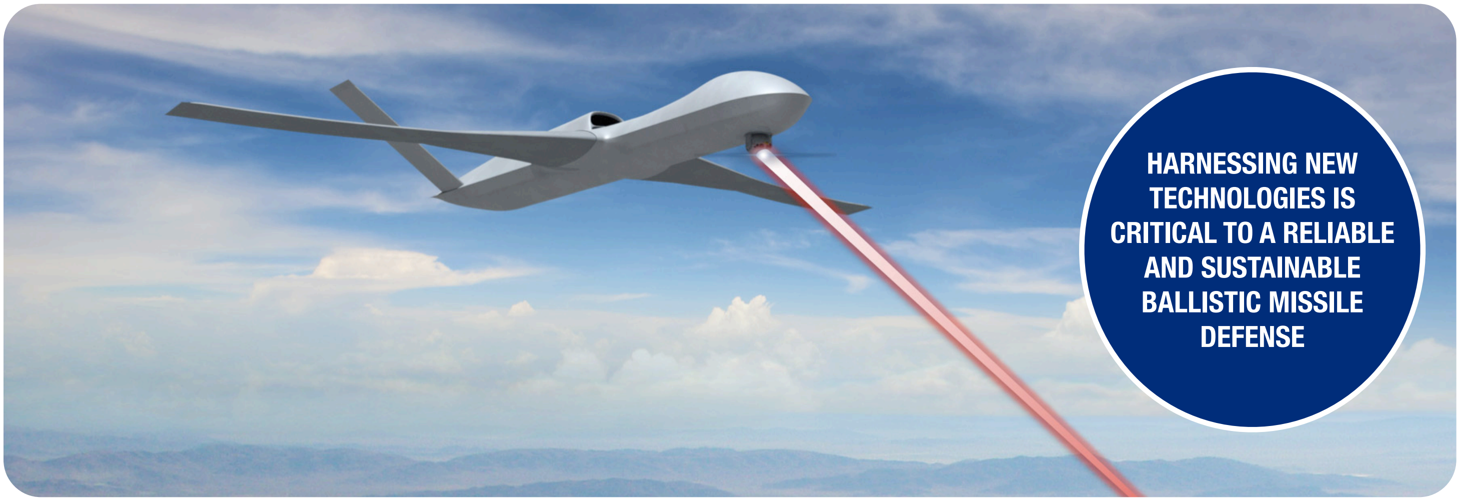
Missile Defense Advocacy Alliance

FUTURE MISSILE DEFENSE SYSTEMS

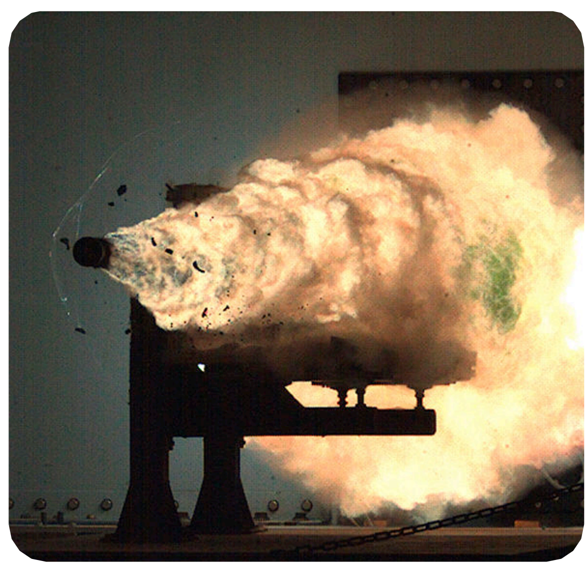
MDAA SYSTEM BRIEF #3
JULY 2015



AS TECHNOLOGY EVOLVES, the options for fielding a robust missile defense to protect the U.S. homeland, our deployed forces and allies continue to broaden. Approaches thought to be unfeasible decades ago are today quickly moving into the realm of the possible, even practical. While some initiatives look to harness revolutionary technologies such as directed energy, others can be done by enhancing currently deployed systems with existing technology.

