United States General Accounting Office

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Report to Congressional Requesters

May 2000

MISSILE DEFENSE

Schedule for Navy Theater Wide Program Should Be Revised to Reduce Risk

GAO

Accountability * Integrity * Reliability

GAO/NSIAD-00-121

Contents

Abbreviations

DOD	Department of Defense
NTW	Navy Theater Wide

United States General Accounting Office
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National Security and
International Affairs Division

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May 31, 2000

The Honorable Carl Levin
Ranking Minority Member
Committee on Armed Services
United States Senate

The Honorable Mary Landrieu
Ranking Member
Strategic Forces Subcommittee
Committee on Armed Services
United States Senate

The Navy Theater Wide system is being developed to defend military and civilian assets, including U.S. and allied military forces in the field, against attacks by medium- and long-range ballistic missiles while they are still outside the atmosphere. The Navy is developing the system in two segments. The first segment, or Block I, is intended to provide an initial capability by 2010 involving the deployment of 80 interceptor missiles aboard 4 ships. The Block II segment is expected to provide an enhanced capability at a yet-to-be-defined date. Total Block I costs are estimated at about $6.4 billion; Block II costs have not yet been estimated.

For fiscal years 1997 through 1999, the Congress increased funding for the program by 150 percent—about $663 million—over the $444 million requested in the President's budgets for those years. The purpose of the increase was to enable the Navy to reduce technical risks and develop system technologies earlier than planned.

You expressed concern that, despite the funding increases, the program was viewed in 1998 by a high ranking Department of Defense official and an independent panel of experts as "high risk" because of technical challenges, such as improving the system's capability to track and destroy enemy ballistic missiles.[1] As a result, you asked us to determine (1) how the additional funding provided by the Congress for the program in fiscal years 1997 through 1999 was used and (2) whether significant risks to the program remain. Within the next month, we also plan to issue reports on the status of two other missile defense systems under development—the Patriot Advanced Capability-3 and National Missile Defense.[2] (A list of related products is included at the end of our report.)

Results in Brief

The Navy used the $663 million in increased funding as intended to reduce technical risks and develop system technologies earlier than originally planned. About 41 percent, or $270 million, was used for system design and analysis efforts, such as reducing the technical risks associated with improving the system's ability to differentiate intended targets from other objects, such as debris. About 20 percent of the funding was used for procuring hardware items, such as rocket motors and test interceptor missiles, earlier than planned. According to program officials, the additional funding also allowed the program to shift from a demonstration effort to determine whether a target in outer space could be hit to an acquisition program in which a weapon system will be fully developed and produced.

Although the Navy used this additional funding to reduce technical risk and develop the system sooner, significant technical and schedule risks still exist. Specifically, the following technical risks remain.

- Technological advancement is required to differentiate the target from other objects. Such discrimination requires, for example, that the

[1] *Report of the Panel on Reducing Risk in Ballistic Missile Defense Flight Test Programs*, Institute for Defense Analyses (Alexandria, Va.: Feb. 1998). The report evaluated the test programs of several missile defense programs.

[2] The ground-based Patriot Advanced Capability-3 system is designed to protect ground troops and assets such as airfields against enemy ballistic missiles while they are within the atmosphere. The space- and ground-based National Missile Defense system is designed to protect the entire United States against long-range enemy missiles while they are outside the atmosphere.

system's computer network can process an enormous amount of data in real time. This network has not been built, and its software must be integrated with the computer code that is already installed on each ship's computer system. Current activities include writing software, examining several computer architectures for the network, and building the capability to test the network.

- Technological advancement is also required in developing the capability of the interceptor missile to seek and destroy the target. We are concerned that the program office has proposed a schedule calling for initial operational testing of the missile in 2010 even though 50 percent of the required 80 missiles would be produced and delivered by 2008 and 100 percent by 2010. Operational testing[3] is designed to provide an independent evaluation of whether a system meets required performance levels prior to beginning production. We have frequently found that cost overruns and the deployment of substandard systems occur when the Department of Defense proceeds into production before systems are tested under operational conditions.

The following schedule risks exist.

- The Navy has scheduled up to seven initial flight tests between July 2000 and September 2001—about one every 2.5 months. This rapid test schedule raises concerns because, according to testing officials, test programs typically separate flight tests by about 6 months. A longer interval between tests gives program officials better opportunities to evaluate test results, understand problems, and incorporate solutions into the next test.
- The Department's approved level of funding does not match the Navy program office's estimate of how much it needs to implement the program on schedule. According to the office, funding levels set by the Department average $282 million per year for fiscal years 2002 through 2005, whereas it estimates a need for an average of $567 million per year to keep to its proposed schedule.

This report contains a recommendation that the Navy revise the proposed funding profile and test schedule for the Navy Theater Wide program to

[3] Operational testing means the field test, under realistic combat conditions, of any item of (or key component of) weapons, equipment, or munitions for the purpose of determining the effectiveness and suitability of the weapons, equipment, or munitions for use in combat by typical military users.

ensure that the Navy can undertake initial operational testing before producing most of its missiles. The Department partially concurred with our recommendation. It agreed to review the funding and schedule. However, the Department did not commit to revising its plans as we recommended.

Background

The Navy Theater Wide (NTW) system is being developed by the Navy and the Department of Defense's (DOD) Ballistic Missile Defense Organization[4] to intercept enemy missiles while they are still above the Earth's atmosphere in a region known as the exoatmosphere. The Army's Theater High Altitude Area Defense system is a land-based counterpart to the Navy's system; it is intended to intercept warheads in the exoatmosphere and as they reenter the atmosphere.[5] The Navy and the Army systems are considered "upper-tier" systems in that they are expected to act as a first line of defense against theater ballistic missiles, which have shorter ranges than intercontinental ballistic missiles. "Lower-tier" systems, such as the Navy Area Defense and Army Patriot Advanced Capability-3 systems, will complement the upper-tier systems, attacking remaining enemy warheads only after they have reentered the atmosphere. In addition, the National Missile Defense system is being developed to defend all 50 states against a limited intercontinental ballistic missile attack.

