Physics 280: Session 23

Plan for This Session

Student questions

News and discussion

Module 7: Defenses Against Nuclear Attacks (cont'd)

Next: "Missile Wars" video, current programs

News and Discussion

Global Security Newswire
by National Journal Group
Daily news on nuclear, biological and chemical weapons, terrorism and related issues.

Implementation of U.S.-Indian Atomic Deal Moving Forward
Thursday, April 7, 2011

The 2008 civilian atomic agreement paved the way for U.S. firms to export nuclear technology and material to India. In return, New Delhi agreed to open its nonmilitary atomic facilities to U.N. monitoring.

News and Discussion

The New York Times

April 11, 2010

By DAVID E. SANGER and WILLIAM J. BROAD

WASHINGTON — Three months ago, American intelligence officials examining satellite photographs of Pakistani nuclear facilities saw the first wisps of steam from the cooling towers of a new nuclear reactor. It was one of three plants being constructed to make fuel for a second generation of nuclear arms.

The message of those photos was clear: While Pakistan struggles to make sure its weapons and nuclear labs are not vulnerable to attack by Al Qaeda, the country is getting ready to greatly expand its production of weapons-grade fuel.

News and Discussion

The Pakistanis insist that they have no choice. A nuclear deal that India signed with the United States during the Bush administration ended a long moratorium on providing India with the fuel and technology for desperately needed nuclear power plants.

Now, as critics of the arrangement point out, the agreement frees up older facilities that India can devote to making its own new generation of weapons, escalating one arms race even as President Obama and President Dmitri A. Medvedev of Russia sign accords to shrink arsenals built during the cold war.

News and Discussion

"President Obama is focusing high-level attention on the threat that already exists out there, and that's tremendously important," said Sam Nunn, the former Democratic senator from Georgia who has devoted himself to safeguarding global stockpiles of weapons material — enough, by some estimates, to build more than 100,000 atom bombs. "But the fact is that new production adds greatly to the problem."

Nowhere is that truer than Pakistan, where two Taliban insurgencies and Al Qaeda coexist with the world's fastest-growing nuclear arsenal. According to a senior American official, Mr. Obama used his private meeting Sunday afternoon with Yousaf Raza Gilani, Pakistan's newly empowered prime minister, to "express disappointment" that Pakistan is blocking the opening of negotiations on a treaty that would halt production of new nuclear material around the world.

News and Discussion

Experts say accelerated production in Pakistan translates into much increased risk.

"The challenges are getting greater — the increasing extremism, the increasing instability, the increasing material," said Rolf Mowatt-Larssen of the Kennedy School of Government at Harvard, who as a C.I.A. officer and then head of the Energy Department's intelligence unit ran much of the effort to understand Al Qaeda's nuclear ambitions.

"That's going to complicate efforts to make sure nothing leaks," he said. "The trends mean the Pakistani authorities have a greater challenge."

News and Discussion

Asked about the production, Pakistan's ambassador to the United States, Husain Haqqani, said, "Pakistan looks forward to working with the international community to find the balance between our national security and our contributions to international nonproliferation efforts."

In private, Pakistani officials insist that the new plants are needed because India has the power to mount a lightning invasion with conventional forces.

India, too, is making new weapons-grade plutonium, in plants exempted under the agreement with the Bush administration from inspection by the International Atomic Energy Agency. (Neither Pakistan nor India has signed the Nuclear Nonproliferation Treaty.)

News and Discussion

The Obama administration has endorsed the Bush-era agreement. Last month, the White House took the next step, approving an accord that allows India to build two new reprocessing plants. While that fuel is for civilian use, critics say it frees older plants to make weapons fuel.

"The Indian relationship is a very important one," said Mr. Nunn, who influenced Mr. Obama's decision to endorse a goal of ridding the world of nuclear weapons. But he said that during the Bush years, "I would have insisted that we negotiate to stop their production of weapons fuel. Sometimes in Washington, we have a hard time distinguishing between the important and the vital."

News and Discussion

Global Security Newswire
by National Journal Group
Daily news on nuclear, biological and chemical weapons, terrorism and related issues.

U.S. Readies Key Ballistic Missile Interceptor Test

Friday, April 8, 2011

The United States is readying for its initial trial of a ship-based antimissile system against an intermediate-range ballistic missile target, Reuters reported on Thursday (see ***GSN***, March 2).

The April test is likely to affect Obama administration assurances that it can meet a self-imposed schedule for establishing a missile shield to defend Europe against potential Iranian missile attacks.

Missile Defense Agency spokesman Richard Lehner said the test would involve a ship-based Aegis antimissile system developed by Lockheed Martin and a Raytheon-produced missile interceptor. The vessel will be located in the south central Pacific and the missile target is to be fired from the Marshall Islands in the central Pacific.

News and Discussion

Earlier ship-based tests have targeted mock enemy missiles with more restricted flight ranges. This month's test would be the first to involve an intermediate-range target that can travel from 2,000 to 3,500 miles. Such a range would put European capitals Berlin, Paris and London within striking distance of missiles fired from Iran's western edge.

The forthcoming test is "to demonstrate a capability against a class of ballistic missiles, and is not country-specific," Lehner said told Reuters by e-mail.

"During [the test] Aegis BMD (ballistic missile defense) will demonstrate for the first time its capability to negate the longer-range threats that must be countered in Phase 1" of the Obama missile defense plan for Europe, Defense Department operational test and evaluation chief Michael Gilmore told Congress in March.

Module 7: Defenses Against Nuclear Attack

- Introduction to Defenses Against Nuclear Attack
- History of Defenses Against Ballistic Missiles
- Current and Proposed Missile Defense Programs

Module 7: Defenses Against Nuclear Attack

Introduction to Defenses Against Nuclear Attack

Types of Defenses Against Nuclear Attack

Passive defenses ("civil defense")

- Seeks to deter or mitigate rather than defend against attack
- Requires sheltering and crisis relocation
- Has been embraced and discarded several times

Active defenses (weapons to destroy weapons)

- Seeks to prevent nuclear weapons from detonating at their targets
- Requires destruction of delivery vehicles (aircraft, ICBMs, SLBMs, cruise missiles, etc.) before they reach their targets
- Must be nearly perfect to avoid enormous death and destruction (offensive weapons costing $1M can kill 1M people and destroy $1B worth of property)

Passive Defense Against Attacks

Sheltering (1950s,1960s,1980s) —

- Blast shelters (could withstand ~ 50–100 psi overpressures)
  - — Only a very small fraction of the land area of the US would be subjected to 50 psi, even in an all-out attack
  - — However, most people live in cities and hence would likely be subject to blast, fire, etc.
- Fallout shelters (could have protection factors ~ 100)
  - — Radiation from fallout decays rapidly with time
  - — Cumulative exposure would still be serious
  - — Submarine attacks might continue for weeks or months
  - — Problems and costs of providing adequate sanitation, ventilation, food, and water are enormous
- Warning time could be very short (~ 10 minutes or less), so most people would not reach shelters

Passive Defense Against Attacks

Crisis relocation (Reagan,1980s) —

- Plans developed by Federal Emergency Management Agency (FEMA)
- Plans called for evacuation of all urban and other "high risk" populations and quartering of evacuees in "host" communities
- There was confusion over whether many communities were high-risk or low-risk
- Feasibility of successful evacuation is very doubtful
- Many urban areas and host regions refused to participate in planning, finding the concept offensive, ludicrous, or dangerous
- By 1985, civil defense was again dropped

Reducing the Threat of Long-Range Nuclear-Armed Ballistic Missiles

Possible approaches —

- Develop friendly relations
- Use diplomacy, incentives, and disincentives to prevent the development and spread of nuclear and missile capabilities and to reduce and eliminate existing threats
- Plan to destroy threatening missiles on the ground
- *Attempt to destroy attacking missiles in flight*

Why Are Programs to Defend Against Nuclear-Armed Ballistic Missiles So Controversial?

Programs to defend against ballistic missiles (anti-ballistic missile or ABM programs) would not be controversial if —

- An effective defense was clearly possible using near-term technology
- Such a system could be built for an acceptable cost
- ABM programs would not cause other countries to do things that would end up decreasing our security
- ABM programs would not distract the U.S. from taking other steps that would be more effective in increasing our security

However, U.S. programs to defend against ballistic missiles have often been used for purposes other than defense —

- As bargaining chips
- To sidetrack or destroy arms control agreements
- To create a (false) sense of security for political advantage
- To win political advantage over critics of missile defense

Phases of Flight of a Long-Range Ballistic Missile

Phases of flight —

- Boost phase (rocket motors burning) ~ 1 to 4 min
- Post-boost phase (MIRVed missiles) ~ 5 min
- Midcourse phase (ballistic flight) ~ 20 min
- Terminal phase (within atmosphere) ~ 20–30 sec

Types of re-entry vehicles —

- MRV = multiple RV (not independently targetable)
- MIRV = multiple, independently targetable RV
- MARV = maneuverable RV

Types of ABM Systems

'Terminal' defenses would attack RVs during re-entry —

- Traditional (radars & rockets armed with conventional or nuclear warheads)
- 'Simple/novel' systems (curtains of projectiles, 'dust defense' using buried bombs)

'Mid-course' defenses would attack RVs in space —

- IR sensors, particle-beams and neutron detectors
- Kinetic-energy warheads or particle beams

'Boost-phase' defenses would attack missiles during powered flight, when their rocket motors are burning —

- IR sensors
- Kinetic-kill vehicles (KKVs), lasers, particle beams

ABM System Requirements

- Sensors
  - — Goal: detect, identify, and track targets
  - — Passive (optical, IR)
  - — Active (radar, particle beams)
- Weapons
  - — Goal: destroy missile boosters or warheads in flight
- Battle management capability
  - — Detection
  - — Identification
  - — Tracking
  - — Discrimination
  - — Targeting
  - — Damage assessment
  - — Retargeting

History of Anti-Ballistic Missile (ABM) Weapon Programs

Past and Current U.S. Missile Defense Programs

Eisenhower Nike-Zeus Program (1950s)

Kennedy Nike-X Program (1960s)

Johnson Sentinel Program (1966–68)

Nixon Safeguard Program (1969–76)

Reagan Star Wars Program (1983–1990)

Bush-I and Clinton GPALs Program (1991–1997)

National Missile Defense Research Program (1997–2001)

Bush-II Missile Defense Program (2001– 2009)

Obama Missile Defense Program (2009–present)

Total spent so far: > $300 billion (2008 dollars).

