CBO PAPER

BUDGETARY AND TECHNICAL IMPLICATIONS OF THE ADMINISTRATION'S PLAN FOR NATIONAL MISSILE DEFENSE

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NOTES

Unless otherwise indicated, all years referred to in this paper are fiscal years.

Numbers in the text and tables may not add up to totals because of rounding.

PREFACE

In response to a request from the Senate Democratic Leader and Senators Lautenberg and Levin, the Congressional Budget Office (CBO) has analyzed the potential costs and technical implications of the Administration's plan for a national missile defense (NMD) system. This paper examines the costs to deploy and operate the planned system (including the costs of complying with recommendations from the recent Panel on Reducing Risk in Ballistic Missile Defense Flight Test Programs), notes other funding proposals by the Administration for efforts to counter weapons of mass destruction, assesses the current status of the NMD program, compares it with previous major acquisition programs, and considers other countries' reactions to NMD and possible U.S. responses to those reactions. In keeping with CBO's mandate to provide objective, impartial analysis, the paper makes no recommendations.

The paper was written by Geoffrey Forden of CBO's National Security Division, under the supervision of Christopher Jehn and R. William Thomas, and by Raymond Hall of CBO's Budget Analysis Division, under the supervision of Michael A. Miller. Jo Ann Vines, Zachary Selden, and Matthew Martin made significant contributions to the analysis. Richard Fernandez reviewed the manuscript and provided helpful comments. The authors are also grateful to the numerous people at the Ballistic Missile Defense Organization, the Department of Defense, various NMD ground-test facilities, and elsewhere who provided invaluable help and comments. Despite their assistance, all responsibility for this analysis lies with the authors and CBO.

Christian Spoor edited the manuscript, Christine Bogusz proofread it, and Cindy Cleveland prepared the paper for publication. Kath Quattrone produced the figures. Laurie Brown prepared the electronic versions of the paper for CBO's World Wide Web site (www.cbo.gov).

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SUMMARY AND INTRODUCTION

The Administration's planned program for national missile defense (NMD) is designed to defend the entire United States from attack by a relatively small number of incoming ballistic missiles. Those missiles could contain nuclear, biological, or chemical weapons capable of killing thousands or even millions of people. Much of the public debate about NMD has centered on how pressing the threat is or whether the method chosen—hitting an incoming missile with an interceptor missile and destroying both of them through the force of the impact (so-called hit to kill)—is technologically feasible. Those are important questions. But other issues also become important if the President decides to deploy a national missile defense, issues such as the cost of the system, the number of flight tests planned, the relative shortness of the development schedule, and the possible reactions of other nations. This paper examines those issues.

Costs and Schedule for National Missile Defense

The Administration's plan for NMD gives policymakers the flexibility of deploying the system in three phases, each with different capabilities. The Administration could choose to deploy all three sequentially or halt deployment after any one of them. The first phase, known as Expanded Capability 1, would cost nearly $30 billion, the Congressional Budget Office (CBO) estimates. That figure includes one-time costs and operating costs through fiscal year 2015. (By comparison, the Administration's estimate is nearly $26 billion.) Continuing on to the second stage, Capability 2, would cost an additional $6 billion, for a total of nearly $36 billion, CBO estimates. Achieving Capability 3, the most extensive and sophisticated stage of NMD deployment, would add more than $13 billion to the costs of Capability 2. Thus, costs for the entire system would total nearly $49 billion through 2015, in CBO's view. (The Administration has not released estimates for Capabilities 2 and 3.) Those CBO estimates do not include the costs of space-based sensors for NMD because the sensors would be used for other missions as well and their costs are included in separate Air Force programs. CBO's estimates attempt to strike a balance between overestimating and underestimating potential NMD costs. (For details of how the Administration's estimate used in this analysis differs from numbers recently reported in the press, see Box 1.)

The Administration's current plan for national missile defense shows Expanded Capability 1 possibly being deployed at the end of fiscal year 2007, Capability 2 at the end of 2010, and Capability 3 at the end of 2011. However, the Administration's current Future Years Defense Program, which runs through 2005, does not include significant funds for those later phases. To begin funding the Capability 2 system after 2005 and still meet the target deployment date of late 2010, CBO estimates, would require annual spending that would surpass $3 billion in 2006

BOX 1.
THE ADMINISTRATION'S ESTIMATE USED IN THIS ANALYSIS

On April 4, 2000, a spokesman for the Department of Defense briefed the press about the costs of the national missile defense system as reported in the December 1999 Selected Acquisition Report (SAR). That document gives the Administration's estimate for total acquisition costs as $20.2 billion (adjusted for inflation) between 1991 and 2026. The $25.6 billion that the Congressional Budget Office (CBO) uses as the Administration's estimate in this paper differs from the SAR value for three reasons: it includes operating costs from 2005 through 2015, which CBO estimates would total $7 billion; it excludes $0.7 billion in design costs incurred between 1991 and 1995; and it excludes $0.9 billion in procurement costs planned for 2016 through 2026 (which is beyond the horizon of CBO's analysis).

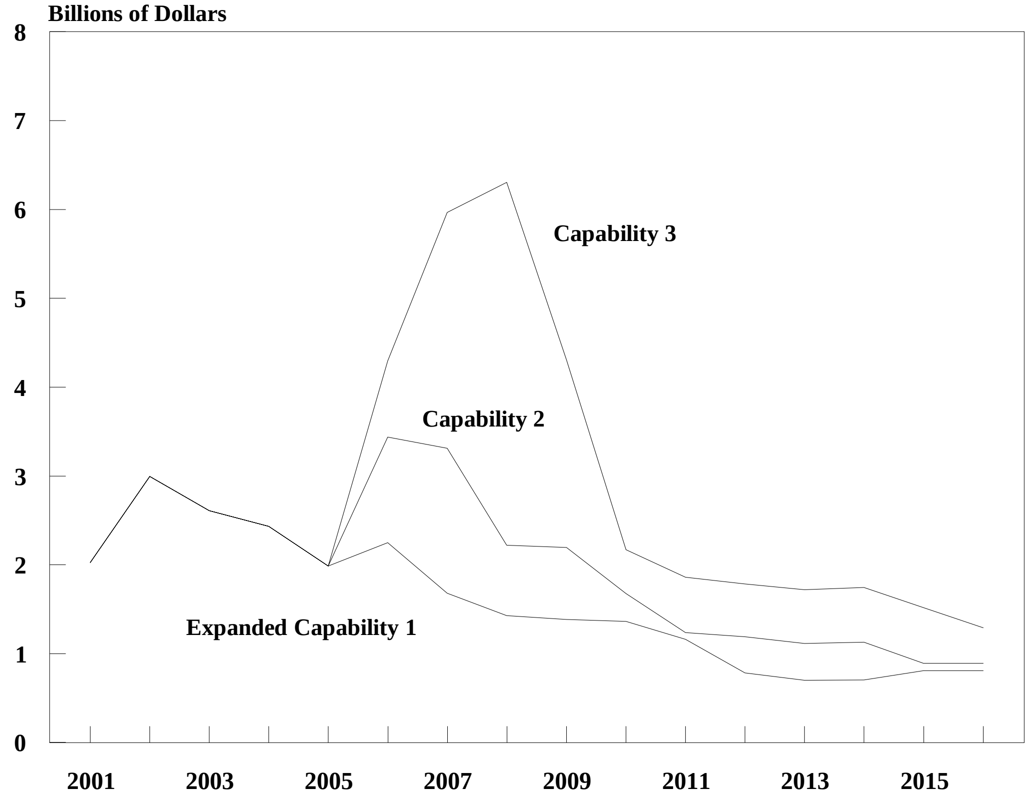
and 2007 (see Figure 1). Moreover, that estimate assumes that the Administration decides not to proceed with Capability 3. If it also attempted to acquire Capability 3 by late 2011—as well as Capability 2 along the way—annual spending would have to exceed $6 billion in 2007 and 2008.

The fact that a number of potentially hostile nations are reported to be developing long-range ballistic missiles has instilled a sense of urgency in the Administration, causing it to propose a very ambitious development schedule for NMD. That schedule is significantly shorter than those of previous missile and satellite programs that CBO examined. The abbreviated schedule raises questions in the minds of some analysts about whether enough tests would be conducted to ensure that the system under development actually worked.

CBO has compared the Administration's flight-test program with those of other major missile development efforts to assess whether the number of proposed test flights is appropriate for a program of this complexity. Unfortunately, the record of past programs is ambiguous. One interpretation of that record—that technological advances in computers and ground tests allow more development to occur with fewer flight tests—suggests that the 21 flight tests proposed for NMD might be sufficient. Another interpretation—that missiles developed from existing systems need fewer flight tests but new concepts need more—suggests that NMD would need more flight tests than the Administration has planned. Those tests cost approximately $80 million each.

Another consequence of the shortened schedule for NMD is a large degree of overlap between developing the system, integrating its various components, and producing it. (For example, all of the interceptors for Expanded Capability 1 would be purchased before the first test flight of the initial operational test and evaluation stage of the development program.) Some overlap is not uncommon in missile development efforts. Program managers use concurrent development and production to quickly field weapon systems that are considered vital to the nation's security—

FIGURE 1. ANNUAL COSTS FOR NATIONAL MISSILE DEFENSE



SOURCE: Congressional Budget Office based on information from the Department of Defense.

which supporters strongly believe NMD to be. However, such overlap can result in both growing costs and, ironically, significant delays in deployment if a system is produced before all of its design problems have been worked out.

