Missile Defense

Missile defense is a critical component of the U.S. national security architecture.[1] It can protect critical infrastructure, ranging from population and industrial centers to politically and historically important sites; strengthen U.S. diplomatic and deterrence efforts; and provide both time and options to senior decision-makers amid crises that involve missiles flying on ballistic and non-ballistic trajectories (e.g., hypersonic weapons).

Missiles remain a weapon of choice for many of America's adversaries because of such important attributes as their extraordinarily high speed (against which the U.S. has a limited ability to defend) and relative cost-effectiveness compared to other types of conventional attacks.[2] As the number of states that possess missiles continues to increase, so will the sophistication of these weapons as modern technologies become cheaper and more widely available. In April 2019, Under Secretary of Defense for Policy John Rood testified before the Senate Armed Services Subcommittee on Strategic Forces that:

> Potential adversaries are developing sophisticated ballistic and cruise missile systems with increased speed, range, accuracy, and lethality.
>
> Over the past decade, North Korea and Iran have accelerated efforts to develop and field missiles capable of threatening U.S. strategic interests. While North Korea has not tested a nuclear-capable missile in over a year, it possesses a range of systems including road-mobile intercontinental-range ballistic missiles, solid-propellant medium-range ballistic missiles, and submarine-launched ballistic missiles.
>
> Iran continues to improve its missile capabilities and develop space launch vehicles which provide knowledge to develop an intercontinental-range ballistic missile. Iran already possesses the largest stockpile of regional missiles in the Middle East. It is now enhancing their precision while developing cruise missiles and anti-ship ballistic missiles.
>
> We also see the re-emergence of long-term, strategic competition by revisionist powers in Russia and China. Russia and China are expanding and modernizing a wide range of offensive missile capabilities.[3]

An additional concern is ballistic missile cooperation between state and non-state actors. Such cooperation furthers the spread of sophisticated technologies and compounds challenges to U.S. defense planning.[4]

To deter an enemy from attacking, one must be able to convince him that his attack will fail, that the cost of carrying out a successful attack is prohibitively high, or that the consequences of an attack will be so painful that they will outweigh any perceived benefit. A U.S. missile defense system strengthens deterrence by offering a degree of protection to the American people, as well as the economic base on which their well-being depends, and making it harder for an adversary to threaten forward-deployed troops and allies with ballistic missiles.

In addition, a missile defense system gives a decision-maker a significant political advantage: By protecting key elements of U.S. well-being, it mitigates an adversary's ability to intimidate the United States into conceding important security, diplomatic, or economic interests. Missile defense systems also enable U.S. and allied conventional operations.

A missile defense system gives decision-makers more time to choose the most de-escalatory course of action from an array of options that can range from preemptively attacking an adversary to attacking his ballistic missiles on launch pads or even conceding to an enemy's demands or actions. Though engaging in a preemptive attack would likely be seen as an act of war by adversaries and could result in highly escalatory scenarios, the United States would do so if there was a substantiated concern that an adversary was about to attack the United States with a nuclear-armed missile. The United States would have an option to back down, thus handing a "win" to the enemy, but at the cost of losing credibility in its many alliance relationships.

Backing down could also undermine U.S. nonproliferation efforts. More than 30 allies around the world rely on U.S. nuclear security guarantees, and questioning the U.S. commitment to allied safety in the face of a ballistic missile threat would translate into questioning the U.S. commitment to allied nuclear safety in the most fundamental sense. Robust missile defense systems would affect the dynamics of decision-making, creating additional options and providing more time to sort through them and their implications to arrive at the option that best serves U.S. security interests. The effect could well be profoundly stabilizing.

Missile defense is an important enabler in nonproliferation efforts and alliance management. Many U.S. allies have the technological capability and expertise to produce their own nuclear weapons. They have not done so because of their belief in U.S. assurances to protect them. U.S. missile defense systems are seen as an integral part of America's visible commitment to its allies' security.

The U.S. missile defense system comprises three critical physical parts: sensors, interceptors, and command and control infrastructure that provides data from sensors to interceptors. Of these, interceptors receive much of the public's attention because of their very visible and kinetic nature. Different physical components of a ballistic missile defense system are designed with the phase of flight in which an intercept occurs in mind, although some of them—for example, the command and control infrastructure or radars—can support intercepts in various phases of a ballistic missile flight. Interceptors can shoot down an adversary's missile in the boost, ascent, midcourse, or terminal phase of its flight.