Most of these systems were never deployed.

None were found to be effective.

1980s: Reagan's 'Star Wars' Program

Why Discuss this in detail?

Because it is a point of reference for many current discussions of missile defense.

Reagan's 'Star Wars' ABM Weapon Program

Began with President Reagan's speech of March 23rd, 1983 —

- Surprised and stunned the entire US government, including the Pentagon
- Expressed a grand vision, intention to replace deterrence by a defensive system
- Was a radical departure from previous US policy
- Contradicted the results of just-completed studies by the White House and the DoD
- Did not say success was assured, but implied it was highly likely and could be achieved soon
- Launched a major, long-term research and development program (the Strategic Defense Initiative – SDI)

Reagan's 'Star Wars' ABM Weapon Program

Why was almost everyone surprised? —

- The President consulted with only a few advisors (not including his Secretary of Defense) before giving his speech.
- The U.S. already had a very large research program that was investigating ABM weapons.
- The White House Science Council had just completed a study which concluded that missile defense would be technologically infeasible for the foreseeable future.
- The Defense Department had just completed a series of detailed studies that concluded the prospects for success were very poor and recommended reducing the funding of the existing ABM research program (DDR&E had testified about them earlier that same day).

Reagan's 'Star Wars' ABM Weapon Program

Some consequences of Reagan's speech—

- Raised public hopes and expectations that could not be fulfilled ("protection of our population against nuclear attack is a practical possibility and might even be accomplished soon")
- Led to doubling and tripling of expenditures on ABM weapon research and development, exacerbating the enormous budget deficits of the Reagan years
- Closed off pursuit of alternative approaches to reducing the threat of nuclear weapons
- Accelerated the building of offensive weapons
- Started expensive programs to develop and deploy extensive missile defenses that continue unsuccessfully to this day

The "Star Wars" program did not cause the Soviet Union's collapse (it was already collapsing)

Reagan's 'Star Wars' ABM Weapon Program

Sensors, computers, and weapons would have had to be integrated into an enormously complex system that—

- Would have had to attack ballistic missiles within seconds after having been dormant for years
- Would have had to work almost perfectly the first time it was used, even though it could not be tested under realistic conditions
- Would have had to work almost perfectly while being attacked by Soviet nuclear and space weapons

Reagan's 'Star Wars' ABM Weapon Program

Some technical realities of the time —

- A system that was 90% effective would have allowed a Soviet attack to kill 75% of the US population immediately, with millions of later deaths
- IR laser weapons would have required space-based mirrors 10 times larger than the largest ever built on the ground and lasers > 10^6 times brighter
- Midcourse intercept would have required detection, tracking, and discrimination of ~ 100,000 objects in space, at *existing* Soviet force levels
- Battle management computer programs would have required more than 100,000 man-years to write using the most advanced techniques then available and would have had to work almost flawlessly the first time they were used

Reagan's 'Star Wars' ABM Weapon Program

For every SDI weapon concept that was proposed or imagined, including all space-based weapons, a counter-measure had already been identified.

Unlike the weapons themselves, these counter-measures were —

- Possible with existing technology
- Relatively cheap

Moreover, the SDI program did not even attempt to address nuclear weapons carried by —

- Air-, sea-, or ground-launched cruise missiles
- Submarine-launched ballistic missiles
- Bombers
- Ships

A main ingredient of SDI was an X-ray laser concept that used a large nuclear weapon as its source of power.

Yet SDI was supposed to make nuclear weapons "impotent and obsolete".

Reagan's 'Star Wars' ABM Weapon Program

Knowledgeable people inside and outside the government knew the goal of complete protection was impossible —

- Knowledgeable scientists and others outside the government spoke out strongly
  - — Gave public speeches, talks, articles, etc.
  - — Pledged not to participate
- Knowledgeable people inside government spoke out
  - — Made cautious public comments
  - — Some gave forceful secret advice
- Allies of Reagan tried to "move the goal posts" to —
  - — Enhancing deterrence
  - — Causing the Soviets to spend money on countermeasures
- However, all this had little impact on the public's perception

Reagan's 'Star Wars' ABM Weapon Program

As a result of its technological unreality, the emphasis of the SDI program fluctuated wildly from year to year —

- Space-based X-ray lasers
- Space-based particle-beam weapons
- Space- and ground-based optical and UV lasers
- Space-based kinetic energy weapons
- Smart rocks
- Brilliant pebbles
- High- and low-altitude rocket interceptors

Reagan's 'Star Wars' ABM Weapon Program

Some consequences of the increase in spending on ABM weapon research —

- Spurred the race in offensive weapons
- Spurred Soviet efforts to develop space weapons
- Poisoned arms control efforts
- Did *not* spur Soviet missile defense efforts
- Had an enormous opportunity cost
  - — Diverted money, manpower, and other resources from education and internationally competitive civilian industries and products to uncompetitive military industries and products
  - — SDI ended up costing more than $100B (2008 dollars) but accomplished very little that was useful

The SDI program was greatly reduced by Bush-I and terminated in 1994 by Clinton, but Clinton felt compelled to restart a program to defend against long-range ballistic missiles in 1998. Bush-II greatly expanded this program.

Spending on missile defense has consumed more than $300B since 1984.

Physics 280: Session 24

Plan for This Session

Student questions

Choose ECEO-C date and time

Module 7: Defenses Against Attacks (cont'd)

"Missile Wars" video

Physics 280 Extra-Credit Essay Opportunity C

Video: "Nuclear Tipping Point"

Choose Date and Time

iClicker Question

About how many *total* nuclear weapons does the UK now have?

A. 50
B. 100
C. 200
D. 500
E. 1,000

Blank

iClicker Question

About how many *total* nuclear weapons does the UK now have?

A. 50
B. 100
C. 200
D. 500
E. 1,000

iClicker Question

About how many nuclear weapons does India now have?

A. 50
B. 100
C. 250
D. 3,000
E. 5,000

Blank

iClicker Question

About how many nuclear weapons does India now have?

A. 50
B. 100
C. 250
D. 3,000
E. 5,000

iClicker Question

About how many nuclear weapons does Pakistan now have?

A. 50
B. 100
C. 250
D. 3,000
E. 5,000

Blank

iClicker Question

About how many nuclear weapons does Pakistan now have?

A. 50
B. 100
C. 250
D. 3,000
E. 5,000

iClicker Question

About how many nuclear weapons does Israel now have?

A. 10–50
B. 100–200
C. 200–500
D. 500–1,000
E. >1,000

Blank

iClicker Question

About how many nuclear weapons does Israel now have?

A. 10–50
B. 100–200
C. 200–500
D. 500–1,000
E. >1,000

iClicker Question

North Korea is thought to have enough Pu for for about how many nuclear weapons?

A. 1 or 2
B. 3–5
C. 6–12
D. 20–30
E. 50–100

Blank

iClicker Question

North Korea is thought to have enough Pu for for about how many nuclear weapons?

A. 1 or 2
B. 3–5
c. 6–12
D. 20–30
E. 50–100

iClicker Question

Which of the following countries has not openly tested a nuclear weapon?

A. India
B. Israel
C. North Korea
D. Pakistan
E. China

Blank

iClicker Question

Which of the following countries has not openly tested a nuclear weapon?

A. India

B. **Israel**

C. North Korea

D. Pakistan

E. China

History of Efforts to Defend Against Ballistic Missiles

PBS Frontline Video
"Missile Wars"

History of Efforts to Defend Against Ballistic Missiles

Discussion of "Missile Wars"

Physics 280: Session 25

ECEO-C: April 25, 6:30 PM, 144 Loomis

"Nuclear Tipping Point" Video

Plan for Today's Session

Student questions

News and discussion

Module 7: Defenses Against Attacks (cont'd)

News and Discussion

Obama Submits Bills to Ratify Nuclear Security Pacts

Thursday, April 14, 2011

The Obama administration on Wednesday sent legislation to Congress that would cement U.S. membership in international accords aimed at safeguarding nuclear materials and deterring acts of nuclear terrorism, the White House announced (see ***GSN***, Dec. 10, 2010).

The legislation calls for ratification of the International Convention for the Suppression of Acts of Nuclear Terrorism and the **2005 Amendment to the Convention on Physical Protection of Nuclear Material**, which legally binds member states to secure civilian atomic material wherever it is used, stored and transported.

News and Discussion

Pentagon Revises Prompt Global Strike Effort

Thursday, April 7, 2011

The U.S. Defense Department has elected not to incorporate standard ballistic missile system technology in the development of its conventional "prompt global strike" initiative, *Arms Control Today* reported in its April issue (see **GSN**, March 24).

Th Bush White House had suggested fixing non-nuclear warheads to submarine-carried Trident ballistic missiles. However, congressional lawmakers stymied that effort due to worries that Moscow could mistake a conventional SLBM firing as a nuclear attack. Kremlin officials argue that any long-range weapon that could be used to strike Russian nuclear assets ought to be categorized as strategic.

News and Discussion

The Pentagon "at present has no plans to develop or field" ICBMs or submarine-launched ballistic missiles that would be tipped with conventional warheads and delivered "with traditional ballistic trajectories," states a Senate-mandated White House report.

The possibility that ballistic missile technology would be used in the Pentagon effort to develop a non-nuclear alternative for quickly eliminating threats such as a WMD stockpile or a missile being readied for launch caused serious concern among members of Congress and in Russia. Critics worried that a U.S. launch of conventionally armed ICBM could be misinterpreted as an atomic attack, potentially resulting in a nuclear response from another nation.