Some problems have already occurred in NMD's development. For instance, the system failed to intercept the incoming target during its most recent flight test because of a faulty cooling system in the interceptor. Does that result indicate a serious design problem or a failure in quality control? Both options are potential procurement issues, even if they are not problems with the basic science of the hit-to-kill approach.

Limitations of This Analysis

Because of time constraints, this paper does not fully address a number of important issues, such as how the schedule and costs of the NMD program would change if the Department of Defense (DoD) opted to follow a more traditional, less risky acquisition path. CBO has also not been able to analyze thoroughly how other countries —such as Russia, China, and various rogue states—might adjust their forces because of NMD or what, in turn, the U.S. response to those countries' actions would be and how much it would cost.

In addition, CBO has not attempted to examine the ultimate effectiveness of the NMD system. The estimates in this analysis reflect the costs of the Administration's proposed program plus some additions—such as more operational test and evaluation flights after the system is deployed—that CBO believes would make the program more like previous missile development efforts. CBO assumed that, if successfully implemented, a national missile defense system would be capable of defending the entire United States against several tens of missiles with sophisticated countermeasures. However, defense analysts disagree about the ultimate effectiveness of the NMD system. Many believe that even the simple countermeasures that a country just developing long-range ballistic missiles could use would render NMD impotent. CBO could not make an independent judgment on that point.

THE ORIGINS OF NATIONAL MISSILE DEFENSE

The current plan for national missile defense has its technological origins in the Strategic Defense Initiative (SDI) of the 1980s. SDI researched a large number of technologies for shooting down incoming missiles. They ranged from orbiting laser battle stations to nuclear-tipped interceptor missiles to the hit-to-kill approach chosen for NMD, in which an interceptor destroys an enemy warhead by relying only on the force of their impact. For instance, if a 50-pound interceptor hits its target, the combined speed of the two can be equivalent to over a ton of high explosive.

The mission and the planned design (or architecture) of the national missile defense system have undergone major changes every few years since the mid-1980s. Initially, plans for phase I of SDI involved thousands of interceptors, stationed both on the ground and in space, to defend the United States from a Soviet first strike. When the Soviet Union collapsed in the early 1990s, that program was scaled back to a plan (called Global Protection Against Limited Strikes) that would have deployed hundreds of interceptors in space and on the ground to protect against accidental or unauthorized missile launches.

In 1993, the Clinton Administration changed the emphasis of national missile defense once again, this time from deploying a well-defined system to concentrating on research and development of the supporting technologies. In a move that has become controversial in hindsight, the Administration, together with the intelligence community and the military, concluded that the United States would be able to detect new ballistic missile threats with enough warning to give the country time to deploy an effective defensive system. On the basis of that conclusion, the Administration switched to a strategy—called the "3 + 3 plan"—that would spend three years developing a national missile defense and be prepared to deploy it three years after that (if the threat warranted and the system was technologically ready). The idea was that each year, starting in 2000, the Administration would decide whether to deploy a system three years later.

Recently, however, the intelligence community shortened its estimate of how much warning the United States would have that countries developing intercontinental ballistic missiles (ICBMs) were close to deployment. That revision in judgment came shortly after the independent Commission to Assess the Ballistic Missile Threat to the United States (the Rumsfeld Commission) issued a report that reached similar conclusions and after North Korea attempted to orbit a satellite. Although those developments argued for faster deployment of an NMD system, a report by the independent Panel on Reducing Risk in Ballistic Missile Defense Flight Test Programs (the Welch Panel) warned that deployment by 2003 would entail very high risks and possible failure. Upon further review, the Administration restructured its plan so that deployment could occur in 2005 if a decision was made this summer to do so.

Until recently, DoD had planned to hold the deployment readiness review for national missile defense in June, after which the President would decide whether to deploy the system by the end of 2005. However, the failure of an interceptor to hit its incoming target in the most recent NMD flight test has prompted a one-month delay in that review. Nevertheless, DoD has stated that because of the weather-related limits on constructing a vital radar in Alaska, a decision must be made soon if NMD is to be deployed in 2005.

THE ADMINISTRATION'S PLAN FOR NATIONAL MISSILE DEFENSE

The Administration's NMD system is designed to shoot down intercontinental ballistic missiles as they travel through space. When an enemy missile is launched, the NMD system must detect it, accurately predict where it will be during the 30 or so minutes it will be in flight, determine which of the objects sailing through space toward the United States is the actual missile (as opposed to decoys designed to confuse sensors), and finally send a computer-guided interceptor to collide with the missile's warhead. To accomplish those tasks, NMD depends on a globe-spanning system of satellites, radars, communications systems, and battle management computers to launch and direct interceptors.

Expanded Capability 1

The Administration's plan for developing NMD calls for the first stage, Expanded Capability 1, to be fully deployed by the end of fiscal year 2007 (see Figure 2). That stage is intended to defend the entire United States from attack by several tens of ICBMs that employ simple countermeasures. Because of the perceived urgency of the threat, Expanded Capability 1 will be preceded two years earlier by a "threshold" deployment of 20 interceptors located in central Alaska (see Table 1). That deployment also requires constructing a high-resolution X-band radar and upgrading several existing early-warning radars. Moving to the full Expanded Capability 1 will involve increasing the number of interceptors in Alaska to 100.

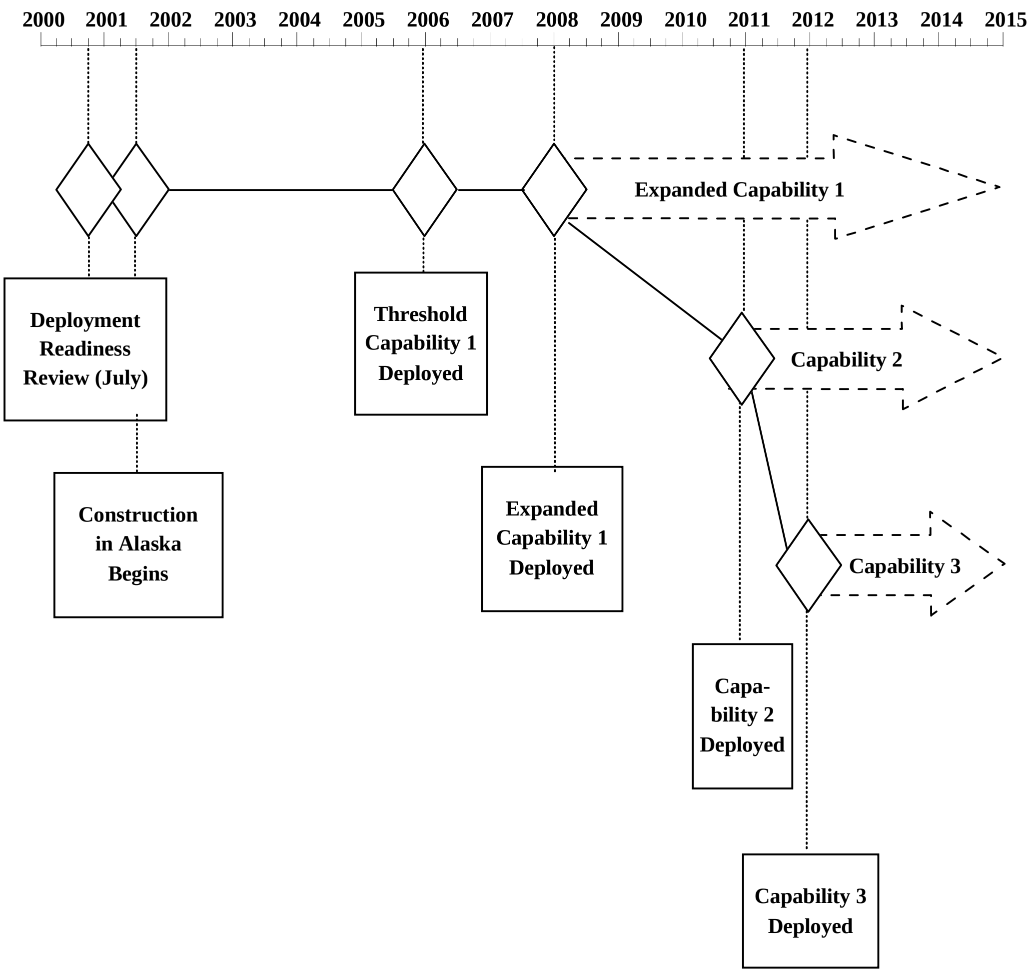
The current system of U.S. space-based early-warning satellites (the Defense Support Program, or DSP) and its replacement (the high-orbit satellites of the Space-Based Infrared System, or SBIRS-high) play an important role for Expanded Capability 1. They will provide the initial warning that an enemy missile has been launched as well as a relatively crude estimate of its trajectory. That information will be used to tell the X-band and upgraded early-warning radars where to search for the incoming missile. (DSP satellites cannot direct missile defenses, however, because they do not provide sufficiently high quality tracking information. SBIRS-high is also not likely to be able to supply good enough tracking data to direct NMD's interceptors.)

