CSBA

Backgrounder

STRATEGY FOR THE LONG HAUL

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THE F-22 PROGRAM IN RETROSPECT

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Overview

It now appears likely that F-22 production will end with a procurement of 187 Raptors, of which 179 will be operational aircraft.[1] The crucial moment came on July 21st, 2009, when the full Senate voted fifty-eight to forty to strip the $1.75 billion Senate defense authorizers had added to the Fiscal Year (FY) 2010 defense bill to keep F-22 in production.[2] This vote came in the wake of intense lobbying by defense secretary Robert Gates and a veto threat from the White House should Congress continue F-22 production beyond FY 2009. In light of these developments, now seems as good a time as any to look back and try to take stock of the F-22 program. Are there any lessons to be learned, and where, if anywhere, is the program likely to go from here?

This paper first reviews the F-22 acquisition program, focusing on the cost increases and schedule slippages that, over time, led to the buy quantity to drop from 750 to 187. It is now almost certain that the US buy will end at 187 F-22s, of which around 130 will be combat-coded. This procurement quantity has been determined more by budget constraints on the F-22 program than by operational requirements. This means that the Defense Department is, in effect, accepting high risk to its future ability to achieve the rapid air dominance that has been central to the American way of war since the Korean conflict.

The main sources of this risk stem from emerging anti-access/area-denial capabilities that, in the case of the People's Republic of China, include ballistic missiles capable of delivering conventional warheads and submunitions accurately against forward US airbases such as Kadena on Okinawa, thereby forcing US forces to operate from as far east as Guam. Further, on the area-denial side of this growing challenge to US power projection, Russia's commitment to developing and selling abroad surface-to-air missile (SAM) systems such as the S-300 and S-400 argues that US-PRC and US-Russia conflicts are not the only future scenarios in which US air dominance could be seriously challenged. The ability of anyone to forecast US requirements for air superiority as far out into the future as the F-22 is

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1 The total of 187 F-22s includes two previously procured EMD (Engineering Manufacturing Development) funded in RDT&E (Research, Development, Test and Evaluation), six Production Representative Test Vehicle (PRTV) II aircraft, and four additional production aircraft in the Fiscal Year 2009 supplemental request.

2 "Senate Drops F-22 Funding," *AIR FORCE Magazine* Daily Report, July 21, 2009, at <http://www.airforcemagazine.com/DRArchive/Pages/2009/July%202009/July%2021%202009/SenateDropsF-22Funding.aspx>.

422nd Test & Evaluation Squadron F-22 at Nellis Air Force Base (Lockheed Martin Photo)

likely to remain in service is limited at best. The fact is that proliferation of S-300 SAMs is already well underway and foreign sales of Su-35s and S-400s to any country with the cash to buy them are probably just a matter of time.

Secretary of Defense Robert Gates proposes to offset the risk of the truncated F-22 procurement by banking on the F-35 Joint Strike Fighter (JSF) to be fielded in large numbers by the US Air Force, Navy, and Marine Corps (2,443 JSFs total), as well as by close allies such as Britain and Australia. History is not encouraging, however. Since the development of the F-117 began, the Defense Department has invested in four programs that initially planned to field nearly 2,800 all-aspect low-observables (LO) combat aircraft. If US F-22 production does end at 187 planes, the total actually fielded from these four programs will end up being only 267 F-117s, B-2s, and F-22s. Thus, whether or not the United States fields significant numbers of so-called 5th-generation combat aircraft—a category currently limited to the F-22 and the JSF—hinges on the F-35 program proving to be a startling exception to past US developments of all-aspect LO aircraft.

Will 187 Raptors be the end of F-22 production? Not necessarily. The Japanese have expressed interest in fielding some Raptors, and Japanese procurement of forty to sixty aircraft would go far to bolster Japan's ability to deter a belligerent North Korea and other prospective security challenges in Northeast Asia. Currently, though, there is a Congressional prohibition against selling F-22s to foreign governments, even to those of close allies. This legislative restriction would have to be lifted for Japan to acquire F-22s, and the Japanese would have to find the funding for such an acquisition. Nevertheless, pursuing overseas F-22 buys that would build partner capacity is an opportunity that the United States should surely pursue.

Cost, Schedule, and Quantity

Even before the Air Force selected Lockheed's YF-22 prototype to be the successor to the F-15 air superiority fighter, cost growth had become an issue in what was then the demonstration-and-validation (Dem/Val) phase of the Advanced Tactical Fighter (ATF) competition between Lockheed (today Lockheed Martin) and Northrop (now Northrop Grumman). In February 1991, the Government Accounting [now Accountability] Office (GAO) reported that inflation, program changes, and adjustments in labor-rate and material costs had increased the projected program cost from $79.5 billion to $103.7 billion.[3] Over time, as the planned buy dropped from the 750 F-22s originally envisioned to less than 200, program-unit costs ballooned to over $350 million per F-22 because the large research, development, test and evaluation (RDT&E) investment—over $24.3 billion[4]—had to be allocated to fewer and fewer aircraft. However, even the unit flyaway cost, which excludes RDT&E, grew substantially. In 1988 the ATF program office established a flyaway unit-cost goal of $35 million per plane in FY 1985 dollars, or roughly $60 million in FY 2009 dollars. As of May 2009, the average flyaway unit cost for 175 production F-22s had grown to $158.8 million.[5] Schedule fared no better in the case of the F-22. The Dem/Val phase, which funded the Lockheed/Boeing/General Dynamics and Northrop/McDonnell Douglas teams to develop two flying prototypes each, began in 1986. The Air Force finally declared initial operational capability (IOC) with the 27th Fighter Squadron at Langley Air Force Base (AFB), Virginia, in December 2005, almost two decades later.