News and Discussion

The Pentagon has said it plans to maintain research into "boost-glide" technology that has a nonballistic flight path, reducing the chances that someone would misinterpret the weapon as a nuclear missile. Boost-glide technology employs nonstandard ballistic missiles to propel into space delivery systems that proceed to five times the speed of sound for more than 50 percent of their flight. Washington believes that these weapons could be identifiable to the Russians as non-nuclear.

News and Discussion

Iran to Prepare Medical Reactor Fuel in 2011

Thursday, April 14, 2011

Iran on Wednesday said it intends this year to deliver nuclear material for operating a medical isotope production reactor in Tehran, the Fars News Agency reported (see ***GSN***, April 13).

The Middle Eastern state early last year began further refining low-enriched uranium from its stockpile, ostensibly to fuel the Tehran reactor. The United States and other Western powers, though, have feared the process could help Iran produce nuclear-weapon material, which requires an enrichment level around 90 percent. Tehran has maintained its atomic ambitions are strictly peaceful.

Meanwhile, China on Thursday said it wanted new multilateral discussions with Iran to convene in the near future. Iranian delegates last met in January with representatives of the five permanent U.N. Security Council member nations and Germany, but the meeting appeared to yield little progress toward addressing the atomic standoff (see ***GSN***, Jan. 24).

Elsewhere, Iranian Oil Minister Massoud Mirkazemi on Wednesday said U.S. and European penalties targeting his country's petroleum industry were having no effect, Faris reported.

Reagan's 'Star Wars' ABM Weapon Program

What if Star Wars weapons had been deployed?

- It would have aggravated crisis instability.
- It would have shortened decision times, removing humans from the loop.
- If the weapons actually worked and were matched by the Soviets, U.S. allies would have been disarmed.
- There would have have been an enormous financial cost [the cost of the originally proposed prototype system exceeded $1 trillion in 1985 $].
- It could have created a false sense of security, possibly leading to tragic mistakes.

The 'Nitze Criteria' for Deploying an ABM System (Important)

In the early 1980s, Paul Nitze argued convincingly that to be considered for deployment, an ABM system must first meet the following three criteria —

1. The system must be effective
2. The system must be able to survive attack
3. The system must be cost-effective at the margin

These criteria were officially adopted ~ 1985 and have become known as the "Nitze criteria" for it to make sense to deploy a missile defense system.

Adoption of these criteria effectively ended any chance of deploying a missile defense system during the 1980's and 1990's, because no system then under development could come close to meeting them.

Bush-II scrapped the Nitze Criteria in 2001 in order to deploy a missile defense system (see "capability-based development and deployment").

Lessons from Reagan's 'Star Wars' Program

- Missile defense technology is highly challenging
- Technology cannot be coerced by wishful thinking, ideology, or policy (engineering programs must be consistent with technical realities, because nature cannot be fooled)
- It is important to understand what technology can and cannot do in a given situation, because to be successful, policies must be consistent with the available technology
- An R&D program without clear goals will always waste time and money
- Frequent testing is critical and the budget for tests must therefore be large; if there is no commitment to such an effort, the program will fail
- An independent evaluation and review process is critical

History of Efforts to Defend Against Ballistic Missiles

The Impact of Patriot in the First Gulf War

Patriot in the 1991 Gulf War

Events that formed the public's impression—

- TV videos of Patriot "engagements" and enthusiastic reports by military spokesmen and news reporters of the Patriot's successes.
- General Schwarzkopf: "The Patriot's success is 100%—so far, of 33 Scuds engaged, there have been 33 destroyed."
- President Bush, during a celebratory visit to Raytheon, said "Patriot is 41 for 42, 42 Scuds engaged, 41 intercepted... Patriot is proof positive that missile defense works."

Patriot in the 1991 Gulf War (cont'd)

Later studies showed the Patriot's actual performance was *very* poor —

- The First Army study (February 1992) was found to have many serious flaws by the GAO and the CRS
- In April 1992, Pedatzur (Tel Aviv) reported only one Scud hit by by a Patriot based in Israel; found that four Patriot warheads had fallen and exploded in populated areas
- A Corrected Army study (April 1992) reported a 'success rate' > 70% in Saudia Arabia and > 40% in Israel (success = incoming WH destroyed, dudded, or deflected) [this is still the official DoD claim]
- A September 1992 GAO study reviewed the Corrected Army study and found only 4 engagements (9% of the total) in which there was strong evidence of a Patriot 'kill'
- A detailed study by Postol & Lewis (MIT, 1991–92) found evidence of three hits but no evidence of any 'kills'
- In the end, there was not a single well-documented intercept but many well-documented complete misses

However, these results came too late and few included videos, so they had little impact on the public's existing perception that Patriot had succeeded.

The Bush-II Missile Defense Program

Similarities of Bush's and Reagan's Missile Defense Programs

- Missile defense was personally identified with a President.
- Missile defense was ideologically driven and highly politicized.
- The policy goals and framework kept shifting.
- Technical goals were unspecified or nonexistent.
- The R&D program was poorly defined and overextended.
- Tests were infrequent and unrealistic or nonexistent, and budgets for testing were far too small.
- There was misleading "information" all over the place.
- Tests and demonstrations of little relevance (stunts) got wide publicity while vital technical information was hidden from the Congress and the public behind a wall of secrecy.

Bush's 'Capability-Based Acquisition'

The 'Nitze Criteria' were officially scrapped.

Instead, the Bush program was "capability-based", which meant —

- It had no specific goals or requirements.
- Congress was supposed to give the Missile Defense Agency (MDA) whatever money it asked for.
- MDA would say later what it did with the money.
- President Bush asked Congress to increase MDA's budget by large amounts every year.
- MDA's budget in FY2009 year was $10 billion, twice the entire budget of the National Science Foundation.

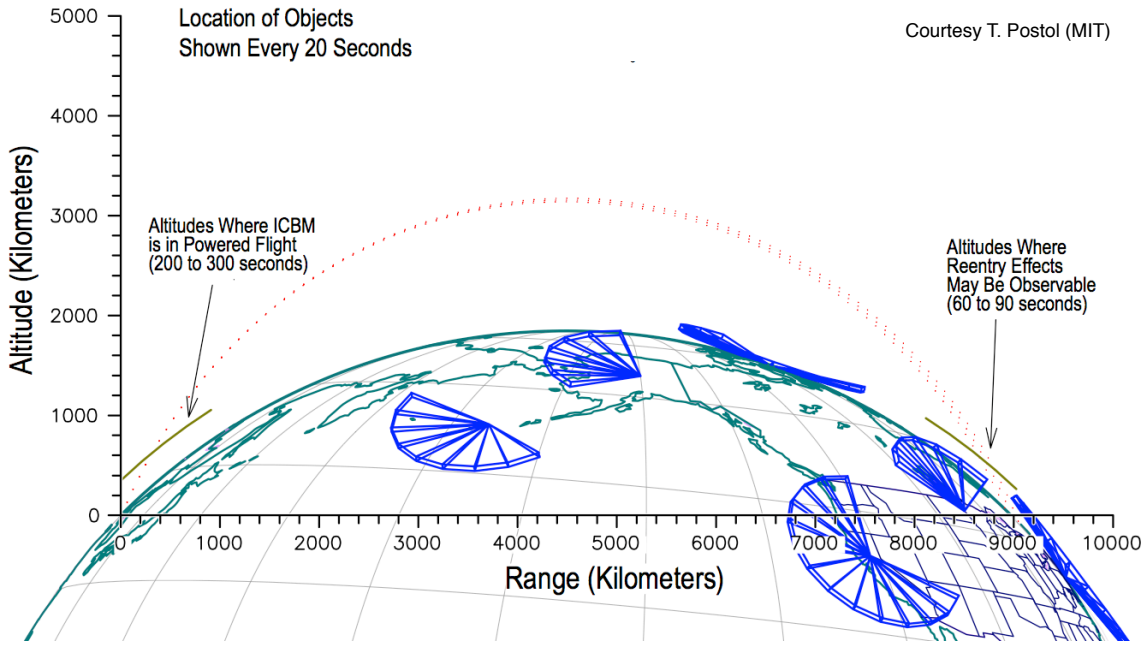
Criteria for the Proposed GMD System

President Clinton had established four criterion for deciding whether to move forward with deploying a system:

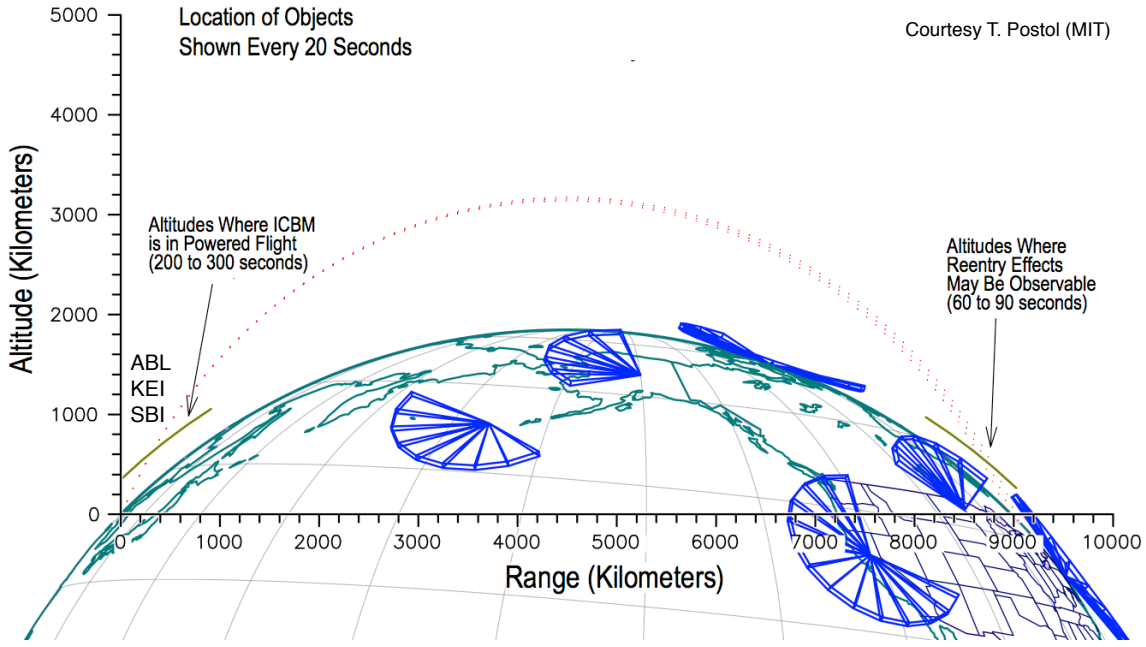
- The threat
- The expected cost
- The technological maturity of the system
- The impact on arms control efforts

President Bush decided to deploy the system without considering any of these factors.

