MISSILE DEFENSE

THE BOOST-PHASE ADVANTAGE

FINDINGS IN BRIEF

Ballistic missiles equipped with nuclear warheads and other mechanisms of mass destruction are the most potent weapons that America's defenders face. The number of ballistic missiles in global arsenals has declined considerably since the end of the cold war, but the number of nations possessing such weapons has increased. At least nine countries today have both ballistic missiles and nuclear warheads, raising doubts about whether the traditional approach to deterrence can work over the long run.

Ballistic-missile defense has the potential to strengthen deterrence by discouraging smaller nuclear nations from acquiring or launching weapons of mass destruction. While current U.S. defensive efforts pose little danger to the deterrent capabilities of Russia and China, they could completely defeat attacks by North Korea or Iran. That is especially true if enemy missiles can be intercepted in the earliest and most vulnerable stage of their trajectory, known as boost phase.

Interception of ballistic missiles in boost phase or the "ascent phase" that immediately follows rocket-motor burnout enables defenders to destroy payloads before they separate into numerous, hard-to-track objects. This maximizes the effectiveness of any defensive system, thinning out or eliminating the threat faced by subsequent layers of defense.

The Missile Defense Agency currently is funding several boost-phase interception programs. The Kinetic Energy Interceptor (KEI) is a mobile, fast-reacting missile that can be quickly deployed worldwide for early interception of ballistic missiles. The Airborne Laser (ABL) is an aircraft-mounted beam weapon that can hit lofting missiles at the speed of light and will be demonstrated against a live target in 2009. The Network Centric Airborne Defense Element (NCADE) and Air Launched Hit-to-Kill (ALHTK) programs are less costly adaptations of existing weapons to the boost-phase interception mission.

This report was written by Dr. Loren Thompson of the Lexington Institute staff as part of the institute's continuing inquiry into future military-technology requirements and options.

MISSILE DEFENSE

THE BOOST-PHASE ADVANTAGE

In the long history of warfare, no weapon has ever surpassed the fearsome lethality of ballistic missiles equipped with nuclear warheads. A single such missile, equipped with multiple warheads, can kill a million people and cause hundreds of billions of dollars in damage. The warheads are so small, and move so fast, that they are devilishly difficult to intercept before they reach their targets.

Because the prospects for effective defense against ballistic missiles seemed bleak during the cold war, America and Russia decided to rely instead on the threat of nuclear retaliation to prevent war. That approach, called deterrence, worked when there were only two countries with sizable nuclear arsenals. Today there are nine countries capable of launching nuclear warheads on ballistic missiles, and several other countries such as Iran that are actively pursuing the capability.

It is not clear whether deterrence based on the threat of retaliation can work in a world of diverse nuclear actors. Some experts doubted it would last even when there were only two major nuclear players, because eventually leaders would arise who were irrational or accident-prone. Today, the global landscape presents several examples of leaders who cannot be trusted to behave in ways required to maintain stable deterrence.

This report is about a different approach to dealing with ballistic missiles capable of causing mass destruction -- regardless of whether they carry nuclear, chemical or biological warheads. It describes the benefits of intercepting ballistic missiles in the earliest, most vulnerable phase of their trajectory, known as boost phase. That is when missiles are easiest to track, and when they present the smallest number of targets that must be destroyed to negate their destructive potential.

Boost-phase interception is not an alternative to deterrence and arms control, nor is it an alternative to intercepting warheads later in their trajectory. It complements all of those other approaches to nuclear security by presenting hostile countries with powerful incentives for not acquiring or launching nuclear weapons. With regard to deterrence and arms control, boost-phase interception reduces the military value of ballistic missiles so that countries possessing them are less likely to take risks and more likely to disarm. With regard to attacking warheads later in their trajectory, boost-phase interception makes that task much easier by thinning out or entirely eliminating threats.

The report begins by describing the ballistic-missile threat, detailing government plans for countering it, and explaining why boost-phase interception offers the greatest potential for effective defense. It then identifies several promising approaches to achieving boost-phase interception, and recommends a low-cost path for moving forward. Although it focuses mainly on ballistic missiles armed with nuclear warheads, the concepts and programs it explores are equally applicable to ballistic missiles carrying other kinds of kill mechanisms -- such as those that threaten U.S. forward-deployed forces.

