MITCHELL INSTITUTE for Aerospace Studies

SECURING THE PACIFIC SKIES:

The Imperative for Expanding Japan's Fifth-Generation Capacity

By Lt Gen David A. Deptula, USAF (Ret.)
Douglas A. Birkey
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Foreword

The government of Japan will soon choose a path to develop a new fighter aircraft to replace the Japan Air Self-Defense Forces' venerable F-2. With tensions on the rise in the Asia-Pacific region, this decision will prove consequential for decades into the future. Air superiority is an essential capability required to secure a broad range of desired effects for territorial defense.

Executing this mission in the modern era demands several key attributes, including stealth-enabled survivability and the ability to gather, process, and share information in real time. Eventually, these capabilities and attributes will play a key role in actualizing the "combat cloud" construct, and will refine modern fifth-generation combat aviation. Of special concern to Japan, China has developed two fifth-generation fighters, the J-20 and J-31, and experts predict a fifth-generation bomber may soon follow. These investments threaten to alter the balance of power in the Asia-Pacific if left unchecked.

Japan requires a fifth-generation air superiority solution for its 'Future Fighter' in the near term that is affordable, does not involve undue technical risk, and is optimized for its own unique mission demands within the Asia-Pacific region—particularly when it comes to range.

This Mitchell Institute report explores a potential path forward that would see Japan acquire a new fifth-generation fighter that leverages the physical design of the F-22 Raptor, enhanced with a larger, range-extending wing. This larger aircraft would also be outfitted with the modern sensing and computing power of the F-35 to assure initial capabilities. Not only would this hybrid approach afford valuable performance attributes, but it would do so in a time and budget-conscious framework favorable to Japanese priorities. This F-2 replacement would also integrate seamlessly with existing allied F-35s and American F-22s.
The future security environment is far from certain in the Pacific region. What is clear is the need to invest in forward-leaning capabilities. Fifth-generation air superiority aircraft stand at the top of this list.

Lt Gen David A. Deptula, USAF (Ret.)
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Executive Summary

Leaders in Japan will soon need to make a decision that will fundamentally reshape the country's security posture for the 21st century—what will replace the aging F-2 multirole fighter aircraft? Derived from the F-16, the aircraft is the Japan Air Self-Defense Force's (JASDF) mainline multirole fighter aircraft, but it is increasingly obsolete against the Asia-Pacific threat picture.

Japan must invest in advanced fifth-generation aircraft to succeed the F-2, using the latest stealth technology to survive threats, advanced sensors for situational awareness, cutting-edge data-processing capacity, and the ability to conduct secure, automated, real-time communications across the joint spectrum. Given that China has developed its own fifth-generation aircraft, it is crucial that Japan's F-2 replacement keeps pace. Anything less capable will leave Japan at risk.

The threat posed by China is not abstract. It has militarized much of the South China Sea by constructing 3,000-plus acres of man-made islands outfitted with military airstrips, sensors, facilities, and surface-to-air missiles (SAMs). To the north, China has forcefully challenged claims over disputed areas in the East China Sea, such as the Senkaku Islands. In 2013, China unilaterally extended an air defense identification zone (ADIZ) into Japan's internationally recognized ADIZ in the East China Sea. Japan's intercepts of Chinese aircraft have grown significantly.

Beijing's aggressive actions are backed up with robust capabilities. The People's Liberation Army Air Force (PLAAF) now possesses 1,700 fighter aircraft, 400 bombers, 475 transports, and 115 special-mission aircraft. The PLAAF has also invested in modernizing its fighter inventory with fourth-generation variants based on Russian designs like the Su-27 and the Su-30, along with the indigenous J-10 fighter. It also developed and fielded two new fifth-generation fighter aircraft in rapid succession, the J-20 and J-31. These will pose critical challenges to the bulk of the JASDF, U.S. Air Force, and U.S. Navy inventories, which are predominantly composed of fourth-generation fighters such as the F-15, F-16, F/A-18, and the F-2.

China has also enhanced the reach of SAMs, air-to-air missiles, and standoff strike missiles. Added to this, PLAAF leadership declared their intention to develop a new long-range stealth bomber. The U.S. Department of Defense estimates this aircraft could be flight ready by 2025 and feature a range of 5,000 miles, holding all of Japan's territory at risk.

To right the power imbalance, Japan must be strategic in its modernization choices and focus on buying or developing new capabilities that will generate an asymmetric advantage. This approach is critical to the success of the JASDF's F-2 replacement effort. Japan should develop and acquire the most capable fifth-generation aircraft with superior range and payload to succeed the fourth-generation F-2, which is slated to leave Japan's force structure by the mid-2030s.

In order to meet this challenge, the Mitchell Institute offers the following recommendations:

- **The F-2 replacement must be fifth generation.** Today, Japan lies within China's anti-access/area denial (A2/AD) threat ranges, with Chinese military power continuing to grow. Coupled with additional regional threats from nations like North Korea and Russia, the F-2 will be outclassed and unable to meet JASDF requirements to provide air superiority over the long term. Even advanced fighters such as the F-15J will not be able to meet the challenge of Chinese fifth-generation aircraft. To retain Japan's air superiority advantage, an F-2 replacement decision must have fifth-generation capability.

- **A solution should leverage the respective strengths of the F-22 and F-35.** Japan can capitalize on proven technology—an F-22/F-35 based replacement solution. This concept leverages the performance characteristics of the F-22, a larger wing to increase range, and the information superiority of the F-35. Combined into one aircraft, this would yield an exceedingly capable air superiority solution. Harnessing known technologies would drive down risk, cost, and development time factors. Interoperability with other allied fifth-generation aircraft would also provide powerful synergies.

- **A replacement solution requires "combat cloud" interoperability.** A fifth-generation F-2 replacement aircraft can become a critical node in a "combat cloud"-capable force. Just as F-22s and F-35s share information through advanced data links and networks, expanding these connections across a battlespace creates a high level of situational awareness. Instead of isolated platforms, the force evolves into a highly integrated enterprise where informationized collaboration determines mission success or failure. In combat cloud operations, the kill chain becomes a "kill web," where finding, fixing, targeting, tracking, engaging, and assessing is weapon and platform-agnostic, a constantly updating process that cannot be broken by a single point of failure. Fifth-generation connectivity and processing power are critical to meeting this new concept of operation.

- **Other options have drawbacks and risks.** While other options exist to replace the F-2, none are as compelling as the approach that leverages the proven F-22 and F-35. Alternatively, Japan could continue procuring new-build fourth-generation aircraft such as a Eurofighter Typhoon or a modernized F-15 tailored to Japanese requirements. But without organic stealth designs and built-in fifth-generation information systems, these aircraft would lack the attributes necessary for future Japanese pilots to survive in an A2/AD environment. Another option under consideration is to partner with a European consortium to develop a new-build advanced fighter. While this approach could yield a promising aircraft, time is a significant factor—neither the Franco-German nor the United Kingdom's advanced aircraft efforts have yet to move past the concept phase. This contrasts with both the Chinese J-20 and J-31, which are well on their way to being operational. Work share factors and political equities are problematic when thinking about any European defense project. It is likely Japan would be a minority stakeholder in any agreement. Given China's aggressive fifth-generation development and modernization drive, a partnership with a European firm might not deliver the capability Japan needs in the timeframe and at the price it wants. The last option is for Japan to develop an all-new fighter on its own. However, given the potential high cost and risk, this option could potentially weaken the posture of the U.S.-Japan alliance by fielding capability later than needed, or diverting budget away from other defense priorities.

The United States pioneered the technological domain of stealth aircraft, and China now seeks to close the gap. The chance for Japan to build its own fifth-generation solution and reduce technological development, schedule, and cost risks is a significant strategic advantage, especially as China shows no sign of slowing its military buildup. The choice is clear.

Introduction

Looking back throughout the annals of air combat, much has changed as technology has progressed. But the mission still relies on a foundation of enduring tenets. First and foremost, air superiority is a crucial mission and a condition necessary for military victory. Second, the ability to gather, process, and act upon high quality information will significantly enhance a pilot's ability to net desired effects, while minimizing undue projection of vulnerability. Third, survival is paramount, for aircraft losses will impede the attainment of desired effects and rapidly erode the ability to sustain a military campaign over time. A nation that fails to abide by these time-proven realities risks defeat.

In the modern era, if a nation's air force is not fifth-generation equipped, it is second rate by a wide margin.

In past eras, achieving these goals involved a disparate force of mission-specific aircraft—air superiority fighters; command and control intelligence, surveillance, and reconnaissance (C2ISR) airplanes; and more recently tailored stealth aircraft. Today, modern technology merges these federated mission areas into a single airplane in the form of a fifth-generation fighter. F-22 Raptors and F-35 Lightning IIs are highly lethal kinetic platforms able to strike targets in the sky or on the ground. They are loaded with sensors, processing power, and advanced pilot interfaces. Their stealth designs, situational awareness, and ability to process real-time threat information, while sharing key data with mission partners, ensures tactical advantage and survivability. While many legacy aircraft possess one or two of these attributes, only fifth-generation airplanes offer the complete package. In the modern era, if a nation's air force is not fifth-generation equipped, it is second rate by a wide margin. There is a reason why F-35 sales remain brisk and adversary nations such as Russia and China are developing their own fifth-generation fighters.