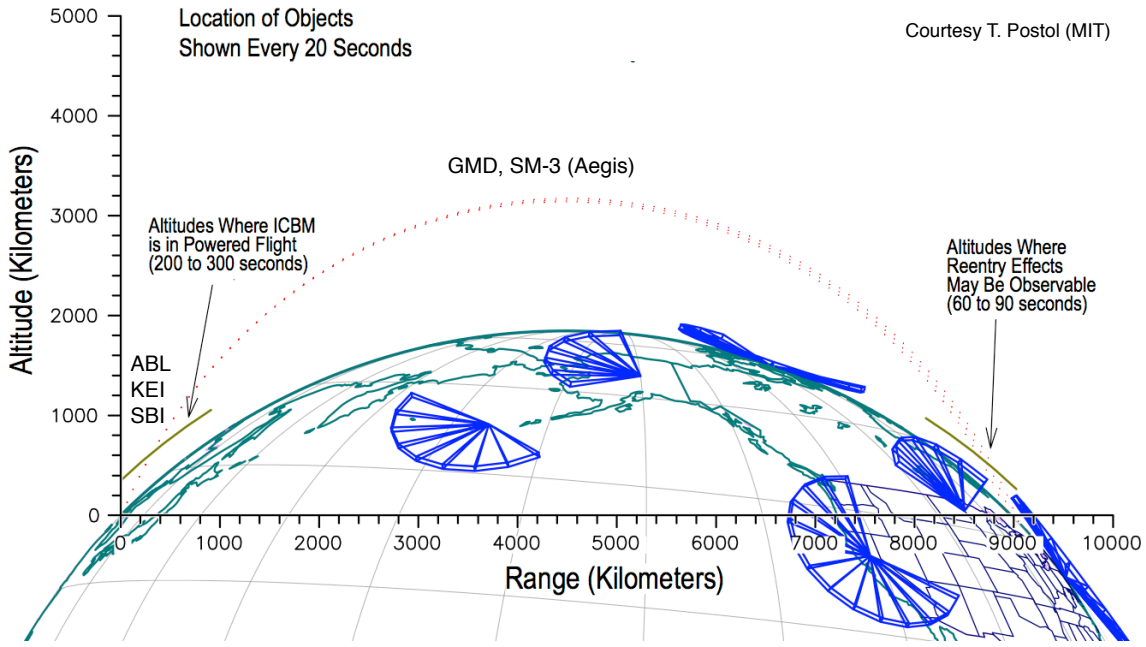
The Bush-II ABM Weapon Program



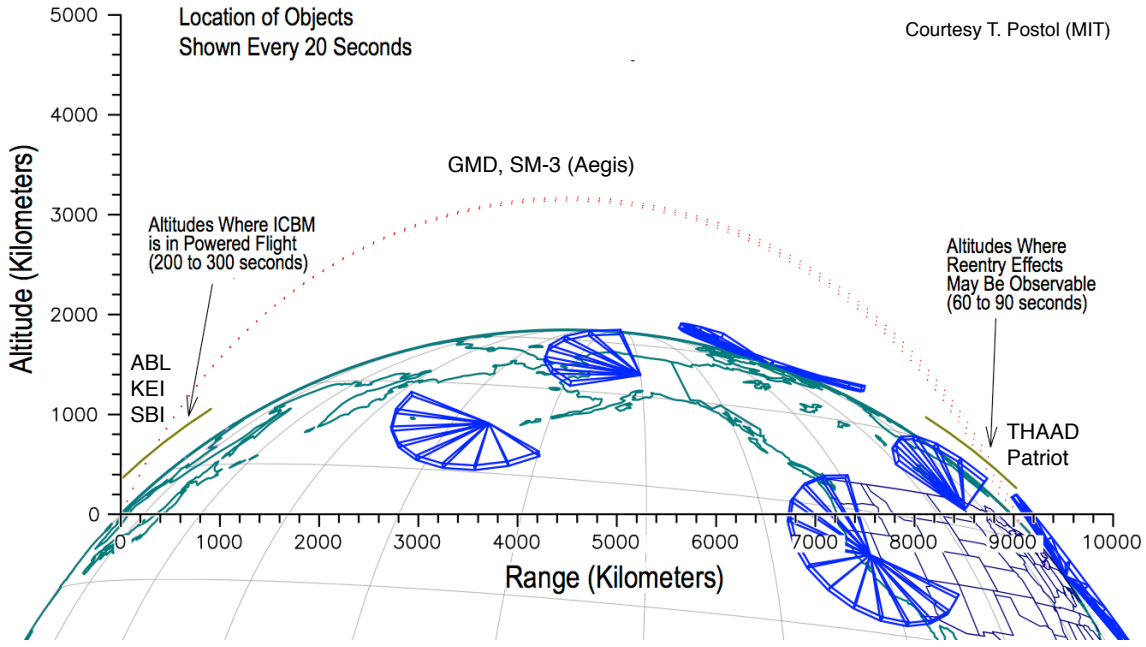
The Bush-II ABM Weapon Program



The Bush-II ABM Weapon Program

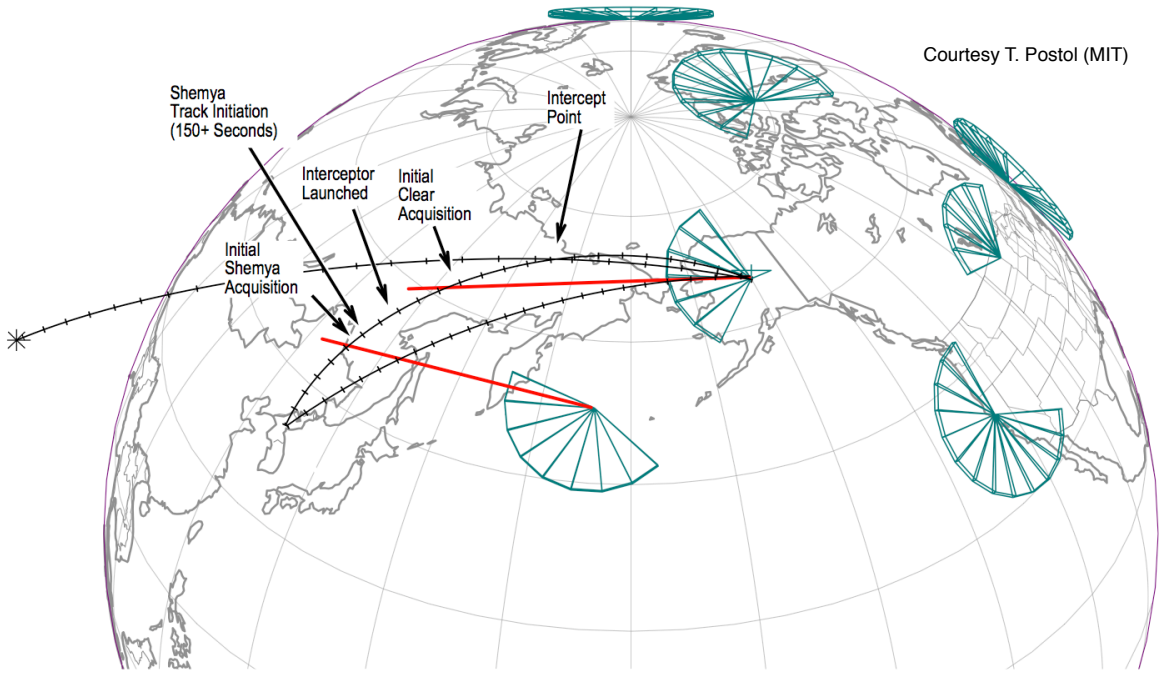


The Bush-II ABM Weapon Program



2001–2009: Bush's Proposed U.S.-Based Midcourse Intercept System

Theoretical Functioning of Proposed Ground-Base Midcourse Intercept (GMD) System



Technological Challenges of Midcourse Intercept

The technological challenge is formidable, most difficult is “discrimination”

- The system has to confront an attacking missile that is designed to fool the interceptor into going after one of many decoys RVs
- The general performance characteristics of the EKV (com links, sensor suite, agility) will be known to the adversary
- The missile’s payload could be one or more nuclear warheads, or dozens or hundreds of hardened chemical or biological munitions (bomblets)
- The system must identify and track RVs in the face of countermeasures, including decoys and anti-simulation devices

The Welch panel labeled the current program “Rush to Failure”

The system failed many tests. The DoD therefore exempted the system from any further testing until it was deployed.

Bush’s Midcourse Missile Defense System

Interceptors:

- Most interceptors to be based in silos in Alaska with a few in California
- Bush’s plan was to deploy 44 total by 2011

Test results:

- 7 hits in 14 highly scripted, simplified tests from 1999 to 2008 (not counting launch failures which were defined as “no tests” by MDA)
- 2 hits in 4 tries since Bush declared the system “operational” in 2002
- The launch time and trajectory of the “attacking missile” are known and always the same, closing velocities are low, no countermeasures are allowed
- Only two tests involved the interceptor rocket intended for the system
- The satellite systems that would be needed to detect and track an enemy missile launch were not complete and were not used

2008 assessment of capability:

- DOT&E rated the existing midcourse system as providing “emergency, low-confidence capability”.

March 2009 Report on the Bush ABM Program by the Government Accountability Office

MDA spent $56 billion researching and deploying elements of the ground-based midcourse defense (GMD) system from 2002–2009.

