Missile defense

Missile defense is a system, weapon, or technology involved in the detection, tracking, interception and destruction of attacking missiles. Originally conceived as a defence against nuclear-armed Intercontinental ballistic missiles (ICBMs), its application has broadened to include shorter-ranged non-nuclear tactical and theater missiles.

The interception technology used has varied over time. In the 1960s, missile defense against ICBMs emphasized nuclear warheads. In recent decades non-nuclear kinetic warheads have been used. Directed-energy weapons such as lasers have been investigated and deployed on a limited basis.

The United States, Russia, France, India and Israel have all developed such air defense systems. In the United States, missile defense was originally the responsibility of the Army. The U.S. Missile Defense Agency has developed maritime systems and command and control that will eventually be transferred to the Navy and Air force for operation and sustainment.

Missile defense can be divided into categories based on various characteristics: type/range of missile intercepted, the trajectory phase where the intercept occurs, and whether intercepted inside or outside the Earth's atmosphere:

Type/range of missile intercepted

The types/ranges are strategic, theater and tactical. Each entails unique requirements for intercept, and a defensive system capable of intercepting one missile type frequently cannot intercept others; however there is sometimes overlap in capability.

Strategic missile defense

Targets long-range ICBMs, which travel at about 7 km/s (15,700 mph). Examples of currently active systems: Russian A-135 system which defends Moscow, and the U.S. Ground-Based Midcourse Defense system that defends the United States from missiles launched from Asia. Geographic range of strategic defense can be regional (Russian system) or national (U.S. system).

Theater missile defense

Targets medium-range missiles, which travel at about 3 km/s (6,700 mph) or less. In this context the term "theater" means the entire localized region for military operations, typically a radius of several hundred kilometers. Defense range of theater defensive systems is usually on this order. Examples of deployed or soon-to-be deployed theater missile defenses: American THAAD and Russian S-400 Triumf.

Tactical missile defense

Targets short-range tactical ballistic missiles, which usually travel at less than 1.5 km/s (3,400 mph). Tactical anti-ballistic missiles (ABMs) have short ranges, typically 20–80 km (12–50 miles). Examples of currently-deployed tactical ABMs: American MIM-104 Patriot and Russian S-300V.

Trajectory phase

Ballistic missiles can be intercepted in three regions of their trajectory: boost phase, midcourse phase or terminal phase.

Boost phase

Intercepting the missile while its rocket motors are firing, usually over the launch territory (example: American aircraft-mounted laser weapon Boeing YAL-1 [under development]).

Advantages

- Bright, hot rocket exhaust makes detection, discrimination and targeting easier.
- Decoys cannot be used during boost phase.

Disadvantages

- Difficult to geographically position interceptors to intercept missiles in boost phase (not always possible without flying over hostile territory).
- Short time for intercept (typically about 180 seconds).

Mid-course phase

Intercepting the missile in space after the rocket burns out (example: American Ground-Based Midcourse Defense (GMD)).

Advantages

- Extended decision/intercept time (the coast period through space before reentering the atmosphere can be several minutes, up to 20 minutes for an ICBM).
- Very large geographic defensive coverage; potentially continental.

Disadvantages

- Requires large/heavy anti-ballistic missiles and sophisticated powerful radar which must often be augmented by space-based sensors.
- Must handle potential space-based decoys.

Terminal phase

Intercepting the missile after it reenters the atmosphere (examples: American Aegis Ballistic Missile Defense System, American Sprint, Russian ABM-3 Gazelle)

Advantages

- Smaller/lighter anti-ballistic missile required
- Balloon decoys do not work during reentry.
- Smaller, less sophisticated radar required.

Disadvantages

- Very short intercept time, possibly less than 30 seconds.
- Less defended geographic coverage.
- Possible blanketing of target area with hazardous materials in the case of detonation of nuclear warhead(s).

Intercept location relative to the atmosphere

Missile defense can take place either inside (endoatmospheric) or outside (exoatmospheric) the Earth's atmosphere. The trajectory of most ballistic missiles takes them inside and outside the Earth's atmosphere, and they can be intercepted either place. There are advantages and disadvantages to either intercept technique.

Some missiles such as THAAD can intercept both inside and outside the Earth's atmosphere, giving two intercept opportunities.

Endoatmospheric

Endoatmospheric anti-ballistic missiles are usually shorter ranged (example: American MIM-104 Patriot).

Advantages

- Physically smaller/lighter
- Easier to move and deploy
- Endoatmospheric intercept means balloon-type decoys won't work

Disadvantages

- Limited range and defended area
- Limited decision and tracking time for the incoming warhead

Exoatmospheric

Exoatmospheric anti-ballistic missiles are usually longer ranged (example: American Ground-Based Midcourse Defense).

Advantages

- More decision and tracking time
- Fewer missiles required for defense of a larger area

Disadvantages

- Larger/heavier missiles required
- More difficult to transport and emplace than smaller missiles
- Must handle decoys

History

In the 1950s and 1960s, the term meant defense against strategic (usually nuclear-armed) missiles. The technology mostly centered around detecting offensive launch events and tracking in-bound ballistic missiles, but with limited ability to actually defend against the missile. The Soviet Union achieved the first nonnuclear intercept of a ballistic missile warhead by a missile at the Sary Shagan antiballistic missile defense test range on 4 March 1961.

