Hypersonic Weapons

APPRaising THE “THIRD Offset”

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Editor’s Introduction

Over the past several decades, the Department of Defense has repeatedly found itself hamstrung by the combination of a continuing post–Cold War reduction in forces and budgets and the immediate post-9/11 need to respond to crises and engage in extended conflicts. As a result, the armed services have failed to sustain the pace of equipment modernization; few programs from the end of the Cold War have made it to serial-rate procurement. Donald Rumsfeld’s plan to “skip a generation” of weapons systems has been carried out, although unintentionally so.

Thus, the Pentagon has periodically sought to leap ahead, to “transform” itself, as Rumsfeld put it. During President Barack Obama’s second term of office, the defense leadership conceived what it styled as a “third offset” along the lines of the “New Look” nuclear posture of the Eisenhower years and the introduction of stealth aircraft and precision munitions in the late 1970s and early 1980s.

Because the third offset is more an approach to technological modernization than a set of particular programs, it has been difficult to assess its status and prospects for success. Moreover, the surprising election of Donald Trump and the change of parties and leadership in the Defense Department puts the future of the project in doubt.

To better understand the “there there” of the third offset, the Marilyn Ware Center for Security Studies commissioned Robert Haffa and Anand Datla, two very experienced analysts who coauthored our 2015 report “Buying the B-3: Procurement Reform and the Long-Range Strike Bomber,” to put hypersonic programs under a microscope. Their report takes a closer look at the progress made to date and the prospects and challenges the technology presents. It provides a clear yardstick for policymakers as they seek to assess what is salesmanship and what is substance in the third offset.

—Thomas Donnelly

Executive Summary

As the Trump administration takes over planning and budgeting the Department of Defense, it will face a host of challenges and options in an unpredictable security environment. Global disorder has increased while elements of America’s comparative military advantages have eroded. Moreover, due to the 2011 Budget Control Act and ongoing and expanding military operations, the new occupants of the Pentagon will inherit something of a budgetary “death spiral.” It will be incumbent upon them to address these challenges by shoring up American military superiority against diverse adversaries in multiple regions of the world.

In the past, when faced with similar troubles, the United States sought to offset emerging challenges to its military power by leveraging its technological talent. Such an approach led to President Dwight D. Eisenhower’s “New Look” strategy to contain the Soviet Union at the dawn of the Cold War by threatening a nuclear response to conventional aggression against American and allied vital interests. Then, when nuclear parity with the USSR no longer made such a containment strategy credible, the United States sought to offset perceived Soviet and Warsaw Pact quantitative conventional advantages by developing and fielding a new generation of guided munitions and battle networks in what some termed a “revolution in military affairs.”

In the current security environment, Deputy Secretary of Defense Bob Work has sought to innovate his way out of the Pentagon’s dilemmas, embarking on a “third offset” strategy designed to mitigate the operational challenges facing the US military and its traditional approach to power projection. The growing vulnerability of close-in regional ports and bases to enemy attack; the increasing likelihood of air and naval forces being detected, tracked, and engaged at extended ranges; and the diminishing sanctuary that space has provided overhead assets call for measures to restore confidence in America’s ability to meet its security commitments abroad.

Sustaining this offset strategy in a new administration will provide a challenge all its own. There is no third offset line item in the fiscal year 2017 defense budget, and there are numerous courses of action available to the US military to operate successfully in a world of proliferating precision munitions. The Defense Department intends to place “multiple small bets” in areas that might make a difference, particularly where emerging technology has the opportunity to yield a long-term competitive advantage, such as robotics, artificial intelligence, and missile defense.

This paper conducts a preliminary appraisal of one of those technologies—hypersonic weapons systems—frequently nominated as a “game-changing” capability that might serve as the centerpiece of and a pathway toward a more complex and complete offset strategy. Like the first two countervailing strategies adopted by the United States, the third offset will surely be composed of various technologies and capabilities, integrated and combined into systems of systems. At this early stage, however, it is useful to consider the contributions that hypersonic weapons systems might make in this larger strategy considering the state of the science and the challenges of engineering raw technologies into viable weaponry, as well as whether such weapons could be transitioned onto the modern battlefield in a smooth and timely fashion.

