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BACKGROUNDER

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MOVING FORWARD ON LONG-RANGE STRIKE

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EXECUTIVE SUMMARY

§ Today, American capabilities for long-range, non-nuclear, precision strike reside primarily in the Air Force's active inventory of some 160 B-52Hs, B-1Bs and B-2As. But only 21 of these aircraft, the B-2As, are capable of delivering relatively inexpensive direct-attack guided weapons such as the Joint Direct Attack Munition inside modern air defenses, suggesting that US capabilities for long-range strike hinge less on the total number of bombers than on the operational characteristics of specific bomber types.

§ Standoff guided munitions such as the Navy's Tomahawk Land Attack Missile or the Air Force's Conventional Air Launched Cruise Missile are too expensive and too few to be other than niche weapons for major campaigns. They do not offer a viable alternative to weapons platforms able to sustain delivery of cheaper, more plentiful direct-attack munitions 1,000 nautical miles or deeper inside defended airspace over days or weeks.

§ The opportunity to move to a smaller, cheaper, more survivable, and more lethal bomber inventory of as few as 50 B-2s has almost certainly passed, and the oldest of the existing heavy bombers, the B-52Hs, were delivered in 1962. Yet the Department of Defense (DoD) does not anticipate beginning development of a next-generation long-range strike system until 2012-15. Meanwhile, the DoD's recent and projected investment patterns favor short-range aircraft such as the F/A-22, F/A-18E/F and the F-35 Joint Strike Fighter over long-range combat aircraft by a ratio of around 20-to-1.

§ There are a number of reasons for doubting that the existing heavy bomber fleet will suffice to meet foreseeable US needs for long-range, precision strike over the next couple decades. First, the focus of American national-security is shifting toward Asia and the Western Pacific where distances for strike operations could easily be several times greater than those the US military faced during recent campaigns in Southwest Asia. Second, anti-access/area-denial capabilities are likely to emerge in future campaigns, forcing US forces to fight initially from a

distance. Third, nuclear proliferation is proceeding relatively unchecked from Iran to North Korea, which points to a more urgent need to be able to conduct prompt, accurate, conventional strikes anywhere on the globe on very short notice.

- Near-term improvements to current American long-range strike capabilities should emphasize the "precision information" needed for precision strike. In the case of the bomber fleet, the next step with the greatest payoff would be to invest around $2 billion to modernize the avionics in the 21 B-2s. Two other near-term possibilities are putting conventional warheads on some existing Peacekeeper intercontinental ballistic missiles for prompt global response while reorienting a portion of the older bombers to the close support of land forces in low-threat air defense environments.

- A wide range of options exist for next-generation long-range strike systems. Possibilities range from a subsonic B-2 follow-on to a space operations vehicle able to dispense maneuverable reentry vehicles against targets anywhere around the globe. Both thoughtful analysis and a readjustment of funding priorities between long- and short-range systems will be needed to satisfy the nation's long-term requirements in this area. Nonetheless, decisions should be taken, and concrete development programs started, sooner than indicated in Air Force planning and budget documents.

INTRODUCTION

Ever since the US 8th Air Force began mounting bombing missions against German targets from English bases in early 1943, America's capabilities to sustain non-nuclear (conventional) strikes against enemy targets over long distances have resided primarily in its bomber fleet. After World War II, it was the offensive-strike potential demonstrated by the marriage of the B-29 and the atomic bomb in August 1945 that quieted any serious public opposition to the creation of an independent US Air Force (USAF) in September 1947.[1] During the US-Soviet Cold War, Strategic Air Command (SAC) bombers constituted a major component—initially the only component—of America's nuclear deterrent, providing the bulk of deployed US "strategic" nuclear warheads through the late 1960s and around 40 percent toward the end of the 1980s.[2] Clearly, then, the long-range strike capability embodied historically in heavy bombers has been important to the United States in the past.

What will be the place of long-range strike in the decades ahead? The USAF's 1999 bomber roadmap declared that the payload, range, and responsiveness of heavy bombers, coupled with guided munitions, made them

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[1] Perry McCoy Smith, *The Air Force Plans for Peace: 1943-1945* (Baltimore, MD: Johns Hopkins Press, 1970), pp. 16-17.

[2] According to the Natural Resources Defense Council's historical data on US and Soviet "strategic" forces (available at http://www.nrdc.org/nuclear/nudb/ndabout.asp), not until 1971 did the number of American nuclear warheads deployed on land- and submarine-based ballistic missiles exceed the number available from SAC bombers in a fully generated posture.

"a cornerstone of America's air power and force projection," adding that long-range bombers "are integral components of the Air Force's Global Engagement vision."[3] More recently, Air Force accounts of its evolving Global Response and Global Strike CONOPS (concepts of operations) have emphasized a growing need to deal with "fleeting or emergent, high-value and high-risk targets" within narrow windows of opportunity, and the probable acquisition of "advanced anti-access systems . . . and weapons of mass destruction" by potential American adversaries.[4] On top of these challenges, which long-range strike could certainly address, there is the widely predicted shift of American national-security interests toward Asia and the Western Pacific, where distances for strike operations could easily be 2-4 times greater than those the US military faced in Afghanistan and Iraq.[5] Thus, good reasons exist for thinking that, during the next couple of decades, long-range strike could become even more important in the application of military force by the United States than it was during the Cold War.

The basic thrust of this paper is that existing American capabilities for long-range strike do not appear to be sufficient for the nation's foreseeable needs. Toward this end, it will do three things: review what the American military has done to improve US long-range strike capabilities since the mid-1980s; flag some steps that could be taken in the near term to improve US capabilities substantially; and, third, outline the wide range of possibilities for future long-range delivery platforms.

TERMINOLOGY AND AN ECONOMIC EXCLUSION

For present purposes, the term long-range will be reserved for combat aircraft with an unrefueled combat radius around 3,000 nautical miles (nm), or missiles with a one-way range around 3,000 nm. Short-range, by comparison, will denote combat aircraft with an unrefueled combat radius around 1,000 nm (or missiles with a one-way range around 1,000 nm). Medium-range will refer to aircraft and missiles with around 2,000 nm reach, the heart of the medium-range envelope being 1,500-2,500 nm.

These definitions, like all definitions, are somewhat arbitrary and, in this instance, dependent on current technology.[6] As will be explained later, they also gloss over the role of aerial refueling in extending the reach of combat aircraft. The KC-135 tanker gave SAC's long-range B-52s truly global reach. Nonetheless, these characterizations of long-, medium-, and short-range provide useful a point of departure.

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[3] Department of the Air Force (DoAF), *U.S. Air Force White Paper on Long Range Bombers*, March 1, 1999, pp. 13, 24.

[4] Headquarters US Air Force, *The U.S. Air Force Transformation Flight Plan* (Washington, DC: XPXC, November 2003), pp. 43-4.

[5] The great-circle distance from Guam to the North Korean nuclear facility at Yongbyon is some 1,800 nautical miles (nm), and the distance from Diego Garcia in the Indian Ocean to northern Pakistan nearly 2,500 nm. By comparison, the great-circle distance from Abu Dhabi, United Arab Emirates, to Baghdad is about 740 nm, and from Muscat, Oman, to Kabul around 860 nm.

[6] The "long-range" B-17 of World War II fame, with a maximum practical combat radius of about 550 nm, would be considered a short-range aircraft today.

Because existing and currently planned fighter-bombers (e.g., the F-16, F-15E, F-117, F/A-18E/F, F/A-22 and F-35) all have unrefueled combat radii under 1,000 nm, they can be categorized as short-range. By comparison, the B-52H is unquestionably a long-range system while the "regional bomber" the Air Force has been discussing as a possible bridge between the current bomber force and a next-generation long-range strike system is medium-range.[7]

As straightforward as these classifications may seem, the US Navy's Tomahawk Land Attack Missile (TLAM) and the Air Force's Conventional Air Launched Cruise Missile (CALCM) reveal their fuzziness at the boundaries. Tomahawk, whose initial variant was nuclear, and the USAF's nuclear AGM-86B Air Launched Cruise Missile (ALCM) were developed during the same period and originally shared guidance, propulsion and other technologies. CALCM later resulted from modifying nuclear ALCMs with conventional warheads and inertial guidance augmented by Global Positioning System (GPS) data in order to give the United States a prompt, standoff, surgical-strike capability against fixed targets anywhere on the globe.[8] Today, TLAM-C and TLAM-D, the conventional land-attack variants of Tomahawk, and CALCM have ranges of 700-1,000 nm, which classify the missiles themselves as short-range.[9] Because heavy bombers such as the B-52 are long-range, the B-52/CALCM combination is also a long-range system even though the munition itself is not. This logic would also extend to B-52s armed with even shorter-range cruise missiles such as the low-observable Joint Air-to-Surface Standoff Missile (JASSM), now in low-rate initial production.[10]

The definitional question that now arises is whether TLAMs launched from nuclear submarines or surface combatants positioned in overseas waters should also be categorized as part of a long-range weapon system. The US Navy has a large and growing capacity to launch TLAMs against targets ashore. If this capacity, including that provided by the four ballistic-missile nuclear submarines (SSBNs) planned for conversion to conventional guided-missile submarines (SSGNs), is counted as long-range strike along with heavy bombers, then the Navy adds roughly 7,000 vertical-launch system (VLS) cells fleet-wide and is building toward a capacity of some 10,000.[11] Should this

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[7] Air Force secretary James G. Roche began describing a strike variant of the F-22, originally referred to as the FB-22, in early 2002. At the time, the combat radius of a two-seat FB-22 was postulated to be around 1,600 nm. The term now preferred is "regional bomber."