A COMPLEX CHALLENGE

The threat posed to the United States and its allies by ballistic missiles in the hands of potentially hostile countries is complex. Ballistic missiles are built with many different ranges, and carry a wide array of warheads. Some countries -- such as Russia and China -- are capable of using ballistic missiles to deliver high-yield nuclear warheads over intercontinental distances, and the warheads are equipped with penetration aids to confuse defenders. Other countries have missiles of lesser range, and fewer warheads with simpler features. And some countries have mastered the technologies associated with ballistic missiles, but currently lack a nuclear-weapons capability.

The defining characteristic of ballistic missiles is that they employ a powerful boost from rocket engines to launch them on their trajectories, after which they coast to their intended destinations. Although the trajectory is predictable, it is traversed so quickly that interception is impossible using conventional weapons. For instance, an intercontinental ballistic missile may move at several miles per second, much faster than any other target that U.S. forces are equipped to counter. Experts distinguish four categories of ballistic missiles, based on their range:

-- Short-range missiles that can reach as far as a 600 kilometers.
-- Medium-range missiles that can reach from 600-1,300 kilometers.
-- Intermediate-range missiles that can reach 1,300-5,500 kilometers.
-- Intercontinental-range missiles that can reach 5,500-10,000 kilometers.

Weapons with longer ranges typically move faster than those with shorter ranges, and therefore are harder to intercept. They also typically have larger payloads, with some carrying ten or more warheads. In general, the further a ballistic missile can reach, the more military options and political prestige it provides to its owner. For example, a short-range missile launched by North Korea cannot hit far beyond the Korean Peninsula, but a medium-range missile can hit most of Japan, an intermediate-range missile can hit Taiwan, and an intercontinental-range missile can hit much of the United States. The power associated with possessing such options is a key reason why countries like Iran and North Korea expend so much effort pursuing ballistic-missile technology. No other class of weapons confers so much military stature on a nation.

A recent study by the Center for America Progress found that the number of medium and intermediate-range missiles in global arsenals has declined by 80% since the closing days of the cold war, and that the number of intercontinental-range missiles has declined by about 70%. These declines demonstrate that when political conditions permit arms reduction, it is feasible to reduce the ballistic-missile threat to America and its allies without investing in elaborate defensive schemes. However, the study also found that during the same period some major powers were paring their arsenals, five countries developed new medium-range missiles, and three of those countries -- Iran, North Korea and Pakistan -- were newcomers or aspirants to the nuclear weapons club.

The spread of ballistic-missile technology has followed a classic proliferation pattern. Russia shared relevant technologies with China, which then shared them with North Korea, which in turn shared them with Pakistan and Iran. Russia, China and North Korea remain contributors to the ballistic-missile efforts of more recent acquirers. Because the regional powers that pursue weapons of mass destruction usually are led by unstable or insecure leaders, there is doubt that they can be included in a stable deterrence regime. However, the arsenals they acquire are so modest that missile defense is far more feasible against them than it would be against a country like China. Building missile defenses may strengthen the prospects for deterrence by reducing the tactical value of small arsenals.

This Minuteman III missile launch illustrates two of the reasons why boost-phase interception is often more advantageous than attempting interception later in a ballistic missile's trajectory. The bright exhaust plume of the booster is relatively easy for remote sensors to detect and track, and in some cases the point of origin for launches will be known in advance -- enabling defensive forces to position themselves during a crisis for early interception.

THE U.S. MISSILE-DEFENSE PLAN

The United States government has funded many missile-defense initiatives in the five decades since Russia launched its first intercontinental ballistic missile. Early programs like Sentinel and Safeguard were designed to use ground-based interceptors armed with nuclear warheads, but the destructive side-effects of those weapons led Washington to pursue other approaches. One alternative was putting high-power lasers in space, as proposed by President Reagan in his 1983 Strategic Defense Initiative. That concept was abandoned when the cold war ended due to high costs, immature technology and fears it might cause an arms race.

