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In 2016 and 2017, North Korea demonstrated a range of technologies that brought it much closer to deploying an intercontinental ballistic missile (ICBM). After the November 2017 test of the *Hwasong-15* missile, Kim Jong Un declared that North Korea has “finally realized the great historic cause of completing the state nuclear force” and is now immune to American nuclear blackmail and coercion.¹ Kim Jong Un’s desire to obtain “strategic equivalence” with the United States has also been driven by his belief that “nuclear weapons will ultimately erode the credibility and durability of the US-ROK alliance,” providing him with the means to resolve the Korean impasse to his advantage.²

Several questions about North Korea’s strategic intentions and capabilities remain unanswered: how advanced and indigenous is its strategic program? What drives its commitment to multiple strategic systems? What does North Korea believe is necessary for its strategic doctrine, and is there a cost-benefit tipping point to its pursuit of an intercontinental-range nuclear arsenal? It is difficult to answer these questions, given North Korea’s proclivity to extreme secrecy about its capabilities and intentions.³ These ambiguities in North Korean strategic intentions, combined with technological advances, have imbued urgency to the US homeland missile defense mission. Recognizing the threat presented by

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North Korean advances, the 2019 Missile Defense Review (MDR) argues that the United States needs to swiftly develop and deploy homeland missile defenses.⁴

An effective defense against North Korean ICBMs is a legitimate and worthy policy goal, and the stakes involved in a nuclear attack are high enough to justify large investments and reasonable risks. Most would agree that the United States should have an effective defense against North Korean ICBMs without compromising strategic stability with Russia and China. But a rush to deployment would be misguided.

The existing homeland missile defense—the ground-based mid-course defense (GMD)—has many weaknesses. The GMD system is susceptible to simple countermeasures. It has not demonstrated high reliability in flight tests, and it has not been tested in realistic operational environments. The Missile Defense Agency (MDA) has adopted a plan to address these issues, but it needs time to implement these steps. Program managers in the DoD and external experts should be involved in evaluating whether a truly effective GMD missile defense system that stays ahead of the North Korean threat can be developed and deployed. A rushed deployment disrupts such efforts. The sensible course of action is to subject the GMD system to normal standards of testing while exploring additional options, such as the airborne boost-phase intercept (ABI) concept discussed below.

The North Korean Missile Threat to the American Homeland

There is considerable debate about North Korean ICBM capabilities. Analysts disagree on how Pyongyang managed to make dramatic gains in 2017 in its missile program with a much lower failure rate than in previous years. Some suggest North Korea has now developed its own technological and manufacturing base for missile design and production.⁵ From this perspective, North Korea's ballistic missile capabilities are irreversible because it can reinstate the program at any time, even if temporarily paused. Others disagree, suggesting that recent successes reflect Russian technology and borrowed expertise. To those suggesting Russian assistance, demonstrated North Korean advances seem limited.⁶

There is also considerable debate over the extent of the threat to the US homeland from a North Korean ICBM, given that North Korea has yet to complete some critical systems integration and operational testing steps. North Korea has not launched ICBMs on a normal (i.e., not-lofted) trajectory, which would provide data necessary for successful reentry. Finally, there is a lack of evidence that North Korea has flight-tested its missiles with a realistic reentry vehicle.⁷

These issues raise doubts concerning North Korea's strategic threat. However, a broad spectrum of policymakers and analysts agree that reality is catching up to Kim's rhetoric.⁸ In 2016 and 2017, North Korea conducted three nuclear tests

—the last of which had a yield ten times greater than previous tests—and test-launched two ICBMs: the *Hwasong-14* and *Hwasong-15*. Both missiles are capable of reaching North America, and the *Hwasong-15* can target the lower 48 states of the United States. North Korea also flight-tested the *Hwasong-12* intermediate-range ballistic missile (IRBM) with the ability to reach Guam. Additionally, North Korea has demonstrated the ability to launch solid-propellant medium-range ballistic missiles. Solid-propellant missiles can be prepared and launched very quickly, complicating US ability to destroy missiles before launch.⁹ Lastly, there is some arguable evidence that North Korea has miniaturized a nuclear warhead and could use it as a payload on a *Nodong* missile.¹⁰

Noting these advances, the 2019 MDR states that for over a decade, North Korea has spent a lot of resources to obtain a “capability to threaten the U.S. homeland” and will soon be able to credibly do so with a nuclear-armed ICBM. The MDR advocates the need for a reliable homeland missile defense, with an emphasis on the GMD system in which the United States has invested almost all of its national missile defense budget since the early 2000s.

