Ballistic Missile Defense

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

The Growing Missile Threat

Missiles remain a weapon of choice for many U.S. adversaries because they possess important attributes like extraordinarily high speed (against which the U.S. has a limited ability to defend) and relative cost-effectiveness compared to other types of conventional attack weapons.[1] The number of states that possess missiles will continue to increase, as will the sophistication of these weapons, as modern technologies become cheaper and more widely available.

Despite U.S. diplomatic efforts, North Korea continues its aggressive development of a nuclear ICBM program that will allow it to strike the United States. It also has recently tested ground-based and sea-based ballistic missiles. Iran continues to modernize and proliferate its regional missile systems. Its recent successful rocket launch demonstrates that Iran has the ability to build and launch sophisticated missiles, which implies that it either has or is developing the know-how to advance to the ICBM-level of capability.[2] According to Dr. Robert Soofer, Deputy Assistant Secretary of Defense for Nuclear and Missile Defense Policy:

> As adversary missile technology matures and proliferates, the threat to the U.S. homeland, allies, partners, and our forces in the field becomes increasingly dynamic and difficult to predict. While traditional fixed and mobile ballistic missile threats continue to grow, adversaries are also investing in ground-, air-, and sea-launched cruise missiles with diverse ranges. China and Russia are also developing and testing hypersonic missile technology, with Russia recently deploying the world's first operational intercontinental-range hypersonic glide vehicle (HGV). These missile technologies are being incorporated into adversary strategies meant to coerce and intimidate the United States and its allies by threatening critical targets in our homelands.[3]

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

The Strategic Role of Missile Defense

Because they are designed to defeat incoming missile attacks, missile defense systems can save lives and protect civilian infrastructure from damage or destruction. More important, missile defense plays a critical role in strategic deterrence. The ability to deter an enemy from attacking depends on convincing 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 the perceived benefit of attacking.

A U.S. missile defense system strengthens deterrence by offering a degree of protection to the American people and the economic base on which their well-being depends, as well as forward-deployed troops and allies, making it harder for an adversary to threaten them with ballistic missiles. By raising the threshold for missile attack, missile defense limits the option for a "cheap shot" against the United States. A missile defense system also 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. Adversaries want to deny the United States the ability to conduct offensive operations during a regional conflict, which they can attempt to do by targeting U.S. and allied forward deployed personnel or military assets. In addition, they might try to decouple the United States from defense of its allies by threatening to strike the U.S. homeland or forces abroad if the United States intervenes in a regional conflict. Missile defenses in place make it easier for the U.S. military to introduce reinforcements that can move more freely through a region and can therefore strengthen the credibility of U.S. extended deterrence.

Finally, a missile defense system gives decision-makers more time to choose the most de-escalatory course of action. Without the ability to defend against an attack, U.S. authorities would be limited to an unappealing set of responses that could range from preemptively attacking an adversary to attacking his ballistic missiles on launch pads or even conceding to his demands or actions. With a missile defense system, however, decision-makers would have additional options and more time to consider their implications and arrive at the one that best serves U.S. security interests. In other words, missile defense systems could be profoundly stabilizing.

The U.S. Missile Defense System

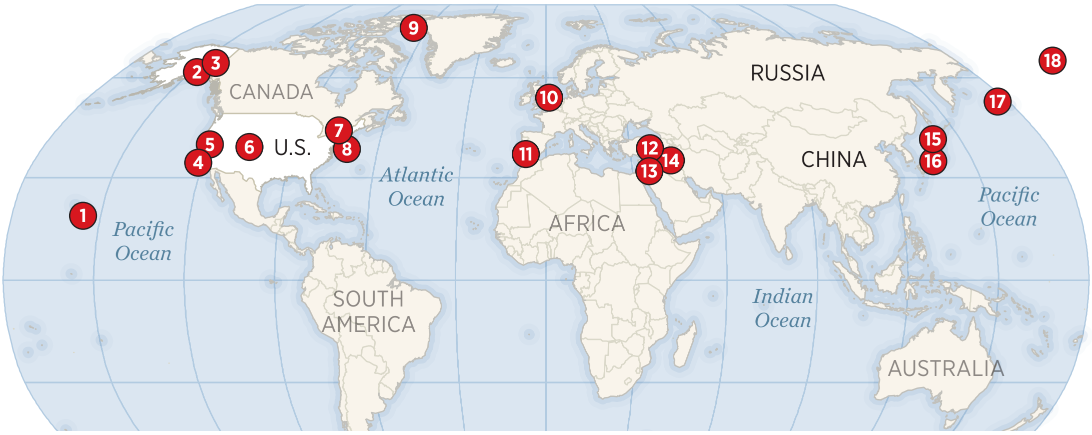
The U.S. missile defense system has three critical components: sensors, interceptors, and a command and control infrastructure that provides data from sensors to interceptors. Of these, interceptors receive much of the public's attention because of their visible and kinetic nature. Different physical 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 flight. Interceptors can shoot down an adversarial 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 intercontinental-range) that an interceptor is designed to shoot down, since 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 intercontinental-range ballistic missiles, the United States has "about 30 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.[5] The time frame is shorter when it comes to medium-range and short-range ballistic missiles.

