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REDEFINING THE CONCEPTUAL BORDERS OF HOMELAND DEFENSE

Tests and Cost and Technical Risk in the US National Missile Defense Program

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Introduction

The following report is a rough initial draft section of a full report on Homeland Defense being prepared as part of the CSIS Homeland Defense project. It is a rough working draft, and reflects solely the views of the author and not of the CSIS team working on the project. It is being circulated for comment and reaction and will be substantially modified and updated before being included in the final report.

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D. Risk, Cost, and Benefits

The current NMD program is already a highly compromised system based on some seventeen years of research and development effort. The devolution of SDI into NMD has already sharply reduced many aspects of risk. At the same time, even a simplified NMD system represents the most complex problem in systems integration and C^4I/BM design in US history, and creates serious questions about the limits of cost estimation, systems design and even test and evaluation. Ironically, the only way to accurate assess the cost-effectiveness of an NMD system may ultimately be to deploy one. Test and evaluation and simulation can accomplish a great deal in reducing uncertainty, but historically, only field deployment and extensive follow-on testing and modification based on user feedback have ever fully solve the problems involved in complex system development.

It is clear from the previous history that the NMD program suffers from its friends as well as its enemies. Attempts to mandate deployment times and set artificial deadlines have their drawbacks as well as their advantages. The entire history of NMD is a history of a program whose artificial deadlines slip towards reality.

1. Generalizations versus Program Specifics

NMD is scarcely unique in that the full details of the Department of Defense's cost and risk analyses are not public. At the same time, SDIO had a long history of using unique and favorable development, test, and cost assumptions, and the limited data available from the GAO indicate that there is good reason to assume that BMDO's cost estimates remain flawed. More generally, there are few indications that the NMD program has been priced using the higher range of cost-escalation resulting from regression analysis. The derived cost method used seems to be modeled on parametric engineering cost estimates of a kind that have a long history of underestimating real-world costs.

There also does not seem to be an official description of how the system is planned to evolve beyond 2005, or of exactly how it is being costed. In June 2000, the Department of Defense gave a briefing stating its cost estimates were under review. It said that it had said in the president's budget request for FY2001 that it would be around a $14 billion acquisition cost for the entire system of 100 interceptors. It also stated that the costs were under review, because of the Welch Panel recommendations but that the previous figure covered 100 interceptors.[1]

These broad statements only cover incremental procurement costs with no RDT&E costs, and are so general as to have little value. They do not include the life cycle costs of operating the program, and discussing an "entire system of 100 interceptors does not define the specific system being costed. BMDO does not describe the probable timing and growth of the NMD system in its testimony or fact sheets.

Department of Defense sources do indicate, however, that the "best case" for a 2005 deployment would be a system of 20 interceptors, 1 high resolution radar, 5 upgrade early warning radars, with a capability to intercept a maximum of five warheads. This system would grow to 100 interceptor by 2007, under best case conditions, and would then have a maximum intercept capability of 20 warheads. Presumably, this is the system that BMDO is discussing in its cost estimates. The US might have deployed the first six SBIRS warhead tracking satellites, however, and this does acquisition cost does not seem to be in the $14 billion figure.

By 2010, this concept of the evolution of the NMD system would add 3 more high resolution warheads, and 24 warhead tracking satellites as part of SBIRS, a much more expensive system. This system would then potentially grow to two sites, with a total of 250 interceptors, 9 high resolution radars, 6 upgraded high resolution warning radars, and the ability to intercept a maximum of 50 warheads, a system costs far more than twice the total estimated by BMDO.

Unfortunately, this picture of system growth is so unofficial that it makes detailed costing and risk analysis moot, and many experts feel that the actual spend out time for the system to be deployed in 2005-2007 would take 12-16 years, greatly reducing the cost burden in any given year.[2] As for risk, it is important to note that a lack of access to classified data and to comprehensive technical expertise make such assessments suspect in an case. There have been many attempts outside government to discuss the risks, costs, and benefits inherent in the current architecture for the NMD system.

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As the previous history of the US NMD program has shown, providing an objective independent analysis of risk and effectiveness requires far more detail on the program than is currently public. It requires detailed access to BMDO and contractor program plans and risk analysis. It requires review of the detailed cost analyses made of each component and the system, and separate analysis of the systems integration phase.

It also requires a detailed picture of the test and evaluation methodology and of the technical results to date. Without such data, each successful test tends to produce claims by the advocates of NMD that the system can be deployed quickly and with limited risk. Each failure tends to produce the opposite result and claims that the program and technology is hopelessly flawed. The end result has much of the intellectual merit of the scholastic debate during the Middle Ages over now many angels can dance on the head of a pin. The reasoning is fascinating, the empirical evidence is limited.

Barring such access, judgments have to be speculative, and there are two major and conflicting trends that have shaped the history of the development and deployment of complex weapons systems in the US.

- *First, the US has consistently failed to accurately predict the cost of similar complex systems, estimate their initial effectiveness and deployment schedule, and develop test and evaluation methods that can be relied on to predict their performance in the field.* It seems fair to state that US cost analysis methods based on derived costs and engineering data almost invariably underestimate deployment and life-cycle costs and often by several hundred percent. It seems equally fair to say that the US has not deployed a major weapons system in the last quarter of a century that did not require at least half a decade of modification in the field after its initial "combat-ready" deployment date, and that there are no examples of a test and evaluation program adequate to avoid the need for such a post-deployment modification effort.

- *Second, the currently contemplated NMD system has relatively mature components that do not involve major technological leaps or breakthroughs, and the US has rarely failed*

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to develop highly effective systems out of the initial systems it has deployed. If the US tends to rely on a set of management and planning myths in deciding when a system is deployment ready, it corrects its mistakes with unmatched success. The same neo-Luddites who are almost always right in challenging the pre-deployment details of US plans are almost always wrong about overall US success in fielding new systems.

2. Independent US Government Efforts to Assess Risk, Cost, and Benefits: The GAO Study

The current NMD architecture is the product of so many changes that there are only limited data available from independent US government sources like the General Accounting Office (GAO) and Congressional Budget Office (CBO) that apply to the current NMD program. Outside US agencies also have a poor history of assessing technical risk, a problem that has been compounded by the fact the US Congress abolished the Office of Technology Assessment (OTA). To paraphrase Oscar Wilde, the US Congress is organized to deal with technology in ways that allow it to assess the cost of everything and the value of nothing.

At the same time, some of these outside critiques of BMDO by US government agencies are still useful. The most recent comprehensive public GAO report on the technical, cost, and schedule risks of NMD program dates back to February 1998, but many of the broad conclusions in this report still seem to apply to the present NMD program.[3]

> ***Cost Uncertainties:*** Future NMD funding requirements depend in large part on how the system is designed and when and where it will be deployed. These factors may not be known for some time. For example, the government and prime contractor have not yet agreed on a final system design. The deployment schedule and location will not be known until at least the fiscal year 2000 deployment review. To provide a basis for estimating near-term funding requirements and to help determine how these differences will impact future funding needs, the program office prepared four different life-cycle cost estimates, based on two locations—one at Grand Forks, North Dakota, and the other in Alaska—and two capability levels—one available in fiscal year 2003 and the other in fiscal year 2006
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> The life-cycle cost estimates show the total costs to develop and produce system components, construct facilities, deploy the system, and operate it for 20 years. Because specific designs have not yet been determined for system components, life cycle cost estimates are based on assumptions about which designs will be chosen. The cost estimates could change based on decisions made by the prime contractor, or evolution of the threat. The higher cost for a deployment in Alaska by 2003 is due, in large part, to the fact that less infrastructure currently exists there, transportation costs are higher, the construction season is shorter, and the environment is harsher. Procurement and operation and support costs are primarily dependent on the type and amount of hardware included in the deployment. Research and development costs would be slightly higher for an Alaska deployment primarily because of the need for additional site

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survey studies.

The 3+3 program is designed to enable a system to be deployed as early as fiscal year 2003, but a more capable system could be operational in fiscal year 2006, according to BMDO. The primary differences between the two capability levels used in the cost estimates are in the type and amount of hardware included. For example, the more capable system would have significantly more interceptors, fewer ground-based radars, but would also include a space-based sensor system. After the space-based sensor system is deployed, fewer ground-based radars will be needed for an Alaskan deployment because of Alaska's location relative to potential threats. The requirement for fewer radars is the primary reason an Alaskan deployment by fiscal year 2006 is estimated to have a life-cycle cost slightly less than a deployment at Grand Forks in that same timeframe. With fewer radars, operating costs would also be lower in Alaska.

Schedule Risk: In December 1997, we reported that DOD faces significant challenges in the NMD program because of high schedule and technical risk. We pointed out that schedule risk was high because the schedule requires a large number of activities to be completed in a relatively short amount of time. Some development activities are not able to proceed in earnest until the government and prime contractor agree on a final system design. Furthermore, developing and deploying an NMD system in the 6 years allotted under the 3+3 program will be a significant challenge for DOD given its past history with other weapon systems. For example, NMD's acquisition schedule is about one-half as long as that of the Safeguard system, the only U.S.-based ballistic missile defense system developed so far. The program's technical risk is high because the compressed development schedule only allows limited testing. The NMD acquisition strategy called for conducting (1) one system test prior to the initial deployment decision—a test that would not include all system elements or involve stressing conditions such as multiple targets—and (2) one test of the integrated ground-based interceptor before production of the interceptor's booster element must begin. If subsequent tests reveal problems, costly redesign or modification of already produced hardware may be required.

Since our December report, DOD has revised program plans to mitigate schedule and technical risk to some extent. Changes include procuring additional spare hardware to protect against further schedule slips and increasing the amount of planned testing. DOD officials told us, however, that overall schedule and technical risk associated with a 2003 deployment will remain high, despite these actions.

… According to the study panel, which was established by BMDO; the Director of Operational Test and Evaluation; and the Director of Test, Systems Engineering and Evaluation; schedule pressures on NMD have created a planning environment at least as optimistic as that which led to test failures and delays in other missile defense programs.[4] Schedule Risk: Even with the additional funding, the program's schedule risk will remain high, according to DOD officials. Accomplishing all of the required contracting, development, integration, and testing planned before the initial decision point in fiscal year 2000 is, and will continue to be, high risk. According to the program manager, additional funding cannot be used to reduce schedule risk because "we simply cannot buy back time."

Technical Risk*:* Technical risks remain high for a fiscal year 2003 deployment even though the program has made some technical progress and has revised plans to increase the amount of testing prior to deployment. The amount of flight testing is still limited compared to other programs. Other outside reviewers have also commented on the limited amount of flight testing planned for the program.

