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STATEMENT BEFORE THE HOUSE ARMED SERVICES SUBCOMMITTEE ON SEAPOWER AND PROJECTION FORCES ON THE FUTURE OF AIR FORCE LONG-RANGE STRIKE

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Chairman Forbes, Ranking Member Courtney, and Members of the Sub-Committee, thank you for the opportunity to present a few thoughts on the future of Air Force long-range strike.

In my testimony, I will suggest a framework for thinking about future long-range strike operational concepts and capability priorities. This framework focuses on two competitions between the U.S. military and its potential adversaries. The first is the "hiders versus finders" competition, which I will use to describe the evolution of capabilities that enable aircraft to "hide" as they penetrate contested areas and the development of defensive systems to "find" penetrating aircraft.[1] The second is the precision strike "salvo competition" which occurs between enemies that are each prepared to conduct high-volume offensive strikes as well as defend against their opponent's precision strikes. Significant changes in both competitions are driving a need for the U.S. military to change its operational concepts and precision strike capability priorities.

I will conclude by addressing several factors that could impact the timely fielding of the Long-Range Strike Bomber (LRS-B) and other new capabilities that are needed to maintain our military's advantage in these competitions.

Maintaining an advantage in the hider-finder competition

The hider-finder competition covers the whole range of capabilities needed to detect, track, and target military forces on the one hand, as well as capabilities to hide, conceal, obscure, deceive, or blind forces on the other. This competition is most pronounced in contested and denied areas where U.S. air forces face a growing array of precision air defense systems.

Two points provide important context for this discussion. First, it is erroneous to think that maintaining the bomber force's ability to penetrate contested areas will require the Air Force to develop aircraft that cannot be detected by enemy air defense systems. "Stealthy" aircraft are not *invisible* to enemy defenses. Rather, stealth results from a combination of exquisite mission planning, operational security, and passive and active measures that prevent defenders from

[1] For an explanation of the hiders versus finders competition, see Michael G. Vickers and Robert C. Martinage, *The Revolution In War* (Washington, DC: Center for Strategic and Budgetary Assessments, December 2004), pp. 109–114. "Penetrating platforms" also includes munitions such as standoff cruise and ballistic missiles that are launched into contested areas.

obtaining sufficient information on a penetrating aircraft's location, altitude, range, airspeed, and flight path to prosecute a successful intercept. Second, similar to other military competitions, the hider-finder competition should be seen as a move-countermove cycle, where advantages gained by competitors are temporary and eventually offset by countermeasures. For instance, the fielding of radar systems capable of detecting aircraft helped motivate the development of countermeasures such as aircraft-dispensed metallic chaff, radar jammers, and stealth technologies.

Broadly speaking, two Cold War cycles of the hider-finder competition influenced development of the Air Force's current bomber force. I'll start with the B-52—an aircraft I used to fly. The Air Force began development of the B-52 in the late 1940s, when the main air defense threats were radar-guided anti-aircraft artillery and fighter-interceptors. Thus, the bomber was designed to fly at high altitudes to avoid ground fires, and it was provisioned with tailguns to defend against Soviet fighter-interceptors. In the late 1950s, improving air defense radars and fighters led the Air Force to begin developing a new bomber, the B-70, capable of flying three times the speed of sound at altitudes thousands of feet higher than the B-52's operational ceiling.

In the late 1950s and early 1960s, the Soviet Union took advantage of emerging missile and guidance technologies to field surface-to-air missiles (SAMs) that could reach aircraft at high altitudes. In light of this threat and the growing sophistication of Soviet fighter-interceptors, the Air Force cancelled the B-70 and modified its B-52s to operate at low altitudes.[2] Flying at low altitudes helped penetrating bombers to avoid SAMs by taking advantage of terrain masking and ground clutter, or "noise" created by ground features, which greatly reduced the effectiveness of enemy fighter radars. The Air Force's B-1 bomber, originally intended to replace the B-52, was designed to penetrate Soviet airspace at low altitudes and sprint at high speeds to reduce the amount of time it would be exposed to air defense threats.