North Korea will soon be able to credibly threaten the US homeland with nuclear-armed ICBMs

The Current Architecture: Ground-Based Mid-Course Defense

The primary defense of the US homeland against North Korean ICBMs is the GMD system. It consists of a global network of sensors, command and control centers, and interceptors. The network of terrestrial and space-based sensors can detect and track missile launches from any location in the world. The command and control centers located in Ft. Greely, Alaska and Colorado Springs, Colorado monitor for missile launches 24/7, and, if a threat to the continental United States is determined, launch the ground-based interceptors (GBIs) to intercept threat missile warheads in their mid-course of flight.¹¹ Currently, 40 GBIs are deployed at Ft. Greely and four more are deployed at Vandenberg Air Force Base in California. A new GBI field is being constructed at Ft. Greely and was expected to raise the number of GBIs to 64 by 2023.¹² However, the October 2019 termination of the Redesigned Kill Vehicle (RKV) program may delay the fielding of these additional interceptors.¹³

Is the GMD System Reliable?

The ability of the GMD system to perform under realistic conditions is often questioned. First, critics have noted that countermeasures against GMD are simple and

Countermeasures against GMD are simple

do not require much money or skill when compared with the effort needed to develop ICBMs.¹⁴ In a 2010 study requested by the US Congress and directed to the MDA, the JASON scientific advisory group evaluated the challenges posed by countermeasures to the GMD system. The report concluded that countermeasure discrimination by GMD radars and other sensors remains a “stringent challenge because, given a reasonable amount of time, money, initiative, and expertise, the offense can (in principle) field countermeasures that the defense cannot handle at any reasonable marginal cost.”¹⁵ The JASON report also criticized the lack of an independent organization

that can “authoritatively review, test, and challenge” the MDA’s ability to develop relatively effective responses to mid-course countermeasures.¹⁶

Second, the limited test conditions and several test failures of the GMD system raise concerns about its ability to perform its mission when called upon to do so. As of 2019, the system has had 11 test successes and 8 test failures.¹⁷ In some instances, the flight test failures have been persistent. For instance, GMD suffered three consecutive failures from 2010 to 2014, all of which were linked to the “poor reliability of the existing GMD kill vehicles—the parts of the interceptor designed to impact and destroy the target warheads.”¹⁸

The MDA initiated the Redesigned Kill Vehicle (RKV) program to improve the GMD system’s reliability, but the RKV program has also faltered. In June 2019, Michael Griffin, Undersecretary of Defense for Research and Engineering (USD[R&E]), issued a rare “stop work order” on the RKV program. A DoD spokesperson stated that Griffin had “determined that the current plan is not viable and has initiated an analysis of alternative course of action.”¹⁹ The DoD has now terminated the RKV program due to serious technical design problems.²⁰ The MDA has now disclosed its intention to develop a new Next-Generation Interceptor (NGI), with an initial request of approximately US\$664 million in FY21.²¹ However, the NGI may not be fielded until 2030, further cementing delays in the GMD program.²²

The vulnerability of the GMD system to countermeasures and its suboptimal test record are a result of a “got to have it as soon as possible” approach to homeland missile defenses in its formative years.²³ When the homeland missile defense architecture was designed during the Bill Clinton and George W. Bush administrations, a choice was made to deploy them as quickly as possible to preempt any threats that could arise, particularly after 9/11.²⁴ As a result, missile defenses were deployed without adequate testing under realistic conditions or a detailed analysis of alternatives.²⁵

