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FROM THE EDITORS

Welcome to the June 2017 issue of AFPC's Defense Dossier. In this edition we return to a them that we have stressed for years, but one which deserves renewed attention: the ballistic missile threats facing America and its allies, and the potential responses to them.

Today, the missile threat to the United States is expanding rapidly. Despite sanctions and international pressure, countries such as Iran and North Korea continue to develop and test offensive missiles at an alarming rate. Meanwhile, strategic competitors such as Russia and China have been modernizing both their nuclear weapon systems and their missile programs.

Working with its allies abroad, America therefore urgently needs to develop cost effective missile programs that are capable of protecting the homeland, forward deployed forces, and partner nations. The robustness of such a system will depend on all relevant technologies and basing modes – including land, sea, and space-based – being harnessed for the common defense. The articles that follow provide important ideas as to how Washington should proceed along this path. As always, we hope you find them both useful and thought-provoking.

Sincerely,

Ilan Berman
Chief Editor

Richard Harrison
Managing Editor

Growing Threats, Declining Budgets

Congressman Doug Lamborn

As recent provocative acts by North Korean dictator Kim Jong-un have highlighted, ballistic missiles pose a real and imminent threat to the United States and our allies. Both North Korea and Iran invest heavily in ballistic missile development in an attempt to offset the strategic balance of power in their favor. Their strategy is to develop and field ballistic missiles that will hold their neighbors, the United States, and our allies at risk—no matter the cost or strain on their domestic economy and their citizens.

This reality is frightening. As a Member of Congress, and as Co-Chair of the House Missile Defense Caucus, I am particularly concerned about the fanatical focus of these rogue nations on the development of nuclear warheads and intercontinental ballistic missiles capable of reaching the U.S. homeland. We urgently need to redouble our efforts to properly resource missile defense technologies, even as we continue diplomatic and economic efforts to stem the development and deployment of missiles by foreign nations.

Updating missile defense policy

In the 2017 *National Defense Authorization Act*, Congress updated the policy of the United States, as encapsulated in the *National Missile Defense Act* (NMDA), to

> …**maintain and improve** an effective, robust layered missile defense system capable of defending the territory of the United States, **allies, deployed forces, and capabilities** against the **developing and increasingly complex** ballistic missile **threat** with funding subject to the annual authorization of appropriations and the annual appropriation of funds for National Missile Defense.

The highlighted words above emphasize the changing nature of the threat we face. We no longer have time and space to wait for moderating forces to prevail in Iran, or for North Korea's missile development program to collapse thanks to years of extreme isolation. Both countries continue to urgently develop missiles of increasing range and lethality. These developments threaten the United States homeland, our deployed forces, and our allies around the world.

Unfortunately, thanks to the Obama administration's insufficient investments in this critical mode of protection, we have already lost a great deal of valuable time and money, both to improve our current system and to develop a future system to defend against future threats. However, in addition to an updated congressional policy, we now also have an administration that prioritizes missile defense.

In fact, the day after his inauguration, President Trump listed developing "a state-of-the-art missile defense system" as one of his five top defense priorities.[1] With increased funding and renewed focus, we must now invest in technologies that can remove a missile threat as close to launch as possible. This includes research and development on updated sensors, command and control, and the Redesigned Kill Vehicle (RKV). Additionally, we must make investments now if we are to have a sufficiently robust layered system—with updated radars, a space sensory layer, Multi-Object Kill Vehicles (MOKV), and directed energy—in the future.

Loosening the purse strings

The first step in developing a robust layered missile defense system is to adequately fund the Missile Defense Agency (MDA). The MDA's mission is akin to the national

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strategy in the NMDA: "…to develop, test, and field an integrated, layered, ballistic missile defense system…to defend the United States, its deployed forces, allies, and friends against all ranges or enemy ballistic missiles in all phases of flight."

Yet MDA has faced topline cuts to its budget for years, which has created massive shortfalls between the Future Years Defense Program (FYDP) and its actual budget. This meant that MDA would project a program's development, only to face a cut to its budget to implement it year after year—a dynamic that hobbled the agency's mission to develop and field systems consistent with our nation's policy.

How adversely has the spiraling MDA budget affected our defense? Over the last decade, MDA received progressively less overall funding year after year, culminating in a total topline decrease of 23.4 percent ($11 billion), leaving its budget at just $8.4 billion.[2] Among MDA's priorities, meanwhile, homeland missile defense fared twice as badly, suffering a 46.5 percent decrease (from $3.7 billion to $2 billion).[3] As Thomas Karako and others noted in a recent report from the Center for Strategic & International Studies, the cuts from the budget from the projected FYDP "…indicates budget instability and therefore difficulty with long-term planning. The shortfalls between enacted funding levels and previously FYDP projections can have a corrosive effect on programs."[4]

> With a mission, and a projected budget with which to accomplish it, effectiveness always suffers as resources are removed.

This intuitive point is one I hear often from those in government and industry alike, but it always bears paying attention to. With a mission, and a projected budget with which to accomplish it, effectiveness always suffers as resources are removed. In the case of the MDA, the mission has continued to increase between 2006 and today, thanks to growing threats from potential adversaries. Funding, however, has headed in the other direction.

This is a dangerous state of affairs. While the United States still maintains technological superiority in this domain, fiscal shortfalls give our adversaries precious time and space to develop and field new missiles and other technologies that compete with ours. The MDA's work in research, development, and acquisition enables the combatant commands to defend our homeland and our allies. The bottom line is that we cannot properly address the threat of ballistic missiles without adequately funding the MDA.

The future of BMD

What should be done? As a first order of business, the MDA should be funded at no less than $10 billion, a topline budget figure that was met or exceeded during the Bush administration.[5] Any lower number simply isn't serious.

More fundamentally, as with our broader defense strategy and budget process, we must return to a strategy-driven budget, rather than a budget-driven strategy. Like our nuclear deterrent, the missile defense budget debate should solely be about priority level, not about nickels and dimes. In other words, we should be asking ourselves: how much is Seattle, or New York, or Washington, DC worth to the American people?

Within that broader strategy, a few priorities should be noted:

- DoD should continue to install Ground-Based Interceptors at Fort Greely, Alaska to maintain our current capability to respond to ballistic missile threats. However, MDA should be mindful of advanced technologies that better address the evolving threat.
- We need to increase and sustain funding for future technologies that counter ballistic missile threats. This includes funding concepts under current development such as the Redesigned Kill Vehicle (RKV), updated sensors such as the Long Range Discrimination Radar (LRDR) in Alaska, command and control

systems, the Multi-Object Kill Vehicle (MOKV), and directed energy (which offers a cost-effective solution to counter expensive missiles developed by our adversaries when they are at their most vulnerable point in the boost phase).

- Finally, future programs must also include a space-based layer, which provides the best available location to track and assess missile threats.

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As North Korea recently reminded, the ballistic missile threat is not going away. We need to be prepared to defend our homeland and our allies. The nature of the threat means that any successful missile attack would be devastating. North Korea and Iran know this very well, and will not stop until they have the capability to back up their clear intent to hold us hostage. Prudent investment in missile defense technologies will ensure that we maintain our self-defense capability, protect the American people, and give the President options should a worst-case scenario become reality. ■

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Adversary Missile Modernization: Understanding the Threat

Harrison Menke

Today, the United States and its allies face a growing and dynamic ballistic and cruise missile threat environment. The missile forces of America's potential adversaries are expanding quantitatively, even as they become increasingly sophisticated and lethal.

Such forces (typically capable of deploying weapons of mass destruction) are perceived as vital to countering the United States and its allies by countries such as Iran, North Korea, China and Russia. The corresponding investments now being made by Tehran, Pyongyang, Beijing, and Moscow and will likely significantly complicate U.S. deterrence, reassurance, and warfighting efforts now and in the future.