Therefore, to evaluate their potential contributions to the third offset, this paper briefly describes and explains the characteristics and status of hypersonic weapons. A wider description of the array of capabilities having game-changing attributes and third offset potential is well beyond the scope of this paper. Nevertheless, it briefly considers
directed-energy and railgun weapons systems to compare and contrast these technologies with hypersonic systems in terms of technical readiness, investment strategies, and plausible applications of these systems by the separate armed services. These weapon systems may not be sufficient by themselves to accomplish a revolutionary change in American military operations, but they indicate whether such changes are possible and perhaps necessary to facilitate a third offset strategy.
Hypersonic Weapons: Appraising the “Third Offset”

ROBERT HAFFA AND ANAND DATLA

As a new team takes over force planning and budgeting in the Department of Defense in January 2017, they will face a number of challenges and options in an unpredictable global security environment. If they review the 2015 National Military Strategy, they will be cautioned by the former chairman of the Joint Chiefs of Staff that global disorder has increased while elements of America’s comparative military advantages have eroded. Thus forewarned, the new occupants of the Pentagon’s E-Ring should address that disorder by shoring up American military superiority against diverse adversaries in multiple regions of the world. Moreover, owing to the spending constraints imposed by the 2011 Budget Control Act and the need to conduct—and finance—continued and constantly expanding military operations, the Department of Defense remains in something of a budgetary “death spiral.” Regrettably, there is no immediate prospect that this downward spiral will be reversed.

If the new Pentagon team also embraces a historical view, they may take solace from the fact that in similar times of trouble the United States sought to offset emerging challenges to its military power by leveraging its technological talent. Such an approach led to President Dwight D. Eisenhower’s “New Look” strategy to contain the Soviet Union at the dawn of the Cold War by threatening a nuclear response to conventional aggression against American and allied vital interests. When nuclear parity with the USSR no longer made such a containment strategy credible, the United States sought to offset perceived Soviet and Warsaw Pact quantitative conventional advantages by developing and fielding a new generation of guided munitions and battle networks in what some termed a “revolution in military affairs.” As Deputy Secretary of Defense Robert Work sees it, the heavy conventional forces and tactics of the Iraqi army modeled after those of the USSR were reduced during Operation Desert Storm in 1990 to an array of targets and aim points waiting to be attacked by an unparalleled “reconnaissance-strike complex.”

Indeed, in the current security environment, Deputy Secretary Work has sought to innovate his way out of the Pentagon’s dilemmas, embarking on a “third offset” strategy designed to mitigate the operational challenges facing the US military and its traditional approach to power projection. The growing vulnerability of close-in regional ports and bases to enemy attack; the increasing likelihood of air and naval forces being detected, tracked, and engaged at extended ranges; and the diminishing sanctuary that space has provided overhead assets call for measures to restore confidence in America’s ability to meet its security commitments abroad.

However, sustaining this offset strategy in a new administration will provide a challenge all its own. There is no third offset line item in the fiscal year 2017 defense budget, and there are numerous courses of action available to the US military to operate successfully in a world of proliferating precision munitions. As Vice Chairman of the Joint Chiefs of Staff General Paul Selva noted recently, the Defense Department intends to place “multiple small bets” in areas that might make a difference, particularly where emerging technology has the opportunity to yield a long-term competitive advantage. Many of those promising technologies are in robotics, artificial intelligence, and missile defense. In missile defense, for example,
directed-energy weapons and hypervelocity rounds might be capable of defending against layered or “haystack” missile attacks that previous missile defense systems could not counter.

Our purpose here is to conduct a preliminary appraisal of one of those technologies—hypersonic weapons systems—frequently nominated as a “game-changing” capability that might serve as the centerpiece of and a pathway toward a more complex and complete offset strategy. Like the first two countervailing strategies adopted by the United States, the third offset will surely be composed of various technologies and capabilities, integrated and combined into systems of systems. At this early stage, however, it is useful to consider the contributions that hypersonic weapons systems might make in this larger strategy considering the state of the science and the challenges of engineering raw technologies into viable weaponry, as well as whether such weapons could be transitioned onto the modern battlefield in a smooth and timely fashion.

Therefore, to evaluate their potential contributions to the third offset, we briefly describe and explain the characteristics and status of hypersonic weapons. A wider description of the array of capabilities having game-changing attributes and third offset potential is well beyond the scope of this paper. Nevertheless, as we conclude, we briefly consider directed-energy and railgun weapons systems to compare and contrast these technologies with hypersonic systems in terms of technical readiness, investment strategies, and plausible applications of these systems by the separate armed services. These weapon systems may not be sufficient by themselves to accomplish a revolutionary change in American military operations, but they indicate whether such changes are possible and perhaps necessary to facilitate a third offset strategy.