The potential now exists for a new chapter in the story of fifth-generation fighter aviation development. With Japan's F-2 multirole fighter aircraft replacement effort underway, the Japanese government can move to develop an airplane that would merge the positive attributes of both the F-22 and F-35, while also fielding custom design features that would address specific mission demands found in the Asia-Pacific region and revitalizing their fighter aircraft industrial base. Capitalizing on the existing technology of the Raptor and Lightning II threads the needle


Photo: A1C Courtney Witt/U.S. Air Force

Figure 1: A Japan Air Self-Defense Force F-2 lands at Andersen AFB, Guam. The JASDF F-2 has long operated alongside U.S. Air Force and allied aircraft, but it is facing an increasingly dangerous threat environment in the Asia-Pacific region.

of acquiring leading edge capabilities, while not pressing into the uncertainty associated with an entirely new design. This buys down risk, development time, and cost. Focused tailoring would allow proven attributes to become even better, because with Japan as the leader in this effort, enhancements would focus on region-specific operational demands. Potential also exists for significant indigenous design, production, and sustainment work for Japan's military aerospace industry.

Given rising threats and the fact that the F-2 replacement will remain in the Japanese inventory for decades, an adapted fifth-generation aircraft that repurposes and is built upon proven F-22 and F-35 technologies is a smart investment versus reinventing them. This aircraft could very likely prove vital in an era were the stakes of conflict are bound to be dramatic against highly capable adversaries. Anyone doubting this need only look at recent operational experience.

Fifth-Generation Technology is the New Standard

During a 2013 nighttime Red Flag exercise at Nellis AFB, Nevada, a mission package comprised of four F-22 Raptors and eight Royal Air Force (RAF) GR9 Harriers idled on the ramp, waiting to take off to execute their assigned missions. Threats in the area included adversary air and advanced surface-to-air-missiles (SAMs). The Harrier flight lead became increasingly concerned watching his fuel burn down to the point where his group's ability to execute their mission was coming into question. He radioed the F-22 flight lead suggesting they needed to take off. But the Raptor pilot responded with caution, "We wait." What the Harrier pilot did not appreciate at the time was that the F-22 pilots were watching the battlespace evolve on their cockpit displays. This meant the fifth-generation-equipped pilots were able to discern when the threat posed by adversary forces had abated to a point where they could successfully execute their mission. The desired window emerged, and the flight launched for a successful sortie based on timing, superior situational awareness, and excess fuel thanks to zero need for evasion. The divide between fourth-generation aircraft and fifth-generation technology proved stark at this exercise, with the F-22's information gathering, processing, and fusion capabilities standing as a game-changing key to mission success.[1]

These capabilities were put to the test in combat one year later. On the night of September 22, 2014, F-22s executed their first combat mission as part of the opening phase of Operation Inherent Resolve (OIR) against the Islamic State (ISIS) over Syria. The mission presented a highly complex set of circumstances that involved advanced air defenses, multi-faceted international dynamics, and the need to avoid unintended escalation at the state-on-state level. As one of the F-22 pilots involved with the combat debut described, "We're essentially going after and targeting a non-state actor within the sovereign state borders of another country that we are not technically at war with, and we're not friends with… Part of the coalition's objective while we're going after ISIS is to not do anything that's going to escalate the situation."[2] This imperative grew with the arrival of Russian combat forces in Syria in 2015. Successful combat operations came down to projecting effective military power via high-fidelity situational awareness.

> On the night of September 22, 2014, F-22s executed their first combat mission as part of the opening phase of Operation Inherent Resolve against the Islamic State over Syria. The mission presented a highly complex set of circumstances that involved advanced air defenses, multi-faceted international dynamics, and the need to avoid unintended escalation at the state-on-state level.

F-22s on that first night of OIR, and well into the campaign, focused a significant portion of their attention on understanding the battlespace and then communicating with coalition aircraft to ensure they were in the right place at the right time to net their desired objectives, out of harm's way, and deconflicted from adversary forces. According to one F-22 pilot who flew over Syria: "We have more information at our fingertips than other aircraft. We have an easier time making big decisions."[3] The power of this capability cannot be overstated, for combat success almost always resides with the side that can best optimize putting the necessary assets in the right time and place to best attain a desired outcome.

Information gathering, processing, and dissemination is not a unique function. Aircraft like the E-3 AWACS and E-8 JSTARS have been executing this function for decades. However, as commercial airline-derivative aircraft, they require air superiority to execute their missions and return home safely. Those conditions did not exist over Syria. The brutal execution of a Jordanian fighter pilot by ISIS a few months into the campaign left no ambiguity about the need to ensure the safety of all coalition actors. That is where the F-22's stealth design proved so crucial, as it allowed it to penetrate defended airspace, execute desired objectives, and return home safe. This was not a simple task. As one F-22 pilot explained, "Everyone on the coalition side was very aware of what [advanced air defense systems] the Syrian regime had [and still has]."[4] Upwards of one hundred aircraft have been shot down during the span of the Syrian Civil War—including advanced variants like an F-16 flown by the Turkish Air Force.[5] Stealth-enabled survivability, paired with situational awareness, set the F-22 apart from its non-low observable counterparts from day one of OIR. In the words of one Raptor pilot, "We go where we need to go."[6]

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Combat commanders recognize these distinct attributes and have kept the F-22 in the OIR fight on a routine basis since that first combat mission in 2014. As the former commander of U.S. Air Forces Central Command and current U.S. Air Forces in Europe-Air Forces Africa commander Gen Jeffery Harrigian explained:

> *The F-22's low observable characteristics, combined with its integrated avionics, in the hands of our outstanding aviators, provided us the ability to project power and freedom to maneuver. Importantly, the Raptors drove down strategic risk to our people in a very complex and dynamic environment with significant threats.*[7]

Such claims are not simply talking points. In a 2018 deployment, F-22s flying defensive counter air missions deterred 587 aircraft during 590 sorties over Syria and in the Middle East. The deployment included flying offensive counter air missions deep into Syria, deterring Syrian fighters and air defenses during the April 2018 U.S.-led military strike responding to the Assad regime's use of chemical weapons. The fact that these F-22s achieved this air superiority objective without kinetic action speaks to the respect commanded by the airplane—by friend and foe alike. Had a Raptor pilot needed to fire a shot, there is little doubt as to the likely outcome.[8]

This sort of record is exactly why nations like Russia and China are focused on developing their own fifth-generation fighters and why allied sales for the F-35 continue picking up pace. It is clear that fifth-generation aircraft provide military commanders, policy makers, and national leaders unique options in a complex security environment. Whether signaling for deterrence, defending personnel on the ground, executing limited operations, or guaranteeing sovereignty, fifth-generation aircraft are now an essential tool underpinning statecraft. The ability to master the information domain and project assured combat power thanks to stealth is the new bar for success in modern conflict. If a nation fails to meet this mark, victory will be far from guaranteed. This effectively changes the standards for the military airpower game going forward, demanding the attributes of fifth-generation technology and associated operating concepts.

The Modern Threat

When it comes to investing in new security capabilities and capacity, decisions must be driven by pragmatic requirements. As far as the Japanese decision-making calculus is concerned, there is one overarching threat that sets the bar under which all other regional security challenges, like North Korea, will fall: China, and the associated forces of the People's Liberation Army (PLA). The Asia-Pacific superpower is matching its aim for regional dominance with the military capabilities and capacity to realize this goal. Effectively checking and deterring this threat demands careful investment that will yield a disproportionately higher return than standard options.

China's threat is very real. It has demonstrated a clear desire to expand its territorial holdings far past established, internationally-recognized boundaries. To the west, this is marked in the form of numerous territorial disputes with bordering neighbors, such the Chinese military's recent attempt to gain possession over territory in the Doklam region, which is contested by both Bhutan and India. Following the resolution of the 2017 dispute, the Chinese have continued to fortify their military positions in the area.[9] To the east, China has expanded its zone of stated control and continued militarization activities on key islets in the South China Sea, contravening the 1982 Law of the Sea Convention and the corresponding claims of Brunei, Malaysia, the Philippines, Taiwan, and Vietnam.[10] Further doubling-down on this position, China has rejected a 2016 ruling by the permanent court of arbitration in The Hague against these expanded claims. Its military forces are now "capable of overpowering any other South China Sea claimant" and significantly challenging U.S. presence operations in the region.[11] To accomplish this, China has constructed in excess of 3,200 acres worth of man-made islands in the region and equipped these locations with sensors, airstrips suitable for fighter aircraft, and surface-to-air missiles.[12] In fact, Indo-Pacific Command's U.S. Navy Adm Philip Davidson explained that the Chinese have rapidly evolved "what was a great wall of sand just three years ago [into] a great wall of SAMs."[13]

China's burgeoning regional ambitions have led to its growing efforts to expand its zone of control in the East China Sea. It continues to dispute ownership of the Senkaku Islands with Japan and has maintained a regular regional presence with a rotation of coast guard ships.