In recent years, the MDA has striven to correct these deficiencies. In his 2019 congressional testimony, the DoD Director of the Office of Operational Test and Evaluation noted that the MDA is planning to perform “more robust ground tests of all missile components, sections, and all-up rounds using the same configuration as flown in flight tests (i.e., ‘test as you fly’)” before actual flight tests in order to discover problems and estimate missile reliability.²⁶

The MDA also made improvements to its flight-testing program. On March 25, 2019, it launched a salvo of two interceptors against an advanced ICBM-class target with countermeasures in its “most operationally realistic flight test” yet.²⁷ This latest test represents a step toward realistically evaluating the performance of the GMD system. But it will require several years for many of these corrective actions to take root and for the effectiveness of the GMD system to be accurately assessed.²⁸ Until then, the ability of the GMD system to provide an effective defense remains dubious.

Effect of GMD System on US Foreign Relations

While defensive benefits of the GMD system are suspect, it continues to impose a substantial stress on US-Russia and US-China relations. The GMD system, combined with other US missile defense deployments, such as the Navy’s Standard Missile-3 (SM-3) interceptors deployed in ships and in ashore sites, has provoked a strong response from Russia and China. Both nations fear American missile defense systems may eventually be able to challenge their nuclear deterrent.

In a 2018 speech, Russian President Vladimir Putin argued that the United States “is creating a global missile defence system” with an “uncontrolled growth of the number of anti-ballistic missiles, improving their quality, and creating new missile launching areas.”²⁹ He claimed that US defensive systems are capable of countering the “backbone” of Russian nuclear deterrent forces and will eventually cause the “complete devaluation of Russia’s nuclear potential.”³⁰

In the same speech, President Putin announced the development of several new systems designed to defeat American national missile defense.³¹ He showcased the *Sarmat* heavy ICBM with a short boost-phase and equipped with hypersonic warheads to defeat American missile defenses. He also discussed other hypersonic delivery systems—including the *Avangard* hypersonic boost-glide vehicle, the *Kinzhal* air-launched hypersonic missile, and the *Tsirkon* hypersonic cruise missile—which are designed to evade anti-missile defense systems.³² Russia is also developing a nuclear-power intercontinental-range torpedo and cruise missile. President Putin justified all these newer nuclear weapon delivery systems as a response to the “unilateral withdrawal of the United States from the Anti-Ballistic Missile Treaty” and the continuing deployment of missile defenses “both in the US and beyond their national borders.”³³

Similar to Russia, China remains deeply suspicious of American missile defenses. *The Science of Military Strategy*, published by the Chinese Academy of

Military Science in 2013, declares that “the United States sees China as its primary strategic adversary and is stepping up the building of a missile defense system for the East Asia region” to contain and dilute China’s nuclear deterrent capabilities.³⁴ Chinese analysts claim that US missile defenses undercut the bilateral strategic nuclear balance and provide the United States with the potential to execute a first strike in a crisis.³⁵ In response, China is also developing and deploying newer nuclear delivery systems to mitigate the perceived effects of missile defense.³⁶ A recent *Global Times* article describing China’s hypersonic flight vehicle claims that “it can carry nuclear warheads and break through any current generation anti-missile system.”³⁷

These new Russian and Chinese nuclear weapons will, in turn, prompt a host of responses by the United States, weakening strategic stability and arms control efforts. The offensive buildups in Russia and China, which appear to be largely a response to US ballistic missile defense (BMD) efforts, are now triggering concerns in the United States. The 2018 US Nuclear Posture Review states that “while the United States has continued to reduce the number and salience of nuclear weapons, others, including Russia and China, have moved in the opposite direction.”³⁸ These concerns are weakening support for New START, a critical agreement providing transparency to the United States and Russia about each other’s nuclear arsenals.