MDA failed to achieve *any* of its 6 testing objectives for 2008.

Nevertheless, system elements, including 24 modified GMD interceptors, are being deployed before being fully tested.

MDA overran its budget by $150 million in 2008. The GMD program cost $56 million less than budgeted because it did not emplace *any* of the 3 GMD interceptors or conduct *either* of the two tests planned for 2008.

The GAO recommended that MDA —

- Test its GMD interceptor against a complex scene with countermeasures.
- Ensure that items are not manufactured for fielding before their performance has been validated through testing.

Module 7: Defenses Against Nuclear Attack

Bush's Proposed European Midcourse Intercept System

Bush's Proposed European Missile Defense

(Missile Defense Agency Slide)

Courtesy: T. Postol (MIT)

- **Up to 10 silo-based long-range interceptors located in Eastern Europe (2011-2013)**
- **Re-location of a narrow-beam, midcourse tracking radar currently used in our Pacific test range to central Europe (2011)**
- **Field an acquisition radar focused on the Iranian threat from a forward position to provide detection, cueing, and tracking information (2010-2011)**

Approved for Public Release
07-MDA-2332 (9 MAR 07)

ms-109395A / 030707

Consequences of the Proposed European Defense Against Ballistic Missiles

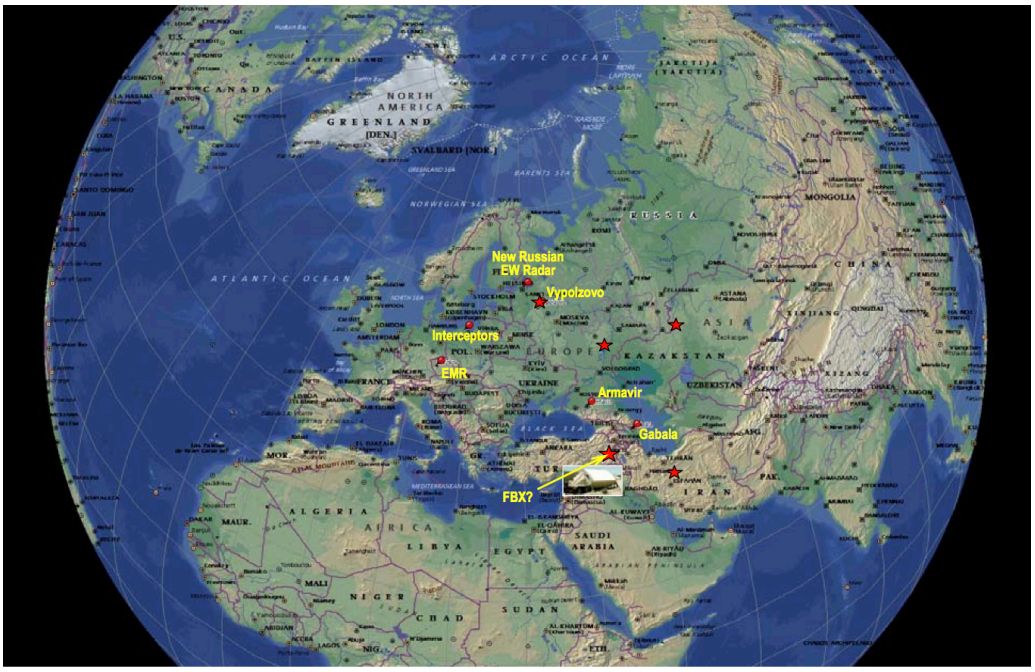
The United States' claims for the proposed missile defense expansion to Europe are summarized in several government documents that were issued in June 2007.

These documents contain extraordinary statements, such as

"Missile defense is our ultimate insurance policy if these other elements of our strategy (diplomacy, export controls, and so forth) fail."

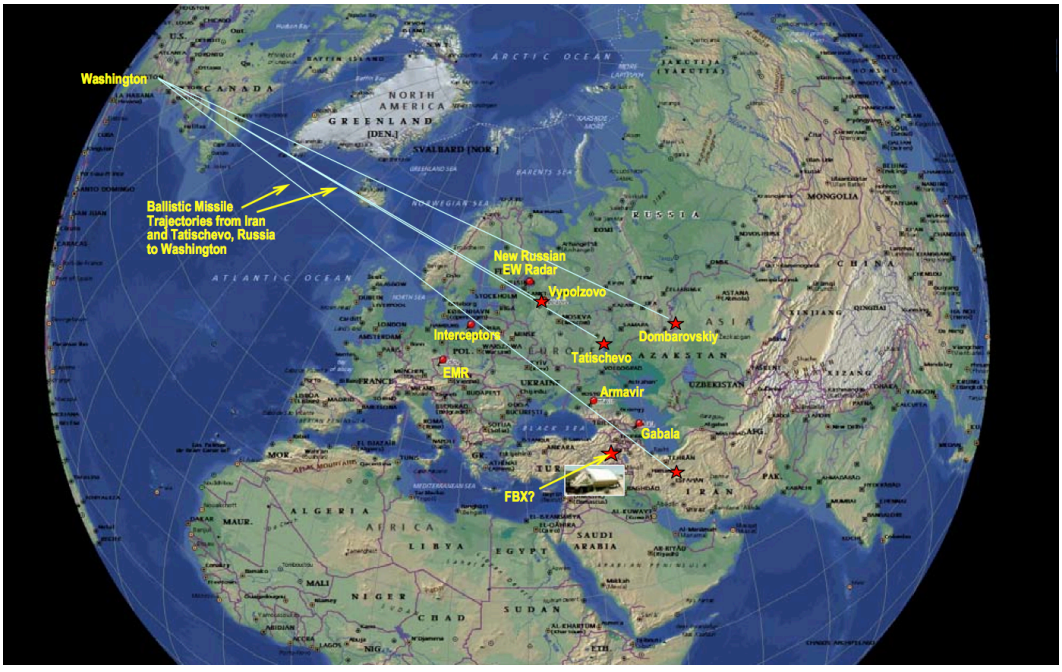
In fact, on technical grounds, no responsible U.S. president should take into account any current defense against ballistic missiles in contemplating a response to perceived nuclear threats.

Proposed European Defense Against Ballistic Missiles



 Courtesy T. Postol (MIT)

Proposed European Defense Against Ballistic Missiles



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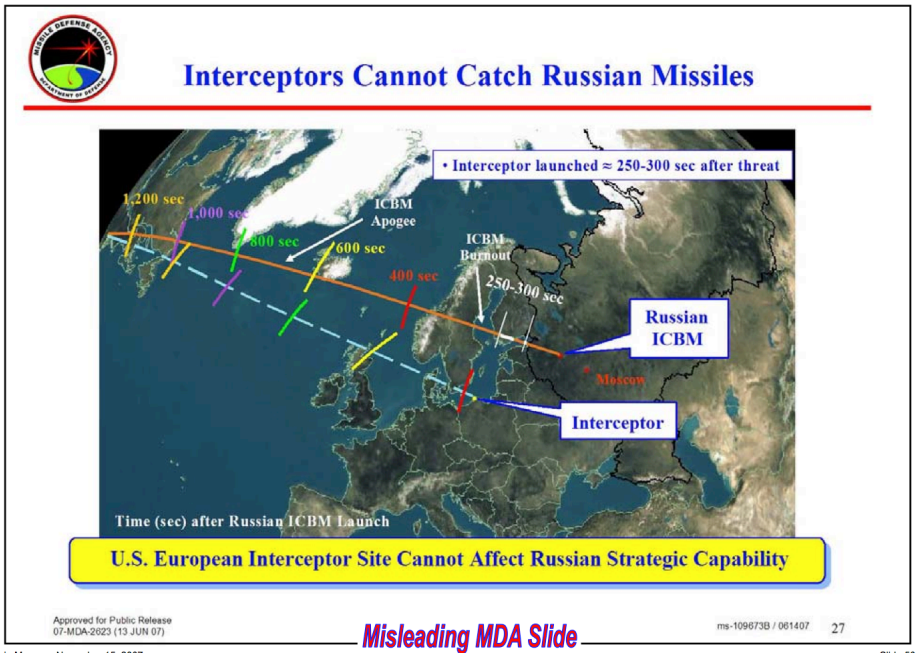
Proposed European Defense Against Ballistic Missiles



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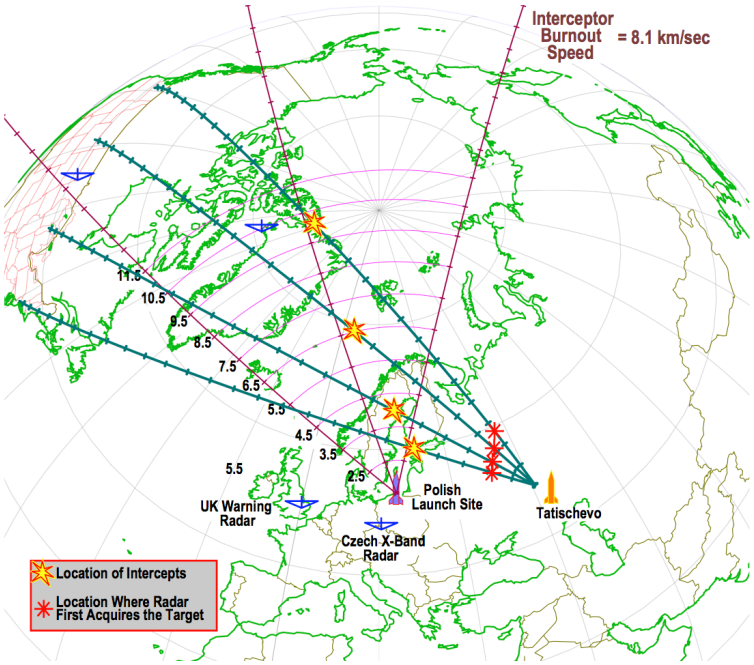
Proposed European Defense Against Ballistic Missiles



Courtesy T. Postol (MIT)

Assessment of Bush's Proposed European Missile Defense System (cont'd)

The January, 2008, Annual Report of DOT&E stated:

• Flight testing of the GMD system, which is the prototype for the proposed European missile defense system "is not sufficient to provide a high level of statistical confidence in its limited capabilities."