Nor are these actions restricted to the South China Sea. China's burgeoning regional ambitions have led to its growing efforts to expand its zone of control in the East China Sea. It continues to dispute ownership of the Senkaku Islands with Japan and has maintained a regular regional presence with a rotation of coast guard ships. The tension over this area is so great that in 2017 Japan and China established a diplomatic hotline to help prevent unintended crisis escalation over the discordant claims. Still, China continues to exercise its naval forces in the East China Sea to prepare for conflict, and in January 2018, a Chinese nuclear submarine sailed underwater in the vicinity of the Senkaku Islands.[14]

The security picture becomes all the more disturbing when these unilateral geographic thrusts are viewed in parallel with Chinese stated strategic intent. According to the Department of Defense (DOD) *Annual Report to Congress, Military and Security Developments Involving the People's Republic of China 2019* (hereafter referred to as the DOD China Report):

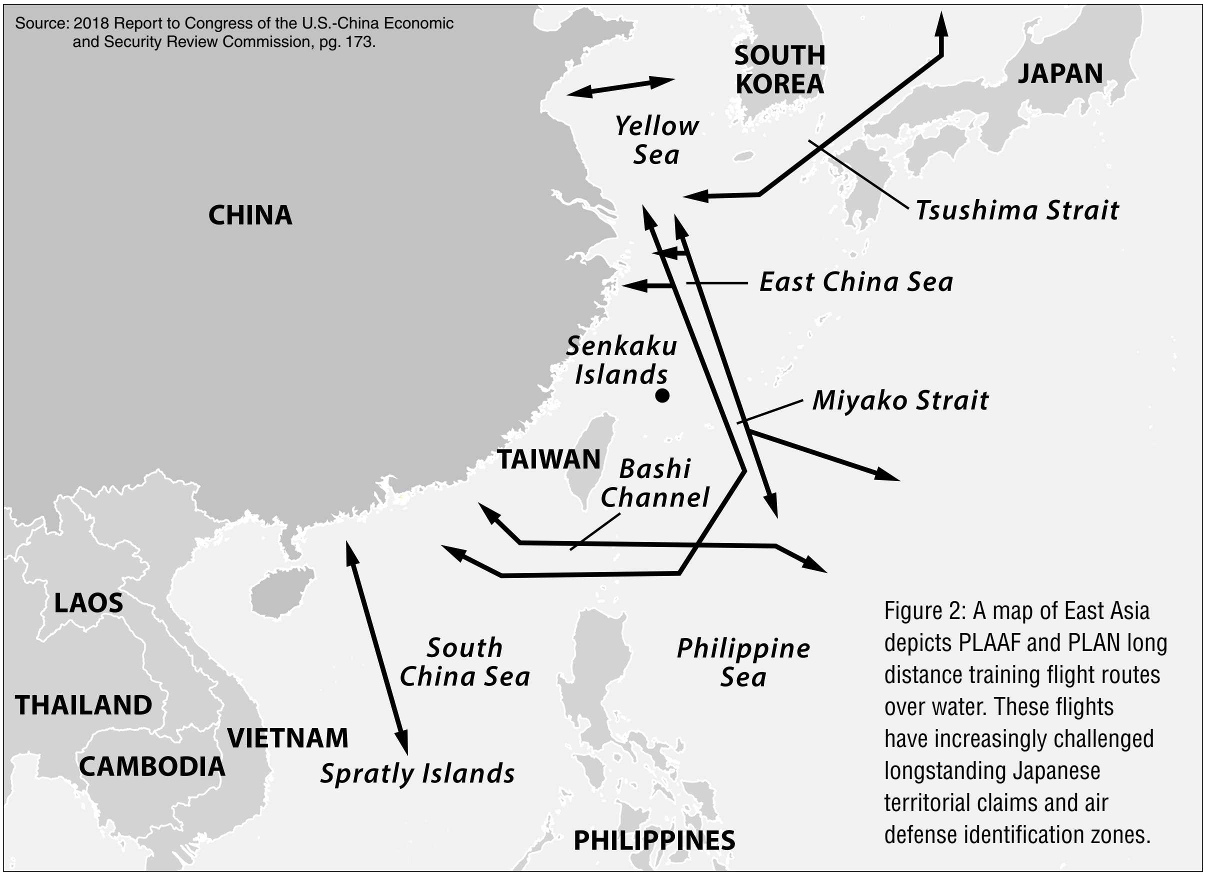
> *China characterizes its military strategy as one of "active defense," a concept it describes as strategically defensive, but operationally offensive. It is rooted in a commitment not to launch a strategic offensive but to respond robustly if an adversary challenges China's national unity, territorial sovereignty, or interests.*[15]

If China chose to respect established territorial boundaries recognized by the international community, this approach would simply reflect a common-sense defensive perspective. However, the problem arises when China unilaterally decides to begin expanding its zone of control and then works to defend this space, in the face of legitimate internationally-recognized claims, with overt military force. The likelihood for a rapid escalation to conflict is clear for all to see. As the *2018 Report to Congress of the U.S.-China Economic and Security Review Commission* explains, the reorganization and enhancement of the PLA's military capabilities and capacities pose challenges across the maritime, air, and information domains. China's growing capability to contest U.S. military presence in the Asia-Pacific enables it to "coerce its neighbors with the implied threat of force," which impedes the United States' ability to maintain a stable regional balance of power, and sustain adherence to international laws and norms."[16]

These concerns are far from academic. As the DOD's 2019 China Report explains:

> *China's continuing improvements of air and ground-based missile strike capabilities within and, increasingly, beyond the first island chain enable other military assets to operate farther from China. These assets can conduct a variety of missions include presence and sovereignty enforcement, as well as offensive missions such as blockades. China also focuses on enhancing the PLA's ISR capabilities, extending the reach of the PLA's situational awareness, as well as enabling improved targeting and timely responses to perceived threats.*[17]

These operations have included long-range bomber flights over the Sea of Japan, and more exercising of long-range power projection capabilities. In 2016, two Chinese H-6 bombers were accompanied by Y-8 airborne early warning and control aircraft on a sortie through the region. This was expanded in January of the following year, with six bombers and two reconnaissance aircraft in the same area. Eight months later, a formation of H-6 bombers flew through the Miyako Strait towards Okinawa, and then to the Kii Peninsula of Honshu. In May 2018, the PLA Air Force (PLAAF) flew fighter aircraft and long-range cruise missile-capable bombers around Taiwan, and employed an early warning aircraft to support Su-35 and J-11 fighter flights to the Miyako Strait near Okinawa and the Bashi Channel between the Philippines and Taiwan.[18] Such operations are not benign. They represent deliberate actions to demonstrate Chinese power, normalize military presence in international regions, and hone operational power projection capabilities.



Source: 2018 Report to Congress of the U.S.-China Economic and Security Review Commission, pg. 173.

Figure 2: A map of East Asia depicts PLAAF and PLAN long distance training flight routes over water. These flights have increasingly challenged longstanding Japanese territorial claims and air defense identification zones.

Chinese investment decisions are also aligned with these activities and increasingly aggressive military stance. PLAAF Deputy Commander Lt Gen Xu Anxiang put the past two decades worth of modernization progress in context when he explained that "the building of a modern Air Force will essentially be achieved by 2035."[19] Core mission areas include air superiority with both manned fighters and sophisticated SAMs, long range strike via manned bombers and guided missiles, logistics functions like aerial refueling and cargo aircraft capacity, and capabilities through the Chinese concept of "informationized warfare"—gathering data, processing it, and fusing it into actionable information to optimize force employment in a knowledge-based fashion. Western militaries have discussed similar concepts using terms like "combat cloud," "fusion warfare," and "multi-domain command and control." No matter the title, this capability will demand robust networks, processing power, integrated command and control functions, and precision strike.[20]

In terms of raw numbers, China possesses significant capacity. This includes 1,700 fighter aircraft, 400 bombers, 475 transports, and 115 special mission airplanes that span activities from C2ISR to aerial refueling.[21] Guided strike missiles also form a significant element of the portfolio, with the PLA possessing 150 to 450 medium-range ballistic missiles, 750 to 1,500 short-range ballistic missiles, and 270 to 540 ground-launched land attack cruise missiles for standoff precision strikes.[22] Naval power also figures as an important arm in China's power projecting arsenal, with China possessing the region's largest fleet—boasting more than 300 surface ships, submarines, amphibious ships, patrol craft, and other specialized vessels. This includes a growing number of aircraft carriers. China's first domestically-built carrier is slated to join the fleet by the end of 2019, and a second (and larger) carrier is now under construction. This new variant will be fitted with a catapult launch system, and will be able to support more advanced fighter aircraft operations, a faster operations tempo, as well as fixed-wing early warning aircraft.[23]

As far as air superiority is concerned, China has focused significant investment in modernizing its fighter inventory with fourth-generation aircraft derived from Russian designs like the Su-27 and Su-30, as well as indigenous designs like the J-10.[24] However, there are also clear signs of progress in developing a significant fifth-generation capability, as seen by the appearance of the J-20 and J-31 stealthy fighters. Both aircraft have been observed demonstrating their ability to carry long range missiles, open weapons bay doors in flight, and operate in numbers that demonstrate a growing inventory.[25] Making its first public appearance in November 2014, the J-31 is also understood to be a variant aimed at China's arms export customers seeking fifth-generation capabilities.[26] Should it proliferate as an export fighter, it will pose an eventual challenge to advanced aircraft like the F-35, and present an even greater threat to legacy fourth-generation fighters like the F-15, F-16, F/A-18, and Japan's own F-2, perhaps even strategically dislocating at the operational level.[27] Several analyses also suggest the Chinese are seeking to arm their new fifth-generation fighters with highly advanced munitions, to include hypersonic weapons. The DOD's annual China report notes that Chinese engineers announced they successfully tested a solid-fuel ramjet missile engine, and have suggested this capability will enable the J-20 to carry future hypersonic air-to-air missiles with a range of 300 kilometers (180 miles).[28]

Figure 3: The Chinese J-20 in flight during an October 2016 airshow in Zhuhai, China.


Photo: Alert5.com

On top of these gains in fighter aviation, the Chinese are also continuing to rely on advanced SAMs that can be based on ships, on land, and even on reclaimed islands in the South China Sea. The PLAAF, Pentagon officials believe, possesses "one of the largest forces of advanced long-range SAM systems in the world…"[29] This arsenal consists of Russian designs like the SA-20 and SA-21 as well as indigenous types such as the HQ-9. These systems are linked to airborne early warning and control aircraft, in order to target threats in varying conditions, in larger volumes, and at greater distances, extending the range of China's "robust and redundant" integrated air defense system architecture.[30] Ranges for these missiles are impressive, reaching up to 250 miles in the case of the SA-21.