Iran: An Improving Arsenal

Iran views its missile force as the backbone of its strategic deterrence posture and military strategy. Although the 2015 Joint Comprehensive Plan of Action (JCPOA) appears to have impeded Iran's push toward nuclear weapons, at least temporarily, Tehran continues to expand and enhance its missile arsenal, which is already the largest in the Middle East. These weapons are potent tools of intimidation, often prominently featured in military parades adorned with banners calling for "death to America" and for Israel to be "wiped off the map."[1] Should deterrence fail, these weapons provide Iran with a deep strike capability that would allow it to threaten states and U.S. military bases throughout the Middle East and Southern Europe. Iranian military planners appear to view massed strikes against cities, critical infrastructure, and military bases to be a viable strategic objective—one that is aimed at demoralizing adversary populations and crippling hostile military operations.[2]

U.S. intelligence officials have judged that Iran "is expanding the scale, reach, and sophistication of its ballistic missile forces, many of which are inherently capable of carrying a nuclear payload."[3] Indeed, the Iranian arsenal now includes over nine distinct missile systems: the *Fateh*-110 and its variants (300-500 km range), the *Shahab*-1 (300 km range), the *Shahab*-2 (500 km range), the *Qiam* (800 km range), the *Shahab*-3 (1,000 km range), the *Ghadr* (1,600 km range), the *Emad* (1,700 km range), the *Sejjil*-2 (2,000 range), the *Soumar* cruise missile (2,000-3,000 km range), and the BM-25 *Musudan* (4,000 km).[4] While numerically impressive, Iranian missiles are considered to be relatively inaccurate—a deficiency Iran has sought to redress by prioritizing precision targeting.[5] For example, the *Emad* (last tested in 2015) appears to be equipped with a separating warhead with aerodynamic winglets to increase the missile's precision and maneuverability.[6] Enhanced missile lethality could necessitate fewer missiles per target and advance Iran's ability to destroy targets such as U.S. forward deployed military bases.

In addition to steady missile improvements, Iran has sought to diversify its missile basing options. Nearly every Iranian missile is attached to a mobile transport erector launcher (TEL), making it difficult to find, fix, and destroy once dispersed. Other systems are deployed at hardened facilities, operating in conventional silos or underground launch complexes.[7] Such measures are evidently intended to frustrate U.S. and Israeli efforts to locate and target missile systems, encumbering pre-strike planning and improving missile survivability.

North Korea: A Diversifying Missile Force

Together with a nascent nuclear capability, North Korea's missile program continues to pose a serious threat to the United States and its allies and partners across the Asia-Pacific. North Korea has sought to rapidly improve its strategic capabilities under Kim

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Jong-Un, conducting missile and nuclear warhead tests at an unprecedented rate.[8] These developments have been accompanied by frequent threats to, among other things, turn the United States and neighboring nations into a "sea of fire."[9] Indeed, while little is known about North Korean strategic doctrine and employment strategy, Kim Jong-Un ostensibly views North Korean strategic assets as inherently usable.[10] By threatening (or actually executing) rapid and deliberate escalation, North Korea appears confident that brinksmanship and blackmail can compensate for limited resources and a decaying conventional military component to compel outcomes favorable to the Kim regime.

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Underpinning the threat has been North Korea's drive to develop nuclear-armed intercontinental ballistic missiles (ICBMs) capable of striking western portions of the United States.[11] Central to this pursuit is the development of the KN-08 family of missiles.[12] The KN-08 has an expected range of around 8,000 km and operates on a mobile TEL.[13] While the ICBM has yet to be flight tested, changes in the missile's appearance (such as a more aerodynamic nose cone) indicate growing technical improvements.[14] Moreover, North Korea has conducted five successful nuclear tests, with each subsequent detonation indicating a greater explosive yield.[15] While uncertainties remain, some U.S. military officials suggest it is prudent to assume North Korea has the capability to miniaturize a nuclear weapon and put it on an ICBM.[16]

North Korea has also continued to aggressively improve missile capabilities required to threaten targets across East Asia. Efforts have primarily concentrated on rapidly improving the current force of Hwasong (300-800 km), Nodong (1,500 km), and BM-25 Musudan (4,000 km) missiles, capable of reaching South Korea, Japan, and Guam respectively. However, North Korea has also tested new capabilities based on a common missile design (identified as Pukguksong): a submarine-launched ballistic missile (SLBM) and a new road-mobile intermediate-range ballistic missile (IRBM). These latest missiles offer improved basing modes and use solid-fuel propellants, which help reduce pre-launch preparation time to as little as five minutes.[17] Once mature, these augmentations should substantially improve missile survivability and responsiveness – key elements to a robust warfighting posture.

Broadening the Aperture: Russia and China

Current U.S. missile defense policy is explicitly arrayed against Iran and North Korea, and does not address Russia or China.[18] However, both states are increasingly assertive in their respective regions, and are seeking to compete with the United States across multiple strategic domains. Moreover, Russia and China attach significant value to nuclear and conventional strike capabilities to support regional aims and undermine U.S. military advantages. As such, prudent U.S. planning must also consider the evolving threat from both.

Russia views nuclear use (broadly defined to include threats, posturing, and actual employment) as the primary means to support national political and military objectives along the entire spectrum of crisis and conflict.[19] Russia increasingly seeks to leverage veiled and explicit nuclear threats to coerce its neighbors, the North Atlantic Treaty Organization (NATO), and the United States from taking unwanted actions.[20] For example, Moscow intertwined nuclear intimidation with

North Korea has sought to rapidly improve its strategic capabilities under Kim Jong-Un, conducting missile and nuclear warhead tests at an unprecedented rate.

hybrid or non-linear war to ensure favorable conditions for Russian operations in Crimea and eastern Ukraine by demonstrating that it was prepared to use nuclear weapons to defend its interests.[21] During a conflict, Russian nuclear strategy reportedly envisions limited first nuclear use as a means to fundamentally shift the nature of a conflict to terminate hostilities on terms favorable to Russia.[22] Such employment could range from a non-lethal demonstration to strikes against key military and logistics infrastructure throughout NATO territory.[23] Underpinning this posture is the assumption that escalation – including nuclear escalation – can be controlled through the careful application of force.

To support this comprehensive strategy, Russia fields a flexible and diverse force capable of calibrated damage against a wide-range of targets. Russia is today updating every component of its nuclear missile force as part of a massive strategic modernization program. The mainstay of this buildup has been new ICBMs, the silo and road-mobile *Topol*-M and the multi-warhead *Yars*-M, as well as *Bulava* SBLMs carried inside the new *Boeri*-class ballistic missile submarines (SSBNs).[24] Russia is also fielding a ground-launched cruise missile (GLCM) – prohibited under the 1987 Intermediate-Range Nuclear Forces Treaty – and developing a new road-mobile ICBM (*Rubezh*), hypersonic vehicle (Project 4202), rail-mobile ICBM (*Barguzin*), "heavy" ICBM (*Sarmat*), and Bulava SLBM follow-on.[25] Many of these capabilities carry multiple warheads and appear specifically designed to penetrate missile defense systems.[26]

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China, too, is modernizing its nuclear forces. According to the Pentagon's 2016 annual report on Chinese military power, "[China] is developing and testing several new classes and variants of offensive missiles, including a hypersonic glide vehicle; forming additional missile units; upgrading older missile systems; and developing methods to counter ballistic missile defenses."[27] China intends to replace its DF-5 liquid-fueled, silo-based ICBMs with the more robust road-mobile DF-41 ICBM capable of carrying multiple warheads, while upgrading its DF-31 ICBMs with a new extended range variant (DF-31A).[28] China has also continued to modernize its sea-based nuclear forces, operating four *Jin*-class SSBNs – and potentially adding a fifth – armed with the new JL-2 SLBM (7,400 km).[29]