• "The addition of limited operational realism to BMDS testing against strategic threats has uncovered unanticipated deficiencies that will require additional development and testing."

iClicker Question

Nuclear Weapon Proliferation

Which of the following countries is *not* a party to the Nuclear Nonproliferation Treaty?

A. India

B. Israel

C. North Korea

D. Pakistan

E. All of the above

Blank

iClicker Question

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iClicker Question

Nuclear Weapon Proliferation

Which of the following countries signed the Nuclear Nonproliferation Treaty but then created a clandestine program to develop nuclear weapons?

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B. Libya

C. North Korea

D. Iran

E. All of the above

Blank

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iClicker Question

Which of the following is **not** one of the "Nitze criteria" for considering deployment of an ABM system?

A. The system must be effective

B. The system must be able to survive an attack

C. The system must use the most advanced technology

D. The system must be cost-effective at the margin

E. None of the above are "Nitze criteria"

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iClicker Question

Which of the following was **not** a consequence of Reagan's Star Wars" anti-missile program?

A. The public developed unrealistic hopes for a perfect shield against long-range missiles

B. The already enormous federal budget deficit was greatly increased

C. The Soviet Union and China moved to increase the size and capability of their missiles

D. The Soviet Union collapsed economically

E. U.S. scientific and engineering talent was shifted from internationally competitive civilian enterprises to uncompetitive military enterprises

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iClicker Question

Missile Defenses

Which of the following is not a lesson of the Star Wars program?

A. Missile defense is highly challenging

B. The necessary technology cannot be produced by wishful thinking or ideology

C. An R&D program without clear goals will always waste time and money

D. Frequent testing is unnecessary

E. An independent evaluation and review process is critical

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iClicker Question

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iClicker Question

Missile Defenses

The reported success of the Patriot missile defense system during the 1991 Gulf War was a key argument used to restart the U.S. program to defend against ICBMs. In the end, how many intercepts of Iraqi short-range missiles were well-documented?

A. 0

B. 5

C. 10

D. 50

E. 100

Blank

iClicker Question

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Module 7: Defenses Against Nuclear Attack

Bush's Proposed Boost-Phase Intercept System

Why is There Interest in Boost-Phase Intercept?

Midcourse Intercept Appears Extremely Challenging

Each missile could launch —

- Multiple warheads
- Dozens of chemical or biological submunitions
- This could overwhelm the defense

Each missile could launch —

- Countermeasures and penetration aids, including large numbers of lightweight decoys
- These would be difficult to distinguish from real warheads above outside the atmosphere
- This could confuse the defense

Why is There Interest in Boost-Phase Intercept?

Boost-phase intercept has been described as easier

- ICBMs are described as slowly-moving, fragile targets
- ICBMs have bright exhaust plumes that are easy to track
- An ICBM is a unitary target if it can be intercepted before it deploys its warheads
- It is usually assumed that there are few if any effective countermeasures to boost-phase intercept

It is therefore argued that boost-phase intercept . . .

- Is an attractive alternative to midcourse intercept, or
- Would reduce the challenge faced by the midcourse layer if it were the first layer of a layered defense

Key Issues for Boost-Phase Intercept

ICBM boost phases are short (4 min liquids, 3 min solids)

- The defense has little time to decide whether to fire
- Interceptors have little time to reach the ICBM

Geographical constraints require high interceptor speeds

- Intercept points for ICBMs from North Korea and Iran are 500 to 1,000 km from potential interceptor basing locations

ICBMs in powered flight accelerate unpredictably

- Burn variations, energy management, programmed evasion
- Interceptors would have to be fast and agile

A successful intercept is unlikely to destroy warheads

- Live warheads could impact the territory of the United States or U.S. friends and allies ("shortfall management problem")

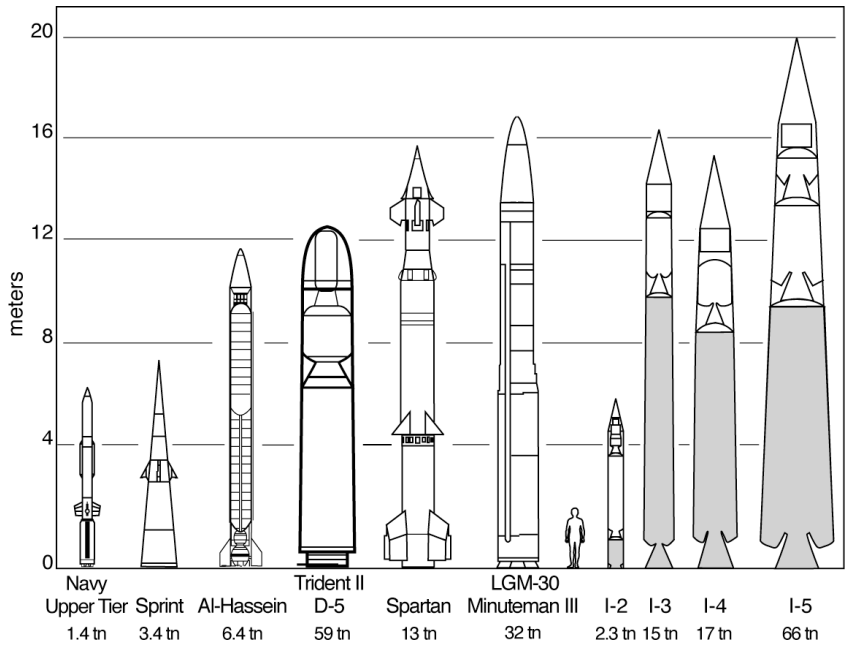
Requirements for a Successful Intercept

- The interceptor rocket must reach the target ICBM before the ICBM has achieved a velocity that will allow its warheads to reach the defended area
- The interceptor's final stage ("kill vehicle") must be able to maneuver to hit the ICBM and disable its warhead(s)

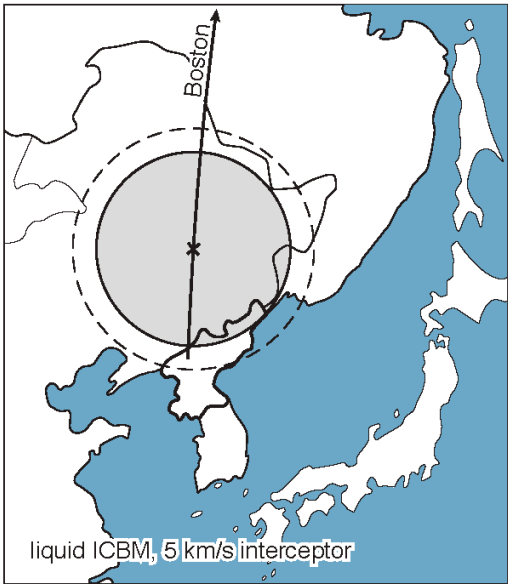
Reaching the ICBM in Time

- In many situations the interceptor rocket would have only ~ 2 min (solids) or ~ 3 min (liquids) to reach the target ICBM, even with a state-of-the-art space-based detection and tracking system
- In some situations, the defense would have only seconds to decide whether to fire, and even if its interceptors were fast and fired immediately, they could have difficulty reaching the ICBM in time

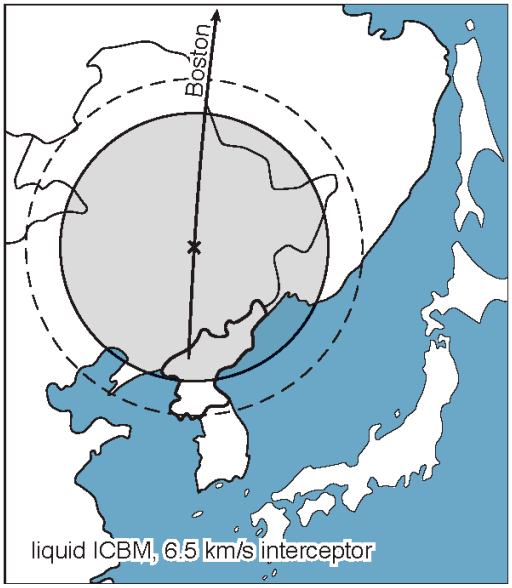
Reaching and Hitting the Target Would Require Large, Fast Booster Rockets



Regional Geography Determines How Close Interceptors Could Be Based



Basing areas for a 5 km/s interceptor to defend Boston against a liquid-propellant ICBM launched from North Korea



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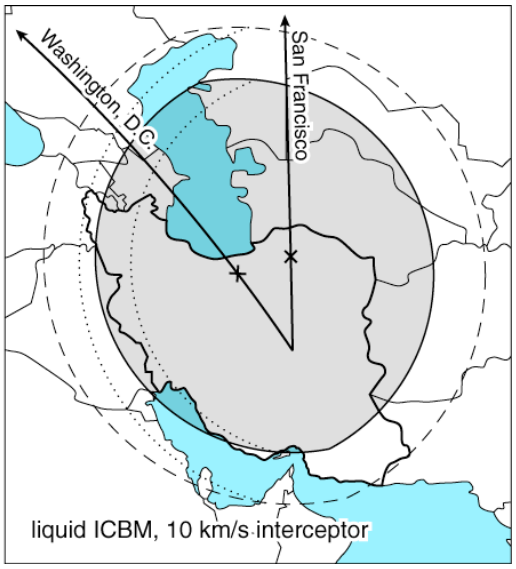
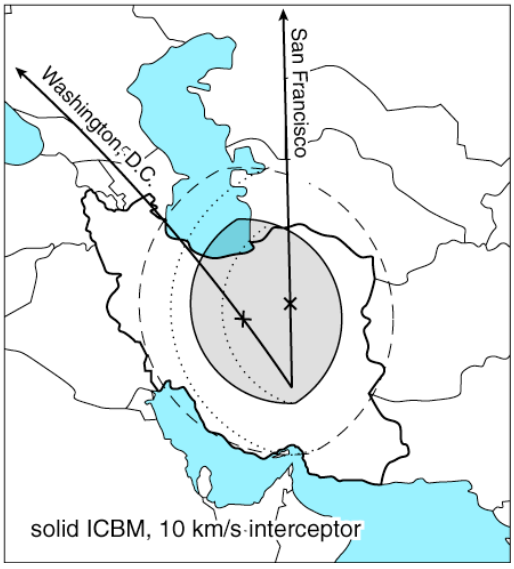