When it comes to strike, China's inventory of ballistic and cruise missiles are cause for great concern. They exist in large numbers and could project large volleys of devastating firepower. Added to this are China's manned bomber aircraft. The current inventory is comprised of a legacy Soviet design, the H-6, which is equipped with an estimated six land-attack cruise missiles per aircraft.[31] However, in 2016, then-PLAAF Commander, Gen Ma Xiaotian, stated that the Chinese were developing a new long-range stealthy bomber. Since the announcement, several reports have suggested the new aircraft (likely named the H-20) could debut in the next decade equipped with features including stealthy design attributes, both conventional and nuclear weapons carriage capability, a payload of at least 10 metric tons, and a range of at least 8,500 kilometers (5,200 miles). The Chinese are also reportedly developing a refuelable bomber variant that could become operational before the long-range H-20—thus expanding the PLAAF's offensive capabilities.[32]

Drawing these disparate tools together in a highly collaborative, mutually supporting power projection force is China's continued focus on "informationized" war. At a macro level, this concept refers to a combat cloud-type enterprise, whereby a broad net of distributed sensors continually gather data, which is processed into actionable knowledge, and made operationally relevant through a robust, agile command and control system. The net effect is that individual pieces of military hardware become far more effective and efficient as part of a broader enterprise approach to warfighting that seeks to minimize vulnerabilities and maximize opportunities by understanding when, where, and how to best project power in a highly dynamic, resilient fashion.[33] This concept is so important to the Chinese vision of future warfare that President Xi has touted the need to accelerate "informationization" efforts, and endorsed a range of national development plans that focus on improving not only information and communications technology, but also "disruptive technologies" that will impart China with a competitive advantage over the United States.[34] In a region as expansive as the Asia-Pacific, the military force that can understand when and where to best project assets will retain a significant advantage in conflict. Even a large military will be stretched thin covering such a broad expanse.

In a region as expansive as the Asia-Pacific, the military force that can understand when and where to best project assets will retain a significant advantage in conflict. Even a large military will be stretched thin covering such a broad expanse. Any nation whose strategic interests compete with those of China must consider the Asian power's growing economic clout in order to make the most of their military vision from both a capability and capacity perspective.

Any nation whose strategic interests compete with those of China must consider the Asian power's growing economic clout in order to make the most of their military vision from both a capability and capacity perspective. China's defense budget has doubled over the past 10 years, with official estimates suggesting eight percent growth per year and actual investment likely even greater. According to recent DOD analysis based on economic data, China is positioned to support continued defense spending growth for at least the next five to 10 years.[35] By way of comparison, in 2017, China officially spent $154.3B on defense and Japan expended $46.1B. Experts believe the actual level of Chinese defense spending is far higher and some analysts estimate the Chinese defense budget may reach $240B by 2021. The US-China Economic Commission Security Review Commission, for example, points out that China routinely omits major defense-related expenditures from its topline budget announcements, such as research and development, arms procurement from abroad, and local support to the PLA.[36] The buying power this continued investment yields on an aggressive modernization plan is significant. It is also bolstered by robust arms sales to China's allies. From 2013 through 2017, China stood as the world's fourth-largest arms supplier, completing more than $25 billion in sales.[37] The net effect of this access to economic capital is the ability for China to invest in advancements across a range of defense technologies, such as counterspace weapons and hypersonic technology, that it hopes to use to "exploit U.S. weakness such as dependence on information systems and space-based assets for precision strike, navigation, and [ISR] operations," according to the U.S.-China Economic and Security Review Commission.[38] This means that not only will China's military be a large force, the country's traditional advantage, it will also be increasingly capable.

Fifth-Generation Aircraft and the Modern Threat

The plain fact of the matter is that today Japan lies well within the Anti-Access/Area Denial (A2/AD) threat ranges developed by China's military power. Coupled with additional evolving threats from actors like Russia and North Korea, it is clear that the aging F-2 fighter fleet will be unable to meet the Japan Air Self-Defense Force (JASDF) requirements to provide air superiority over the long term. Even advanced fourth-generation aircraft, like the F-15Js currently in the Japanese inventory, will be unable to survive and operate in an A2/AD threat environment. Recapitalizing the F-2 inventory with fifth-generation aircraft stands as an imperative if Japan is to successfully meet the demands of its future security environment.

Figure 4: Japan Air Self-Defense Force F-15Js prepare to take off during a Red Flag-Alaska exercise at Eielson AFB, Alaska. Even advanced fourth-generation aircraft like the F-15J would be unable to survive and operate against Chinese A2/AD capabilities and defenses.


Photo: SrA Joshua Turner/U.S. Air Force

Fifth-generation aircraft share four basic attributes: all-aspect stealth; superior aerodynamic performance; advanced automated sensors; and information fusion. It is the synergy of these capabilities that makes fifth-generation aircraft so survivable and lethal.

Stealth is perhaps the attribute for which fifth-generation aircraft are best known. It is a lynchpin capability, for without it, none of the other functions would matter due to a lack of survivability. To understand this technology, it is important to realize that it extends far past minimizing the radar cross section (RCS) of an aircraft design. Stealth is a holistic approach that goes beyond shaping the airframe or specialized coatings. In order to delay or deny detection to an adversary's threat systems, designers must manage multiple signatures and emissions across the spectrum. These design features must be built into an airframe from the beginning. These signatures encompass everything from radar, radio, electronic warfare, data links, to thermal or infrared signatures.

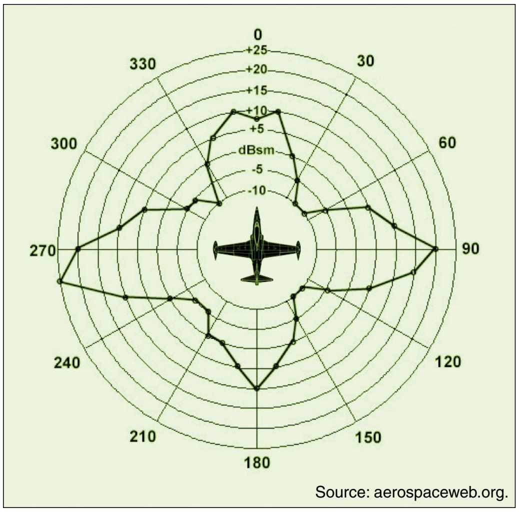


Figure 5: The simulated radar cross section (RCS) of a T-33 first-generation jet trainer. To minimize vulnerability, aircraft attempt to present their smallest reflection to adversary radars. Here, the smallest reflection would be between 30 and 60 or 120 to 150 degrees.

From a basic signature perspective, the RCS—that is, the magnitude of radar energy from a threat system that reflects off an aircraft—is not uniform. As radar energy bounces off the surface of an aircraft, it may return straight back, redirect to an axis different than the original energy, or generally scatter. As a consequence, the radar return can "bloom," reflecting energy more brightly from some aspects (see Figure 5). Part of this shaping means that all sensors and weapons must be carried internally. Any external store is a major radar reflector, even when shaped and coated. Additionally, some materials can absorb radar energy while others reflect it like a mirror. The challenge facing aircraft designers is to create a stealthy signature that does not bloom dramatically in any aspect, including three-dimensional elevations (for example, the "look" angle of a surface threat system at the underside of an aircraft).

In the past, designers had to compromise between aerodynamic performance and stealth given that faceted designs required to redirect radar energy did not support fighter-type aerodynamics and maneuverability. The "Have Blue" prototype and its successor the F-117, both examples of early stealth aircraft, show how radically the design demands of stealth changed an airframe—they did not even look like a traditional airplane. According to one former F-117 pilot, the engineering technology, manufacturing materials, and computational power of the early stealth era "drove a design that constrained aircraft maneuverability to deliver low observability. The F-117 was a fighter in name only, lacking the maneuverability of other comparable-sized aircraft of its time."[39] The aerodynamics of the faceting that redirected radar energy, for example, were so marginal that they required a digital flight control computer for basic control. There was no manual flight control option. Without the stabilty augmentation of the digital flight computer, the aircraft would depart controlled flight. While other aircraft, like the F-16, exploited digital control technology to enhance maneuverability, the F-117 design literally could not have gotten airborne without it. Today's technology embodied in the F-22 and F-35 have signifigantly reduced these constraints.

Modern Stealth and Survivability in Advanced Threat Environments

The advanced maneuverability of both the F-22 and F-35 is even more impressive, given the limitations of past stealth aircraft designs. Unlike early development stealth programs, modern fifth-generation aircraft do not have to compromise fighter performance for an RCS that is classified as "very low observable" (VLO). Thanks to the computational power of today's advanced processing, 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 maneuverability of fourth-generation fighters. Both the F-22 and F-35 retain controllability past their critical angle of attack, are supersonic, are high-G airframes, and their roll and pitch rates are competitive in any dogfight.

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But low observability is not only about shapes and materials. Emission and signature control comprise other critical design elements of stealth that must be built into an aircraft from the beginning. Aircraft equipped with infrared sensors can detect opposing airplanes because they are hot against a cold sky. Managing the thermal signature must also be integrated from day one. Passive sensors have improved in sensitivity and fidelity, 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/LPI transmissions make it extremely difficult for adversaries to use passive detection to exploit fifth-generation aircraft radios and data links for locating, targeting, or even early warning. Fifth-generation aircraft must also manage the power and direction of their own sensors and rely upon passive sensors as well when circumstances dictate.

These advanced and automated sensors are another fifth-generation hallmark. All active sensors, like modern electronically scanned array radars, must manage their emissions to avoid alerting the adversary. Too strong or too broad of a pulse, and threat sensors can detect and potentially track an emitting airplane. Thus, fifth-generation aircraft use a suite of active and passive modes plus sensors that are automated and work together to create an integrated, highly accurate, real-time picture of the battlespace. Any fifth-generation pilot will declare that while they deeply appreciate the survivability afforded by stealth, it is the information and decision superiority provided by their integrated avionics that is the true difference-maker in their aircraft.