Capability 2

The next stage of national missile defense, known as Capability 2, builds on Capability 1 and is designed to cope with more complex countermeasures, but at the price of being able to handle only a few incoming missiles. Current plans call for Capability 2 to be deployed completely by the end of 2010. To achieve the increased abilities of Capability 2, the system would add three more X-band radars at various sites around the world and more facilities to communicate with interceptors in flight. Most important, the system would draw on 24 SBIRS satellites in low-Earth orbit (known as SBIRS-low). Those satellites will track not only missiles under powered flight (as DSP and SBIRS-high satellites will) but also missiles that are gliding through space and thus are not giving off the bright light associated with powered flight. The number of deployed interceptors and the hardware of those interceptors would not change under Capability 2, according to current plans.

By the time it was deployed, Capability 2 would have the full benefit of both SBIRS-high and SBIRS-low satellites. According to the Administration's plan, SBIRS-high would continue, under Capability 2, to supply early-warning information to the national missile defense system as well as to the rest of the U.S. strategic forces. Those satellites' preliminary estimate of an incoming missile's trajectory

FIGURE 2. PROPOSED TIMELINE FOR NATIONAL MISSILE DEFENSE
(By fiscal year)



SOURCE: Congressional Budget Office based on information from the Department of Defense.

would be passed to both the ground-based radars and the SBIRS-low satellites. Most likely, SBIRS-low satellites would spot the incoming missile's warhead and any countermeasures the missile released before ground-based radars could.

If all went according to plan, at least two SBIRS-low satellites would focus on the approaching warhead and determine a more precise path for it. The earlier a precise determination of an incoming warhead's path is made, the sooner the first salvo of interceptors can be fired. SBIRS-low would also record valuable information about the amount of heat given off by the object, which could prove helpful in distinguishing a warhead from decoys.

TABLE 1. NUMBER OF COMPONENTS DEPLOYED AT EACH STAGE OF NATIONAL MISSILE DEFENSE

Component	Threshold Deployment of Capability 1	Expanded Capability 1	Capability 2	Capability 3
Interceptors[a]	20	100	100	250
Launch Sites	1	1	1	2
X-Band Radars	1	1	4	9
Upgraded Early-Warning Radars	5	5	5	6
Interceptor Communications Facilities	3	3	4	5
Memorandum:				
Early-Warning Satellites (SBIRS-high)	2[b]	4[b]	5	5
Warhead-Tracking Satellites (SBIRS-low)	0	6[c]	24	24
Deployment Date[d] (Fiscal years)	2005	2007	2010	2011

SOURCE: Congressional Budget Office based on information from the Department of Defense.

NOTE: SBIRS = Space-Based Infrared System.

a. The number of "kill vehicles" and their associated booster rockets that are deployed. (The national missile defense system will use additional kill vehicles and boosters for testing purposes.)

b. Existing Defense Support Program satellites will also be used for national missile defense.

c. These satellites are planned engineering prototypes.

d. The Department of Defense lists all deployments as occurring in the last quarter of the fiscal year.

Although SBIRS-low is intended to continuously buttress the national missile defense system, it will also support theater missile defenses (systems designed to defend areas outside the United States from relatively short range missiles). Both the precise tracking of SBIRS-low and its ability to distinguish warheads from decoys should significantly aid theater missile defenses. Unlike NMD, however, those defenses are limited in both the area they protect and the length of time for which they are designed to be deployed.

Capability 3

The final level of NMD deployment is Capability 3, which includes all of the assets of Capability 2 plus 150 additional interceptors, more radars, another communications facility, and improved software for each of the systems' components. This stage would combine the capabilities of the two earlier stages by defending the country from several tens of incoming missiles with complex countermeasures.

Some of the additional interceptors would be stationed at a second site, currently planned for Grand Forks, North Dakota. That would improve the system's coverage of the United States by placing interceptors closer to the East Coast. From there, they could attack warheads originating in the Middle East at farther distances from the United States—and thus earlier in the warheads' flight—than interceptors based in Alaska could.

COSTS OF NATIONAL MISSILE DEFENSE

CBO estimates that costs for the Expanded Capability 1 stage of NMD would total $29.5 billion through 2015—$20.9 billion for one-time costs and about $8.5 billion for initial operations (see Table 2). That total is $3.9 billion more than the Administration's estimate. Total costs would increase by $6.1 billion if the system progressed to Capability 2 and by another $13.3 billion if it moved to Capability 3—for a total system cost of $48.8 billion. (The Administration has not estimated the additional costs of Capability 2 or 3.)

CBO's estimates of total costs include one-time expenses for such things as design, procurement, and construction as well as operations costs through 2015. The estimates for operations costs cover different periods of time based on when parts of the system would be initially operational. The estimate for operations for Expanded Capability 1 covers 2005 through 2015; the added operations costs for Capability 2 occur in 2010 through 2015; and the additional costs for Capability 3 come in 2011 through 2015. Those estimates assume that the systems complete more rigorous operational test and evaluation programs than those planned by the Administration during their first five years of operation and reach a steady-state level of

TABLE 2. TOTAL COSTS FOR NATIONAL MISSILE DEFENSE, BY LEVEL OF CAPABILITY, 1996-2015 (In billions of dollars)

	Administration's Estimate[a]	CBO's Estimates		
Type of Cost	Expanded Capability 1	Expanded Capability 1	Capability 2	Capability 3
Design, Procurement, and Construction				
Interceptors	6.1	7.1	9.5	12.7
X-band radars	1.1	1.2	2.5	4.6
Early-warning radars	1.2	1.3	1.3	1.7
Command and communications facilities	2.0	2.2	2.2	3.6
Test and evaluation	2.2	2.2	2.8	2.8
System integration	5.4	5.4	5.4	5.4
Construction	0.5	1.5	1.8	4.0
Subtotal	18.6	20.9	25.6	35.0
Operations[b]				
Operational tests	2.7	4.2	5.2	5.2
Day-to-day operations	1.9	1.9	2.4	3.4
Operational integration	2.4	2.4	2.4	5.3
Subtotal	7.0	8.5	10.0	13.9
Total	25.6	29.5	35.6	48.8
Memorandum:				
Annual Cost for Operations After 2015 (In 2000 dollars)	0.6	0.6	0.7	1.1
Costs of SBIRS-Low[c]	0	0	10.6	10.6

SOURCES: Congressional Budget Office; Department of Defense.

NOTE: The estimates do not include the costs associated with space-based sensors.

a. The Administration has not released estimates for Capability 2 or Capability 3.

b. These estimates for operations show the costs that would be required through fiscal year 2015. They cover different periods of time based on when each level of capability would be initially operational. The estimate for operations for Expanded Capability 1 covers fiscal years 2005 through 2015; Capability 2, 2010 through 2015; and Capability 3, 2011 through 2015.

c. CBO does not include the costs of the low-Earth orbit satellites of the Space-Based Infrared System (SBIRS) in the costs of national missile defense (NMD) because it believes the satellite program will be deployed—even without NMD—to serve other important missions. Nevertheless, SBIRS-low is critical to the performance of Capability 2, especially in determining how that system is structured. Failure to deploy SBIRS-low would either increase the costs of NMD, reduce its effectiveness, or both.

operations costs in their sixth year. In this paper, annual operations costs after 2015 are expressed in fiscal year 2000 dollars, and all other costs are expressed in the dollars of the relevant year (in other words, adjusted for expected inflation).

CBO's estimates for national missile defense do not include the costs of any of the SBIRS space-based sensors because, as noted earlier, those satellites will have other important missions besides supporting NMD. For example, SBIRS-high and SBIRS-low will replace some current aging systems and will contribute new capabilities for theater missile defense, intelligence, and possibly other programs. Those additional missions may be sufficient to ensure that SBIRS is funded and deployed even if a national missile defense is not. However, failure to deploy those space-based sensors would render NMD less effective and possibly lead to changes in the system that would increase its costs.

In determining the potential costs of national missile defense, CBO attempted to strike a balance between overestimating and underestimating. As with any new and complex program, NMD's future costs are uncertain for several reasons, including the usual imprecision that accompanies cost estimates, the chance that the system as currently envisioned will not work as planned, and the likelihood that circumstances will change and call for a major redefinition of the program.

Estimates can and often do go awry for any program (such as development of a weapon system) that depends on technology. But programs that are at the cutting edge of technology (such as NMD) or that employ new methods of production introduce more risk than programs that are based on the use of proven technology and well-established production methods. CBO's estimates of NMD costs have been adjusted to reflect those risks. For example, they include probable cost growth that is common to systems with many sophisticated components, such as interceptors and radars.

Changes in the threat that the national missile defense system is designed to counter may also lead to significant changes in the plans and consequent costs for NMD. If the planned system does not accomplish all of its objectives, engineering and other changes could add to its costs. For example, some defense analysts believe that certain countermeasures could render NMD less effective; should those concerns, or others, prove true, the NMD system will most likely need some design changes or equipment upgrades to improve its effectiveness. As a result, the potential for cost increases may be somewhat greater than the potential for declines in total costs. However, CBO does not yet have a sufficient basis to determine the likelihood of significant design or implementation changes or to estimate the corresponding increase in NMD costs.