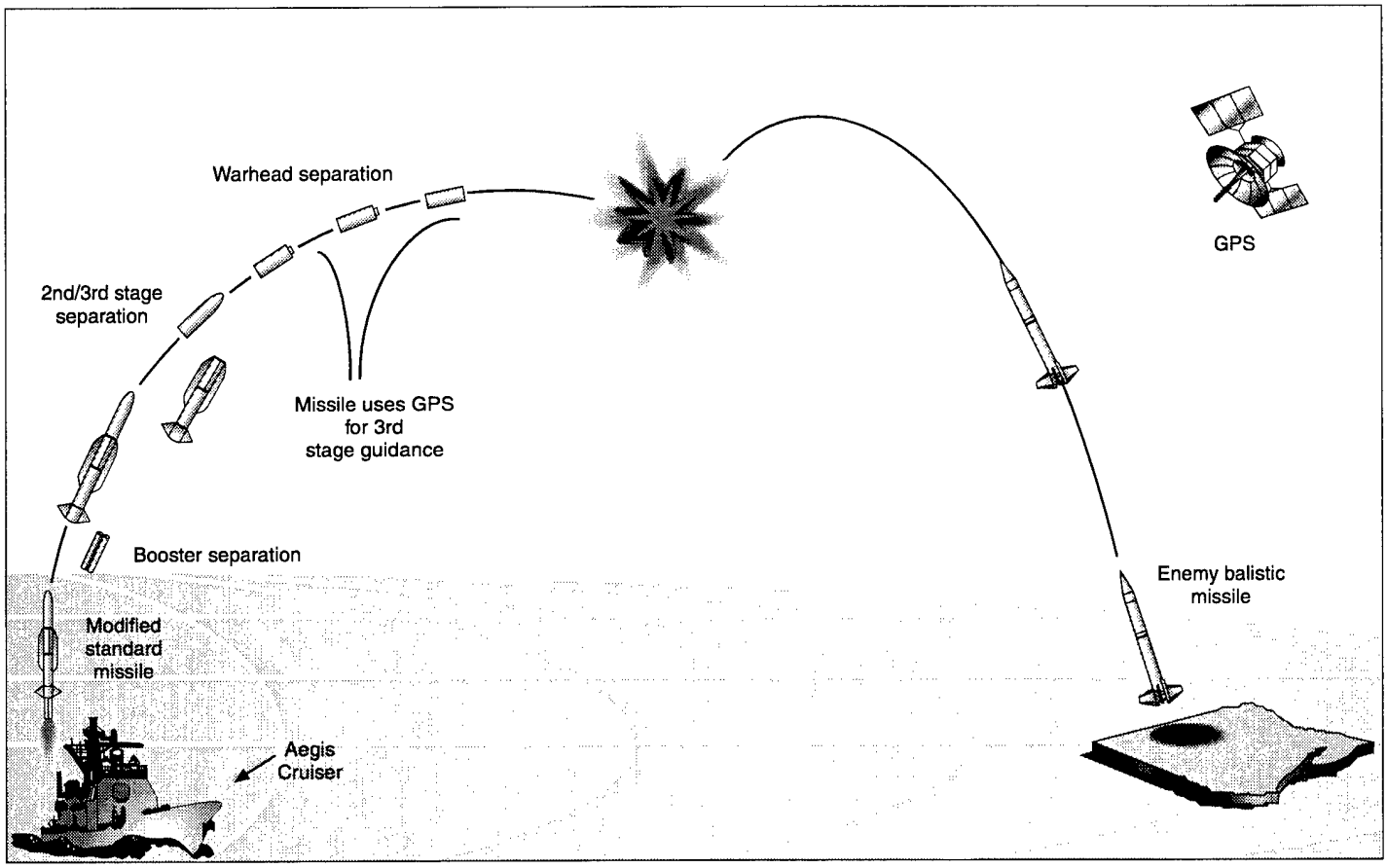
[4] The Ballistic Missile Defense Organization is responsible for managing, directing, and executing DOD's ballistic missile defense program. In the case of NTW, the Organization funds and oversees the Navy's development and implementation of the system.

[5] *Missile Defense: THAAD Restructure Addresses Problems but Limits Early Capability* (GAO/NSIAD-99-142, June 30, 1999).

The Navy Theater Wide system consists of modifications to the Navy's Aegis weapon system and Standard missile. The Aegis weapon system, which is used by certain classes of Navy cruisers and destroyers, is a multimission combat system capable of simultaneous operations against air, surface, and submarine threats. The NTW system, as depicted in figure 1, employs radar (called the AN/SPY-1) to detect and track targets. The NTW system is designed to employ a version of the Navy's Standard missile known as the Standard Missile-3, which is a four-stage guided missile.[6] The missile would be launched from a vertical launching system, which would stow and launch various missiles from Aegis cruisers. NTW-equipped cruisers are expected to use their radar to track enemy missiles and guide the modified Standard missiles to them. The Standard missile features a solid-fueled third stage designed to be fired in two pulses in order to allow the warhead to close on its target. Once in close proximity to its target, the intercepting missile is expected to use an onboard infrared detection system, or "seeker," to discern the heat signature of the incoming warhead. The Standard missile's warhead would then ram the target with enough speed, and in precisely the right location, to significantly damage or destroy it. This "kinetic warhead" is being designed to contain no explosives, it will rely on the force of impact to obliterate its target. This concept is known as "hit-to-kill."

[6] Multiple stages increase the missile's range. The first and second stages are designed to boost the missile into the atmosphere. The purpose of the third stage is to boost the missile further into the exoatmosphere and then guide the missile to the target after separation from the first two stages. The fourth stage, or kinetic warhead, is designed to impact the target.

Figure 1: Depiction of the Navy Theater Wide System



Source: U.S. Navy.