Basing areas for intercepting a liquid-propellant ICBM from Iran to the Lower 48 States



Basing areas for intercepting a solid-propellant ICBM from Iran to the Lower 48 States

Implications of the Time Constraints

The very short time available to complete the intercept poses significant command-and-control issues —

- In some situations the decision whether to fire interceptors would have to be made within a few seconds after a firing solution was obtained
- There would generally be too little time to determine using the system's sensors whether the rocket is an attacking ICBM, a theater ballistic missile, or a rocket launching a satellite
- Consequently, interceptors would have to be fired whenever a large rocket in powered flight is detected, without waiting until the nature of the rocket or its trajectory is established
- Giving commanders the ability to divert or destroy interceptors in flight might extend the assessment time by 100 seconds or so

A System of Space-Based Interceptors Would Require Many Large Satellites

Placing interceptors in space would avoid geographic restrictions on basing, but global geographic constraints would still determine when ICBM must be intercepted

To counter *solid-propellant ICBMs*, at least 1,600 interceptors would be required, each at 840 kg, for a minimum mass in orbit of 2,000 tonnes

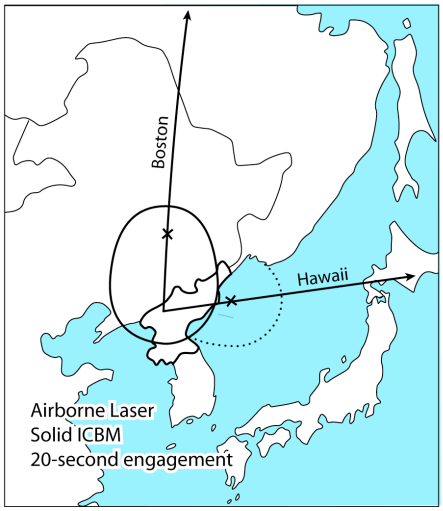
- Would require a 5- to 10-fold increase in the annual U.S. space launch capability

To counter *liquid-propellant ICBMs*, roughly half as many interceptors and space launches would be required

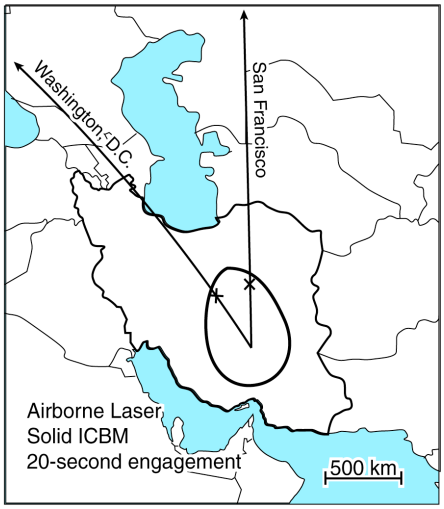
- However, a space-based system designed to counter only liquid-propellant ICBMs could become obsolete quickly

The Airborne Laser Would Have Only Limited Capability Against ICBMs

Basing areas for intercepting a solid-propellant ICBM from North Korea



Basing areas for intercepting a solid-propellant ICBM from Iran



Countermeasures Would Challenge Boost-Phase Intercept

A boost-phase defense would not be susceptible to some of the proposed countermeasures to midcourse defense, but it would face countermeasures

Examples of countermeasures to both hit-to-kill and the ABL
- Launch several ICBMs nearly simultaneously
- Deploy solid-propellant ICBMs

Examples of countermeasures to hit-to-kill
- Deploy payload during powered flight
- Program evasive maneuvers
- Deploy decoys and jammers
- Deploy fast-burn boosters with multiple upper stages
- Mask the kill-vehicle aim point (to defeat warhead kill)

Examples of countermeasures to the ABL
- Attack the airframe
- Roll the ICBM
- Use ablative coating
- Change the optical properties of the ICBM

Physics 280: Session 26

ECEO-C: April 25, 6:30 PM, 144 Loomis

"Nuclear Tipping Point" Video

Plan for Today's Session

Student questions

Module 7: Defenses Against Attacks (cont'd)

Module 8: Nuclear Arms Control

GAO Report on Missile Defense

G A O
Accountability * Integrity * Reliability

GAO-11-555T

April 13, 2011

MISSILE DEFENSE

Actions Needed to Improve Transparency and Accountability

GAO does not make new recommendations in this testimony but emphasizes the importance of implementing past recommendations.

GAO Report on Missile Defense

I am pleased to be here today to discuss the transparency and accountability progress made by the Department of Defense's (DOD) Missile Defense Agency (MDA). MDA has been charged with developing and fielding the Ballistic Missile Defense System (BMDS), a system expected to be capable of defending the United States, deployed troops, friends, and allies against ballistic missiles of all ranges in all phases of flight. The BMDS is DOD's single largest acquisition program—spending between approximately $7 billion to $9.5 billion per year – to develop and field nine elements and supporting efforts. The system's architecture includes space-based and airborne sensors as well as ground- and sea-based radars; ground- and sea-based interceptor missiles; and a command and control, battle management, and communications system to provide the warfighter with the necessary communication links to the sensors and interceptor missiles.

GAO Report on Missile Defense

When MDA was established in 2002, it was granted exceptional flexibility in setting requirements and managing the acquisition, in order that its BMDS be developed as a single program, using a capabilities-based, spiral upgrade approach to quickly deliver a set of integrated defensive capabilities. This decision deferred application of DOD acquisition policy to BMDS until a mature capability is ready to be handed over to a military service for production and operation. Because the BMDS program has not formally entered the DOD acquisition cycle, application of laws that are designed to facilitate oversight and accountability of DOD acquisition programs and that are triggered by phases of this cycle, such as the engineering and manufacturing development phase, has also effectively been deferred. This gives MDA unique latitude to manage the BMDS and it enabled MDA to begin delivering an initial defensive capability in 2004. However, the flexibility also came at the expense of transparency and accountability.

GAO Report on Missile Defense

Specifically, a BMDS cost, schedule, and performance baseline does not have to be established or approved by anyone outside MDA. Recent laws have created some baseline-related requirements for parts of the BMDS.[8] In addition, while most major defense acquisition programs are required by statute to obtain an independent verification of cost estimates, MDA has only recently developed cost estimates for selected assets and plans t

Since its inception, MDA has employed at least three different strategies to acquire and deploy missile defense systems. Because these changes involved different structures for reporting cost, schedule, and performance data, they have exacerbated transparency and accountability challenges—each time a strategy changes, the connection between the old and new strategy planned scope and resources is obscured.

GAO Report on Missile Defense

As we concluded in a prior report, having less transparency and accountability than is normally present in a major weapon program has had consequences.[9] The lack of baselines for the BMDS along with high levels of uncertainty about requirements and program cost estimates effectively set the missile defense program on a path to an undefined destination at an unknown cost. Across the agency, these practices left programs with limited knowledge and few opportunities for crucial management oversight and decision making concerning the agency's investment and the warfighter's continuing needs. At the program level, these practices contributed to quality problems affecting targets acquisitions, which in turn, hampered MDA's ability to conduct tests as planned.

GAO Report on Missile Defense

MDA was still transitioning to this new capabilities-based block approach when the Director, MDA terminated it in June 2009. According to MDA, this was done in order to address congressional concerns regarding how to structure MDA's budget justification materials. This termination marked the third acquisition management strategy for the BMDS in the prior 3 years and effectively reduced transparency and accountability for the agency. The agency then began to manage BMDS as a single integrated program but planned to report on cost, schedule, and performance issues by each element within the program.

Changing the acquisition strategy is problematic because each time it is changed, the connection is obscured between the old strategies' scope and resources and the new strategy's rearranged scope and resources. This makes it difficult for decision makers to hold MDA accountable for expected outcomes and clouds transparency of the agency's efforts.

Module 7: Defenses Against Nuclear Attack

2009–present: Obama's Missile Defense Program

Current Direct Threats to the United States Posed by Nuclear-Armed Ballistic Missiles

Only two countries currently have nuclear-armed ballistic missiles that threaten the territory of the United States —

- *Russia*: currently has 4,000 strategic warheads on delivery vehicles on high alert; on course to reduce this number to 2,000 by 2012; may have as few as 150 land-based missiles by 2015
- *China*: currently has ~ 12 liquid-propellant long-range missiles; warheads are stored separately; has a solid-propellant program

Other countries of concern —

- *North Korea*: Taepo Dong-2, 5,000 km? failed tests in July 2006, April 2009.
- *Iran*: Shahab-3, up to 2,000 km, liquid, deployed; Ghadr, 2,000–3,000 km, solid, untested; unlikely to field a 10,000-km missile by 2015 unless given one by NK.

Obama's Proposed European Missile Defense

The Obama administration's **"phased adaptive approach"** to European missile defense emphasizes deploying Standard Missile 3 interceptors in and around the continent as a defense against Iranian missile threats, while ground-based interceptors fielded in the United States are intended to provide protection against a long-range missile attack.

Obama's Proposed Midcourse Missile Defense

5 Minuteman III ICBM silos at Vandenberg AFB (California) have been converted for missile defense interceptors.

14 new interceptor silos have been built at Ft. Greeley (Alaska); 6 old silos are being phased out.

