B–2 aircraft will be capped at its current total of 21 operational aircraft

U.S. Air Force (Kevin J. Gruenwald)

# Long-range Conventional Strike

# A Joint Family of Systems

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U.S. plans to modernize long-range conventional strike have undergone significant changes over the last decade. In 2001, the U.S. Air Force elected to cap the B–2 fleet at the 21 already in service, based on the belief that the stealth bomber did not offer the advanced technologies needed to penetrate the integrated air defenses expected to be fielded by future adversaries. The Air Force supposed the technologies required for the next-generation long-range strike system—supersonic cruise, large payload, and very low observability—might not be available until about 2037.

The 2006 Quadrennial Defense Review (QDR), expressing concern regarding a more salient threat, pulled the next-generation long-range strike system ahead by nearly two decades, calling for an initial operational capability in 2018. Subsequently, an Air Force analysis of alternatives scaled down the requirements for a new aircraft to meet that timeline. The 2018 bomber was to be manned, subsonic, and "highly survivable." Skills and facilities to develop and produce such an aircraft were judged to be at hand, while planned upgrades would add capability as technology matured. The 2018 goal was within reach.[1]

The 2010 QDR Report offers a different approach. While it agrees with previous assessments regarding the need to expand conventional long-range strike capabilities, the report does not focus solely on a long-range bomber to meet those requirements. Rather, it advocates a "family of systems" to "support U.S. power projection operations over the next two to three decades." Included in that "family" are a number of parallel efforts:[2]

- expand the capacity of the *Virginia*-class attack submarines
- experiment with prototypes of a naval unmanned combat aerial system (N–UCAS)
- examine options for a new Air Force long-range surveillance and strike aircraft
- assess alternatives for a new joint cruise missile
- experiment with conventional prompt global strike prototypes.

This article examines the capabilities that each of these family members brings to meeting the Nation's conventional long-range strike requirements, and estimates when such capabilities might be fielded. To do so, we need to first set aside some major factors that will influence choices and trades among this mix of strategic systems.

The first of these factors are the "enablers" that permit such a family of strike systems to operate effectively. Central to any long-range strike capability, as recognized in the QDR, are robust command, control, communications, and computers, and intelligence, surveillance, and reconnaissance (ISR) capabilities. Survivable airborne ISR assets, jam-resistant satellite communications, and long-endurance unmanned air vehicles to act as communications relay platforms are essential components of this infrastructure. Additionally, the 2010 QDR calls for improving the survivability and capability of space-based ISR assets, increasing investment in electronic attack, and improving the resiliency of U.S. forward bases. Regardless of the composition of a layered mix of long-range strike systems, these improvements will have to be made, acknowledging that some of these needed capabilities will be organic to long-range strike family components.

The second issue that this article does not address is the nuclear mission. The 2010 Nuclear Posture Review (NPR) makes clear U.S. nuclear priorities and programs required to underwrite deterrence while reducing deployed nuclear weapons and launchers in accordance with arms control negotiations. As the nuclear triad is downsized, a prudent

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hedge within an uncertain international security environment, as recognized by the NPR, is a modernized conventional long-range force. That future force is likely to be composed of a layered mix of the family of systems enumerated in the QDR.

Third, this is a *capability*, not a budgetary assessment. Speaking at the Eisenhower Library in May 2010, Secretary of Defense Robert Gates stated, "Realistically, it is highly unlikely that we will achieve the growth rates necessary to sustain the current force structure."[3] Thus, the family of conventional long-range strike systems will face programmatic and budgetary hurdles as they are developed and fielded. That said, with respect to long-range surveillance and strike, the U.S. defense portfolio has been significantly out of balance for more than a decade, with serious shortfalls in long-dwell surveillance and prompt global strike. For example, between 1999 and 2006, the Air Force invested $48.6 billion in short-range systems, compared with $5.1 billion in long-range capabilities.[4]

