The Space-Based Laser Integrated Flight Experiment: Global Missile Defense in the Boost Phase

The Space-Based Laser (SBL) is a next-generation directed energy missile defense system being explored today to provide global, boost-phase intercept of ballistic missiles tomorrow.

SBL is being pursued in a technology demonstration program aimed at launching an experimental laser into space in 2012 to shoot down a ballistic missile in 2013. The technology demonstration will be conducted in full compliance with all relevant international treaties, including the Anti-Ballistic Missile Treaty of 1972. Known as an Integrated Flight Experiment, or IFX, the program will help Department of Defense policy-makers decide whether to pursue an operational SBL system designed to protect the United States and its allies from ballistic missiles as part of a layered defense.

In the future, an operational SBL would be integrated within the National Missile Defense architecture and the family of theater missile defense programs.

Why Missile Defense Is Needed

Ballistic missiles have represented one of the greatest vulnerabilities for all the nations of the world ever since the Nazis first launched the V-2 rocket near the end of World War II. One of the tragic reminders of the real and increasing threat to U.S. forces deployed abroad was the death of 28 U.S. soldiers caused by a Scud missile that struck a barracks in Dhahran during the Gulf War. More than five decades after the V-2 first appeared and nearly a decade after the Gulf War, U.S. forward-deployed troops, allies, and even the U.S. mainland remain vulnerable to missile attack and the potential delivery of weapons of mass destruction.

In his February 2000 testimony on the Worldwide Threat, CIA Director George Tenet said that the proliferation of weapons of mass destruction had "become even more stark and worrisome" than just a year before. "Transfers of enabling technologies to countries of proliferation concern have not abated," he said. "Many states in the next ten years will find it easier to obtain weapons of mass destruction and the means to deliver them."[1]

Tenet added that "the missile threat to the United States from states other than Russia and China is steadily emerging. The threat to US interests and forces overseas is here and now." Tenet pointed out that, over the next 15 years, U.S. cities will face ICBM threats from a wider variety of nations, including North Korea, Iran, and possibly Iraq. He also expressed concern about the security of nuclear weapons and materials in Russia.[2]

In its unclassified version of its 1999 National Intelligence Estimate, the intelligence community reiterated that "the proliferation of medium-range ballistic missiles (MRBMs) – driven primarily by North Korean No Dong sales – has created an immediate, serious, and growing threat to US forces, interests and allies, and has significantly altered the strategic balances in the Middle East and Asia."[3]

In South Asia, Pakistan and India are locked in a nuclear rivalry, and the intelligence community has assessed that both countries' short-range and medium-range ballistic missiles may have nuclear roles.[4]

Foreign assistance has played a key role in the increasing proliferation of missile technology, with Russia, China, and North Korea as the principal suppliers. And, Tenet warns, the recipients of missile-related technology, such as Syria and Iraq, "may emerge in the next few years as suppliers."[5]

Where SBL Fits In

The United States is currently pursuing a limited National Missile Defense program that will employ "hit-to-kill" interceptors to shoot down a small number of missiles that could be launched by a rogue regime or by accident. Hit-to-kill, or kinetic kill, occurs when a defensive interceptor missile collides with and destroys an incoming warhead by force of impact as it travels through space or the atmosphere.

In addition to the National Missile Defense program, there is a family of theater missile defense systems under development to protect forward-based troops, allies, other countries, and areas of vital interest. They include the Theater High Altitude Area Defense (THAAD), Navy Theater Wide, Navy Area, the Airborne Laser (ABL), Patriot Advanced Capability-3, and the multi-national Medium Extended Area Defense systems. All of these except Navy Area and the Airborne Laser use hit-to-kill technology to destroy ballistic missiles. Navy Area uses a proximity-explosion, in which an interceptor flies close to an incoming theater missile and then explodes, destroying the missile. And ABL, which consists of a laser mounted on a modified 747 aircraft, uses directed energy to achieve destruction of aggressor missiles during the boost phase, soon after they launch.