The biggest problem proponents of missile defense faced during the cold war was that Russia's nuclear arsenal was huge, and could easily overwhelm any defensive system then feasible. The same was true of America's nuclear arsenal, so the two superpowers focused mainly on stabilizing the nuclear balance. But other powers were gradually joining the nuclear club, and as they did U.S. leaders became concerned that they might not be as tractable as the Russians. In 1998 a presidential commission warned that the nuclear threat from "rogue states" such as North Korea was growing rapidly. In response, the Clinton Administration proposed a $60 billion plan to build radars and interceptor missiles that could defend all 50 states against a limited nuclear attack.

President Bush entered the White House in 2001 committed to deploying a missile-defense system "as soon as technologically possible." During his first year in office, Bush decided to withdraw from the Anti-ballistic Missile Treaty signed with the Russians 30 years earlier, arguing that it was an impediment to building effective defenses and no longer served U.S. interests in the post-communist world. A year later, he directed the reorganized Missile Defense Agency to begin deploying national missile defenses by 2004. As a result, the United States now has an operational system of missile-defense sensors and interceptors tied together by a dedicated command network.

The current system, called Ground-based Midcourse Defense, is designed to intercept long-range missiles during the part of their trajectory when they are coasting through space. Radars and infrared sensors for tracking warheads are deployed in space and at various surface locations around the world, while several dozen high-performance interceptor missiles are deployed at two sites in Alaska and California. The Missile Defense Agency plans to build out this initial network by gradually adding systems that can attack ballistic missiles of any range in all of the phases of their trajectory. Components of the plan include:

-- The Airborne Laser (ABL) and ground-mobile Kinetic Energy Interceptor (KEI) for destroying ballistic missiles of any range in the initial boost phase of their flight when they are most vulnerable.

-- The Ground-based Midcourse Defense (GMD) and sea-based Aegis Ballistic Missile Defense (ABMD) for attacking incoming warheads after boost phase while they are hurtling through space.

-- The ground-mobile Terminal High Altitude Area Defense (THAAD) and Patriot Advanced Capability Three (PAC-3) systems for intercepting warheads during the final 30-60 seconds of their trajectory, as they reenter the atmosphere.

The Missile Defense Agency is also funding a global sensor network and command system, plus a variety of other items such as realistic targets for testing defenses and low-cost interceptor concepts. The final goal is a layered architecture in which ballistic missiles launched against U.S. territory, forces or allies will face several lines of defense that cumulatively thin out or completely eliminate the threat. The agency does not expect any particular layer or weapon system to function perfectly, but if each one can achieve some reasonable degree of success, then the number of warheads that actually reach targets will be very small. The agency's budget for all of its activities currently totals about one percent of annual defense spending.

The Sea-Based X-Band Radar is a mobile missile-defense radar with sophisticated capabilities for tracking ballistic targets and distinguishing warheads from non-threatening items such as decoys. The radar was developed by the Missile Defense Agency to support testing of defensive systems, and to participate in the protection of U.S. territory, forces and allies.

THE BENEFITS OF BOOST PHASE INTERCEPTION

Ballistic missiles and the warheads they carry traverse several distinct phases between the moment when they are launched and the moment when they impact on their targets. During the first three to five minutes of flight, booster rockets are firing, generating the velocity required so warheads can reach distant targets. This portion of the trajectory is called boost phase, and it typically ends at altitudes of no more than 500 kilometers. Boost phase is followed by a brief period called ascent phase when rocket motors have ceased firing but warheads and penetration aids are not yet fully separated from the final stage of the missile. Ascent phase is followed by midcourse, the period when the payload is coasting through space that comprises most of the time between launch and impact. This is followed by a brief descent phase and then the terminal phase, a period of less than a minute when warheads re-enter the atmosphere and reach their target areas.