Expanded Capability 1

Acquiring the Expanded Capability 1 system would cost about $20.9 billion, CBO estimates. Including operations through 2015—if the NMD system stayed at that capability level for that long—would bring total costs to $29.5 billion. Annual operating costs after 2015 would total $600 million (in 2000 dollars).

As Table 3 outlines, CBO's estimate for Expanded Capability 1 is $3.9 billion more than the Administration's estimate for the same period because of different assumptions about procurement of NMD components, construction, and operations.

Differing estimates for procurement arise for two reasons. First, CBO believes that in addition to the 100 deployed interceptors, the system would need 82 additional interceptors to use in testing and to replace ones lost in accidents or engagements. The Administration puts the number of additional interceptors at 47. However, CBO's larger figure is more consistent with the experience of previous missile programs. It includes 20 additional interceptors for operational testing and evaluation because CBO assumes that the system will need a total of 30 tests over its first five years of operations. (The Peacekeeper missile program conducted about 20 tests during its initial five years of operations, and the Navy's Trident missile program conducted about 40 tests in its first five years.) In addition, CBO projects that a greater number of spare interceptors (20 instead of five) will be necessary to replace ones that are destroyed during engagements or tests and to allow for unforeseen events such as damage during maintenance. CBO assumes that the NMD system is more like tactical air defenses than strategic missile systems in that after an attack, it would be restored to its former condition—a task that would require spare interceptors. In all, the 35 additional interceptors that CBO includes in Expanded Capability 1 would cost almost $0.6 billion, or about $18 million apiece.

Second, CBO's estimates for procurement are higher because they assume that the Expanded Capability 1 system will experience cost growth comparable to that of both analogous strategic systems (such as the Air Force's Minuteman and Peacekeeper missiles and the Navy's Trident missile) and various tactical systems (such as the Air Force's Advanced Medium-Range Air-to-Air Missile, the Navy's Standard missile, and the Army's Patriot missile). The average growth of production costs for those programs has been about 20 percent compared with projections made at a point in their acquisition cycle similar to where NMD is now. As a result, CBO estimates that such growth will add $0.4 billion to the production costs of interceptors and another $0.4 billion to the combined production costs of the X-band radar, the upgraded early-warning radars, and the command and communications facilities. (Because the Administration's estimate includes about 5 percent for cost growth, CBO's estimate reflects an increase of about 15 percentage points.)

TABLE 3. COSTS FOR EACH LEVEL OF CAPABILITY IN THE NATIONAL MISSILE DEFENSE SYSTEM (By fiscal year, in billions of dollars)

	1996-2005	2006-2010	2011-2015	Total, 1996-2015
Expanded Capability 1				
Administration's Estimate	15.5	6.3	3.8	25.6
CBO's Adjustments				
Interceptors	0.4	0.7	*	1.0
X-band radars	0.1	0	0	0.1
Early-warning radars	0.1	0	0	0.1
Command and communications facilities	0.1	*	0	0.2
Test and evaluation	0	0	0	0
System integration	0	0	0	0
Construction	1.0	0	0	1.0
Operational tests	0	1.2	0.3	1.5
Day-to-day operations	0	0	0	0
Operational integration	0	0	0	0
Subtotal	1.7	1.9	0.3	3.9
CBO's Estimate	17.2	8.1	4.2	29.5
Capability 2				
Additions for Capability 2				
Interceptors	0	2.4	0	2.4
X-band radars	0	1.3	0	1.3
Early-warning radars	0	0	0	0
Command and communications facilities	0	0	0	0
Test and evaluation	0	0.7	0	0.7
System integration	0	0	0	0
Construction	0	0.3	0	0.3
Operational tests	0	0	1.0	1.0
Day-to-day operations	0	0.1	0.4	0.5
Operational integration	0	0	0	0
Subtotal	0	4.7	1.4	6.1
CBO's Estimate	17.2	12.9	5.5	35.6

(Continued)

TABLE 3. CONTINUED

	1996-2005	2006-2010	2011-2015	Total, 1996-2015
Capability 3				
Additions for Capability 3				
Interceptors	0	3.3	0	3.3
X-band radars	0	2.2	0	2.2
Early-warning radars	0	0.4	0	0.4
Command and communications facilities	0	1.2	0.2	1.4
Test and evaluation	0	0	0	0
System integration	0	0	0	0
Construction	0	2.1	0	2.1
Operational tests	0	0	0	0
Day-to-day operations	0	0	1.0	1.0
Operational integration	0	1.0	1.9	2.9
Subtotal	0	10.2	3.1	13.3
CBO's Estimate	17.2	23.1	8.6	48.8

SOURCES: Congressional Budget Office; Department of Defense.

NOTES: These estimates do not include costs associated with the low- or high-orbit versions of the Space-Based Infrared System.

* = less than $50 million.

In the area of construction, CBO estimates that building the necessary facilities would cost some $1.5 billion—or $1 billion more than the Administration estimates. Those construction costs cover the X-band radar site, command and communications facilities, 100 missile silos, access roads, housing for personnel, and other infrastructure support. CBO's estimate is based primarily on the cost of constructing the Safeguard missile defense site at Grand Forks, North Dakota, in the early 1970s (about $1.5 billion in today's dollars). It also takes into account similar expenses for land-based ICBMs and planning factors from DoD about relative construction costs in different areas of the country.

CBO expects that operating the Expanded Capability 1 system would cost a total of about $8.5 billion through 2015, which is some $1.5 billion more than the Administration estimates for the same period. All of the difference results from CBO's assumption that 30 operational tests will have to be conducted over the first five years rather than the 10 tests that the Administration now plans.

Eventually, operations costs for Expanded Capability 1 will reach a steady-state level of about $600 million a year (in 2000 dollars). Steady-state operations have three main components: day-to-day costs to run the equipment and keep it ready and to staff the command and communications facilities (a total of about $100 million per year); costs for an operational integration program, which would continually upgrade the NMD system to incorporate new technologies ($300 million per year); and the cost to conduct operational tests (about $200 million per year). Those costs are based on information provided to CBO by the Ballistic Missile Defense Organization.

Capability 2

Although the Administration's plan for NMD indicates possibly upgrading Expanded Capability 1 to a more sophisticated Capability 2 system by the end of 2010, the Administration has not estimated the costs associated with that stage of deployment. However, it has specified what the Capability 2 architecture would consist of as well as the areas in which most of the improvements would be made. Based on that information, CBO estimates that upgrading Expanded Capability 1 to Capability 2 would cost $6.1 billion—for a total cost of $35.6 billion for that level of national missile defense (see Tables 2 and 3).

Although the number of deployed interceptors would remain the same, improving the ability of the Expanded Capability 1 system to handle complex threats (specifically, ballistic missiles with sophisticated countermeasures) would add more than $2 billion to the cost of the interceptors. (The exact technical details of moving from Expanded Capability 1 to Capability 2 have not been announced, but CBO assumes that the budgetary impact would be comparable to that of upgrading the Standard missile to the Block IVA configuration or improving the Patriot missile to the PAC-3 configuration. When those upgrades are complete they will cost $2 billion and $3 billion, in 2000 dollars, respectively.) Moreover, a further 19 interceptors would be needed for integrated flight tests and operational tests, at a cost of slightly more than $0.3 billion, bringing the total increase in interceptor costs to about $2.4 billion.

DoD has indicated that the hardware for the high-resolution X-band radar and the upgraded early-warning radars would not need improvement for Capability 2. But buying three more X-band radars would cost about $1.3 billion, and constructing radar platforms and domes would cost another $0.3 billion ($100 million per radar).

Additional flights to test the upgrades made for Capability 2 would cost about $0.7 billion, CBO estimates. That figure includes seven additional integrated flight tests during 2008 or 2009 (at a cost of about $80 million each) and engineering support. In addition, CBO estimates, 12 more operational tests—which occur after a system has been deployed—would be needed between 2012 through 2014, at a total cost of about $1 billion. Those tests would allow for a rate of six operational tests per year during the first five years of Capability 2's operations.

Finally, moving to Capability 2 would increase the day-to-day operations costs for national missile defense by nearly $100 million a year (to support the three additional X-band radars), or a total of about $0.5 billion. Annual operating costs after 2015 would total $0.7 billion (in 2000 dollars).

The effectiveness of the Capability 2 system depends on the deployment of the SBIRS-low satellites, which, according to the Air Force, will provide the NMD system with 24-hour coverage of global threats. As mentioned earlier, CBO's estimates for national missile defense do not include the costs of those satellites, even though they are essential to Capability 2's success. Those costs would total nearly $10.6 billion through 2015, CBO estimates—$4.2 billion for research and development, $2.7 billion for purchase of the initial 24 SBIRS-low satellites (about $100 million apiece), $1.1 billion for operations (about $5 million a year per satellite), and $2.7 billion for purchase of replacement satellites (assuming each satellite has an average mission life of about eight years). If SBIRS-low was unavailable for any reason, Capability 2 could be achieved by using faster interceptors, deploying more forward-based radars, and developing more capable "kill vehicles" (the part of the interceptor that hits the incoming warhead). None of those changes or additions are currently planned.

Capability 3

The Administration's plan for Capability 3 of NMD calls for deploying 125 additional interceptors (with Capability 2 sophistication) by 2011, probably in Grand Forks, North Dakota. It also calls for adding 25 interceptors to the site in Alaska, for a combined deployment of 250 interceptors. CBO estimates that moving from Capability 2 to Capability 3 would cost more than $13.3 billion through 2015—or a total of $48.8 billion for that level of national missile defense.