**Hypersonic Weapon Systems**

Hypersonic weapons systems project payloads at speeds of Mach 5 (five times the speed of sound or roughly 3,600 mph) or higher. As described in a recent publication by the Air Force Association’s Mitchell Institute, hypersonic systems employ various kinds of platforms. Early military rockets and spacecraft, including the X-15 rocket plane, were the first hypersonic vehicles. Today, hypersonic systems take two principal approaches: “scramjets” using a rocket to accelerate a vehicle to hypersonic speeds but then, hybrid-like, switching to an air-breathing engine to sustain that high speed, and rocket-assisted “boost-glide” systems. The scramjet uses three components: an inlet to draw in the air surrounding the vehicle, a combustor to burn fuel combined with that air, and a nozzle to release the pressurized air to maintain the vehicle’s hypersonic speed. The boost-glide approach to hypersonic speed uses multiple-stage rocket engines to take the vehicle into the upper atmosphere. Then that vehicle rapidly descends, skipping across the atmosphere to sustain its hypersonic speed to its final destination.

Whether using scramjet or boost-glide propulsion, hypersonic systems promise new capabilities to defense planners. As Richard Hallion suggests, hypersonic weapons overcome the tyranny of distance, time, and defenses that currently limits conventional power projection. Owing to their unprecedented speed, hypersonic weapons systems shorten the decider-shooter-target loop, compressing the time between actionable intelligence and weapons effects on a time-sensitive target. As concerns mount regarding an adversary’s ability to push US power projection forces further from a prospective battlefield through “anti-access/area denial” (A2/AD) capabilities, hypersonic weapons can hold at risk multiple target sets from afar without the flight-time penalty of conventional subsonic munitions. Hypersonic weapons systems may also contribute to the strategic requirement for conventional prompt global strike.

Recent advances in hypersonic technology rest on new developments in scramjet and boost-glide technology. Early progress resulted from a partnership between the National Aeronautics and Space Administration (NASA) and the Defense Advanced Research Project Agency (DARPA). NASA’s contributions stemmed from its X-plane efforts designed to test new concepts in aerodynamics. DARPA, with its charter to pursue game-changing technology innovation,
was a natural partner to explore the military applications of hypersonic propulsion systems.

For three years beginning in 2001, NASA partnered with DARPA to develop the X-43 vehicle to test advanced hypersonic scramjet concepts. The X-43 was dropped from a B-52 mother ship, launched by a Pegasus rocket into the upper atmosphere, and then powered by a scramjet engine to reach hypersonic speed during its descent. Although the vehicle exceeded speeds of Mach 9 during three flight tests and follow-on X-planes were planned, the program was cancelled due to other priorities, competing programs, and fiscal constraints.9

A follow-on hypersonic program to the X-43 was the Falcon hypersonic vehicle cosponsored by DARPA and the US Air Force Research Laboratory (AFRL). The lab’s mission to advance the discovery, development, and integration of innovative and affordable warfighting capabilities made it a natural partner to collaborate with DARPA on hypersonic weapons systems.10 The agencies’ work in this area focused on the Hypersonic Test Vehicle 2 (HTV-2), with the purpose of developing a reusable hypersonic long-range strike vehicle, as well as designing and deploying a launcher capable of accelerating the strike vehicle into a hypersonic flight regime. Test launches began in 2010 from Vandenberg Air Force Base in California using a Minotaur IV rocket as a booster with an objective of reaching speeds up to Mach 20.11 Two tests were conducted, each resulting in the hypersonic vehicle departing controlled flight and crashing into the Pacific Ocean. During the first test the vehicle sustained nine minutes of hypersonic speed before malfunctioning. DARPA and the Air Force judged these tests sufficient to meet their research needs and began to shift their focus from long-range strike to tactical hypersonic weapons designed to defeat enemy defenses.12

The US Army’s Space and Missile Defense Center, working with the prompt global strike program in the Pentagon,13 has also pursued boost-glide hypersonic vehicles. The center’s mission to develop technologies supporting Army requirements fits well the offset strategy’s approach of conducting research for rapid transition to meet battlefield needs.14 Like previous Air Force and DARPA efforts, this joint initiative sought to examine the possibility of using boost-glide hypersonic weapons systems to strike targets within an hour at any point on the globe. The Army’s boost-glide system mirrored the approach of previous concepts, with a rocket launch, a detachable scramjet operating in suborbital space, and the release of a reentry vehicle using its descent to reach hypersonic speeds as it glided toward the intended target. This system also tested a flattened, depressed trajectory designed to differentiate the flight of the vehicle from the ballistic course of an intercontinental missile—a profile considered destabilizing owing to a conceivable miscalculation that the missile might be nuclear tipped.