The next cycle in the hider-finder competition began before the B-1 entered the Air Force's active inventory. In the late 1970s, DoD determined the Soviet Union was developing "look-down/shoot-down" radars and missiles that would allow its fighter aircraft to attack U.S. bombers flying at low altitudes. The proliferation of man-portable air defense systems (MANPADS) with infrared sensors also increased the lethality of the low altitude operational environment. These threats added impetus to the Carter administration's creation of an Advanced Technology Bomber (ATB) program to develop a stealth bomber that would replace increasingly vulnerable B-52s. The ATB program evolved into a program to procure 132 stealthy B-2s for the Air Force. However, the collapse of the Soviet Union combined with DoD's shift in focus toward defeating regional aggressors, who during the 1990s lacked sophisticated air defenses, led to a decision to truncate the procurement of B-2s far short of its original acquisition target.

[2] The B-70 was not suitable for high-speed, low-altitude flight.

Instead of replacing aging B-52s with a stealthy penetrator, B-2 procurement was cut to 75 aircraft in 1990 and finally capped at 21 aircraft in 1997.[3]

The B-2 program's reduction marked the beginning of a multi-decade break in DoD's procurement of long-range, penetrating strike aircraft. While the Pentagon continued to pursue technologies that could be incorporated into future stealth platforms, it deferred funding for a new penetrating bomber in favor of upgrading its existing bombers. It also shifted toward using short-range fighter aircraft as the predominant means of delivering weapons on targets. This shift was partly based on the assumption that U.S. fighter forces would be able to operate with near impunity from regional airbases that were located close to an enemy's territory. The 1997 QDR report asserted that DoD did not require more than 21 B-2s because the bombers would not "provide the same weapons delivery capacity per day as the forces [mostly fighters] that would have to be retired to pay for B-2s," and the advantages that bombers offered early in conflicts with enemies invading a U.S. partner state diminished as U.S. land- and sea-based fighters arrived in theater.[4]

As a result, the Air Force's bomber force is now the smallest and oldest that it has ever operated (see Table 1).

TABLE 1. 2015 AIR FORCE BOMBER FORCE

	Total Aircraft Inventory	Primary Mission Aircraft Inventory	Average Age (Years)
B-52H	77	54	54
B-1B	62	41	28
B-2	20	19	21
Total	159	114	39

Unfortunately, America's potential enemies did not pause in their efforts to develop more capable surveillance systems and air defenses; the hider-finder competition continued. China, Russia, Iran, North Korea, and others now have sensors and precision-guided defensive weapons that are capable against non-stealthy B-52s and B-1s. With the exception of 19 primary mission B-2s, the Air Force's long-range strike force is limited to operating in low- to medium-threat environments. If required to operate from bases that are 1,500 or more miles from target areas, this small B-2 force would generate only ten to twelve strike sorties per day.[5]

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3 DoD's decision to cap B-2 procurement was supported by its Deep Attack Weapons Mix Study (DAWMS), which was part of the 1997 Quadrennial Defense Review (QDR). This author participated in DAWMS.

4 Department of Defense (DoD), *Report of the Quadrennial Defense Review* (Washington, DC: DoD, 1997), Section 7, available at http://www.dod.mil/pubs/qdr/sec7.html.

5 For instance, it is about 2,700 nautical miles (nm) line-of-sight from Diego Garcia in the Indian Ocean to Natanz, Iran, and over 2,100 nm from Guam in the Western Pacific to the interior of China.

The good news is the development of new stealth capabilities including the LRS-B, F-35, and cruise missiles indicates DoD has reengaged in the hider-finder competition. However, while initial procurement of the F-35 is underway, it has been about ten years since DoD's 2006 Quadrennial Defense Review (QDR) directed the Air Force to develop "a new land-based, penetrating long-range strike capability," and it will be another ten years before LRS-Bs begin to join the force in significant numbers.[6] At least six years of this delay can be attributed to Secretary of Defense Robert Gates' 2009 decision to cancel the precursor to the LRS-B, the so-called Next Generation Bomber. Further delays in procuring the LRS-B or low LRS-B production rates that are driven by budget cuts would worsen America's long-range, penetrating strike capability gap.