The additional costs would come from several areas. CBO estimates that purchasing 150 more deployed interceptors and 30 more spares would cost about $3.3 billion (nearly $18 million each). Buying five additional X-band radars, stationed both in the United States and abroad, would cost a total of about $2.2 billion. Constructing the radars' platforms and domes would cost another $0.5 billion. In addition, buying an upgraded early-warning radar and deploying it in Asia would cost about $0.4 billion, and building the command and communications facilities would cost about $1.4 billion. Other construction costs at Grand Forks would total about $1.6 billion (equivalent to the Alaskan site).

Adding a second site to the NMD system would increase the costs of both day-to-day operations and operational integration. CBO estimates that daily operations at Grand Forks would cost a total of about $1 billion through 2015, or an average of about $200 million a year. Operational integration at that site would start in 2008 and would total about $2.9 billion. Those estimates for day-to-day operations and operational integration are comparable to the costs at the Alaskan site. Annual operating costs after 2015 would total about $1.1 billion (in 2000 dollars).

OTHER ADMINISTRATION PROPOSALS TO COUNTER WEAPONS OF MASS DESTRUCTION

Besides $1.9 billion for national missile defense, the President's latest budget request (for fiscal year 2001) includes funding for a number of other initiatives to prevent the use of weapons of mass destruction against the United States. One of the most important initiatives is U.S. nuclear deterrence, on which the Administration proposes to spend about $20 billion next year. Nuclear deterrence has been the linchpin of U.S. national security strategy for the past 50 years, and some analysts believe it has prevented a third world war. However, some may question whether terrorist groups or countries such as North Korea can be deterred by the threat of massive U.S. nuclear retaliation.

The Administration has also requested funding for a number of missile defense programs other than NMD. While not intended as a national missile defense system, the Air Force's Airborne Laser, if it works as planned, is expected to have significant capabilities to defend the United States against ICBMs launched from North Korea. The President's budget for 2001 contains $150 million for the laser. Furthermore, theater missile defense programs (such as Theater High Altitude Area Defense, Navy Area Wide, Navy Theater Wide, and Patriot), which are designed for use on a battlefield, might also be used to defend parts of the United States against short-range ballistic missiles launched from ships or aircraft. Total proposed funding for those programs in 2001 is $1.7 billion. To defend the United States, however, those systems would have to be deployed in this country, and no plans exist to do so.

The Administration is also proposing to spend $0.5 billion next year on the Cooperative Threat Reduction program, which helps countries of the former Soviet Union dismantle and destroy nuclear, chemical, and biological warheads and systems. In addition, the President's budget requests $0.3 billion for Department of Energy programs to prevent nuclear materials, technologies, and know-how from leaving the former Soviet Union.[1] Also, the Administration is proposing to spend

1. For more information about those programs, see Congressional Budget Office, *Cooperative Approaches to Halt Russian Nuclear Proliferation and Improve the Openness of Nuclear Disarmament,* CBO Memorandum (May 1999).

$55 million next year to implement the Agreed Framework with North Korea, which the State Department says has been instrumental in persuading North Korea to freeze its plutonium production and allow inspections of its nuclear facilities by the International Atomic Energy Agency.

Many U.S. government departments and agencies have programs aimed at either preventing terrorist attacks or responding to such attacks. The Office of Management and Budget has compiled a list of those activities and reports that of the roughly $9 billion proposed for countering terrorism in 2001, $1.6 billion is devoted to countering terrorist weapons of mass destruction. It is not clear, however, that the list includes all U.S. government programs intended to combat weapons of mass destruction. A 1999 report by former Director of Central Intelligence John Deutch and others stated that no one in government knows exactly how much money is being spent on that effort.[2] CBO has not attempted to exhaustively list such activities.

THE STATUS OF NATIONAL MISSILE DEFENSE

The Congressional Budget Office has used briefings from DoD, the annual reports of the Director of Operational Test and Evaluation, and several visits to ground-test sites to assess the current status of the national missile defense program. Although flight tests are the most visible feature of the program, the information needed for the development process comes primarily from ground tests and computer simulations.[3] Hence, much of the recent progress in developing components of the NMD system is based on ground tests and simulations.

Ground tests of NMD components, however, are inherently limited in how completely they can reproduce the environment of combat. Instead of attempting to try out a complete component—such as the interceptor—tests are focused more narrowly, on a single task. For instance, the interceptor's ability to maneuver by using thrusters is examined in tests in which the interceptor hovers above the ground inside a fairly small laboratory space. But the software that controls the interceptor during those hover tests is very different from the programs that would be used during an actual intercept. Other, separate tests examine the actual guidance-control computers and software, but they use computer simulations of the thrusters.

2. Commission to Assess the Organization of the Federal Government to Combat the Proliferation of Weapons of Mass Destruction, *Combating Proliferation of Weapons of Mass Destruction* (July 1999), p. 9.

3. Panel on Reducing Risk in BMD Flight Test Programs, *National Missile Defense Review* (1999), p. 14.

Kill Vehicle and Booster

Two different designs for the interceptor's kill vehicle have flown on flight tests.[4] The first test, in 1997, used a kill vehicle designed by the Boeing Company. However, early the following year, NMD program managers selected a competing Raytheon kill vehicle as the primary design. It has flown on all subsequent flight tests. The first two flights were intentional flybys of an incoming target warhead and associated decoys to test the kill vehicle's sensors and homing guidance; they were deemed highly successful.

In the third flight test, on October 2, 1999, the kill vehicle successfully intercepted the incoming target. That intercept was considered an important milestone for the project. However, DoD's Director of Operational Test and Evaluation raised concerns that the large balloon that accompanied the target warhead as a decoy—to test the interceptor's ability to distinguish countermeasures from warheads—actually helped the kill vehicle pick out the warhead from the blackness of space.[5] Some analysts believe that a lack of sophisticated ground-test capabilities or of time to use existing facilities fully will prevent scientists and engineers from ever knowing whether the interceptor would have seen the incoming warhead without the large balloon.

A fourth flight test, on January 18, 2000, was designed to demonstrate the functionality of all of the NMD components. However, some of the supporting information that would normally have come from certain components—such as the X-band radar—was simulated by position data transmitted from the target warhead itself. That data was considerably more accurate than what the X-band radar would have generated.[6] Nevertheless, in the fourth test flight, the kill vehicle failed to intercept the incoming warhead. DoD analysis indicates that the system used to cool the infrared sensors on the interceptor failed, and therefore the kill vehicle could not see the target to maneuver itself for the impact.

The booster rocket that DoD plans to use to launch the interceptor when the NMD system is actually deployed has not yet been used in a flight test. It is based

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4. NMD flight tests use a target warhead, currently launched from Vandenberg Air Force Base in California, and an interceptor launched from Kwajalein Missile Range in the Marshall Islands in the Pacific. The flight paths of both the target and the interceptor have been chosen so that the two are in the downward portions of their trajectories during the intercept, which prevents debris from an impact from being thrown into outer space and possibly damaging satellites in orbit. Those conditions, however, are considerably different from what an actual engagement might look like.

5. Department of Defense, Director, Operational Test and Evaluation, *Annual Report FY 1999* (February 2000), p. VI-9.

6. Ibid.

on a commercially available rocket motor that is normally strapped to the side of Delta II rockets to give them additional thrust. As such, it has flown successfully a number of times. The second and third stages of the booster will use a different commercially available rocket motor. However, the booster's nozzles for those stages must be modified for use in the NMD system to allow their thrust to be steered when the upper stages ignite. That modification will be tested during three booster-only flight tests scheduled for this year.

The Welch Panel has raised concerns that during launch, the planned booster will subject the interceptor to much greater high-frequency vibrations than the slower booster used in flight tests so far. The shock of those extra vibrations could possibly damage the interceptor. The first test flight using both the interceptor and the new booster is planned for early in fiscal year 2001, but that schedule could slip, as those for all of the recent flight tests did.

X-Band Radar

The high-resolution X-band radar is a primary sensor for national missile defense. In response to cues from other sensors (such as satellites), it will search for incoming warheads, try to discriminate between real warheads and decoys, and supply high-quality tracking information to the interceptor. After an intercept attempt, X-band radars will determine whether the warhead was successfully destroyed (so-called kill assessment).

A prototype X-band radar is functioning at Kwajalein Missile Range in the Marshall Islands and was used in the third and fourth flight tests. It has also been used in risk-reduction flights in which a Minuteman missile was launched from Vandenberg Air Force Base in California, as part of routine testing for Minuteman, but no interceptors were launched. During the third flight test and the risk-reduction flights, the prototype radar successfully picked out the incoming "warheads" from the other objects flying alongside and tracked them. In addition, it successfully performed its kill-assessment tasks during the fourth flight test (when the kill vehicle failed to hit the incoming warhead). Integrated ground tests conducted since April 1998 have also used versions of the signal and data processors from the X-band radar. (Other aspects of the radar's performance were simulated.) Those ground tests demonstrated the integration of the X-band radars into the battle management system.