[8] Major Stephen R. Hess, "Conventional Air Launched Cruise Missile Development—Employment and the Costs of Global Presence," Marine Corps University, April 18, 1995. According to Hess, the impetus for CALCM was the loss of a USAF F-111F while attacking a target in Libya during Operation El Dorado Canyon in 1986.

[9] Tactical Tomahawk (TLAM-E), like the original nuclear Tomahawk variant, has a reported range of up to 1,350 nm, or around 1,000 nm with two hours of loiter. The Navy typically cites ranges for TLAM-C and TLAM-D of 700 or 900 nm depending on the variant and block. CALCM's range is generally cited as 900-1,000 nm.

[10] The Air Force and Navy are also working on an extended-range variant of JASSM.

[11] Improved *Ticonderoga*-class cruisers (CGs) have 122 VLS cells each, *Arleigh Burke* destroyers (DDGs) 90 or 96, and the plan is for 154 on each of the SSGNs. Of course, in the case of surface combatants a good portion of their cells would normally be loaded with Standard Missiles for air defense rather than TLAMs. Also, even after the four SSGNs come on line, 85-90 percent of the Navy's TLAM potential will still reside in

capacity be included, then it would appear that the United States has such a surfeit of long-range strike capability that neither the shortcomings in the current bomber force nor the lack of visible progress toward a next-generation long-range strike system ought to be of much concern.

This conclusion can be rejected on two grounds. First, naval combatants, unlike aircraft, are tied to the sea. Second—and more important—TLAMs, like CALCMs, are over 80 times more expensive than a Joint Direct Attack Munition (JDAM).[12] The cost differential with direct-attack munitions such as JDAMs and laser-guided bombs (LGBs) alone makes TLAM and the USAF's CALCM niche munitions for precision strike except for small-scale punitive strikes such as Operation Desert Fox in December 1998, when over 300 of these missiles were expended against targets in Iraq.[13] By contrast, during the major US combat operations of 1991, 1999, 2001-02 and 2003 (Operations Desert Storm. Allied Force, Enduring Freedom and Iraqi Freedom), the US military expended over 53,000 guided munitions (excluding ground-force guided munitions such as the helicopter-launched Hellfire).[14] TLAMs constituted only 2.6 percent of this total and CALCMs but another 0.5 percent, whereas JDAMs and LGBs together totaled over 78 percent. The standoff land-attack capability provided by the Navy, therefore, is of far more limited utility than the large and growing number of VLS tubes suggests. For major campaigns, the bulk of the guided munitions expended are likely to remain direct-attack munitions such as JDAMs and LGBs for some time to come. Long-range bombers are the only platforms with the reach to deliver such weapons deep in enemy territory in large quantities, and only the 21 B-2s can reliably do so over long distances inside defended enemy airspace. Consequently, it appears that more needs to be done in the area of long-range strike than buying a few thousand improved TLAMs (Tactical Tomahawks)

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surface combatants. The main advantage of submarines as TLAM shooters is that they can attack undetected from a covert posture, and the SSGNs will offer higher strike volume than *Los Angeles*-class attack submarines with 12 VLS cells.

[12] The eighty-fold cost differential between TLAM and JDAM is based on production-unit cost data and does not include Tactical Tomahawk production since Fiscal Year (FY) 2002. The average unit-production cost for the 4,201 TLAMs produced through FY 1999 is nearly $2 million each, whereas the comparable JDAM unit cost (including a 2,000-lb bomb body, guidance kit and fuze) is around $24,000 (both prices in FY 2004 $).

[13] Ronald O'Rouke, "Cruise Missile Inventories and NATO Attacks on Yugoslavia: Background Information," Congressional Research Service, RS20162, April 20, 1999, p. 3.

[14] The main sources for the expenditure data cited in this paragraph are: Gulf War Air Power Survey (GWAPS), Vol. V, *A Statistical Compendium and Chronology*, Part 1, *A Statistical Compendium* (Washington, DC: US Government Printing Office, 1993), pp. 553-554; USAF, "Air War over Serbia (AWOS) Fact Sheet," Washington, DC, January 31, 2000; HQ USAF/XOOC (Checkmate), "ISO Joint Staff 'Quick Look' After-Action Review Panel," PowerPoint slides, December 15, 1999; William Arkin, "Weapons Total from Afghanistan Includes Large Amount of Cannon Fire," *Defense Daily*, Vol. 213, No. 42, March 5, 2002; and, Lieutenant General T. Michael Moseley, *Operation IRAQI FREEDOM—By the Numbers* (Prince Sultan AB, Kingdom of Saudi Arabia: US Central Air Forces, April 30, 2003), p. 11.

while trying to keep the older bombers, particularly the B-52s, flying into the 2030s.[15]

LONG-RANGE STRIKE DEVELOPMENTS SINCE THE MID-1980S

Since the mid-1980s, various decisions and developments have substantially altered American capabilities for long-range strike. The more significant of these, which mainly involved the Air Force's bomber fleet, are the following:

- In May 1986 the last of 100 production B-1Bs was delivered to the Air Force. Ignoring the medium-range B-58 and FB-111, the B-1Bs were SAC's first new bomber since taking delivery of the last B-52Hs in October 1962.

- In January 1988, the AGM-86C CALCM entered operational service with SAC. On the opening night of Operation Desert Storm (January 17, 1991), B-52G crews flying from Barksdale Air Force Base (AFB), Louisiana, launched 35 CALCMs against high-priority Iraqi targets while standing off outside Iraqi air defenses. Around 30 of the CALCMs are believed to have hit their targets.[16]

- The Pentagon's 1990 major aircraft review, conducted during Dick Cheney's tenure as defense secretary and after the fall of the Berlin Wall, reduced the B-2 buy from 132 to 75 aircraft.[17] Both declining strategic-nuclear requirements and budgetary pressures on the US defense budget influenced this decision.

- In his January 1992 state-of-the-union address to Congress, President George H. W. Bush halted production of the low-observable B-2A bomber at 20 aircraft due to end of the Cold War.[18]

- In the summer of 1992, the Air Force dissolved SAC, transferred its bomber force to the newly created Air Combat Command (ACC), the successor to Tactical Air Command (TAC), and elected to retire the remaining B-52Gs, leaving a residual B-52H inventory of some 95 aircraft. Ultimately only the B-52Hs were retained as a part of the

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[15] Even if Tactical Tomahawk achieves its production cost goal of under $600,000 per round, the DoD's August 13, 2004, selected acquisition report indicates that the Navy only plans to buy some 2,800 rounds whereas the projected JDAM quantity is over 207,000 kits. The planned JASSM buy for the Navy and Air Force is currently some 4,300 missiles, but they are primarily intended for short-range fighters and attack aircraft.

[16] See John Tirpak, "The Secret Squirrels," *AIR FORCE Magazine*, April 1994. The CALCMs were targeted against three electric power plants and five command-and-control facilities.

[17] Because the B-2's large research-and-development cost was now spread over 75 instead of 132 aircraft, this programmatic decision increased the plane's unit-acquisition cost overnight to some $900 million each in FY 2004 dollars.

[18] President George H. W. Bush's third state-of-the-union address is available online at http://www.polsci.ucsb.edu/projects/presproject/idgrant/sou_pages/bush3su.html. Reducing the B-2 buy to 20 aircraft pushed the B-2's unit-acquisition cost to almost $3 billion in FY 2004 dollars.

nuclear triad's bomber leg, which in time of nuclear war would be employed by US Strategic Command (STRATCOM).[19]

§ In January 1993, Presidents Bush and Boris Yeltsin signed a treaty on further reduction and limitation of strategic offensive arms (START II). START II gave both sides the right to reorient heavy bombers to a conventional-only role, and the Air Force soon began doing so with its B-1Bs.