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In contrast to Russia, China's nuclear policy is more opaque. Beijing publicly espouses a no first-use posture, claiming that nuclear weapons will only be used in retaliation. However, the Department of Defense has indicated that Beijing may not consider strikes on what China perceives as its own territory, demonstration strikes, or high-altitude bursts (nuclear generated electromagnetic pulse) as constituting first-use.[30] Indeed, some experts argue that during a high-stakes conflict with a conventionally superior adversary, China could posture or employ nuclear weapons to limit conventional escalation and compel conflict termination.[31] To be sure, China's modern nuclear capabilities could allow for more limited and tailored use. According to Elbridge Colby, "a more sophisticated force will give China better options for how it might seek to use these weapons not only, as in the past, as a desperate last resort, but also to deter U.S. escalation of a conflict—escalation the United States might need to resort to if it is to prevail."[32]

Both Russia and China also field a host of dual-capable ballistic and cruise missiles (i.e., systems able to carry either conventional or nuclear munitions) for regional deterrence, coercion, and warfighting.[33] Modern dual-capable systems include Russia's *Iskander* short-range ballistic missile (SRBM), *Kalibr* submarine-launched ballistic missile (SLCM), and Kh-101/102 air-launched cruise missile (ALCM), and China's road-mobile DH-10 GLCM, DF-15 SRBM, DF-21 MRBM, and DF-26 IRBM. Dual-capable missiles enhance operational flexibility by providing conventional options to inflict damage against important military and civilian infrastructure short of the nuclear threshold. The same missiles can also be armed with nuclear munitions for rapid escalation up to and past the nuclear threshold. During a conflict, U.S. intelligence may not be able to distinguish which capabilities are nuclear-armed, blurring the distinction between conventional and nuclear systems. This ambiguity appears to be a deliberate attempt to manipulate risk; by introducing dual-capable systems as a coercive lever, U.S. and allied planners are forced to account for the nuclear dimension, fundamentally changing the nature of a crisis or conflict.

Potential adversaries are building a spectrum of complex and sophisticated capabilities to impose severe costs on the military assets and civilian populations of the United States and its allies during a regional crisis or conflict.

The continuing need for missile defense

Clearly, the evolving missile threat should no longer be considered limited, but expansive and highly dynamic. Potential adversaries are building a spectrum of complex and sophisticated capabilities to impose severe costs on the military assets and civilian populations of the United States and its allies during a regional crisis or conflict. These capabilities can be wielded coercively in an attempt to constrain U.S. freedom of action, or actually employed to limit or offset U.S. military options, thereby reducing the ability of the United States to defend its regional allies. In the case of the nuclear-armed actors described herein, the threat of rapid and deliberate escalation past the nuclear threshold (to include threats against the U.S. homeland) could be utilized in an attempt to de-couple the United States from its regional allies, creating perceived space for regional aggression. These developments aim to weaken U.S. deterrence, reassurance, and warfighting efforts.

As long as the missile threat exists, the United States will have an enduring interest in defending itself and its allies. As such, it is incumbent on the United States to continue to develop and field robust systems, to include missile defenses, to mitigate this threat. To be sure, missile defense is not a panacea; the United States will need to integrate a range of instruments into a cohesive missile defeat toolkit.[34] However, point, regional, and homeland missile defenses may allow the United States and its allies to better deter, weaken, or eliminate some missile operations aimed to escalate a crisis or degrade regional mobilization, conventional strike capabilities, and civilian infrastructure. This could induce greater uncertainty into the strategic calculations of potential adversaries and deny benefits from standoff attacks. In this way, the United States and its allies will be better postured to deter and, if deterrence fails, to respond to a missile attack that would otherwise reach its target(s) unopposed. ■

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A Primer on American Missile Defense

Riki Ellison

In order to properly assess America's global position regarding missile readiness and missile defense, a basic understanding of its current capabilities is necessary. While the current U.S. program has many strengths, certain areas nevertheless need improvement in order to provide the country with the best possible means to guard against missile attacks. As threats from North Korea and Iran, among others, continue to proliferate, ensuring the robustness of America's missile defenses is increasingly critical.

Evolution of threat and response

Over the past quarter-century, the U.S. has deployed operational ballistic missile defense systems both at home and in various regions around the world. These deployments have been driven, in terms of development, acquisition, testing and operation, by three major milestones.

The first was the modern warfare use of the SCUD ballistic missiles by Iraq against Israel and Saudi Arabia during the course of the 1991 Gulf War—which highlighted the utility of ballistic missiles, and the need to develop defenses against them, in the post-Cold War strategic environment. The second was the passage of the National Missile Defense Act of 1999. Drafted in response to the North Korean launch of a ballistic missile over Japan the preceding year, that law made it national policy for the U.S. to have at least a limited missile defense capability in place against threats such as North Korea and Iran as soon as was technically possible.

The third inflection point was the decision of the George W. Bush administration to withdrawal from the 1972 Anti-Ballistic Missile (ABM) Treaty on December 13th, 2001. This decision reversed Cold War era policy – which had continued throughout the Clinton administration – of intentional vulnerability to missile attack, and made it possible for the United States to at long last build the necessary capabilities to defend the U.S. homeland from an assortment of missile threats.

Land-based missile defense systems are currently deployed in the United States, the American Territory of Guam, as well as in the territory of American partners and allies including Denmark, Germany, Romania, Spain, Turkey, the United Kingdom, the Republic of Korea, Japan, Israel, Kuwait, Bahrain, Jordan, Qatar, and the United Arab Emirates. U.S. systems are also deployed at sea in the Atlantic Ocean, the Mediterranean Sea, the Red Sea, the Persian Gulf, the Indian Ocean, the South China Sea, the Sea of Japan and the Pacific Ocean. Finally, there are also missile defense sensors deployed in both low-Earth orbit and geosynchronous orbits in space around the world.

U.S. Homeland Missile Defense Systems and Operations

The Ground-based Midcourse Defense (GMD) system is the only interceptor system deployed today for the U.S. homeland defense against intercontinental ballistic missile (ICBM) threats. Sea-based defenses can only guard against short to intermediate range missile threats, and there are currently no space-based interceptors. There are 38[1] Ground-based Interceptors (GBIs) deployed at present, 34 of them siloed at Ft. Greely in Alaska and four located at Vandenberg Air Force Base (AFB) in California (see Table 1). The U.S. currently plans to deploy another six third-generation GBIs to Ft. Greely by the end of the year, increasing the total number deployed to 44. However, the United States will unlikely be able to maintain a fielding of 44 GBIs past 2018 because of attrition from testing and the replacement of older interceptors. The current shot doctrine for GMD requires a minimum of at least two GBIs for every long-range ballistic missile targeted. This

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Table 1: Interceptors | U.S. Homeland Missile Defense

Type	Mission	Interceptor Details	Quantity	Location
LAND-BASED Ground-based Midcourse Defense (GMD) System uses Ground-based Interceptors (GBIs)	· Defense against Intercontinental Ballistic Missiles (ICBMs) · Exo-atmospheric Kill Vehicle (EKV) uses kinetic hit-to-kill technology to destroy incoming warheads	There are currently three generations of EKVs on the current 38 GBIs: · Capability Enhancement-I (CE-I) -most common interceptor configuration · Capability Enhancement-II (CE-II) - a small amount of interceptors use this configuration · Capability Enhancement-II Block I (CE-II Block I) - newest interceptors use this configuration	34	Fort Greely, Alaska
			4	Vandenberg Air Force Base (AFB), California

means that, by the end of this year, the United States will possess the capability, in a best-case scenario, to engage 22 long-range ballistic missile threats to the U.S. homeland. Today, GMD provides limited ballistic missile defense for all 50 states. However, coverage, shot opportunities and battlespace varies, with Hawaii and Florida possessing the least amount of shot opportunities vis-à-vis threats emanating from North Korea and Iran.