Each of these phases has special characteristics that demand unique defensive responses. For example, midcourse provides the longest time for defenders to sort out the elements of a threat, but warheads are harder to discriminate from decoys and debris while they are in space, and require very sophisticated defensive sensors to successfully engage. In contrast, the terminal phase allows defenders to use atmospheric filtering to sort out warheads from decoys and debris because they traverse the atmosphere at different rates, but defenders have less than a minute to intercept warheads before impact on target.

The Missile Defense Agency describes boost-phase and ascent-phase as the "ideal" time to intercept ballistic missiles, given the characteristics the missiles exhibit during the earlier stages of flight:

-- The flaming booster stages present a bright signature that can be easily tracked from thousands of miles away.

-- The warheads and decoys have not fully separated from the missile, so there are fewer targets to engage.

-- The amount of time remaining to defenders to correct for misses is greater than at later phases in the trajectory.

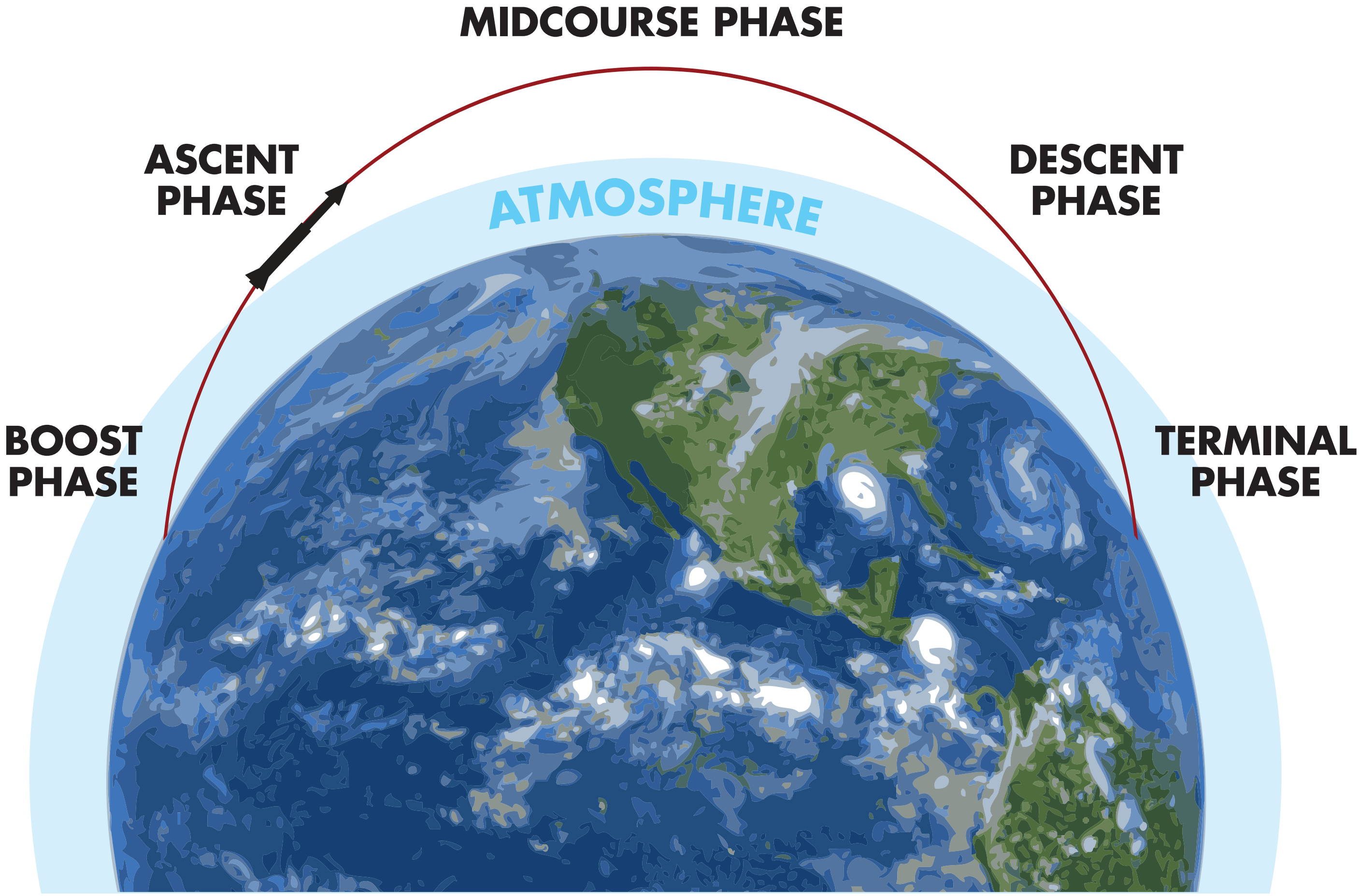
-- The amount of down-range space that can be protected by defensive efforts is maximized.