Throughout the 1950s and 1960s, the United States Project Nike air defense program focused initially on bombers, then ballistic missiles. In the 1950s, the first United States anti-ballistic missile system was the Nike Hercules, which had a limited ability to intercept incoming ballistic missiles, although not ICBMs. This was followed by Nike Zeus, which using a nuclear warhead could intercept ICBMs. However Nike Zeus had other limitations which prevented it being deployed. In any case, by the early 1960s the Nike Zeus was the first anti-ballistic missile to achieve hit-to-kill (physically colliding with the incoming warhead).

The Zeus missile was enhanced, and the shorter range Sprint missile was added to the Nike defense system, then called Nike-X. The system included large powerful radars and a computer complex.

Eventually, the Nike-X program was realigned and renamed Sentinel. This program's goal was to protect major U.S. cities from a limited ICBM attack, especially focusing on China. This in turn reduced tensions with the Soviet Union, which retained the offensive capability to overwhelm any U.S. defense.

The Soviet Union deployed the A-35 anti-ballistic missile system around Moscow in 1966, which also defended nearby ICBM sites. That system has been upgraded several times and is still operational. The United States announced an ABM program to protect twelve ICBM sites in 1967.

In 1967, then-Secretary of Defense Robert McNamara stated: *"Let me emphasize -- and I cannot do so too strongly -- that our decision to go ahead with a limited ABM deployment in no way indicates that we feel an agreement with the Soviet Union on the limitation of strategic nuclear offensive and defensive forces is in any way less urgent or desirable."*

The SALT I talks began in 1969, and led to the Anti-Ballistic Missile Treaty in 1972, which ultimately limited the U.S. and U.S.S.R. to one defensive missile site each, with no more than 100 missiles per site.

As a result of the treaty and of technical limitations, along with public opposition to nearby nuclear-armed defensive missiles, the U.S. Sentinel program was redesignated the Safeguard Program, with the new goal of defending U.S. ICBM sites, not cities. The U.S. Safeguard system was deployed to defend the LGM-30 Minuteman ICBMs near Grand Forks, North Dakota. It was deactivated in 1976 after being operational for less than four months due to a changing political climate plus concern over limited effectiveness, low strategic value, and high operational cost

An artist's concept of a Space Laser Satellite Defense System as a part of the Strategic Defense Initiative

In the early 1980s, technology had matured to consider space based missile defense options. Precision hit-to-kill systems more reliable than the early Nike Zeus were thought possible. With these improvements, the Reagan Administration promoted the Strategic Defense Initiative, an ambitious plan to provide a comprehensive defense against an all-out ICBM attack. Reagan established the Strategic Defense Initiative Organization (SDIO), which was later changed to the Ballistic Missile Defense Organization (BMDO). In 2002, BMDO's name was changed to its current title, the Missile Defense Agency (MDA). See National Missile Defense for additional details. In the early 1990s, missile defense expanded to include tactical missile defense, as seen in the first Gulf War. Although not designed from the outset to intercept tactical missiles, upgrades gave the Patriot system a limited missile defense capability. The effectiveness of the Patriot system in disabling or destroying incoming Scuds was the subject of Congressional hearings and reports in 1992.

In the late 1990s, and early 2000s, the issue of defense against cruise missiles became more prominent with the new Bush Administration. In 2002, President George W. Bush withdrew the US from the Anti-Ballistic Missile Treaty, allowing further development and testing of ABMs under the Missile Defense Agency, and allowing for deployment of interceptor vehicles beyond the single site allowed under the treaty.

There are still technological hurdles to an effective defense against ballistic missile attack. The United States National Ballistic Missile Defense System has come under scrutiny about its technological feasibility. Intercepting midcourse (rather than launch or reentry stage) ballistic missiles traveling at several miles per second with a "kinetic kill vehicle" has been characterized as trying to hit a bullet with a bullet. Despite this difficulty, there have been several successful test intercepts and the system was made operational in 2006, while tests and system upgrades continue. Moreover, the warheads or payloads of ballistic missiles can be concealed by a number

of different types of decoys. Sensors that track and target warheads aboard the kinetic kill vehicle may have trouble distinguishing the "real" warhead from the decoys, but several tests that have included decoys were successful. Nira Schwartz's and Theodore Postol's criticisms about the technical feasibility of these sensors have led to a continuing investigation of research misconduct and fraud at the Massachusetts Institute of Technology.

As of February 2007, the U.S. missile defense system consists of 13 ground-based interceptors at Ft Greely in Alaska, plus two interceptors at Vandenberg AFB, California. The U.S. plans to have 21 interceptor missiles by the end of 2007. The system was initially called National Missile Defense (NMD), but in 2003 the ground-based component was renamed Ground-Based Midcourse Defense (GMD).

Defending against cruise missiles is similar to defending against hostile, low-flying manned aircraft. As with aircraft defense, countermeasures such as chaff, flares, and low altitude can complicate targeting and missile interception. High-flying radar aircraft such as AWACS can often identify low flying threats by using doppler radar. Another possible method is using specialized satellites to track these targets. By coupling a target's kinetic inputs with infrared and radar signatures it may be possible to overcome the countermeasures.

In March 2008, the U.S. Congress convened hearings to re-examine the status of missile defense in U.S. military strategy. Upon taking office, President Obama directed a comprehensive review of ballistic missile defense policy and programs. The review's findings related to Europe were announced on 17 September 2009. The full Ballistic Missile Defense Review (BMDR) Report was published in February 2010. As of 2012, there is no pressing need for an American missile defense system. Those countries that do have nuclear armed missiles that can reach the United States are all either American allies, or are in the case of Russia and China, in a stable deterrence posture with the United States.