Another way to consider ballistic missile defense systems is by the range of an incoming ballistic missile (short-range, medium-range, intermediate-range, or long-range) that an interceptor is designed to shoot down. The length of the interceptor's flight time determines how much time is available to conduct an intercept and where the various components of a defense system must be placed to improve the probability of such an intercept. With long-range ballistic missiles, the United States has no more than 33 minutes to detect the missile, track it, provide the information to the missile defense system, come up with the most optimal firing solution, launch an interceptor, and shoot down an incoming missile, ideally with enough time to fire another interceptor if the first attempt fails. The time frame is shorter when it comes to medium-range and short-range ballistic missiles.

Finally, missile defense can be framed by the origin of interceptor launch. At present, U.S. interceptors are launched from the ground or from the sea. In the past, the United States explored concepts to launch interceptors from the air or from space, but limited efforts have been made on that front since the U.S. withdrawal from the Anti-Ballistic Missile Treaty in 2002.[5] There is renewed interest in boost-phase missile defense concepts within the Trump Administration, although the fiscal year (FY) 2020 budget submission for the Missile Defense Agency (MDA) allocates only about $34 million for boost-phase missile defense systems, which is certainly not enough to develop and deploy a boost-phase missile defense system anytime soon.

The current U.S. missile defense system is a result of investments made by successive U.S. Administrations. President Ronald Reagan's vision for the program was to have a layered ballistic missile defense system that would render nuclear weapons "impotent and obsolete," including ballistic missile defense interceptors in space.[6] These layers would include boost, ascent, midcourse, and terminal interceptors, including directed-energy interceptors, so that the United States would have more than one opportunity to shoot down an incoming missile.

The United States stopped far short of this goal, even though the Strategic Defense Initiative (SDI) program resulted in tremendous technological advances and benefits.[7] Instead of a comprehensive layered system, the U.S. has no boost-phase ballistic missile defense systems and is unable to handle more qualitatively and quantitatively advanced ballistic missile threats like those from China or Russia.

Regrettably, the volatility and inconsistency of priority and funding for ballistic missile defense by successive Administrations and Congresses controlled by both major political parties have led to the current system, which is numerically and technologically limited and cannot address more sophisticated or more numerous long-range ballistic missile attacks. Until the 2017 National Defense Authorization Act (NDAA), U.S. policy was one of protection only from a "limited" ballistic missile attack.[8] The 2017 NDAA dropped the word "limited" that had been a fixture of policy since enactment of the National Missile Defense Act of 1999[9] even as it continued to focus on ballistic missiles.

In the future, as technological trends progress and modern technologies become cheaper and more widely available, North Korean or Iranian ballistic missiles may rival in sophistication if not numbers those of Russia or China. Consequently, the U.S. must remain aware of how such threats are evolving and alter its missile defense posture accordingly.

In January 2019, the Trump Administration published its congressionally mandated *Missile Defense Review* (MDR), a statement of policy intended to guide the Administration's missile defense programs. The MDR endorses a space-based sensor layer,[10] which is needed to make existing missile defense systems more effective, but the Administration failed to request resources for such a sensor layer in the MDA's FY 2020 budget. In FY 2020, the Trump Administration requested $9.431 billion for the MDA, the government agency with primary responsibility for developing, testing, fielding, and integrating a layered ballistic missile defense system. The request is a decrease of $1.06 billion from the FY 2019 enacted budget.[11]

Interceptors

A limited U.S. missile defense system has been supported by Administrations and Congresses controlled by both major political parties, Republican and Democrat, as all have found such a system to be of immense importance in dealing with some of the most challenging national security problems of our time, including the North Korean and Iranian ballistic missile threats. That said, different types of interceptors have been emphasized over the years, and the composition of today's U.S. missile defense reflects these choices.

Ballistic missile defense interceptors are designed to intercept ballistic missiles in three different phases of their flight.

- **The boost phase** lasts from the launch of a missile from its platform until its engines stop thrusting.

- **The midcourse phase** is the longest and thus offers a unique opportunity to intercept an incoming threat and, depending on other circumstances like the trajectory of the incoming threat and quality of U.S.

tracking data, even a second shot at it if the first intercept attempt fails.

- **The terminal phase** is less than one minute long and offers a very limited opportunity to intercept a ballistic missile threat.