Suffice it to say, the ATF/F-22 development was not exactly a model acquisition program. The program, of course, faced the considerable technical challenges of designing a stealthy, but highly agile fighter that could fight and survive in the daytime as readily as at night. Both the F-117 and B-2 had been basically "bomb trucks" that only operated in enemy airspace at night due to the threat of visual acquisition by enemy fighters. The Air Force's emphasis on incorporating every available state-of-the-art technology into the F-22 also tended to affect cost and schedule adversely. Also, due to the F-22's long gestation period, some elements of the design have required modernization even as the plane was still in production. And the Air Force's single-minded drive to get as many Raptors "on the ramp" as possible inevitably led the Service to neglect other worthy acquisition programs as F-22 costs grew and IOC slipped.

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The Air Force itself probably deserves the lion's share of the responsibility for the Raptor's cost and schedule difficulties. However both the Office of the Secretary of Defense (OSD) and Congress made significant contributions to cost growth and schedule slippage,

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3 GAO, "Aircraft Development: Reasons for Recent Cost Growth in the Advanced Tactical Fighter Program," GAO/NSIAD-91-138, February 1991, p. 1.

4 The total of $24.3 billion is for F-22 RTD&E in Program Element 0604239F only (U.S. Air Force, SAF/FMB, "Committee Staff Procurement Backup Book: FY 2010 Budget Estimates, Research, Development, Test and Evaluation (RDT&E), Descriptive Summaries," Vol. 3, May 2009, p. 150).

5 US Air Force, SAF/FMB, "Committee Staff Procurement Backup Book: Fiscal Year (FY) 2010 Budget Estimates, Aircraft Procurement, Air Force," Vol. 1, May 2009, P-40 No. 3, p. 1. The average weapon-system unit cost for 175 production F-22s in this document is $192.3 million (ibid.).

starting with (then) defense secretary Dick Cheney's decisions in April 1990 to delay F-22 production two years to FY 1996 and cut the peak production rate from seventy-two to forty-eight planes per year.[6] It is also worth remembering that the F-22 had the misfortune of entering full-scale engineering development in 1991, the same year as the first Persian Gulf War (Operation Desert Storm) and the collapse of the Soviet Union. The program, therefore, was confronted almost immediately with tectonic changes in the international security environment. Finally, the US Navy, which originally planned to buy over six hundred carrier versions of the ATF, eventually dropped out of the program, reducing the total buy by 45 percent.

One Hundred and Thirty Versus Operational Requirements and Long-Term Risk

Given the unfortunate acquisition history of the F-22 together with staunch opposition to further production from Secretary Gates and acquiescence by Air Force leaders, there is good reason to suspect that the Senate's July 2009 vote against further production will stand, ending the buy at 187 aircraft. When the last F-22s are delivered in 2012, about 130 in seven squadrons are now planned to be combat-coded and available for operations. Thus the F-22 fleet will have been sized primarily as a consequence of fiscal constraints on the production part of the program rather than by future US operational requirements for air superiority. The pivotal budgetary decision came in December 2004 when OSD cut $10.473 billion from the F-22 program, reducing the buy at that time to 179 aircraft.[7] Granted, there was some later backtracking. In the February 2006, the *Quadrennial Defense Review Report* directed that the F-22 program be restructured to extend production through FY 2010 with a multi-year contract to "ensure the Department does not have a gap in 5th generation stealth capabilities" for air dominance.[8] It now appears that this direction will end up adding four more production aircraft, bringing the final buy to 179 operational aircraft.

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Is there any clear linkage between this outcome and potential operational requirements? Based on the United States fighting two major regional contingencies (MRCs, or Major Combat Operations, MCOs) near simultaneously against high-end adversaries able to contest air superiority, the Air Force has long argued that the minimum buy for a low-risk F-22 force is 381 aircraft. Among other things, this total would allow the Air Force to equip each of its ten air expeditionary forces with a 24-aircraft F-22 squadron (plus two operational spares) and have ample additional planes for pilot transition training into the F-22 (the "school house"), the weapons school and operational test squadron at Nellis Air Force Base (AFB) in Nevada, depot maintenance, further developmental work, and, most importantly, attrition. To date, two F-22s have been lost in accidents, and the Raptor's