§ In 1995 Congress added $493 million to the B-2 program for Fiscal Year (FY) 1996. In the spring of 1996, after President Bill Clinton had certified to Congress that 20 B-2s were sufficient to support US defense needs, the administration bowed to congressional pressure to use the $493 million to convert a flight-test aircraft into an operational aircraft for a total inventory of 21 B-2s.

§ In July 1997 the Independent Bomber Force Review, chaired by Brent Scowcroft, reached two fundamental conclusions about the planned future bomber force: first, since long-range air power will be more important than ever in the decades ahead, the planned force of 21 B–2s will not "satisfy foreseeable U.S. military requirements"; second, Pentagon opposition to further B–2 production is "shortsighted and parochial."[20]

§ In 1998 the congressionally mandated panel on Long-Range Air Power (LRAP), headed by former USAF chief of staff Larry Welch, concluded that it would be "ill-advised" to use the B-2 funding for FY 1998 to restart low-rate production of additional stealth bombers, and that any additional FY 1998 funding added by Congress should be used to improve the B-2's "deployability, survivability, and maintainability."[21] This panel's conclusions probably ended any hope of additional B-2 production.[22]

§ In March 1999, the Air Force sent Congress a legislatively mandated bomber road map. While this document declared that the payload, range and responsiveness of heavy bombers, coupled with precision attack, made them a cornerstone of America's air power, force-projection capability and global-engagement vision, it deferred initial operational capability (IOC) of a B-2 follow-on until 2037.[23]

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[19] "The Changing World of Nuclear Deterrence," *AIR FORCE Magazine*, September 2001, pp. 92-93.
[20] *Congressional Record—House*, Vol. 143, June 23, 1997, p. H4176.
[21] The unclassified summary of the LRAP panel's SECRET report is available online at http://www.gpoaccess.gov/crecord/index.html.
[22] "It appears that time and circumstances have run out on the idea of production additional B-2 bombers" (John T. Correll, "Long Range Blind Spot," *AIR FORCE Magazine*, June 1998).
[23] DoAF, *U.S. Air Force White Paper on Long Range Bombers*, March 1, 1999, p. 21. IOC is the date when the initial unit equipped with a new weapon system is declared

- During the North Atlantic Treaty Organization's 78-day air campaign against Serbia (Operation Allied Force) in 1999, 45 B-2A sorties delivered over 650 JDAMs operating from Whiteman AFB, Missouri.[24] Allied Force marked the initial combat use of all-weather, guided "smart bombs" by American aircraft, whether fighters or bombers. "Reports of B-2 effectiveness, estimated by battle damage assessment, stated that B-2s damaged a higher percentage of their targets than any other aircraft participating in combat operations."[25]

- In early November 2001, E. C. "Pete" Aldridge, then under secretary of defense for acquisition, technology and logistics, asked the Air Force to "take action to develop" a future long-range strike aircraft that could begin a "development program in the 2012-2015 timeframe," 4-7 years earlier than the 2019 start date in the Air Force's 1999 bomber roadmap.[26]

- For the major-combat phase of the US-led campaign against al Qaeda and the Taliban in Afghanistan (Enduring Freedom), B-1Bs and B-52Hs (as well as most fighters) were able to employ the GPS-aided JDAM. As a result, the entire bomber fleet was now capable of delivering cheap, through-weather guided munitions, but the older bombers could only do so in the absence of enemy air defenses.

- By early 2002, Air Force officials were publicly reiterating their longstanding opposition to additional B-2s, arguing that the money would be better spent on an array of other, more pressing needs such as fielding the F-22.[27]

- In August 2002, the Air Force began a planned reduction of the active B-1B inventory from 93 to 60 aircraft (six B-1s having been lost in accidents and a seventh during combat operations in 2001).[28] However, in the FY 2004 defense authorization bill Congress directed the Air Force

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trained and capable of conducting combat operations. Backing up from the 2037 IOC for a B-2 follow-on, the 1999 road map postulated concept exploration in 2016, a new acquisition program in 2019, initial production 15 years later in 2034, and IOC in 2037 (ibid., p. 22)

[24] 509th Bomb Wing, "Operation Allied Force," August 1999, slide 22. During Allied Force B-2s delivered 609 JDAMs with 2,000-lb Mk-84 warheads (GBU-31v1s), 43 JDAMs with 2,000-lb BLU-109 hard-target warheads (GBU-31v3s), and four 4,700-lb GBU-37s.

[25] Director, Operational Testing and Evaluation, "B-2 *Spirit* Advanced Technology Bomber," *FY99 Annual Report*, p. V-31.

[26] E. C. Aldridge Jr., "Future Long-Range Strike Aircraft (LRSA-X)," Memorandum for Secretary of the Air Force, November 2, 2001.

[27] Harold Kennedy, "Air Force Steps Up Efforts To Care for Its Aging Aircraft," *National Defense*, January 2002 (available online at http://www.nationaldefensemagazine.org/article.cf m? Id=704 ; also Bill Gertz and Rowan Scarborough, "Inside the Ring," January 2002 (available online at http://www.gertzfile.com/gertzfile/ring012502.html).

[28] The B-1B lost in December 2001 went down in the Indian Ocean on its way to Afghanistan due to numerous onboard system failures (Herbert, "The Long Reach of the Heavy Bombers," p. 27).

to return 23 of the retired B-1Bs to active service. As of early 2004, the Air Force was trying to reduce the number of reactivated B-1s from 23 to just eight.

- During the major-operations phase of Iraqi Freedom in 2003, two B-52Hs were equipped with Litening II targeting pods, thereby enabling US bombers, for the first time, to employ laser-guided bombs autonomously, a capability Pave Knife F-4Ds had famously used in May 1972 to drop the Paul Doumer and Thanh Hoa bridges in North Vietnam.[29]

- To the extent that the 1999 bomber roadmap has been superceded by USAF's Transformation Flight Plan, the service's vision of a next-generation long-range strike system has not grown clearer in recent years. The 2003 Transformation Flight Plan mentions such options as a supersonic "B-X Bomber" and a "New Long-Range Platform" armed with subsonic and hypervelocity missiles.[30] Air Force budget documents for FY 2005 contain a wedge for development of a next-generation bomber in FY 2008-09, but that money could very well go to a medium-range regional bomber.

These various decisions, developments and studies have several implications. First, during the 1990s wide differences of opinion emerged over the adequacy of the US bomber force. One need only compare the conclusions of the 1997 Independent Bomber Force Review, chaired by Brent Scowcroft (a retired USAF lieutenant general and national security advisor to two presidents), with those of the 1998 Long-Range Air Power panel, chaired by retired USAF general Larry Welch (then the head of the Institute for Defense Analyses and former commander of the first operational F-15 wing). Scowcroft's commission thought that the only option for maintaining the viability of the bomber force over the long term was B-2 production beyond 21 aircraft, whereas Welch's panel judged the existing bomber force would suffice "for the next 15 years of so" if certain improvements were made.[31]

Second, the fighter generals who now dominate the Air Force have shown little interest in buying any long-range systems for many years to come. Scowcroft concluded that by the mid-1990s there was service-wide consensus that long-range bombers were no longer needed, a view for which there is no shortage of evidence. The absorption of SAC's bombers into ACC in 1992 amounted to a hostile takeover of the bomber force by Tactical Air Command (now ACC) fighter pilots, and eliminated from the Air Force a major-command, four-star advocate for long-range strike systems.[32] The protracted

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[29] Moseley, *Operation IRAQI FREEDOM—By the Numbers*, p. 15.
[30] Headquarters USAF, *The U.S. Air Force Transformation Flight Plan*, pp. D-3 and D-9. This document also mentions the possibility of converting a 747-400 into a high-volume standoff strike platform (ibid., p. D-5).
[31] General Welch's April 1, 1998, House testimony on his panel's findings is available at http://commdocs.house.gov/committees/security/has162200.000/has1622000f.htm.
[32] Starting in 1992 SAC's successor, STRATCOM, unified for the first time under a single commander the planning, targeting and wartime employment of American long-

and troubled gestation of the costly F-22 (redesignated the F/A-22 in September 2002 to portray it as more than an air superiority fighter) has only served to mute serious discussion within the Air Force of the United States' need to bolster its capabilities for long-range strike.[33] About the best that can be said is that Air Force leaders have construed Aldridge's request to initiate a new acquisition program for a long-range strike system in the 2012-15 timeframe as a justification to begin exploring a medium-range "regional bomber." In this regard, Air Force officials argue that employing current low-observable strike platforms—the F-117 and B-2—in the daytime is too risky because, among other things, they cannot defend themselves against enemy fighters or prevent visual acquisition and tracking.[34] Still, the Air Force's preference appears to be for an extended-range variant of the F/A-22 rather than a genuine long-range system.[35] The fact that Air Force leaders are "loath to say a follow-on system will be a 'B-3' or even a bomber" seems to confirm Scowcroft's doubts that the US military services remain convinced that long-range air power is needed in the long run.[36]