Boost-Phase Interceptors. The United States currently has no capability to shoot down ballistic missiles in their boost phase. Boost-phase intercept is the most challenging option technologically because of the very short time frame in which a missile is boosting, the missile's extraordinary rate of acceleration during this brief window of time, and the need to have the interceptor close to the launch site.[12] It is, however, also the most beneficial time to strike. A boosting ballistic missile is at its slowest speed compared to other phases; it is therefore not yet able to maneuver evasively and has not yet deployed decoys that complicate the targeting and intercept problem.

In the past, the United States pursued several boost-phase programs, including the Airborne Laser; the Network Centric Air Defense Element (NCADE); the Kinetic Energy Interceptor (KEI); and the Air Launched Hit-to-Kill (ALHK) missile. Each of these programs was eventually cancelled because of insurmountable technical challenges, unworkable operational concepts, or unaffordable costs. As stated in the MDR, the Trump Administration is exploiting an option of incorporating the F-35 initially as a sensor platform and later potentially as an interceptor platform for boost-phase intercepts.[13]

The MDA is working to leverage unmanned and space-based sensor technologies to utilize existing SM-3 interceptors (typically carried aboard ships for long-range anti-aircraft defense) for a boost-phase ballistic missile intercept, but these sensors are years from being deployed. In addition, the current budget environment does not adequately fund research into future missile defense technologies and is barely enough to keep the existing missile defense programs going or enable even their marginal improvement.

Midcourse-Phase Interceptors. The United States deploys two systems that can shoot down incoming ballistic missiles in the midcourse phase of flight. This phase offers more predictability as to where the missile is headed than is possible in the boost phase, but it also allows the missile time to deploy decoys and countermeasures that are designed to complicate interception by confusing sensors and radars.

The Ground-Based Midcourse Defense (GMD) system is the only system capable of shooting down a long-range ballistic missile headed for the U.S. homeland. The Trump Administration decided to increase the number of GMD interceptors in Alaska and California from 44 to 64 early in its term to keep up with the advancing ballistic missile threat. At about $70 million apiece, the GMD interceptors may be rather expensive, but they are also a lot cheaper than a successful ballistic missile attack. In March 2019, the MDA conducted a groundbreaking and successful GMD test against a target simulating an intercontinental-range ballistic missile.

The Aegis defense system is a sea-based component of the U.S. missile defense system that is designed to address the threat of short-range; medium-range (1,000–3,000 kilometers); and intermediate-range (3,000–5,500 kilometers) ballistic missiles. It utilizes different versions of the Standard Missile-3 (SM-3) depending on the threat and other considerations like ship location and quality of tracking data. The U.S. Navy is planning to increase the number of BMD-capable ships "from 38 at the end of FY2018 to 59 at the end of FY2024."[14] This planned increase reflects an increase in demands for these assets.

The Aegis-Ashore system in Romania and one being deployed to Poland will relieve some of the stress on the fleet because missile defense–capable cruisers and destroyers are multi-mission and are used for other purposes, such as anti-piracy operations, when released from ballistic missile missions by the shore-based systems. The Aegis-Ashore site is meant to protect U.S. European allies and

U.S. forces in Europe from the Iranian ballistic missile threat.

In order to increase the probability of an intercept, the United States has to shoot multiple interceptors at each incoming ballistic missile. At present, because its inventory of ballistic missile defense interceptors is limited, the United States can shoot down only a handful of ballistic missiles that have relatively unsophisticated countermeasures. Different technological solutions will have to be found to address more comprehensive and advanced ballistic missile threats like those from China or Russia.

Terminal-Phase Interceptors. The United States currently deploys three terminal-phase missile defense systems: Terminal High Altitude Area Defense (THAAD); Patriot Advanced Capability-3 (PAC-3); and Aegis BMD.

The THAAD system is capable of shooting down short-range and intermediate-range ballistic missiles inside and just outside of the atmosphere.[15] It consists of a launcher, interceptors, AN/TPY-2 radar, and fire control. The system is transportable and rapidly deployable. THAAD batteries have been deployed to such countries as Japan, South Korea, Israel, and the United Arab Emirates. The United States has also been planning to deploy a THAAD battery to Romania in support of NATO ballistic missile defense in the summer of 2019.[16]

The PAC-3 is an air-defense and short-range ballistic missile defense system. A battery is comprised of a launcher, interceptors, AN/MPQ-53/65 radar, an engagement control station, and diesel-powered generator units. The system is transportable, and the United States currently deploys it in several theaters around the world.[17] The system is the most mature of the U.S. missile defense systems.