6 Office of Assistant Secretary of Defense (Public Affairs), "Cheney Cuts Major Pentagon Aircraft Buys," news release, April 26, 1990, p. 4.
7 OSD, "Program Budget Decision No. 753," December 23, 2004, p. 9.
8 Department of Defense, *Quadrennial Defense Review Report*, February 6, 2006, p. 46.

service life could very well extend through mid-century.[9] Consequently, as recently as mid-July 2009, the chief of the Air Force's Air Combat Command, General John Corley, reiterated that 381 F-22s is the minimum for a low-risk force, even though commitment to the two-MRC force-sizing criterion inherited from defense secretary Les Aspin appears to be waning.[10]

By the spring of 2009, however, the Air Force secretary and chief of staff had acceded to capping the F-22 buy at 179 production aircraft. On April 6, 2009, Secretary Gates announced his decision to recommend to President Obama that F-22 production be ended with the FY 2009 increment.[11] One week later, Air Force Secretary Michael Donley and Chief of Staff General Norton Schwartz explained in *The Washington Post* that although a buy of 243 F-22s would provide a moderate-risk force, buying sixty more Raptors would create an unfunded $13 billion bill and prevent the Air Force from funding other capabilities critical to ongoing joint operations.[12] Thus, based on the assumption that the F-35 Joint Strike Fighter program moved ahead successfully, Donley and Schwartz were willing to endorse Gates' decision to end F-22 production at 187 aircraft.

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These choices will leave the United States with, at best, a high-risk F-22 force. A glimpse of what "high-risk" might mean can be found in a 2008 RAND Corporation study that explored, among other things, 2020 scenarios in which the United States sought to achieve air dominance over the Taiwan Strait against the People's Republic of China (PRC). The analysis assumed that all 130 combat-coded F-22s were committed to the conflict. Unfortunately, since 1996 the PRC has been investing in a range of anti-access/area-denial capabilities, including the ability of the 2nd Artillery Corps to deny US forces the ability to operate from forward bases such as Kadena AFB on the island of Okinawa.[13] Kadena, after all, only has fifteen hardened shelters, and a saturation attack with as few as thirty-four CSS-6 ballistic missiles, each delivering 750 1.1-pound bomblets similar to those used as area submunitions by the US Army Tactical Missile System (ATACMS), could, theoretically, hit all the aircraft on Kadena's parking ramps.[14]

Given this growing PRC capability to deny US forces the use of bases such as Kadena, RAND's 2008 analysis considered scenarios in which the F-22 force had to operate from Andersen AFB on Guam, which is outside the reach of missiles like the CSS-6. Given the long distance of the Taiwan Strait from Guam, RAND calculated that the PRC's projected

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9 The first F-22 loss in 2004 was a PRTV II bird, whereas the second, in 2009, was a production aircraft.

10 William Matthews, "Senate F-22 Foes Outnumbered But Still Fighting," *Defense News*, July 14, 2009, online at <http://www.defensenews.com/story.php?i=4187281 >.

11 Robert M. Gates, "Budget Press Briefing (Arlington, VA)," as prepared for delivery, April 6, 2009, online at <http://www.defenselink.mil/speeches/speech.aspx?speechid=1341>.

12 Michael Donley and Norton Schwartz, "Moving Beyond the F-22," *The Washington Post*, April 13, 2009, p. A12. The estimate of $13 billion for 60 more F-22s yields an average unit price of $217 million per plane.

13 OSD, "Annual Report to Congress: Military Power of the People's Republic of China 2009," 2009, pp. 20–21.

14 John Stillion, "Fighting Under Missile Attack," *AIR FORCE Magazine*, August 2009, pp. 35–36.

inventory of advanced Flanker fighters could generate some 1,300 sorties per day over the strait whereas the entire F-22 force could only mount around 140, giving the People's Liberation Army Air Force (PLAAF) an average nine-to-one numerical advantage.[15] The upshot was that even assuming the F-22s over the strait would be able to shoot down significant numbers of opposing PLAAF Flankers without losses even when heavily outnumbered, by the time the F-22s ran out of missiles and fuel, enough Flankers were still available to begin attacking high-value assets such as air refueling tankers and E-3 AWACS (Airborne Warning and Control System) aircraft. As a result, F-22s were lost not due to being shot down by PLAAF fighters but because they could not rendezvous with tankers to get the fuel to make it back to Guam.[16]

Many will view the United States-PRC scenario that produced this outcome as extremely unlikely. Indeed, Secretary Gates has argued that while the F-22 "is clearly a capability we do need," it is only needed "for one or two potential scenarios," namely those involving "the defeat of a highly advanced enemy fighter fleet." Judging such scenarios to be extremely few and far between, his conclusion is that if the JSF can be fielded on time and on cost, the risk of not having enough F-22s for such conflicts is minimal.[17] Indeed, in the case of the PRC, Gates projects that in 2020 the United States will have nearly 1,100 F-22s and F-35s, whereas the PLAAF will have no 5th-generation fighters, and by 2025 this gap will only widen.[18] Moreover, the PRC seems to be making sufficient, if gradual, progress toward bringing Taiwan under Beijing's control to provide little incentive to hasten reunification by resorting to the overt use of military force. Still, the RAND analysis does illustrate the potential risk inherent in terminating the F-22 buy at 187 aircraft as well as the importance of the JSF program moving ahead without major delays or cost growth. It also gives rise to the suspicion that it might not have been prudent to terminate F-22 production until there was solid evidence that the F-35 would not going to encounter major delays, cost increases, or related developmental problems.