Sensor Systems for U.S. Homeland Defense

Missile interceptors involved in U.S. homeland defense rely on a vast and comprehensive network of sensors to track, target and discriminate incoming ballistic missiles (see Table 2). A total of six land-based sensors are active across the world and fused together to provide overall missile warning and tracking with some limited discrimination for GMD in the protection of the U.S. homeland. Also, not integrated with GMD but part of the overall missile warning architecture are two radars located in Clear, Alaska and Cape Cod, Massachusetts.

Sea-based sensors provide GMD with additional tracking and discrimination and are distributed throughout the Atlantic and Pacific Oceans. Aegis Ballistic Missile Defense (BMD) capable ships outfitted with AN/Spy-1 radar provide limited tracking and discrimination for GMD, however, GMD's tracking and discrimination capabilities are significantly enhanced by a Sea-Based X-Band Radar (SBX) deployed in the Pacific. Aegis BMD ships operating in the Pacific Fleet can provide GMD with initial tracking of rocket stage separation, fill in sensor gaps and help to cue the SBX on missiles originating from North Korea launched towards Hawaii and the continental United States. Aegis BMD ships in operations in the Atlantic, Mediterranean, Baltic and North Seas can provide GMD with early-warning, tracking, and discrimination on missiles originating from Iran launched towards the U.S. Homeland.

In addition to land- and sea-based systems, space-based sensors are critical to GMD, and cumulatively provide the first identification and first early warning of launches anywhere in the world on all ballistic missile threats to the U.S. homeland.

Limitations of the U.S. Homeland Defense

The U.S. homeland defense system today is limited by U.S. policy in both capacity and capability. There is a lack of overall persistent sensor discrimination and tracking of missile threats. New space-, air-, land-, and sea-based sensors are required for discriminating and tracking ballistic missile threats. The United States is currently constructing a Long-Range Discrimination Radar (LRDR) that will be deployed and operational at Clear

TABLE 2: SENSORS | U.S. HOMELAND MISSILE DEFENSE[2]

Type	Sensor Details	Location
LAND-BASED	Upgraded Early Warning Radars (UEWR) at three locations are tied into the GMD sensor network	Beale AFB, California
		Royal Air Force Flyingdales, United Kingdom
		Thule Air Base, Greenland
LAND-BASED	Cobra Dane Radar provides tracking for ballistic missiles	Shemya Island of the Aleutian Islands, Alaska
LAND-BASED	Two U.S. AN/TPY-2 radars deployed forward-based in Japan provide early warning, initial tracking, queuing, and discrimination of ballistic missiles coming from North Korea	Kyogamisaki Sub Base, Japan
		Shariki Military Base, Japan
LAND-BASED	Not integrated with GMD, but two radar systems are part of the overall missile warning architecture	Clear, Alaska
		Cape Cod, Massachusetts
SEA-BASED	One Sea-Based X-band radar (SBX) provides the GMD system targeting discrimination data on ballistic missiles fired from North Korea toward the United States	Hawaii (deployed throughout the Pacific)
SEA-BASED	33 Aegis BMD-capable ships have AN/SPY -1 Configured radars provide tracking of ballistic missile threats from North Korea and Iran to the U.S. homeland	Aegis BMD-capable ships operate in the Pacific, Atlantic, Mediterranean, Baltic, and North Sea
SPACE-BASED	The Defense Support Program (DSP) satellites provide early warning and first identification	Geosynchronous orbit (5 satellites)
SPACE-BASED	Space-Based Infrared System (SBIRS) satellites provide early-warning and first identification	Geosynchronous orbit (3 satellites)
		High Earth orbit (3 satellites)
SPACE-BASED	Space-based Tracking and Surveillance System (STSS) satellites provide limited space-based tracking capability as they are reaching expiration of mission	Low Earth orbit

Air Force Base, Alaska in the 2020 timeframe. This radar will provide discrimination targeting capability over a vast range of space protecting the U.S. homeland from ballistic missiles coming over the Northern Pacific and North Pole. The capability provided by LRDR will also increase the reliability of GBIs in tracking and discrimination. A second LRDR is currently being considered for deployment and operation at RAF Fylingdales in the United Kingdom, and a third land-based discriminating radar is being considered for deployment and operation in Hawaii.

East Asia: U.S. Missile Defense Systems in Operation

The United States has deployed a robust missile defense program throughout East Asia (See Table 3) and works closely with its allies in the region, namely Japan and South Korea, to defend against the threat posed by North Korea. Currently, the United States is installing a missile defense system within South Korea and is working with Japan to develop the next generation of sea-based interceptors. Both countries also cooperate with the United States on the deployment of sensors. The United States likewise uses its territory of Guam as a center for tracking missiles, and has necessary defenses around the island in the event that it is threatened.

There are two U.S. Army missile defense systems deployed and fully operational in this region of the world: the Patriot Advanced Capability (PAC) and the Terminal High Altitude Area Defense (THAAD). The United States has stationed two Patriot Air Defense Artillery (ADA) battalions, both of which are positioned to defend air bases, ports and logistical hubs throughout South Korea. A third U.S. Patriot battalion is fully operational in Okinawa, Japan defending air and military bases there. There is one THAAD system currently deployed and fully operational on Guam, where it defends the entire island from the North Korean ballistic missile threat. A second THAAD system is being deployed in South Korea, the first components for which arrived in early March 2017 at Osan AFB, South Korea. The system will be permanently based in the country's southern Seongju region, and will enable Seoul, for the first time, to defend much of the country and its population of approximately 50 million against a North Korean ballistic missile threat.

There are seven Aegis BMD-capable ships assigned to the 7th Fleet out of Yokosuka, Japan, and additional Aegis BMD Ships out of Pearl Harbor, Hawaii and San Diego, California under the command of the U.S. Pacific Fleet that can be used for a maritime "surge" in the Asia-Pacific region. These ships are equipped with various processor configurations that influence their missile defense capabilities. Most are configured with the earliest Aegis 3.6 and follow-on 4.0 software, and three are equipped with the newest 5.0 software (also known as Baseline 9). All vessels equipped with Aegis BMD software are capable of sharing ballistic missile tracking information with each other. This allows an Aegis BMD capable vessel to acquire missile tracking information from other remote sensors, integrate that tracking data into its own fire-control solution, and cue its radar and defensive interceptors more effectively; increasing the probability of missile intercept. Aegis BMD capable vessels equipped with more-advanced 4.0 and 5.0 software are able to engage and fire missile defense interceptors off of remote sensor data. This more-advanced software enables an Aegis BMD capable ship to fire defensive interceptors at ballistic missile targets before the targets are in view of its onboard AN/SPY-1 radar.

To intercept ballistic missiles, Aegis BMD capable vessels are equipped with two types of interceptors: The Standard Missile-3 (SM-3) and the Standard Missile-6 (SM-6). The SM-6 is the first true multi-mission capable interceptor that supports a fully integrated, extended-range, detect-to-engage capability for U.S. Navy vessels. The SM-3 is the only exo-atmospheric interceptor that has successfully engaged intermediate-range ballistic missiles and is currently in use on U.S. and Japanese BMD capable vessels.

Today, the United States and Japan are in the final testing phases of a seventeen-year cooperative development effort that will produce the next-generation SM-3 interceptor variant: the SM-3 Block IIA. The SM-3 Block IIA missile incorporates a much more capable homing kill vehicle, which is larger and much faster than the current Block IA and Block IB interceptors. The Block IIA also has over twice the range of the SM-3 Block IB. Relative to the current SM-3 Block IB, the SM-3 Block IIA kill vehicle has twice the seeker sensitivity and more than three times the maneuverability of previous generations. These performance improvements allow the Block IIA to defend much larger areas against longer-range and more sophisticated missiles.

East Asia Sensor Network

The sensor network in East Asia contains radars that contribute to defeating long-range threats to the U.S. homeland, as well as countering regional threats from North Korea. There are two forward-based AN/TPY-2 radars deployed in Japan at Kyogamisaki Sub Base and Shariki Military Base. These are fielded in forward-based mode and operate in conjunction with U.S. homeland missile defense, but also support Japan's missile defense architecture (see Table 2). They provide early warning, initial tracking, and discrimination data, and cue other air and missile defense sensors in the region.