The predecessor of the PAC-3 system, the Patriot, played a critical role in allied assurance during the First Gulf War when it was deployed to Israel. The purpose was to assure Israeli citizens by protecting them from Iraqi missiles, thereby decreasing the pressure on Israel's government to enter the war against Iraq. The U.S. sought to prevent Israel from joining the U.S. coalition against Saddam Hussein's forces in Iraq, which would have fractured the Arab coalition.

The Aegis defense system also provides terminal capability against short-range and medium-range ballistic missiles, aerial threats, and cruise missiles, among others.[18]

Sensors

The space sensor component of the U.S. missile defense system is distributed across three major domains—land, sea, and space—that are meant to provide the U.S. and its allies with the earliest possible warning of a launch of enemy ballistic missiles. Sensors can also provide information about activities preceding the launch itself, but from the intercept perspective, those are less relevant for the missile defense system.

Additionally, new threats are not flying on ballistic (and therefore relatively more predictable) trajectories, and U.S. sensors are not well equipped to handle these developments. Sensors do this by detecting the heat generated by a missile's engine, or booster. They can detect a missile launch, acquire and track a missile in flight, and even classify the type of projectile, its speed, and the target against which the missile has been directed. The sensors relay this information to the command and control stations that operate interceptor systems like Aegis (primarily a sea-based system) or THAAD (a land-based system).

On land, the major sensor installations are the upgraded early warning radars (UEWRs), which are concentrated along the North Atlantic and Pacific corridors that present the most direct flight path for a missile aimed at the U.S. This includes the phased array early warning radars based in California, the United Kingdom, and Greenland that scan objects up to 3,000 miles away.[19] These sensors focus on threats that can be detected starting in the missile's boost or launch phase when the release of exhaust gases creates a heat trail that is "relatively easy for sensors to detect and track."[20]

A shorter-range (2,000-mile) radar is based in Shemya, Alaska. Two additional sites, one in Cape Cod, Massachusetts, and the other in Clear, Alaska, are being modernized for use in the layered ballistic missile defense system.[21]

The other land-based sensors are mobile. These sensors are known as the Army Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2) and can be forward-deployed for early threat detection or retained closer to the homeland to track missiles in their terminal phase. Of the United States' 12 AN/TPY-2 systems, five are forward-deployed with U.S. allies.[22]

In March 2017, in cooperation with the Republic of Korea, the United States deployed a THAAD missile system to the Korean peninsula. This system was then accompanied in April by an AN/TPY-2. The THAAD deployment was heavily criticized by China for allegedly destabilizing China's nuclear deterrence credibility because the system would allegedly be able to shoot down any Chinese nuclear-tipped missiles after a U.S. first strike.[23] However, the THAAD system deployed in South Korea for the purposes of intercepting North Korean missiles is not set up in a way that could track or shoot down Chinese ICBMs directed toward the United States, which calls into question why China would be so opposed.[24]

There are two types of sea-based sensors. The first is the Sea-Based X-band (SBX) radar mounted on an oil-drilling platform, which can be relocated to different parts of the globe as threats evolve.[25] SBX is used primarily in the Pacific. The second is the SPY-1 radar system that is mounted on all 85 U.S. Navy vessels equipped with the Aegis Combat system, which means they can provide data that can be utilized for ballistic missile missions. Of these 85 ships, 38 are BMD-capable vessels that carry missile defense interceptors.[26]

The final domain in which U.S. missile defense operates is space. In a July 2017 conference call with reporters, the head of U.S. Strategic Command, General John Hyten, stated that space-based sensors are "the most important thing for [the U.S. government] to invest in right now."[27] Control of the space BMD system is divided between the MDA and the U.S. Air Force. Regrettably, as noted, the Trump Administration largely failed to request funding for a space-based sensor layer in the MDA's FY 2020 budget.