The Uncertainty of the Future

The risk Gates, Donley and Schwartz appear to be taking in betting future US air dominance on the F-35 "in the bush," rather than on the F-22 "in the hand," becomes clearer when one considers the uncertainty of the future together with the opportunities being foreclosed by terminating the F-22 program in FY 2010. Consider, first, just how unpredictable the future course of events in international affairs or warfare really is. The disappearance of the Soviet Union's external empire and the collapse of the Soviet Union itself from 1989 to 1991 are a case in point. Very few in the West, or anywhere else, predicted what happened in any detail. One partial exception is Peter Schwartz, who has argued that, in 1983, he was able to use scenario analysis to foresee the collapse of the

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15 John Stillion and Scott Perdue, "Air Combat Past, Present and Future," Project Air Force briefing, August 2008, Unclassified/FOUO/Sensitive, Slide 29. Despite the FOUO (For Official Use Only) caveat on this briefing, it has been circulated over the Internet.

16 Stillion and Perdue, "Air Combat Past, Present and Future," Slide 50.

17 Robert M. Gates, speech delivered to the Economic Club of Chicago, July 16, 2009, online at <http://www.defenselink.mil/speeches/speech.aspx?speechid=1369>.

18 Gates, speech delivered to the Economic Club of Chicago.

Soviet Union if Mikhail Gorbachev came to power.[19] But even Schwartz did not predict the relatively bloodless way in which the Soviet regime unraveled, or the speed and precise timing with which that unraveling occurred. What he really predicted was that if Gorbachev came to power, *perestroika* and *glasnost* would lead to "massive economic and political restructuring," a reduction in East-West tensions, and "major shifts in international relationships."[20] Similarly, who predicted during the 1990s that the United States would invade Afghanistan in 2001 and overthrow Saddam Hussein's regime in Iraq in 2003? To paraphrase an Arab proverb, predictions of the future are lies even when they turn out to be accurate.[21]

Second, Gates' assertion that 187 F-22s (130 combat-coded) will suffice through mid-century is the sort of prediction about the future that can never be made with confidence. The future is simply too uncertain to be sure that Gates is right. Yet he is betting heavily on the accuracy of his prediction while precluding the possibility of overseas sales to close US allies, starting with the Japanese. Particularly questionable is his insistence that the F-22 only has value in one or two low-probability scenarios.

It is certainly possible that US military forces will neither confront nor fight Russian or Chinese military forces during the service life of the F-22. But that is not the end of the story. Both Russia's Sukhoi design bureau and the Russian Aircraft Corporation "MiG" are reportedly trying to develop a 5th-generation fighter comparable to the F-22. Sukhoi appears to be ahead. In July 2008, Russian Air Force commander Colonel-General Alexander Zelin

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19 Peter Schwartz, *The Art of the Long View: Planning for the Future in an Uncertain World* (New York: Doubleday, 1991), pp. 58-59, 64-65.

20 Schwartz, *The Art of the Long View*, pp. 37, 58.

21 The actual Arab proverb is: "He who predicts the future lies, even if he tells the truth." I first heard this proverb during a 2007 presentation on business strategy by Richard Rumelt of the Anderson School of Management at the University of California Los Angeles. Rumelt, in turn, got the proverb from Royal Dutch/Shell's famous scenario planner Pierre Wack.

S-400 Transport Erector Launcher, Moscow, May 2009 (Released into the public domain by the author, UMNICK)

stated that first flight of Sukhoi's PAK FA [*Perspektivnyi Aviatsionnyi Kompleks Frontovoi Aviatsyi*] would occur in 2009.[22] It is very likely that event will be delayed. Since 2004, the Russian aircraft industry has been saddled with heavy debt even though state funding has increased twentyfold.[23] However, during a meeting at Zhukovsky Air Base outside Moscow on August 18, 2009, Prime Minister Vladimir Putin stated that "the 5th-generation military aircraft project will receive full funding," and emphasized that work on the PAK FA "is one of our priorities."[24] The likelihood, therefore, is that, in the long run, the Russians will develop a 5th-generation fighter to compete with the F-22 and F-35.