Hypersonic weapons overcome the tyranny of distance, time, and defenses that currently limits conventional power projection.

In November 2011, the Army’s Advanced Hypersonic Weapon (AHW) was launched from the Pacific Missile Range Facility in Kauai, Hawaii, to the Reagan Test Site in the Marshall Islands. The glide vehicle successfully hit the target located approximately 2,300 nautical miles from the launch site. Unfortunately, a second test in August 2014 launched from the Kodiak Alaska facility failed. However, neither the booster rocket nor the hypersonic vehicle was found faulty. Further testing is planned, and funding has been requested to support manufacture of both the glide body and the rocket booster.

The Air Force initiated the latest series of hypersonic weapons testing with the X-51A Waverider program, launching a scramjet-powered vehicle from a B-52 bomber. This collaborative approach between
the service’s research lab and DARPA also emerged from the broader prompt global strike initiatives. Nevertheless, Waverider continued the shift in focus for hypersonic weapons systems from a prompt conventional global strike capability to tactical operations designed to attack A2/AD targets, allowing the penetration of other air assets into contested airspace. In simple terms, Waverider was developed to hit lesser targets at shorter range, while taking advantage of hypersonic speeds. The fourth and final test of the system successfully launched a hypersonic munition that flew 230 nautical miles. For those advocates who, over decades, had been involved in the research and testing of a scramjet-based solution to hypersonic flight, the “X-51A proved beyond any doubt that a high-Mach craft could be powered by a long-lived engine that burns a petroleum-based fuel while surviving the intense heat and extreme aerodynamic forces associated with sustained hypersonic flight.”

Operational Applications

From the perspective of the US armed forces, hypersonic weapons systems have been seen as helping to overcome A2/AD threats. An A2/AD threat can best be described as the ability of a prospective adversary to deny the US military its traditional means of projecting power through forward deployment to large fixed bases and ports. Anti-access strategies are apparent in the military modernization programs of China and Russia. Iran, flush with cash after the agreement on its future nuclear program and the easing of sanctions, may be pursuing a similar path.

The idea of A2/AD is to prevent the entry of US forces into a theater of operations by holding these forward operating locations at risk, principally through the delivery of precision-guided munitions, such as rockets, artillery, mortars, and missiles. Complementary area-denial strategies seek to limit the freedom of action of US forces already in the region. For example, aerial area-denial actions would coordinate offensive air operations and integrated air defense systems to “maintain a degree of air parity or superiority over their territory and forces.” Modern advanced air defense systems including networked (and exported) Russian S-300 and S-400 surface-to-air missiles can deter nonstealthy aircraft from flying within 200 nautical miles of the battlefield. Shore-based batteries with antiship precision-guided ballistic and cruise missiles might dissuade Navy ships from moving to forward offensive positions. Regardless of the scenario, whether in the Western Pacific, Northeast Asia, or the Persian Gulf, the US military would be forced to operate at longer ranges—and thus with less efficacy—to account for the capabilities of these offensive and defensive systems.

Hypersonic weapons systems could take the form of cruise missiles powered by a scramjet that flies several hundred miles in a matter of minutes or the form of conventional bombs or cluster munitions that reach hypersonic speed on a rocket booster and then glide at that speed over long ranges to impact a target with precision. In their recent paper for the Mitchell Institute, Hallion and Bedke note several advantages these weapons systems offer over conventional systems currently employed by US armed forces. Hypersonic systems provide rapid reach, flying at least six times faster than a conventional cruise missile, thereby shortening the time from target detection to target destruction.

Hypersonic weapons would also be valuable in negating adversaries’ investments in modern air defense systems. By striking such systems, these weapon systems could act as a “tip of the spear,” suppressing air defenses to allow the penetration of slower-moving, nonstealthy forces. Moreover, these supersonic systems appear nearly invulnerable to those air defense networks, using their high speed, rather than stealthy design, to overcome existing detecting and tracking radars and command and control systems. For example, enemy defenses fortunate enough to detect a hypersonic weapon at a range of 150 miles would have only about two minutes to launch an interceptor—and that system would need to be capable of hitting a target travelling five times the speed of sound or faster. This hypersonic speed further compresses the adversary’s decision-making cycle, allowing US forces to operate well within the adversary’s observation and reaction loop.
Strategic Speed?