In December 1999, DOD restructured its upper-tier ballistic missile defense programs—NTW and the Army's Theater High Altitude Area Defense—to make possible the funding of both programs in future years. Prior to the restructuring, NTW Block I was scheduled for deployment in 2007. Block I is now scheduled to be deployed in three stages:

- By 2006, Block IA is expected to consist of an Aegis test ship armed with up to six test missiles for use against nonseparating and simple separating enemy missiles.[7]
- By 2008, Block IB is expected to use two Aegis cruisers armed with 50 missiles. The ships would have the capability to change from the missile defense to anti-air warfare mission. They would not, however, be able to operate in both missile and anti-air defense modes simultaneously and would likely require another ship for their own defense against airborne and seaborne threats while conducting the missile defense mission. Block IB is designed to counter all of the Block I threats, including warheads that separate from their missiles.
- By 2010, Block IC is expected to deploy 80 missiles aboard four Aegis cruisers.[8] These ships are intended to perform all of their defense missions simultaneously against all of the Block I threats.

The Navy plans to conduct five series of flight tests in developing the NTW system between 2000 and 2010. The first of these tests, known as the Aegis Lightweight Exoatmospheric Projectile Intercept tests, are designed to test the system's ability to intercept simple targets. If these initial tests are successful, program officials plan to conduct the more challenging Threat Representative Testing against nonseparating targets, followed by the Threat Representative Separating Testing against separating targets. If these tests are successful, the Navy plans to conduct the final two series of tests—the Developmental Test/Operational Assessment and the Developmental Test/Operational Test. The series of operational tests is to be conducted by an independent Navy testing organization in conditions that simulate actual operational conditions.

The Navy also plans to develop a Block II version of the NTW system with increased capability. Block II is expected to intercept more types of theater ballistic missiles at greater ranges than Block I is capable of reaching. Although the Navy is not due to define the Block II architecture and prepare preliminary cost and schedule estimates until November 2000, DOD has begun exploring some of the advanced technologies likely to be

[7] A nonseparating target is one in which the warhead has not separated from the missile. A separating target is one in which the warhead and missile have separated. To destroy a separating target, the system would have to differentiate among the warhead, its missile, and the debris created when the warhead is separated from the missile. A simple separating target is one that, for example, lacks an attitude control module to guide the warhead.

[8] The 80 missiles would include the 50 Block IB missiles as well as 30 additional missiles.

required by the system. A description of these technologies is provided in appendix I. Some DOD officials have stated that the Navy should proceed directly to the development of the Block II system. According to these officials, development resources should be concentrated on the more capable Block II system since Block I will provide only a limited capability and may not be "on the path" to the development of Block II. Other DOD officials have stated that Block I is needed because it would provide a theater missile defense capability that does not currently exist. DOD has required the Navy to report by June 2000 on whether the program should proceed directly to developing the Block II system.

As directed by the conferees for the National Defense Authorization Act for Fiscal Year 1998,[9] DOD has also been exploring what would be involved in adding a sea-based national missile defense capability to the NTW architecture. In response to the conferees, DOD submitted a report in 1999 describing whether and how NTW could be upgraded in the future to provide a limited national missile defense capability.[10] DOD concluded that the Block II system, without upgrades, would have "no useful capability" against longer-range ballistic missiles, but may be useful against shorter-range missiles. Developing a capability against longer-range missiles would involve several improvements, including greater target identification and tracking accuracy, better target discrimination, and a faster and more lethal warhead. In its report, DOD also stated that the yet-to-be-defined Block II system could include a sea-based national missile defense capability and, if fully funded, could be deployed within 4 years of NTW's Block I deployment date (currently estimated to be 2010).

Increased Funding Used to Reduce Technical Risks and Develop Technologies Earlier

The Navy used the increased funding provided by the Congress for the Navy Theater Wide program to reduce risks and develop system technologies earlier than planned. From the NTW program office perspective, the additional funding also allowed the program to shift from a demonstration effort (designed to determine whether the Standard missile could be modified to hit a target in outer space) to an acquisition program (in which a weapon system will be fully developed and produced).

[9] H.R. Conf. Rep. No. 105-340, at 658 (1997).

[10] *Summary of Report to Congress on Utility of Sea-Based Assets to National Missile Defense.* Ballistic Missile Defense Organization (Washington, D.C.: June 1999).

Recent annual reviews of the program issued by DOD's office for operational testing and evaluation and a review in 1998 by an independent panel of experts found NTW to be "high risk" because of technical challenges such as improving the system's capability to track and destroy enemy ballistic missiles. These reviewers noted that NTW needed to improve its test program in order to address these technical challenges. The additional funding provided by the Congress helped the program to address some of these challenges.

The Congress provided DOD with $663 million more than the $444 million requested for NTW in the President's budgets for fiscal years 1997 through 1999. Over 90 percent of the additional funding has been allocated to seven program areas—design and analysis, hardware fabrication and procurement, systems engineering, test and evaluation, ship system modifications, software development, and engineering support. Table 1 shows how the funding increases for the 3-year period, fiscal years 1997 through 1999, have been allocated. Appendix II shows, in detail, the amounts proposed in the President's budget and allocated by DOD after congressional appropriations for fiscal years 1997 through 1999 for the various program areas.

Table 1: Allocations of Congressional Funding Increases for Fiscal Years 1997 Through 1999

Dollars in millions

Program area	Funding increase	Percent of total
Design and analysis	$270	41
Hardware fabrication and procurement	135	20
Systems engineering	67	10
Test and evaluation	47	7
Ship system modifications	32	5
Software development	30	4
Engineering support	24	4
Other[a]	57	9
Total	**$663**	**100**

Note: Totals may not add due to rounding.

[a]Funding for several other program areas, including program management, test equipment, and program support.

Source: Navy.

Details on how the increased funds were used for the top seven program areas are provided below.