Missile defense can also be framed by origin of interceptor launch. At present, U.S. interceptors are launched from the ground or from

MAP 10

U.S. Missile Defense Assets



GBI—Ground based interceptors
GFC—Fire control center
GMD—Ground-based midcourse defense

IDT—In-Flight Interceptor Communications System (IFICS) Data Terminal

TPY-2—Transportable Radar Surveillance and Control Model 2
UEWR—Upgraded early warning radar

1. **Pearl Harbor, HI (base)**
   - Sea-based X-Band radar
2. **Clear, AK**
   - UEWR
3. **Ft. Greely, AK**
   - 40 GBIs
   - GMD
   - GFC
   - IDT
4. **Vandenberg AFB, CA**
   - 4 GBIs
   - 2 IDTs
5. **Beale AFB, CA**
   - UEWR
6. **Scriever AFB, CO**
   - GFC
7. **Ft. Drum, NY**
   - IDT
8. **Cape Cod, MA**
   - UEWR
9. **Thule, Greenland**
   - UEWR
10. **Fylingdales, UK**
    - UEWR
11. **Rota, Spain (base)**
    - Sea-based Aegis BMD SPY-1 radar
12. **Kurecik AFB, Turkey**
    - TPY-2 radar
13. **Israel**
    - TPY-2 radar
14. **CENTCOM-Middle East**
    - TPY-2 radar
15. **Shariki, Japan**
    - TPY-2 radar
16. **Kyogamisaki, Japan**
    - TPY-2 radar
17. **Shemya, AK**
    - Cobra Dane radar
    - IDT
18. **Outer space**
    - Defense support program satellites
    - Space-based infrared system satellites
    - Space tracking and surveillance system-demonstrator

NOTE: Locations are approximate.