Battlespace Awareness and Decision Superiority in Fifth-Generation Aircraft

The sheer volume and quality of information available to a fifth-generation pilot is a key discriminator when compared to what is available to fourth-generation pilots, and one that dramatically contributes to 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 for the pilot.

The importance of this capability cannot be overstated. The F-22 Raptor, the world's first true high-performance fifth-generation fighter, introduced a low probability of intercept/detection intra-flight data link that allowed multiple F-22s to securely share large volumes of data for collectively-enhanced situational awareness and coordinated attacks. This data link, combined with the F-22's stealth characteristics, allowed for Raptor pilots to revolutionize combat tactics. Pairing the data link with stealth, F-22 pilots freely positioned themselves in exercises and in battle for the greatest potential advantage. These same capabilities have further evolved, with the introduction of the F-35 Lightning II into the combat air forces of the U.S. military and its allies. These new capabilities include distributed, real-time processing of threat information across multiple F-35s. The resulting potential combat effectiveness of the F-35, as a result, is now being demonstrated and fully understood at large-scale exercises, such as Red Flag, where the F-35 appears likely to surpass even the F-22's capabilities in specific areas such as situational awareness and data sharing.

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The increasing power of fifth-generation aircraft to gather, process, exploit, and share information in effect turns operators of these advanced aircraft into mission commanders, according to an analysis from two veteran fifth-generation fighter pilots, "rather than having them focus on managing and operating subsystems."[40]

The battlespace awareness provided to a fifth-generation pilot from information fusion is significantly advanced when compared to the awareness provided by fourth-generation aircraft, which largely have federated sensors. In fourth-generation aircraft, the radar system is separate from the data link system, which is separate from the electronic warfare system, which is separate from the electro-optical system. Other systems are similarly separated. It is the responsibility of the pilot to not only manage each and every sensor and system individually, but they must also interpret the information gathered from the sensor or system, and make sense of that information in relation to the information gathered from all the other sensors on their aircraft. Situational awareness—battlespace awareness—is something that every fourth-generation pilot must build for himself, and is the result of personal experience, aptitude, and proficiency.

Sensor management and interpretation is a skill that takes years to develop. Inadvertent errors in high-demand, dynamic environments can be insidious, leading to faulty tactical decisions and disjointed execution. The multi-tasking required by federated systems means that a new fourth-generation fighter pilot will require intense instruction, rigorous practice, and accumulated experience before true mastery of their aircraft can be attained. As one pilot with time piloting both the F-15 and F-22 explained:

> *In fourth-generation fighters, after pilots master the operation of the airplane and subsystems, all of the mission training is practicing and perfecting the management of onboard systems. This training also involves effective communication and gaining experience in building a 3D picture of the battlespace. It would take years for fourth-generation pilots to become masters of this as they move from wingman, flight lead, four-ship flight lead, instructor and mission commander. Even as a highly experienced mission commander, the pilot must still manage his own onboard sensors while trying to make effective and timely battle decision.*[41]

Furthermore, because that battlespace awareness is an internal mental construct, every fourth-generation pilot has a slightly different interpretation. Even when sensor management and interpretation is performed by highly skilled fliers, the friction that results from each pilot having a unique understanding of the battlespace can detract from tactical execution, tasks that include intercept geometry, allocation of forces, identification, weapons employment, and defensive maneuvers. If the mental picture that one pilot has is incomplete, erroneous, or different from other pilots or flights of aircraft, the consequent engagement decisions will be as well.

Without the burden of sensor management or having to build a mental picture, fifth-generation pilots are far more combat effective than their peers in fourth-generation aircraft.

The advantage that sensor fusion provides the fifth-generation pilot is dramatic. Sensors are highly advanced, automated, and require little to no active control from the pilot. Sensor data is shared with other flight members via directional/secure data link, allowing a collaborative approach where fifth-generation aircraft correlate, compare, and fill in best-of-the-best information with other aircraft in their flight automatically and in real time. The result is a robust common picture shared among all flight members. As one F-22 pilot who flew over Syria explained, “We have more information at our fingertips than other aircraft. We have an easier time making big decisions.”[42] Unlike fourth generation, fifth-generation pilots share the same battlespace understanding, enabling more coordinated, efficient, and effective operations.

Without the burden of sensor management or having to build a mental picture, fifth-generation pilots are far more combat effective than their peers in fourth-generation aircraft. It simply does not take as long to train a young fifth-generation pilot. Fourth-generation pilots require years of training and constant practice in their aircraft to master sensor management and learn how to accurately build a picture of the battlespace. Instead of focusing on teaching a young wingman how to control and interpret the radar, one fifth-generation pilot explained their young wingmen "are making tactical decisions and executing accordingly at a level that historically, in our fourth [generation] fleet, we would not expect out of them until they were a seasoned flight lead, if not a mission commander or instructor pilot."[43]

Information in fifth-generation aircraft is presented to the pilot on an intuitive, top-down range display. This includes a four-aircraft flight's collaborative picture, as well as information from other off-board sources via data link. Called a "tactical situation display" in the F-35, this fused battlespace picture essentially provides a map to the pilot of all threats, targets, friendlies, geographic and navigation points, and hostile tracks. Unencumbered by the burden of managing and interpreting a federated system, 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 an advanced fighter aircraft, and in aerial combat, time is range. The longer these tasks take, the less initiative, surprise, or maneuvering room is available to a pilot. Pilots who are consumed with operating sensors simply have fewer options. But because these tasks are automated in fifth-generation aircraft, pilots can execute better threat avoidance, direction of forces, engagement decisions, withdrawal, and other command decisions. In short, fifth-generation aircraft provide information and decision advantage.

This dynamic is transforming how fifth-generation aircraft operate in modern conflicts. Increasingly, these pilots are acting as battle managers. Given that traditional battle management wide-body aircraft are unable to trespass into any A2/AD environment, the ability of fifth-generation pilots to assume this role is vital to combat effectiveness. As Gen Herbert "Hawk" Carlisle, Air Combat Command's then-commander explained in 2016, F-22s over Syria were "serving as the quarterbacks of the campaign." As the forward-reaching eyes and ears of the Air Force, the Raptors directed strikes, shepherded air packages away from danger, destroyed high-value ground targets, and vastly enhanced the situational awareness of the whole enterprise, he noted.[44]

The Synergy of Stealth and Information—Offensive Initiative and Maneuver

This information and decision superiority simply cannot be achieved by fourth-generation aircraft. Like stealth, these highly integrated avionics cannot be retrofitted into a federated system, or be achieved through a piecemeal upgrade program. Fusion must be designed in from the beginning. Of course, 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. With advanced threat systems, like the SA-20, HQ-9, and SA-21 SAMs fielded by China, fourth-generation aircraft cannot get in to the fight regardless of their avionics or information systems. Their airframes are simply not survivable in an A2/AD threat environment.

A2/AD threats make stealth signatures mandatory, and the cost of entry to the battlespace. But stealth by itself is a passive defense, one that is rigid and inflexible. This kind of passive stealth, without the advanced sensors and fused avionics of fifth-generation technology, requires mission planners to work closely with intelligence to develop a fixed flight path from which the aircraft cannot deviate. Using an all-aspect RCS model, planners use complex programs to optimize how the aircraft will present itself to known threat systems along its flight path in order to minimize radar return against those threats. But without fifth-generation information systems, a stealth airplane must stay on the "black line" and not deviate from planned flight routes. To deviate would trespass into the unknown, negate careful planning, and leave the pilot with no knowledge of how effective their stealth was in denying or delaying detection by the adversary.

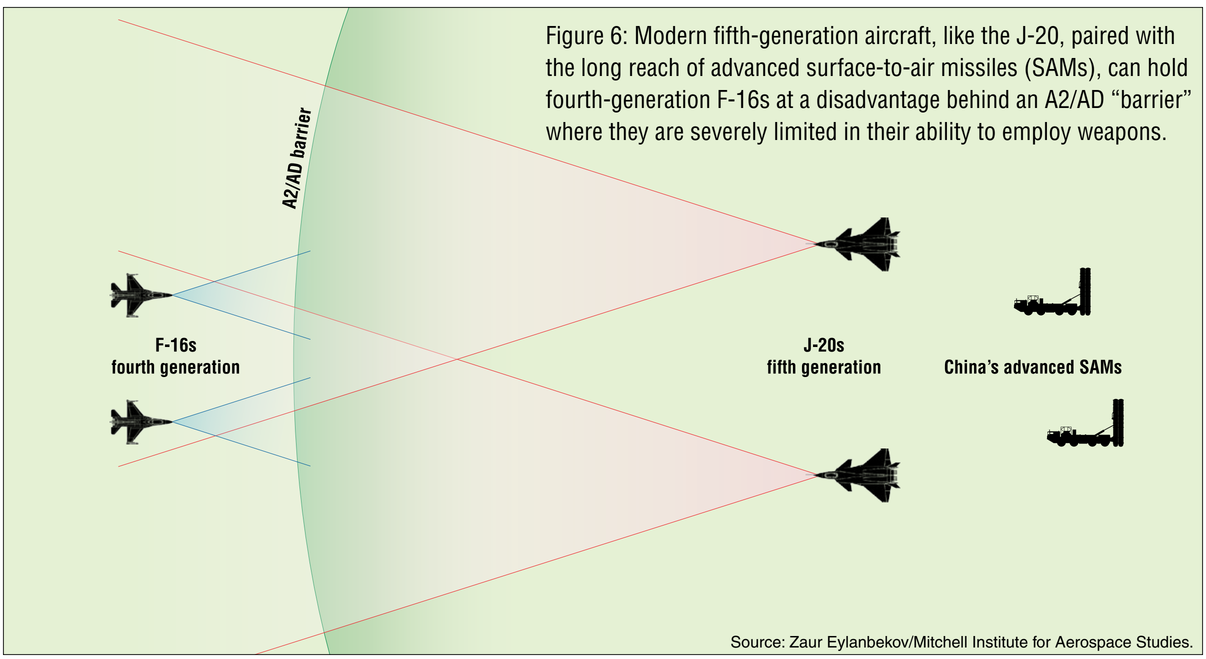

Figure 6: Modern fifth-generation aircraft, like the J-20, paired with the long reach of advanced surface-to-air missiles (SAMs), can hold fourth-generation F-16s at a disadvantage behind an A2/AD "barrier" where they are severely limited in their ability to employ weapons.