Although the current focus on hypersonic weapons systems appears to be on overcoming A2/AD capabilities in theater scenarios, it is worthwhile recalling that the impetus for the most recent efforts and experiments in hypersonic flight were spurred by requirements for conventional prompt global strike, meant to be a “strategic” substitute for nuclear weaponry. The need for such a capability has been emphasized in a series of defense documents, including the 2001, 2006, and 2010 Quadrennial Defense Reviews. Key to these requirements was the ability to strike conventionally over long ranges in a matter of minutes or hours and to be able to attack in regions where the United States lacks forward-deployed forces. A March 2009 Defense Science Board task force formulated five representative scenarios that might require such a precise, long-range, nonnuclear strike:

- A near-peer competitor in the process of launching a series of missiles targeted against US space-based assets;
- A package of special nuclear materials shipped by a terrorist organization to a neutral country;
- Weapons of mass destruction imported to a temporary location in a neutral country;
- The leadership of a terrorist organization gathered in a known location for a short time, far beyond the reach of conventional US forces; and
- A rogue state with a nuclear weapon threatening to use it against a US ally.

Hypersonic weapons programs such as the Falcon, the HTV-2, and the AHW were oriented toward and outlined the requirements of a conventional prompt global strike mission. Falcon was planned to be ready for launch in less than two hours from its alert status and poised to strike the target within one hour. The HTV-2, as planned and tested, was to be launched into the earth’s upper atmosphere, descend with speeds in the neighborhood of 13,000 miles per hour, and reach a distant target in about 30 minutes—approximating the flight time, accuracy, and probability of kill of a nuclear-armed intercontinental ballistic missile. The Army’s AHW was designed to have similar properties. Finally, the Air Force’s X-51 Waverider, although performing at lower altitudes and speeds and launched from a relatively close-in aircraft, offered the advantages of atmospheric flight and a nonballistic trajectory, thereby addressing the nuclear ambiguity issues that have plagued other proposed conventional prompt global strike solutions.

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To summarize, the potential military applications of hypersonic weapons systems are plentiful. They could be an effective way to “knock down the door” (at a very high speed) to clear a path for slower and nonstealthy weapons systems to penetrate contested airspace and sea lanes. They could be stalwart counters to adversaries implementing A2/AD strategies intended to forbid the forward deployment of US military forces and deny them freedom of action in an impending conflict. And they could be used in a prompt conventional long-range strike against various targets threatening US and allied interests when deployed US forces are stymied by the tyranny of distance and time.
Hypersonics and the Third Offset

The third offset strategy, like its progenitors, is intended to leverage US technology and innovation to sustain and enhance the US military’s competitive edge over future adversaries. Similar to those earlier offset initiatives, this third strategy faces a proliferation of conventional capabilities that the US chooses not to try to match one-on-one, but to substitute technological quality for quantity and to leap-frog adversaries’ fielded capabilities with game-changing military inventions, applications, and innovations. As defense analyst Robert Martinage has argued, the third offset should reduce dependence on close-in theater land and sea bases, take advantage of the global reach of US air and naval forces, exploit strategic asymmetry to hold targets at risk far from the immediate zone of conflict, and shape the competition to areas advantageous to the United States.25

In setting the stage for a future administration’s third offset initiatives, one point of departure is that the third offset must ensure that US military forces can “successfully operate in a world of ubiquitous precision munitions.”26 It is the proliferation of these precision-guided munitions that gives rise to fear of increasingly capable A2/AD defenses prohibiting traditional US military power projection strategies and tactics. Those growing capabilities, not unlike the quantitative margins held by Soviet and Warsaw Pact conventional forces during the Cold War, now threaten the qualitative edge that allowed the US military to be confident that it could fight outnumbered and win. The task of the new leadership in the Pentagon, therefore, will be to explore, develop, and field advanced weapons systems capable of negating these long-range precision weapons and maintaining America’s competitive edge. One goal of the third offset is to prevent a putative adversary from achieving parity in the qualitative dimension of warfare characterized by precision munitions and integrated battle networks.