Since our December 1997 report, the program has made some technical progress. In January 1998, BMDO conducted its second kill vehicle sensor test. An earlier test in June 1997 included a sensor built by a competing company. The purpose of both tests was to analyze the ability of the respective sensors to identify and track objects in space. According to DOD, both sensor tests were successful. The sensors successfully tracked and obtained data needed to identify simulated threat targets and decoys. The two competing contractors are scheduled to test the ability of their kill vehicle designs to actually intercept targets in space during fiscal year 1999. This data will be used to select a single kill vehicle design and

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contractor.

As a result of added funding, BMDO has also increased the number of tests planned. For example, BMDO almost doubled the number of planned integrated ground tests,\12 added one integrated flight test prior to the fiscal year 2000 deployment readiness review, and increased the number of flight tests planned between the readiness review and the system's initial operational capability date. The number of flight tests to be conducted after the readiness review depends on whether or not a decision is made to deploy. Without a deployment decision, there will be two integrated flight tests per year. If a deployment decision is made in fiscal year 2000, with a target deployment of fiscal year 2003, there would be three flight tests in fiscal year 2000, and four a year in fiscal years 2001 through 2003.

Overall technical risk associated with a fiscal year 2003 deployment remains high because the amount of testing, although increased, is still limited compared to other programs. Even after the increase in the number of tests, the program manager told us that in his view, the planned flight test program is anemic. The program plans a maximum of 16-system level flight tests through the end of fiscal year 2003, the earliest planned deployment date. By contrast, the Safeguard\13 program included 111 flight tests before the system became operational. Of these 111 tests, 70 were intercept tests, 58 of which were successful. The panel on reducing risk in ballistic missile defense programs also concluded that plans for the 3+3 program are based on inadequate test assets and testing. The panel recommended increasing the number of tests (both ground and flight tests) and that the flight test program be restructured to allow more time between tests to ensure that problems are corrected and the corrections are tested.

Technical risk in the NMD program is also of concern to DOD's testing organization. According to the Director of Operational Test and Evaluation's Annual Report for fiscal year 1997, the planned NMD test program will provide only a limited basis for evaluating system performance. The limitations cited in the report include (1) the limited amount of testing planned prior to the deployment readiness review; (2) the fact that the booster to be used in the ground-based interceptor will not be tested prior to the readiness review; (3) the interface between the system's battle management, command, communications, and control element and the national command authority will not be tested before the decision review; (4) the system's performance against multiple targets will not be tested; and (5)models and simulations used to support the review will have minimal validation by real flight data. NMD program officials told us that they are in the process of redefining the program's risk. The new risk assessment is scheduled to be completed and documented by early June 1998. They also pointed out that the prime contractor's system design and program plans may impact risk. According to the program's test and evaluation master plan, the amount of testing is unlikely to change as a result of prime contractor selection.

3. Independent US Government Efforts to Assess Risk, Cost, and Benefits: The Report of the Panel on Reducing Risk in Ballistic Missile Defense Flight Test Programs: "Welch Panel"

Many of the GAO's conclusions are similar to those in the Report of the Panel on Reducing Risk in Ballistic Missile Defense Flight Test Programs. This panel was chaired by General Larry Welch and was sponsored by the Director, Operational Test and Evaluation (DOT&E) of the Department of Defense, the Director, Test, Systems Engineering and Evaluation (DTSE&E) and the Director of BMDO.

The Welch Panel released one key report on February 27, 1998, and has been noted

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earlier, this report was a key factor that led to a significant restructuring of the NMD program. Even so, many of its conclusions also still seem valid, and were raised again in the Panel's report in June 2000.[5]

> Programs have been characterized by pressures for higher risk approaches to meet an "urgent need" for early capability [e.g., THAAD User Operational Evaluation System (UOES), but this capability is inconsistent with the technical challenge
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> - Program "urgency" is reflected in less-than-minimal or highly compressed planned flight testing
> - THAAD: 20 night tests in 24 months
> - Now 13 flight tests, with the schedule continuing to slip
> - 1 intercept required to exercise the 40-missile DOES buy
> - NTW: 9 flight tests in 48 months
> - Patriot PAC-3: 16 tests in 2+ years (11 BMD)
> - NMD: 6 tests in 2+ years before readiness-to-deploy review
> - Peacekeeper program planned 20 night tests in 4+ years (flew 19)
>
> The "early capability" approach demands operational capability before system design is completed through the Engineering Manufacturing Development (EMD) phase. This approach is inconsistent with the complexity of the task and has, thus far, not accelerated operational capability. Instead, the added risk has produced little discernible benefit and has actually delayed operational capability.
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> The most convincing evidence of the risk pressures from this approach is found in the test planning. This planning is characterized by either less-than-minimal testing or highly compressed testing or both.
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> For THAAD, the original plan was 2 years to the first test flight and then almost a test flight per month for the next 2 years. Thus far, the response to failures has been to reduce the testing in an attempt to maintain the schedule. The NTW test schedule is not compressed, but the number of planned tests is not consistent with the task. The Patriot program, which, in most respects, is carefully planned and is building on a legacy of well-developed processes, also has been forced into the less-than-minimum test mode.
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> Current planning for the NMD test program is even more optimistic than the theater HTK programs.
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> As noted here, as a benchmark, the Peacekeeper program certainly no more technically challenging than HTK responded to intense schedule pressure with a clearly adequate and well-paced test program and delivered the required capability on schedule.
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> ….The strategy of accepting a high level of risk to shorten schedule time has been counterproductive THAAD is 4 years behind schedule NTW has just delayed its deployment date and has begun a risk-reduction program (ALI). The path to NMD operational capability is largely undefined. Historically, the most likely cause of program slips has been high technical risk
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> The study group was not surprised to find that accepting higher risk is not accelerating fielded capability.

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> The virtually universal experience of the study group members has been that high technical risk is not likely to accelerate fielded capability. It is far more likely to cause program slips, increased costs, and even program failure.
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> …Schedule and cost pressures on NMD have created a pleading environment at least as optimistic as that which teas lead to test failures and delays in TMD programs
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> The NMD program consists of a series of very difficult challenges. Although NMD activity has been ongoing for a long time, there has not been a coherent, consistent path and a realistic plan leading to a deployed system
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> There are high schedule risks and inadequate test assets and testing planned in the 3 + 3 formulation In the judgment of the study group, successful execution of the 3 + 3 formulation on the planned schedule is highly unlikely. The program will benefit from the earliest possible restructuring to contain the risk
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> For NMD, the schedule and cost pressures inherent in the 3 + 3 formulation and the system requirements are inherently even more severe than those for the TMD programs that have experienced excessive flight test failures.
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> To succeed, the NMD program must meet a series of formidable challenges. The effort to meet these challenges must emanate from a clear set of requirements, consistent resource support (which includes an adequate number of test assets), well-defined milestones, and a rigorous test plan. The study group believes that current NMD program is not characterized by these features and is on a high-risk vector. It will benefit from the earliest possible restructuring to a more achievable set of goals.

One key conclusion of the 1998 report of the Panel on Reducing Risk in Ballistic Missile Defense Flight Test Programs was a warning that the currently contemplated NMD system can only be made to work if the test program is extended to the level of a trial deployment of at least one interceptor unit and an operational command and control and sensor system.[6]

> The mind set that risky "key demonstration" tests can prove readiness for early deployment has permeated some BMD DT programs and is a key departure from the test paradigm that has proven to be successful in other complex programs
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> BMD programs need to pay more attention to ground testing, simulation, and analyses to reduce known areas of uncertainty to be resolved in flight tests to only those issues that cannot be investigated with ground testing. The more limited the flight testing program, the more essential it is to reduce uncertainty
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> The philosophy appears-to be to plan for a single test in each 'regime" (e.g., exo, endo, long-range, short-range) and then move on. There is a need to hold the test vehicle configuration as constant as possible for a needed series of tests
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> "The rush to failure in flight testing has been partially caused by a fundamental misunderstanding of the purpose of developmental testing. Some of these tests were treated as demonstrations of known capabilities where "fly to verify" was the purpose. In practice, the unknowns made them "fly to learn" experiences. The "demonstration mindset" was evident in flight tests conducted without complete component qualification and ground testing. One program office espoused the concept of "test a little, learn a lot." The drive for early capability based on minimum capability demonstration has been a factor in this "key demonstration" mentality that is, a single success is regarded as a large step forward and becomes the criteria for a key program decision, such as exercising an option to buy operational missiles. This approach and mindset are

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sharp departures from experience on successful flight test programs that have followed the practice of "learn a lot" and then "test to verify."

BMD programs need to pay more attention to reducing the uncertainties to only those issues that cannot be tested on the ground or adequately simulated. One example is that none of the infrared (IR) HTK programs (THAAD, ALI, and NMD) have exploited or plan to exploit existing high-fidelity scene generation capabilities to exercise their hardware to the maximum advantage.

Test planning needs to be very explicit in identifying the ground test and flight test needs for each key issue.

In general, the test programs are designed to provide a single shot in each operating regime. While back-up hardware is available in most cases to repeat tests, the single-shot planning produces unrealistic test schedules and pressures to move on despite failures to achieve test objectives."

Problems in the Past Test Effort

As the Welch Panel points out, the test effort to date has had very mixed results. A test on January. 17, 1997 was a failure because the booster carrying the kill vehicle failed to launch because of a communication malfunction. The test on July 7, 1997 repeated the test of January 17 and demonstrated kill vehicle's ability to identify and track objects in space, using infrared sensor. A test on January 15, 1998, again tested kill vehicle's ability to identify and track objects in space but only under very limited conditions. A test on October 2, 1999 resulted in an interceptor hit on target warhead, but there was a failure in the star tracker. On January 18, 2000, the interceptor missed its target because the kill vehicle missed the mock warhead by between 300 to 400 feet after a cooling line clogged and shut down its heat-seeking sensors. A test on July 7, 2000 failed because the kill vehicle did not separate from its booster in the second stage, and the decoy balloon accompanying the mock warhead did not inflate.[7]

There have also been reports that indicated that an accelerated schedule and impossible expectations may have had an impact on contractor performance. An investigative report in the New York Times indicates that TRW, a key software contractor, may have taken the risk of pushing inadequate software to distinguish between incoming warheads and decoys. Although the Raytheon interceptor was later selected over the TRW candidate, this even may be a warning of broader problems. At least some reports indicate that an over-ambitious schedule was also a factor in limiting the number and type of decoys the interceptor must be able to discriminate against.[8]

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The June 2000 Welch Panel Report and the Department of Defense Response

A new report of the Panel on Reducing Risk in Ballistic Missile Defense Flight Test Programs, issued in the spring of 2000, was somewhat more optimistic. The Panel again concluded that there were serious developmental problems. These included problems with the booster, and the ability of the interceptor to distinguish warheads from decoys. The new report a indicated that much more sophisticated testing and development might be needed to deal with decoys and that the construction schedule for the deployment of an X-band radar on Semya Island in Alaska was unrealistic.[9]

The key findings identified three major program issues. First, continuing schedule compression and its effect on schedule and performance risk; second, the need to expand the test envelope beyond the one available with the current Kwajalein test range impeded by restrictions on the conduct of tests; and third, the need to move beyond the design capabilities needed to meet the C-1 threat with a well-defined, funded program to match target-decoy discrimination capability to fund likely countermeasures.