However, the advantages afforded by boost-phase or ascent phase interception come at a price. Defenders must detect a launch and respond very quickly, because boosters will burn out and payloads will divide into many discrete objects in only a few minutes. In fact, the timelines for successful interception are so compressed that a 2003 study by the American Physical Society found it would not be feasible to achieve boost-phase interception of missiles launched by North Korea or Iran under normal circumstances. The society calculated there would be only 170 seconds from the moment of launch to booster burnout in a missile using solid propellant, and 240 seconds in a missile using less energetic liquid propellant. It concluded that in most scenarios there would be insufficient time for defenders to detect a launch and then intercept the missiles from likely defensive sites.

These findings are valid given the assumptions the study made, but there are several ways of improving the chances for defenders. First, missiles and their warheads can be engaged in the ascent phase, providing more time to respond and a wider range of basing options while still avoiding the challenge of numerous, hard-to-track targets. Second, high-energy lasers can be used to eliminate any delays associated with intercepting missiles from distant defensive sites, since light travels at a speed of 300,000 kilometers per second. Third, interception can be achieved from stealthy aircraft that hostile nations cannot detect even though they are loitering very close to launch sites. Examples of each approach are provided in the following pages.

BALLISTIC MISSILE TRAJECTORY

Ballistic-missile ranges vary considerably, from less than 1,000 kilometers to over 10,000. Regardless of their ranges, though, all of the ballistic missiles posing a major threat to U.S. security have trajectories exhibiting the same distinct phases:



BOOST PHASE

is the earliest segment of the missile trajectory, when rocket boosters are providing the momentum that will carry warheads to their targets.

ASCENT PHASE

is the segment of the trajectory after boosters have cut off, but before the payload has separated into warheads, decoys and counter measures.

MIDCOURSE PHASE

is the longest portion of the trajectory, during which warheads coast through space before reentering the atmosphere.

DESCENT PHASE

is the initial stage of reentry, when contact with the upper atmosphere begins to separate warheads from lighter objects.

TERMINAL PHASE

is the final, brief stage of the trajectory within the atmosphere immediately prior to detonation on target.

THE KINETIC ENERGY INTERCEPTOR

The Kinetic Energy Interceptor (KEI) is a mobile system of agile, surface-launched missiles designed to intercept most types of ballistic missiles in the boost, ascent or early midcourse phases of their trajectory. The program derives its name from the fact that the interceptor missiles use the force of impact -- pure kinetic energy -- to destroy their targets. It was begun in 2002 as a hedge against the possible failure of other approaches to boost-phase interception, and to cope with anticipated changes in the threat that would make midcourse discrimination of warheads more challenging.

KEI is conceptually similar to a Patriot air defense battery, consisting of mobile launchers, interceptor missiles and a command unit. It would initially be carried by ground vehicles that can be delivered anywhere in the world within a few hours on C-17 cargo planes, but it is designed to also be deployed at sea. The system's mobility was made possible by the fact that KEI is the first missile-defense program the United States has developed outside the constraints of the 1972 antiballistic missile treaty. As a result, it is more flexible than earlier defensive systems, and can be quickly dispatched to the borders of hostile countries in periods of heightened tension. Proximity to the launch sites of ballistic missiles is essential if they are to be intercepted during the early phases of their trajectory.