The combination of high speed, long range, and precision suggests a prominent place for hypersonic weapons systems in any third offset strategy. If adversary precision munitions are proliferating at a rate suggesting qualitative parity, then the US must add qualitative improvements to its own conventional arsenal to offset those gains. If military competitors are investing in long-range ballistic and cruise missiles with guided warheads, then the US should invest in weapons systems that can defeat those missiles through the fourth dimension of time. If guided rockets, mortars, and missiles make US and allied close-in bases and ports more vulnerable, then US military forces require munitions that can deny those capabilities from long range, and suppress the defenses that surround them.

Perhaps as important as placing hypersonic weapons systems high on the agenda of the third offset is recognizing the likelihood that the competition in precision-guided munitions will also extend to high-speed weapons. As documented in the Mitchell Institute report, Russia and China are making major strides in hypersonic design, prototyping, testing, and investment.27 The Russian navy’s efforts include testing the BrahMos II, a short-range hypersonic missile with speeds of Mach 5–7, as a replacement for its current supersonic antiship missile.28

The Russians intend to test a new hypersonic weapon by 2020. Additionally, in response to the US “phased adaptive approach” of placing Aegis missile defense systems on destroyers in the Eastern Mediterranean and ashore in Romania and Poland to defend against a plausible Iranian missile launch, Russia is pursuing hypersonic missiles and munitions to thwart those systems.29

Chinese hypersonic missile tests have focused on short-range systems, leading analysts to believe that China sees these weapons as underwriting their plans for regional hegemony rather than adding to their long-range strike capability.30 The Chinese conducted three tests of their Wu-14 hypersonic strike vehicle in 2014 and two test missions in 2015. Chinese testing of hypersonic weapons thus far suggests use against targets such as air defenses and anti-missile sites.

Making It Real

The challenge for the third offset strategy, of course, comes in making the leap from laboratory and test
range to force structure and operational reality. Therein lies the rub, especially the rub of money, which is in short supply in the Pentagon. Difficult choices face Pentagon planners as they distribute limited resources among investment, operations, and support accounts. However, in many ways, hypersonic weapons incorporate mature technologies. As US military planners look forward to introducing these weapon systems into a new offset strategy, they can point to previous tests and programs demonstrating that such weapons are desirable, feasible, and acceptable.

AFRL had posited that a hypersonic weapon could be operational in the early 2020s.\textsuperscript{31} Other forecasts propose air-launched, medium-range hypersonic missile by the 2020s, a hypersonic reconnaissance-strike vehicle in the 2030s, and a persistent, reusable reconnaissance-strike version in the 2040s.\textsuperscript{32} According to Hallion and Bedke, the US is probably four or five years from reaching what the Pentagon calls Technology Readiness Level 6, meaning that a representative model has been realistically tested and is ready for weaponization and operational test and evaluation.\textsuperscript{33} In other words, just one step short of an actual procurement program.

Two current hypersonic weapons programs should lead the way into a hypersonic weapons regime. The Hypersonic Air-Breathing Weapon Concept (HAWC), an Air Force/DARPA collaborative project, will accelerate a vehicle to hypersonic speed by rocket engine boosters and then engage a scramjet engine.\textsuperscript{34} In this concept of operations, a weapon could be carried internally by a B-2 bomber, allowing penetration of hostile airspace before launch and shortening the time from launch to target impact, thus limiting the exposure of the aircraft. A hypersonic weapon carried externally on nonstealthy aircraft could be larger and have longer range—required for a launch farther from enemy defenses. In either case, as the HAWC project advances in technological readiness and weaponization, the Department of Defense and the Air Force will need to consider tradeoffs among cost, size, range, and expected initial operating capability of these hypersonic weapons systems.\textsuperscript{35} The Tactical Boost-Glide project, also building on previous similar programs, will rely on aircraft-assisted launches into the atmosphere and a rocket boost to obtain hypersonic speeds in a subsequent descent.\textsuperscript{36}

### Other Offsets: Directed-Energy Weapons and Railguns

True “offsets” in military affairs do not result from single technologies, and forces developed through both the first and second offset strategies relied on various weapons concepts and technologies. Eisenhower’s New Look spawned the nuclear triad of long-range bombers, land-based intercontinental ballistic missiles, and submarine-launched ballistic missiles. Within that triad, each of the three legs developed additional innovations, such as cruise missiles and multiple independently targeted reentry vehicles. Equally, the second offset—spurred by precision-guided munitions, wide-area sensors, and automated command and control systems that gave rise to conventional “reconnaissance-strike complexes” and the “revolution in military affairs”—featured combinations of systems. Unsurprisingly, a third offset strategy will also consider various technological candidates as game-changers in an effort to preserve US global power projection capability. Two of those munitions programs worth a brief mention here, in effect complements to hypersonic weapons systems, are railguns and directed-energy weapons.