Maintaining an advantage in the precision strike salvo competition

A salvo competition can be described as the dynamic where combatants seek to gain advantages by improving their ability to attack with precision and defend against enemy strikes.[7] The U.S. military's ability to conduct sustained, large-scale precision strike operations has been unmatched by the enemies it has fought since the end of the Cold War. Today, however, the proliferation of precision guidance systems and other weapons technologies have enabled potential enemies to create their own inventories of PGMs, including guided missiles capable of striking U.S. airbases located across the Western Pacific and Middle East. In future salvo competitions, continuing to rely almost exclusively on close-in regional airbases that are within range of an enemy's air and missile forces could greatly reduce the tempo of U.S. military strike campaigns.

There are alternatives that could help maintain America's precision strike advantage. For instance, DoD could adopt new concepts for conducting "distributed" operations from networks of highly dispersed close-in bases, including civilian and improvised airfields. It could also shift most of its strike aircraft to bases that are located out of range of most air and missile threats. While both concepts would complicate an opponent's targeting problem, operating U.S. strike aircraft further from the battlespace would also force an enemy to use longer-range, more expensive guided missiles to attack U.S. airfields.

It is important to consider that the opposite is also true: the size of U.S. precision strikes are sensitive to the ranges over which they are launched. While using more distant airbases could decrease the risk of enemy attacks, the need to fly longer distances to target areas would also reduce the number of sorties U.S. air forces could generate each day. For instance, operating from airbases on Guam and Diego Garcia would require U.S. strike aircraft to fly thousands of

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6 Department of Defense, *Quadrennial Defense Review Report* (Washington, DC: DoD, February 2006), p. 46.

7 This dynamic is different than that of previous salvo competitions, such as between French and British warships in the 19th century, or Allied and German naval forces in World War I. In those early competitions, combatants did not have capabilities to intercept each other's salvos.

miles to attack targets on the Asian mainland. This would reduce their daily sortie rates and the number of PGMs they could deliver. The Government Accountability Office determined B-52s flew an average of 0.6 sorties per day during Operation Desert Storm primarily because they operated from "far more distant bases" than fighters, which included the joint-use base on Diego Garcia.[8]

This suggests it would be inefficient to use fighter aircraft with about one-fifth the unrefueled range and one-tenth the payload of a bomber to routinely conduct strike missions from distant airfields. Alternatively, it would be more feasible to frequently move fighters (rather than bombers) in shell-game fashion around a distributed network of close-in temporary and permanent airfields to complicate the enemy's targeting problem. In other words, the relationship between range, sortie rates, payload size, and emerging threats makes a compelling case for using bombers staged from distant airfields for the bulk of the U.S. military's airstrikes in future salvo competitions. In lieu of using fighters for long-range strikes, U.S. fighter forces could operate from a network of close-in, highly distributed bases to counter threats to penetrating bombers.

Some implications for the future long-range strike force

Several major insights can be drawn from assessments of the hider-finder and salvo competitions. Perhaps the most important is that the time has come for DoD to flip the prioritization of fighter and bomber forces it adopted in the immediate aftermath of the Cold War. The primacy of fighters over bombers was reasonable in the 1990s when air operations could largely be conducted from close-in regional bases in relatively permissive environments to quickly establish air superiority and attack targets nearly at will. But considering changes to the operational environment, those days are long over.

According to DoD's own planning documents, U.S. combat air forces may have to stage their initial operations from distant bases that are less susceptible to missile attacks, and then penetrate areas that are defended by a new generation of SAMs, fighters, and other sophisticated threats. The most advanced SAMs in the world are no longer in the hands of only one or two countries like Russia and China, but are rapidly proliferating in regions such as the Middle East.