Despite its superficial similarity to Patriot, KEI is unique in several ways that collectively make it much more capable than other missile-defense systems utilizing ground-based interceptors:

-- Its multi-stage interceptor missiles are faster than any other tactical missile used by the U.S. military, quickly accelerating to eight kilometers per second so that the kill vehicles they carry have the speed necessary to destroy target missiles in the early phases of their trajectory.

-- Its command unit is able to receive and process sensor inputs from many different sensors elsewhere in the defensive network, including ground-based radars and satellites using infrared detection, eliminating the need to carry organic sensors with the KEI battery.

-- Its mobility on the ground, in the air and at sea enable the system to get as close as possible to enemy launch sites, affording more options for achieving early interception of hostile missiles than any other surface-based missile defense system currently being developed.

These and other features make KEI a highly versatile defensive system, able to intercept missiles of widely varying ranges and characteristics in three distinct phases of their trajectory. The flexibility of the system is further enhanced by the capacity of each interceptor to host multiple kill vehicles that can home in on all the targets presented by a lofting missile in ascent phase, thereby reducing the challenge of discriminating warheads from boosters. The latter capability is becoming more important as adversaries implement evasive tactics designed to foil the targeting systems of earlier missile defenses.

Despite its many promising features, the Missile Defense Agency has repeatedly restructured KEI. Initially viewed as mainly a boost-phase interception system, it was later shifted to emphasis on midcourse interception as the ability of other systems to intercept warheads in space was called into question. However, the ability to make such shifts underscores the intrinsic versatility of the system, a key reason for keeping it on track. The first booster flight of the KEI is planned for 2009, and could prove to be a key factor in deciding whether the new administration continues to fund the program.

The Kinetic Energy Interceptor was conceived as a fast-reacting missile that could intercept ballistic threats at multiple points in their trajectory. Once integrated into a defensive network, it will receive inputs from a wide array of sensors that enable the system to optimize interception opportunities.

THE AIRBORNE LASER

The Airborne Laser (ABL) is the most revolutionary component of the nation's ballistic missile defense system. The program was begun in 1996 with the goal of integrating a megawatt-class laser on a commercial transport that could fly close to launch sites in enemy countries and destroy ballistic missiles while they were still in the boost phase of their trajectories. Light travels at a constant speed of 300,000 kilometers per second, so substitution of a high-energy laser for interceptor missiles greatly improves the prospects of achieving interception during the three to five minutes when boosters are burning. Doubts about the feasibility of boost-phase interception typically focus on the time required to reach a hostile missile once detection of a launch occurs, but ABL reduces that time to seconds.

The ABL weapons system is carried on a heavily modified Boeing 747-400 commercial transport. Other than the airframe itself, the weapon consists of three major sub-systems:

-- An oxygen-iodine laser that generates intense light by chemical reaction and then focuses the light into a tight beam that can be delivered against targets hundreds of kilometers away.

-- A beam control and targeting assembly that aims the beam with extreme precision and compensates for atmospheric distortion to maintain lethal levels of energy over long distances.

-- A battle management suite that detects and tracks hostile missiles, and then coordinates the engagement sequence so that laser energy is deposited on the missiles while they are still in their vulnerable boost phase.

The latter subsystem uses half a dozen infrared sensors and several low-power lasers to find targets and measure the factors relevant to achieving maximum performance from the larger oxygen-iodine laser. Unlike other missile-defense systems, which require one or more interceptors to destroy a single ballistic missile, an ABL can destroy up to 20 missiles before its chemical supply is depleted and must be refilled. Thus, a handful of ABL planes could potentially provide around-the-clock protection against fairly sizable missile attacks emanating from a country such as North Korea. Experts estimate that ballistic missiles propelled by liquid fuel could be successfully intercepted using ABL at distances up to 600 kilometers, while less vulnerable solid-fuel missiles could be destroyed at distances up to 300 kilometers.