At the same time, the report concluded that the overall system of targeting radars, high speed computers and interceptor missiles would work, even if the system could not be made operational by 2005. The report stated, “the technical capability to develop and field the limited system to meet the defined CI threat is available…there is substantial schedule risk,, but not particularly high technical risk. It is like remodeling a kitchen. It may not get done by the date the builder promised, but it will get done.”[10] It noted that the schedule had already slipped 6-8 months, but that this slippage was not critical, although the development of a new booster would almost certainly slip beyond the scheduled date of 2001. It also estimated that the test of a production configuration of the interceptor might slip beyond the test deadline scheduled for 2003, although shifting the test from the 13th to the 12th major system test might allow the schedule for EKV testing to be met.

More generally, it concluded that the present test range and restrictions on its use meant that the current test program would not provide a realistic test of the system throughout its

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operating area because of restrictions on overflight, impact area, and debris in space. The Welch Panel found that fixing these problems required significant new policy decisions and funding.

The Welch Panel also concluded that "

> ...more advanced decoy suites are likely to escalate the discrimination challenge. The mid-course phase BMD concept used in the current NMD program has important architectural advantages. At the same time, that concept requires critical attention to potential countermeasure challenges. There is an extensive potential in the system to grow discrimination capabilities. The program to more fully understand needs and to exploit and expand this growth potential to meet future threats needs to be well-defined, clearly assigned, and funded now."

Finally, the Welch Panel concluded that there were continuing key risk areas in:

- Technical – Completing the design, testing, and production of the EKV to include manufacturing and quality control to meet the high reliability requirements remains a high risk.
- Requirements – There is an urgent need to complete the definition of all environmental conditions and accompanying design and test requirements.
- Schedule – As already discussed, stressing challenges remain to demonstrate the required performance, and reliability of the Ground Based Interceptor for a 2005 IOC.
- Integration – There are still high-risk software and hardware challenges in moving from legacy or prototype program elements to production configurations and converging them into an integrated system.
- Special area – Providing confidence in performance to the specified level across the operating envelope depends to an unprecedented degree on confidence in system simulations. Confidence will be heavily dependent on the degree to which the simulations are anchored in physical testing.
- Threat evolution: A parallel, continuing development program is needed for the deployed system to deal with future countermeasures.

These conclusions won almost immediate acceptance within the Department of Defense. Jacques S. Gansler, the Under Secretary of Defense for Acquisition and Technology, discussed the June 2000 report of the Welch Panel during a Defense Department briefing on June 20, 2000: [11]

> We had a series of reports from General Welch's task force earlier on, and many of you realized that in fact they been used by the critics of the system because they were quite critical of the way we were going about doing it.
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> In fact, he had basically three criticisms that he highlighted in his earlier report. In fact, one of them, the so-called "rush to failure" criticism, was the fact that we were being too schedule-driven and not enough event-driven. And so in fact we modified the overall program. Remember, we had a three-plus-three, and as

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a result of that earlier report that General Welch put out, the schedule was modified from 2003 to 2005, giving us more time. And then we made a major change philosophically, namely to be event-driven rather than schedule-driven. And those milestones that I showed you on that prior chart where we have certain things we want to do before we make commitments were these events that would then drive our activities.

The second thing that General Welch had in his earlier reports was that we were trying too hard to do too much too soon, that we should have more of an evolutionary approach: start out with simpler decoys and start out with—and evolving the system over time. That's exactly what, as I showed you, we are now doing.

And thirdly, he felt that we didn't have enough testing being done and we should add additional tests. And we added a significant amount of testing as a result of that.

Now, more recently, Secretary Cohen asked General Welch to reconvene that whole group, all the scientists and the people with experience, and come back and do another independent assessment of where we were. And that's the one that we just passed out to you in an unclassified version. Of course, there's the classified version that he did that has the back-up for all of those findings.

We were very pleased with that report. As you notice in his transmittal letter to the secretary, General Welch stated—and I'll read you this from his report. It said the independent review team believes that with the adjustments to the schedule and the phased decision approach that was implemented in January 1999 and, quote, "the program is on track to achieve the earliest capability to meet the defined limited threat." Now—that's the end of the quote. He also told us in the briefing that he did with it that that was the unanimous finding of the task force.

Now, he had specifically four recommendations that he felt were very important for us to recognize. One—and this is the one that I basically was quoting about—namely, that the technical capability to develop and field the limited system to meet the defined threat—the C-1 is the threat that's been defined initially. This is the relatively limited threat—is available. It's the available technical capability that he's commenting on here.

Secondly, he says that it's a high-risk schedule. Well, as we have been saying for a number of years now, it's a high-risk schedule. Secretary Cohen has said that, General Kadish has said it, we've all said it, it's a high-risk schedule. And he continues to state that, which we agree with. The important part of this is that, however, no technical reason at this point to change the schedule. So we are continuing with the schedule that we have now, based on both his assessment and our own, that we have the ability to meet the 2005, if things go according to plan.

The third thing he said is that there are inherent restrictions in our flight testing that will be very limiting in terms of this program. And that's true. For example, you know, objects falling onto fisherman in the South Pacific. So we have range limitations. There's a law about putting objects in space, and you can see we're doing our intercept at mid-course and putting objects into space, because we shatter this booster, is a serious violation. So we have limitations of debris in space, we have limitation on impact area. Our intent is to try to come up with some ways that either through changes in those restrictions or other things, we can in fact satisfy what he is looking for, because it's clear that you'd like to have the ability to have longer-range flights, higher-speed intercepts, and that's what his objective is, and it's our objective as well. So we're doing to look into trying to do that. It will obviously add some cost because it will add some additional flights and probably even additional launch points for the targets.

And then, he has also addressed, as we have, the discrimination capability that has to evolve with this system. As people develop more and more sophisticated decoys, we have to develop more and more discrimination capability. What was really encouraging about the findings that he's had in this area was the fact that he felt we have the inherent capability in our design, should we choose to add the additional sophistication, to be able to handle those sophisticated decoys. And that's a question then again, about

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> money and time, spending the extra effort, adding the extra discrimination capability to the systems, and then later, adding on to the SBIRS-Low in order to get that additional discrimination from the infrared capability. No question in our minds, or his, that more advanced decoy suits are likely to escalate the problem and escalate the demand on us to do something about them, but with the inherent capability in the system to be able to handle those.
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> …He's highlighted the risks associated with these three decision points that I mentioned to you earlier, associated with the flight that we have coming up, and then the one that's scheduled in the fall; the flight that we have coming up with the new booster, and of course, this is the booster development, but then this is the booster with the intercept, with the kill vehicle; and then the production kill vehicle. And these are the gating items in terms of schedules, and so these events are, in a sense—are the things—these events are the ones that drive these decision points. He labeled these decisions a feasibility assessment for the first one, a decision to purchase for the second one, and a decision to deploy for the third one. That was the terminology that he used, and that's consistent with the way I described to you what those decisions are going to do.

Given this response, it is clear that the Department of Defense still regards the current program as an acceptable mid to long-term risk, but recognizes the fact that its current test program is too limited, and that the program is underfunded and the schedule is unrealistic. As a result, the subtext in the Department's response to the Welch Panel seems to be that it would benefit from either a delay in a deployment decision, or from the or the kind of deployment decision that would defer key arms control and expenditure decisions until President Clinton's successor took office and then move forward in phases dictated by the success of a more demanding test program and the evolution of the threat..

4. Independent US Government Efforts to Assess Risk, Cost, and Benefits: Tests in 1999 and 2000 and the Report of the Director of Operational Test and Evaluation

Other reviews of the NMD test program raise equally serious issues. The Department of Defense's test and evaluation plan as of early is shown in Table III.13, and it is clearly a bare bones program.[12]

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Table III.13

CURRENT SCHEDULE OF MAJOR FLIGHT TEST MILESTONES

Capability Level	Event	Planned Date	Purpose
Capability 1	IFT-3	October 1999	First intercept of a target in the exoatmosphere using range instrumentation and EKV guidance-achieved an intercept.
Capability 1	IFT-4	January 2000	First intercept attempt using NMD system prototype elements or surrogates, *except* the In Flight Interceptor Communications System and objective booster-failed to achieve an intercept.
Capability 1	IFT-5	3QFY00	First intercept attempt with all NMD prototype or surrogate elements integrated together *except* the objective booster.
Capability 1	IFT-7	2QFY01	First intercept attempt with objective, off-the-shelf booster.
Capability 1	IFT-14	2QFY03	First flight test against dedicated LFT&E target (Uses production representative EKV).
Capability 1	IFT-19	1QFY05	First IOT&E flight test.
Capability 2	TBD	TBD after FY05	First intercept at enhanced deployed capability on path to User's objective operational requirements.
Capability 3	TBD	TBD after 2007	Demonstrate intercept at objective Capability 3 performance level.

Source: Phillip E. Coyle III, Director of Operational Test and Evaluation, Department of Defense, Annual Report for FY1999, Section VI, February 2000.

As the Welch Panel makes clear, it is not clear that either success or failure in the test program summarized in Table III.13 would be enough to establish system capability, as distinguished from proof of principle. The success in September 1999 involved a "hit" of two missiles aimed at each other without any link to the proposed NMD C4I and sensor system. The failure on January 2000 involved a leak in the coolant for the infrared guidance system typical of systems failures in the final development phase of virtually every complex weapons system the US now has in service.[13]

Even if every aspect of each component in a series of such limited tests was successful, the results could not be representative of system behavior in a complex system. The "law of large

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numbers" is simply statistical shorthand for the historical lesson that small tests and statistical samples cannot be reliably scaled up to predict the behavior of a large number of complex systems interacting in more complex ways.