The Space-Based Laser is the only ballistic-missile, boost-phase intercept system being pursued by the Department of Defense to provide global defense coverage to counter ICBM attacks against the United States or its allies. Like ABL, it will rely on directed energy to destroy missiles shortly after launch. An operational SBL would be the first line of defense against ICBMs launched by an aggressor, and it would complement the capability of the land-based interceptors currently being developed under the National Missile Defense program. An SBL system could provide a robust additional layer to the currently planned missile defense architecture in response to the expected growth of ICBM threats now projected by the intelligence community. If the Space-Based Laser Integrated Flight Experiment (SBL-IFX) is successful, it will provide the technological path for the development of a prototype SBL and, eventually, an operational system sometime around 2020.

An operational SBL could also provide strategically significant ancillary capabilities in the area of space control, surveillance and reconnaissance, strike and interdiction, and defensive and offensive counter air missions.

A Layered Defense

The best way to counter even a limited number of missiles is through defense in depth. Defense in depth means there will be a number of opportunities to destroy missiles as they are launched and move through the various stages of their flight paths, or trajectories. For National Missile Defense, a land-based, hit-to-kill interceptor is currently being developed to intercept warheads in the middle of their flight paths. There is also discussion and study of using sea-based missile defenses to complement the land-based system. For its part, SBL represents a potential future space-based component of a national missile defense architecture with residual capability that will enhance the planned theater missile defense architecture.

Today, theater missile defense is already being pursued in the form of a layered defense. A family of defensive systems will be able to attack short- and medium-range missiles in various stages of their flight. The boost phase, which occurs shortly after a missile is launched, is the first shot defensive systems have at destroying a hostile missile. Presently, the Airborne Laser is the only theater system being developed that will be capable of attacking and destroying a ballistic missile in the boost phase. The boost phase lasts only a few minutes, after which the launcher burns out. The warhead then continues to ascend and travels outside the atmosphere into space during the middle, or mid-course phase, of its trajectory. A typical trajectory looks like an arc. The mid-course comes after boost phase and before the descent phase. It is during the mid-course phase that decoys might be deployed, complicating the defending nation's ability to intercept the actual warhead.

The final phase of a ballistic missile attack occurs when the warhead descends back into the atmosphere toward its target on the ground. Here, in what is also called the terminal phase, the warhead picks up more speed. The critical aspect of an intercept during this final phase is to hit and destroy the warhead before it explodes. It is also important to hit it high enough to avoid any damage from nuclear, chemical or biological debris.

The only active defense the United States has deployed today is a slightly upgraded version of the Patriot missile system used in the Gulf War against short-range Scud missiles. This system is not designed to intercept ICBMs, just short-range ballistic missiles. It will be replaced by the PAC-3 Patriot system in 2001, which will be able to intercept short- and medium-range missiles inside the atmosphere during their descent phase, along with cruise missiles. The Navy Area system, based on Aegis cruisers and destroyers, will complement PAC-3, helping to intercept these shorter-range missiles inside the atmosphere.

The Advantages and Challenges of Boost Phase Intercept

There are a number of advantages to intercepting an aggressor's missile in the boost phase. The first is that the missile is most vulnerable during its launch. There is a large infrared signature, thanks to the burning fuel; the missile maintains a slowly changing attitude, making it easier to track; and the rocket body is relatively fragile and under great aerodynamic stress. Additionally, because the warhead has not separated from the launcher, there is a relatively large lethal-hit area when attempting to destroy the missile.

The boost phase also occurs before any decoys or countermeasures can be initiated by an aggressor. One of the greatest challenges for hit-to-kill kinetic interceptors attempting to destroy warheads in the mid-course or descent phases is the ability to distinguish between the warheads and the decoys. In the descent phase, advanced warheads may also maneuver and be less predictable in terms of their flight paths.

The combination of using directed energy intercept in the boost phase and kinetic intercept in the mid-course and terminal phases would increase the likelihood of successfully defeating countermeasures aimed at thwarting missile defense systems. In fact, countermeasures, like deploying decoys and maneuvering outside of the projected target track, which may be effective against kinetic interceptors, are ineffective against directed energy attack during boost phase. Likewise, countermeasures that are aimed at reducing the effectiveness of directed energy systems, like hardening of missiles to prevent laser penetration and fast burn to shorten the boost phase, are ineffective against mid-course and terminal phase kinetic interceptors.