HIGHLIGHTS:

- Capitalizing on technology developed for the Airborne Laser, MDA is researching the potential for **UAV's armed with directed energy systems** as a viable option for boost phase missile defense.
- Advances in **space-based tracking and surveillance** offer the opportunity to overcome the geographic limitation of ground and sea based radars for persistent tracking and kill assessment.
- The U.S. Army, Navy, and Air Force are investing in **directed energy platforms for force protection**, helping to pave the path for directed energy-based ballistic missile defense systems.



Railgun test firing, Naval Surface Warfare Center, January 2008

Boost Phase Missile Defense: A Second Look

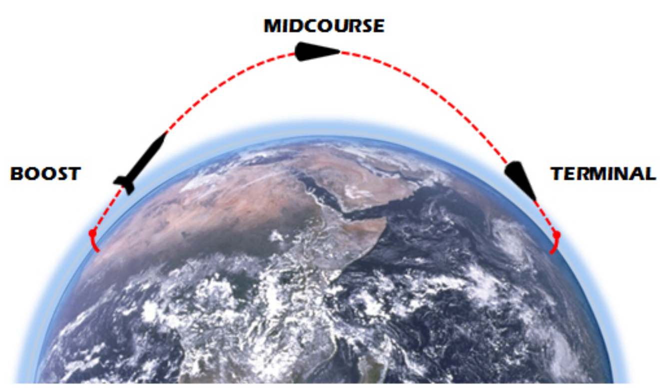
Boost phase missile defense entails the destruction of an enemy missile during the earliest stages of its flight, while it remains within the Earth's atmosphere. Having a viable boost phase defense has long been considered the "holy grail" of BMD, as boosting missiles are much slower and easier to track than during the midcourse or terminal stage. This makes them more vulnerable to interception. Boost phase defense also overcomes the challenges of discriminating between lethal warheads and debris, as the missile remains largely intact at this stage and has not had the opportunity to deploy decoys.

The main challenges for boost phase defense include the short window of opportunity between launch detection and the missile entering the midcourse phase. Kinetic interceptor systems must be placed either very close to a missile's launch point or be fast enough to cover the necessary distance before the missile enters midcourse. This has proven problematic from both geographic and engineering standpoints. The small window of opportunity also makes a dense system of early warning sensors necessary to ensure the maximum time possible to conduct an interception.

Boost phase defense was prominent in the Strategic Defense Initiative, launched in 1983. Defense Secretary Caspar Weinberger envisioned a constellation of orbiting interceptors that would intercept Soviet ICBMs in the boost phase to prevent the Multiple Independent Reentry Vehicles (MIRVs) and countermeasures from deploying. The Missile Defense Act of 1991 forced an end to serious exploration of space-based systems as Congressional pressure limited research to terrestrial systems that fell within limitations imposed by the Anti-Ballistic Missile (ABM) Treaty.