- Forty-one percent of the additional funding was used for design and analysis. This program area primarily consisted of design efforts for the Aegis weapon system, the Standard Missile-3, and the vertical launching system. For example, to improve the ability of the system's radar to differentiate the target from other objects, such as debris, engineers developed the High Range Resolution concept for Aegis. High Range Resolution studies were done in 1997 to determine the effectiveness of the AN/SPY-1 radar system in conducting target length measurements, which are used to discriminate the target warhead from the other objects. The additional funding allowed the radar work to be done earlier and allowed a successful at-sea demonstration to be conducted in 1998. The additional funding also led to earlier than planned specification changes, studies, and missile design reviews that determined the Standard Missile-3 had only a minimal impact on the vertical launching system.
- Hardware fabrication and procurement accounted for 20 percent of the additional funding. These funds allowed the program to procure, earlier than planned, rocket motors and material for the fabrication of the initial Aegis Lightweight Exoatmospheric Projectile Intercept test missiles and the Threat Representative Test missiles. In addition, funding went to a laboratory effort that determined the program's signal processing requirements could be met using commercial software. Signal processing requires a large computational capacity, which in the past has been met using computers specifically designed for DOD.
- Systems engineering, which works to match system design to system requirements, accounted for 10 percent of the additional funds. Several documents necessary to initially define requirements for the program were prepared in early 1999. Studies of alternative seekers and other technological options were also completed and provided input into system design decisions. Program officials said that without the additional funding, these efforts would not have been completed until later.
- Test and evaluation accounted for 7 percent of the additional funding. Program officials said that the additional funding allowed them to plan more tests, which should help them to reduce technical risk. The revised test plan increases the number of Aegis Lightweight Exoatmospheric Projectile Intercept test flights from six to seven and starts the flight tests sooner. Furthermore, the revised plan adds the Threat Representative Testing and Threat Representative Separating Testing to

reduce risk. It also increases the number of developmental and operational tests in the last two series of tests from 6 to 20. Overall, the program office was able to triple the number of planned flight tests. The additional funding also allowed program officials to add more ground tests and to conduct them sooner. For example, wind tunnel tests were conducted for the interceptor nose cone and guidance system. In addition, the NTW program used a simulator to test hardware, computer programs, and the AN/SPY-1 radar. Program officials told us that the enhanced test plan should help the program to address the independent review panel's concern that ballistic missile defense programs had not built sufficient developmental testing into their schedules.

- Ship system modifications accounted for 5 percent of the additional funding. To reduce technical risks, program managers used the additional funding to procure and install modifications to an Aegis weapon system development site and to the U.S.S. Paul Hamilton and other test ships. They also procured hardware modifications for vertical launching system test sites, including the purchase of prototype circuit cards for the launch sequencer, and procured and installed the High Range Resolution test bed in the simulator and the test ships.
- Funding for software development, about 4 percent of the additional funding, was used to develop software for the Standard Missile-3, the Aegis weapon system, and the vertical launching system earlier than planned. Much of the funding for Aegis has involved upgrading the Aegis software and ensuring computer software compatibility with commercial computer systems. To achieve the accuracy required for targeting the Standard Missile-3, system engineers had to write a new computer program for the launch control computer so that integration of the launch system with the Global Positioning System[11] could be achieved.
- Engineering support accounted for 4 percent of the additional funding. Most of these funds were used to reduce technical risks by ground testing the NTW system's ability to destroy enemy targets.

[11] The Global Positioning System is a space-based radio navigation network designed to provide precise positioning and navigation capabilities to the military services.

Significant Technical and Schedule Risks Exist

Although the additional funding provided by the Congress was used to reduce technical risk and develop the system sooner, some significant technical and schedule risks remain as the Navy Theater Wide program prepares for flight testing later this year. Technical risks remain, particularly in the areas of target discrimination and the Standard missile. In addition, the program office's proposal to produce the Block I missiles before conducting the initial operational testing is risky because testing frequently reveals problems that require system redesign or modification. The schedule risks stem from (1) compression of the proposed testing schedule and (2) the uncertainty over future budget levels.

Technical Risks

Technical risks for the Block I system remain in the areas of differentiating the target from other objects and upgrading the Standard missile. NTW program documents assess the overall Block I technical risk as moderate to high pending demonstration that the NTW system can hit an exoatmospheric target. The demonstration of a hit-to-kill capability has generally proven to be a difficult technical challenge. Since 1982, even in controlled flight tests, various missile defense programs have successfully demonstrated the hit-to-kill capability above the atmosphere in only 4 of 14 intercept attempts—some 29 percent of the tests. Navy officials acknowledged that developing a hit-to-kill technology has been a difficult technical challenge, but noted that recent intercept attempts have been successful.

Target discrimination

Program managers have to determine whether the Block I system can effectively identify an enemy's ballistic missile warhead above the atmosphere and then guide NTW's Standard missiles to the target. One area of technical risk is the use of the Aegis system's AN/SPY-1 radar. The radar must obtain sufficiently accurate length measurements of objects above the earth's atmosphere to allow the NTW system to discriminate among the warhead, its missile body, and debris created by the release of the warhead from the missile. One DOD testing official described the radar as the "weak link in NTW," and several DOD officials also expressed concerns about the radar's abilities. The AN/SPY-1 is an S-band radar[12] originally designed to deal with targets at lower altitudes, including airplanes and cruise missiles. The NTW program has already begun to test a potential enhancement to the radar's discrimination capability."[13] An NTW program official noted that if the system can discriminate among the objects it will have to deal with, Block I should be able to counter expected threats.

Another risk area is "signal processing," which helps to differentiate the target from other objects. NTW's signal processing would be carried out by a computer network that breaks down large volumes of data in real time and parcels them out to multiple processors. This network has yet to be built, and the NTW computer software must be integrated with the computer code in the existing Aegis weapon system software. Current activities include writing system software, examining several computer architectures for the network, and building test beds to demonstrate the signal processing options.

Standard missile

The NTW system is designed to use a variant of the Navy's Standard missile—the Standard Missile-3—to intercept enemy warheads in the exoatmosphere. Technical concerns about the Standard Missile-3 include: (1) whether it will be able to "see" the enemy warhead through debris created by its own kinetic warhead, (2) whether the kinetic warhead is lethal enough to destroy enemy warheads, and (3) whether all of the

[12] "S-band" and "X-band" refer to particular portions of the radio wave region of the electromagnetic spectrum. Radar employs radio waves to determine characteristics of distant objects, including their ranges. The X-band portion of the spectrum has a shorter wavelength than the S-band and is more useful in determining the length of objects.