Electromagnetic railguns use electricity to fire inert projectiles placed between two rails at speeds of Mach 6 (4,500 mph). This enormous amount of energy is transferred to the target at impact over a range of roughly 125 miles. Suitable as a kinetic kill system for fixed land-based targets, the railgun is often portrayed in a defensive mode to shield valuable assets from a missile attack through its ability to rapidly fire its rounds for long times at an intense rate of fire.\textsuperscript{37} That rate of fire poses a challenge for the weapon system in terms of the continuing generation of large amounts of electricity. Therefore, the platform most commonly seen as hosting a railgun system is a Navy ship.\textsuperscript{38} After 10 years of testing, the Office of Naval Research unveiled a hypersonic
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To summarize, in many respects railguns and directed-energy weapons systems seem just as attractive as hypersonic weapons to those planners seeking to sustain America’s precision strike advantage. All three increase the speed of flight of precision munitions to improve their ability to penetrate defended areas for use against time-sensitive targets. All three are in various stages of development and testing. The Department of Defense and the armed services planning on using these weapons systems face important decisions in determining tradeoffs among technical readiness, cost, size, range, accuracy, and reliability. As Vice Chairman Selva observed, placing multiple bets on would-be breakthrough technologies is probably the right approach to pushing and sustaining the third offset. Those technologies that appear to be able to “change the pace and scope of the fight on the battlespace” will be those most deserving of future investment.
Conclusion

We have conducted a preliminary appraisal of hypersonic weapons systems with the purpose of placing them in the context of the third offset strategy—an attempt once again to leverage technology to gain and maintain a competitive military edge over America’s global rivals. Previous formulations of offset strategies have been carried through different administrations, as foreign and defense policy objectives of containment held fast despite differing perceptions of resources available to underwrite the strategy. This international setting for an offset approach is quite different, owing to the multiple competitions facing a new administration in international security ranging from near-peer powers to regional hegemons and nonstate terrorist actors with radical agendas. Often, when such diverse alternative futures and scenarios are projected, defense planners look for common capabilities cutting across an array of plausible hypothetical contingencies that will have payoff in most or all of them. Following that approach, sustaining and enhancing the US military’s edge in precision-guided munitions and battle networks appears to be a prudent objective those planners should pursue.

Within that very broad objective our preliminary appraisal of hypersonic weapons systems suggests that they are worthy to receive some portion of those multiple bets being made by the architects of the third offset. Hypersonic weapons systems leverage American technical strengths in air and space and contribute to solving some of the most pressing military challenges facing the United States, such as overcoming A2/AD strategies and delivering prompt long-range conventional strike.

Offset strategies do not materialize quickly. Both the New Look and the “assault breaker” capabilities of the second offset took years to reach peak effectiveness. Even the most optimistic appraisals of some of the game-changing technologies referenced here acknowledge that they are probably a decade away from an initial operating capability. That understanding should be enough motivation for a new administration to move forward promptly with a third offset strategy. It appears prudent to include within that agenda the development of high-speed weapons systems to counter the growing capabilities of our adversaries and to sustain America’s long-term competitive advantage in precision-guided munitions.

While these systems are technologically and operationally promising, the challenge of diminished Pentagon budgets must be solved. Small bets may foreshadow big rewards, but only if funds are made available to introduce technologies while they are new and at a scale large enough to make a difference on the modern battlefield. In many ways, the biggest challenge to the third offset strategy is no different than that facing current modernization programs: lack of funds to recapitalize a US military hamstrung by budget reductions and sequestration-level cuts. It would be regrettable, indeed, if artificial and arbitrary limits imposed on the defense budget prevented the very investments required to develop and sustain the game-changing technologies essential to offsetting the future capabilities of our adversaries.

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Notes


operating-from-range-to-defeat-irans-anti-access-and-area-denial/publication.

23. Ibid., 5.
24. Ibid., 38.
39. Barnes, “A First Look at America’s Supergun.”

47. Ibid., 36.