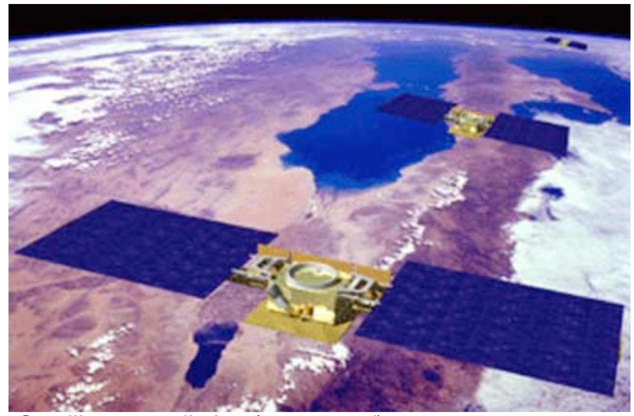
Subsequent discussions of boost phase missile defense in the 1990's centered on placing a high-speed air-launched rocket on either a bomber or Unmanned Aerial Vehicle (UAV) for theater missile defense missions. The last of these efforts in the 1990's was a joint U.S.-Israeli effort to place a Moab interceptor on an Israeli UAV, but the program was cancelled in 1999. In 1996, the Department of Defense invested in the Airborne Laser (ABL), which was intended to deploy a megawatt-class chemical laser aboard a 747 aircraft to destroy the skin of a missile during its boost phase. In 2004, the Missile Defense Agency (MDA) tested the ABL's laser on the ground and throughout 2010, the MDA Airborne Laser Test Bed (ALTB) proved the capability to destroy missiles in their boost phase. However, practical concerns about providing support aircraft to continuously deploy a 747 in enemy airspace eventually ended the project.

The long loiter times of UAVs make them the ideal systems to deploy advanced sensor capabilities and to potentially deploy future directed energy (laser) based systems for boost phase missile defense. Further development of solid-state lasers may be required to make such a system viable, as the ALTB had to be housed in a 747 due to the weight associated with its chemical laser. Sea-based interceptors could also be used in boost phase intercepts as long as the associated ships were deployed sufficiently close to adversary missile sites. The SM-3 Block IIA, co-developed with Japan and tested in June 2015, could also be outfitted for boost phase defense with investment in a lighter kill vehicle that would allow the system to reach the intercept speeds necessary to hit an accelerating missile.



PHASES OF BALLISTIC MISSILE FLIGHT
Image by Nuclear Threat Initiative

Space-Based Tracking and Discrimination: Current Status


Satellite constellation (conceptual)

Space-based radar systems provide a potential solution to the geographic problems associated with terrestrial radars. By operating from the ultimate high ground, they also cover significantly more of the globe than any single terrestrial radar can. A future constellation of satellites could provide birth-to-death tracking of adversary missiles, making the task of discrimination easier by providing a picture of the whole track of its flight. They also do not require negotiating basing agreements with foreign countries.

Current Systems and Programs

Cold War doctrine of massive and prompt retaliation to a nuclear attack drove the United States to deploy its first early warning satellites to detect missile launches in the 1950's. In 1960, the United States launched its first satellite as part of the Infrared Missile Defense Alarm System (MIDAS). The MIDAS program participated in 12 successful launches throughout the 1960's deploying increasingly sophisticated sensors. This success spawned the Defense Support Program (DSP), which launched its first satellite in November of 1970 and continued launches until 2007. Following the Scud battles of the 1991 Gulf War, DSP was enhanced to allow for detection of theatre ballistic missiles.

In addition to DSP satellites, agencies tasked with missile defense have attempted to develop midcourse missile tracking satellites. Efforts towards a constellation of low orbiting satellites to perform this mission started in the 1980's with Brilliant Eyes, a program run by the Strategic Defense Initiative Office (SDIO). In 1994, responsibility for the program transferred to the Air Force and became the low earth orbit element of the Space-Based InfraRed System (SBIRS). Initially known as the Space and Missile Tracking System, the program was eventually renamed SBIRS-Low.

In 2001, the SBIRS-Low program moved to the Missile Defense Agency. In 2002, it was renamed again as the SpaceTracking and Surveillance System (STSS). STSS launched its first satellites in November 2009 and completed the first birth-to-death tracking of a ballistic missile target in March 2011. In February 2013, the STSS demonstrators delivered missile track information for a live-fire intercept test of an Aegis system, proving that orbiting satellites can cue missile defense systems. The effort was part of MDA's Precision Tracking Space System (PTSS), which would have provided tracking data for all United States missile defense platforms.

Concerns about cost overruns and unmet deadlines caused PTSS funding to be zeroed out in FY2014. The demonstration satellites for STSS remain in use.