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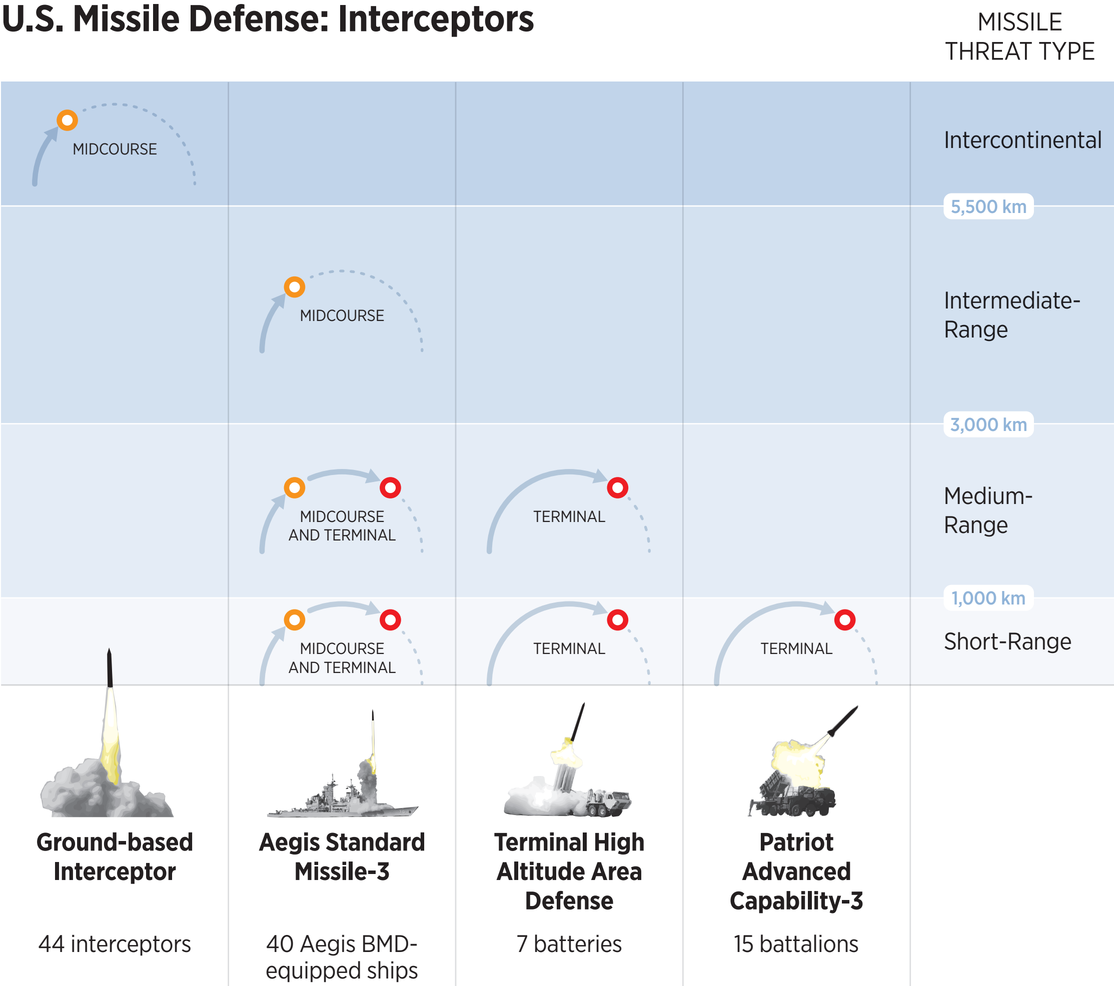
FIGURE 6

U.S. Missile Defense: Interceptors



SOURCES:

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the sea. In the past, the United States explored concepts to launch interceptors from the air or from space, but only limited efforts have been made since the U.S.'s withdrawal from the Anti-Ballistic Missile Treaty in 2002.[6] There is renewed interest in boost-phase missile defense concepts within the Trump Administration, but the fiscal year (FY) 2021 budget submission for the Missile Defense Agency (MDA), a U.S. Department of Defense agency charged with "develop[ing] and deploy[ing] a layered Missile Defense System to defend the United States, its deployed forces, allies, and friends from missile attacks in all phases of flight,"[7] does not include funding to explore space-based or air-based missile interceptors.

The current U.S. missile defense system is a result of investments made by successive U.S. Administrations. President Ronald Reagan envisioned the program as having a layered ballistic missile defense system, including ballistic missile defense interceptors in space, that would render nuclear weapons "impotent and obsolete."[8] 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 program resulted in tremendous technological advances and benefits.[9] Instead of a comprehensive layered system, the U.S. has no boost-phase ballistic missile defense systems and is unable to handle the advanced ballistic missile threats from China or Russia.

The volatility and inconsistency of priority and funding for ballistic missile defense by successive Administrations and Congresses—Administrations and Congresses, it should be noted, 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. Historically, U.S. policy has been one of protecting the homeland only from a "limited" ballistic missile attack.[10] The National Defense Authorization Act (NDAA) for Fiscal Year 2017 dropped the word "limited" that had been a fixture of policy since the National Missile Defense Act of 1999 even as it continued to focus on ballistic missiles. The 2020 NDAA made it a matter of policy to rely on nuclear deterrence to defend against "near-peer intercontinental threats" and focus on improving missile defense against "rogue states."[11]

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 addresses the dangerous threat environment that has evolved since the last MDR in 2010 and advocates a comprehensive approach to all missile threats that integrates offensive capabilities, active defenses, and passive defenses. It also acknowledges that the United States is no longer vulnerable only to ballistic missiles and recognizes the need to defend against cruise and hypersonic missiles as well.[12] For FY 2021, the Trump Administration requested $20.3 billion for missile defeat and defense (MDD), including $9.2 billion for the MDA (a decrease of $1.2 billion from the FY 2020 enacted budget); $7.9 billion in missile defense capabilities outside of the MDA, such as the Space Development Agency (SDA) and the services; and $3.2 billion for "missile defeat or left-of-launch activities."[13]

Interceptors

Interceptors comprise one major component of the U.S. missile defense system. Different types of interceptors that respond to different missile threats have been emphasized over the years, and these choices are reflected in the composition of today's U.S. missile defense.