When they do, moreover, there is every reason to think that variants will be sold to any country willing to pay for the airplane. The prospect of US forces one day facing Russian- or Chinese-designed 5th-generation fighters in air combat, then, is not limited to conflict scenarios against Russia or the PRC. The same is true of advanced, long-range surface-to-air missiles such as the Russian S-300 Favorit and S-400 Triumf SAMs.[25] The F-22's ability to cruise at high altitudes at Mach 1.5 or above without engaging fuel-guzzling afterburners (supercruise) and low-observability, combined with the Small Diameter Bomb (SDB), make the Raptor the US aircraft most capable of surviving inside the engagement envelopes of these lethal SAMs, or even directly attacking them. Again, though, the Russian inclination to sell S-300 and S-400 systems to any country willing to pay for them means that they could show up in more conflict scenarios than those in which US forces fight either Russian or PRC forces.[26]

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Technical Performance versus Situation Awareness

What other capabilities does the F-22 uniquely provide? The argument has been repeatedly made that the F-22 is a "Cold War relic" designed to "combat a force of advanced Soviet fighter jets that never materialized."[27] True, funding limitations have limited Russian

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22 "PAK FA [*Perspektivnyi Aviatsionnyi Kompleks Frontovoi Aviatsyi*]," Global Security, online at <http://www.globalsecurity.org/military/world/russia/pak-fa.htm>, information as of September 11, 2008, downloaded August 18, 2009.

23 "Aviation Industry Will Drop 'Toxic' Ballast," Interfax, August 18, 2009, online at <http://www.ifx.ru/txt.asp?rbr=1495&id=1255375>, trans. Natalya Anfilofyeva. Sukhoi did enter into a joint venture with India to develop a 5th-generation fighter in 2007, and the Israelis have apparently talked to the Russian Aircraft Corporation "MiG."

24 "Aviation Industry Will Drop 'Toxic' Ballast," Interfax, trans. Natalya Anfilofyeva.

25 The 40N6 missile associated with SA-20/21 has an advertised engagement range of 215 nautical miles (nm), nearly an order-of-magnitude greater than that of the SA-2 used during the Vietnam War (Carlo Kopp, "Almaz S-300P/PT/PS/PMU/PMU-1/PMU-2, Almaz S-400 Triumf, SA-10/20/21 Grumble/Gargolye," March 2009, online at http://www.ausairpower.net/APA-Grumble-Gargoyle.html). Little is presently known about 40N6 missile other than it is intended to engage ISR (intelligence, surveillance, reconnaissance) platforms such as AWACS and the E-8 JSTARS (Joint Surveillance and Target Attack Radar System). The 48N6E3 missile that both the SA-10 and SA-20 can employ has an engagement range of 130 nm (ibid.),

26 For recent data on the proliferation of these SAMs, see Carlo Kopp, "Proliferation of Advanced Surface to Air Missiles," June 2009, online at <http://www.ausairpower.net/APA-S-300-Proliferation.html>.

27 "No More F-22s," *The Washington Post*, July 18, 2009, p. A14.

Su-35 "Super Flanker"Flight Test (source: Sukhoi) (http://www.sukhoi.org/enggallery/?gallery_id=56&cur_gallery_id=1116)

progress in recent years toward designing, much less fielding, a fighter with the all-aspect LO and other advanced capabilities of the F-22. Nevertheless, advanced Russian fighters that substantially outclass the F-15 have in fact materialized. The strongest competitor is the Sukhoi Flanker, variants of which have been exported to the PRC and India. The first country to receive Flankers after the Cold War ended was the PRC, and the PLAAF has imported two models in addition to the licensed manufacturing of around one hundred J-11 Flanker Bs.[28]

The latest Flanker variant in operational service, the Su-35 Super Flanker, incorporates fly-by-wire controls and two-dimensional thrust vectoring, which give the plane phenomenal maneuverability at any angle of attack. This upgrade of the Su-27 includes digital avionics and a "glass" cockpit with large programmable displays. The hybrid (gimbaled) but electronically scanned Irbis E radar can track up to thirty targets at a time and engage up to eight of them with active radar homing missiles.[29] In an air superiority role, the SU-35 can carry mixed loads of as many as fourteen active, passive, and infrared-guided air-to-air missiles. The F-15, by comparison, carries only eight air-to-air missiles, as does the F-22 in a stealthy configuration. Flankers are also equipped with infrared search and track systems not carried on US fighters, and the Russian fighter comes with a head-mounted sight for high-angle-off employment of infrared missiles when the engagement has evolved into a close-in dogfight. The engines, which use key components of the Al-41F core, make the Super Flanker the first non-US fighter with a substantial capability for sustained

[28] Carlo Kopp, "Sukhoi/KnAAPO Su-35BM/Su-35-1/Su-35S Flanker," Air Power Australia, last updated August 22, 2009, at <http://www.ausairpower.net/APA-Su-35S-Flanker.html>.

[29] Andre Fomin, "SU-35: A Step Away from the Fifth Generation," *Take-off*, June 2007, p. 49. Вэлет [*Take-off*] is Russia's national aerospace magazine.

supersonic cruise without afterburners.[30] The SU-35 has just entered service with Russian units, and a buy of sixty of these "4.5-generation" fighters is now planned.[31] Export sales are also anticipated, probably including the PRC. In light of the Su-35's technical features and performance, the Super Flanker is considered superior in technical performance to all fighters now in service except the 5th-generation F-22A Raptor.