These and other threats are cratering America's preferred way of war. This necessitates a fundamental rethinking of how the U.S. military should conduct power-projection operations and the mix of capabilities it will need in the future. DoD is taking initial steps toward developing a family-of-systems that will sustain America's long-range strike strategic advantage. Unlike the B-2, the foundation of this family-of-systems—a new stealth bomber—will be needed in

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8 Government Accountability Office (GAO), *Operation Desert Storm Evaluation of the Air Campaign* (Washington, DC: GAO, June 1997), p. 170.

quantity.[9] Instead of a niche capability, stealth, coupled with long ranges and large payloads payload—will be the price of admission into the fight for operations against enemies equipped with anti-access and area-denial (A2/AD) capabilities.

Managing growth in the cost and time needed to field new LRS family-of-systems capabilities

Members of this Subcommittee understand that prolonging the development of new weapon systems combined with excessive requirement changes during their development can increase program cost. According to analyses conducted by RAND and the Institute for Defense Analyses, budgets "can and do change annually without regard for programmatic effect" thereby resulting in "substantial total cost growth, both from stretching the development program, as well as lowering production rates, which increases unit production costs."[10] DoD should guard against program cost growth that can reduce the number of new long-range strike capabilities it can afford to buy. In particular, changing the LRS-B's requirements during development, cutting its planned production, accepting an inefficient production rate, and changing production rates in mid-stream could significantly increase its cost.

Changing requirements. Basing capability requirements on assessments of future needs, rather than current war plans and threats, coupled with disciplined efforts to refrain from adding new requirements can reduce the number of costly change orders needed for a major weapon system. Keeping programs on schedule may also help avoid the problem of early obsolescence for capabilities that take a decade or more to field. The good news is the LRS-B is designed to periodically incorporate upgrades after it is fielded to refresh its technology and address new threats as they emerge. Planning for incremental block upgrades to the LRS-B will also help spread its total cost over time.

Reducing production quantities. Reducing the planned buy of a weapon system in mid-production can also increase its program unit cost, which is the total cost of a program (development plus production) divided by the number of articles procured. Historical data shows that cutting the number of aircraft—military or commercial—procured often leads to significant

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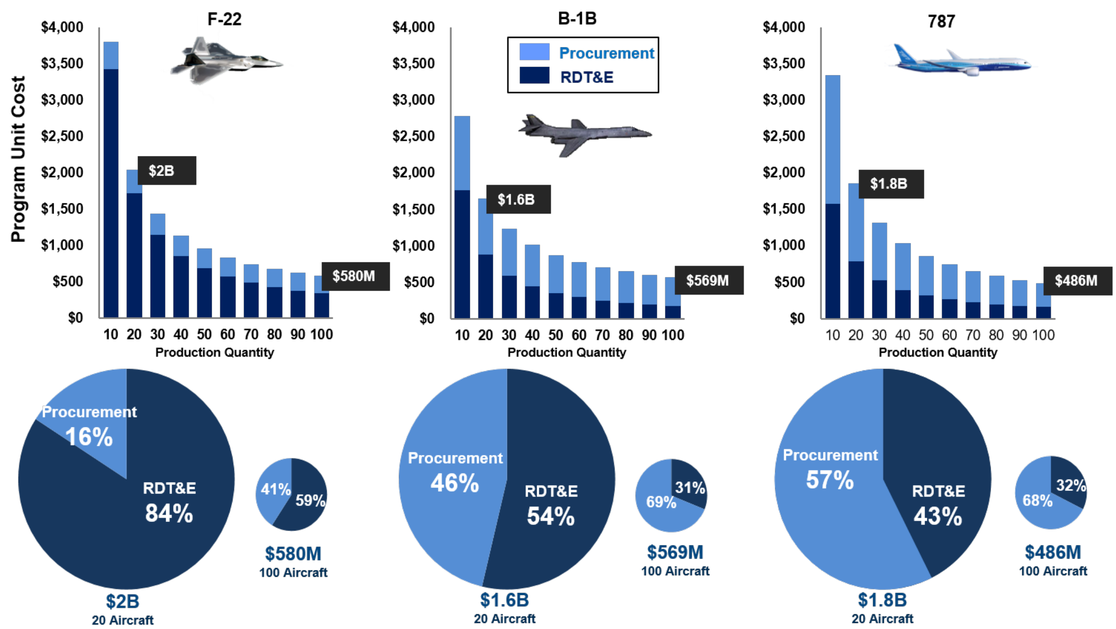
9 The long-range strike family-of-systems will include the LRS-B and other systems such as a new, penetrating cruise missile and supporting "intelligence, surveillance and reconnaissance (ISR), electronic attack (EA), and command, control and communications (C3) assets." Air Force Global Strike Command (AFGSC), *Strategic Master Plan 2014* (Barksdale AFB, LA: AFGSC, March 1, 2014), p. 10, available at http://www.defenseinnovationmarketplace.mil/resources/AFGS-2014StrategicPlan.pdf.