The January 2000 test, for example, did not involve the full use of the X-band radar in a mode similar to a full-scale operational system. At the same time, it came close to hitting its target in spite of the failure of the leak in the coolant for the warhead's IR guidance. It did test the possible use of two decoys, but only came near the "real" warhead by accident. The test came closer to simulating a real intercept than any prior test, but scarcely simulated what might happen in a defense against even one real incoming warhead. As a result, it simultaneously succeeded in being a success, a failure, and unrepresentative of the kind of test needed to realistically validate full-scale system deployment [14]

These issues may help explain why the FY1999 annual report of the Director of Operational Test and Evaluation, Phillip E. Coyle III, which was issued in February 2000, concluded that the present NMD program was by driven by its artificial deadlines and not be its scientific requirements, and "to meet an artificial decision point in the development process…This pattern has historically resulted in a negative effect on virtually every troubled D.O.D development program…Unrealistic pressure has been placed on the program to meet an artificial decision point." [15]

The report provides the following detailed description of the NMD test and evaluation program, and its strengths and weaknesses:[16]

> The system is currently in the Initial Development phase. It is during this phase that an initial NMD capability will be developed and its technological maturity demonstrated. This period will culminate in the DRR, which will determine whether the NMD Capability 1 system is technologically ready, if warranted by the emerging threat, to proceed to deployment. The previous TEMP is being revised. The purpose of the new TEMP is to define the specific progression of the T&E program from the present to an IOC in 2005. The revision will be accomplished in two phases. Phase I addresses the changes to pre-DRR ground and flight testing, brought on by the advent of the LSI and the down-select to a single EKV contractor. The Phase I TEMP was approved by OSD on December 21, 1999. The Phase II edition will provide a detailed T&E roadmap, to include modeling and simulation, for the evolution of the NMD system to the Capability 1 deployment. The Phase II document is expected at OSD in 3QFY00.
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> Near-term NMD T&E planning focuses on the ability to provide accurate test information and data in support of the DRR, and the ability of the system to achieve the following objectives:

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- Demonstrate end-to-end integrated system performance, including the ability to prepare, launch, and fly-out a designated weapon; and kill a threat-representative target through body-on-body impact.

- Demonstrate end-to-end target detection, acquisition, tracking, correlation, and handover performance.

- Demonstrate real-time discrimination performance.

- Demonstrate NMD system kill assessment capability.

- Demonstrate the ability of the NMD battle management software to develop and coordinate battle engagement plans; prepare, launch, and fly out a designated weapon, and kill a threat representative target.

- Demonstrate integration, interface compatibility, and performance of system and sub-system hardware and software.

- Demonstrate human-in-control operations of the NMD system.

- Demonstrate system lethality.

Capability 1 system elements are derived from previous technology programs and will be integrated and tested in a series of Integrated Flight Tests (IFTs). Initially using surrogates to approximate NMD elements (as needed), then progressing to prototypes, IFTs are designed to collect data that address system issues and key technical parameters, verify the performance of NMD elements, and demonstrate overall system effectiveness. IFT-5, the final test to demonstrate overall system performance before the DRR, is scheduled for 3QFY00, and will play a key role in demonstrating that overall system objectives are met. The following table shows the major milestones in the flight testing program.

The initial flight test, IFT-1, was attempted in January 1997, but the Payload Launch Vehicle, the surrogate for the missile booster, failed to launch and the test was aborted. Since then, the NMD T&E program has performed two integrated flight tests: IFT-1A and IFT-2. IFT-1A, executed in June 1997, and IFT-2, executed in January 1998, were deemed highly successful. Both IFT-1A and IFT-2 were non-intercept, fly-by tests, designed to assess EKV seeker discrimination and homing algorithm design. Boeing and Raytheon built the EKVs for IFT-1A and IFT-2, respectively. IFT-3 and IFT-4 were previously planned to be intercept attempts by Boeing and Raytheon in support of an EKV contractor down-select prior to IFT-5. At the recommendation of the LSI, the NMD Joint Program Office (JPO) opted to down-select to a single EKV design prior to IFT-3. This approach has the advantage of three possible intercept flights with the selected EKV prior to the DRR, but added the risk of no attempts prior to down-select.

IFT-3 was conducted on October 2, 1999. It was the first attempt at intercepting a threat-like ICBM test target. The target complex, which consisted of an RV and a large balloon decoy, was launched by a Minuteman based Multi-Service Launch System from Vandenberg AFB, CA. The GBI surrogate, the Payload Launch Vehicle (PLV), was launched about twenty minutes later from Meck Island in the Kwajalein Atoll, about 4,200 miles west of Vandenberg. While the test examined all aspects of the NMD system design to some degree, its principal focus was the EKV. The EKV was boosted to its deployment location by the PLV and guided to its initial acquisition position by range instrumentation and Global Positioning System data downloaded from the target RV. After separation from the PLV, the EKV oriented itself to look at known star configurations to correct for any altitude bias. Errors induced in the inertial navigation system during this orientation process , coupled with incorrect star data that was loaded into the system pre-flight, subsequently induced additional aiming errors into the EKV. Given these errors, when the EKV aimed itself toward the expected target location, nothing appeared in the field of view. After executing its search routine, it acquired the large balloon and subsequently the rest of the target complex. From that point, the EKV discriminated the RV from the other objects and diverted to an intercept. The

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large balloon aided in acquisition of the target. It is uncertain whether the EKV could have achieved an intercept in the absence of the balloon, although analysis of the data indicates that achievement of the intercept cannot be discounted.

IFT-4 was conducted on January 18, 2000. It was the first flight test for which the LSI assumed complete responsibility. Previous flight tests were run by the Government. IFT-4 attempted to demonstrate the functionality of all of the NMD elements, although the PLV was again used to launch the EKV and the In Flight Interceptor Communications System was not fully exercised. Additionally, mid-range target tracking was accomplished using beacon tracking or GPS data from the target RV. The interceptor Weapon Task Plan initial targeting coordinates and In Flight Target Updates were created using the GPS data, which is significantly more accurate than similar data from the Early Warning X-Band Radar. IFT-4 failed to achieve an intercept. Forensic analysis of the test data is ongoing to understand the cause(s) of the missed intercept.

Integrated Ground Tests (IGTs) will be conducted utilizing the Integrated System Test Capability (ISTC), a computer-based hardware/software-in-the-loop test tool that uses actual NMD element data processors and software in an integrated configuration. Unlike the range-constrained IFTs, IGTs will look at the total engagement space in a tactical environment. They will also: (1) validate the functional interfaces between the elements; (2) subject those interfaces to stressing environments and tactical scenarios; and (3) evaluate target-intercept boundary conditions. In short, IGTs will enable identification of "unknown unknowns" in an interactive system context, and verify the interoperability of NMD elements.

Prior to the formalization of the NMD program, IGTs-1 and 2 were informally conducted to verify the development of the ISTC and assess preliminary functional interactions and interfaces among NMD element representations. IGT-1A was the first formal ground test designed to demonstrate successful exchange of messages between the BMC3 and the prototype XBR, (the Ground Based Radar Prototype (GBR-P)). IGT-1A was conducted from April to May 1998, using ISTC Configuration Build 4.0.2, which incorporated BMC3 Capability Increment-2 and GBR-P Increment-1 processors. The IGT-1A threat scenarios were representative of IFT scenarios, derived from measurements by range sensor data recorded during IFT-1A. All IGT-1A objectives were successfully accomplished. IGT-3 added a UEWR processor to the GBR-P and BMC3 network and exchanged information using the Capability Increment-3 message set. There were 75 good run-for-record test runs conducted from February 1-18, 1999. All objectives were achieved, although the UEWR was sometimes overwhelmed by the number of cues it received from the BMC3. Also, the UEWR did not always track all of the objects that it should have. In addition, during six control tests, significant unexpected variability was exhibited in system performance.

There were 50 acceptable runs-for-record for IGT-4, conducted during August 9-18, 1999. IGT-4 was not intended to assess the performance of the C1 architecture. The test successfully demonstrated integration of the BMC3, GBR-P/XBR, and UEWR. There was no direct communication between the BMC3 and the EKV. The UEWR was more successful in maintaining connections to the BMC3 than it had been in IGT-3. The run-to-run variability was significantly smaller in IGT-4 than it had been in IGT-3.

There were 55 acceptable runs-for-record for IGT-5, conducted during October 12-19, 1999. The test continued to successfully demonstrate integration of the BMC3, GBR-P/XBR, and UEWR. In addition, IGT-5 provided a preliminary assessment of the NMD performance against a subset of C-1 requirements. Of the six different types of scenario examined in IGT-5, only one scenario type had nominal performance. Most of the problems in the other scenarios were due to the lack of maturity of the NMD system representations used in IGT-5.

Computer models and simulations will provide representations of elements that are not mature enough for the test program. The principal simulation tool providing DRR support is the LSI Integration Distributed Simulation (LIDS). Modeling and simulation will be employed to effectively repeat hypothetical experiments in order to improve the statistical sample or determine the values of key technical parameters

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possibly overlooked or unmeasured.

All NMD flight testing will be in compliance with the Anti-Ballistic Missile (ABM) Treaty and other applicable treaties at the time of testing. Kwajalein Missile Range (KMR) and White Sands Missile Range are authorized to launch interceptors under the ABM treaty, but only KMR is configured to accept incoming strategically representative target flights. Accordingly, flight tests will use target suites launched from Vandenberg and directed towards KMR.

The LFT&E Working Group, a subgroup of the NMD Lethality IPT, has developed the LFT&E strategy for NMD. LFT&E activities include flight testing, sub-scale light-gas-gun testing, and simulation analyses. Sled tests are also being considered for low-end intercept velocities. Three dedicated LFT&E flight tests are planned to be conducted.

The NMD T&E program also includes a number of pre-DRR lethality test and analysis activities to support the development and accreditation of first-principles physics codes, commonly known as hydrocodes, for application to NMD. This testing will also support the development and accreditation of the lethality simulation known as Parametric Endoatmospheric/Exoatmospheric Lethality System. These simulation tools will be used for analyses in both pre- and post-DRR timeframes. The activities include: (1) target aerothermal shield damage analyses; (2) hydrocode analyses that define kill criteria for the respective EKV designs proposed by Boeing and Raytheon; (3) light-gas-gun impact testing for hydrocode validation; (4) kill-enhancement device testing; and (5) light-gas-gun testing to develop and validate material equations of state at high velocities. The analysis activities are currently ongoing. Twenty light-gas-gun tests planned for hydrocode validation were successfully completed in FY99. Testing to develop equations-of-state (the characterization of the physical phenomena that occurs during impact) is in its initial stages.