With ISR, nuclear, and budgetary issues reserved for future analysis, what are the challenges this family of systems will be called upon to meet in the future? A number of nations have invested in capabilities to deny the U.S. military the ability to operate with impunity in and around their territory, resulting in a diverse array of antiaccess and area-denial (A2/AD) technologies being developed and deployed. Those capabilities act to push U.S. forces further back from forward bases used previously to project military power. Which are the most worrisome A2/AD capabilities?[5]

Short- and medium-range ballistic missiles (SRBMs and MRBMs) in the hands of plausible military opponents, particularly when armed with cluster-type submunitions, place aircraft on U.S. forward bases in U.S. Central Command and U.S. Pacific Command at risk. China has fielded over 1,000 such missiles while continuing to produce more each year. The Chinese DF–21 ballistic missile, with a range of 1,500 nautical miles and guided by the Global Positioning System, can reach U.S. and allied bases in Korea, Japan, the Philippines, and Thailand. The closest air base outside its range is in Guam, more than 1,500 nautical miles from the Chinese mainland. In another region of U.S. vital interest, Iran has between 300 and 1,500 SRBMs and MRBMs. The Shahab-3, with a range of 1,000 nautical miles, could strike U.S. and allied bases as far west as Incirlik, Turkey, or Akrotiri, Cyprus, and as far east as Manas, Kyrgyzstan, while holding bases and ports throughout the Middle East at risk.[6]

Land-based bombers outfitted with cruise missiles could also threaten forward U.S. forces and allied facilities. The Chinese HK–6k aircraft has a 2,000-nautical-mile combat radius but when outfitted with six CJ–10 cruise missiles can reach another 1,300 miles, holding at risk U.S. installations in Guam and Wake Island, as well as facilities and forces in all of Japan and the northern half of Australia. U.S. and allied naval forces also must contend with the A2/AD challenge. The HK–6k can employ the Mach 2+ Kh-31, a sea-skimming missile armed with a high explosive or antiradiation warhead. Bomber forces could be escorted by the Su–30, a fourth-generation fighter equal to the Air Force's F–15E with a refueled range of 1,400 nautical miles. Whether targeting land- or sea-based forces, an adversary's composite fighter-bomber strike force could confront the United States and its allies with an air-sea battle the likes of which has not been seen since World War II.[7]

Cruise missiles also expand the arc of area denial. Iran has 300 or more Silkworm antiship missiles that could clog the Strait of Hormuz with damaged military and civilian ships, while their fast naval boats, equipped with the 100-mile-range C–802 cruise missile, could deny access to naval forces attempting to pierce a blockade.[8]

Submarines in an A2/AD role present a two-pronged threat to U.S. forces. Both Iran and China have diesel submarines to endanger close-in naval task forces. The Chinese have also acquired a dozen Russian *Kilo*-class submarines capable of launching the Sizzler cruise missile, designed to penetrate a maritime air defense network. China is producing 3 to 4 diesel submarines per year to field a future fleet of about 60 attack submarines.[9]

Integrated air defenses can deny U.S. airpower access over contested territory, with the Russian-exported "double digit" surface-to-air missile (SAM) systems effective out to 125 nautical miles.[10] China is deploying advanced SAM systems with its naval forces—creating lethal engagement zones for U.S. fighter and bomber crews far from the Chinese coastline.[11]

Advanced jet fighters will add to the A2/AD challenge. The Sukhoi-developed T–50, a fifth-generation fighter designed to rival the F–22 and F–35, is expected to reach initial operational capability with the Russian air force in 2015.[12] China is pursuing a similar aircraft—the J–XX—building on the fourth-generation Russian Su–30 and Chinese F–10 inventory.[13]

Collectively, these offensive and defensive capabilities will stress current U.S. and allied power projection forces in the Western Pacific and Persian Gulf regions. Carrier- and land-based aircraft may need to operate at least 1,500 nautical miles from an adversary's coastline to reduce risk. If conventional forces attempt to penetrate that arc, they will require highly effective air and missile defenses plus passive survival capabilities.