Source: Zaur Eylanbekov/Mitchell Institute for Aerospace Studies.

This concept of operations was effective when threats were largely fixed and the order of battle of adversaries relatively static. But the advent of highly lethal and mobile SAM systems, as well as the requirement for stealth to be effective against extremely capable adversary aircraft, has significantly decreased the survivability of stealth when used only as a passive defense of an aircraft. One only has to consider the complexity of ship-based SAMs, and the added burden they place on dynamic decision-making requirements in a combat scenario.

Modern stealth is no longer just a defensive survival attribute, but rather the offensive advantage, both surprising and lethal.

It is the synergy of stealth with information and decision superiority that transforms battlespace awareness into real initiative and maneuver. Automated, multi-spectral sensors can build a highly accurate real-time threat picture for a pilot, who can then manage the presentation of their RCS to a threat. With this kind of knowledge, the "black line" no longer matters for survivability. Fifth-generation aircraft have freedom of maneuver because they are both stealthy and know the location of threats. In the words of two experienced F-22 pilots:

> *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 signature management, enabling the aircraft to survive and maintain situational awareness of events in combat even when operating in close proximity to advanced threats.*[45]

An F-22 pilot flying OIR combat sorties said that during flight operations he possessed unparalleled awareness of the operational environment. "I see radars. I see airplanes," he said. "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."[46]

Fifth-generation pilots can seize the initiative in combat with this battlespace picture, optimizing and managing their RCS presentation—denying detection to the adversary as they maneuver. As did the Raptors in OIR over Syria, fifth-generation aircraft simply "go where they need to go"—while fourth-generation aircraft cannot. Delaying or denying detection compresses an adversary's reaction time, and together with freedom of maneuver, gives truth to the fifth-generation pilot's motto of "first look, first shot, first kill." The combination of information and decision superiority with stealth doesn't just enhance the survivability of the aircraft in a dynamic battlespace—it makes it more lethal. Modern stealth is no longer just a defensive survival attribute, but rather the offensive advantage, both surprising and lethal.

The Liability of Mixed Fourth and Fifth-Generation Fleets

Fifth-generation aircraft have proven themselves to be force multipliers, making legacy fourth-generation fleets more effective. The F-22 has 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 could not do."[47] Fifth-generation aircraft can provide escort and act as forward battle managers, enhancing fourth-generation survivability and the effectiveness of the entire package. This kind of integration makes the most of existing force structure and capabilities as air forces transition their inventories from fourth to fifth-generation aircraft. Ultimately, however, this kind of mixed fleet degrades the combat potential of fifth-generation aircraft.

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 hard points under their wings and fuselages, powerful and active sensors, and no LPI/LPD radios or data links, fourth-generation aircraft are noisy, bright targets for the advanced threat systems fielded by China and Russia—as well as the militaries that field their weapon systems. Stealth and emission control is crucial to surviving these threat environments.

Fourth-generation aircraft limit the potential of fifth-generation aircraft. Fifth-generation aircraft are constrained from fully exploiting their initiative and offensive potential when employed in a mixed force package. Certainly, there is value in exploiting the forward battle management potential of a fifth-generation aircraft, and fifth-generation aircraft do enhance legacy capabilities, but the incredible battlespace awareness that fifth-generation aircraft bring to the fight is limited by the vulnerabilities of their legacy counterparts.

Fifth-generation aircraft must be freed from the constraints of a mixed fleet so that warfighters can fully develop and mature the operational concepts, tactics, and networked information enterprise of the future.

Fifth-generation aircraft must be freed from the constraints of a mixed fleet so that warfighters can fully develop and mature the operational concepts, tactics, and networked information enterprise of the future. Unless and until a fully fifth-generation force is fielded, the true transformative potential of fifth-generation combat operations cannot be realized.

It is the synergy of information and stealth that truly makes fifth-generation aircraft revolutionary. Fighter pilots are no longer sensor managers, and the automated, fused, and shared battlespace awareness provided by fifth-generation systems facilitates self-synchronization of tactics and operational decisions. As one Air Force officer explained, fifth-generation pilots now "have the kind of information that was previously only available nearly fused but far more imperfectly fused in the [combined air operations center]. That information will now be distributed in the battlespace."[48] One warfighter who had experience in a range of fighter aircraft from the F/A-18, to the F-16, F-22, and F-35 explained:

The difference between a Hornet or a Viper and the Raptor isn't just the way you turn or which way you move the jet or what is the best way to attack a particular problem. The difference is how you think. … In the Raptor, the data is already fused into information thereby providing the situational awareness. … Indeed, the processing of data is the key to having high [situational awareness] and the key to making smart decisions. [49]

The fifth-generation advantage is a fundamentally different paradigm of operations. With the survivability and initiative afforded by stealth, fifth-generation pilots are able to exploit the incredible informational power of their platform to turn awareness into offensive action.

Fifth-Generation Aircraft and the Combat Cloud—Highly Effective and Lethal Operations

Advanced data links will even further transform fifth-generation operations. Just as the F-22 and the F-35 share critical information among their flights to build an integrated common operating picture of a conflict, expanded LPI/LPD connectivity across the battlespace will ensure that all platforms share the same battlespace awareness. But this connectivity will move operations beyond self-synchronization, coordination, or even integration. Information and data is the force evolving all the tools of military power from isolated instruments into a highly integrated enterprise where the exchange of information and data will determine success or failure in 21st century warfare. Fifth-generation connectivity will transform information sharing into a highly lethal "combat cloud enterprise."

In this vision, information will power combat operations. All platforms in a given battlespace will be connected to each other through LPI/LPD networks, sharing data and filling in gaps to create a highly accurate, real-time, common picture of combat. This enhanced situational awareness will synthesize masses of disparate data into decision-quality knowledge, so that no obvious point of vulnerability exists for adversaries to exploit.[50] Combat cloud is a robust and resilient operational concept that complicates an adversary's problem set and targeting plan, and strategically dislocates any military challenger.[51]

For example, in a combat cloud operational concept, the kill chain becomes a "kill web." In the traditional kill chain, target information must pass through each step of the "find-fix-track-target-engage-assess" process with positive custody and integrity. If at any point the chain is "broken" and the targeting information lost, the engagement will most likely be defeated or denied. But in the combat cloud, this process is no longer a fragile, linear sequence of steps in which the target information has a single point of failure. Combat cloud is sensor, platform, and even weapon agnostic; the target information resides in multiple entities and across multiple axes. Even if one line of effort is unsuccessful, targeting information persists in the combat cloud and the target prosecuted until the desired effect is achieved. The kill chain of information custody cannot be broken because as a "web" other links continue to exist.

This kind of lethality is only possible in a fully mature, fifth-generation force. Similar to the constraints imposed by a mixed fourth and fifth-generation fleet, the presence of fourth-generation aircraft will degrade the combat potential of combat cloud. Instead of focusing all efforts on surprising the adversary with offense and initiative, combat cloud operations would be restrained by the vulnerabilities of legacy fighters and other legacy-type platforms. Without the survivability afforded by stealth and the quality of information, battlespace awareness, and decision superiority enabled by the advanced, integrated sensors and avionics of fifth-generation aircraft, the full potential of combat cloud operations cannot be achieved.

The Case for Japanese Fifth-Generation Aircraft

A fully fifth-generation fleet capable of executing combat cloud operations is the best option for Japan to provide for its defense interests. The coupling of China's aggressive territorial and economic ambitions with its massive military investments signals its intent to dominate the Asia-Pacific region. Its interests are bound to come in conflict with those of Japan. The dispute surrounding the Senkaku Islands may be just the first stage of increasing tension between Japan and China, as the steadily strengthening Asian power continues to expand its zone of control through means that are not sanctioned by international convention or other authority, such as the Permanent Court of Arbitration at The Hague. With a military strategy of "active defense," China is building both military capacity and capability that threaten Japan's sovereignty.

As China expands its zone of control to encompass historically Japanese islands, waters, and airspace, such influence is not merely defensive. The power projection capabilities of China's SAMs, long-range bombers, air-refueling capabilities, and advanced stealth fighters are meant to give nations in its sphere of influence pause. Military overmatch on China's part is just another diplomatic and economic tool it plans to wield in its rise as a regional and global power. As Japan lies well within the envelope of China's reach, not developing a fully fifth-generation JASDF poses risks to Japan's sovereignty. The number of scrambles to identify unknown aircraft entering Japan's air defense identification zone (ADIZ) has spiked over the last several years, from around 300 a year in 2012 to nearly 1200 in 2016, before declining slightly to 900 in 2017. Through the third quarter of 2018, according to the Japanese Ministry of Defense, there were 758 scrambles to identify aircraft, most of which were Chinese fighters.[52]

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Japan must have fifth-generation aircraft capable of combat cloud operations to deter and dissuade Chinese aggression going forward. Japan was delayed in fulfilling this requirement by the U.S. government's decision to not sell it the F-22. Japan's failure to secure the Raptor as a keystone of its air defenses has seriously hindered its defense capabilities. Japan "completely lost its Cold War era air superiority advantage in light of the fast growing capabilities of neighboring China – with Beijing's fleet today vastly surpassing that of Tokyo both quantitatively and qualitatively," according to one Asia-Pacific military analyst.[53] Though Japan plans to acquire a total of 147 F-35s going forward, this will not provide enough fifth-generation capacity in the critical air defense mission and others. Estimates suggest China will have over 300 fifth-generation fighters by 2030, which would outnumber Japan's F-35 capacity by two or even three to one. If the implicit threat of Chinese military coercion prevented Japan from pursuing or asserting its interests, the country's sovereignty would begin to erode. Japan must have a fifth-generation force capable of repelling the PLAAF.