NMD Y2K vulnerability assessment addressed all aspects of the program, including the system elements (especially the BMC3 system), the flight and ground testing supporting systems, and the models and simulations used to predict performance. All NMD mission critical deployable systems, as well as science and technology support systems, were declared Y2K Compliant by the Ballistic Missile Defense Organization Y2K Compliance Review Board in July, 1999. The process of Y2K compliance includes assessment, renovation, validation, and implementation phases. The NMD program office will continue to work with the LSI to ensure Y2K compliance of the deployable systems through a configuration management process as hardware/software development continues. The program also conducted a Y2K Operational Evaluation Test of system prototypes to preclude a Y2K anomaly during any flight testing after January 1, 2000. Associated elements for conduct of IFTs and IGTs also underwent extensive Y2K testing. Two Y2K Operational Evaluation tests were conducted within the flight and ground test schedules. The first occurred at the ISTC prior to pre-mission testing for IFT-4. The second was conducted at KMR in early January 2000 during the pre-mission checkout for IFT-4. During the pre-mission dry runs and readiness tests, participating elements and the mission control support tested Y2K dates. This testing verified: (1) interface hardware and software; (2) sub-system functions; and (3) that the adequacy of operator training and procedures are not affected by Y2K dates. Testing through IFT-4 has not identified any Y2K problems.

TEST & EVALUATION ASSESSMENT

Despite the revised program, the aggressive schedule established for the NMD Program presents a major challenge. The NMD program will have to compress the work of 10 to 12 years into 8 or less years. As a result, many of the design and T&E activities will be performed concurrently. Program delays also caused the conduct of IFT-3 to slip to October 1999. This represents almost a 20-month slip over the last two years and demonstrates an extremely high-risk schedule. Additionally, the failure of IFT-4 to achieve an intercept may result in a further setback to the NMD schedule. The revised program has alleviated some of the long-term risk by deferring and staging the decision process as described earlier. However, since the DRR date has not been deferred, undo pressure has been placed on the program to meet an artificial decision point in the development process. The DRR will be a "come as you are" type of review which will examine the

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maturity and potential of the program at that point. This is driving the program to be "schedule" rather than "event" driven. This pattern has historically resulted in a negative effect on virtually every troubled DoD development program. In spite of this intense pressure, the program manager is doing an excellent job in trying to efficiently and effectively manage the preparation for the DRR and ultimately the deployment.

The complex operating characteristics and environments of the NMD T&E Program make it necessary to plan and conduct IFTs that are restricted in scope. DRR information based on a few flight tests with immature elements will be limited. Although IFT-3 was an important test in ballistic missile defense and demonstrated a new technology, it had significant limitations to operational realism, as noted throughout this report.

Due to the restrictions on realistic operational flight testing, the T&E program will rely heavily on ground testing and the execution of simulations for assessing the maturity and performance of the NMD system concept. The LIDS model development is proceeding much slower than planned. It is extremely doubtful that the model will be completed in time to allow for a rigorous system analysis for the DRR, resulting in limited analysis. A "beta" version of the software is promised to be ready by the end of February 2000. Service Operational Test Agencies may have to rely on alternative low fidelity models to assess the potential system effectiveness.

The FY98 DOT&E Annual Report identified a number of risks that could have significant impact on the NMD T&E program's ability to test, analyze, and evaluate system performance. The degree to which those risk areas have changed from the last reporting cycle are addressed below:

- Limited Pre-DRR system-level testing: Only three intercept flight tests are planned before the DRR. Furthermore, the IFT-5 configuration will differ from the Capability-1 system; it uses prototype and surrogate sensors and a surrogate GBI booster stack. Nothing in the program alleviates this system maturity or schedule issues. Since IFT-3 was not conducted until October 2, 1999 and IFT-4 failed to achieve intercept, the schedule risk is increasing. On a positive note, while stretching out the program does not increase or decrease the number of pre- or post-DRR flight tests, it does allow more opportunity for operational testing a more mature system prior to fielding.

- Limited engagement conditions: Flight test launches from California and interceptors from Kwajalein Missile Range, along with safety constraints, place significant limitations on achieving realistic geometry and closing velocities. This area is unchanged. The geometry of an intercept of a missile launched *from* Vandenberg AFB, CA, presents an easily detectable, large, then decreasing radar return signal to the surrogate early warning radar used to support the flight tests. The mid-range tracking coordinates of the target RV are provided by a beacon transmitter on the RV or through a GPS receiver on the RV relayed to the ground. Pre-launch Weapon Task Plans for the interceptor are created using these data sources. This approach is acceptable for early developmental testing, but it does not suitably stress the NMD system in a realistic enough manner to support acquisition decisions. Additionally, the intercept velocities that are safely permitted during testing are on the low end of what might occur in a real ICBM attack. This limits the operational realism and engagement conditions.

- GBI booster testing: The NMD T&E program makes use of a surrogate launch vehicle, the Payload Launch Vehicle, for all flight tests until IFT-7. The program restructure has not affected this limitation. The objective booster contract was awarded in July 1998, and first delivery will not occur until after the FY00 DRR. Lack of IFT data without the objective GBI capability (e.g., larger burnout velocity than the Payload Launch Vehicle) before the DRR will limit the GBI evaluation. Since the date of the DRR is not being changed, the evaluation will not have the benefit of data from intercept flight tests using the new booster. However, the risk of limited GBI booster testing has been mitigated somewhat by the scheduling of two Boost Vehicle Tests before

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the DRR. These tests will evaluate the performance of the booster with an emulated EKV package added to the front end of the missile. However, IFT-7 is the first integrated system test *against a target* that makes use of the objective booster. The mitigating factor in this risk area is that the weapon decision will not be made until 2003.

- Limitations of ground testing: The ISTC will be the major source of data generated from ground testing. This area has been improved somewhat through the incorporation of common scenarios from one IGT to the next. This will allow the tracking of progress in the ISTC development. However, test articles used to represent NMD elements in the testbed will still have minimal verification or validation in time for the DRR. Additionally, the validation process is not linked directly to flight test scenarios, since the IGTs use actual Element processors versus the surrogate Elements that currently support flight testing. The risk in this area should be reduced in the post-DRR timeframe, as the program embarks on an aggressive, comprehensive end-to-end hardware-in-the-loop effort. However, it is imperative that the hardware-in-the-loop program focus its initial efforts on the EKV.

- Target suite: The NMD T&E program is building a target suite that, while an adequate representation of one or two RVs, may not be representative of threat penetration aids, booster, or post-boost vehicles. Use of the large balloon in the target complex has some value, but continued use should be reevaluated for future flight tests. Test targets of the current program do not represent the complete "design-to" threat space and are not representative of the full sensor requirements spectrum (e.g., discrimination requirements). Much of this limitation, however, is attributable to the lack of information surrounding the real threat. As the knowledge of the threat evolves, the risk in this area should decrease slightly. However, specific details on threat characteristics are rarely readily accessible.

- Multiple target testing: NMD system performance against multiple targets is still not currently planned for demonstration in the flight test program. There are, however, plans to begin construction on two silos at KMR, which can be employed to do flight testing against multiple targets. The focus in this area is to use validated simulations to evaluate multiple simultaneous target engagement.

- BMC3 interoperability testing: The BMC3 to Commander-In-Chief interface inside Cheyenne Mountain will not be tested prior to the DRR. Little has changed in the pre-DRR timeframe under the current program. Build Increment-1, the first significant BMC3 release, will not be available until 2QFY00, providing very little time to be fully evaluated by the June 2000 DRR. The revised deployment schedule does reduce risk in this area, however, by providing more time for post-DRR BMC3/Cheyenne Mountain Operations Center integration and testing. Additionally, the decision on whether to initiate the integration has been deferred to the 2QFY01 Defense Acquisition Board.

- Spare test articles: The previous TEMP identified a lack of spare test articles due to a resource allocation trade-off. Current program planning uses a rolling spare concept in which the test target for the immediate future test flight serves as the backup for the current flight test. This approach will mitigate the spare target problem; however, the spare test article issue also applies to the interceptor and EKV, where test failures have major schedule impacts.

- Limitations of ground lethality testing: Currently, there is no ground test facility capable of propelling EKVs or their full-scale replicas against targets at the closing velocities expected for NMD intercepts. These closing velocities will exceed 7 kilometers per second (KPS) and in some cases will even exceed 10 KPS. Existing full-scale sled track facilities have only approached 3 KPS. Additionally, propelling a non-aerodynamic structure, such as the EKV, down a sled track through an atmosphere at the operational velocities involves special considerations. Holloman High Speed Sled Track is working on measures to achieve much higher velocities approaching

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Mach 10 (approx. 3.5 KPS), still much lower than tactical intercepts. If this work is successful, the lethality test data to support DRR will still have to be collected from light-gas-gun tests of reduced-scale replicas of EKV surrogates and targets at the lower-end (six kilometers per second or less) of the intercept velocity spectrum, with hydrocode simulations for the higher velocities.

- Programmatic Issues: The LSI contractor has taken time to overcome the inertia of bringing the program up to full speed. The Government's System Evaluation Plan was supposed to be replaced by a LSI generated System Verification Plan (SVP). The LSI has now determined that the SVP is not sufficient to evaluate the program for the DRR, and is developing a System Analysis Plan that will provide the roadmap for DRR assessment. The High Fidelity System Simulation, which was to be the fast running, system performance, digital simulation for assessing many scenarios throughout the threat space, has been abandoned in favor of Boeing's LIDS model. It now appears that LIDS is at high risk of being delivered in time to allow for a robust system evaluation for the DRR or will have a reduced functionality and only allow for minimal evaluation.

- Logistics Support (*New concern*): Mathematical predictions for the Element reliability and availability goals that are needed to satisfy operational requirements are extraordinarily high. These requirements may be either unachievable or necessitate extensive spare parts supplies or intense maintenance efforts.

VALUE ADDED

DOT&E has been a significant contributor through the IPT process to formulate the NMD T&E program on practically a daily basis. We have been one of the principal stimuli to the JPO's plan to develop a comprehensive integrated HWIL effort. This will enable an effective and efficient ground testing capability, which will significantly reduce the risk of successful flight testing.

At DOT&E's recommendation, the JPO is proposing to alter the 2003 weapon decision to seek low rate rather than full-rate production authorization. It will permit dedicated LFT&E flight tests to be performed with production representative EKVs and allow the IOT&E to be conducted prior to full-rate production. This will reduce the risk of prematurely committing to the production in large quantities of interceptors that may not have sufficient lethality to defeat threat RVs.

Many of DOT&E's concerns and recommendations have likewise been independently captured in the second Welsh panel report.