An Alternative: Airborne Boost-Phase Missile Defense

ABI missile defenses would be designed to destroy enemy missiles during the boost phase, preventing the missile from reaching its intended target in the United

Airborne boost-phase intercepts are effective only against geographically small states such as North Korea

States. An ABI capability could offer a way to mitigate the strategic stability challenges posed by the pursuit of the GMD and the Aegis missile defense systems while also delivering a more effective defense against North Korea at comparable or lower cost. North Korea’s *Hwasong-14* and *Hwasong-15* are both liquid-fueled ICBMs with a boost-phase of approximately five minutes (or 300 seconds).³⁹

Benefits of ABI Capabilities

A significant virtue of ABI missile defense is its inherent limitation: they are effective only against geographically small states such as North Korea, where missile launches cannot be far from the coast, thus allowing defense from platforms over the ocean. But such a system would have no capability against missiles launched

from deep within Russia or China. It is not possible to repurpose an ABI system against Russia or China because both have the geographical depth to place missile launch sites far out of range of airborne missile defense platforms operating outside their national territory.⁴⁰ Therefore, a limited ABI system might help to reassure Russia and China.

ABI missile defense capabilities also provide a prudent hedge to the many performance risks in GMD systems, as discussed above. Boost-phase intercept occurs *before* an adversary can deploy warheads and decoys or other countermeasures and therefore avoids many of the discrimination challenges faced by mid-course missile defenses. Additionally, it offers a larger defensive footprint and may provide a way to execute a more efficient shoot-assess-shoot approach (i.e., waiting until the first interceptor either succeeds or fails before committing a second interceptor) in a multilayer defense.⁴¹

ABI systems also offer the ability to cheaply and quickly test a capability before deployment. Flight testing of the GMD system is extremely costly and entails several safety considerations. The latest GMD test, conducted in March 2019, for example, cost more than US\$300 million,⁴² and several rigorous tests in which the test environment mirrors a true threat profile may have to be conducted before the GMD system can claim reasonable effectiveness against North Korean ICBMs. These necessary tests are limited by this cost as well as by “the availability of test assets, a limited test infrastructure, the lack of lethality testing against newer threat designs, long target development timelines, range safety complexity, and high costs,” leaving ground testing and modeling and simulation (M&S) as the only viable means to increase confidence in the GMD system.⁴³

By contrast, ABI missile defenses could be tested more frequently, easily, and cheaply to “generate a high degree of confidence.”⁴⁴ Extrapolating from empirical data on smaller tactical missiles, Mike Corbett and Paul Zarchan, experts with long-standing involvement in US missile defense projects, speculate that a 500 kg ABI would cost almost 20 times less than the GMD interceptor.⁴⁵ They note that the Network Centric Airborne Defense Equipment (NCADE) ABI experiment cost about US\$25 million and required only three years to develop and test.⁴⁶ Testing boost-phase interceptors does not require the use of long-range radars and other costly testing infrastructure associated with the GMD system. Given the lower cost of interceptors, reduced testing infrastructure needs, and the possibility of faster flight testing, ABI missile defense systems are a very attractive option.

Finally, over the long-term, ABI systems seem to be cost competitive to operate and support (O&S). The O&S cost for a five-year service life of an airborne aircraft-based boost-phase system might be between US\$30 million and US\$240 million.⁴⁷ Richard Garwin and Ted Postol, distinguished scientists on national security matters, estimate that the O&S cost for a five-year service life of an

airborne drone-based system to be around US\$260 million.⁴⁸ By comparison, a 2012 National Academies Study estimated five-year service life O&S costs of US\$290 million for the GMD system.⁴⁹ These estimates indicate that ABI missile defenses are cost-competitive and may even prove to be the most economical missile defense system under certain military Concept of Operations (CONOPS). If research, development, and production costs were included, an airborne drone-based defense might be highly attractive.