Upgraded Early-Warning Radar

Because they can see incoming missiles before the X-band radars do, upgraded early-warning radars will allow the national missile defense system to engage incoming warheads earlier in their flight, an important contribution to NMD's capability. They will also assist the higher-resolution X-band radars in tracking and identifying incoming objects. Recent major ground tests appear to show steady improvement in integrating the upgraded early-warning radars into the NMD system as a whole. For example, the first time actual hardware for the radars' computer was included in a major system ground test, it was overwhelmed by the number of instructions the battle management center gave it. Those problems were apparently resolved during the next major ground test.

Battle Management Command, Control, and Communications Systems

The battle management system for national missile defense is designed to plan and assess engagements with incoming missiles, control and direct the operation of the various NMD components, and manage NMD's communications network. That network (known as the In Flight Interceptor Communications System) consists of newly developed, high-bandwidth communications ground antennas used to send information up to the interceptor as it approaches the incoming warhead.

The prototype battle management system was used successfully in the third and fourth flight tests to manage tracking and some communications. Prototype hardware for communicating with the interceptor was also tested during the fourth flight test, though it was not actually used for communicating. In that flight, the battle management system successfully sent the interceptor in-flight target updates about the incoming objects. The major ground tests to date have used the same type of battle management computer that will be deployed in the NMD system. However, those ground tests did not include a direct communications link between the NMD system and the Commander in Chief at Cheyenne Mountain Air Force Base (who serves as the "human in control" for NMD). That link will not be tested before the deployment readiness review this summer.

Significant problems remain with the ground tests, however. Those problems are probably exacerbated by trying to get the entire NMD system working harmoniously while components—such as the upgraded early-warning radars—are still being developed. In the most recent ground test, the system failed to meet program managers' expectations in five out of six scenarios. Most of those failures were caused by problems not with the system hardware or software actually being tested but with the computer models substituted for other components in the simulations. That situation appears to be directly attributable to the difficulties of developing the subsystems at the same time that they are being integrated into the NMD system as a whole.

Space-Based Sensors

During the early stages of NMD deployment (before SBIRS-low becomes operational in 2010), space-based sensors will be able to supply launch-detection and tracking information only during the powered phases of an incoming missile's flight. Initially, that information will be supplied by existing Defense Support Program satellites in geostationary orbits. By 2008, that function will be taken over by SBIRS-high satellites—some in geostationary orbits and others in highly elliptical orbits that cover the North Pole region. When the SBIRS-low satellites (in low-Earth orbit) become fully operational in 2010, they will be able to track incoming objects that are gliding through space as well as ones using powered flight.

The DSP satellites, which have been operating for about 30 years, successfully detected launches during the third and fourth flight tests as well as the risk-reduction flights. Both SBIRS-high and -low satellites are still undergoing development; the Air Force made substantive programmatic changes to both during 1999. In addition, technical problems with some aspects of SBIRS development could affect ground tests for national missile defense. For instance, data from tests of the SBIRS-high sensors are being used to validate computer models that are employed in major ground tests essential for integrating the parts of the NMD system. But the validity of those data—and hence the models based on them—has been questioned because the data were obtained using uncalibrated equipment. If integration work on the NMD system has to be repeated as a result, that system may face delays.

The programmatic changes to SBIRS-low may be even more significant for national missile defense than the technical problems might be. Early in 1999, the Air Force canceled the planned in-orbit tests of those satellites because of cost overruns. Instead, it introduced a more rigorous ground-testing program. However, at the request of DoD's Director of Operational Test and Evaluation, the Air Force instituted a new flexible-design approach in which the first six SBIRS-low satellites would be subject to in-orbit experimentation and testing. That approach is intended to allow modifications in sensor designs and system capabilities at many levels. Although programmatic changes to SBIRS-low are likely to reduce the risks associated with deploying those satellites, they could have serious effects on ground testing and system integration for Capabilities 2 and 3 of NMD.

The NMD System as a Whole

The national missile defense project is making considerable progress integrating its diverse components into a working whole. Much of that progress is being made in sophisticated ground tests of key hardware. Those ground tests, however, must be tied to reality using data from actual test flights. Thus, although most development progress is occurring on the ground and in the laboratory, flight tests remain vital to the program.

How the NMD program will respond to failures during flight tests is uncertain, however. The fact that the national missile defense system has encountered failures to intercept target warheads and other problems is not in and of itself particularly surprising or worrisome. Every major missile program has had flight-test failures of one sort or another.

Historically, programs have taken at least two approaches to proceeding after a failed flight test. One approach replaces any subsystem that might have caused the failure without spending time to determine the exact cause. The Navy followed that approach when it developed the Polaris missile.[7] When a missile igniter system failed, the Navy replaced the entire component with a new design and moved on to the next flight test without repeating the failed mission. That approach has been credited with contributing to the swift and successful development of Polaris. A second approach might make a more deliberate attempt to fix the problem: analyze the data, determine a change, and fly the exact same flight-test mission with the new design to verify that it worked.

Program managers for NMD have decided to follow a third path in dealing with the failure to intercept the dummy warhead during the most recent flight test: they will fly the next test as planned but with increased attention to quality control. Scientists and engineers have devoted considerable effort to finding the exact cause of the failure and have concluded that one of the two cooling systems in the interceptor was obstructed, preventing the infrared detectors from functioning. However, no design changes are anticipated for the next flight; instead, increased care will be paid to ensure that the cooling systems are not blocked. With that change in quality control and a two-month delay, program managers are proceeding with the next planned test-flight mission. The current schedule of flight tests does not provide an opportunity to refly the failed mission.

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7. Harvey M. Sapolsky, *The Polaris System Development: Bureaucratic and Programmatic Success in Government* (Cambridge, Mass.: Harvard University Press, 1972), p. 142.

FLIGHT-TESTING, SCHEDULE, AND DEVELOPMENT ISSUES

According to the most recent report of the Welch Panel, the national missile defense program is following a high-risk acquisition path, in large part because of its compressed schedule.[8] That schedule has been justified by pointing to the uncertainty about when the potential threat might emerge; some analysts have suggested that it already exists. The Welch Panel emphasized the importance of comparing the NMD development program with previous missile and satellite programs. CBO has followed that guidance in considering three areas for comparison: the number of flight tests used during the research and development phase, the length of the development phase, and the overlap of the development and production phases.

The Flight-Test Program

Past missile development programs do not provide a clear indication of how many developmental flight tests such a program should have. (Those tests are used to remove design flaws that might, for example, prevent the rockets from firing, the cooling system from pumping fluids, or the thrusters from maneuvering the interceptor.) On the whole, more recent programs appear to have conducted fewer developmental flight tests than earlier programs did (see Table 4). One possible interpretation of that trend is that the increasing sophistication of ground tests and computer simulations has allowed those types of testing to be substituted for flight tests.

Alternatively, that trend might indicate that familiarity and increasing expertise have allowed DoD to reduce the number of flight tests it needs when it develops new versions of existing missile systems. For instance, Polaris A-2 had fewer flight tests than Polaris A-1, both of which were single-warhead ballistic missiles. Polaris A-3, however, was the first U.S. missile to have multiple warheads—a significant advance in sophistication—and its development included considerably more flight tests than even Polaris A-1 had. Intercontinental ballistic missiles deployed after 1960 also saw an increase in the number of flight tests for the first multiple-warhead missile (Minuteman III), but not as marked an increase as with the submarine-launched ballistic missiles.

Other missile programs had substantially more developmental flight tests than either ICBMs or submarine-launched missiles did. That fact is particularly striking given that many of those programs also flew "captive carry" tests, in which a number of the weapon's functions can be tested in a realistic environment without the expense of destroying the missile. For example, the guidance and control system of

8. Panel on Reducing Risk in BMD Flight Test Programs, *National Missile Defense Review*, p. 6.

TABLE 4. COMPARISON OF TEST PROGRAMS FOR VARIOUS MISSILES

Missile Program	Year of Initial Operational Capability	Number of Test Flights for Research and Development: Single-Warhead Missiles	Multiple-Warhead Missiles
Intercontinental Ballistic Missiles			
Minuteman I	1961	56	n.a.
Minuteman II	1965	20	n.a.
Minuteman III	1970	n.a.	25
Peacekeeper	1986	n.a.	19
Submarine-Launched Ballistic Missiles			
Polaris (A-1)	1960	42	n.a.
Polaris (A-2)	1962	28	n.a.
Polaris (A-3)	1964	n.a.	55
Poseidon (C-3)	1971	n.a.	25
Trident I (C-4)	1979	n.a.	25
Trident II (D-5)	1990	n.a.	28
Other Missiles			
Safeguard Missile Defense	1975	165	n.a.
Standard Missile 2 Block I & II	1981	88	n.a.
Patriot (Air-defense system)	1985	114	n.a.
Tomahawk (Navy)	1986	74	n.a.
Advanced Medium-Range Air-to-Air Missile	1991	111	n.a.

SOURCE: Congressional Budget Office based on information from the Department of Defense and the Federation of American Scientists.

NOTE: n.a. = not applicable.

an antiaircraft missile can be tested (the optical system can sense the target, the computer can decide what maneuvers to make, and the missile's fins can be turned in the right direction) while the missile remains attached to an aircraft that flies toward the target.