RECOMMENDATIONS

The DRR is currently firmly scheduled in June 2000 rather than after completion of the analysis of IFT-5. This is a strongly "schedule driven" (vice "event driven") approach, thereby placing unrealistic pressure on the JPO. IFT-5 will be the first intercept attempt with all NMD elements integrated except the booster. DOT&E is recommending that preparations for the DRR allow time for a thorough analysis of the IFT-5 test data in order to inform the DRR decision, especially in light of the failure of IFT-4 to intercept the target. This would provide a clear technical understanding of the results and avoid forcing the DRR before the analysis is complete.

Several factors drive the need for an improved hardware-in-the-loop approach. They include the failed IFT-4 intercept, the role of the large balloon in supporting an intercept and speculation on the EKV's ability to discriminate countermeasures. DOT&E strongly recommends an intensive effort to develop a flexible, comprehensive hardware-in-the-loop facility that presents a high fidelity representation of the threat target for designing and testing of the EKV.

5. BMDO Defenses and Warnings About the Test and

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Evaluation Program

These technical issues are not an argument against the near-term deployment of a basic single-site NMD system per se, but they indicate that there is little meaningful prospect that the present NMD system will be technically ready for deployment as a full-scale combat system under the present schedule.

The BMDO Overview of the Test Program

These conclusions have been reinforced by testimony and reports by BMDO. For example, Lt. General Ronald Kadish, the head of BMDO, send a letter to Congress in February 2000 stating that the program could use some $300 million in additional development funding to reduce the risks in the current test program in the coming fiscal year alone. BMDO has also had to postpone the systems test originally planned for April 27, 2000 to late-June 2000 at the earliest.[17]

At the same time, Lt. Gen. Ronald Kadish, the Director of BMDO, has stated that major progress was made during these tests. He provided the following explanation to the Year 2000 Multinational BMD Conference on June 5, 2000:[18]

> Some are proposing that we wait until we get the results of "real-world" tests against real-world countermeasures in order to reduce our risks before we make our decision to deploy. Delay the decision to proceed with deployment, in other words, to sometime in the middle of the coming decade before we begin the multi-year process of constructing the system. A decision to delay on these grounds, of course, will not allow us to achieve initial operational capability until well after the 2005 date, probably around 2010. This risk-averse acquisition approach is not one that is tailored very well to our current national security requirements. It ignores the one factor that is driving us to consider a decision to proceed this year–the threat. As I said earlier, North Korea is capable of testing its Taepo-Dong 2 missile at any time. The more pressing and relevant question, therefore, is this: can the United States afford to wait?
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> Our flight test last January, when we missed the target warhead, has received a great deal of attention. But that test was a partial success, because hitting the warhead was only one of our objectives. In the context of testing, it was a successful developmental test that proved we could integrate the far-flung and separate major elements and make them work together as one system. The interception phase of the NMD mission is clearly the most visible phase and it is key to our success. Yet we must not lose sight of the fact that the successful integration of the highly interdependent system elements is no less critical. The integration and support aspects of our testing events are transparent to most people, and we could not do this mission without them.
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> In the final six seconds of that January test, we had a malfunction in our interceptor sensor system that prevented us from colliding with the target. (We missed by 76 meters.) We've since taken the necessary corrective actions, both on the equipment and in our processes, to mitigate against a recurrence. As a result

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of the fixes we have had to make, we postponed by two months the next integrated flight test. But we should remember that the one thing that failed in January's test worked last October. At this point in time, we've no reason to conclude that the overall design of the NMD system is flawed.

By the DRR this summer, we'll have tested some 45-50 percent of the functionality of the system, almost 90% of the elements, and we'll have gained enough data to be able to support a decision by the President. Remember, we've been testing and doing simulations to prove the elements of the NMD system for many years now. There has been significant ground testing as well as flight testing against the radars, and we use the data from these tests to validate the results we derive from our extensive modeling and simulations exercises. So, while we view the upcoming flight test to be very important to the progress of the program and the decision to proceed, we will not be developing a recommendation for the President based only on this one flight test. Our entire testing program has given us a lot of good and very valuable data upon which we can base our decisions.

I'd like to close by leaving you with what I think ought to be in the headlines today.

- First, the threat is real, and growing.
- Second, we are making significant technological advances, making a limited missile defense of the United States possible. We can hit a bullet with a bullet. Indeed, we've already demonstrated it.

Third, the upcoming decisions on whether and how to proceed with the NMD program will influence U.S. defense thinking, shape our offensive and defensive strategic forces, and impact foreign policy for many years to come. The debate over the U.S. NMD program is perhaps one of the most important national security discussions to be held in the United States in the last twenty-five years.

Lt. General Ronald T. Kadish has also put the current test program in the following perspective.[19]

A great deal of attention has been given to the integrated flight test that occurred on January 18 of this year. It was one in a long-line of testing events we have planned through 2005. While many have called IFT-4 a failed test, I take exception to this characterization of this very important and valuable test event.

Viewed in a mission context, IFT-4 was a failure - we missed the RV. The miss speaks for itself. However, in the context of testing, IFT-4 was a successful developmental test that proved under very stressful conditions the X-Band Radar, the Upgraded Early Warning Radar, and the BM/C3 capability of our proposed architecture. The NMD system is one of the most complex systems our country ever has attempted to develop and produce. The interception part of the NMD mission is clearly the most visible and most highly regarded phase, yet we must not lose sight of the fact that the successful integration of the system elements is no less critical. The integration and support aspects of our testing events are transparent to most people, but I assure you that we could not do the job without them.

We will continue to test our national missile defense system based upon strict, proven scientific methods learned over more than four decades of missile development, deployment, and operations. Our tests are designed to weed out flaws. While we strive for success on every test, we do not expect that we will always have it. Very often problems occur and elements of our tests fail. Indeed, we should expect failure from time to time, sometimes spectacular failure, as the price of ultimate success in this highly challenging endeavor. We learn a lot from our testing successes and failures. We gain knowledge and pick up important information from problems and mistakes discovered during testing and incorporate the necessary changes into our systems before they go into our deployed weapon systems. We must ensure that the NMD system we eventually deploy will work with a very high level of confidence - our testing program is designed to do

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just that.

One more Integrated Flight Test, our third attempt at a successful intercept, is scheduled before the DRR in July. IFT-5, now scheduled for June 26, will meet the requirements of an integrated system test in which all the elements of the NMD system will participate together in the engagement and destruction of the target. We decided to delay this test by two months in order to deal satisfactorily with the problem we encountered with the krypton cooling system in IFT-4. In the two months that followed this anomaly, which caused the EKV to lose track of the target cluster six seconds prior to impact, we examined the failure options comprehensively. In the end, we decided that our EKV systems did not require design changes, but nevertheless we wanted to ensure that we thoroughly reviewed all test hardware and processes prior to proceeding with the IFT-5. A testing delay at this point in our program was prudent from a technical standpoint. We believe that we will have enough technical data from this test in order to move forward with the DRR in July.

From FY01 through FY05, we will conduct three intercept flight tests each year. This will allow us to demonstrate the increasing sophistication of the kill vehicle and integrated system. Flight Test 7, scheduled to take place in Fiscal Year 2001, will be the first flight test to incorporate both the exo-atmospheric kill vehicle and the proposed operational booster. Flight Test 13, scheduled for Fiscal Year 2003, will fly the production-configuration ground-based interceptor - including the kill vehicle and booster.

The NMD Flight Test Program follows a very specific path to allow an initial operational capability (IOC) in Fiscal Year 2005. This path includes a number of milestones that, in effect, postpone the need to freeze the interceptor design until the latest possible time dictated by lead-time to the 2005 deployment date. The interceptor remains the element with the highest risk within the NMD architecture. Therefore, by waiting to lock in the interceptor design until after we have tested the production-configuration "round," we can be more confident in the system we will deploy.

The NMD program has been executed along a high-risk schedule. High-risk has a very specific meaning -- we are executing this program at such an accelerated pace, that significant failure in any of the program elements may well cause us to slip our development timelines. Our recommended approach, however, is designed to handle this schedule risk by phasing our decisions based on test and programmatic performance, allowing more time to develop, demonstrate and, ultimately, deploy the system elements in a prudent manner. We have a demanding challenge and we are managing aggressively to meet it.

…While we have been developing and testing the system elements, we also have been proceeding vigorously on deployment planning activities. We have conducted fact-finding and siting studies for two potential site locations - Alaska and North Dakota. We have initiated site designs for the X-band radar, weapon sites, and BM/C3 facilities. On October 1, 1999, we published in the Federal Register a Notice of Availability of the NMD Program's Deployment Draft Environmental Impact Statement (EIS), inviting the public to review and comment on that document. The public comment period ended on January 19, 2000. In October and November of last year, over 650 people attended public hearings on the draft EIS in Alaska, North Dakota, and Washington, D.C. We are considering the input received as we prepare the Program's Final Environmental Impact Statement, which we have scheduled for completion later this spring. As required by law, the results of the EIS will represent one of many inputs into the deployment decision process.

We initiated ground-based element facility planning and design in FY99 and have completed the 65% design for the weapon system and X-band radar facilities. We will start the design of the BM/C3 facilities later this year. For FY01, we are submitting a request for construction of the tactical and support facilities for an Expanded C1 capability. This will consist of an X-Band Radar Complex, a Ground-Based Interceptor Missile Launch Complex, and a series of dispersed facilities for Battle Management/Command, Control, and Communication. We request a FY01 MILCON appropriation of $101.6M to begin construction of the X-band radar, conduct site preparation of the interceptor site, and continue planning and

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design work.

In accordance with budget guidance, we will further define the facility and systems requirements associated with potential deployment of 100 interceptors in an Expanded C1 architecture by FY07, including the installation of 80 additional missile silos and non-tactical facilities. In order to remain on schedule for the deployment of the first 20 missiles in FY05, we plan to issue a Request for Proposal and award the contract(s) this fall, if approval for deployment is given.

We have made important technical progress in many areas in the National Missile Defense program. Nevertheless, this is an extremely complex program and we still have many significant challenges ahead of us.

The Year 2000 Test Program

In June 2000, Lt. General Ronald T. Kadish addressed a growing controversy over Flight Test 5 in the year 2000 phase of the test schedule in light of the reservations raised earlier by BMDO, the Director of Test and Evaluation, and the Welch Panel. While the issues involved are complex, they also highlight the near-term limits of what is being tested and the ability of the test program to adapt to failures:[20]

The objectives of this flight test are basically the same as we have had for our previous two flight tests. But we have an important element of emphasis where we want to actually put the integrated system together,,,we have a complex system of ground-based radars and kill vehicle and interceptors hooked together by a communications and computer system that controls it all.