Third, since the late 1980s the conventional capabilities of the US long-range bomber fleet have been greatly increased by the addition of guided munitions—especially inexpensive ones such as JDAM.[37] Indicative of an inclination to base force requirements more on capabilities than platform numbers, the bomber-inventory requirement has been allowed to decline

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range nuclear forces—bombers, land-based intercontinental ballistic missiles (ICBMs), and submarine launched ballistic missiles (SLBMs)—although the day-to-day training, equipping and maintenance responsibilities of its forces remained with the Air Force and Navy. While STRATCOM's first commander was the USAF general who had previously headed SAC (George Butler), its subsequent commanders have consisted of three admirals (Henry Chiles, Richard Mies and James Ellis), one Marine Corps fighter pilot (James Cartwright, the current commander), and a single USAF general (Eugene Habiger during 1996-98). Given the withdrawal of the B-1 from a nuclear role, it should not be surprising that STRATCOM has failed to advocate long-range bombers with the same fervor as SAC commanders such as Curtis LeMay (1948-57) or Russell Dougherty (1974-77).

[33] According to the Air Force, the F/A-22 has evolved into an air dominance aircraft capable of "kicking down the door" in anti-access situations, and the redesignation simply reflects the inherent air-to-ground and air-to-air capabilities of the Raptor (Staff Sgt. A. J. Bosker, "F-22 Redesignation Reflects Combat Role," September 17, 2002, available online at http://www.af.mil/news/Sep2002/91702361.shtml). For a fuller discussion of this notion, see General John P. Jumper, "Global Strike task Force," *Aerospace power Journal*, Spring 2001, pp. 24-33.

[34] The section below on making the most of the existing bombers discusses the planned upgrade of the B-2's radars. Once the new radars are installed, there will be no good reason, other than the costs of software and computer upgrades, why the B-2 could not be equipped with air-to-air missiles such as the AIM-120. Moreover, once enemy air bases have been attacked and the F/A-22s have gained air control, the fighter threat to daytime B-2 operations would, surely, be minimal.

[35] See, for example, Richard Whittle, "F-22 Bomber Studied," *Dallas Morning News*, July 30, 2002; Bill Sweetman, "Raptor Could Hatch a Delta Bomber," *Jane's International Defense Review*, June 2002; and Bill Sweetman, "Smarter Bomber," *Popular Science*, June 13, 2002 (available online at http://www.popsci.com/popsci/aviation/article/ 0,1 2543, 262063-1,00.html).

[36] Herbert, "The Long Reach of the Heavy Bombers," p. 29.

[37] Again, a full-up JDAM currently costs around $24,000 in FY 2004 dollars. A comparable unit-procurement price for a CALCM is probably $2-3 million each.

somewhat. Whereas the 1999 bomber roadmap called for 170 active bombers, Air Force leaders now view "the right number" as around 150 (of which 44 B-52Hs, 36 B-1Bs, and 16 B-2As would be combat coded).[38] Air Force leaders can take deserved credit for the dramatic gains in bomber lethality that resulted from putting unpowered guided munitions on all its combat-coded bombers, a capability improvement that occurred after SAC had been disestablished and its bombers transferred to ACC. In Afghanistan and Iraq, Air Force officials were particularly pleased with the utility of B-1Bs as "roving linebackers" that could loiter behind the battlespace and then come forward to unleash JDAMs on demand. Again, this B-1B "success story" was contingent on the complete absence of functioning enemy air defenses at medium or higher altitudes.[39] Nevertheless, the fielding of the through-weather JDAM across the entire American bomber fleet occurred long after the World War II bomber generals who founded the US Air Force had given way to fighter generals whose foremost priority was fighter force structure.[40]

At the end of the day, however, the Air Force's contention that the current bomber inventory will be able to satisfy the nation's needs for long-range/global strike into the late 2020s or beyond rests on at least a couple key assumptions. One is that the existing bomber fleet will not suffer significant combat attrition during the next several decades. This premise may be plausible so long as US opponents remain lesser states such as Serbia and Iraq, or terrorist organizations such as al Qaeda. Whether it would hold up in a protracted conflict against a larger, more-capable adversary is far less clear, particularly if enemy air defenses and anti-access/area-denial capabilities were able to inflict significant attrition on the bomber force, or if political decisions in foreign capitals prohibited basing US fighters within 1,000-1,500 nm of the theater.[41]

A second assumption underlying the Air Force's reluctance to invest much in long-range strike is that bombers, while "particularly good" against the relatively small numbers of "fixed targets," lack any appreciable capacity against "things that move," which are becoming more numerous as adversaries

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[38] Herbert, "The Long Reach of the Heavy Bombers," p. 27. Combat-coded aircraft are those available for operations in trained combat units. The active B-2 inventory is 21 aircraft but only 16 are combat coded.

[39] Herbert, "The Long Reach of the Heavy Bombers," p. 24. The B-1's large payload—24 JDAMs—and long on-station or loiter time were the features that so pleased Air Force leaders in Afghanistan and Iraq.

[40] The rise of fighter generals to dominance of the Air Force occurred in the decade following the end of the Vietnam War—see Colonel Mike Worden, *Rise of the Fighter Generals: The Problem of Air Force Leadership 1945-1982* (Maxwell AFB, AL: Air University Press, March 1988), especially pp. 211-28.

[41] For a thorough treatment of theater basing requirements for short-range fighters in an anti-access environment, see Christopher J. Bowie, *The Anti-Access Threat and Theater Air Bases* (Washington, DC: Center for Strategic and Budgetary Assessments, 2002). For treatment of how the US military is planning to deal with the challenge of anti-access and area-denial capabilities, see Andrew Krepinevich, Barry Watts and Robert Work, *Meeting the Anti-Access and Area-Denial Challenge* (Washington, DC: Center for Strategic and Budgetary Assessments, 2003).

adapt to US capabilities against fixed targets.[42] This assumption seems open to some question given the success the B-2/JDAM had in 1999 against targets such as Serbian SA-3 surface-to-air missile (SAM) sites, which had avoided being targeted by other NATO aircraft by moving short distances overnight.[43] The deeper issue here, which will be covered below in the discussion of making the most of the existing bombers, is the B-2's currently limited ability to deviate from a preplanned route once inside defended airspace.

THE GROWING CHALLENGE OF PRECISION INFORMATION

Most public debate over American long-range, nonnuclear, precision strike capabilities—especially since the B-2 buy was cut to 20 aircraft in 1992—have centered on the numbers and types of heavy bombers the United States should have. B-2 supporters in Congress such as Representatives Norm Dicks and Duncan Hunter, as well as Brent Scowcroft and former Air Force secretary Donald Rice, have advocated buying more B-2s despite opposition from many quarters, including the Air Force itself.[44]

In hindsight a larger B-2 buy would undoubtedly have given the nation a more survivable and lethal bomber force. In the early 1990s, Major General (USAF, ret.) Jasper Welch conducted campaign analyses of a major regional contingency aimed at determining how many and what kinds of bombers the United States should retain for future conventional operations.[45] His 1992 analysis took into account attrition to enemy air defenses, the increased lethality provided by guided weapons such as JDAM, the costs of using guided munitions to prosecute the campaign, and the costs of bomber-force modernization (i.e., modifications to the older bombers and/or the costs of additional B-2s). His 1994 analysis used tactical-fighter as well as bomber forces to prosecute the campaign. Both analyses credited the enemy with air defenses capable enough to demand stealth, standoff or low-level tactics until

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[42] John A. Tirpak, "Roche Plots a Course," *AIR FORCE Magazine*, October 2001, p. 67; "Roche Sorts It Out," *AIR FORCE Magazine*, March 2002, p. 39.