If the increasing sophistication of ground-testing and computer capabilities is really the cause of recent declines, the 21 developmental test flights scheduled for NMD would appear to be adequate. If, by contrast, the number of test flights that a missile development program needs is mainly a function of the missile's resemblance to previously developed systems, the 21 test flights might be insufficient. In that case, however, estimating how many test flights the NMD program would actually need on the basis of such simple historical precedents would be impossible.

System Development Time

The historical record provides a more straightforward picture of the length of time needed to develop a new weapon system. Several missile and satellite development projects—the Welch Panel pointed to both types as good historical examples for NMD—that a 1997 report by the General Accounting Office listed had an average duration of nearly 13 years.[9] The recent restructuring of the NMD program to deploy a threshold system in late 2005 gives an expected development time of about 10 years, three years shorter than what a "traditional" program might take. (DoD says the current national missile defense program began in 1996.) Of course, that difference does not indicate how changes in the system's architecture, which have been made frequently during the NMD project, affect the schedule. Some analysts would argue that such changes either slow down the program further or add to costs.

Extending the acquisition schedule for the threshold deployment of Capability 1 to the more traditional 13 years—with deployment by the end of 2008—would have some advantages. Perhaps most important, the technology needed to discriminate between decoys and real warheads would have an additional three years to develop. Currently, the Defense Acquisition Board is scheduled to decide in the middle of 2003 whether to procure the interceptors. Moving that date back to 2006 would allow the board to have information from significantly more developmental test flights. Further, when flight-test failures occurred, the tests could be repeated. Some close observers have stressed the importance of repeating such flight tests, with exactly the same mission profiles, to ensure that changes made in response to failures actually worked.

Another significant advantage gained by extending the acquisition schedule would be improved ground tests and simulations, which are constantly evolving. Currently, system integration for NMD is taking place using computer models of important components. Although that situation is to some extent inevitable given the physical constraints of ground tests, the most recent major ground test (conducted between October 12 and 19, 1999) suffered problems because the computer models —not the components they represented—failed to perform up to expectations in the majority of scenarios tested. Extending the acquisition program would allow more

9. General Accounting Office, *National Missile Defense: Schedule and Technical Risks Represent Significant Development Challenges*, GAO/NSIAD-98-28 (December 1997).

time to improve those simulations and reduce the risk that future integrated ground tests would experience similar problems.

The most expensive aspect of switching to a more traditional acquisition schedule—if policymakers decided to do so—would be the additional test flights. Because of uncertainty about how many test flights a "traditional" NMD procurement path might entail, CBO cannot estimate how much such a path might cost. However, if the program was stretched out to 13 years, there would be at least two alternatives for a new flight-test program. One would be to keep the 21 tests currently planned but increase ground testing to make better use of the data gained. Another possibility would be to launch the maximum number of flight tests during the program extension. (Four per year is the current maximum launch rate at the Kwajalein Missile Range, although that number could increase once a second launch facility being built there is finished.) Conducting four flight tests a year for an additional three years might imply an increase in costs of roughly $1.8 billion (half for the tests and half for the added years of system integration). Of course, that number of additional flights is based on launch capacity rather than known need. But some analysts believe that the NMD program would benefit from more flight tests. However, other analysts believe that the recent restructuring of the NMD flight-test program—which increased the number of developmental flights to 21 from 19—is sufficient given the high cost of each test (roughly $80 million).

Parallel Development and Production

One way to meet an urgent defense need is to overlap the development and production of a weapon system. Building such parallel development and production into an acquisition program can have significant advantages in reducing the time required before deployment, lowering costs, and improving management efficiency. It can also cause significant problems, however.

Design problems that require major alterations can come to light after production has started. That was the case with the B-1B bomber. That aircraft was intended to quickly close a perceived "window of vulnerability" in U.S. strategic forces and was authorized to begin production about three years before its developmental testing was scheduled to be completed. However, serious problems were discovered with the bomber's defensive avionics (a system designed to jam or confuse Soviet radars) several years after production began. Some analysts believe that the development and production overlap might have caused, or at least contributed to, those problems.

National missile defense is a highly concurrent acquisition program. The threshold system of 20 interceptors will become operational before the first of the initial operational test and evaluation (IOT&E) flights takes place in 2006. In fact, the Administration's schedule for NMD would purchase all of the interceptors and boosters needed for Expanded Capability 1 before the first IOT&E flight.

Although national missile defense is an extreme example of production overlapping development, other major missile programs have had significant overlap. For instance, production of the Peacekeeper missile was approved a year and a half before IOT&E started. Furthermore, Peacekeeper became operational only 15 months after that first operational test. Initial deployment of Peacekeeper was followed by more than two years of further initial operational testing. The Trident II missile program was also highly concurrent, with a production decision almost two years before the first performance evaluation test flight. However, Trident II completed those test flights a month before reaching initial operational capability.

Although some analysts would argue that the threat of attack from ballistic missiles justifies such concurrent development and production of NMD, it does entail significant risks. For example, as noted earlier, the Welch Panel says that the booster planned for actual operations will subject the kill vehicle to 10 times more high-frequency vibrations than the rocket used on all of the test flights so far. The increased vibrations could conceivably distort or damage the kill vehicle's optics or electronics, rendering the interceptor impotent.

If that occurred—and it is by no means certain—one possible solution might be to change the structure supporting the kill vehicle on the booster. That in turn could add so much weight that the booster would need to be redesigned. Following that worst-case scenario to a logical conclusion, the silos meant to house the system might also need to be enlarged. However, silo construction would begin in the spring of 2002 to be ready for threshold deployment by the end of 2005. A decision about silo construction in turn is tied to the deployment readiness review scheduled for July.

GLOBAL REACTIONS TO NATIONAL MISSILE DEFENSE

Countries around the world are likely to react in a variety of ways if the United States deploys a national missile defense. The importance of their reaction, how the United States responds to it, and how much that response will cost will depend on the country.

Reactions of Allies

The Administration's plan for NMD involves basing various types of radars at foreign sites. So far, however, no government allied with the United States has publicly taken an unequivocal position on U.S. national missile defense. CBO has not attempted to analyze any potential costs associated with negative reactions by allies.

Reactions of Russia and China

Russia and China will remain the countries with the most lethal ICBM forces threatening the United States for the next 15 years, regardless of whether the United States deploys a national missile defense. Nevertheless, deployment could have discernable consequences. For instance, Russian president-elect Vladimir Putin has warned that if the United States does not adhere to the 1972 Anti-Ballistic Missile Treaty—which is widely believed to prohibit the planned NMD system—Russia might withdraw from the second Strategic Arms Reduction Treaty (START II), which it recently ratified, and all other nuclear and conventional arms control treaties.[10] (Withdrawal from all arms control treaties with the West would have such sweeping security implications for Russia that some analysts might doubt the seriousness of that threat.) Further, some Russian military officers have stated that their newest ICBM, the SS-27, will carry devices capable of allowing their warheads to penetrate any defensive system. However, according to the unclassified summary of the government's 1999 National Intelligence Estimate, economic problems mean that Russia will not be able to maintain forces even as large as those allowed under START II.

China is developing advanced ICBMs and, according to the National Intelligence Estimate, also has the technology to help those missiles penetrate defenses. Many analysts believe that China could also put multiple warheads on its ICBMs—a significant advance. However, it is far from clear that China is pursuing those modernizations out of concern that the United States might deploy a national missile defense. The country has sought to develop an advanced, mobile ICBM for many years as part of its normal modernization program. Of course, if China wanted to respond to NMD by deploying more long-range missiles than it would otherwise, having a modernization program in place might make that easier.

How would the United States respond if Russia backed out of the START II treaty or China deployed additional, advanced ICBMs? The Administration had planned to remain at START I force levels if Russia did not ratify START II. Since that was the plan underlying the President's most recent budget, Russia's withdrawal from the treaty would not entail any additional direct costs for the United States. (But if the United States remained at START I levels, it could not realize any of the

10. Anthony Louis, "Russia Ratifies START-II Treaty; Putin Warns U.S.," *United Press International*, April 14, 2000.

substantial savings associated with decreasing its forces.)[11] Moreover, relations with Russia might sour so much that the Cooperative Threat Reduction program and similar efforts became unworkable. Although that would save the United States money, it might also fuel the proliferation of weapons of mass destruction.

Potential Adversaries Developing ICBMs

According to the unclassified summary of the 1999 National Intelligence Estimate, countries that are developing their first ICBMs would most likely respond to a U.S. national missile defense by deploying more missiles with countermeasures and other aids for penetrating that defense—possibly using technologies purchased from Russia or China. However, the Capability 2 and 3 stages of NMD are designed to counter increasingly sophisticated countermeasures. If those capabilities are sufficient, the United States will not face any additional costs (beyond the $49 billion for Capability 3) to counter those countries' actions. But if Capability 3 proves to be insufficient, there may be substantial development costs associated with designing an improved interceptor—one that might use more advanced technologies such as laser range finding and imaging.

The United States may not have a very clear idea about what types of countermeasures its interceptors will face. Both the Rumsfeld Commission and the National Intelligence Estimate stated that developing countries are unlikely to conduct extensive tests of their missiles before deploying them. For example, North Korea's relatively short range No Dong missile had only one test flight before it was deployed operationally. For that reason and others, some analysts assume that those countries' testing programs for countermeasures will present a minimum of detectable activity. For instance, North Korean missile designers might consider it sufficient simply to suspend a missile's upper stage from a laboratory ceiling while they tested the effectiveness of mechanisms for deploying decoys. Such indoor tests would make it nearly impossible for the United States to gather information about a decoy system.