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

- **The boost phase** is 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 should the first intercept attempt fail.

- **The terminal phase** is less than one minute long, occurring as the missile plummets through the atmosphere toward the target, 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.[14] 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, the Kinetic Energy Interceptor, and the Air Launched Hit-to-Kill 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 considering an option that would incorporate the F-35 initially as a sensor platform and later potentially as an interceptor platform for boost-phase intercepts. However, the current budget does not include funding for MDA development of a boost-phase interceptor program.

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 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. It consists of 40 Ground-Based Interceptors (GBIs) in Alaska and four in California. In 2017, Congress approved a White House reprogramming request to increase the number of GBIs from 44 to 64 to keep up with the advancing ballistic missile threat, but this project has yet to be completed.[15] At about $70 million apiece, GBIs are rather expensive—but they are also a lot cheaper than the damage that would be caused by a successful ballistic missile attack. In March 2019, the MDA conducted a groundbreaking and successful "salvo" GMD test against an ICBM target in which one GBI intercepted the target and a second intercepted the biggest piece of debris from the exploded target.[16]

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.[17]

The Aegis defense system is a sea-based component of the U.S. missile defense system. It 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 48 at the end of FY 2021 to 65 at the end of FY 2025.[18] The 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 wartime fleet operations and even anti-piracy operations, when released from ballistic missile missions by the shore-based systems. These Aegis Ashore sites will help to protect U.S. allies and forces in Europe from the Iranian ballistic missile threat. Two Aegis Ashore batteries were sold recently to Japan to help protect U.S. allies and forces in the Indo-Pacific from the North Korean and Chinese threats, but this project has since been suspended.[19]

In February 2020, the MDA "confirmed it would conduct an ICBM intercept test with the SM-3 Block IIA missile in the third quarter of 2020." The test would be "the first ICBM-class intercept attempt for the SM-3 Block IIA missile."[20] The Pentagon hopes to use SM-3 Block IIAs as an "underlay" to the GMD system to defend the homeland, with GBIs taking the first shot at an incoming target and SM-3 interceptors taking a second shot if GBIs missed.[21] Deploying such an underlay would require the Pentagon to develop a concept of operations that includes deployment of SM-3 interceptors on Aegis ships or Aegis Ashore sites across the United States.

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.

A THAAD battery is capable of shooting down short-range and intermediate-range ballistic missiles inside and just outside of the atmosphere.[22] It consists of a launcher, interceptors, the Army Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2) radar, and fire control.[23] 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 deployed a THAAD battery to Romania in support of NATO ballistic missile defense in summer 2019 and signed a deal this year to deliver THAAD to Saudi Arabia.[24] This year's budget also included funding "to prove the technologies to enable expansion of engagement options and coverage areas for the THAAD weapon system."[25]

The PAC-3 is an air-defense and short-range ballistic missile defense system. A battery includes 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.[26] The system is the most mature of the U.S. missile defense systems.

The PAC-3's predecessor 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. In so doing, 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.[27]

Assessment: Interceptor strength is difficult to assess because deploying more interceptors to increase capacity or defend more targets would always be better than simply relying on the number currently deployed. To strengthen regional interceptor capability in the Middle East, for instance, after the January 2020 Iranian ballistic missile attack on al-Asad Air Base, which had no missile defenses, the Pentagon moved a Patriot battery to al-Asad to provide a short-term solution to the Iranian threat.[28] Nevertheless, deployment of more short-range to medium-range interceptors to more unprotected locations *ad infinitum* is clearly not sustainable.