So this test is important in that we want all these elements to work together in an integrated whole so we can accomplish the intercept. And the way the intercept is accomplished is basically having all the ground-based elements with the computers controlling, getting this kill vehicle right here, that is half-scale, into a point in space at which it could go autonomous and intercept the incoming warhead. And I'll talk more about that a little bit later.

The last flight test we had had a lot of these elements already operating with the exception of the in-flight communications system. And this system is important to us because it's the system that actually tells the kill vehicle what the other radars in the system are finding out from the target complex through the battle management system. So this is a very important element.

Now, the kill vehicle, as you know, had a problem in the last flight test. And I think I'd just take a minute to recap what we have done in order to get ready for this flight test to correct that particular anomaly.

This kill vehicle is, as I said, half-scale, and it weighs about 130 pounds, and it goes very fast to do its job. There are no explosives on that kill vehicle. There are no other kill mechanisms other than a collision at very high speed with the target vehicle. But what there is is an awful lot of complex electronic sensor and the associated cooling mechanisms to make the infrared spectrum work. This telescope here has an infrared detector set—two of them—that require nitrogen and krypton cooling—very low temperatures—in order to sense the target arrays in the backdrop of space. Heat sensors, in other words. What we had was some moisture in this krypton system that prevented the proper cooling at the time. We went back and spent about two months fixing that problem, understanding it, analyzing the data, and we believe we have fixed that problem by adding a number of things into the system. And that took us about two months. We originally were going to do this flight test in April, and now we're at 7 July, about 11 days off of where we

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thought we would be a few months ago.

So we're ready from a kill vehicle standpoint. Now, let me take a minute and describe this test and its complexity in some detail, and then …put it in perspective as to how we're actually going to do this test.

It's an intercontinental range test. This will cover about 5,000 statute miles, from Vandenburg Air Force Base to the Marshall Islands in the South Pacific. We will launch a target vehicle out of Vandenburg that will include a re-entry vehicle, a balloon decoy, a decoy that we call a balloon, and its associated carrying vehicle. At the time that this is launched, our satellite in orbit, that has been there for some time and that we will use in the operational system, will detect the launch and send messages to our battle management capability in Colorado Springs, where the Command Section will analyze the data and authorize release of the weapons and the execution of our battle management software. That data will go over a satellite communication and into a battle management node in Kwajalein. As these target complexes are flying over Hawaii, we will have test assets tracking these things to make sure that they're on track for range safety purposes. We don't want that target vehicle going anywhere except where we want it to go.

About the time that we need to, the battle management system will direct the launch of the interceptor and also tell the X-band radar where to look for this kill vehicle—for the kill vehicle intercept point and find this target complex. It will do a discrimination on that target complex and tell the battle manager where the reentry vehicle is headed, and it will update the in-flight booster to get that kill vehicle in the proper position.

As the kill vehicle separates, the kill vehicle will do two navigation star shots—and I'll describe those in a little bit of detail here shortly—to orient itself in a position in space. It will get two separate communications from the battle management center—that's the new part of this test—where that communication will use the X-band radar and early warning radars to update the kill vehicle as to where that target is and what is in that target complex in terms of what to hit. …This radar is at Kwajalein. But it will operate with the battle management system that we are developing. And this is a prototype X-band radar.

Once the kill vehicle gets a second communication from the ground, it is totally autonomous and uses its on-board electronics and computer system to discriminate the target vehicle from the decoy and its associated debris, and home in, in the last hundred seconds, for the intercept. And as I said before, the intercept is hit-to-kill kinetic energy, which essentially ionizes the warhead in space.

So that's the test setup. And what I'd like to do now is to kind of visualize this in a cartoon film to give you a perspective of the complexity, as well as the technical challenge, we have ahead of us.

As I said, this is an intercontinental type of flight…we launch a Minute Man II rocket that's 37 years old right now, into space. And this starts the process of the test. As it rises from Vandenberg, it will do its first-stage burn and head out into the South Pacific. About this time the space sensors are detecting the launch because of the brightness of the plume. Here is a satellite in orbit, and it will be detecting the launch as it stands and looks for launches as it does every day.

It reports that launch to our Battle Management in Colorado Springs, and that begins the process of weapons task planning to plan the mission to launch the interceptor. And there is also a human in the loop to authorize the weapon to be released. As the target flies on, it will do second-stage burn and gain into altitude for an insertion of the warhead.

the bus…contains decoys and maneuver capability. It orients itself in space, releases the reentry vehicle. The reentry vehicle spins up in order to reenter the atmosphere adequately, and then we release the decoy, which happens to be a large balloon that is representative of a threat that we expect to see. And all three of those objects are now traveling through space towards the South Pacific to present a threat complex and a

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challenge to the system.

Now, about that time, the Battle Management is telling our X-band radar at Kwajalein to start searching for that target complex, and it does so. It puts intense beam, it can measure things very accurately, and we expect it to discover that target and to tell the battle manager where it's going. It will release the weapon; the weapon will launch from Kwajalein Island. There will be a first-stage burn. All this time the Battle Management is working to precision it. This is what we call an energy dissipation maneuver, because in order to stay on the range, we have to dissipate energy for that booster because it has a lot more than is required. Very stressful.

It releases the kill vehicle, and the kill vehicle immediately goes into a navigation mode; it looks for stars—two of them—and it does an upgrade of its inertial navigation system, as well as its pointing accuracy. And then it orients its antenna in the rear towards the ground to get its first communication of upgrade from the radars and what they're seeing. It does an adjustment of its flight path and then goes into a second maneuver to again look for stars to confirm where it is in space and its pointing accuracy, and readies itself for a second update as to where that target complex is.

As it approaches the acquisition phase, it will open its sensors eyes, as depicted here, to spot where that target complex is. And if everything goes right from the ground, we should see in the center of the complex the warhead that is the target. And that's depicted here. If it doesn't go right, it has the capability of searching a volume of space to find these threat objects. It'll do onboard discrimination. At this point, it's totally autonomous, doesn't talk to anybody. It will discriminate. Hopefully we will have the balloon pass by and other debris, and it will lock on to the warhead and collide at a closing velocity of 4.6 miles per second. And at that speed there won't be anything left of that target reentry vehicle—if everything goes right. (Laughter.)

… we have a very complex test: many launches. A lot of things have to happen. And when it gets to the end game and actually goes against that warhead, it will look to hit that five-foot-long warhead in a space about this big. And that's what happened on Flight Test 3, when we did a successful intercept. So we have a complex test ahead of us and a big challenge to make this work.

… in the Welch report, and one of the things he's been very—his group has been very helpful to us on is to understand this unprecedented nature that we have of our test challenge in how to do intercontinental-level testing on a magnitude of this scale and do it in as good a way as we can from a national standpoint. The constraints that we have I think I ought to point out at this point in time based on the nature of this test and the way we conduct it.

We are limited, as Dr. Gansler said, because of policy and rules about space debris and making sure that we have range safety, and that whatever we put up in the air, we know where it's going to come down, and that it doesn't contaminate the environment. So the first thing that I'd like to point out is that because of the position of these radars that we have, our expanded Kwajalein and our early warning radar in California, they are out of position to do the testing the way we would like to do them. It's a fact of life. So we have to use surrogates in the process. But we're using them as minimally as possible. For instance, there'll be a radar at Hawaii that we call the FTQ-14 radar that's been there for some time that monitors the overall test progress and will be a surrogate for our early warning radar, because since we're shooting this way, the early warning radar is out of position to actually looking at things going away from it instead of coming towards it. We get good data out of it and we analyze it, and it's part of the system, and we'll get a cue from it—properly—but in order to do the mid-course-type of early warning we need a surrogate.

Now, that radar out there is not powerful enough to see that small 5-foot long reentry vehicle, so the reentry vehicle has an acquisition aid on it for that radar. And it's called a C-band beacon, and it helps that radar acquire the activity.

Now, because we have a beacon on the warhead, I want to make it clear what that beacon does not do. That

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beacon does not help the kill vehicle in the acquisition phase of that requirement. It is only for this radar here. And this radar is a surrogate, using the same type of data we will get from this into our battle manager. So it's a very complex arrangement. But we have to do that because of the out-of-position nature of our radar.

The other thing we do is we have global positioning capability on here, as well. And the reason why we do a lot of this location of the target warhead is because we need to have a range safety; we need to know where that warhead's going, over Hawaii and into the South Pacific. And the other thing we need to know is that, when the test is over, we need to post-process this data so we know what truth was, in terms of where these positions actually were. So when we do very intense analysis of our test, we can compare it to what actually happened, as opposed to what we thought happened. And that type of global positioning does not enter this situation at all, unless we have an anomaly where something breaks down, and we don't expect that to happen.

So there are a lot of constraints on our test program. It's very complex. The tests cost about $100 million to accomplish, so we want to make every single one of those things count in the process. And as a result, we do a lot of things to back things up here, to make sure that we can accomplish the test and get the most out of it, even though we have the possibility of something not working right during the test process.

Dr Gansler provided the following additional risk data:

…there are many things that could go wrong, including with the target or with one of the radars on the range or with the communications system or with the interceptor, and so forth. And recognize that this is the third intercept flight and this is early in a development program. You look back at a typical missile development program, not as complex as this, and we had lots of failures before we had lots of successes. Remember the THAAD is the most recent example of it. But we've made lots of efforts here to address the quality, partly because of the high cost of each flight, as General Kadish mentioned, but partly because of the very fact that we won't have a lot of them, and so we have to spend a lot of time on each one of them. But I would say… it's clearly a high risk overall program, and it's not a high probability of being able to precisely get everything to work on this flight.

Q: would you say fifty-fifty?

Mr. Gansler: I don't want to play that game. I just don't know what the numbers—

These remarks again made it clear that there are no binary events in the NMD schedule, and no one make or break test. At the same time, they also made it clear that Department of Defense would probably purse a different test and program schedule if it was given all of the funding its needs and was allowed to let success drive development and deployment, rather than a legislative mandate.