Several close observers of the NMD program believe that the United States will have to develop responses to countermeasures largely on the basis of ground tests and computer simulations—not flight tests. That may be one reason that the Welch Panel strongly argued that the program should pay more attention to continuing to develop its technologies after deployment. For example, an upgraded interceptor might include not only laser range finding and imaging but also an infrared sensor that used far more than two regions of infrared light. Another

11. If the United States reduced its strategic forces to START II levels by 2007, it could save between $900 million and more than $8 billion over 10 years, depending on the final force structure, CBO has estimated. See Congressional Budget Office, *Budget Options for National Defense* (March 2000), pp. 30-32.

upgrade, which could possibly employ the existing interceptor hardware, might use the visible image that the interceptor already has in guidance and in the distinguishing of targets. But even if those technologies were already available and the NMD program began incorporating them today, developing the necessary ground-test facilities would take five years.

APPENDIX: COSTS OF IMPLEMENTING THE WELCH PANEL'S RECOMMENDATIONS

In 1999, the independent Panel on Reducing Risk in BMD Flight Test Programs, chaired by General Larry Welch (retired Air Force Chief of Staff and former commander of the Strategic Air Command), made a number of recommendations that it believed would reduce risks in the flight-test program for national missile defense. Those recommendations range from increasing both the quantity and quality of ground tests to having the lead system integrator (a private contractor charged with managing the program) take more responsibility for ensuring the performance of subcomponents.

The Department of Defense (DoD) concurs with all of the panel's recommendations and says it has either completed them or is implementing them now. DoD officials told the Congressional Budget Office that they are spending a total of $366 million to comply with the recommendations of the Welch Panel (see Table A-1 for a breakdown of those costs).

TABLE A-1. THE ADMINISTRATION'S ESTIMATE OF THE COSTS OF COMPLYING WITH THE RECOMMENDATIONS OF THE WELCH PANEL
(By fiscal year, in millions of dollars)

Recommendation	2000	2001	2002	2003	2004	2005	Total, 2000-2005
Improve Ground Testing of Hardware	20	41	25	23	24	24	157
Develop a Target More Representative of Likely Threats	7	4	7	0	0	0	18
Add a Risk-Reduction Flight for X-Band Radar	6	0	0	0	0	0	6
Add a Risk-Reduction Flight for Upgraded Early-Warning Radar	0	6	8	0	0	0	14
Improve Capability to Launch Target Missiles from Alaska	6	0	0	0	0	0	6
Increase Capability to Launch Target Missiles from Vandenberg Air Force Base	0	1	0	0	0	0	1
Build a Second Integrated System Test Center for Ground Testing	27	46	28	30	16	17	164
Total	66	98	68	53	40	41	366

SOURCE: Congressional Budget Office based on information from the Department of Defense.

Ballistic missile: a missile that after a short, powered flight coasts to its target (as opposed to a cruise missile).

Battle management: in national missile defense, battle management consists of analyzing incoming warheads and deciding on the appropriate response, such as how many interceptors to fire and when they should be launched.

BMD: ballistic missile defense, intended to protect an area or country from ballistic missiles.

Booster: the rocket stages that boost the kill vehicle into space.

Command and communications facilities: command centers (where commanders direct operations and control forces) and facilities to communicate with forces.

Countermeasures: measures taken by an attacker to increase the likelihood that its warheads will get past defensive systems.

Cruise missile: a missile that remains under powered flight until it reaches its target (as opposed to a ballistic missile).

Decoy: an object designed to look like a warhead that is released by an incoming missile, thereby attracting the missile defense system to attack the decoy and not the real warhead.

Defense Support Program: DSP satellites are the current U.S. early-warning satellites, based in geostationary (deep-space) orbits. They have been operating since the early 1970s. DSP satellites scan the Earth's surface looking for the intense infrared light given off by missiles under powered flight.

Deployment readiness review: a Department of Defense review of the feasibility to deploy the national missile defense system. After the review, the President must decide whether to proceed with deployment.

Flight tests: in the national missile defense program, flight tests are designed to test an individual component (such as the booster) or the entire system. The latter are known as integrated flight tests. To date, they have involved a target warhead launched from Vandenberg Air Force Base in California and an interceptor launched from Kwajalein Missile Range in the Marshall Islands. The flight paths of both of those have been chosen so that they are in the downward portions of their trajectories when impact occurs, which prevents debris from being thrown into outer space and possibly damaging satellites in orbit. That situation is considerably different from what an actual engagement would look like.

Ground tests: in the national missile defense program, ground tests consist of laboratory tests of actual components and subcomponents, such as the kill vehicle's infrared camera, and tests of the entire system (known as integrated ground tests) in which most of the components are simulated.

Hit to kill: a method in which the interceptor's kill vehicle destroys the incoming warhead by colliding with it, relying only on the force of the impact and not on explosives.

ICBM: intercontinental ballistic missile, a land-based missile with a range of more than 3,000 nautical miles.

Interceptor: in the national missile defense program, the interceptor consists of a kill vehicle to collide with a target and a booster to launch the kill vehicle into space.

IOT&E: initial operational test and evaluation. IOT&E tests are conducted on weapon systems to provide a valid estimate of the system's expected operational effectiveness and suitability for its mission. Those tests are performed on prototypes that are similar to what the production process will produce.

Kill vehicle: the component of an interceptor that is designed to collide with an incoming ballistic missile's warhead, destroying both by the force of the impact. The kill vehicle is released from its booster after leaving the atmosphere. The kill vehicle for national missile defense contains an infrared camera, used to guide it to its target, and small rocket engines for maneuvering.

NMD: national missile defense, intended to protect the entire United States from an attack by at most a few tens of intercontinental ballistic missiles.

Operational integration: a term used by the Congressional Budget Office to distinguish system integration that occurs after the national missile defense is operational from system integration that occurs during development.

Risk-reduction flights: flight tests that involve two or three Minuteman III missiles, with dummy warheads, launched each year from Vandenberg Air Force Base as part of the ongoing test regimen for that weapon system. Various national missile defense sensors, such as the prototype X-band radar at Kwajalein Missile Range and the Defense Support Program satellites, try to observe those missiles or their warheads at various stages in their trajectory, but an interceptor is not launched.

Rumsfeld Commission: Commission to Assess the Ballistic Missile Threat to the United States, informally known by the name of its chairman, former Secretary of Defense Donald Rumsfeld. It was mandated by the defense authorization act for fiscal year 1997 to perform an independent assessment of the potential threat to the United States from ballistic missiles. The commission concluded that "The threat to the U.S. posed by [developing ballistic missile programs] is broader, more mature and evolving more rapidly than has been reported in estimates and reports by the Intelligence Community." (Besides Chairman Rumsfeld, the members of the commission were Barry M. Blechman, retired Air Force general Lee Butler, Richard L. Garwin, William R. Graham, William Schneider, Jr., retired Air Force general Larry D. Welch, Paul D. Wolfowitz, and former Director of Central Intelligence R. James Woolsey.)

SBIRS: the Space-Based Infrared System. SBIRS-high consists of next-generation early-warning satellites in geostationary or highly elliptical orbits. SBIRS-low consists of 24 satellites in low-Earth orbit that are designed to track missiles under powered flight (which are very bright when viewed in infrared light) as well as warheads that are gliding through space and thus are much harder to observe.

SDI: Strategic Defense Initiative. Originally proposed by President Reagan as a shield for the United States against massive nuclear attack, SDI evolved into a way to strengthen U.S. deterrence against Soviet ballistic missiles.

System integration: the process of combining components (radars, missiles, communications systems, and so on) into an effective whole.

Theater missile defense: a defensive system designed to protect a relatively small area outside the United States, such as a battlefield, from attack by ballistic missiles with ranges of less than 1,500 nautical miles.

Upgraded early-warning radar: the United States' current group of early-warning radars, situated around its borders and in other countries, continuously scans the horizon for incoming enemy missiles and warheads. Under the national missile defense program, some of those radars will be enhanced with more powerful electronics and more sophisticated software.

Welch Panel: the Panel on Reducing Risk in BMD Flight Test Programs, known informally by the name of its chairman, General Larry Welch, retired Air Force Chief of Staff and former commander of the Strategic Air Command. In two separate reports, the panel concluded that deploying a national missile defense by 2003 would involve a great deal of risk, and it made a number of specific recommendations to reduce the risk of cost increases, schedule delays, and even program failure. (Besides Chairman Welch, the members of the panel were Charles Adolph, Penrose Albright, retired Air Force lieutenant general Aloysius Casey, Charles Cook, Edgar Cortright, retired Army major general Eugene Fax, Michael Fossier, retired Army lieutenant general Donald Lionetti, retired Navy rear admiral Wayne Meyer, Robert Pedraglia, and Maile E. Smith.)

X-band radar: a very high resolution radar that can, in principle, observe the shape and other characteristics of incoming objects as they glide through space. X-band radars are used for precision tracking and to help pick out a real warhead from any decoys or other benign objects that a missile might have released.