Near Term Movement and Issues

MDA has requested investment in the Space-Based Kill Assessment project, which was highlighted by Director VADM James Syring in hearings. This program would attempt to defray some of the costs of space-based sensors for government by using commercially hosted payloads to launch government instruments on commercial satellites. This model is based on the Air Force Commercially Hosted Infrared Payload (CHIRP). The first sensor is scheduled to launch in the fourth quarter of FY2016.

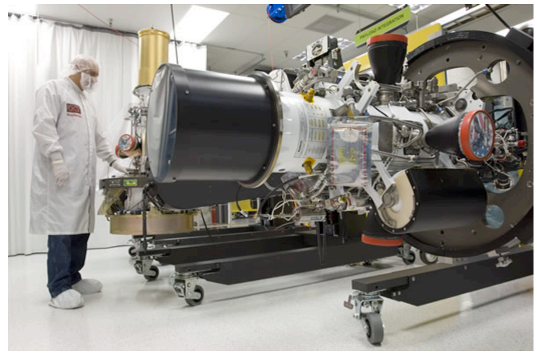
In addition to controlling costs, another important issue is making U.S. defense satellites less vulnerable to the growing threat of anti-satellite (ASAT) weapons. Reducing costs will aide in this, as it would allow for larger satellite constellations that are more resilient to ASAT attacks.


CHIRP Satellite (conceptual)

What's Next in Missile Defense: An Overview

The following is a brief overview of some (not all) of the important active and conceptual programs being pursued. While not all are directly in pursuit of ballistic missile defense, they are laying critical groundwork for that potential application.

Redesigned Kill Vehicle (RKV) - The RKV is the next generation of kill vehicle for the U.S. homeland missile defense systems. MDA requested $279 million in its FY 2016 budget request to start the project. Taking lessons learned from the development of the currently deployed CE-1 and CE-2 kill vehicles, the RKV's design will emphasize greater reliability and modularity for increased producibility. It is expected to begin deployment onto Ground Based Interceptors in Alaska and California by 2020.



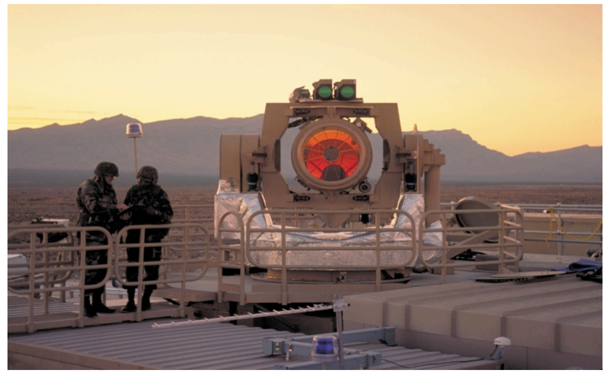
Multiple Object Kill Vehicle (MOKV) - The problem posed by missile salvos and decoys led MDA to research the Multiple Kill Vehicle (cut in 2009), which has since been revived as the MOKV. Envisioned as a follow on to the RKV, the design would allow multiple kill vehicles to deploy on a single missile interceptor missile allowing it to engage multiple targets. The House Armed Services Committee allocated $86 million for the MOKV development program in the FY2016 budget.

Long Range Discriminating Radar (LRDR) - The LRDR will be a large S-Band radar deployed in central Alaska. The S-Band radar will provide persistent tracking and discrimination data of ballistic missiles heading towards the United States from the Asia-Pacific region. Its long range will fill in many of the gaps that currently exist in U.S. situational awareness over the Pacific Ocean.

Clear Air Force Station, Alaska, chosen site of LRDR

Extended Range Terminal High-Altitude Air Defense (THAAD ER), a longer ranged version of the current THAAD system, presents a possible solution to the emerging threat of hypersonic glide vehicles. MDA provided $2 million to study the concept in FY2014 but currently the program remains in the company funded concept phase. The extended range would likely come from an expansion to the boosters, which would require changes to the ground launchers, but not to the interceptors.