[43] General John P. Jumper, "21st Century Aerospace Force: Essentials for Operational Success," DFI transcript of a congressional seminar, Rayburn House Office Building, Washington, DC, April 13, 2000. Jumper noted that, after he had flown to Whiteman AFB in Missouri to get the B-2 pilots thinking in a "flex-targeting mode," the B-2 got two SA-3 sites the very next night. In the case of a Serbian surveillance radar destroyed by a B-2 as a flex target, the post-strike photo showed bomb craters from other strikes that had missed because the radar had been repeatedly moved. The B-2 crew was able to adjust for those movements.

[44] See, for example, Donald B. Rice, "No Stealth to Pentagon's Bias against the B-2," *The Los Angeles Times*, May 9, 1999. Among other comments, Rice wrote that the "1999 bomber road map reflects the myopic focus of today's Air Force on short-range aircraft." Rice was also a member of Scowcroft's Independent Bomber Force Review.

[45] These analyses were done for the Northrop Analysis Center, which obviously had an interest in more B-2s. Nonetheless, Welch's studies were the first serious attempts to explore mostly precision air campaigns. At the time Air Force leaders were inclined to dismiss Welch's work for at least three reasons: disbelief in the likelihood of strong enemy air defenses, disbelief in the possibility of inexpensive guided munitions such as JDAM, and disbelief in the ability of the US intelligence community to provide the targeting information for a mostly precision campaign. In 1999 the US faced air defenses competent enough to bring down an F-117, and since 1991 mostly precision air campaigns have become the norm for the US military.

the radar-guided SAMs had been effectively suppressed and most opposing fighters had been shot down or destroyed. The results of these analyses, expressed in such metrics as total cost, B-2 equivalent sorties, and the time to complete all seven campaign objectives, suggested that a total inventory of 50 B-2s (40 combat coded) would have enabled the Air Force to retire all of its remaining B-52s (rather than flying them into the 2030s), and perhaps the B-1s as well.[46] Indeed, when the costs of direct-attack and standoff guided munitions, modifications to the older bombers, and more B-2s were included, Welch's analyses indicated that a force of 50 B-2s would be cheaper than the current mix of B-52s, B-1s, and B-2s, despite the procurement price of additional B-2s.[47] Unfortunately, the time for moving to this sort of smaller, cheaper, and more lethal bomber force has almost certainly passed due to the resistance of B-2 opponents.[48]

However, as Welch himself subsequently recognized, the most crucial issue for the effectiveness of the sorts of precision campaigns he had analyzed after Desert Storm was not the composition and size of the bomber force but the availability, timeliness, and accuracy of the information demanded by modern guided munitions.[49] One of the enduring lessons from the 1991 Persian

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[46] Major General Jasper Welch, "Analyses of U.S. Requirements for Conventionally Armed Bombers," July 1994, pp. 11-14. More recently, a Heritage Foundation analyst argued that the US could afford to move to a force of "something like 60 B-2s, 60 B-1s, and a handful of B-52s with advanced ALCMs" by 2015 (Jack Spencer, "Achieving Balance in American's Long-Range Strike Aircraft Capabilities," Heritage Foundation Backgrounder No. 1706, November 13, 2003, p. 5). However, this recommendation appears to have been based primarily on the number of bombers rather than on the costs and operational requirements of actual campaigns, or the likelihood that guided munitions would enable fewer bombers to do far more than in the past.

[47] Welch, "Analyses of U.S. Requirements for Conventionally Armed Bombers," Table 4, p. 13. Welch's analyses did not look at operations-and-support (O&S) costs because no actual data on the B-2 existed at the time. Based on more recent information, the annual O&S cost for 40 combat-coded B-2s would be about 25 percent less than a combat-coded force of 44 B-52s, 36 B-1s, and 16 B-2s. This estimate, moreover, is several years old and does not reflect ongoing improvements in the maintainability of the B-2's low observability.

[48] In fairness, there were serving Air Force officers with fighter backgrounds who argued openly for a larger B-2 buy into the mid-1990s while still in uniform. See, in particular, Commission on Roles and Missions, *Future Bomber Force*, May 1995 (published by the Air Force Association in 1996). The team leader for this issue paper was then Colonel (now Major General) David A. Deptula. The question his team sought to answer was: Should the US terminate bomber production or continue building long-range stealth bombers? As Brent Scowcroft noted in 1997, this report was "the only government study to provide empirical insights into the value of stealth" (*Congressional Record—House*, Vol. 143, June 23, 1997, p. H4180). Generals Charles Horner and Richard Hawley also became supporters of a larger B-2 inventory, but only after they had retired. For example, two years after Horner retired he wrote that "it is difficult to comprehend how the Pentagon could so actively resist expanding the [B-2] fleet" (General Charles A. Horner, USAF Ret., "What We Should Have Learned in Desert Storm, But Didn't," *AIR FORCE Magazine*, December 1996).

[49] In 1996, Welch concluded that foreseeable improvements in precision attack would come predominately from such things as matching warheads to targets, timing attacks for periods of maximum target vulnerability, attacking targets when their destruction would have the greatest impact on the enemy, and implementing attack strategies to exploit target-system level weaknesses. Most of these ideas have been taken up in USAF

Gulf War was that precision munitions require "precision information." Even in the case of fixed targets, inaccurate targeting information can have long-lasting adverse consequences, as the precise placement of five 2,000-lb JDAMs on the Chinese embassy in Belgrade during Operation Allied Force in 1999 illustrates.[50] In the case of fleeting, emergent, or time-sensitive targets—which have become an increasing focus of Air Force attention since General John Jumper improvised "flex targeting" to deal with them during Operation Allied Force—the pressure to reduce sensor-to-shooter timelines with more timely targeting information has grown enormously. For instance, on the afternoon of April 7, 2003 (Baghdad time), US intelligence sources received information that Saddam Hussein, his two sons, and up to fifty members of the top Ba'ath leadership were meeting in Baghdad's al-Mansour district. It took 35 minutes to confirm the tip with other sources, reach a decision to strike, forward the targeting information from the theater to the National Imagery and Mapping Agency (now the National Geospatial-Intelligence Agency) for the development of precise ("mensurated") GPS coordinates, select the best available asset to conduct the strike (a B-1B), "weaponeer" the target in the Combined Air Operations Center in Saudi Arabia, pass the "precision" information to the controlling E-3 Airborne Warning and Control System (AWACS), and have the AWACS relay the information on the aim points to the inbound B-1B over western Iraq.[51] Twelve minutes later four 2,000-pound JDAMs hit two aim-points, leaving nothing but a deep smoldering crater.[52] By then, though, the key Ba'athist leaders either had left the facilities or had not been there in the first place.

Accuracy and timeliness are not the only requirements for guided weapons. As American capabilities for precision strike have expanded over the last decade or so, the amounts of precise information required per hour or day have grown even faster. Current US efforts to develop smaller guided weapons such as the 250-pound class small diameter bomb (SDB) seem destined to bring about further growth in the sheer quantity of precision-targeting information American forces will require per unit of time. B-2s, for example, have largely operated with payloads of 16 JDAMs on a given strike mission. In 2003 a B-2 released 80 500-lb JDAMs, all of which hit within 10 feet of their

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discussions of effects-based operations, and all of them hinge on precision information rather than munition accuracy.

[50] William W. Arkin, "Chinese Embassy Continues to Smolder," special to washintonpost.com, November 8, 1999. The attack occurred on the night of May 7-8, 1999. On October 17, 1999, the London *Observer* and the Danish newspaper *Politiken* jointly published an article claiming that NATO had intentionally targeted the Chinese embassy, a view for which Arkin could find no credible evidence. Nevertheless, as of late 2000, the Chinese foreign ministry was still adamant in rejecting American insistence that the attack had been an unfortunate mistake.

[51] Adam J. Herbert, "The Baghdad Strikes," *AIR FORCE Magazine*, July 2003, pp. 49-50.

[52] "B-1 Pilot Telephone Interviews," DoD news transcript, April 8, 2003, on the web at http://www.defenselink.mil/transcripts/2003/tr20030408-t408phin.html. According to the B-1 pilot and weapon-systems operator, the controlling AWACS passed the GPS coordinates for two desired mean points of impact (DMPIs) along with munition selections for each (one GBU-31v3 followed by one GBU-31v1 with a 25-millisecond fuse delay per DMPI).

aim-points, on a single pass.[53] Looking ahead, with dense packing, a single B-2 could carry 108-120 SDBs in one of their two weapons bays, and eight 2,000-lb munitions in the other. These payload options entail a fivefold to eightfold increase in the precision-targeting information required per B-2 mission. And, if significant portions of the payload are targeted (or retargeted) after takeoff, then the time windows for the distribution of that information will be compressed. Similarly, the Air Force hopes that SDBs will enable late-block (spirals 4 and 5) F/A-22s to cover eight aim-points on a sortie rather than just two (assuming internal munitions carriage only).