Since ABL is an airborne system, it can be deployed anywhere in the world on short notice. In addition to its primary mission of intercepting ballistic missiles, it is intrinsically capable of performing other missions such as early warning of missile launches, estimation of launch and impact points, target cueing of other defensive systems, and defense against airborne targets such as cruise missiles. Some observers have suggested ABL could also be used for attacking targets on the earth's surface or in orbit, although the current system architecture is not designed to support those missions. Nonetheless, ABL is a highly versatile system, and enjoys strong support from both the Missile Defense Agency and combatant commanders. The program is scheduled to conduct its first shoot-down of a realistic target in 2009, after which the experimental aircraft performing that feat will be available for real-world missions if needed.

The Airborne Laser is the most revolutionary system in current missile-defense plans, combining speed-of-light interception with low-costs per kill and global mobility. The system is scheduled to execute shoot-down of a ballistic target in 2009, the first time such a feat has ever been achieved at great distance by a high-power laser.

THE NETWORK CENTRIC AIRBORNE DEFENSE ELEMENT

The Network Centric Airborne Defense Element (NCADE) is a low-cost concept for intercepting short and medium-range ballistic missiles in boost phase using a modified version of the main air-to-air missile carried on most U.S. fighter aircraft today. The weapon's explosive charge is replaced with a second propulsion stage and a heat-seeking sensor is installed in its nose, thereby converting it into a ballistic-missile interceptor that rams vulnerable missiles in boost phase with sufficient force to destroy them. The information needed to guide the weapon to the vicinity of its target is provided by netted sensors on and off the host aircraft, which is why the phrase "network centric" is used in its name.

Compared with most other missile-defense concepts, NCADE is relatively simple and inexpensive. Because it relies on hardware already available in the joint force, it will cost less than half a billion dollars to develop and can be operationally available in four years. The unit cost of each round will be less than a million dollars, which is a fraction of what other missile interceptors cost. And while it will cost more per interception than the Airborne Laser, it presents few of the technical challenges associated with the latter system. Its main drawback is that it probably cannot successfully engage longer-range missiles, which constitute the greatest threat to the U.S. homeland. For that reason, it is best thought of as a complement to the Kinetic Energy Interceptor and Airborne Laser, rather than an alternative.

Aside from its low cost and simple design, one of most appealing features of NCADE is that it would fit within the design constraints of existing tactical aircraft such as the F-22 and F-35 fighters, enabling them to participate directly in missile-defense missions. In its modified form, the Advanced Medium-Range Air-to-Air Missile used for NCADE would have the same configuration as munitions already carried by those planes, so few changes would be required to the airframe or support systems. Many of the wireless links required to access off-board sensors such as Air Force radar planes already exist. The weapon can also be adapted for use on unmanned combat aircraft such as the Air Force's Reaper, enabling defenders to maintain a continuous presence near enemy launch sites during periods of heightened tension.

A somewhat similar concept called Air Launched Hit-to-Kill (ALHTK) has been proposed that would enable Air Force F-15C fighters to carry the Patriot Advanced Capability Three (PAC-3) missile for both boost-phase and terminal-phase interception missions. PAC-3 has superior performance characteristics to NCADE, because it was designed from its inception to be used for intercepting ballistic missiles. However, it costs much more per round than NCADE. In addition, the configuration of the proposed system would make it dangerous to use in hostile airspace since it would lack the low observable characteristics of F-22 or F-35 carrying interceptors internally. Thus, it probably would not be as well-suited to approaching the launch sites of enemy countries during periods of heightened tension, because it could be tracked much more easily. PAC-3 also cannot accomplish interception outside the atmosphere, while NCADE can.

The operating concept for NCADE envisions using the host aircraft to do much of the lifting required to position the interceptor for attack, which is why a relatively small missile can be adapted to the mission. Once aircraft sensors lock onto the target missile and sufficient proximity is achieved, the NCADE interceptor is released at high altitude. It maintains a digital link with the host aircraft en route to the target, which is then acquired by the interceptor itself using an infrared seeker in its nose adapted from the Sidewinder air-to-air missile. This all must unfold in a few minutes due to the compressed period of time before boosters burn out, but having the option of carrying the interceptor internally on a stealthy aircraft greatly enhances the likelihood of being in position for a successful engagement.