Another key advantage and potential deterrent to a would-be aggressor is the fact that ballistic missiles destroyed early in the boost phase usually explode and fall over the aggressor's own territory, forcing the aggressor to confront the risk of nuclear, chemical or biological debris.

The greatest challenge of boost phase intercept is the speed required to catch an aggressor's missile in the first few minutes of flight. Although the United States has the capability to detect missile launches very early in flight, the speed limitations of interceptor missiles being developed make it unlikely that they could destroy the aggressor missile before its launcher burns out.

This challenge, however, can be overcome by using directed energy, which moves at the speed of light 186,000 miles per second (or 300,000 kilometers per second). To illustrate this advantage, consider the speed of the ground-based interceptor being developed for National Missile Defense, which is in the vicinity of 7 kilometers per second. (This is faster than today's theater interceptors under development, which were capped at 5.5 kilometers per second in the September 1997 Agreed Statement to the ABM Treaty of 1972.) Even if the interceptor were positioned close enough to achieve intercept, it is a very challenging task and not nearly as efficient as directed energy, which travels about 43,000 times faster than the most capable ground-based interceptors. Given its speed, directed energy should be seen as complementing the critical role kinetic interceptors play in the mid-course and terminal phases of a missile attack.

Both the Airborne Laser, which is being developed to address short- and medium-range theater ballistic missiles, and the Space-Based Laser, which is being designed to counter ICBMs deep in the aggressor's

territory, can detect and intercept missiles almost instantaneously. Each works by acquiring the infrared signature of the boosting missile, tracking its course with a low-power laser, and then focusing a high-power laser on the body of the boosting missile. The heat of the laser weakens the missile's skin, and the internal pressures and supersonic aerodynamic flight stresses cause it to explode.

Currently, the Airborne Laser is scheduled to attempt a lethal intercept of a theater missile in 2003. The SBL's flight experiment will attempt its first intercept ten years later in 2013. If both systems were to become operational in the future, they would afford the United States a robust first line of defense during the boost phase.

Directed Energy: It's Here Now

In June 2000, the Tactical High Energy Laser, or THEL, successfully shot down a Katyusha rocket at the White Sands Missile Range in New Mexico. On several occasions in August and September, THEL managed another feat by engaging and destroying two-missile salvos of Katyusha rockets. To date, THEL has negated a total of 13 Katyusha rockets. Although THEL is being designed for tactical use by the U.S. Army and the Israeli Army, its success demonstrates how far directed energy research and development have progressed in recent years.

The SBL-IFX program builds on more than twenty years of research and investment by the nation in the development of directed energy weapon systems, technologies and related facilities. The Defense Advanced Research Projects Agency initiated the SBL program in 1977. It was later transferred to the Strategic Defense Initiative Organization (SDIO) in 1984. In May 1997, a Memorandum of Agreement was signed transferring execution of the SBL-IFX from the Ballistic Missile Defense Organization, SDIO's successor, to the Air Force.

Over the years, the members of Team SBL-IFX have played central roles in several directed energy programs that have advanced the nation's understanding of a space-based laser missile defense option, including Zenith Star, Mid-InfraRed Advanced Chemical Laser (MIRACL), Alpha, the Airborne Laser (ABL), the Tactical High Energy Laser (THEL), the High Energy Laser Systems Test Facility (HELSTF), and the Alpha-LAMP Integration (ALI) program. This heritage of success provides the foundation for a successful Space-Based Laser Integrated Flight Experiment □ a critical step toward providing the nation and its allies with a global, boost-phase defense against the evolving threat of ballistic missiles.

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[1] George J. Tenet, "The Worldwide Threat in 2000: Global Realities of Our National Security," Statement before the Senate Select Committee on Intelligence, February 2, 2000.
[2] Tenet, "The Worldwide Threat," February 2, 2000.
[3] "Foreign Missile Developments and the Ballistic Missile Threat to the United States Through 2015," National Intelligence Council, September 1999.
[4] Robert D. Walpole, National Intelligence Officer for Strategic and Nuclear Programs, "The Ballistic Missile Threat to the United States," Statement for the Record, Senate Subcommittee on International Security, Proliferation, and Federal Services, February 9, 2000.
[5] Tenet, "The Worldwide Threat," February 2, 2000.