Additionally, there are 12 Patriot radars deployed operationally in East Asia. All Patriot batteries in East Asia are equipped with Patriot radars to provide search, detection, tracking, discrimination, and fire solution capabilities. Patriot batteries equipped with PAC-2 interceptors use AN/MPQ-53 radar, which is a passive, electronically scanned array radar. For Patriot batteries equipped with PAC-3 interceptors, an AN/MPQ-65 radar is employed that has increased search, detection, and tracking capability.

East Asia also houses the two THAAD AN/TPY-2 radars deployed with THAAD interceptors in Guam and South Korea, each integrated into an individual THAAD battery for intercept solutions in terminal phase. These two radars work directly in conjunction with THAAD launchers to properly identify, track, engage, and intercept multiple complex ballistic missile threats.

In addition to the land-based sensor systems, sea-based and space-based sensors also contribute to the regional sensor architecture. Stationed aboard each of the seven Aegis BMD-capable vessels in East Asia are AN/SPY-1 radars that can be used for early warning, tracking and discrimination, and - if equipped with Baseline 9 software – interceptor cueing for other Aegis BMD-capable vessels. Regarding space-based assets, there is a Joint Tactical Ground Station (JTAGS) in theater that provides a redundant capability, and is responsible for receiving and disseminating regional information regarding ballistic missile launches provided by space-based sensors. This early-warning data is used to provide real-time warning, alerting, and queuing information on ballistic missile launches.

Middle East: U.S. Missile Defense Systems in Operation

The missile defense program in the Middle East is more limited in scale than in East Asia. Unlike in Asia, these systems are intended to provide small area defense, mainly around U.S. bases and ports, and interceptors are often rotated between countries.

The United States deploys rotating ADA battalions from the 11th, 31st, 69th, and 108th ADA brigades throughout the Middle East, with each battalion consisting of around four Patriot batteries. These include Patriot batteries in Qatar, the United Arab Emirates, Bahrain, Jordan, and Kuwait. U.S. Patriot batteries provide small area defense for U.S. military bases and ports in those countries.

There are no U.S.-manned, deployed, and operational land-based interceptors in Israel. If required, U.S. ADA Patriot battalions from the 10th AAMDC from Kaiserslautern, Germany and the 32nd AAMDC from Ft. Bliss, Texas would be mobilized for forward-deployment in Israel. Each of these ADA battalions has four Patriot batteries apiece. The Israelis have their own missile defense system, but U.S. Aegis destroyers ported at Rota, Spain regularly deploy to the Eastern Mediterranean, where they can provide additional ballistic missile defense coverage of the country.

On average, there are approximately two U.S. Aegis BMD capable vessels in the Middle East, controlled by the U.S. Fifth Fleet operating out of Bahrain. These Aegis ships persistently patrol the Arabian Gulf, Red Sea, Gulf of Oman, and the Indian Ocean. To intercept ballistic missiles, Aegis BMD-capable vessels are equipped with two types of interceptors: the SM-3 and the SM-6. U.S. Aegis BMD-capable vessels in the Middle East are equipped with SM-3 Block IA and SM-3 Block IB interceptors, as there are no current plans to deploy the SM-3 IIA to the Middle East.

Middle East Sensor Systems

Similar to the East Asia sensor network, the region relies on a combination of land-, sea- and space-based radar to guard against threats emanating from Iran. There

TABLE 3: INTERCEPTORS | EAST ASIA MISSILE DEFENSE

TYPE	Mission	Interceptor Details	Battalion	Location
LAND-BASED Patriot Advanced Capability (PAC)	· Missile defense for small areas including airports, military facilities, and city blocks · Intercept incoming missiles in low altitudes	-Average of six launches per battery with a maximum of 16 launchers per battery There are currently three interceptor variants: · PAC-2 - equipped with high explosives and proximity fuse to detonate near target · PAC-2 Guidance Enhanced Missile TBM (GEM-T)- equipped with high explosives and proximity fuse to detonate near target · PAC-3 - launch load of 16 / PAC-3 Missile Segment Enhancement (MSE) - launch load of 12 - uses hit to kill intercept	6-52 (equipped with 4 firing batteries)	South Korea
			2-1 (equipped with 4 firing batteries)	South Korea
			1-1 ADA (equipped with 4 firing batteries)	Okinawa, Japan
LAND-BASED Terminal High Altitude Area Defense (THAAD)	· Missile defense for large areas , such as a small country or island	· Average of six launchers per battery with a maximum of 16 launchers per battery · Can engage warheads inside the atmosphere and in lower edges of space	1 unit fully deployed	Guam
			1 unit not yet fully operational	South Korea
SEA-BASED Aegis Ballistic Missile Defense Ships use Standard Missile-3 (SM-3) and Standard Missile-6 (SM-6) Interceptors	· Defense against short to intermediate range ballistic missiles · SM-3 is the most advanced standard missile and defeats exo-atmospheric ballistic missiles · The SM-6 is capable of defeating high speed maneuvering cruise missiles and sea based terminal threats and demonstrated surface-strike capability	· SM-3 uses advanced onboard processor and two-color target discrimination seeker hit-to-kill warhead designed for exoatmospheric defense · SM-3 has Block 1A, Block 1B, and Block IIA variants · SM-6 incorporates an advanced fragmentation warhead designed for long range air-defense and low tier ballistic threats	· Aegis BMD Cruisers hold 120 vertical launch tubes · Aegis BMD destroyers hold 90 vertical tubes	Pearl Harbor, Hawaii
				San Diego, California
				Yokosuka, Japan

is a forward-based AN/TPY-2 radar deployed in the Middle East that provides early-warning, initial tracking, discrimination, and is used to queue other missile defense sensors in the region. In addition, all U.S. Patriot PAC-3 batteries in the Middle East are equipped with the AN/MPQ-65 radar to provide search, detection, tracking, discrimination, and fire solution capabilities.

U.S. Aegis BMD-capable ships operating in the Middle East each have their own AN/SPY-1 radar that can be used for early warning, tracking, and discrimination of air and ballistic missile threats. Space-based sensors also provide data to U.S. missile defense systems in the Middle East. There is a JTAGS in theater that is a redundant capability and responsible for receiving and disseminating regional information provided by space-based sensors regarding ballistic missile launches. This early-warning data is used to provide real-time warning, alerting, and cueing information on ballistic missile launches.

Europe: U.S. Missile Defense Systems in Operation

Although the European Phased Adaptive Approach (EPAA) missile defense plan is not as strong as originally conceived, there is still a flexible and robust missile defense architecture in Europe in place to counter threats from Iran. The United States has Patriot and Aegis Ashore systems deployed to provide land-based missile defense. In Germany, U.S. Patriots are fielded by the 5-7 ADA battalion located in Kaiserslautern. U.S. Patriot batteries in Europe can be mobilized to provide small area defense for U.S. military bases in the NATO theater. The United States also fields an Aegis Ashore site in Deveselu, Romania. The site is equipped with SM-3 Block IB interceptors to protect Southeastern Europe and is designed to intercept ballistic missiles from Iran.

Sea-based intercept options add to this protection. There are four U.S. Aegis BMD capable destroyers ported at Rota, Spain, each equipped with SM-3 Block IA and IB interceptors, as well as with SM-6 interceptors. These destroyers deploy throughout the Mediterranean and provide missile defense coverage for Europe from Iranian ballistic missiles. If required, additional sea-based BMD capability in Europe can be provided by the U.S. Sixth Fleet out of Naples, Italy, which is supported by fleet forces in Norfolk, Virginia that can deploy and surge into the European region if required.