[13] Called the High Range Resolution waveform, this software modification pulses emissions from the AN/SPY-1 radar differently than normal and helps process the returning radar signal. It is not in itself a radar wave emitter.

technical concerns have been tested and resolved before the Navy produces all of the Block I missiles.

NTW uses a kinetic, rather than exploding, warhead to ram and destroy enemy ballistic missiles by force of impact. In such a hit-to-kill system, the interceptor missile must be able to hit the target in the right place with enough speed to significantly damage or destroy the missile. The NTW's Standard Missile-3 would be guided to its target by shipborne radar, but in the final moments of flight the missile would be guided by an onboard detection system, known as a seeker.[14] The Block I seeker has already been flown aboard aircraft used to observe flight tests of other missile defense programs and has successfully tracked targets during tests of the Theater High Altitude Area Defense program.

Program officials are generally confident that the seeker will be able to counter the expected threat, but Ballistic Missile Defense Organization officials and testing officials have raised concerns about whether the seeker will be able to "see" the target through the debris cloud created by the kinetic warhead's own "solid divert and attitude control" system, which maneuvers the warhead toward the target. This control system would fire hot gases and solid fuel debris into space around the warhead, possibly creating "plume effects" that could reduce the sensitivity of the infrared seeker. Although ground tests are to be conducted using computers to simulate these effects, program officials have acknowledged that they do not yet know whether this debris cloud will be a problem. These officials said that upcoming initial flight tests are designed to determine the magnitude of the challenge posed by the plume effects. DOD testing officials are concerned, however, that if the number of flight tests is reduced because early intercept attempts are successful, the plume effects may not be sufficiently studied.

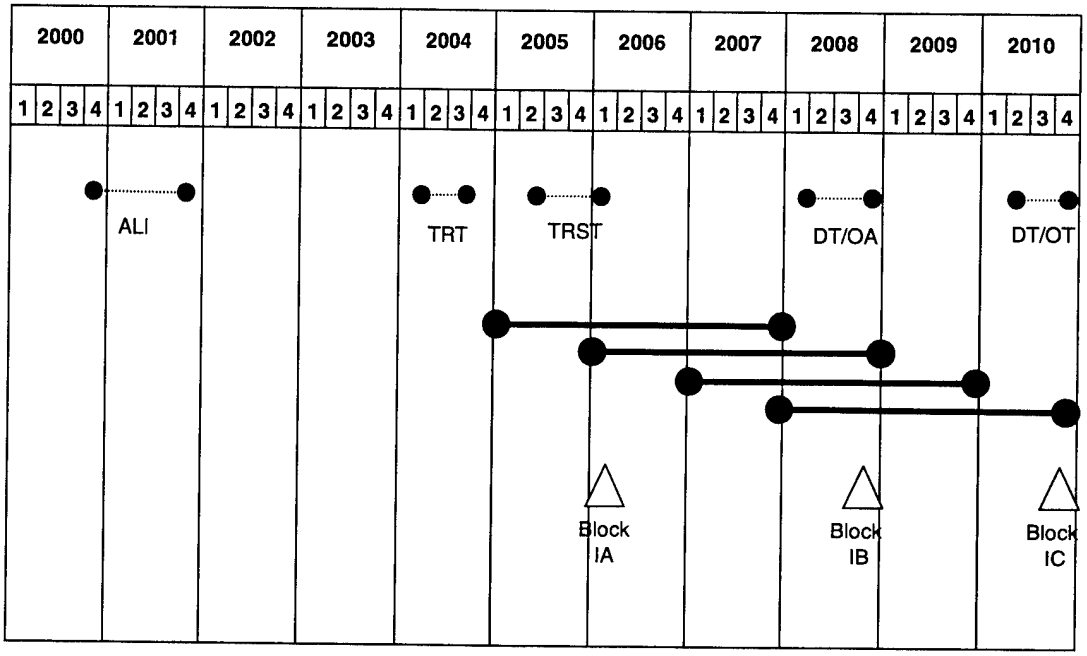
In addition to finding the target, NTW's warhead must hit it with enough force to degrade its mission or destroy it outright. Some DOD officials are concerned about the ability of the lightweight kinetic warhead to destroy enemy ballistic missiles. Program engineers have conducted extensive ground tests of the warhead's lethality against targets with chemical payloads, and they have run computer simulations to predict impact effects

[14] The seeker uses a portion of the infrared region of the electromagnetic spectrum to discern the heat signature of the target warhead. Block I is designed to employ a one-color seeker, utilizing only a single part of the spectrum.

on all targets, including those carrying explosive or nuclear payloads. Based on test results to date, program officials have expressed confidence in the ability of the warhead to damage the target sufficiently to degrade its mission. However, they plan additional ground tests and acknowledge that flight testing is required to prove the viability of the hit-to-kill concept.

Operational testing is designed to independently evaluate whether a system meets required performance levels prior to beginning production and that technical challenges have been resolved. The program office intends, if it gains DOD's approval, to produce all of the Block I interceptor missiles before conducting the initial operational testing. As shown in figure 2, procurement of 20 Block I missiles per year would begin in 2005. After procurement funding is received, the program office estimates that at least 24 months are needed to build a missile. The first delivery is scheduled for 2007 and the last in 2010. However, 50 percent of the missiles are scheduled for delivery before completion of the fourth testing series in 2008 and 100 percent of the missiles before completion of the fifth series, which is operational testing, in 2010.

Figure 2: Proposed Navy Theater Wide Block I Schedule



ALI Aegis Lightweight Exoatmospheric Projectile Intercept test
TRT Threat Representative Testing
TRST Threat Representative Separating Testing
DT/OA Developmental Test/Operational Assessment
DT/OT Developmental Test/Operational Test

Source: GAO.