It is in this context that Japan is recapitalizing its F-2 fleet. Unable to meet the demands of the evolving threat environment, the F-2 is slated for retirement in the mid-2030s. Open reporting has indicated that Japan's Ministry of Defense has considered options such as: developing an indigenous stealth fighter with Mitsubishi Heavy Industries (based on the experimental X-2 program); partnering with a European consortium; and soliciting the U.S. defense industry. The Japanese government has received several responses to its request for information for the program, including one that proposes a fifth-generation F-22/F-35 based aircraft solution. This solution would merge and repurpose proven technologies (including the best attributes of the F-22 and F-35) and would leverage the strengths of both aircraft to provide the JASDF not just a viable fifth-generation F-2 replacement, but a highly capable aircraft that could meet and exceed the demands of Japan's evolving threat environment. At the same time, this aircraft would also bolster its domestic aerospace industry and provide capacity for future upgrades.

Repurposing the Proven Strengths of the F-22 and F-35

From an operational perspective, the value of this F-22/F-35 fifth-generation solution is in combining the proven strengths of both aircraft with enough room for novel modifications specifically designed to address Japan's unique threat environment. Conceptually, this approach would likely combine the prime advantages of both aircraft—all aspect stealth, superior aerodynamic performance, advanced automated sensors, and information fusion. For Japan's purposes, though, the attributes from the F-22 would include high-altitude operations, high Mach speeds (including supercruise), and high-performance fighter maneuverability with the use of thrust vectoring.

But Japan's security environment demands an aircraft with greater range to patrol the airspace over areas such as the Senkaku Islands. This would require significantly increased internal fuel volume via enlarged wings. While this would be a major modification, it would not be an unprecedented one. A larger wing design could be similar to the fighter-bomber variant of the F-22 studied by the Raptor's manufacturer Lockheed Martin as far back as 2002—but never built. While the large delta-like wing design slightly decreased the maximum G-force limits of the airframe, it provided significant benefits that outweighed the performance tradeoffs, most notably reducing the need for aerial refueling. This design retained the fuselage mold lines of the F-22, and by adding only a large wing, the concept aimed to limit cost growth, increase payload, and even enhance the VLO signature of the aircraft. Although the "FB-22" design concept was intended as a regional bomber for the U.S. Air Force, adapting this design for Japan's long-range air dominance mission could provide dramatic benefits, and afford it the opportunity to increase the internal and external payload of the planned F-2 replacement aircraft. [54]

The standard air-to-air load-out for an F-22 is six medium range radar-guided missiles (MRMs) in the main internal weapons bays and two short-range missiles (SRMs), one on each side bay. For an air-to-ground mission, an F-22 could carry up to eight GBU-39 small diameter bombs (SDB) with two SRMs in the side bays. Accommodating a

Figure 7: A larger wing design of the F-22 Raptor was studied as a fighter-bomber variant by Lockheed Martin as far back as 2002.

larger wing design would require the redesign of the mid and aft fuselage structure of the aircraft, however, which would afford the opportunity to extend the side bays. This modification would also allow the modification of the main weapons bay doors to accommodate larger weapons. These modifications would allow the new aircraft to carry up to eight MRMs internally, or carry anti-ship missiles in the main bays. The larger wing variant could also carry stealthy, faceted wing-mounted pods to double MRM capacity, or double the number of SDBs that could be carried in a stealth configuration (for example, the FB-22 proposal, with its larger wing, was slated to carry as many as 35 SDBs).[55] Such a deep magazine would have significantly more capacity than any fourth-generation fighter.

What will ultimately matter in the Asia-Pacific theater will be an aircraft's range and ability to stay engaged in the fight. This is perhaps the most important set of attributes that a big wing fifth-generation aircraft would bring to a F-2 replacement solution—its range and ability to stay on station. The combat radius for a standard F-22, depending on the flight profile, ranges between 400 and 600 nautical miles (nmi)—just under the distance from the Chinese coast to Japan. A big wing fifth-generation fighter aircraft could double those combat ranges. The increased fuel capacity of "wet wings" (integral fuel tanks in the wings) could also provide for long duration air combat patrols. Quick calculations of fuel burn rates suggest that a big wing aircraft could offer over two hours of loiter time at distances approximating standard F-22 maximum ranges. With distances between the coast of China to Japan between 400 to 800 nmi, such range or loiter times would give Japanese air defenses flexibility in their operations. Whether expanding defense areas, extending combat air patrol times, or decreasing aerial refueling requirements, large internal fuel reserves make the most of available aircraft. While stealthy wing pods might degrade the overall signature to a degree, the combination of increased magazine, range, and comparable stealth would be a dramatic advantage over not just any fourth-generation fighter, but certainly any Chinese or Russian stealth fighter.

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Despite its larger wing, maintaining the F-22 fuselage would allow a large-wing fifth-generation aircraft to likely meet or exceed the VLO signature of the standard F-22. Without horizontal slabs (the tail surface) to reflect radar energy, the large delta wing might actually decrease the overall signature of the proposed aircraft. When studying the delta wing FB-22 concept, Lockheed Martin discovered that the FB-22 would in fact be stealthier than the F/A-22.[56] A "new" F-2 replacement aircraft with a similar wing could also benefit from F-35 skins and coatings that are now significantly more rugged, radar-attenuating, durable, repairable, and absorbent than those used on the original F-22. Designed to withstand corrosive sea air for the U.S. Marine Corps' F-35B model and the U.S. Navy's C model, F-35 low-observable materials on the F-22 shape would provide a substantially enhanced effect on the durable signature of this F-22/F-35 based solution.

An F-2 replacement aircraft utilizing a modified F-22 fuselage, a larger delta wing, and F-35 skin and coatings would provide unprecedented survivability in the threat environment Japan faces. But increased lethality will also come from the advanced, integrated sensors and fused processing that support state-of-the-art weapons on this aircraft. F-22 avionics, as leading-edge as they still are, no longer represent the newest state-of-the-art. The F-35 has significantly surpassed F-22 informational capabilities in sensors, avionics, data links, fusion processing, and presentation since the last Raptor rolled off the assembly line in December 2011. The F-2 replacement solution should include not only F-35-derived mission sensors and systems, but also the F-35's now-proven integrated processing system and fusion engine. This will help save development costs and accelerate fielding in order to meet a growing pacing threat from China.

Like the F-35, an advanced active electronically scanned array (AESA) radar on this proposed solution would have passive and active modes, and more powerful and effective electronic attack and electronic protection capabilities than any legacy aircraft. This F-2 replacement should also have IR systems to work with radio frequency (RF) sensors for target detection and tracking. The F-35 has a distributed aperture system (DAS), a 360-degree spherical scene created from IR sensors, to aid the pilot in dynamic targeting while still being able to manage their signature presentation. Similarly, the electro-optical targeting system (EOTS) provides the IR scene in a different wavelength for passive target detection and tracking, and to support laser-guided weapons. And of course, the new aircraft should have high-speed LPI/LPD data links to facilitate interoperability with other Japanese and allied systems to build the battlespace awareness necessary for decision superiority. All this, like the F-35, displayed on an intuitive and interactive screen that dramatically increases decision superiority and combat effectiveness. Advanced, automated sensors, with integrated avionics, and fusion processing could make this F-22/F-35 based solution an extraordinarily connected and capable asset in any battlespace, wired for eventual connectivity to the combat cloud.

An F-2 replacement solution, that repurposes the best of both F-22 and F-35, will be tailored to the needs of Japan's air defense requirements and the threat environment. Sensors and avionics derived from the F-35 will not only ensure the most advanced capabilities are available to the Japan Self-Defense Forces, but deliberately deriving such systems will provide benefits and efficiencies beyond operational missions.

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Practical Efficiencies of the F-22/F-35 Replacement Solution for Japan

Because the F-35 production and final assembly lines and extensive supply chains are already operating at nearly maximum rate, and these aircraft are now entering the JASDF inventory, there are many practical efficiencies that would be gained from replacing the F-2 with a solution that shares some of the same technologies and components that made the F-22 and F-35 successful. Industrial and economic dynamics suggest that an F-2 replacement solution, based on mature designs with a current production line and supply chain, could deliver capability much sooner and more reliably than other options. Furthermore, commonalities between the F-35 and the proposed F-2 replacement aircraft could deliver benefits in areas ranging from maintenance and logistics to modernization and training.

The F-35 production line in Fort Worth, Texas will soon be operating at near-peak capacity, and should continue to do so well into the 2030s. This rate will drive the aircraft's supply chains to produce the best cost-per-unit outcomes. Sensors, avionics, or any other systems slated for the F-2 replacement that share some commonality with the F-35 should benefit from these cost efficiencies, and provide leading-edge capabilities for the most reasonable cost. Given the sheer size of the F-35 fleet worldwide (which only continues to grow), parts, logistics, and sustainment of Japan's F-2 replacement aircraft should likewise benefit. Amortizing the cost of supplies across the Japanese and global inventory of F-35s would avoid the many problems associated with small, unique fleets. The benefits of sharing deep similarities between the F-35 and the proposed F-2 replacement aircraft go beyond just the supply chain, since maintenance practices would likely also share many commonalities. Benefits might also be found in maintenance training and increasing the proficiency of personnel due to similarities between the two aircraft systems.