Making ABI a Reality

Since the early 1990s, the United States has been accumulating expertise and capabilities in platforms and interceptors with the potential to perform ABI.⁵⁰

Since the early 1990s, the US has been accumulating expertise and capabilities to potentially perform ABI

The F-35 fighter plane is seen as a viable candidate platform that could be adapted to boost-phase missile defense. The 2019 Missile Defense Review (MDR) notes that the “F-35 Lightning II has a capable sensor system that can detect the infrared signature of a boosting missile, and its computers can identify the threatening missile’s location.”⁵¹ The MDR further suggests that “in the future, [F-35s] can be equipped with a new or modified interceptor capable of shooting down adversary ballistic missiles in their boost phase and could be

surged rapidly to hotspots to strengthen US active defense capabilities and attack operations.”⁵²

The F-35 is packed with an array of electro-optical and infrared sensors, including the Distributed Aperture System (DAS) that provides sensor coverage in every direction around the aircraft. The ability of the DAS to aid in the interception of boosting ballistic missiles has been tested and confirmed in many experiments. In three experiments conducted in 2010, 2014, and 2016, the F-35 DAS sensors detected and tracked various target missiles and were able to effectively communicate the tracked data over secure military networks.⁵³ In the 2016 experiment, the tracked data was passed to the Aegis missile defense system, which then “shot the threat down.”⁵⁴ These experiments demonstrate the potential for F-35s to act as sensor platforms in a boost-phase intercept missions.

In addition to the F-35s, the MQ-9 *Reaper* Unmanned Aerial Vehicle (UAV) has been employed in ballistic-missile tracking. In 2016, two MQ-9 *Reaper* UAVs equipped with the Multi-Spectral Targeting System-C electro-optical/infrared turret demonstrated that the system is capable of tracking missiles.⁵⁵ Lt. Gen. Samuel Greaves, Director of the MDA, recently testified that the agency was

outfitting MQ-9 with passive sensors and tracking laser to understand boost-phase tracking capabilities and ways to increase tracking precision and range.⁵⁶

The MQ-9 *Reaper* UAV has unique advantages. The C-type sensor package in the MQ-9 incorporates a long-wave IR sensor that might provide a “cold body” detection capability in the future and enable tracking beyond the boost phase.⁵⁷ If tracking can continue after the boost phase, the defensive capabilities do not stop after burnout because it takes an adversary time to separate the warhead and dispense countermeasures.⁵⁸ A Defense Science Board study, relying on classified intelligence information on a variety of US and foreign ballistic missiles, including both test articles and operational missiles, noted that countermeasure dispense times might be as much as “100 seconds post-boost”⁵⁹ An increase in time available for intercept by 100 seconds could substantially increase the feasibility of boost- and ascent-phase intercept.

The MQ-9 *Reaper* could also potentially act as the launch vehicle for the boost-phase interceptors. Garwin and Postol have examined the ability of MQ-9 to loiter outside North Korean airspace and engage ICBMs in the boost-phase.⁶⁰ Compared to the F-35, the unmanned MQ-9 has the advantage of longer endurance, lower operational costs, and no risk to a pilot.

Over the years, the DoD and the MDA have also supported the development of two interceptors capable of performing ABI. Raytheon developed the NCADE program, an ABI that shared many technological commonalities with the AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM).⁶¹ In December 2007, Raytheon demonstrated a proof-of-concept for boost-phase intercept by using its NCADE interceptor to hit a boost-phase target.⁶² In 2009, Raytheon expressed readiness to produce the NCADE interceptors within four years at the cost of US\$1 million apiece.⁶³

Similarly, Lockheed Martin developed an Air-Launched Hit-to-Kill (ALHK) boost-phase ballistic missile interceptor in the early 2000s. The interceptor was a derivative of the Patriot Advanced Capability 3 (PAC-3) interceptor currently in use by US and allied forces. The ALHK interceptor was equipped with an active radar seeker similar to the AMRAAM's, but it is a larger missile and faster than NCADE. While the ALHK interceptor was never put to field test, the PAC-3 is an established missile and arguably has a well-documented performance record.⁶⁴