Unfortunately, the current inventory of conventional U.S. long-range strike systems provides a limited range of options and displays a force declining in quantity and quality. The


Lockheed (David Drais)

**AF–1 and AF–2 models of F–35A Lightning II joint strike fighter complete test flight**

inventory consists of conventional air- and sea-launched cruise missiles and the B–2 bomber.

The Air Force conventional air-launched cruise missile (CALCM) inventory has dwindled. The CALCM is no longer in production; the only source of additional missiles is conversion from the nuclear variant. A single B–52 can carry up to 20 CALCMs, which rely on a combination of satellite navigation and on-board guidance systems to deliver a 3,000-pound warhead over a range of roughly 600 nautical miles. The Tomahawk land-attack missile (TLAM)—armed with either a 1,000-pound unitary warhead or 166 submunitions—can range up to 1,000 nautical miles and has been upgraded with satellite navigation allowing for reduced mission planning time and in-flight target updates. Up to 36 TLAMs can be carried on a *Virginia*-class submarine, while the number on surface combatants varies with the number of vertical launching systems (VLS) aboard. The B–2 bomber is a low-observable aircraft with an unrefueled range of 6,000 nautical miles. Its two-man crew can use onboard sensors to search, track, and engage mobile targets, while delivering 80 500-pound Global Positioning System–guided bombs or 16 2,000-pounders (for fixed targets), or large numbers of the 250-pound small diameter bomb.

Of this force, only the B–2 (supported, perhaps, by F–22 fighters) provides commanders the confidence to operate effectively within a sophisticated integrated air defense system. While the air- and sea-launched cruise missiles, flying at low altitude, may penetrate hostile airspace, their predictable flight paths and nonstealthy airframes make them vulnerable to interception by advanced SAMs and modern air-to-air fighters.[14]

Cognizant of the increased challenges and the need to forge a stronger team to address the A2/AD challenge, the Air Force Chief of Staff and Chief of Naval Operations signed a memorandum initiating a joint effort to develop a new concept of operations (CONOPS) called "AirSea Battle." Although the memorandum was classified, subsequent wargames and publications suggest that this CONOPS focuses on ensuring the ability to project U.S. military power into the Western Pacific and Persian Gulf. In addition to engaging in conflicts in which adversaries employ A2/AD capabilities, this CONOPS will take into account scenarios that give rise to "overnight" demands for striking targets at intercontinental distances from North America, operations in which prospective adversaries increasingly confront U.S. forces with time-sensitive targets, and situations in which long-range strike systems would need to be able to reach deep targets from the last refueling point.[15] Therefore, an understanding of the complementary capabilities of a family of long-range conventional strike systems is essential to developing the right joint force mix to assure access and successfully fight any future AirSea Battle.

The attributes that the family of long-range strike systems may require will be defined in part by the types of targets they may have to strike in addition to the scenario. The following offers a representative cross section of targets that air and maritime commanders may engage during the early stages of major combat operations.

The 2010 QDR advances a family of systems to underwrite future U.S. power projection capabilities. By expanding the long-range strike solution beyond solely a bomber aircraft, the QDR seeks to provide the joint commander with a range of options to hold at risk fixed and mobile targets over great distances where adversaries seek to protect their territory with state-of-the-art defenses. The value added by each member of this family of systems can be defined, in part, by assessing their contribution to eight operational attributes:

- promptness: reach any target worldwide within 1 hour
- persistence: maintain on station/position for ISR and time-sensitive targeting for more than 4 hours
- time-sensitive: possess organic as well as integrated "find, fix, and track" capabilities to engage fixed or highly mobile targets
- multitarget: engage more than one target nearly simultaneously
- command and control: retasking assets to meet the commander's intent in a denied communications environment
- standoff: achieve desired effects from a range of 1,000 nautical miles or more
- penetration: operate, succeed, and survive within a high threat environment
- nonkinetic: provide options such as electronic attack and cyber capabilities.