Of course, there is more to gaining air superiority than the technical performance of opposing aircraft, their sensors, or their weaponry. Well-documented combat experience going back to the Vietnam War, tests such as the AMRAAM (Advanced Medium Range Air-to-Air Missile) Operational Unity Evaluation in the early 1980s, and extensive training experience at Red Flag and other exercises have confirmed, time and again, that the situation awareness (SA) of the aviators inside the cockpits has been the driver in engagement outcomes about 80 percent of the time.[32] The important point here is that the F-22 is the first US fighter in which pilot SA was given priority in the plane's design from the outset. Indeed, reflection on the F-22's better-known technical characteristics—all-aspect LO, supercruise, and avionics automation to lighten the pilot's workload—suggests that various technical features were integrated into the overall design to maximize the SA advantage of Raptor pilots over their adversaries.

The main reason for the F-22's astonishing dominance over 4th-generation F-15s and F-16s flown by some of the Air Force's top pilots, then, is SA. How dominant has the F-22 been in operational testing and training exercises? To cite one representative example, during Exercise Northern Edge in Alaska in 2006, F-22s achieve an exchange ratio of 108-to-zero despite being substantially outnumbered in the simulated air battles.[33] It is the SA superiority designed into the F-22 that has consistently enabled Raptor pilots to target and "kill" opposing fighters before their pilots had even been able to detect the F-22. Thus, the short answer to the question of what capabilities the F-22 uniquely provides—besides an ability to attack advanced SAMs—is an unprecedented superiority in SA over all other fighters flying today.

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A point recently emphasized by some opposed to F-22 production beyond 187 is that the plane has "never flown over Iraq or Afghanistan."[34] But ongoing US involvement in both

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30 Carlo Kopp, "The Flanker Fleet—The PLA's 'Big Stick'," International Assessment and Strategy Center, May 3, 2006, at <http://www.strategycenter.net/research/pubID.106/pub_detail.asp>.

31 "Russian Air Force Could Get 60 Su-Family Jet Fighters by 2015," RIA Novosti newswire, August 17, 2009, online at <http://en.rian.ru/mlitary_news/20090817/155831625.html>.

32 Barry D. Watts, *Six Decades of Guided Munitions and Battle Networks: Progress and Prospects* (Washington, DC: CSBA, 2007), pp. 45-53. Contrary to expectations when the F-15 was fielded, the plane has amassed a combat record of 96 kills of opposing fighters against zero losses in the hands of American, Israeli, and Saudi pilots. But the pilots in question were generally very well trained.

33 Staff Sgt. C. Todd Lopez, "F-22 Excels at Establishing Air Dominance," Air Force Print News, June 23, 2006, online at <http://www.af.mil/news/story.asp?storyID=123022371>. Of course, this degree of air-to-air dominance depends on F-22 "stealth" (minimal vulnerability) and beyond visual range (BVR) missiles (the AIM-120 AMRAAM) working "as advertised," thereby giving the Raptors the enormous advantage of "first look, first shot, first kill" (Stillion and Perdue, "Air Combat Past, Present and Future," Slides 4, 5, 53).

34 No More F-22s," p. A14.

countries ranges from counterinsurgency to stability, security, transition, and reconstruction (SSTR) operations, and the F-22 was obviously not designed for such operations. Using the F-22 in either conflict would have been massive overkill. Indeed, one suspects that the deployment of the F-22 to Iran or Afghanistan prior to Gates' recommendation to end production in April 2009 would have sparked a firestorm of criticism that the Air Force was misusing the aircraft in order to bolster the case for additional Raptors. And the critics would have had a point.

Trends the Fielding of All-Aspect LO Combat Aircraft

Since Lockheed's stealth fighter demonstrator program (HAVE BLUE) showed that the radar signature of fixed-wing aircraft could be reduced by orders of magnitude, the United States has fielded three combat aircraft with all-aspect LO designs: the F-117A, the B-2A, and the F-22A. In only one of these three programs, the F-117, were more operational aircraft built than initially envisioned. While the original F-117 plan was to build only twenty-five planes—five test vehicles and twenty production aircraft—a total of fifty-nine operational F-117s were eventually produced in addition to the test birds.[35] In the case of the B-2, the buy was originally 132 production aircraft for Strategic Air Command's nuclear bomber fleet. Secretary Cheney, however, cut the planned buy to seventy-five in 1990 as part of his major aircraft review, and in January 1992, after the Cold War had ended and the Soviet nuclear threat had largely vanished, President George H. W. Bush halted production at twenty B-2s. The ATF/F-22 program, like the B-2 development, started with a large planned buy: 750 for the Air Force and 618 carrier versions for the US Navy's carrier air wings. The Navy dropped out of the program in favor of an upgraded variant of the F/A-18 Hornet,[36] and the Air Force, it now appears, will end up with only 187 F-22s. Finally, the Navy's Advanced Tactical Aircraft (ATA) or A-12 program, which aimed at fielding an all-aspect LO successor to the A-6, also came to naught. Early planning anticipated a buy of 858 ATAs, for the Navy and Marine Corps plus another 400 for the Air Force. In the end, none were produced. The program was famously cancelled by Secretary Cheney in 1991, and, in the Navy's case, the F/A-18s have had to shoulder the missions of both the A-6 and the F-14.[37]

The US military has invested considerable money in developing four different all-aspect LO combat aircraft. However, the Defense Department has ended up fielding much smaller numbers than initially planned.

