# U.S. Ballistic Missile Defense

Ballistic missile defense systems seek to defend a given area from attack by locating and tracking an incoming ballistic missile and then launching an interceptor to destroy the missile before it can reach its target. All U.S. interceptors are made up of a booster rocket and a kill vehicle. While most interceptors are "hit-to-kill," meaning the kill vehicle crashes into the incoming missile to destroy them, others use a blast fragmentation warhead that detonates an explosive charge and sprays shrapnel in the hopes of detonating the payload in the incoming missile. The United States employs missile defenses that launch both types of interceptors.

The U.S. Missile Defense Agency (MDA) has worked to develop and deploy a number of such systems to defend the homeland, allies and assets abroad. In this vein, the United States has developed three theater (regional) systems and one to protect the homeland, the Ground-Based Midcourse Defense (GMD) system.

Theater Ballistic Missile Defense systems target incoming short-, medium- and intermediate-range ballistic missiles. These systems include the land-based Patriot Advanced Capability (PAC-3) and Terminal High Altitude Area Defense (THAAD) systems deployed in Europe, the Middle East and Asia, and the sea-based Aegis system, although the Aegis Ashore can be deployed on land.

The GMD system aims to protect the U.S. homeland from intermediate and long-range intercontinental ballistic missiles (ICBMs) by destroying the incoming warhead in its midcourse phase, outside of the Earth's atmosphere. First deployed in 2004, this system currently comprises 40 ground-based interceptors at Fort Greely in Alaska and four at Vandenburg Air Force Base in California, in addition to associated satellite and radar systems. The Pentagon is also constructing a new missile field at Fort Greely, which is slated to host 20 new interceptors, bringing the eventual total to 64 interceptors.

The United States' deterrence strategy proclaims that offensive nuclear weapons deter nuclear weapon states, like Russia and China, and U.S. missile defenses are meant to protect against rogue state threats, like North Korea and, maybe in the future, an Iranian ICBM. However, under the Trump administration, the United States shifted its strategy toward creating a layered missile defense system that plans to integrate the systems deployed abroad with those deployed at home. The new strategy is now targeting cruise and hypersonic weapons as well. As of April 2021, it is unclear what the Biden administration will do.

## How do these systems work?

While engaging hypersonic and cruise missiles requires defending areas, ballistic missile defense considers engaging threats during three stages: the boost phase, the midcourse phase and the terminal phase of flight.

Boost-phase defense encompasses engagements while the booster rocket is still accelerating. The midcourse defense layer can be divided into 1) the ascent phase, when the incoming missile is engaged prior to apogee; 2) the descent phase, when intercept occurs after apogee. Finally, terminal defense refers to engagements as and after warheads reenter the atmosphere and become subject to drag and reentry heating.

Engagements in the boost phase are ideal but very difficult because there is such a short time period to make a decision. Boost-phase engagements also require engagement by systems that are deployed near enemy territory, which can undermine the strategic deterrents of adversaries. Presently, the United States does not have this technology and it was found not to be "practical or feasible" by the National Academy of Sciences.

Terminal defense is dangerous because it is the last shot at interception. The PAC-3, THAAD and Aegis systems all target the terminal phase. In November 2020, the Aegis SM-3 Block IIA was tested against an ICBM-class target and deemed successful, although it was not conducted under real-world conditions.

The U.S. GMD system, as its name dictates, seeks to engage incoming missiles in the midcourse layer. It relies on an extensive network of ground- and space-based sensors and radars, which are deployed from Greenland to Japan, and from the Pacific Ocean to launch detection satellites orbiting the Earth.

## Do these systems work?

Despite the assurances of MDA officials, presently, these defense systems have a very lackluster testing record. Not only that, but the Government Accountability Office found that the MDA failed to meet its planned testing goals in fiscal year (FY) 2019 due to significant development delays. The lack of testing is problematic as it results in less data to validate system capabilities. These failures are particularly concerning given the MDA's $152 billion in funding from 2002 to 2018 and requested $47 billion from FY 2019 through 2023.

In the tests that have occurred, the GMD system has proven largely ineffective. Both newer and older kill vehicles currently deployed have an approximate 50% success rate in scripted tests and replacements for these weapons are years away. In October of 2019, the Pentagon terminated its Redesigned Kill Vehicle program, intended for deployment in 2023, to augment and replace the GMD's outdated and unreliable interceptors, due to technical design flaws.

Now, after Congress allocated more than $1 billion on the failed program, MDA requested $664.1 million in FY 2021 for the development of a Next-Generation Interceptor. The development timeline for this new program could extend past 2030, leaving GMD stuck with ineffective interceptors based on outdated and possibly faulty technology. In the interim, Congress has asked MDA to field a separate interceptor by 2026.

The present situation becomes more problematic when considering that tests of these systems are conducted under controlled conditions and do not fully account for an adversary's use of decoys and debris that may exponentially complicate real-world use. Not only is the MDA's most expensive system mired by failure, new technological developments by the agency have shown to be ineffective and wasteful. There is a long list of expensive agency flops, including $2.2 billion for a failed sea-based radar, $5.3 billion on a scrapped chemical laser system, and $2.7 billion on an ineffective blimp-based radar system.

While the theater missile systems have a better testing record, they are not immune to reliability concerns. Up until 2006, THAAD had an exceedingly poor testing record of 2 out of 16, but since then, its testing record has improved to 16 out of 16. The Aegis continues to have a mixed record of 34 successes out of 43 attempts. The PAC-3's record is quite poor in the field, and the numbers from the Pentagon are highly disputed.

## Threat to strategic stability and arms control

In theory, effective missile defense should increase homeland security. However, the considerable funds budgeted toward largely ineffective systems like GMD could actually make the United States less safe.

While GMD is billed as a defense against a rogue state adversary with a small arsenal, such as North Korea, questions remain about the dangerous effects that ballistic missile defense systems may have on the behavior of more capable adversaries like Russia and China.

Specifically, Moscow and Beijing are concerned about the Aegis SM3-Block IIA, which the United States tested against an ICBM-class target in November 2020. The United States plans to deploy the system in Poland, ostensibly to counter a future potential Iranian threat, and in the Asia pacific. However, Russia and China have responded with a wide array of new missile capabilities that are meant to defeat U.S. missile defense systems. Testing theater missile defenses against ICBMs has led them to believe that U.S. theater missile defenses deployed near their borders may undermine their strategic nuclear deterrent.

Suspicion or concern about the expansion of missile defenses may encourage these adversaries to develop more evasive cruise missiles or build up their offensive ballistic missile capabilities to simply overwhelm mounting defenses – prompting a risky and counter-productive arms race.