These rapidly ballooning requirements for precision information to "inform" US guided munitions explain why the first two recommendations by the 2004 Defense Science Board (DSB) task force on "Future Strategic Strike Forces" were about (1) command-and-control networks; and (2) intelligence, surveillance, and reconnaissance (ISR) and battle-damage assessment (BDA).[54] When, as the third area listed, the DSB task force turned to delivery platforms, the specific recommendations were to: (a) develop conventional warheads for 50 Peacekeeper intercontinental ballistic missiles (ICBMs) currently being deactivated to "give the United States a 30-minute response capability for strategic strike worldwide"; (b) develop a nonnuclear ballistic missile for the Navy's SSGNs with a range of 1,500 nm and 2-meter accuracy; and, regarding a follow-on to the present delivery systems, (c) "initiate an analysis of alternatives for prompt strike capability [italics in the original]."[55]

By and large, the prioritization and thrust of these recommendations is sound. The emphasis given to the escalating precision-information requirements of strike regardless of range, both before and after munition impact, seems on target. The suggestions for conventionally modifying 50 Peacekeeper ICBMs and developing a ballistic round for the four SSGNs address the growing need to be able to strike targets from 1,500 nm to global distances within minutes rather than hours or days. In 1999 the Serbs had considerable success moving radars and SAM sites small distances often enough to stay inside NATO's targeting cycle. The growing prospects for a failed nuclear state suddenly presenting the United States with a time-urgent requirement to find, secure or destroy loose nuclear weapons, as well as fleeting terrorist targets, underscore the need to be able to strike within very narrow windows of opportunity. While there is much truth to the Air Force's claim of having largely solved the challenges of fixed targets, relocating assets

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[53] John A. Tirpak, "Toward a New Style of Warfare," *AIR FORCE Magazine*, November 2003, pp. 80-81.

[54] This DSB task force defined the scope of its work as follows: a strategic strike is "a military operation to decisively alter an adversary's basic course of action within a relatively compact period of time." A strategic strike can be either (1) an isolated event such as the El Dorado Canyon attack on Libya, or (2) part of a military campaign such as the Vietnam War's Linebacker II strikes or the attack on Saddam Hussein himself at the outset of Operation Iraqi Freedom—Admiral Dennis Blair, General Michael Carns, and Vincent Vitto, *Report of the Defense Science Board Task Force on Future Strategic Strike Forces* (Washington, DC: Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, February 2004), p. 1-2.

[55] Blair, Carns, and Vitto, *Report of the Defense Science Board Task Force on Future Strategic Strike Forces*, pp. 1-8 to 1-9.

inside US sensor-to-shooter cycle times offers adversaries another way of denying precision targeting information to American forces. Ballistic missiles, with times of flight from launch to impact measured in minutes, are a way of addressing the problem of out-of-date targeting information.

MAKING THE MOST OF THE EXISTING BOMBERS NOW

The Future Strategic Strike Forces DSB's assessment of B-2 modernization, however, was not as thoughtful as its recommendations concerning precision information and ballistic-missile delivery options. Here is all the task force's February 2004 report had to say on the stealth bomber:

> Near-term modernization efforts are underway for the B-2 . . . As with the B-52 and B-1, LINK-16 is being added. A new center instrument display with an in-flight replanner to handle large amounts of threat information is being added. The radar's operating frequency is being changed to avoid significant frequency interference. The conventional weapons capability is also being increased. The 500-pound Joint Direct Attack Munition (JDAM)—an all-weather, GPS-aided, general-purpose bomb—is being integrated; the B-2 can carry 80. The B-2 will also be able to carry the enhanced GBU-28 (a 5,000-pound GPS-aided/INS-guided, all-weather weapon). With the [enhanced] GBU-28, the B-2 will be capable of attacking HDBT [hard and deeply buried targets].[56]

The impression these comments convey is that adequate improvements to the B-2 are proceeding apace—at least in the near term—and there is no hint that anything significant needs be done in the longer term.

This impression, though, turns out to be misleading. Consider the change now planned in the operating frequency of the B-2's radar.[57] The change is going to be accomplished by installing active electronically scanned array (AESA) radars in the B-2. With software and adequate computational power, these arrays should enable the resolution of the synthetic-aperture-radar (SAR) images B-2 crews use—primarily to minimize target-location error—to be reduced from the present 3 meters to about one foot. This resolution improvement is roughly an order of magnitude and would transform aim-point identification by B-2 pilots from a difficult imagery-interpretation skill into something closer to recognizing objects in a clear photograph. Yet, the requisite software and computational upgrades needed to achieve high-resolution SAR, or to exploit the ground-moving-target indicator

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[56] Blair, Carns, and Vitto, *Report of the Defense Science Board Task Force on Future Strategic Strike Forces*, p. 5-5.

[57] The problem that currently exists is that the B-2's radar operates in a portion of the electromagnetic spectrum allocated to primary commercial use. The radar does not merely interfere with commercial systems which have been fielded in this band, but can actually damage hardware.

(GMTI) potential of an AESA radar, have neither been programmed nor funded.[58]

The reason appears to lie ultimately in the B-2's underlying computer architecture, which dates from 1984 when the first Macintosh personal computer was introduced. The original Macintosh was built around a Motorola 68000 microprocessor running at 8 megahertz with 128 kilobytes (KB) of random access memory (RAM), expandable to 512 KB. The microprocessors used throughout the B-2 for such tasks as flight-management control, vehicle interface with new capabilities such as Link 16,[59] displays and controls, stores management, and emitter-threat location are military versions of the Intel 286 with 512 KB of RAM. In most of these areas, the processors are operating at 90-99 percent of their dynamic memory capacity, and sensible upgrades such as enabling the stores-management system to address a rotary launcher in one bay and a smart bomb rack assembly in the other cannot be implemented without more RAM. To drive home how antiquated 512 KB of RAM are by today's standards, this paper was composed on a laptop computer with one gigabyte of RAM, which is some 2,000 times (over three orders of magnitude) more dynamic memory than that in the B-2's core processors. Beyond RAM limitations, the B-2's current processors also run at very slow speeds compared to the 1 gigahertz microprocessors used in the JSF demonstrators, and the B-2's underlying avionics architecture faces significant limitations getting data on and off the plane's data buses.

These observations suggest two points. First, if the Air Force is going to operate the B-2 into the 2030s, then updating its computer architecture will almost certainly be required before then. Second, an argument can be made for doing so sooner rather than later on the grounds that a modern computer architecture—one comparable to the open, easily upgraded architecture designed for the F-35—would permit large improvements in the bomber's capabilities.

The most dramatic improvement in operational capability that would flow from updating the B-2's computer architecture has to do with its stealth. Stealth is a function of tactics and low observability. The primary way a B-2 avoids getting too close to an enemy SAM is to preplan a route through defended airspace—the so-called "blue line"—that stays far enough away from the locations of known SAMs to avoid being detected.[60] The Joint Strike Fighter, by comparison will have the sensors and computational capacity to

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[58] GMTI would give the B-2 some capability to track moving ground targets such as tanks or other vehicles similar to that available on the E-8C Joint Surveillance and Target Attack Radar System (JSTARS).

[59] Link 16 is a more affordable version of the Joint Tactical Information Distribution System (JTIDS). JTIDS and Link 16 are tactical networks that enable all aircraft on the net to share on their cockpits displays both threat and friendly force location data. For example, if an F-15 flight was linked together by JTIDS, then a radar contact by any jet in the flight would be automatically shown on the radar displays of all the other flight members.

[60] Active jamming from EA-6Bs is also usually figured into B-2 or F-117 mission planning.

sense threat radars and maintain sufficient distance from them in real time or dynamically, which means the plane can operate in defended airspace without being tied to a preplanned blue line. A thoughtful upgrade of the B-2's computer architecture would, therefore, free the plane from blue-line stealth and reduce its vulnerability to "pop-up" SAMs while, at the same time, permitting mixed munition loads and enabling its new AESA radars to provide high-resolution SAR as well as GMTI. In addition, air-to-air modes could be added to the radar to give B-2 some active self-protection against enemy fighters by arming the plane with AIM-120 Advanced Medium Range Air-to-Air Missiles (AMRAAM). In short, upgrading the B-2's computer architecture is the key to transforming the plane from fixed-target, night-only, "blue-line" bomber into a weapon system able to conduct persistent surveillance-strike deep in defended airspace, perhaps even in the daytime when necessary.