The implication of these numbers is that the US military has invested considerable money in developing four different all-aspect LO combat aircraft. The combined RDT&E bill for the B-2 and F-22 alone probably approached $45 billion. Despite the large investment

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35 Giles K. Smith, Hyman Shulman, Robert S. Leonard, "Application of the F-117 Acquisition to Other Programs in the New Acquisition Environment," RAND, 1996, p. 9.

36 The F/A-18E/F design does incorporate a reduced front-aspect radar signature. But the plane is not an all-aspect LO design.

37 OSD/PA, "Cheney Cuts Major Pentagon Aircraft Buys," p. 3. Cheney's cancellation of the A-12 program produced two decades of litigation between the Pentagon and the A-12 contactors, now Boeing and General Dynamics. The latest court ruling requires the two contractors to pay the government $1.35 billion plus interest of $1.45 billion (Donna Borak, "Court Upholds Navy Cancellation of A-12 Aircraft," ABC News, June 2, 2009, online at <http://abcnews.go.com/Business/wireStory?id=7739193>.

in all-aspect LO aircraft programs, however, the Defense Department has ended up fielding much smaller numbers than initially planned. The buys originally envisioned for the F-117, B-2, ATF (including the naval variant), and ATA programs totaled 2,778 production aircraft. With the termination of F-22 production, the total that will actually be fielded is a paltry 267 planes, including the twenty-first B-2 which Congress added by funding the conversion of a test vehicle into an operational aircraft. The 267 all-aspect LO aircraft that now appear to be the final buy of these four designs is but 10 percent of the total envisioned at the beginning of the F-117, B-2, F-22 and ATA programs, and the last F-117s were retired in August 2008.

Why emphasize this unfortunate history regarding the procurement of all-aspect combat aircraft? The reason, of course, is the JSF. The current program envisions a US buy of 2,443 F-35s, of which 1,763 will be F-35As for the Air Force, and the remaining 680 will be divided between the F-35B STOVL (short take-off and landing) variant for the Marine Corps and the carrier-based F-35C for the Navy. In addition, the Pentagon and Lockheed Martin anticipate at least a couple thousand more JSFs being sold to close allies as successors to 4th-generation fighters such as the F-16. Will F-35 production unfold as now planned? Secretary Gates is betting heavily that it will. Indeed, he hopes to accelerate production by increasing the JSF buy in FY 2010 from fourteen to thirty aircraft.[38] In light of the history of US all-aspect LO designs so far, however, one cannot help but wonder how realistic the US goal of 2,443 F-35s augmented by substantial foreign sales really is. The GAO's latest report on the program documents that since system development started in October 2001, the JSF's total program acquisition cost has grown from $233 billion to $298.9 billion, including a $10 billion increase in development costs, and the estimated delivery date for the first operational aircraft has slipped from 2008 to 2010.[39] These numbers, like the buys of earlier all-aspect LO aircraft, are hardly encouraging.

Preserving the Industrial Base with Overseas Sales

In 1997, Representative David F. Obey added an amendment to the defense appropriations bill for FY 1998 that prohibited the sale of the F-22 to any foreign government. At the time, there was legitimate concern that overseas sales might compromise some of the key technologies in the F-22. In light of present plans to sell thousands of JSFs overseas, though, this concern no longer appears justified. After all, in several areas the technologies in the F-35s are more advanced than those in the Raptor, and the JSF is being built by the same company that has been building the F-22. Nevertheless, Obey's restriction on overseas sales of the F-22 remains in force today. The effort in the House of Representatives in 2006 to repeal Obey's amendment ultimately failed, with Obey saying that he was "significantly uncomfortable" with lifting the restriction.[40]

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38 Gates, "Budget Press Briefing (Arlington, VA)," April 6, 2009.

39 GAO, "Joint Strike Fighter: Accelerating Procurement before Completing Development Increases the Government's Financial Risk," GAO-09-303, March 2009, p. 6.

40 Renae Merle, "House Votes to Let Allies Buy Top U.S. Fighter," *The Washington Post*, July 1, 2006, accessed August 20, 2009, online at <http://www.washingtonpost.com/wp-dyn/content/article/2006/06/30/AR2006063001695_2.html>.