In 2018, Phase III of the EPAA will authorize the operational deployment of a second Aegis Ashore site to Poland. The Poland site will be equipped with SM-3 Block IB interceptors and the more-capable SM-3 Block IIA interceptors. The Romania Aegis Ashore site could look to add the SM-3 Block IIA interceptors for increased range and capability. When equipped with the SM-3 IIA interceptors, the two Aegis Ashore sites and the multiple Aegis BMD-capable ships in Europe will provide protection for all of Europe.

European Sensor System

In Turkey, one forward-based U.S. AN/TPY-2 radar is currently deployed and operational, providing early warning, initial tracking, queuing, and discrimination of missiles launched from Iran into Europe. Data collected by the forward-based AN/TPY-2 in Turkey is used to queue other sensors and interceptors from Aegis BMD ships and the Aegis Ashore site in Romania. In Germany, there are four U.S. Patriot batteries deployed, each equipped with a Patriot radar to provide search, detection, tracking, discrimination, and fire solution capabilities. In Romania, there is one deployed operational Aegis Ashore site equipped with the AN/SPY-1 radar. In the United Kingdom, the U.S. UEWR at Fylingdales also provides tracking data for some parts of Northern Europe.

In addition to land-based sensor assets, each of the four U.S. Aegis destroyers deployed to Rota, Spain include corresponding AN/SPY-1 radars that provide early warning, tracking, and discrimination capabilities. As is the case in the Middle East and Asia, space-based sensors also provide data to U.S. missile defense systems in the Europe. Additionally, there is a JTAGS in theater that is a redundant capability and responsible for receiving and disseminating regional information regarding ballistic missile launches provided by space-based sensors. This early-warning data is used to provide real time warning, alerting, and queuing information on ballistic missile launches.

Addressing Global Missile Threats

Considering the pervasive offensive missile threats from Iran and North Korea, it is imperative that the U.S. and its allies maintain an integrated global missile defense architecture. The respective regional missile shields must be adaptive in order to address changing threats, as adversaries advance their missile programs. To help counter emerging threats, in addition to regional responses, the United States has developed the Global Response Force (GRF), an airlift capability available for emergency deployment around the world. The GRF consists of one THAAD battery and one Patriot battery stationed at Ft. Bliss, Texas. ■

Endnotes

1. For the remainder of 2017, an additional new GBI will be deployed approximately each month until the total reaches 40. The 37 GBIs tallied in this review represents a number in constant fluctuation.

2. Today, the United States has fully committed and is constructing a Long-Range Discrimination Radar (LRDR) that will be deployed and operational at Clear Air Force Base, Alaska in 2020. This radar provides discrimination targeting capability over a vast range of space protecting the U.S. homeland from ballistic missiles coming over the North Pole. The capability provided by LRDR increases the reliability of GBIs in tracking and discrimination.

Enhancing Allied Air and Missile Defenses

Ian Williams

Throughout the world, missiles of all kinds are proliferating at an alarming rate. Ballistic and cruise missiles are becoming more numerous, precise, and of increasing importance to the security strategies of China, Iran, Russia, North Korea, and others. Due to the proliferation activities of these countries, ballistic and cruise missiles are also making their appearance in conflicts such as the current war in Yemen, and can be seen in the increasingly sophisticated rocket capabilities of non-state actors like Hezbollah.

These trends have created a threatening and potentially unstable security environment for U.S. forces, allies and partners. Forward deployed U.S. forces are increasingly vulnerable to missile strikes, which may begin to undermine their deterrent power—a detriment to regional stability. Allies and partners are equally under threat, including their civilian areas, inviting the possibility that regional alliance structures could be coerced and fractured during a crisis.

Air and missile defense (AMD) systems are essential to countering these threats. The 2010 Ballistic Missile Defense Review looked to craft tailored "phased adaptive approaches" (PAA) to enhance regional missile defense capability.[1] The European PAA (EPAA), however, was the only one to be fully articulated, and the bulk of the EPAA continues to be funded by the United States. Indeed, the United States has assumed a major portion of the AMD mission worldwide, with ballistic missile defense systems hosted by at least 15 countries.[2] U.S. AMD assets are limited, however. Given the fiscal environment and the increasing concern about North Korea's nuclear and long-range missile programs, future U.S. missile defense priorities could well shift back to an emphasis on U.S. homeland defense. As such, sustaining adequately robust defensive architectures at the regional level moving forward will likely require greater contributions from allies.

Fortunately, there appears to be a growing willingness among some U.S. allies and partners to do just that. In Europe, Poland is looking to acquire two tiers of air and missile defenses to address the Russian threat. The UAE recently purchased two THAAD batteries as an overlay to its Patriot units to counterbalance Iran's missile arsenal. Saudi Arabia is also looking to acquire as many as seven THAAD batteries.. Qatar recently signed a deal to acquire a large early warning radar that could support regional defense. Japan may also be moving towards an expansion of higher-tier, land-based missile defenses. South Korea likewise is looking to bolster its defenses through the development of the Korean Air and Missile Defense "kill chain," integrating both offensive and defensive systems.

This growing appetite for AMD presents an opportunity for the United States to more effectively counter missile threats and relieve strain on its own missile defense forces. It also may help to facilitate a reprioritization of U.S. homeland missile defense, which is in need of modernization and for which funding has stagnated over the past eight years.[3]

Helping others

As the world's leader in air and missile defense, it falls to the United States to be an active facilitator in building partner capacity. Each region, and indeed each ally, has unique tactical and geostrategic situations and fiscal constraints. Missile defenses are expensive, and out of reach for many allies even if the strategic need and political will to acquire them is present. As such, the United States should look to craft more detailed, region by region plans to enhance allied AMD capabilities that include ways of making allied contribution more affordable. The

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> One nearly unexploited opportunity to help defray costs for both the United States and allies is the coordinated aquisition of interceptors and other hardware. Bulk buying reduces costs by taking advantage of the industrial efficiencies of larger production.

elements of such a strategy could be laid out as part of the forthcoming Missile Defeat Review mandated by the FY 2017 National Defense Authorization Act, which requires an articulation of ways to increase allied cooperation on missile defense and defeat.[4]

Over the past two decades, the United States has pursued internationalization of the missile defense mission primarily through foreign military sales, direct foreign assistance, deployments of U.S. missile defense assets to allied soil, and greater integration and interoperability. NATO has made good progress, for example, integrating various sea-based sensors into the Alliance's Active Layered Theatre Ballistic Missile Defence (ALTBMD) system. Political and export control issues have slowed the integration of Gulf Cooperation Council's sensor elements, but efforts in this area are still ongoing. These activities should continue, to the extent that technological, fiscal, and legal constraints allow.

There are however, other approaches that have been undertaken to a lesser degree, but which could help to increase burden sharing of the missile defense mission at relatively less cost to the United States, and which could help make allied AMD contributions more affordable. These include cooperative development, coordinated multinational acquisition, system sharing agreements, and an emphasis on lower-tier defenses in U.S. partnership capacity building efforts.

Cooperative development

One powerful way to capitalize on allied interest in missile defense is to embark on the cooperative development of new systems, or joint enhancements to existing systems. This approach helps defray U.S. and partner costs for system development. Moreover, the co-production component of such agreements also makes allied purchases more appealing, as its own industries stand to benefit.
A prime example has been development the Standard Missile-3 Block IIA, the latest installment of the family of Aegis interceptors. Japan and the United States embarked on the joint program in 2006, and the SM-3 IIA achieved its first successful test-intercept this February.[5] The interceptor is now on track for deployment at the Aegis Ashore site in Redzikowo, Poland in 2018, and ultimately on U.S., Japanese, and potentially other ballistic missile defense ships as well.