Yet, while the F/A-22—which is still in operational test and evaluation at Nellis AFB, Nevada, and will not achieve IOC before December 2005—already has a formal block-upgrade program, the B-2, whose IOC was in April 1997, does not. This situation, besides reflecting the preference of Air Force leaders for short-range fighters, suggests a near-term recommendation that escaped even the DSB task force on "strategic strike:" a formal B-2 block-upgrade program. Such a program is long overdue and should be initiated as early as possible.61 This program, moreover, should include avionics modernization aimed at giving the B-2 the global communications and, above all else, the computational capacity to receive, generate, and process precision information—imagery as well as data—at whatever rate and density future operations may require.

An issue worth considering is whether similar upgrades to the older bombers would also make sense in the long run. Because neither the B-1 nor the B-52 remotely approaches the low observablity of the B-2 or F-117, the gains in operational capability would not be as dramatic as in the case of the B-2. Still, if the older bombers are going to remain in the active force through the 2020s, some additional investments in their capabilities to generate, receive, exploit, and transmit precision information would probably be in order. Also, re-engining the B-1Bs might permit earlier retirement of the B-52s than now planned.[62]

A somewhat more radical option from the standpoint of traditional notions of long-range strike would be to reorient the B-1s toward close support of ground and special-operations forces in relatively permissive air-defense environments. This idea simply extends the use of B-1s as roving linebackers in Afghanistan and Iraq. The premise, of course, is that most of the operations

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[61] While the B-2 has, of course, undergone upgrades, the money came from congressional adds rather than being programmed by the Air Force and the upgrades have lacked the coherence and vision of the F/A-22 modernization program. While the USAF's 1999 bomber roadmap highlighted the need to modernize the bomber's computers and processors in the long term, nothing has been programmed, much less funded. Currently 20 of the 21 B-2s are in the Block-30 configuration.

[62] Nick Cook, "Boeing Offers US Interim Strike Capability Options," *Jane's Defense Weekly*, August 25, 2004, p. 30.

the US military is likely to conduct over the next 10-15 years will be against lesser opponents with limited capacity to contest air control. For such contingencies, the long loiter times and large payloads of a heavy bomber could provide highly mobile, on-call, all-weather joint fire support. The costs to optimize some number of either of the two older bombers for this role would be minimal. A set of options such as Litening II targeting pods for LGBs, better displays for situation awareness of both low-altitude air defenses and friendly ground forces, robust communications for connectivity and radio relay to special forces, and perhaps a capability to act as a mother ship for unmanned reconnaissance vehicles such as Predator would not break the bank.

In the near term, then, there are at least two attractive options for making the most of the existing bombers. One is to bring the B-2's avionics into the 21st century; the other is to reorient some of the older bombers toward close support of land forces.

OPTIONS FOR FUTURE LONG-RANGE STRIKE PLATFORMS

For some years now, the Air Force has been exploring a wide range of platform options for next-generation long-range strike capabilities. In 1999, for example, Air Force engineers at Wright-Patterson AFB in Ohio explored the following speed options for a "global mission vehicle" whose goal was specified as being able "to respond quickly to anywhere in the world from the continental United States (CONUS), while being highly survivable": subsonic (Mach 0.85), Mach 2.4 (the maximum for aluminum structure), Mach 4.0 (the maximum for uncooled titanium honeycomb), Mach 7 (the maximum for endothermic hydrocarbon fuels), Mach 11 (the maximum for hydrogen fuel), and orbital ("Mach 26").[63] Similarly, the web site for the Air Vehicles Directorate at the Air Force Research Laboratory currently displays no less than eight long-range strike concepts, including: a stand-off "missileer,"[64] a subsonic penetrator along the lines of the B-2, low- and high- supersonic manned penetrators (around Mach 2 and 4, respectively), a hypersonic vehicle (Mach 5-plus), and an orbital space operations vehicle that would release common aero vehicles (CAVs)—maneuverable reentry vehicles able to dispense guided munitions over the target.[65]

Suffice it to say that there are a lot of options from which to choose a next-generation long-range strike system. Besides cruise speed, there are a number of other basic parameters to consider, including unrefueled combat radius, munitions payload, vehicle signature (for lower Mach numbers), and whether or not to stay with a manned platform. These choices, however,

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[63] Gordon C. Tamplin, John W. Livingston, David L. Hammond, Donald P. Breidenbach, et al., "System and Operational Implications for Choosing the Best Speed for Global Missions," Aeronautical Systems Center, Wright-Patterson AFB, OH, December 1999, p. 2.

[64] The usual notion of a missileer is to modify a large commercial jet, such as a 747-400, to be able to launch scores to a couple hundred cruise missiles from outside the reach of enemy air defenses. Note that by the late 1980s, the B-52 armed with nuclear Advanced Cruise Missiles had become, in effect, a nuclear missileer.

[65] Available at http://www.va.afrl.af.mil/IC/LRS/lrs_index.html.

involve technological and engineering issues that lie far beyond both the author's competence and the scope of this paper. As already noted, even the 2004 DSB task force on "Future Strategic Strike Capabilities" elected to recommend further analysis rather than hazard a definite choice. And, to make the obvious point, while higher speed may be inherently more desirable in some respects, options between high-supersonic and suborbital may lie beyond the DoD's technological reach at affordable costs for a decade or more to come.[66] Thus, some choices are more feasible than others.[67]

Nevertheless, the range of choice is wide and should be informed by, if not driven by, operational needs and tactical realities. Low observability to radar was designed into the F-117, B-2 and F/A-22 to reduce vulnerability to radar-guided missiles, whether launched from an enemy fighter or a SAM battery.[68] For a given radar signature, an air vehicle platform penetrating defended airspace at Mach 2-3 is less vulnerable to advanced SAMs, such as the Russian S-300 and S-400 (SA-10 and SA-20), than one penetrating subsonic.[69] Is there a Mach number between subsonic and hypersonic cruise that provides enough added survivability against this class of threats to justify a supersonic platform solution? While a lot of technical and operational analysis would be required to give an informed answer to this question, it is certainly one that merits exploration.

Other issues stemming from operational needs and tactical realities that warrant serious examination include the following:

- In the mid-term, would a "regional bomber" derived from the F/A-22 (or, better yet in terms of payload and supercruise range, the YF-23) make more sense—at least as a gap filler?[70] Unfortunately, the Air Force's experience with the B-58 and the FB-111, both of which were medium-range aircraft, does not provide much encouragement.

- How much payload is enough? The B-2's maximum weapons load is over 40,000 pounds (lbs), but the order-of-magnitude or greater efficiencies

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[66] A question that could be raised is whether the Air Force ought to delay any decision on a next-generation long-range system long enough to see if breakthroughs in hypersonic propulsion occur during the next decade. Major General David Deptula, for example, has recently flirted with this idea (Herbert, "The Long Reach of the Heavy Bombers," pp. 27-28).

[67] For example, in light of the substantial standoff capability inherent in the US Navy and aircraft such as the B-52, it is difficult to see a persuasive reason for choosing a missileer unless the missiles themselves are medium- or long-range.

[68] See Rebecca Grant, *The Radar Game: Understanding Stealth and Aircraft Survivability* (Arlington, VA: IRIS Independent Research, 1998), especially pp. 22-29.

[69] See John A. Tirpak, "The Double-Digit SAMs," *AIR FORCE Magazine*, June 2001, pp. 48-49.

[70] For a review of public statements by DoD officials on "regional-bomber" options, see Christopher Bolkcom, "Air Force FB-22 Bomber Concept," Congressional Research Service, RS21848, May 26, 2004. Supercruise refers to the ability of a plane to sustain speeds above Mach 1.0 without engaging afterburners.

inherent in guided weapons suggest that payloads in the vicinity of 20,000 lbs might suffice.[71]

- How much range is needed? For aircraft, long-range was arbitrarily defined at the outset as an unrefueled combat radius around 3,000 nm. However, operational requirements for range are more complicated in that refueled and unrefueled ranges are determined by very different considerations. The unrefueled range a strike aircraft requires is a function of the distance it needs to be able to penetrate into defended airspace, where aerial-refueling tankers cannot go, plus whatever loiter time may be required to find targets. A plane's refueled range, by contrast, is the distance between its main operating base and the edge of enemy air defenses, which bound airspace in which tankers can operate. Thus, the refueled range requirement for sustained combat operations is driven by considerations such as the availability of aerial tankers, the geographic proximity to enemy airspace of main operating bases, the political availability of those bases, and the sortie throughput needed to achieve the desired campaign strike intensity.[72] Current short-range fighter-bombers lack the unrefueled range to attack targets much deeper inside defended airspace than 500-750 nm. Yet a number of potential adversaries could locate key facilities deeper inside their borders than 500-750 nm. Moreover, appreciable loiter time for more continuous surveillance may be increasingly important for locating elusive or time-sensitive targets.