## The Family of Long-range Strike Systems

***Expand the Capacity of the* Virginia*-class Attack Submarines.*** Enabled by stealth, the nuclear-powered attack submarine (SSN) has long been recognized as a platform that can penetrate otherwise credible A2/AD zones to conduct ISR and strike operations. U.S. attack submarines are not detectable by most of the sensors deployed to find surface and airborne systems (to include over-the-horizon radar), employ sea-launched cruise missiles such as the conventional Tomahawk, and covertly infiltrate special operations forces. Assuming adequate connectivity and stealth superior to that of the adversaries' submarines and sensors, the SSN, given state-of-the-art weapons and signature, is a capable platform operating autonomously in an area as large as 1.5 million square miles with a 1,000-mile cruise missile. As it sails today, the SSN is a premier conventional long-range strike system when facing an antiaccess environment.

Adding capability to the new *Virginia*-class SSN will make it even more effective as that environment becomes increasingly dangerous. Current plans for the Block 3 (and later) *Virginia*-class submarines are to replace the 12 VLS now hosting the Tomahawk cruise missile with 2 *Virginia* payload tubes (VPT) that can launch 6 missiles from a Multiple All Up Round Canister in each tube. The additional volume provided by the VPT allows the *Virginia*-class SSN to accommodate a larger ballistic missile, adding greater range while cutting the time to target and, simultaneously, improving platform connectivity. The first of these boats, the *North Dakota*, with an improved bow and launcher technologies borrowed from the *Ohio*-class guided missile submarines, is scheduled for delivery in 2014. Such a capability would counter antiaccess threats by being able to hold at risk a range of fixed targets at long ranges from a stealthy stance.

***Experiment with Prototypes of a Naval Unmanned Combat Aerial System.*** The N–UCAS now in development could make significant contributions to conventional long-range strike. This unmanned combat air vehicle (UCAV), about the size of a modern jet fighter, is expected to cruise at 450 knots and operate with a 1,500-nautical-mile combat radius unrefueled, while having the potential to remain airborne for 50 to 100 hours when air-refueled. Planned for the UCAS ISR suite are electro-optical/infrared and infrared search and track sensors, signal collection, and advanced radar capable of electronic attack. Its weapons bay can carry 4,500

pounds and deliver a wide array of air-to-air and air-to-ground munitions.

While UCAS CONOPS are still being shaped, the combination of sensors, range, and weapons could allow the UCAV to detect and track mobile targets out to 100 nautical miles, and, if loitering in hostile airspace, place weapons on target within 15 minutes of tasking. Its sensors are being developed to provide both wide area search and precise tracking of mobile or fixed targets for precision weapons employment, allowing UCAS to operate in a semi-autonomous mode.

The UCAS will be a low-observable airframe with self-protection systems enabling it to operate in an A2/AD environment. If launched from a carrier 1,500 nautical miles from an adversary's shore, the UCAS can operate for 24 hours along a hostile coastline, or penetrate 500 nautical miles inland and loiter for more than 11 hours during a 50-hour sortie with repeated autonomous refuelings. A carrier-based UCAS squadron, composed of 12 air vehicles, could support 5 continuous orbits along the coast or 2.4 continuous orbits 500 nautical miles inland for 24 hours each day. In contrast, a squadron of manned fighter aircraft, owing to human performance limits, could maintain at best only one orbit along the coast.

The most valuable capability UCAS brings to a family of long-range strike systems may be its ability to engage and defeat a time-sensitive target in a matter of minutes owing to its persistence, sensor suite, multiple-target capability, and kinetic or nonkinetic weapons systems. It also offers the joint force the ability to function as a communications relay node in a communications-denied environment, allowing the afloat commander to dynamically adjust the tasking for airborne assets.