Program officials told us that they structured the production schedule to achieve deployment of the Block IB system no later than 2008 and Block IC by 2010. They also told us that the risk is low of producing a missile that would require extensive changes based on the later tests. They stated that the design of the Standard Missile-3 is only an evolutionary change from designs of previous Standard missiles; the engineering effort for the missile was "front-loaded;" and successful completion of the earlier tests should enable DOD to fully evaluate the NTW's missile. They said that the main purpose of operational testing will be to evaluate the missile's integration

into the Aegis weapon system rather than the missile's design. They also told us that funding constraints prevent them from conducting the operational test series any sooner.

As discussed above, however, some technological advances in the missile have yet to be proven, such as the ability of the missile's seeker to "see" the target through a debris cloud. Even if program officials are correct in assessing the technical risk with the Standard missile upgrade as low, no guarantee exists that the missile would still not require extensive changes based on operational testing. In the case of the seeker, if testing shows that the seeker's performance is degraded by the debris cloud created by the kinetic warhead's solid divert and attitude control system, then redesign of the control system and the kinetic warhead may be necessary. If it becomes necessary to use a liquid-fueled control system, Navy officials have told us that a redesign of the ship's vertical launching system would be necessary since liquid fuel is more explosive and corrosive than solid fuel.

Our past work has frequently shown that cost overruns and the deployment of substandard systems occur when DOD proceeds into production before systems are tested under operational conditions.[15] When operational testing reveals problems, some of these systems experience design changes and modifications or are never able to perform as required. Also, according to DOD's Risk Management Guide, significant risks result when production begins before the development effort has sufficiently matured.[16] In the case of NTW, DOD testing officials stated that they share our concern about operational testing and said they are currently discussing with the Navy how to revise the proposed schedule for testing and production.

Schedule Risks

We have two concerns about the proposed NTW schedule. Our first concern is compression of the initial flight-test schedule. According to DOD's Risk Management Guide, a program faces significant schedule risk if insufficient time is allotted for thorough testing. The first set of NTW flight tests (the Aegis Lightweight Exoatmospheric Projectile Intercept tests) is to consist of up to seven flight tests within the 15-month period between

[15] *Major Management Challenges and Program Risks: Department of Defense* (GAO/OCG-99-4, Jan. 1999).

[16] *Risk Management Guide for DOD Acquisition*, Department of Defense, Defense Acquisition University, Defense Systems Management College (Second Edition, May 1999), pp. 40-41.

July 2000 and September 2001—about one every 2.5 months. Program officials told us that the maturity of the missile technology and their extensive ground-test program has mitigated the schedule risk. As a result, they believe that although the lack of test targets could cause delays, the gap between flight tests should be sufficient to set up a test and incorporate lessons learned from the previous missile shot. A Navy testing official told us that, in his view, the Navy has a 50-percent chance of maintaining its schedule. He said that programs typically separate flight tests by about 6 months. The longer gap between flight tests helps program officials to better evaluate test results, understand problems, and incorporate solutions into the next test.

We found that the Army's Theater High Altitude Area Defense program took an average of about 3 months between its initial flight tests. However, after three successive test failures, an independent review panel[17] reported that schedule compression may have contributed to problems discovered in one flight test not being fully understood before conducting the next test. Subsequent to this report, the Army's program took over a year between some tests.

Our second concern about the proposed schedule is the mismatch between approved funding levels and the planned activities. According to DOD's Risk Management Guide, significant schedule risks can occur if resources are not available to meet the schedule. In December 1999, DOD restructured NTW's projected funding levels to be able to fund both it and the Army's Theater High Altitude Area Defense programs. Proposed DOD funding for the NTW program averages $282 million per year for fiscal years 2002 through 2005, whereas Navy program officials estimate that they will need an average of $567 million per year to implement the program on its proposed schedule. According to NTW program officials, NTW's proposed schedule is not currently executable because of the budget shortfalls.

Conclusions

The Navy is planning to produce the Block I missiles before it has demonstrated their effectiveness in operational testing. A more prudent, less risky strategy would be to revise the proposed NTW schedule so that the Navy conducts initial operational testing before it produces most of the

[17] *Final Report*, THAAD Independent Review Panel (July 29, 1996).

interceptor missiles. Key technical advances have yet to be proven and conducting operational testing earlier would reduce the risk of incurring additional costs or deploying substandard missiles if testing shows that significant redesign or modification of the missiles is necessary. In our view, the Navy should not defer needed testing because of program officials' concerns about the availability of funding for such testing. A mismatch already exists between approved funding levels and planned activities. It would make more sense to request the funds for operational testing when that testing is most needed—namely, before most of the missiles are produced.

Recommendations

To reduce the risk of producing unproven missiles, we recommend that the Secretary of Defense direct the Secretary of the Navy to revise the proposed funding profile and test schedule for the Navy Theater Wide program to ensure that the Navy conducts initial operational testing before producing most of the Block I missiles.

Agency Comments and Our Evaluation

In written comments to a draft of this report, DOD stated that it partially concurs with our recommendation. It agreed that the NTW program's funding and schedule require review and stated that DOD, the Ballistic Missile Defense Organization, and the Navy are currently reviewing proposed changes to the NTW program test schedule. In addition, DOD said it will review funding profiles for the NTW program in the fall of 2000. However, the Department did not commit to revising its plans to ensure that the Navy conducts initial operational testing before producing most of the Block I missiles, as we recommended. DOD's comments are reprinted in appendix III. We have incorporated DOD's suggested technical changes, as appropriate.

We are concerned about DOD's position because it is only during operational testing that independent testing officials can test the complete weapon system under conditions that simulate actual operational conditions. As noted earlier, we have frequently found that cost overruns and the deployment of substandard systems occur when DOD proceeds into production before systems are operationally tested.

Scope and Methodology

To determine how DOD and the Navy have used the additional funding provided by the Congress for the program in fiscal years 1997 through 1999, we compared original budget documents to current funding allocation documents and discussed reasons for differences in funding levels with officials responsible for managing various elements of the NTW program, such as the ship design and test and evaluation managers.