Another example has been the several cooperative programs launched to date with Israel—an effort that the United States has supported financially since at least 1990.[6] These efforts have helped to produce Israel's Arrow II, Arrow III, David's Sling, and Iron Dome systems. Although the United States does not appear to have any plans to deploy these systems, certain components, such as David Sling's Stunner interceptor, could make a lower-cost supplement to U.S. Patriot loadouts. The U.S. Army has also tested the compatibility of Iron Dome's Tamir interceptors in its Multi-Mission Launcher currently in development.[7]

There are challenges to pursuing cooperative development approach that must be considered, particularly in the concept development and requirement phase. Even well-integrated allied militaries have differing requirements, and consensus may not always be found. The less flexible nature of multilateral programs, moreover, can result in undesirable outcomes, even when requirements are agreed to initially. For example, the Medium Extended Area Defense Systems (MEADS) program led by Germany, Italy, and the United States was managed under NATO procedures and policies, which contributed

> To help these allies better defend themselves and contribute more to the alliance in the air and missle defense space, it may be worth looking at new kinds of sharing agreements, whereby surplus systems being phased out of existing arsenals are lent, sold or rented to allies.

to bureaucratic inefficiencies, delays, and cost overruns. The United States ultimately withdrew from the program in 2011, opting to prioritize Patriot modernization over acquiring a new lower-tier system.[8] Germany, however, remains on track to acquire MEADS.[9]

Nevertheless, the opportunities for future cooperative development are numerous. The UAE, for example, has reportedly expressed interest in co-financing the development of an extended-range interceptor for the Terminal High-Altitude Area Defense (THAAD) system.[10] The UAE has acquired two THAAD batteries, and is currently the only non-U.S. THAAD user. Current estimates suggest that an extended range THAAD interceptor, or THAAD-ER, could have 9-12 times the defended area of the current system.[11]

Cruise missile defense is another area where a joint development program might make sense. Both Japan and NATO face significant cruise missile threats, as does the U.S. homeland and forward deployed U.S. forces. With the cancellation of the Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS) program in 2016, a vacuum exists for another system that can provide long-range detection, tracking and targeting of cruise missiles.

Building a wider network of international partners for missile defense development may furthermore be a wise investment for the future, when the U.S. ability to pursue next-generation systems may be more dependent on international buy-in. As one analyst recently noted, "The ability [for the United States] to go it alone on complex weapon systems probably has its timeframe, and that timeframe may not be as long as most people think."[12]

Coordinated multinational acquisition

One nearly unexploited opportunity to help defray costs for both the United States and allies is the coordinated acquisition of interceptors and other hardware. Bulk buying reduces costs by taking advantage of the industrial efficiencies of larger production.

Should the United States purposefully coordinate multilateral acquisitions with allies, savings could be significant, allowing for deeper U.S. and allied interceptor inventories. It may also encourage the acquisition of systems by a wider swath of countries, particularly if such acquisitions were coordinated with and tailored toward specific regional alliance structures, such as the Gulf Cooperation Council or NATO.

Sharing agreements

Not all U.S. allies have the fiscal means to acquire top-of-the-line AMD systems, even if their strategic situation warrants them. This is particularly true of the Baltic States, who face significant threats from Russia. Even if a smaller country such as Lithuania were to double its annual defense spending, for example, this would amount to only around $1.5 billion.

> Enabling partner capacity in the lower-tier could help address the volume issues that have stretched the U.S. air and missile defense forces so thin.

To help these allies better defend themselves and contribute more to the alliance in the AMD space, it may be worth looking at new kinds of sharing agreements, whereby surplus systems being phased out of existing arsenals are lent, sold or rented to allies. This practice is widespread in other defense areas. Romania, for example, recently acquired F-16s from Portugal. Some examples also exist in the AMD world, such as Germany's sale of its older Patriot systems to Spain.

Older members of the Standard Missile family may also have chances for a second life in other militaries that could put them to good use. Denmark, for example, has three state-of-the-art Iver Huitfeldt-class air defense frigates, equipped with SMART-L radars that contribute to the ALTBMD. Yet, due to competing priorities within the Danish defense budget, the Vertical Launching System (VLS) tubes on these three ships are empty. These VLS tubes are identical to those on U.S. Aegis BMD ships. As the U.S. Navy phases out its SM-2 Block IV air defense missiles, it could be worth considering transferring some of these interceptors to Denmark or others to help fill this unused capacity.

Emphasize lower-tier defense

Missile defense is usually considered in terms of intercepting long-range ballistic missiles with expensive exoatmospheric interceptors in space. Yet the majority of air and missile threats are lower-tier and endoatmospheric, such as cruise missiles, short-range or depressed-trajectory ballistic threats, attack aircraft, and unmanned aerial vehicles. This lower-tier threat is particularly pronounced in Eastern Europe. Lithuania, for example, recently signed an agreement with Norway to acquire two batteries of the Norwegian Advanced Surface-to-Air Missile System (NASAMS).[13]

Enabling partner capacity in the lower-tier could help address the volume issues that have stretched U.S. AMD forces so thin. Should allied and partner capabilities in this area increase, future U.S. basing agreements could include the provision of lower-tier air defense for these forces, be they conventional units, or of higher tier missile defense systems, such as the Aegis Ashore sites in Romania and Poland. This is not to say that the United States should seek to alter the terms of past agreements, but such arrangements could be considered in the future as a way of relieving strain on U.S. AMD forces. Such agreements could furthermore include assistance in building a host nation's AMD capacity where needed, such as through foreign military financing or more imaginative sharing or leasing arrangements.

Thinking creatively

These approaches are neither new nor revolutionary. Nevertheless, they could offer some alternatives to help overcome the cost barriers that can often preclude allied contribution to the AMD mission, and carry with them benefits to U.S. security as well. In any case, finding creative solutions to make AMD more accessible to allies while reducing burden on the United States should be a part of any reformulation of U.S. missile defense policy. ■

Endnotes

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Reexamining the Strategic Defense Initiative

Henry F. Cooper, Malcolm R. O'Neill, Robert L. Pfaltzgraff, Jr., and Rowland H. Worrel

Growing terrorist attacks, deteriorating U.S. military capabilities, and the consequences of an American withdrawal from its global leadership role will confront the Trump administration with an increasingly dangerous and complex national security environment. To date, the United States has focused on the development of limited missile defenses to counter smaller nuclear states such as North Korea and potentially Iran, and chosen not to defend against the larger nuclear forces of China or Russia. But forgoing protective measures against large scale and smaller scale attacks is a major risk in today's rapidly changing strategic landscape.

Today, the strategic choice in favor of limited defense embraced by multiple U.S. administrations makes little sense, given the challenges the United States faces from Russia and China and the fact that advanced technologies/weapons being developed and deployed by those two nations will become increasingly available to others, even to terrorist actors. Both nations are also developing hypersonic glide vehicles, maneuverable warheads, and more sophisticated decoys that could defeat current U.S. ground- and sea-based interceptors. Moreover, Russia and China are sources for enabling rogue states/terrorists to develop asymmetric strategies and capabilities to conduct cyber and EMP attacks on a variety of critical U.S. civilian, commercial, and military targets.

The Trump administration has a vital opportunity to remedy these glaring security challenges with advancements to U.S. missile defenses. Specifically, the Administration should reexamine several aspects of President Ronald Reagan's Strategic Defense Initiative (SDI) and focus on revitalizing and deploying the portions of the program that involved the use of space-based interceptor (SBI) defense systems. With monumental advances in space technology – including on-orbit sustainment, reusable rockets, and cheaper launch and computing costs – space-based missile defense programs now represent a more cost-effective and potentially more successful missile defense program than any that the U.S. has fielded to date. A space-based missile defense system, when integrated with the current U.S. arsenal of BMD systems, has the potential both to reduce operating costs and to increase the rate of success and efficiency of our overall defense against ballistic missile attack.

Space-based missile defense, revisited

Admiral William Gortney, the former Commander of U.S. Northern Command, has observed that, in order to counter offensive nuclear ballistic missile threats, the United States needs to destroy ballistic missiles in their boost phase (shortly after launch), and not rely solely on midcourse- and terminal-phase interception, the current focus of U.S. ballistic missile defense (BMD) systems. Such boost-phase missile defense is most effectively provided from space, something that was judged feasible back in 1990, based on then maturing technology, and which served as the focus of President Ronald Reagan's Strategic Defense Initiative.