10 Obaid Younossi, David E. Stem, Mark A. Lorell, and Frances M. Lussier, *Lessons Learned from the F/A-22 and F/A-18E/F Development Programs* (Santa Monica, CA: RAND, 2005), available at available at http://www.rand.org/content/dam/rand/pubs/monographs/2005/RAND_MG276.pdf; and Gene Porter, Project Leader, *The Major Causes of Cost Growth in Defense Acquisition, Volume II: Main Body* (Alexandria, VA: Institute for Defense Analyses, 2009), p. 54, available at www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA519884.

program unit cost growth.[11] Figure 1 illustrates three theoretical examples of cost growth that could result from production quantity cuts.[12]

FIGURE 1. ILLUSTRATIVE AIRCRAFT PROGRAM UNIT COST GROWTH FOR DIFFERENT PRODUCTION QUANTITIES



Similar to the B-2, a limited purchase of 20 F-22s, B-1Bs, or Boeing 787 Dreamliners would result in unit costs that range between $1.6 billion and $2 billion per copy. In contrast, buying 100 aircraft slashes their cost by 70 percent or more. Much of this reduction is due to the fact that their fixed development costs would be amortized over a larger fleet. In other words, as the production quantity increases, the fleet shoulders the development costs more evenly.

A series of production cuts as well other factors contributed to growth in the F-22's cost (see Figure 2).[13]

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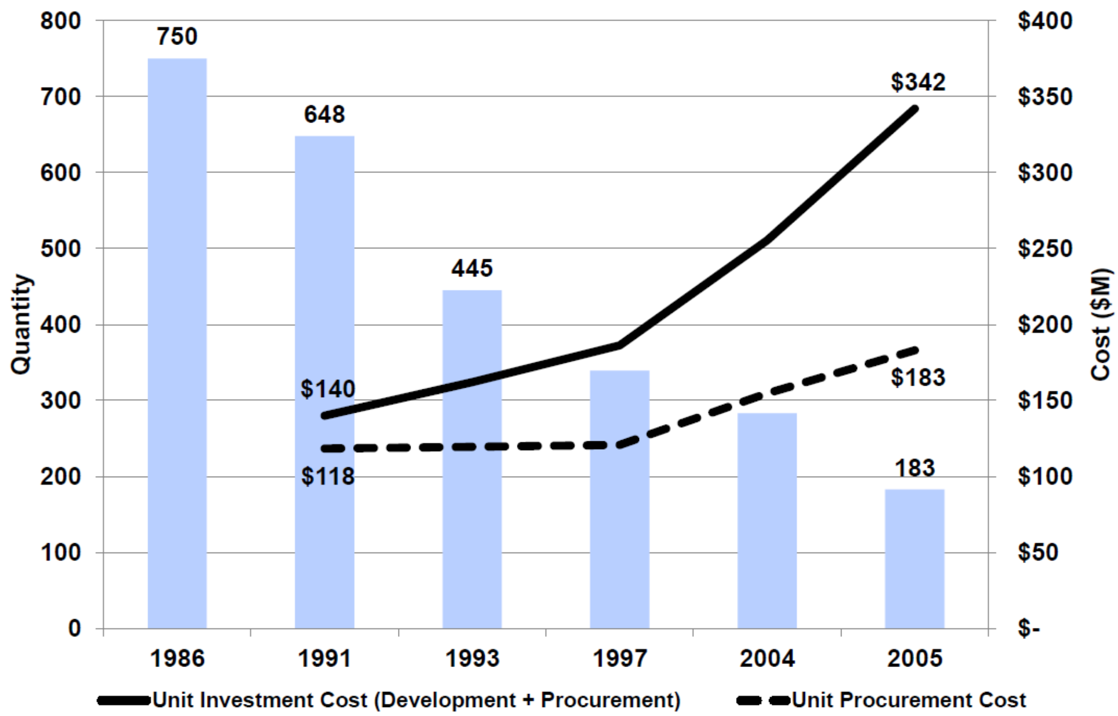
[11] A 2011 independent assessment of DoD's major acquisition programs concluded, "For programs with upfront research and development costs, reducing the number of units lowers the overall program cost but it increases the per-unit cost, effectively curtailing the government's buying power." Joachim Hofbauer, Gregory Sanders, Jesse Ellman, and David Morrow, *Cost and Time Overruns for Major Defense Acquisition Programs* (Washington, DC: Center for Strategic and International Studies, 2011), p. 6, available at http://csis.org/files/publication/110517_DIIG_MDAP_overruns.pdf.