To identify the program's current risks, we analyzed the program's status, strategy for accomplishing the remaining development work and meeting Block I fielding requirements, and approaches to demonstrating the system's capabilities and military suitability. We also reviewed an independent study of the system's risk and discussed risk levels and approaches to mitigating risk with DOD program and testing officials. We discussed possible Block II technologies with agency officials and reviewed program documentation.

We interviewed responsible agency officials at the Office of the Secretary of Defense, the Joint Staff, Ballistic Missile Defense Organization, and the Office of the Director for Operational Test and Evaluation, in Washington, D.C.; the Navy Program Executive Office for Theater Surface Combatants, Office of the Deputy Chief of Naval Operations, in Washington, D.C.; the Navy Operational Test and Evaluation Force, Norfolk, Virginia; and the Office of the Army Deputy Chief of Staff for Operations and Plans, in Washington, D.C.

We conducted our review from May 1999 through March 2000 in accordance with generally accepted government auditing standards.

As arranged with your staff, unless you publicly announce its contents earlier, we plan no further distribution of this report until 7 days from its issue date. At that time, we plan to provide copies of this report to the Honorable William Cohen, Secretary of Defense; the Honorable Richard Danzig, Secretary of the Navy; the Honorable Jacob Lew, Director, Office of Management and Budget; and key committees of the Congress. We will make copies available to others upon request.

If you or your staff have any questions concerning this report, please contact me on (202) 512-4841. Major contributors to this report were Bob Levin, Lee Edwards, David Hand, and Richard Irving.

Allen Li
Associate Director
Defense Acquisitions Issues

Description of Block II Technologies for Navy Theater Wide Program

Although the Block II version of the Navy Theater Wide program has not yet been defined, program officials recognize that the Block II system depends on substantial advances in state-of-the-art technology.[1] A few of the Block II technologies that we have discussed with program officials are as follows.

- The Block II system is expected to differ from Block I in its need to counter a greater range of threats, some of which could employ countermeasures designed to foil missile defense efforts. As a result, Block II is likely to require more sensitive target discrimination systems that are able to differentiate among warheads and various types of countermeasures at greater distances. To improve Block II discrimination capability, the Navy plans to use improved hardware for the AN/SPY-1 radar. It is exploring a technology called the High Power Discriminator that would enable the radar to pick out smaller objects while searching for the incoming warhead. This capability is critical to the differentiation of the actual warhead from various countermeasures. The basic technology of the High Power Discriminator, which is an adjunct piece of hardware to be mounted in the ship's antennae and integrated into the radar system, is not considered by program officials as high risk. An integration issue does, however, exist. The discriminator would need to be developed for use with Aegis equipment. Currently, two contractor teams are examining the use of X-band and other radar bands for inclusion in the Navy's next-generation radar system, an effort expected to be completed in 2004. Also, a Navy study of future radar systems is ongoing.
- The Navy also plans to develop the Cooperative Engagement Capability to leverage its detection and tracking technologies and enable "shooters" to take advantage of multiple sources of information during battle. Thus, the crew of an Aegis ship could potentially use aircraft or other surface vessels to direct missiles at a target well beyond the range of the ship's radar. If NTW Block II and the Cooperative Engagement Capability could be integrated, battlefield commanders would have a substantial advantage in conducting the theater ballistic missile defense mission, since enemy missiles could be engaged well beyond the line-of-sight radar range of the defending cruisers. Currently, this integration has not occurred, and thus represents an unknown risk.

[1] DOD has entered into a cooperative program with the Government of Japan to jointly develop selected Block II technologies.

- One of the technologies under consideration for Block II is the two-color infrared seeker, which, unlike Block I, has to defeat various countermeasures during the final phase of the intercept; therefore, it requires greater sensitivity than its Block I counterpart. Officials told us that this two-color seeker would take advantage of the greater volume of information that can be gained by using two portions of the infrared region of the electromagnetic spectrum to discern the heat signature of the target warhead. The program is attempting to develop a small, lightweight seeker that could switch from one infrared band to the other rapidly enough to provide nearly simultaneous two-band measurements. The Navy is currently exploring this technology with experimental equipment in a laboratory, but it has not yet been flown. Officials plan to test an experimental version of the seeker during a Ballistic Missile Defense Organization test scheduled for 2001. Even so, one official emphasized that even a two-color seeker might not be able to defeat every type of countermeasure. Also, since the two-color seeker is larger than the one-color seeker, program officials have said that the Standard missile will have to be redesigned to accommodate it, resulting in extensive integration efforts. They said that the two-color seeker would represent a substantial improvement over the Block I seeker in terms of its ability to discriminate between actual warheads and intentional countermeasures. According to a program official, the two-color seeker is already in the early stages of development because it is the highest risk technology envisioned for Block II.
- Program engineers are reviewing the level of lethality needed against high-velocity Block II targets and are considering using kinetic energy devices to enhance Block II's lethality.
- For Block II to counter all of its expected threat, it would require a missile with a higher velocity than that used by Block I. Program officials told us that the simplest way to give the Standard missile greater speed would be to retain the existing first stage and use a larger-diameter second stage, which has yet to be developed. This approach would increase the missile's propellant load and give it greater speed. NTW program officials have already examined this technological approach and consider it to be low risk. Integration into the ship's vertical launch system is also not seen as a major problem.