The budget for FY 2021 includes funding to procure additional PAC-3, SM-3, and THAAD interceptors, but DOD can also improve the effectiveness of interceptors more creatively.[29] For instance, the Pentagon is developing a THAAD remote launch capability, which can enable a commander to spread out THAAD interceptors to expand a defended area.[30] In addition, the Army recently increased its THAAD battery requirement from seven (the existing number) to eight.[31] This eighth THAAD battery was not included in the FY 2021 budget request; instead, it appeared as the number two priority on the MDA's Unfunded Priorities List.[32]

In terms of GBI capacity and capability to defend the homeland, Air Force General Terrence J. O'Shaughnessy, Commander, U.S. Northern Command (NORTHCOM), recently stated that he "retains confidence in the current ground-based interceptor fleet" but that it will need to improve to remain ahead of emerging threats.[33] After a series of North Korean provocations in 2017, the Trump Administration and Congress agreed on the need to expand interceptor capacity from 44 to 64 to keep pace with the growing North Korean threat. Twenty new silos are under construction in Alaska, but they will remain empty because DOD does not have enough interceptors available to fill them.

Existing GBIs carry Exoatmospheric Kill Vehicles (EKVs) to intercept the target with kinetic kill technology, but EKVs are no longer manufactured. The MDA intended to produce a Redesigned Kill Vehicle (RKV) to top the 20 new interceptors, but this program was canceled in 2019. The MDA instead initiated the Next Generation Interceptor (NGI) program to develop advanced kill vehicles to fill the 20 new silos and replace the 44 existing GBIs, but fielding of NGIs will not begin until 2028 at the earliest.

In addition to a delay in capacity, the GMD system will lose capability as the existing EKVs face aging and obsolescence issues. RKV would have begun to replace EKVs as early as 2021, but with NGI not expected until the end of the decade, the 44 deployed interceptors may be at heightened risk. In fact, senior defense leaders estimate that the problems of North Korean ICBM advancement and aging EKVs will converge around 2025.[34]

General O'Shaughnessy recently expressed his concerns to the Senate Armed Services Committee:

> I want to make it clear that I am deeply concerned with the resulting delay in adding to our ground-based interceptor capability and capacity. As we progress toward a next-generation interceptor (NGI) capability, USNORTHCOM remains responsible for defending the homeland from missile attacks. It is therefore necessary to swiftly develop and field a lower-tier missile defense capability as a complement to NGI to intercept current and emerging missile threats. Given the nature of the ballistic missile threat, I am a strong advocate for bringing a layered capability on board for the warfighter well before NGI is fielded.[35]

Another way to improve interceptor capability is by fielding an interceptor as part of the Army's Indirect Fire Protection Capability (IFPC) Increment 2 to defend against short-range rockets, artillery, and mortars, as well as cruise missiles, against which the United States lacks sufficient defense capability.[36] As a system, IFPC would fill the gap between short-range tactical air defense and ballistic missile defense like PAC-3 and THAAD.

In response to a congressional requirement to field an interim cruise missile defense capability to meet the increasing cruise missile threat, the Army purchased two Iron Dome batteries manufactured by the Israeli company Rafael. While Iron Dome has successfully defended Israel from short-range attacks, particularly on the Israeli border with the Gaza Strip,[37] the Army has identified problems with integration of Iron Dome as part of an enduring IFPC solution.[38] The Army is working to find the best option for a long-term IFPC solution, but until it finds that option, it will lack a strong capability in the area of cruise missile defense.

Overall, the United States has multiple capable interceptors, but there is much room for improvement. The Pentagon has viable plans in place to improve the capability of Aegis and PAC-3 assets and to acquire additional systems of each, but it will need to focus on stabilizing the homeland missile defense system in particular in the near future.

Sensors

The sensor component of the U.S. missile defense system is distributed across the land, sea, and space domains and provides the United States and its allies with the earliest possible warning of a launch of enemy missiles in addition to missile tracking and discrimination. The 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 United States. These include the phased array early warning radars based in California, the United Kingdom, and Greenland that scan objects up to 3,000 miles away.[39] 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."[40]

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.[41]

The other land-based sensors are mobile. These AN/TPY-2 sensors can be forward-deployed for early threat detection or retained closer to the homeland to track missiles in their terminal phase.[42] Of the United States' 12 AN/TPY-2 systems, five are forward-deployed with U.S. allies.[43]