The most recent development regarding this restriction occurred in June 2009 when Senator Daniel Inouye sent letters to the Japanese ambassador Ichiro Fujisaki and Secretary Gates, presumably suggesting that in light of Japan's defense needs and a desire to preserve a portion of the US industrial base, it may be wise to reconsider selling F-22s to Japan.[41] Reportedly, the Japanese have expressed interest in acquiring F-22s, possibly under a licensed-production agreement such as they used to build F-4s and F-15s for the Japanese Air Self-Defense Force (JASDF) in the past. One problem is timing. With US production ending in FY 2009, it is likely that some of the key F-22 suppliers will be lost as early as 2010 even though the last deliveries to the Air Force will not occur until 2012. So there are legitimate questions about the timing of reopening or building an F-22 production line in the event of a Japanese Raptor buy. In fact, the shutdown of the US F-22 production line has yet to be negotiated between the Pentagon and Lockheed Martin.[42]

With the Pentagon shifting to the F-35, the possibility of F-22 sales to, or co-production by, Japan appears to be an opportunity that the United States should aggressively pursue.

The bigger obstacle, however, is cost. Japan's defense budget has been relatively flat, and Tokyo would probably have to sacrifice some other programs to find the money for an F-22 buy due to the 1 percent of Gross Domestic Product cap on the country's defense budget.[43] One recent estimate is that Japanese F-22s would cost some $250 million each (compared to the Air Force's $192 million weapon-system unit price).[44] Further, if some of the most sensitive F-22 technologies are removed from the Japanese version, then the JASDF might end up with a less capable plane while paying a higher per-unit price than the Air Force has for its 187 Raptors. At $250 million each, a buy of forty JASDF F-22s would come to $10 billion. In short, even if the Obey amendment is repealed by Congress, it is not self-evident that the acquisition of modified F-22s by Japan would go forward. Still, with the Pentagon shifting to the F-35, the possibility of F-22 sales to, or co-production by, Japan appears to be an opportunity that the United States should aggressively pursue.

Conclusions

In retrospect, the F-22 program suffered from unfortunate timing, cost growth, and schedule slippage virtually from the outset. Given the various programmatic "children" the Air Force had to neglect to achieve IOC in 2005, one can certainly sympathize with Secretary Gates' desire to put an end to the program, even if a final buy 187 is clearly not based on the operational needs for air dominance that could materialize in coming decades. The proliferation of S-300 and S-400 SAMs, the already formidable capabilities of Russian designs such as the Su-35 along with that plane's likely proliferation, and the inherent uncertainties of the future suggest that 130 combat-coded F-22s may not be enough through

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41 Andrea Shalal-Esa, "Cost of F-22 Fighter for Japan as Much as $250 Mln," June 5, 2009, at <http://www.reuters.com/article/marketsNews/idINN0530055420090605?rpc=44&sp=true>.

42 David A. Fulgum, "Japanese F-22 Campaign Lives On," AviationWeek.com, June 3, 2009, at <http://www.aviationweek.com/aw/generic/story_channel.jsp?channel=defense&id=news/JF22060309.xml>.

43 Weston S. Konishi and Robert Dujarric, "Hurdles to a Japanese F-22," *The Japan Times,* May 16, 2009, online at <http://search.japantimes.co.jp/cgi-bin/eo20090516a1.html>.

44 Shalal-Esa, "Cost of F-22 Fighter for Japan as Much as $250 Mln," June 5, 2009.

mid-century. Secretary Gates has opted to offset that risk with the F-35, specifically by endorsing the planned US buy of 2,443 JSFs. But whether the Air Force, for example, really needs the 1,763 F-35s to replace, for the most part, around 1,200 aging F-16s is certainly open to debate.[45] Thus, the big bet being made of the F-35 program proceeding as currently planned is surely also questionable—especially if the history of the nation's other all-aspect LO aircraft programs is any guide.

All that said, there is one opportunity to extend the Raptor program: namely overseas sales or co-production of the F-22 to build capacity in close US allies. The legislative restriction on foreign sales of the F-22 would have to be withdrawn for this opportunity to be exploited. Further, the most plausible candidate to acquire F-22s, Japan, would have to find the necessary funding. But the opportunity to build partner capacity and preserve a piece of the US industrial bases is not one that the US defense establishment should ignore.

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[45] See Steve Kosiak and Barry Watts, *US Fighter Modernization Plans: Near-Term Choices* (Washington, DC: CSBA, 2007), pp. 44–50.

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The Center for Strategic and Budgetary Assessments (CSBA) is an independent, nonpartisan policy research institute established to promote innovative thinking and debate about national security strategy and investment options. CSBA's goal is to enable policymakers to make informed decisions on matters of strategy, security policy and resource allocation.

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The F-22 E&MD program experienced difficulties typical of aircraft programs in E&MD. Airframe design refinements had negative impacts on weight and drag. In particular, "bumps" resulting from the repackaging of internal systems caused increased drag.Â The highest technical risk in the F-22 program stemmed from a new concept in aircraft avionics, a highly integrated avionics functionality expected to reduce pilot workload substantially and provide the pilot with unprecedented situation awareness. During the Dem/Val phase of this program, algorithms for data fusion and software development were examined, and a flying testbed was used to reduce the risk for some elements of the avionics.