***Assess Alternatives for a New Joint Cruise Missile.*** A number of alternatives exist from which a new joint cruise missile program could be pursued to augment U.S. conventional long-range strike capability. In 2002, the Defense Threat Reduction Agency initiated an Advanced Concept Technology Demonstration with the purpose of showing a joint supersonic cruise missile capable of "functionally disabling time sensitive weapons of mass destruction (WMD) targets" as well as hardened and deeply buried targets. Key performance parameters for the demonstrator included a terminal accuracy of 3 meters or better, a range of 400 to 600 nautical miles, a cruising speed in the range of Mach 3.5–4.5, warhead penetration capability, and a single-digit minutes response time. The missile was to be designed to be launched from surface ships, airborne platforms, and submarines.[16]

At least two joint cruise missile platforms may have been developed in response to this request. The U.S. Air Force Research Laboratory has reportedly been testing hypersonic propulsion technology in the X–51A "WaveRider" program under the Rapid Identification and Prosecution of Targets in Denied Environments (RIPTIDE) project.[17] Based on the X–51A missile designed to achieve Mach 6 over a range of several hundred miles, the RIPTIDE range requirements will exceed 1,000 nautical miles to demonstrate long-range, quick-response strike. Envisioned to be launched by a bomber aircraft and incorporating various payloads, a hypersonic cruise missile will need several years of testing before reaching the technological readiness levels suitable for fielding.

A second technology demonstration effort is being conducted by the Office of Naval Research in collaboration with the Defense Advanced Research Projects Agency (DARPA), U.S. Air Force, and National Aeronautics and Space Administration.[18] The Revolutionary Approach to Time-critical Long Range Strike program seeks to develop a cruise missile with Mach 3 speed and a 500-pound penetrating warhead. Although initial flight tests may be restricted to about 5 minutes, implying a range of about 150 nautical miles, desired growth opportunities for the missile call for increased speed (Mach 4), cruise (15 minutes), and range (more than 600 nautical miles). While these objectives suggest the application for such a missile to long-range strike, the flight demonstration vehicle is being designed to show the potential as a tactical weapon.[19] Thus, the missile could be launched from a tactical fighter or from a VLS on a ship or submarine.

Conventional cruise missiles have been used successfully by U.S. forces in recent conflicts. However, their advantages of standoff range have often been offset by the lengthy duration of their subsonic flight (making them impractical to use on a mobile moveable target), their unreliability, their vulnerability, the one-way nature of their mission (they are neither recallable nor recoverable), and, notably, their relative cost per precision round—roughly 80 times the cost of a direct-attack munition. Thus, when budgetary factors are considered, the value of alternative cruise missiles being evaluated for their contribution to a family of long-range strike systems may be dependent on the platform carrying them and how deeply it can penetrate the A2/AD zone before launch to maximize the probability of prompt target destruction.

***Examine Options for a New Air Force Long-range Surveillance and Strike Aircraft.*** Often viewed as the backbone of the Nation's long-range strike capability, the heavy bomber provides a variety of options based on its payload and range. Following the 2006 QDR, an Air Force analysis of alternatives concluded that a bomber built within the next decade could provide a payload capacity of 14,000 to 28,000 pounds and have an unrefueled combat radius up to 3,000 nautical miles while operating in the subsonic flight regime. It would require a mix of low-observable technology and advanced self-protection systems to ensure survivability in an A2/AD environment. If the next-generation bomber (NGB) is to be more a member of a family of long-range strike systems, rather than its sole provider, then these relatively modest capabilities, already at a high level of technological readiness, may suffice.

The NGB also requires a wide area surveillance and search sensor system, plus capabilities to provide precise tracking and engagement of fixed or mobile targets. With a payload three to six times larger than the UCAS, the NGB could strike a wider array and quantity of aimpoints, including deeply buried and/or hardened targets demanding a single 4,800-pound bomb. Loiter time will also matter; therefore, one approach to the NGB may be to have an optional unmanned version. An NGB based 2,500 nautical miles from a tanker orbit 500 miles from an adversary's coast could remain 10 hours along the littoral and penetrate an additional 500 miles inland during a 26-hour mission. If the next-generation bomber were remotely piloted, the total time on station per sortie could match that of the UCAS, with the added value of a significantly greater payload. Like the UCAS, NGB can provide a prompt response during times of heightened tensions from an airborne alert posture.