In March 2017, in cooperation with the Republic of Korea, the United States deployed a THAAD missile system to the Korean Peninsula; in April, it was accompanied 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 be able to improve U.S. early warning, and therefore interception, of any Chinese nuclear-tipped missiles and undermine China's second-strike capability.[44] 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, so why China would be so opposed to it is unclear.[45]

There are two types of sea-based sensors. The first is the Sea-Based X-band (SBX) radar that is mounted on an oil-drilling platform and can be relocated to different parts of the globe as threats evolve.[46] SBX is used primarily in the Pacific. The second radar is the SPY-1 radar system that is mounted on all 84 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 84 ships, 40 are BMD-capable vessels that carry missile defense interceptors.[47]

Finally, U.S. missile defense sensors operate in space. Control of the space BMD system is divided among the MDA, the U.S. Space Force, and the SDA.

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 has gradually been replaced by the Space-Based Infrared Radar System (SBIRS) to improve the delivery of missile defense and battlefield intelligence.[48] For instance, SBIRS can 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.[49]

However, congressional funding delays have left SBIRS underfunded and have hampered the system's full development and deployment.[50] In 2017, the Air Force decided to end production of SBIRS early and move on to developing its replacement, the Next-Generation Overhead Persistent Infrared (Next-Gen OPIR) satellites. The first of these satellites, which are designed to be more survivable against cyber and electronic attacks, are scheduled for delivery in 2025.[51]

The MDA also 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.[52] 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.

From as far back as President Reagan's Strategic Defense Initiative, successive presidential Administrations have called for a layer of sensing satellites in space to track a missile's flight from birth to death. From the ultimate high ground, space-based sensors can detect missile launches from almost any location from boost phase to terminal phase, compared to ground-based radars that are limited in their tracking range.[53] In particular, space-based sensors can help track hypersonic vehicles, which fly at lower altitudes than ballistic missiles and can maneuver during their trajectories.

Since many new threats are not flying on ballistic trajectories, the Trump Administration has paid close attention to developing this space sensor layer as endorsed by the MDR. In FY 2020, Congress provided slightly more than $140.5 million to the MDA to develop the Hypersonic and Ballistic Tracking Space Sensor (HBTSS) to fulfill this need.[54] This year, the President requested $99.6 million for the SDA to integrate the MDA's HBTSS payload into a future architecture of sensing and tracking satellites proliferated in Low Earth Orbit (LEO).[55]

Assessment: Senior defense leaders have stated repeatedly that the most important way to advance sensor capability is to deploy sensor satellites to space in order to track missiles throughout their entire flight from the high ground. Today's deployed radars and sensors are both vulnerable to adversary attack and limited in tracking range. As Admiral Charles Richard, Commander of U.S. Strategic Command, has explained:

> Future space-based sensors may be able to provide birth-to-death detection, tracking, and discrimination of hypersonic glide vehicle, cruise missile, and ballistic missile threats globally. These abilities cannot be fully achieved with the current or future terrestrial-based radar architecture due to the constraints of geography and characteristics of future missile threats.[56]

Similarly, General O'Shaughnessy recently stated that given the emerging threat, "the urgency of taking steps now to develop and field a future space-based sensing layer as soon as technology allows cannot be overstated."[57]

But the space sensor layer program has been unnecessarily plagued by bureaucratic infighting and insufficient funding requests. In FY 2019 and FY 2020, the Administration did not request funds for a space sensor layer, so Congress unilaterally provided funding to the MDA for HBTSS. In FY 2020 and FY 2021, the Administration tried to move the program to the SDA, even though Congress expressed its desire that HBTSS remain in MDA. Moreover, a decrease in research and development funding as requested in FY 2021 would increase the difficulty of demonstrating this space sensor layer quickly, especially because of the technological challenges associated with developing a sensor that can perform in LEO.[58]

In addition to space sensors, there is a gap in missile discrimination capability over the Pacific for tracking North Korean missiles. The MDA's Long Range Discrimination Radar (LRDR) being built in northern Alaska will improve coverage in the northern Pacific but will leave a tracking and discrimination gap over Hawaii and elsewhere in the Pacific. In the FY 2021 budget, the MDA omitted plans to build a Homeland Defense Radar (HDR)-Hawaii and another HDR-Pacific due to budgetary restraints. DOD plans to use deployed AN/TYP-2 radars, the SBX radar, and radars on Aegis ships while these homeland defense radars remain delayed.[59] Eventual deployment of the space sensor layer will also improve this capability, but it is no substitute for a long-term solution that completely closes this Pacific midcourse discrimination gap.[60]