With all these established subsystems, the DoD should be able to develop, test, and validate a Concept of Operations for boost-phase intercept.⁶⁵ In 2018, MDA Director Lt. Gen. Samuel Greaves said, “I’d say six to seven years to essentially work out the Concept of Operations and develop the capabilities—whether it’s sensor-based or a new fast missile that’s hung on the bottom of an F-35 for the BMDS mission—integrate those capabilities, test them, and deliver them into a theater of operations.”⁶⁶ Similarly, Mike Griffin, the current undersecretary of

defense for research and engineering, has indicated that it is “possible and cost-effective” to deploy boost-phase air-to-air interceptors against North Korea, though a new design may be needed.⁶⁷

There is some evidence that the United States is moving cautiously and investing in the boost-phase intercept concept. General David Goldfein, the current Air Force Chief of Staff, has directed the launch of a “rapid prototyping project” of the Extended Range Weapon (ERW_n) in 2019.⁶⁸ The ERW_n interceptor will be designed for launch from fighter aircraft and will be capable of engaging adversary ICBMs during boost-phase of flight.⁶⁹ The DoD should exhaustively investigate the capabilities of the ERW_n interceptor and other ABI missile defense programs discussed above. They may offer an efficient defense against North Korea, particularly in comparison to the performance deficiencies of the GMD program.

Improving US Catastrophe Insurance

An ABI defense may be more effective against North Korea than the current GMD system, far less vulnerable to countermeasures, and far less likely to stimulate buildups in Russian and Chinese strategic forces. If the United States shifts to a less threatening boost-phase missile defense system, Russia may be more willing to engage in strategic arms reductions with the United States. Similarly, China might agree to participate in such arms control processes in the future if it did not believe it needed to expand its nuclear-armed ICBM forces to counter the GMD system.⁷⁰

The deployment of an effective missile defense might make North Korea more likely to launch (or launch earlier) in a crisis in order to avoid preemption and increase the number of ICBMs that are launched in order to penetrate the BMD shield. Missile defenses might also increase the likelihood of an initial all-out salvo launch, rather than a limited strike that North Korea might hope would cause the United States to back down or would generate pressure from South Korea and Japan to end hostilities. This situation is sometimes called a “use ‘em or lose ‘em” dilemma for Pyongyang.

North Korean fears of nuclear decapitation should be more sensitive to US counterforce capabilities that require US and allied aircraft to penetrate deep into North Korean airspace than to defensive airborne BMD patrols on the periphery of its airspace. The United States already deploys BMD in the region and plans to deploy more; unless North Korea is highly confident that it can penetrate existing BMD systems (and it is hard to see why they would be highly confident), the deployment of an airborne system should not constitute a substantial and destabilizing change.

The US Congress should more strongly encourage the DoD to thoroughly investigate the advantages offered by an ABI defense system. A full-fledged experimental program is needed to determine if technological advances have made the concept of ABI missile defense viable. The United States should pursue homeland missile defense only if it can be effective without undermining strategic stability.

Policymakers should refrain from rushing the GMD system into deployment or claiming that the United States is secure, despite political pressure.⁷¹ The focus should instead lie on enabling the GMD system to adopt a rigorous science-driven approach to testing and deployment. To its credit, the MDA has made some changes in response to the countermeasure challenge. The JASON report notes that the MDA “discrimination paradigm changed radically,” following an external review of its approach to addressing adversary countermeasures. The report also states that “long-held assumptions were overthrown in favor of a more realistic view of the threat” and embraced the development of new technical programs “needed to discriminate effectively.”⁷²

These improvements and efforts will progress slowly, however. The GMD system should not be rushed and made to operate under artificial deadlines driven by the North Korean threat or other domestic political considerations. Neither should the GMD system be given unfair privileges. Homeland missile defense is catastrophe insurance that becomes relevant only if diplomacy and deterrence fail. In spite of the rhetoric that may emerge from North Korean leadership, diplomacy and deterrence will play a major role in a crisis. All decisions on deployment should be based on the capabilities of the proposed defense and its ability to bolster deterrence with North Korea, minimize complications with China and Russia, and effectively respond to the magnitude of the threat if deterrence should fail.

A full-fledged experimental program is needed to determine if ABI missile defense is viable

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