[12] Figure 2 costs are in 2010 dollars. B-1B cost data is from Congressional Budget Office, *Total Quantities and Unit Procurement Cost Tables 1974 to 1995*, April 13, 1994; Susan J. Bodilly, *Case Study of Risk Management in the USAF B-1B Bomber Program*, Santa Monica: RAND Corp., 1993; and the Department of Defense, *B-1 SARS and ATB R&D Cost Estimates*. F-22 cost data is from DoD P-1 and R-1 budget displays for FY1999 to FY2014. B787 cost data is the from Boeing company's website, and Lisa A. Schwartz and Jeremy Busby, *The 787 Dreamliner: Will It Be a Dream or Nightmare for Boeing Co.*, Wingate University, available at http://abeweb.org/proceedings/Proceedings13/Schwartz.pdf.

FIGURE 2. IMPACT OF QUANTITY REDUCTIONS ON F-22 UNIT COST



The relationship between production quantity and unit cost is not unique to aircraft. The history of the Navy's DDG-1000 program shows how major weapon systems that begin with a low planned procurement objective are extremely sensitive to quantity reductions. The Navy initially planned to buy 32 DDG-1000s to provide naval surface fire support from littoral waters.[14] This was reduced to just ten ships when the DDG-1000 entered development, and then capped at three ships. This resulted in a unit price increase of nearly 80 percent, primarily because its development costs were spread over three ships.[15]

Inefficient production rates. Buying major new long-range strike capabilities at economically inefficient *rates* can also increase their unit cost. Stretching acquisition programs subjects them to the effects of inflation, increased labor costs, the inefficient use of manufacturing infrastructure, and slower progress on the production learning curve. While reducing the annual procurement of modern military aircraft may help reduce DoD's near-term outlays, in the long run it can be a Faustian bargain.

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[13] Figure 1 is a slightly modified version of the column chart published in 2006 by the Government Accountability Office. See Government Accountability Office (GAO), *Questions Concerning the F-22A's Business Case* (Washington, DC: July 2006), p. 3, available at http://www.gao.gov/assets/120/114521.pdf.

[14] Ronald O'Rourke, *Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress* (Washington, DC: Congressional Research Service, 2015), p. 30, available at https://www.fas.org/sgp/crs/weapons/RL32109.pdf.

[15] Irv Blickstein et al., *Root Cause Analyses of Nunn-Mccurdy Breaches, Volume 1* (Santa Monica, CA: RAND, 2011), p. 23, available at http://www.rand.org/content/dam/rand/pubs/monographs/2011/RAND_MG1171.1.pdf.