The Network Centric Airborne Defense Element is potentially the most economic system available for accomplishing early interception of ballistic missiles. By mounting the modified air-to-air missile on a stealthy, highly survivable fighter such as the F-22 fighter, the joint force could quickly and cheaply deploy a boost-phase interceptor capable of closely approaching enemy launch sites.

BOOST-PHASE CAPABILITIES MUST BE PRESERVED

The United States is currently facing the worst economic downturn in three generations. In such times, it is natural for the government to rethink priorities. But there are some things that are worse than a weak economy, and the possibility of a nuclear attack against America's homeland, its forward-deployed forces, or its allies is one of those things. The number of countries possessing nuclear warheads and the ballistic missiles needed to deliver them quickly against distant targets is growing. As that worrisome trend unfolds, U.S. policymakers have to seriously consider the possibility that nuclear deterrence will fail.

It was precisely that concern that led the Clinton Administration to increase funding for both national and theater missile defenses in 1998. The Bush Administration has stayed on the course established in the Clinton years, spending a relatively modest amount of money -- about one percent of the military budget -- on defenses capable of countering a small strategic missile attack. It is also funding a variety of systems for protecting deployed forces against shorter-range ballistic missiles. None of these programs threatens the effectiveness of the Russian or Chinese deterrent force. They can only cope with the lesser nuclear challenges posed by countries such as North Korea and Iran, or an accidental launch of a few long-range missiles. Countries with large nuclear arsenals can easily overwhelm them.

Most experts believe that it is the smaller arsenals that pose the greater danger today, because the countries possessing them are less stable and less predictable in their behavior. Even if that were not the case, the absence of effective defenses against small attacks employing ballistic missiles increases the incentives for additional countries to acquire such weapons. Thus, a strong case can be made that building modest missile defenses strengthens deterrence and discourages nuclear proliferation. But that is only true when the defenses are actually capable of destroying attacking missiles, and boost-phase systems are more likely to achieve that goal. At the very least, they reduce the challenge faced by other defenders by thinning out an attack before each missile becomes a cloud of warheads, decoys, countermeasures and debris.

The new administration can keep this promise alive for a small amount of money. The resources required to sustain all of the boost-phase interception concepts currently funded by the Missile Defense Agency is much less than the federal government spends each day. In round numbers it is three to four billion dollars per year, which is not much money compared with the consequences of even one nuclear weapon reaching American soil. The three programs that offer the most potential for effective boost or ascent-phase interception of ballistic missiles are:

-- The Kinetic Energy Interceptor

-- The Airborne Laser

-- The Network Centric Airborne Defense Element

Other programs could also potentially be applied to boost-phase interception, such as the Navy's sea-based missile defense system based on Aegis warships and the Air Launched Hit-to-Kill effort discussed in the previous section. However, these latter programs are dependent on favorable geographical and threat circumstances to succeed against ballistic missiles in the earliest and most vulnerable phase of their flight. KEI, ABL and NCADE are more flexible, employable options in a wide range of circumstances. Therefore, they are the most important boost-phase concepts to keep on track.

The targeting mechanism of the Airborne Laser is emblematic of the advanced technology developed by the military to intercept ballistic missiles over long distances. In order for the chemical laser to successfully destroy incoming missiles, it must dwell on a fast-moving target from hundreds of kilometers away while compensating for any turbulence in the intervening atmosphere.

The Aegis combat system carried on naval surface combatants is being adapted for midcourse interception of ballistic missiles, and in some cases might be used for boost-phase interception too. The United States currently plans to deploy a layered defensive architecture in which weapons like the Airborne Laser would thin out threats before they were engaged later in their trajectory by systems such as Aegis.

Related Lexington Institute Studies:

Loren Thompson, *Cruise Missile Defense: Connecting Theater Capabilities to Homeland Needs*, 23 pages, December 2004.

Loren Thompson, *CGX and the Future of Naval Warfare*, 13 pages, December 2007.

Rebecca Grant and Andrew J. Grotto, *Sea-Based Missile Defense: Expanding the Options,* published jointly with the Center for American Progress, 13 pages, August 2008.

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