Perhaps more important, the manned NGB provides combatant commanders with an airborne command and control capability that can operate autonomously with greater flexibility in a denied communications environment. Thus, the NGB could act as the

quarterback for the long-range strike team when in line of sight to the UCAS, *Virginia*-class submarine, and cruise missiles, ensuring a more accurate, timely, and all-azimuth strike. Such a CONOPS suggests that the NGB will not be a B–2–like "lone wolf" aircraft, but rather a weapons system capable of integrating and executing the air and maritime commanders' AirSea Battle gameplan.[20]

***Experiment with Conventional Prompt Global Strike Prototypes.*** The option of conventional prompt global strike (PGS)—usually interpreted as placing conventional warheads on top of existing U.S. land- or sea-based intercontinental ballistic missiles—is probably the most controversial member of this proposed family of systems. Yet the need has been noted, and concrete proposals for acquiring such a capability have been advanced for some time. A February 2007 report issued to Congress by the Secretaries of State and Defense posited that such a capability was desirable, feasible, and acceptable.[21] In fact, the 2010 NPR calls out the need for such a conventional system and the necessity of keeping margins in the nuclear force structure under the arms control treaties to account for the systems. Thus far, Congress has not agreed to field a PGS system, owing principally to a concern that a launch might be misinterpreted by an adversary to be a nuclear attack, provoking an in-kind response.

Nevertheless, there are a number of scenarios that call for a prompt conventional strike on a fixed target: the need to strike a missile launcher poised to attack the United States or an ally, perhaps with WMD; an opportunity to strike key terrorist leaders or a cache of WMD at a time-sensitive moment; or the need to take down elements of an adversary's integrated air and missile defenses prior to a wider assault into an A2/AD region. If the risk to the current inventory of U.S. long-range strike systems is to increase at a pace more rapid than the proposed development and fielding of some of the family members noted above, then the deployment of a prompt global strike capability becomes more important in the near term.

Clearly, a PGS system would provide a niche capability, and measures would have to be instituted to distinguish prompt conventional strike from the triad of nuclear deterrent forces. Land-based conventional intercontinental ballistic missiles (ICBMs) could be deployed on U.S. territory, but not in hardened silos, separated from any nuclear weapons storage facility, and subject to inspection and verification under established arms control regimes. A more futuristic version of a land-based PGS capability envisions an ICBM launching a hypersonic glider that would remain within the atmosphere and use satellite communications to maneuver and deliver a 1,000-pound conventional weapon. With the glide range of these systems and the relatively small size of the reentry vehicle, a single land-based PGS missile could be used to hit multiple targets thousands of miles away. Currently, DARPA is pursuing the Force Application and Launch from Continental United States program, which is intended to demonstrate the flight characteristics of hypersonic glide vehicles launched from a decommissioned Peacekeeper ICBM system. These vehicles are designed to have global coverage from a single continental U.S.–based launch point. Although the first flight test of the vehicle in April 2010 was unsuccessful, DARPA intends to fly a second vehicle to demonstrate the technology in early 2011 to help determine if a deployment date of 2020 is realistic.[22]

Both land- and sea-based PGS systems have political challenges, including arms control limits and nuclear ambiguity. Because of these challenges, limited numbers of systems are expected to be employed. Here, various basing modes (land-based, nuclear-powered cruise missile submarine, *Virginia*-class) and missiles (two-stage SLBM variants, kinetic energy warhead, boost-glide missile, or hypersonic cruise missile) could substantially lower the nuclear ambiguity that has thus far stymied conventional Trident modification development and deployment.[23]

Any prognosis on when the family of systems might be available to the joint force is fraught with budgetary and political uncertainty. Based on reasonable technological and fiscal assumptions, a timetable to begin deploying a family of long-range strike systems could be similar to the accompanying figure.