Some progress in sensor capability has been made over the past year. Congress reprogrammed funds for Next-Gen OPIR last year after the requirement for the program moved up in schedule. If implemented by Congress, the budget for FY 2021 should fully fund the program.[61] Additionally, the Army recently awarded a contract for the Lower-Tier Air and Missile Defense System radars that will provide 360-degree threat coverage for PAC-3 and other regional missile defense batteries; for comparison, the current Patriot radar can only scan the sky one slice at a time.[62]

Despite this progress, achievement of an advanced sensor capability requires stabilization of the space sensor layer program. Due to their ability to track and characterize missiles throughout the entirety of their flight, space sensors are essential to development of an interceptor capability against advancing threats like hypersonic vehicles.

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), which is 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 at Schriever 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.[63]

Command and control operates through a series of data collection and communication relay nodes among military operators, sensors, radars, and missile interceptors. To command and control the GMD system to defend the homeland, 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 Greely, Alaska, and Vandenberg Air Force Base, California, or 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 the NORTHCOM Commander (who becomes the supported commander during GMD execution) 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 GBIs in the field.[64] 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.[65]

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 among the multiple layers of the ballistic missile defense system.[66] More than 70 C2BMC workstations are distributed throughout the world at U.S. military bases.[67] C2BMC has undergone multiple technical upgrades, called "spirals," since 2004 to bring more missile defense elements into the network. Last year, the MDA completed an upgrade that will help to expand Aegis missile defense coverage by enabling Aegis Weapons Systems to engage on remote. In FY 2021, the MDA plans to complete another upgrade to incorporate the LRDR into C2BMC.

Regional missile defense systems like THAAD, PAC-3, and Aegis are equipped with their own individual fire control systems to command and control the launch of their interceptors. The C2BMC system can also provide tracking information to individual missile defense batteries from other regional sensors. Aegis BMD systems have onboard command and control governed by the Aegis Combat System, but they can also provide their sensor data to the GMD system through C2BMC.[68]

C2BMC connects sensors and shooters around the world to a global network, but there is no comparable system to link sensors and shooters in a single region. The Army is developing the Integrated Air and Missile Defense (IAMD) Battle Command System (IBCS) to provide this capability. Once fielded, IBCS would connect all sensors and shooters in a region to a single fire control network, as opposed to having each missile defense battery operate its own collocated sensor and launcher as is done today.[69] IBCS would also link defenses against smaller threats, like IFPC, with ballistic missile defense.

Assessment: The United States has maintained a global command and control system that it continues to improve and update. In 2018, the MDA completed updates to the aging GFC system to improve efficiency.[70] Recent spiral upgrades to C2BMC have improved capability, and future spirals that are planned will continue to increase the integration of ballistic missile defense elements across the world. As global missile threats advance to include not just ballistic missiles, but cruise and hypersonic missiles as well, the United States will need a more advanced command and control capability to address this increasingly vast range of threats.

DOD is currently developing a Joint All Domain C2 (JADC2) system so that it can integrate non-compatible sensors across all domains into a single network to respond more efficiently to this complex threat, and missile defense command and control will strengthen as the services begin to field JADC2 capabilities. IBCS will also provide an important improvement to regional missile defenses and must remain on schedule. IBCS was originally scheduled to reach initial operating capability in FY 2019 but has already been delayed to FY 2022 because of technical issues.[71] Although the current missile defense command and control architecture can address today's threat, advancements that are underway will become increasingly necessary to strengthen command and control for the future.

Conclusion

By choice of successive 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.

While the United States has in place multiple types of capable interceptors, a vast sensor network, and a command and control system, many elements of the missile defense system need to improve to defend more effectively against today's threat. At the same time, the development of missile threats, both qualitative and quantitative, outpaces the speed of missile defense research, development, and deployment to address the future threat.

The United States has not invested enough 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. This Administration has stressed the importance of U.S. missile defense, but Congress also needs to recognize its importance and provide sufficient funding for struggling programs like GMD and space sensors if we are to reap the strategic benefits that it provides.

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