The oldest system that contributes to the missile defense mission is the Defense Support Program (DSP) constellation of satellites, which use infrared sensors to identify heat from booster and missile plumes. The DSP satellite system is set to be replaced by the Space-Based Infrared Radar System (SBIRS) to improve the delivery of missile defense and battlefield intelligence.[28] One of the advantages of SBIRS is its ability to scan a wide swath of territory while simultaneously tracking a specific target, making it a good scanner for observing tactical, or short-range, ballistic missiles.[29] However, congressional funding delays have left SBIRS underfunded and hampered the system's full development and deployment.[30]

Finally, the MDA operates the Space Tracking and Surveillance System-Demonstrators (STSS-D) satellite system. Two STSS-D satellites were launched into orbit in 2009 to track ballistic missiles that exit and reenter the Earth's atmosphere during the midcourse phase.[31] Although still considered an experimental system, STSS-D satellites provide operational surveillance and tracking capabilities and have the advantage of a variable waveband infrared system to maximize their detection capabilities. Data obtained by STSS-D have been used in ballistic missile defense tests.

Command and Control

The command and control architecture established for the U.S. ballistic missile defense system brings together data from U.S. sensors and relays them to interceptor operators to enable them to destroy incoming missile threats against the U.S. and its allies. The operational hub of missile defense command and control is assigned to the Joint Functional Component Command for Integrated Missile Defense (JFCC IMD) housed at Schriever Air Force Base, Colorado.

Under the jurisdiction of U.S. Strategic Command, JFCC IMD brings together Army, Navy, Marine Corps, and Air Force personnel. It is co-located with the MDA's Missile Defense Integration and Operation Center (MDIOC). This concentration of leadership from across the various agencies helps to streamline decision-making for those who command and operate the U.S. missile defense system.[32]

Command and control operates through a series of data collection and communication relay nodes between military operators, sensors, radars, and missile interceptors. The first step is the Ground-based Midcourse Defense Fire Control (GFC) process, which involves assimilating data on missile movement from the United States' global network of sensors.

Missile tracking data travel through the Defense Satellite Communications System (DSCS), which is operated from Fort Greeley, Alaska, and Vandenberg Air Force Base, or through ground-based redundant communication lines to the Command Launch Equipment (CLE) software that develops fire response options, telling interceptors where and when to fire. Once U.S. Strategic Command, in consultation with the President, has determined the most effective response to a missile threat, the CLE fire response option is relayed to the appropriate ground-based interceptors in the field. When the selected missiles have been fired, they maintain contact with an In-Flight Interceptor Communications System (IFICS) Data Terminal (IDT) to receive updated flight correction guidance to ensure that they hit their target.[33]

Overlaying the command and control operation is the Command and Control, Battle Management and Communication (C2BMC) program. Through its software and network systems, C2BMC feeds information to and synchronizes coordination between the multiple layers of the ballistic missile defense system.[34] More than 70 C2BMC workstations are distributed throughout the world at U.S. military bases.[35] C2BMC has undergone multiple technical upgrades since 2004.

Conclusion

By successive choices of post–Cold War Administrations and Congresses, the United States does not have in place a comprehensive set of missile defense systems that would be capable of defending the homeland and allies from robust ballistic missile threats. U.S. efforts have focused on a limited architecture protecting the homeland and on deploying and advancing regional missile defense systems.

The pace of the development of missile threats, both qualitative and quantitative, outpaces the speed of missile defense research, development, and deployment. To make matters worse, the United States has not invested sufficiently in future ballistic missile defense technologies, has canceled future missile defense programs like the Airborne Laser and the Multiple Kill Vehicle, and has never invested in space-based interceptors that would make U.S. defenses more robust and comprehensive.

Endnotes

1. Following missile threat developments, Congress mandated that the Trump Administration conduct a review of missile threats to the U.S. and its interests, as opposed to the Obama Administration's mandate to focus on ballistic missiles only. This section of the *Index* has been updated to reflect these developments.
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8. National Defense Authorization Act for Fiscal Year 2017, Public Law 114–328, 114th Cong., December 23, 2016, https://www.congress.gov/114/plaws/publ328/PLAW-114publ328.pdf (accessed August 24, 2019). The understanding of the word "limited" itself changed over time, from scaling a missile defense system to shoot down about 200 reentry vehicles right after the end of the Cold War (because that is how many a rogue Soviet commander was believed to be able to launch from a submarine) to only a handful of relatively less sophisticated North Korean or Iranian ballistic missiles. For more information, see Independent Working Group on Missile Defense, the Space Relationship, and the Twenty-First Century, *2009 Report*, Institute for Foreign Policy Research and Analysis, 2009, p. 17, http://www.ifpa.org/pdf/IWG2009.pdf (accessed August 24, 2019).
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