In analyzing the QDR's directive to expand future U.S. conventional long-range strike capabilities, we have briefly described and compared some of the attributes of the systems suggested in that report. The table reflects a partial evaluation of each of the members of a family of long-range strike systems. Unsurprisingly, the worth of these individual systems varies markedly with the scenario envisioned. Penetrating deep into defended territory, attacking targets from the continental United States or U.S. territory, hitting time-sensitive targets by loitering and surviving in defended airspace, and striking promptly and preemptively can all lead to differing solutions. Given this range

**Figure. Timetable for Deploying Family of Long-range Strike Systems**

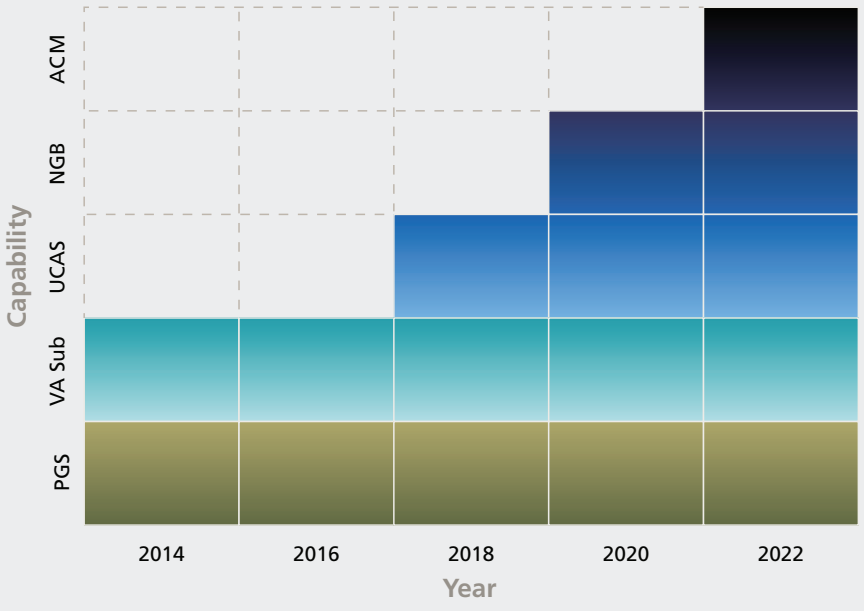

**Table. Summary of Family of System Attributes**

| | Prompt | Persistent | Time-sensitive | Multitarget | Command and control | Standoff | Penetrating | Nonkinetic |
|---|---|---|---|---|---|---|---|---|
| *Virginia*-class submarine | | | | | | | | |
| Unmanned combat aerial system | | | | | | | | |
| Cruise missile | | | | | | | | |
| Next-generation bomber | | | | | | | | |
| Prompt conventional global strike | | | | | | | | |

of requirements, a move away from a single, large, technologically sophisticated, and costly conventional strike platform toward a family of systems offering varied long-range strike options and capabilities appears prudent in a security environment populated by diverse adversaries presenting varied antiaccess challenges.

There is more work to be done, and several studies are under way. One task that we have embarked on with our colleagues is to employ a physics-based model comparing and contrasting the capabilities of these separate family members in an illustrative major combat operation scenario where the joint team must operate in an A2/AD environment. Preliminary runs suggest that a family of long-range strike systems would significantly increase the options available to combatant commanders in an A2/AD environment—from 16 B–2s to 5 additional weapons systems and capabilities offering reduced risk to mission execution and improved assurance of mission accomplishment. An increased capacity *Virginia*-class submarine may be the first of this family of systems that can be fielded. But PGS and advanced cruise missiles offer great promise in the near and longer term to rapidly engage fixed and hardened targets, while UCAS and NGB offer short- and far-term options for the time-sensitive targeting necessary to engage mobile and fleeting targets.

The Secretary of Defense, building on the QDR's findings, was right to direct a study of long-range strike systems to shape future investment decisions. To ensure that U.S. long-range capability does not continue to atrophy in the face of increasingly nonpermissive environments, it is important to accelerate the studies and initiate the investments. **JFQ**

## NOTES

[1] See Robert P. Haffa, Jr., and Michael W. Isherwood, *The 2018 Bomber: The Case for Accelerating the Next Generation Long-Range Strike System*, Northrop Grumman Analysis Center Papers, August 2008.