Research, Development, Test, and Evaluation Funds Budgeted and Allocated for Navy Theater Wide in Fiscal Years 1997-1999

Dollars in millions

	Fiscal year 1997		
Program element	**Budget**	**Allocation**	**Difference**
Design and analysis	$31.00	$129.61	$98.61
Hardware fabrication and procurement	0.00	59.90	59.90
Systems engineering	11.49	23.47	11.98
Test and evaluation	3.50	19.61	16.11
Ship system modifications	0.00	12.68	12.68
Software development	4.00	20.62	16.62
Engineering support	2.00	9.75	7.75
Program management	3.66	9.02	5.36
Test equipment	0.00	10.55	10.55
Program support	2.23	5.36	3.14
Other	0.30	3.61	3.31
Total	**$58.17**	**$304.17**	**$246.00**

Fiscal year 1998			Fiscal year 1999			
Budget	Allocation	Difference	Budget	Allocation	Difference	Total increase
$45.12	$149.47	$104.35	$43.46	$110.34	$66.88	$269.84
58.43	106.75	48.32	55.49	82.63	27.14	135.36
37.62	54.91	17.29	12.92	51.01	38.09	67.36
7.81	39.06	31.25	30.20	30.10	-0.10	47.26
3.88	16.45	12.57	7.16	14.21	7.05	32.31
18.80	20.85	2.05	10.03	21.05	11.02	29.69
6.98	14.82	7.85	5.75	14.64	8.88	24.48
5.82	11.93	6.11	5.69	12.88	7.19	18.66
3.30	10.48	7.18	16.05	15.82	-0.22	17.51
5.39	8.26	2.87	3.39	8.13	4.75	10.75
1.78	4.94	3.16	0.30	3.47	3.17	9.64
$194.90	**$437.90**	**$243.00**	**$190.45**	**$364.28**	**$173.84**	**$662.84**

Comments From the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE
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WASHINGTON DC 20301-3000

ACQUISITION AND TECHNOLOGY

3 MAY 2000

Mr. Allen Li
Associate Director, Defense Acquisitions Issues
National Security and International Affairs Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Li:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "MISSILE DEFENSE: Schedule for Navy Theater Wide Program Should be Revised to Reduce Risk," dated April 5, 2000 (GAO CODE 707420/OSD Case 1976).

The Department partially concurs with the draft report's recommendation. The draft report states (page 17), "To reduce the risk of producing unproven missiles, we recommend that the Secretary of Defense direct the Secretary of the Navy to revise the proposed funding profile and test schedule for the Navy Theater Wide (NTW) program to ensure that the Navy conducts initial operational testing before producing most of the Block I missiles." The Department agrees that the Navy Theater Wide program's funding and schedule require review. The Department, Ballistic Missile Defense Organization, and the Navy are currently reviewing proposed changes to the NTW program test schedule. The Department will review funding profiles for the NTW program in the fall as part of the planned review of the Upper Tier programs.

Suggested technical changes for clarification and accuracy have been provided separately. The detailed DoD comments on the recommendations are enclosed.

The Department appreciates the opportunity to comment on the draft report.

Sincerely,

George R. Schneiter

George R. Schneiter
Director
Strategic and Tactical Systems

Enclosure

GAO DRAFT REPORT DATED April 5, 2000
GAO CODE 707420/OSD Case 1976

"MISSILE DEFENSE: Schedule for Navy Theater Wide Program Should be Revised to Reduce Risk"

DOD COMMENTS ON GAO DRAFT REPORT

RECOMMENDATION 1: To reduce the risk of producing unproven missiles, we recommend that the Secretary of Defense direct the Secretary of the Navy to revise the proposed funding profile and test schedule for the Navy Theater Wide (NTW) program to ensure that the Navy conducts initial operational testing before producing most of the Block I missiles. (p. 17/ GAO Draft Report)

See p. 21.

DOD RESPONSE: Partially Concur. The Department, BMDO, and the Navy are currently reviewing proposed changes to the NTW program test schedule. The Department will review funding profiles for the NTW program in the fall of 2000 as part of the planned review of the Upper Tier programs.

In Fiscal Year 1999, the Department of Defense embarked on an intensive review of the Upper Tier Theater Ballistic Missile Defense (TBMD) programs. The purpose of the review was to define an Upper Tier Strategy that: 1) reduces overall programmatic risk; 2) delivers capability as early as possible; and 3) if possible, reduces program costs. The Upper Tier Strategy approved by the Department satisfied those objectives and complied with Congressional guidance regarding management and funding of the Upper Tier programs. The Department funded NTW to continue the Aegis LEAP Intercept (ALI) test program through FY 2002, and to continue substantial development of the NTW program through FY 05. Upon completion of the ALI tests, the Department will determine how to programmatically proceed with NTW. The Director, BMDO, subsequently directed the NTW Program Manager to develop a program plan that incrementally deploys Block 1A, 1B, and 1C configurations of the system in FYs 06, 08, and 10.

To support the Department review of the Upper Tier programs this fall, the NTW program is developing a revised program baseline to present to the NTW Overarching Integrated Product Team in June 2000. Program officials are continuing to explore options with respect to production authority and testing requirements, while at the same time trying to hold down total program costs and provide this very important upper-tier TBMD capability to the warfighters as soon as practical.

Related GAO Products

Ballistic Missile Defense: Prototype THAAD System (GAO/NSIAD-97-137R, Mar. 27, 1997).

Ballistic Missile Defense: Improvements Needed in THAAD Acquisition Planning (GAO/NSIAD-97-188, Sept. 12, 1997).

Theater Missile Defense: Significant Technical Challenges Face the Airborne Laser Program (GAO/NSIAD-98-37, Oct. 23, 1997).

Ballistic Missile Defense: Improvements Needed in Navy Area Acquisition Planning (GAO/NSIAD-98-34, Nov. 14, 1997).

National Missile Defense: Schedule and Technical Risks Represent Significant Development Challenges (GAO/NSIAD-98-28, Dec. 12, 1997).

Defense Acquisition: Decision Nears on Medium Extended Air Defense System (GAO/NSIAD-98-145, June 9, 1998).

National Missile Defense: Even With Increased Funding Technical and Schedule Risks Are High (GAO/NSIAD-98-153, June 23, 1998).

Cruise Missile Defense: Progress Made but Significant Challenges Remain (GAO/NSIAD-99-68, Mar. 31, 1999).

Defense Acquisitions: DOD Efforts to Develop Laser Weapons for Theater Defense (GAO/NSIAD-99-50, Mar. 31, 1999).

Ballistic Missile Defense: More Common Systems and Components Could Result in Cost Savings (GAO/NSIAD-99-101, May 21, 1999).

Missile Defense: THAAD Restructure Addresses Problems but Limits Early Capability (GAO/NSIAD-99-142, June 30, 1999).