High Energy Laser Mobile Demonstrator (HEL MD) - This U.S. Army system is being developed to provide force protection against rockets, artillery, cruise missiles and UAVs. The system was successfully tested in 2013, downing more than 150 targets, including mortar shells and UAVs in flight. During testing, the HEL MD also showed an ability to operate in inclement weather, including rain, high wind and fog.



The **High Energy Liquid Laser Air Defense System (HELLADS)** is the Defense Advanced Research Project Agency (DARPA) developmental solid-state laser project to produce a 150 kW laser weapon. Innovation in solid-state lasers allows the system to be ten times lighter and smaller than current chemical lasers, allowing the system to be integrated on tactical aircraft. DARPA announced that the system would move from laboratory development into Air Force field-testing in May.

The **LPD Based Ballistic Missile Defense Ship (BMD Ship)** is a conceptual redesign of the LPD-class hull to house a 30-35 foot multi-faced S-Band radar for mobile, large area missile tracking and discrimination. Certain configurations of the ship would also facilitate launch tubes for interceptors, directed energy weapons, and a rail gun.

The U.S Navy's **Laser Weapon System (LaWS)** successfully engaged targets from the USS Ponce during tests from September to November 2014. These tests led to the deployment of the weapon and authority to use LaWS in the Persian Gulf to counter drones, helicopters, and small patrol boats. In the future, the Navy hopes to expand the power available to lasers to allow them to counter anti-ship ballistic missiles.

The U.S. Navy and DARPA is working to develop an **Electromagnetic Railgun**, which uses a burst of electricity to propel a projectile for missile defense purposes. In June 2015, railgun projectiles with on-board electronics passed tests in the launch environment marking a major step toward deployment of the system. Interceptors for the railgun would be significantly cheaper than missile interceptors used in current missile defense systems.

Directed Energy Basics: Laser Types

Chemical

Chemical lasers use the energy-liberating reaction of a mix of chemicals in their gaseous states to create atoms and ions in excited states that can be focused on a point by a lasing medium. The reactions must take place at very low temperatures, which requires a series of vacuum pumps, chemical management systems, and low-pressure reaction chambers. All of this equipment takes up a significant amount of space and requires toxic chemicals, limiting the number of platforms that can house chemical lasers. Chemical lasers also require a significant amount of chemical feedstock to equip the war fighter with a large enough magazine to take multiple shots. The Airborne Laser Test Bed used a chemical oxygen-iodine laser (COIL), which has been the most developed chemical laser concept, to produce the megawatts of power required for boost phase missile intercepts.

Solid-State

In contrast, solid-state lasers (SSL) use electrical energy and ceramic or glass-like solid as a lasing media. The shape of the lasing media differentiates the three types of SSLs: bulk lasers, fiber lasers, and thin-disk lasers. Bulk and thin-disk lasers both use glass or crystalline slabs of various thickness coated with elements whose excited ions produce the beam. Fiber lasers use strands of fibers, much like optical fibers, coated in similar elements to slab style lasers. Outputs of multiple SSLs can also be combined to generate a single beam with a higher output. While these systems require less space to house components than chemical lasers, they have yet to produce sufficient power in the beams to pierce ballistic missile casing.

Free Electron

The Navy has worked on developing free electron lasers (FEL), which use beams of electrons accelerated to nearly the speed of light in rings and powerful magnets to then "wiggle" the electron beams into a focused beam of laser photons. These beams can be tuned to different wavelengths to adjust to different atmospheres, making them adaptable in the maritime environment. The Navy hopes to produce a multi-megawatt FEL in the 2020's. To accomplish that and turn an FEL into a deployable system, work will need to be done to increase the efficiency of its energy use, regulation of thermal loads and shielding of systems of personnel.

Graphic by the Center for Strategic and Budgetary Assessments