://www.airspacemag.com/military-aviation/raptor-strikes-180957782.

39 Harrigian and Marosko, "Fifth Generation Air Combat," 2.

40 United States Air Force, "F-22 Raptor," U.S. Air Force, September 23, 2015, https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104506/f-22-raptor/.

41 Authors' note: The requirement for F-22s still stands at 381 aircraft. The Joint Requirements Oversight Council (JROC), the joint military body that validates each service's capability requirements, last approved 381. The 243 and 187 figures were never approved by the JROC.

42 Authors' note: The F-105 force was battered during the Vietnam War, as the aircraft was purposefully designed for delivering nuclear weapons at low altitude and at high speed, sacrificing maneuverability. As a result, 334 F-105s were counted as combat losses during the war, out of a total production run of 833 aircraft. See: Rebecca Grant "The Crucible of Vietnam," *Air Force Magazine*, February 2013, 77-78.

43 See David A. Deptula and Douglas A. Birkey, *Building the Future Bomber Force America Needs: The Bomber Re-Vector* (Mitchell Institute for Aerospace Studies: Arlington, VA, September 2018), 37.

44 Tyler Rogoway, "Exclusive: Unmasking the F-15X, Boeing's F-15C/D Eagle Replacement Fighter," *The Warzone,* July 25, 2018, http://www.thedrive.com/the-war-zone/22372/exclusive-unmasking-the-F-15X-boeings-f-15c-d-eagle-replacement-fighter.

45 Rachel Cohen, Brian Everstine, and John Tirpak, "What's in the 2020 Budget Plan—and What's Not," Air Force Magazine, April 2019, http://www.airforcemag.com/MagazineArchive/Pages/2019/April%202019/Whats-in-the-2020-Budget-Plan%E2%80%94and-Whats-Not.aspx.

46 "History: JAST," F-35 Joint Program Office website, http://www.jsf.mil/history/his_jast.htm.

47 Authors' note: There are significant manpower considerations that go beyond aircraft production. It also takes roughly three to four years to develop a skilled combat pilot, and even more time to develop the training facilities, instructors, and aircraft necessary to support a pilot production pipeline. It takes about one year for a pilot to earn their basic wings, and another six months to a year to become basic qualified in their weapons system. From there, it will take another two to three years in an operational unit for that pilot to become experienced enough to truly be combat effective.

48 Helmut Sonnenfeldt and Ron Nessen, "You Go to War with the Press You Have," The Brookings Institution, December 30, 2004, https://www.brookings.edu/opinions/you-go-to-war-with-the-press-you-have/.

49 *Current Readiness of U.S. Forces: Department of the Air Force Presentation to the Subcommittee on Readiness and Management Support,* U.S. Senate, 115th Congress, first session, February 14, 2018. https://www.armed-services.senate.gov/imo/media/doc/Wilson_02-14-18.pdf, 5.

50 Eric Edelman, Gary Roughhead, et. al., *Providing for the Common Defense: The Assessment and Recommendations of the National Defense Strategy Commission* (Washington, DC: United States Institute of Peace, 2018), https://www.usip.org/sites/default/files/2018-11/providing-for-the-common-defense.pdf 52.

51 Senior Air Force official, personal communication with authors, January 25, 2019.

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