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> The strategic choice in favor of limited defense embraced by multiple U.S. administrations makes little sense, given the challenges the United States faces from Russia and China and the fact that advanced technologies/weapons being developed and deployed by those two nations will become increasingly available to others.

The most advanced SDI concept, Brilliant Pebbles, consisted of a constellation of small interceptors that combined their own early warning and tracking capability with high maneuverability to engage attacking ballistic missiles in all phases of their flight trajectory, thereby providing multiple opportunities for interception. The then-cutting edge technology enabled lightweight onboard computers with sufficient capability to fully manage the entire constellation of thousands of lightweight "Pebbles," each autonomous and networked with near- and far-neighboring sensors, to provide a comprehensive overall defensive system that could be managed by a relatively small operations cadre.

Each interceptor, or "Pebble," was designed to identify the nature of the attack, which might include thousands of ballistic missile warheads, based on a defense that included thousands of "Brilliant Pebbles." And since it knew its own location and that of all other Pebbles, each "Pebble" could calculate an optimum attack strategy from its own perspective and execute an interception, while simultaneously informing other units of its action. The basic idea was to exploit the then-cutting-edge computational power of small handheld computers (and miniaturized sensors)—now several generations more mature—to enable a large constellation of small, low-earth-orbit satellites to perform the primary elements of battle management and maneuver into the path of ballistic missiles/warheads, beginning in the missile's boost phase and continuing throughout its midcourse trajectory in space until some time after it began to reenter the Earth's atmosphere in the terminal phase of flight.

Internally, the rejection of the Strategic Defense Initiative in 1993 for political reasons, and the corresponding emphasis on minimalist, or "limited," missile defense that has evolved since, has placed the U.S. in a precarious position regarding its national security. Current BMD systems, such as Aegis and THAAD, were designed to defend against a small-scale attack from a state such as North Korea or Iran. They are thus largely incapable of handling a potential large-scale attack (or one utilizing hypersonic weapons) from a state such as Russia or China, or an attack from an advanced cruise missile by a hostile non-state actor. Additionally, due to the current reliance on a limited missile defense system and the lack of development of significant space-based BMD assets, the U.S. lacks robust early-warning coverage in its southern hemisphere, and is reliant on inadequately-tested and largely unreliable systems to provide multi-faceted BMD protection. With modern technology and adequate funding, a 21st century Brilliant Pebbles program could present the most comprehensive, integrated, and cost-effective multi-layered BMD system out of all in use by the United States.

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The benefits of space-based defense

As envisioned, the autonomy of Brilliant Pebbles in detecting launch and dispatching interceptors would have complicated the use of countermeasures against them. And because of their number, these defenses would have multiple opportunities for interception, thus increasing their chances of a successful intercept in the boost and midcourse phases, or even high in the Earth's atmosphere during the terminal phase. Such characteristics stand in contrast to the current generation of interceptors in use by the United States, which are hard pressed to provide more than one independent intercept opportunity because they lack redundancy and depend on proper positioning to carry out interception.

Although the Brilliant Pebbles program was terminated in early 1993, major advances in the commercial, civil, and other defense sectors since then should now permit even lighter mass, lower cost, and higher performance technologies, components, and systems than would have been achieved by the 1990-era technology base. Thus, lighter weight and smarter components building on twenty-first-century robotic technologies could now empower SBIs with greater acceleration/velocity, enabling boost-phase intercept of even short- and medium-range ballistic missiles, as well as high-acceleration ICBMs, thus surpassing the capabilities of the 1990 Brilliant Pebbles. For example, boost-phase interception will be essential to countering the hypersonic missiles of the next decade in their boost phase, before they reach maximum speed and maneuverability.[1]

In addition, the capabilities of a twenty-first century space-based interceptor system would support other vital national security missions and enhance the survivability of critical space assets, on which all U.S. military operations depend. Such additional missions include early-warning, space domain awareness, anti-satellite (ASAT) detection and interdiction, detecting nuclear-test detonations, tactical intelligence, monitoring treaty compliance, and tracking the activities of potential proliferators.

Cost considerations

In the budget-constrained environment facing the Trump administration, Brilliant Pebbles has an additional advantage that addresses the offense/defense cost-effectiveness problem. With the progress made in the past 25 years—including miniaturization, reduced computing, sensor, and launch costs, etc.—the price tag for a new Brilliant Pebbles program should be even lower than estimates of the originally conceived system, while providing substantially greater intercept capabilities and cost effective adjuncts to the overall missile defense system now operating around the world.

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A price tag of $20 billion or less for an updated Brilliant Pebbles effort represents an extremely low and manageable cost given its vitally important mission to protect the U.S. homeland. The costs for space launch and on-orbit sustainment and operations have decreased in the last decade. Additional cost savings should also materialize as we develop robotic on-orbit autonomous servicing of satellites.[2] Moreover, advances in miniaturization will allow more components to be packed into smaller packages and thus increase capabilities while simultaneously lowering launch costs. The availability and use of low cost, commercial off-the-shelf products and components will further reduce costs.

A new space based interceptor program should adopt a framework that includes leveraging technologies, products, and innovative manufacturing and management processes spearheaded in the commercial sector—as was pioneered with Brilliant Pebbles in the SDI era. Key programs also should restore active development of directed energy BMD systems. Competition in the commercial sector to provide reusable rocket boosters and engines, commercial off-the-shelf products and components such as computers, software, sensors, lightweight materials, etc., should be employed. It is equally important to utilize low-cost fabrication techniques and streamlined, best-practices management. Such a framework would restrain cost growth and reduce the time necessary to develop and deploy the Brilliant Pebble constellation.

"Space-based interceptors have the potential to provide the greatest leverage against ballistic missiles of all ranges in a world of proliferating capabilities. In particular, SBIs hold out the prospect of interdiction in the boost phase of a ballistic missile's flight, when the missile is most vulnerable and has not yet released its warheads and decoys.

The logic of space

Today, space-based interceptors have the potential to provide the greatest leverage against ballistic missiles of all ranges in a world of proliferating capabilities. In particular, SBIs hold out the prospect of interdiction in the boost phase of a ballistic missile's flight, when the missile is most vulnerable and has not yet released its warheads and decoys. A boost-phase interception capability will greatly shift the cost exchange balance in favor of the defender, creating disincentives for attackers to invest in such technologies in the first place. A truly robust missile defense system, incorporating these capabilities, would give the United States the power to defend against a missile strike and provide it with strategic options other than resorting to a devastating nuclear attack in response. Finally, a Brilliant Pebbles-type system has the ability to support other crucial national security missions, resulting in operational efficiencies and cost savings.

For all of these reasons, the Trump administration should focus on revitalizing the concept of space-based missile defense to regain America's military advantage and advance U.S. national security. ■

**NOTE: This article is adapted from the comprehensive white paper on missile defense produced by the Independent Working Group titled "Missile Defense: Challenges and Opportunities for the Trump Administration." The full report can be accessed at http://www.ifpa.org/pdf/IWGWhitePaper16.pdf*

Endnotes

[1] Swarm robotic technologies could support a twenty-first century Brilliant Pebbles. There are numerous similar characteristics, including low-cost systems that could be deployed in large quantities, in this case, to overwhelm offensive systems, namely ballistic missiles, by their sheer numbers. As in today's robotic swarming, Brilliant Pebbles operated as networked, cooperative systems.

[2] For example, the Pentagon's Defense Advanced Research Project Agency (DARPA) is developing a capability for autonomous, on-orbit servicing/maintenance and repair of satellites reaching up to geosynchronous orbit. See http://www.darpa.mil/news-events/2016-03-25.

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