Changing production rates. Changing production rates in midstream can increase or decrease the unit cost of weapon systems. Projected unit costs for military aircraft are tied to specific production rates that are often determined during the early stages of their development. Defense industry uses planned production rates to size their production facilities, procure tooling, and hire and train a work force for a specific program. Production rate cuts driven by factors such as year-by-year fluctuations in funding can result in significant cost growth due to the inefficient use or unplanned expansion or contraction of production lines and work forces. Based on a 1990 Government Accountability Office assessment of the F/A-18, F-16, and F-15 programs, reductions in their procurement rates could significantly increase total program unit costs (see Table 2).[16]

TABLE 2. ILLUSTRATIVE IMPACT ON TOTAL PROGRAM UNIT COSTS DUE TO PROCUREMENT RATE REDUCTIONS

	Example Procurement Rate Cuts	Annual Quantity	Unit Cost (FY2010 $M)
F/A-18	Example baseline	72	25.7
	25% decrease	54	40.0
	50% decrease	36	45.9
F-16	Example baseline	120	36.7
	25% decrease	90	41.2
	50% decrease	60	49.1
F-15	Example baseline	36	48.2
	25% decrease	27	52.0
	50% decrease	18	61.8

In a more recent study of 35 Major Defense Acquisition Programs (MDAPs) including the Air Force's B-1B, C-17A, and F-22 programs, RAND determined that nine percent of their total unit cost growth occurred as a result of decisions to change their development and production schedules.[17]

A planned increase in production rate can have the opposite effect. Another RAND assessment of Air Force and Navy aircraft programs determined that, on average, "A doubling of annual

[16] GAO, *Weapons Production: Impact of Production Rate Changes on Aircraft Unit Costs* (Washington, DC: GAO, December 1990), available at http://www.gao.gov/assets/220/213494.pdf.

[17] Joseph G. Bolten et al., *Sources of Weapon System Cost Growth Analysis of 35 Major Defense Acquisition Programs* (Santa Monica, CA: RAND, 2008), p. xvii, available at http://www.rand.org/content/dam/rand/pubs/monographs/2008/RAND_MG670.pdf. Another RAND study found that the overhead costs for F-22 production were higher than expected because its peak production rate was cut from 48 to 32 per year after its manufacturer had completed an expensive expansion of its production facility. Younossi, Stem, Lorell, and Lussier, *Lessons Learned from the F/A-22 and F/A-18E/F Development* Programs, p. 20.

procurement quantity yields an 11 percent decrease in unit cost."[18] Over the life of a multi-billion dollar acquisition program, fluctuations in unit cost could result in significant savings or major bills.

Conclusion

In summary, the Air Force, in cooperation with the other Services, has an opportunity to create a family-of-systems that will maintain America's long-range strike advantage well into the future. Requirements for this family-of-systems should be based on assessments of future threats and operating concepts, rather than today's operational environment.

In the context of the hider-finder and precision strike salvo competitions, DoD may need to flip the pecking order it established for its fighter and bomber forces after the Cold War. Stealth aircraft should no longer be considered as niche, "knock down the door" capabilities that are best used to suppress air defenses and enable follow-on non-stealthy aircraft to penetrate. Rather, stealth has become an entry-level capability for operations in contested areas. Moreover, the proliferation of missile threats will necessitate operating our combat air forces from bases located farther from an enemy. DoD will need a penetrating bomber force that is large enough and has sufficient range to ensure it is able to deliver high volumes of munitions deep into denied areas.

Developing and fielding substantial numbers of LRS-Bs and other family-of-systems capabilities needed to support this reversal in priorities will be a challenge given defense budgets capped by the Budget Control Act of 2011. Reacting to budget cuts by reducing LRS-B production rates or allowing procurement reductions similar to what occurred to F-22, B-2, and other major programs could balloon the bomber's unit cost and lead to an acquisition death spiral. It could also result in a smaller overall force of penetrating bombers. Either would extend America's long-range strike capability gap and allow future enemies more time to mature capabilities that threaten our ability to project power.

Thank you again for the opportunity to present on this critical capability area.

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[18] Mark V. Arena et al., *Why Has the Cost of Fixed-Wing Aircraft Risen?* (Santa Monica, CA: RAND, 2008), p. 39, available at http://www.rand.org/content/dam/rand/pubs/monographs/2008/RAND_MG696.pdf.