[2] Department of Defense (DOD), *Quadrennial Defense Review Report* (Washington, DC: DOD, February 2010), 33.

[3] Remarks as delivered by Secretary of Defense Robert M. Gates, Eisenhower Library, Abilene, KS, May 8, 2010, accessed at <www.defense.gov/Speeches>.

[4] See Michael G. Vickers, "The QDR and Long-range Surveillance and Strike," November 10, 2005, available at <www.csbaonline.org/4Publications/PubLibrary/B.20051110.LRSSOvrvw/B.20051110.LRSSOvrvw.pdf>.

[5] For an earlier but more comprehensive analysis, see Andrew F. Krepinevich, Jr., Barry D. Watts, and Robert O. Work, *Meeting the Anti-Access and Area-Denial Challenge* (Washington, DC: Center for Strategic and Budgetary Assessments, 2003).

[6] Anthony H. Cordesman and Adam C. Seitz, *Iranian Weapons of Mass Destruction: The Birth of a Regional Nuclear Arms Race?* (Washington, DC: Center for Strategic and International Studies, 2009), 103–108.

[7] Andrew F. Krepinevich, Jr., *Why AirSea Battle?* (Washington, DC: Center for Strategic and Budgetary Assessments, 2010), 20–21. See also Jan Van Tol et al., *AirSea Battle: A Point of Departure Operational Concept*, available at <www.csbaonline.org/4Publications/PubLibrary/R.20100518.Air_Sea_Battle__A_/R.20100518.Air_Sea_Battle__A_.pdf>.

[8] In 2006, Hizballah effectively used this missile against an Israeli ship. See Krepinevich, 30–31.

[9] Ronald O'Rourke, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress* (Washington, DC: Congressional Research Service, October 21, 2009), 6.

[10] Krepinevich, 32–33.

[11] David A. Deptula, *Global Threat Brief*, May 2008.

[12] David Nowak, "Russia Tests 5th-generation Fighter Jet," Associated Press, January 29, 2010.

[13] Deptula.

[14] Various open sources credit the SA–10 target tracking radar with the ability to detect and track low altitude targets, to include cruise missiles. Globalsecurity.org reports that the "76N6S low altitude target search radar/low altitude detector (LAD) is independent for detecting approach of going away air targets, including cruise missiles with small reflecting surface at low and extreme low altitudes under conditions of reflecting signals from objects and effective electronic counter-measures." The SA–10 (S–300) can detect and track targets with a cross section of 0.02 $m^2$. See <www.ausairpower.net/clamshell.html>.

[15] See Barry D. Watts, *The Case for Long-Range Strike: 21st Century Scenarios* (Washington, DC: Center for Strategic and Budgetary Assessments, 2009), accessed at <www.csbaonline.org/4Publications/PubLibrary/R.20090203.The_Case_for_Long-/R.20090203.The_Case_for_Long-.pdf>.

[16] See "Joint Supersonic Cruise Missile (JSSCM)," accessed at <www.patriotfiles.com>.

[17] "USAF Studies Riptide Hypersonic Missile Plan," *Aerospace Daily*, April 14, 2010, 3.

[18] See <www.onr.navy.mil/en/Media-Center/Fact Sheets/RATTLRS>.

[19] See <www.globalsecurity.org/military/systems/munitions/rattlrs.htm>.

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[22] "U.S. Faces Choice on New Weapons for Fast Strikes," *The New York Times*, April 23, 2010, A1.

[23] *U.S. Conventional Prompt Global Strike: Issues for 2008 and Beyond* (Washington, DC: The National Academies Press, 2008). See also Bruce M. Sugden, "Speed Kills: Analyzing the Deployment of Conventional Ballistic Missiles," *International Security* 34, no. 1 (Summer 2009), 113–146.