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Leveraging the substantial investment made in the research and development of F-35 systems, sensors, and software lowers the overall risk to the proposed F-2 replacement. There is no reason why a Japanese F-22/F-35 based solution should not take as much advantage as possible of the groundwork that has already been completed by the F-35 program in technology development, which would see an F-2 replacement aircraft fielded more quickly than a wholly new platform. Where elements of Japan's solution may differ from the F-35, risk can be minimized and managed by transferring best practices, lessons learned, and creating solutions that are similar in approach. Modernization and upgrades to the new aircraft's systems would also be part of the larger modernization dynamic. As the capabilities of the broader F-35 fleet advance, there might be opportunities for both Japan's F-35s and its F-2 replacements to incorporate select upgrades. Amortizing these costs across the entire F-35 program would ensure that Japan would always have the most advanced capabilities possible, without shouldering the burden of development alone.

Figure 8: The F-35 production line at Lockheed Martin's facility in Fort Worth, TX. The investments made in the development of the F-35 will pay dividends by lowering the overall risk to a proposed F-2 replacement aircraft.

Sensors and software technologies are not the only areas where Japan could take advantage of matured research and development efforts. Clearly, the shaping of the F-22 main body, engine intakes and ducting, the F119 engines themselves, thrust vectoring, and flight controls could be leveraged or repurposed in an F-2 replacement aircraft. Importantly, the low observable skins and coatings from the F-35 would be part of this solution. It is difficult to stress how revolutionary these technologies and materials are in radar attenuation and absorption, and how practical and durable they are compared to the materials used in first-generation stealth aircraft decades ago, such as the F-117.

From a size, weight, power, and cost (SWaP-C) perspective, it is useful to note that the advancements made in the F-35 program have yielded smaller, less power-intensive systems. The size of the F-22 mission system storage bays, optimized to accommodate older avionics and hardware, could easily accommodate this newer technology while also allowing room for further growth and addition of new systems. It is simply a matter of new technology affording a greater return in a smaller physical package.

In looking at the relevant physical structures derived from the F-22, the tooling for major assembly construction still exists, and nuanced construction knowledge was documented and archived in video format prior to the end of the production line.[57] The 2010 National Defense Authorization Act specifically directed that steps be taken to allow for the reopening of the production line, should events warrant. It states:

The Secretary of the Air Force shall develop a plan for the preservation and storage of unique tooling related to the production of hardware and end items for F–22 fighter aircraft. The plan shall—(1) ensure that the Secretary preserves and stores required tooling in a manner that—(A) allows the production of such hardware and end items to be restarted after a period of idleness. ...[58]

The tooling for the F-22 alone, an estimated 30,000 items used by prime contractors Lockheed Martin, the Boeing Company, and Pratt and Whitney, represents between two and three billion dollars' worth of investment by the U.S. government, major elements of which would assist in a fifth-generation F-2 replacement aircraft production program.[59]

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It should follow that a F-2 replacement solution, that leverages the F-22 and F-35, would provide the most advanced capability for Japan at an affordable development cost. Specifically adapted to meet the unique threat environment of the Asia-Pacific region, it would deliver the high-end performance, survivability, and lethality necessary to deter and counter Chinese aggression while also being the lowest-risk solution, especially when compared with alternatives. Given that the U.S. no longer produces the F-22 and there would be few other competing international workshare agreements to satisfy, most of this new aircraft's airframe components could be produced wherever the Japanese government deemed most sensible. This could see major high-tech production efforts come to Japan. With the F-22 tooling already in existence, this effort holds the potential to be a quick-turn modernization program relative to a new-start aircraft.

Figure 9: The final F-22 Raptor rolls off of the assembly line at Lockheed Martin's Marietta, GA facility on December 13, 2011. Though the fighter production line is now closed, the tooling still exists along with documented and archived technical data and construction knowledge. Major elements of these resources can support an F-2 replacement program.

Japan's Plan B Options

Looking past a proposed F-22/F-35 based aircraft as a potential F-2 replacement, Japan has several options to consider. But each has drawbacks, such as capability, cost, risk, and procurement schedule concerns.

Japan could continue procuring fourth-generation aircraft in the form of a new-build F-15, upgraded F-2, or Eurofighter Typhoon tailored to Japan's specific requirements. However, even if these aircraft are upgraded with combat cloud-capable sensors, processing power, and modern data links, they lack the organic stealth design necessary to ensure survivability in the threat environment future Japanese combat pilots are likely to encounter. Nor would these aircraft be inexpensive. Given that the majority of aircraft cost lies in mission systems, not physical structures, a sensor or mission system computer is just as expensive whether it is bolted to a stealthy or non-stealthy aircraft. It makes little sense to procure a legacy fighter that will be challenged to execute a mission in an advanced A2/AD threat environment and return home safe. This also would drive significant cost growth in the form of a bigger attrition inventory, and a necessarily larger pool of pilots, given expected losses. Finally, there is the technological competition aspect of the problem. Does Japan really want to invest in fourth-generation aircraft if its main pacing adversary, China, is already seeking to field two fifth-generation fighters—specifically, the J-20 and J-31? Japan will always be challenged due to the raw force structure numbers, should it ever face China in an overt, high-end conflict. Its main advantage though will come down to advanced technology and its alliance with the U.S. This is where leveraging and adapting leading, proven fifth-generation systems will yield significant value. It is also the key ingredient necessary to credibly deter Chinese aggression.

Japan will always be challenged due to the raw force structure numbers, should it ever face China in an overt, high-end conflict. Its main advantage though will come down to advanced technology and its alliance with the U.S.

Beyond current, proven fourth-generation aircraft, Japan could also opt to align with European nations seeking to develop their own next-generation designs, with the United Kingdom and a Franco-German effort offering obvious partnership opportunities.[60] While both endeavors could yield promising aircraft, there are a few important factors the Japanese should consider. First, these are both concepts at present, either on paper or in mockup form. No prototypes of future fighter concepts have yet flown, no production lines exist, and the political support necessary to see these aircraft through to outright production is a hurdle that must be continually addressed through shifting political landscapes. As with any new aircraft design, especially one that will see both teams work with technologies like stealth for the first time, technologically-driven delays and associated cost growth are near certainties.

There are also workshare variables. A guiding principle with almost any European defense project is the need to retain as much work between the core partners as possible. Japan would almost always be a minority stakeholder in such a balance compared to the largely unilateral production share it could structure for a proposed F-22/F-35 based aircraft. One only need look at the history of Airbus' A400 transport or the Typhoon fighter. Design factors, integration concerns, and team coordination have proven to be second-rate priorities often when it comes to European defense programs, versus maintaining a balanced workshare agreement for the sake of political equities. This also explains a great deal why both aircraft have retained a price tag far and above their competitors.[61]

In one of the most recent international sales for the F-35 program, which saw Belgium purchase the fighter, government leaders signaled the fifth-generation aircraft offered a cost advantage over the legacy European-built Typhoon.[62] This is a powerful statement about the advantages afforded by a system offering performance and cost as its key drivers, without political workshare variables adding complexity to the design, development, and production equation. While the Japanese could certainly opt to partner with one of the European next-generation development efforts, it would not be a prudent expectation to plan on getting operational jets on the ramp any time soon—and a wide margin for cost growth should be anticipated. Given that China is fielding the J-20 and J-31 today, this course of action would be a large gamble. The threat environment Japan faces does not allow the luxury of time.

Conclusion: Next-Generation Airpower in the Asia-Pacific

As Japan considers its F-2 replacement options, one aspect of the challenge is clear: fifth-generation technology is vitally linked to empowering its security imperatives for the foreseeable future. The United States pioneered this new technological domain, and nations like Russia and China are rapidly seeking to close this gap. As one of the United States' closest treaty allies in the Asia-Pacific, Japan has the opportunity to fully leverage this significant technological and operational advantage. The attributes of low observability, sensors, processing power, and maneuverability cannot be effectively federated. Full benefit can only be achieved by integrating these advantages into a single aircraft. Focusing on one or two attributes in the absence of others simply risks expending considerable resources on an aircraft that will fall short in modern combat, likely failing to survive in modern threat environments against A2/AD weapon systems. When facing an adversary with disproportionally more abundant resources like China, reverting to a war of attrition is unsustainable.

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When assessing the future, the picture becomes very clear from Japan's perspective. It faces very real threats for which leaders have to develop highly credible courses of action within fiscal realities. Cost effective investment in proven fifth-generation fighter technology will be crucial to achieving success. The economic advantages of pursuing a replacement aircraft that leverages and repurposes proven F-22 and F-35 technologies and components for the F-2 would allow Japan to focus available resources on putting fighters onto ramps as soon as possible, not long-term development goals attempting to reinvent technology that could readily be available via the United States.

The opportunity for Japan to harness a solution that repurposes and improves upon the proven technologies and components of the F-22 and F-35 reduces risk from a technological development, schedule, and cost perspective. If successful, this aircraft secures a significant strategic advantage for Japan as well—especially given China's recent progress with fifth-generation aircraft technology. A successful F-2 replacement aircraft in this vein would empower seamless integration with U.S. and allied air forces who operate the F-22 and F-35. This is a solution that offers a leap in advantage. It will set the bar high for airpower capability in the Asia-Pacific for decades into the future.

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