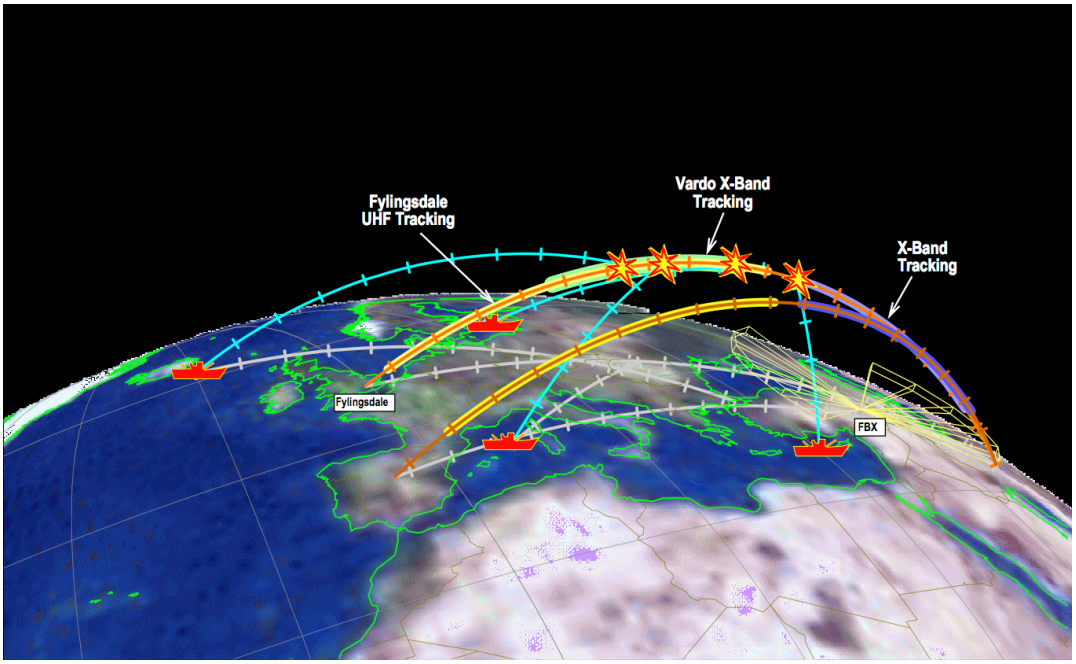
5 new missile interceptors for the new silos have been delivered to Ft. Greeley.

Obama's proposed FY2011 budget would finish the new silos at Ft. Greeley and purchase 5 more interceptors for them.

The U.S. early warning radar at Thule (Greenland) has been upgraded.

Obama plans to upgrade the early warning radar at Clear (Alaska).

Obama's Proposed European Missile Defense



Courtesy T. Postol (MIT)

Obama's Proposed European Missile Defense

Phase 1 of Obama's European missile defense is scheduled for completion in 2011.

This phase will base radars and interceptors on 20 Aegis Cruisers and will deploy forward-based sensors, including a radar, in Israel.

Phase 2 is scheduled for completion in 2015.

This phase will deploy 38 ships with missile-defense radars and interceptors in and around Europe and the Middle East.

It will add sea- and land-based interceptors, including in Poland and Romania, and a radar in southern Europe.

GAO Report on Missile Defense

GAO-11-555T

April 13, 2011

MISSILE DEFENSE

Actions Needed to Improve Transparency and Accountability

GAO does not make new recommendations in this testimony but emphasizes the importance of implementing past recommendations.

GAO Report on Missile Defense

In 2010, MDA made significant progress in addressing previously reported concerns about transparency and accountability. Specifically, MDA :

- Established resource, schedule, test, operational capacity, technical, and contract baselines for several missile defense systems. It reported these to Congress in its June 2010 BMDS Accountability Report.
- Identified three phases of development where baselines are approved—technology development, product development, and initial production phases—and specified the key knowledge that is needed at each phase.
- Established processes for reviewing baselines and approving product development and initial production jointly with the military services that will ultimately be responsible for those assets.

GAO Report on Missile Defense

GAO also reported last year that MDA extensively revised the test plan to increase its robustness and ability to inform models and simulations for assessing missile defense performance.

While it is clear that progress has been made in terms of implementing new acquisition reviews and reporting detailed baselines, there remain critical gaps in the material reported, particularly the quality of the underlying cost estimates needed to establish baselines. Moreover, GAO still has concerns about realism in test planning and acquisition risks associated with the rapid pace of fielding assets. These risks are particularly evident in MDA's efforts to develop systems to support a new approach for missile defense in Europe as well as the Ground-based Midcourse Defense system.

GAO Report on Missile Defense

Ground-based Midcourse Defense: GMD is a ground-based defense system designed to provide combatant commanders the capability to defend the homeland against a limited attack from intermediate, and intercontinental-range ballistic missiles during the midcourse phase of flight. The GMD consists of a ground-based interceptor—a booster with an Exoatmospheric Kill Vehicle on top—and a fire control system that receives target information from sensors in order to formulate a battle plan. GMD continues to deliver assets

GAO Report on Missile Defense

before testing has fully determined their capabilities and limitations. The Director, MDA testified on March 31, 2011 that he considers the GMD interceptors essentially prototypes. In the urgency to deploy assets to meet the Presidential directive to field an initial capability by 2004, assets were built and deployed before developmental testing was completed. During the ongoing developmental testing, issues were found that led to a need for retrofits. GMD intercept tests conducted to date have already led to major hardware or software changes to the interceptors—not all of which have been verified through flight testing. In addition, manufacturing of a new variant called the Capability Enhancement

GAO Report on Missile Defense

of which have been verified through flight testing. In addition, manufacturing of a new variant called the Capability Enhancement II is well underway and more than half of those variants have already been delivered although their capability has not been validated through developmental flight tests. To date, the two flight tests utilizing this variant have both failed to intercept the target. According to MDA, as a result of the most recent failure in December 2010, deliveries of this variant have been halted. Again, because of the urgency to deploy some capability, limited work was undertaken on long-term sustainment for the system which is critical to ensure the system remains effective through 2032. In September 2010, MDA finalized the GMD Stockpile Reliability Program Plan, a key step in developing the knowledge needed to determine the sustainment needs of the GMD system.

GAO Report on Missile Defense

Aegis Ashore: Aegis Ashore is MDA's future land-based variant of the ship-based Aegis BMD. It is expected to track and intercept ballistic missiles in their midcourse phase of flight using Standard Missile-3 (SM-3) interceptor variants as they become available. However, while Aegis BMD has demonstrated performance at sea, these demonstrations used the currently fielded 3.6.1 version of Aegis BMD with the SM-3 IA interceptor, not the newer variant of the Aegis operating system and new interceptor that Aegis Ashore will use. Aegis Ashore is dependent on next-generation versions of Aegis systems—Aegis 4.0.1 and Aegis 5.0—as well as the new SM-3 IB interceptor, all of which are currently under development. Moreover, a series of changes are required to further modify these new variants of Aegis BMD for use on land with Aegis Ashore.

GAO Report on Missile Defense

Changes to those existing Aegis BMD components that will be reused for Aegis Ashore may reduce their maturity in the context of the new Aegis Ashore program, and new features will require testing and assessment to demonstrate their performance. MDA plans to make production decisions for the first operational Aegis Ashore before conducting both ground and flight tests. We concluded in this year's report that it is a highly concurrent effort, with significant cost, schedule and performance risk.

Defenses Against Long-Range Nuclear-Armed Ballistic Missiles

Summary and Conclusions

Status of the U.S. Missile Defense Program

The technical performance of the current U.S. ABM system is dubious.

The few tests that have been conducted have not been realistic operational exercises.

Moreover, a very substantial fraction of these tests have resulted in failures, not because of fundamental design flaws but because of insufficient quality control needed by complex systems. The items which failed in these tests had functioned previously.

The target missile trajectories were known beforehand, and no decoys or other means of deceptive tactics to defeat the ABM system were employed.

Technically, such decoys are considerably easier to produce than the missile itself; therefore, any nation capable of ballistic missile delivery against the United States could also employ countermeasures adequate to render the United States ABM system useless.

Missile Defense Conclusions

The current defense of the United States against nuclear weapons is seriously unbalanced.

We have spent more than $300 billion on defenses against nuclear armed long-range ballistic missiles and are currently spending $10 billion per year.

But nothing stemming from this effort enhances the real security of the United States.

As one example, relative to defenses against ballistic missiles, the effort to improve the security of the vast foreign stockpiles of nuclear weapons and critical nuclear weapons usable material has been less by about a factor of 10.

But this effort is the principal way we can prevent clandestine delivery of nuclear weapons against this the United States.

Nuclear Threats to the United States

Some Missile Defense Questions

The material presented in this module shows that the political actions in this area by the U.S. and Russia are not consistent with the scientific-technical realities. What is the reason for this failure?

- Is it insufficient scientific-technical advice reaching the highest levels of governments?
- Is it deliberate disregard of such advice by national leaders?
- Is it simply the inherent conservatism of governments in their inability to change past erroneous decisions?

One fact is clear: scientific-technical realities cannot be overcome by political claims or wishful thinking. Ignoring the scientific-technical realities creates grave risks for our nation.

iClicker Question

Which of the following missile defense programs was cancelled because it was judged technically infeasible for the foreseeable future?

A. Sea-based Interceptor rockets
B. Interceptor rockets with multiple kill vehicles
C. The Airborne Laser
D. Space-based interceptors
E. All of the above

Blank

iClicker Answer

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C. The Airborne Laser
D. Space-based interceptors
E. **All of the above**

iClicker Question

Even though the tests have been highly scripted and have not included realistic decoys or other simple countermeasures, the ground-based midcourse defense (GMD) system has only achieved what success rate?

A. 0%
B. 10%
C. 50%
D. 80%
E. 90%

Blank

iClicker Answer

Even though the tests have been highly scripted and have not included realistic decoys or other simple countermeasures, the ground-based midcourse defense (GMD) system has only achieved what success rate?

A. 0%
B. 10%
C. 50%
D. 80%
E. 90%

iClicker Question

The interceptor rockets for President Bush's European-based missile defense program:

A. Were tested about a dozen times

B. Were tested only 3 times

C. Were tested only once

D. Were never even built

Blank

iClicker Answer

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Obama's proposed European missile defense system will rely primarily on what type of interceptor?

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B. Small ship-based interceptor rockets

C. Ship-based lasers

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E. All of the above

Blank

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