- Should a next-generation long-range strike system be manned? Unmanned air vehicles, if shot down, do not produce grieving mothers, wives, or children. Nor do they get tired on long-duration missions. The Air Force has received industry proposals for an unmanned strike system with an unrefueled range around 6,000 nm and a 20,000-lb payload. For deep, persistent strike, this solution would appear, at first blush, to be a viable alternative to the USAF's regional bomber, as well as to a short- or medium-range uninhabited aerial combat vehicle (UCAV). And while doubts about the technical feasibility of uninhabited systems

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[71] A good summary metric for the efficiency improvements afforded by laser-guided bombs, JDAMs, and other guided munitions is the tonnage of ordnance that normally needs to be expended to take out a given target. To offer an empirical data point using this metric, after Desert Storm a DSB task force concluded that "for many types of targets, a ton of PGMs [precision-guided munitions] typically replaces 12-20 tons of unguided munitions on a tonnage per target kill basis"—Alexander H. Flax and John S. Foster, Jr., *Report of the Defense Science Board Task Force on Tactical Air Warfare* (Washington, DC: Office of the Under Secretary of Defense for Acquisition and Technology, November 1993), p. 17.

[72] Major General Jasper Welch deserves credit for distinguishing refueled and unrefueled range requirements. The suggestion that air refueling makes the reach of current or future fighters "almost infinite" only refers to the distance between an aircraft's takeoff base and defended airspace, which is to say to the refueled portion of its range requirement (see "Ask the Air Force," WTOP AM radio interview with the Honorable James G. Roche and General John P. Jumper, February 19, 2003; available at http://www.af.mil/lib/wtop_transcript.html).

persist, a 2004 DSB task force concluded that there "is no longer any question" of their "technical viability and operational utility."[73]

§ What tradeoffs should be considered between platform speed and persistence? The Air Force argues that the supercruise speed of the F/A-22 (Mach 1.5+) offers the best solution—if not the only solution—for dealing with time-sensitive targets or advanced SAMs inside enemy airspace. However, the F/A-22 is not capable of deep persistence, particularly at supercruise speeds.[74] Also, as aircraft designers know well, higher speed in an air-breathing platform entails tradeoffs against other desirable performance parameters such as range and payload. Indeed, these tradeoffs largely explain why the Mach 2 B-58 was only in active service with SAC from 1962-70 while the subsonic B-52 is still flying.

These questions are not, of course, a complete or exhaustive list of the operational issues and tactical imperatives that should shape the design of a next-generation long-range strike system. Rather, they illustrate the kinds of questions that need to be answered before choosing from a range of options that runs from missileers and upgraded B-2s to UCAVs, hypersonic penetrators, and CAVs released from ballistic missiles or space-operations vehicles.

MOVING FORWARD

In hindsight, the United States missed the opportunity to draw down to a small, efficient, more lethal, and more cost-effective bomber force during the initial decade after the Cold War ended. Even the seemingly obvious step of adding guided bombs to existing US bombers took a surprisingly long time. The Air Force's bomber generals, having concentrated so long on nuclear deterrence, evidently never embraced adding affordable conventional precision to the bomber force. Efforts by industry and Congress to field a JDAM antecedent (the GPS-aided munition or GAM) on the B-2 in the mid-1990s, before JDAM was likely to be available, were resisted by Air Force officials. Similarly, although USAF fighters began employing LGBs with great success in 1968, the first combat use of an LGB from a heavy bomber did not occur until 2003.

Yet, as the post-Desert Storm history of the American bomber force also documents, the fighter generals who have increasingly dominated the Air Force since the Vietnam War have been equally short-sighted in their neglect of the very long-range air power that had given birth to an independent US Air Force in the first place. Their unwavering focus on short-range fighters in recent decades has led to vastly greater investment in aircraft such as the F-22 (now the F/A-22) and the Joint Strike Fighter (now the tri-service F-35) than

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[73] MajGen Kenneth Israel and Robert Nesbit, *Report of the Defense Science Board Task Force on Unmanned Aerial Vehicles and Uninhabited Combat Air Vehicles* (Washington, DC: Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, February 2004), p. iii.

[74] As an illustrative rule of thumb, if an F/A-22 runs at its top supercruise speed for 100 nm inbound and 100 nm outbound, its combat radius drops from over 600 to under 500 nm.

in long-range systems of any sort. By way of confirming that the word vastly is not ill chosen, a review of DoD budget data submitted in February 2004 for the FY 2003-05 defense program indicates that the Air Force and Navy are spending about 20 times as much on fighter RDT&E (research, development, test and evaluation) and procurement as on the existing bomber fleet and next-generation long-range strike systems.[75] Indeed, this fact may have played a role in Aldridge's decision to ask the Air Force to begin developing a new long-range strike system sooner than called for in the service's 1999 bomber roadmap.

Where does the issue of long- or global-range strike stand today? Time is passing, but there have been few programmatic signs of progress in the area of long-range strike. The fall of the Berlin Wall and the breakup of the Soviet Union now lie, respectively, 15 and 13 years in the past. There is every reason to expect that American national-security interests will continue to shift toward Asia and the Pacific over the next 10-15 years, where distances from the few large, reasonably secure bases the US military can expect to count on will almost certainly be double or quadruple those encountered during operations in the Afghanistan and Iraq campaigns of 2001-03. Further, nuclear proliferation appears to be spreading relatively unchecked in this part of the world; there is no indication that the terrorist challenge of organizations such as al Qaeda is likely to abate anytime soon; and the spread of advanced missile and surveillance technologies argue that states such as the People's Republic of China and even Iran could field formidable anti-access/area-denial capabilities over the next 10-15 years. Yet the modernization investments in the latest Pentagon future years defense program (FYDP) remain heavily skewed in favor of short-range fighters.

In the near-term, then, making the most of the existing B-2s by instituting a formal upgrade program focused on ensuring that the stealth bomber has the "precision information" to go from being a fixed-target, night-only, "blue-line" bomber to a system able to conduct persistent surveillance-strike at depths of 1,000 nm or more inside defended airspace seems a prudent first step. Again, the key is to invest the estimated $2 billion or so to modernize the B-2's avionics.[76] After all, similar improvements aimed at putting the "A" in the F/A-22 are already programmed, and the first couple spirals in the F/A-22

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[75] For FY 2003-05, procurement and RDT&E spending on short-range systems such as the F/A-18E, F/A-22, and Joint Strike Fighter totals nearly $37 billion versus less than $1.8 billion on existing bombers and a next-generation long-range strike system. Budget projections though FY 2009 suggest that this spending bias in favor of short-range platforms will persist. In fact, if the $780 million the USAF has earmarked for a next-generation bomber in FY 2008-09 ends up going to regional bomber, then the total investment in long-range bombers for FY 2005-09 will be less than $4 billion.

[76] A rough order-of-magnitude guess is that the avionics of the B-2 fleet could be modernized for around $2 billion, including upgrade of the plane's computer architecture and recoding software into C+/C++ as well as adding 1-foot SAR, GMTI, a fiber-optic bus, freeing the plane from a preplanned blue-line with an LO autrouter, and providing a capability against moving targets. To put $2 billion for B-2 avionics modernization in perspective, in 2001 alone the cost overrun in the production portion of the (then) F-22 program was $5.4 billion (E. J. Aldridge, Jr., letter to Representative John F. Tierney, October 3, 2001).

modernization program are funded. At the same time, optimizing some of the older bombers to provide joint fires for land forces in low-threat air-defense environments appears prudent, as well as reconfiguring some Peacekeepers with CAVs for very prompt global response.

In the longer term, some serious thinking and planning for one or more next-generation long-range strike systems needs to be initiated. To be specific, the Air Force should be directed to do something more concrete than, say, conduct yet another study of the wide range of options described above. Any analyses of alternatives must lead, in the longer run, to diverting a sensible portion—possibly as much as 10-15 percent—of the planned investment in short-range fighters into recapitalizing American long-range strike capabilities for the long haul. Having not yet done the careful analysis of operational needs, tactical realities, and technological feasibility raised in the preceding section, it would be imprudent to hazard a guess as to whether the DSB's emphasis on prompt long-range strike is the right one. In the meantime, however, there does not appear to be much doubt about the near-term improvements the United States should make in its long-range strike capabilities. The only question is whether they will be made.