The July 7, 2000 Test Failure

It is hardly surprising under these conditions that a critical test on July 7, 2000 was a failure. While this test was scarcely a make or break test of any critical aspect of the technology, it was important because it was the test that was supposed to give President Clinton a milestone

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on which he could make his legal mandated decision whether or not to proceed with deployment, although senior US officials attempt to limit the public impact of the test. White House spokesman P.J. Crowley briefed reporters on July 7, and stated that the outcome of the test would only have a limited impact on Clinton's decision, "I would say a hit doesn't automatically suggest success, nor does a failure automatically come with a miss tonight," Crowley said. "I think everyone needs to understand that this is going to be a process that unfolds over many weeks..." He also stated that "the election is not a factor in the president's decision-making process." [21]

Secretary of Defense William Cohen stated in an interview on National Public Radio on the night before the test that, …(the test) is an important part of the analysis that needs to be done. As I've indicated before, the test itself is not dispositive of a recommendation to go forward, and a failure would not be dispositive of a recommendation not to go forward. What we have to do is analyze the totality of the information that we have gathered to date, and then put that through a very critical analysis before a recommendation is made. So I would suspect that following the test this evening that there will be at least three or even four weeks before a recommendation to the President will be made…with the understanding that we have at least another dozen or more tests coming before a system would actually be deployed. So there are plenty of checks and balances against deploying a system that would be ineffective. Frankly, I have no interest in recommending to the President that he deploy or make preparations for the deployment of a system that would be ineffective to protect the American people. That is not something I would advocate, and certainly the President wouldn't support it."[22]

Cohen responded to other questions during the interview as follows:

> Q: Given that the system that's being talked about and tested has critics on both sides—those who say it's too small a system to be effective, and other who say there shouldn't be any kind of national missile defense system at all. Do you think the most sensible thing here is to keep testing and push off big
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> decisions about what to develop for another year or two and perhaps into another administration?
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> Secretary Cohen: We are responding to a law that was passed by Congress and signed by the President. It had strong bipartisan support—Republicans and Democrats in the House and the Senate, mandating that we deploy a national missile defense system as soon as technologically feasible, and that's precisely why we have been conducting the research and development to achieve that goal. This is not something that is suddenly being rushed into judgment by President Clinton for any legacy purposes. He has been trying to

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respond to, number one, the nature of the threat; and number two, complying with congressional demands.

Q: But there seems to be something circular about saying when technologically feasible. As you've said, the test that you're putting the system through tonight is designed to be easy. Not to show that it's technologically feasible. You can continue taking new steps and advance this process for years with such tests, making them harder and harder.

Secretary Cohen: The question really is whether or not we can deploy a system that would be capable of intercepting a limited type of an attack, and that is something we believe we are on track—we will determine that ultimately after this test and more as to whether or not that is technologically feasible.

But again, I point to General Welsh who indicated that there is nothing that would preclude, from a technological point of view, the deployment of a system to achieve this goal—although he questioned whether or not we could reach that goal by 2005.

The test involved launching a Minuteman intercontinental missile with a dummy warhead from Vandenberg Air Force Base, California, toward the Pacific Marshall Islands. The 63-foot long rocket was to carry a mock warhead and a deflated Mylar balloon to act as a decoy. Five minutes after launch, the rocket was to release its fake warhead, and the balloon decoy was supposed to inflate to more than six feet in diameter. A U.S. "hit-to-kill" weapon was then to be fired atop its own rocket from Kwajalein Atoll 4,300 miles (6,919 kilometers) away about 15-20 minutes after the Vandenberg launch in an attempt to maneuver, intercept and smash into the "enemy" warhead at an altitude of around 144 miles. The 54-inch exoatmospheric, 121-pound, hit-to-kill weapon was designed to hit and smash the target into space dust at a speed of 15,000 mph in a flash that would be captured by long-range cameras – essentially hitting a bullet with a bullet.

The test sequence was supposed to work as follows:

- Target missile with mock warhead and decoy balloon launches from Vandenberg Air Force base in California.
- Satellite sensor detects plume from launch of target missile and notifies the US battle management center in Colorado Springs.
- The center analyzes the data on the target missile launch and provides targeting and launch authorization data to battle management node in Kwajalein to launch kill vehicle.

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- Kwajalein launches interceptor missile and activates the X-band radar for tracking.

- The exoatmospheric hit-to-kill vehicle separates from booster, takes star sightings to determine its coordinates, and receives updated information on the target's location from the X-band and early warning radars.

- Kill vehicle becomes autonomous and uses on-board electronics to distinguish the target from a decoy and debris and homes in.

The test proved to be a failure, but for reasons than had nothing to do with the technology of the NMD system per se. The Department of Defense statement on the test described the failure as follows:[23]

> …preliminary analysis from the planned intercept of a ballistic missile target early this morning over the central Pacific Ocean concluded that no separation occurred between the Payload Launch Vehicle (PLV) booster rocket, and the Exoatmospheric Kill Vehicle (EKV). Reports from program officials indicate that while the first and second stages of the booster separated successfully, the PLV started to tumble slowly after it made an energy management maneuver designed to keep it safely within the confines of the missile test range. The second anomaly was that the EKV never received a message from the PLV indicating that the second stage rocket motor had completed its propellant burn. Receipt of this signal is required for the EKV to separate and perform its intercept function. Initial cooldown of the EKV's infrared sensors and all other functions of the EKV were performing as designed up to the point where separation was to occur.
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> All other elements, including the sensors, the in-flight interceptor communications system (IFICS) and the battle management, command and control and communication systems performed as expected. Preliminary indications are that the prototype X-band radar at Kwajalein Atoll performed well and discriminated the mock warhead from all other objects, including the debris from an improperly inflated decoy balloon.

The fact that separation did not occur is scarcely a test of principle since hundreds of of separation tests have occurred in the past, and this failure precluded a meaningful test of NMD system performance. At the same time, the failure illustrated the risk of an accelerated and limited test program – a risk that Lieutenant General Ronald Kadish, the Director of BMDO, and Dr. Jack Gansler, the Under Secretary of Defense, Acquisition, Technology and Logistics) made clear during a briefing on the test:[24]

> General Kadish: We did not intercept the warhead that we expected to have tonight. We're disappointed with that, but let me explain what I think happened, and I'll have some visual aids here to properly put it in context. We had the launch of the target out of Vandenberg and that operation appeared to be fairly successful. We had an initial delay to the launch because of some battery problems that we worked out on the target. We had, as far as I know, only one anomaly with the target launch in that we did not get the decoy balloon to inflate, so it was an uninflated decoy.

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Everything appeared to be on track with the launch in the battle manager type systems, the integrated part of the system, to work right. We launched the interceptor. But we failed to have the kill vehicle separate from the booster second stage.

All we know based on telemetry now, and of course we will get more data as time goes on, is that the kill vehicle was waiting for a signal that we had second stage separation. We did not receive that signal. Therefore, the timeline shut down and the kill vehicle did not separate, and therefore, we did not attempt or have any activity in the intercept phase.

So we had a failure of the booster kill vehicle separation. …So what we know today, or as of this hour, is that we did not get to this point on the flight. So none of this occurred. The failure was in the boost phase here.

I would point out that, as you know, those who have followed the program, that the booster we are using is not the booster we intend to use in the operational system. It is a surrogate. A payload launch vehicle, which is second stage Minuteman booster that we have had high reliability with. So somewhere in this area we failed to get the proper sequence, and therefore the kill vehicle never separated to do its job.

… The EKV separation is about 157 seconds…It was looking for a second stage separation signal. It did not get that. So the timeline shut down….It's a part of the integrated system on the booster/kill vehicle combination. There's a series, and I need to caveat this, is that we are very early, we're only an hour or some minutes away from the event. All I can give you is what we have initially from our look at the telemetry. There is a lot I might say here that could turn out to be wrong, so please bear with me as we go through our investigation. So I would not like to speculate on a lot of this. But the way the normal sequence works, as I understand it, is that as the booster separates stages there are signals given to the computers on the kill vehicle and to other computers on board, and all those signals are supposed to line up and as a part of the sequence of events to make things happen.

Q: General, with many experts claiming that this is a possible $60 billion boondoggle, a system that won't work, you now have two failures and one success. Doesn't that weaken your position considerably?

Kadish: What it tells me is we have more engineering work to do. And as we've said all along, this is a very difficult, challenging job. This is rocket science, so there's a lot of things that can happen in this process In this particular case it appears it happened in an area that has little to do with the functionality of the key component of the system that we're testing.

Q: With the Pentagon supposed to make its decision, the review decision in the coming weeks, can they decide at this point to move forward with this?

Dr. Gansler: Let me just make a couple of observations first on this. …I should point out that this is only the fifth time that that particular booster which was configured for this particular flight has been used. In other words, we used it on the first four flights. They're standard boosters, but the configuration is different and therefore the staging is somewhat different. It is planned to be used only another three times, and then after that we use the real booster. So it's a special arrangement that was set up in order to have a surrogate early on until we could get the operational booster.

So the focus therefore of the booster portion of it is an important one. We do need to develop the booster. Unfortunately, what we'll learn from this one isn't what's wrong with the operational one and we'll have to go through the normal check out of what one would do on developing a Minuteman or developing an MX or so forth. It's that same kind of a booster development program.

The thing we were hoping to get out of this was much more information on the interceptor portion of it, which is really the part that is unique and different about this particular flight versus, say, a normal booster

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development or a missile development. This is closer to, say, a development that we've gone through in the past of anti-aircraft missiles, something like that. You want to see what the end game looks like. In that we normally have development problems, and that's the kind of thing that this represents as far as I can see.

Q: But do you still think it's possible for the Pentagon to go ahead with a deployment decision in the coming weeks after what happened tonight?

Gansler: The secretary and then the president are going to be evaluating a variety of things. As the president in fact said, there were four measures that he was going to be using—important inputs for that decision will be threat information that we'll get from intelligence inputs, also impacts on what it would likely mean in terms of the arms control agreements, other considerations that the Secretary first and then the President will be evaluating. I would say the Secretary certainly over the next month, and the President over the months shortly thereafter, trying to assess, based upon what we've learned from these three flights in terms of design information, what we have on other threat information. He'll have to make an assessment of whether or not it is still critical to try to make the 2005 date. That was the thing that was driving us.

That's the thing that the decision now relative to trying to build a site at Shemya for the X-band radar—which, by the way, the X-band radar part of it was working. That was something we were able to determine from the X-band radar that the balloon didn't inflate.

Others have said how easy it is to put up decoys, by the way. This is the proof that one decoy we were trying to put up didn't go up.

Q: The Secretary has already said he thinks the threat is there, and he thinks the cost is such that we should go forward. But as far as technical feasibility, do you think that it's still possible to give thumbs up for?

Gansler: That's something we're going to be evaluating. To be honest with you, I think it's fair to say that had we not had a kill in that third flight, that you would probably have very low confidence. The fact that the system, which we tested tonight again, and we tested in the second flight with the battle management system, the thing that was added tonight that was different was the link from the ground up to the intercept vehicle while it was in its boost phase. That was really the only new item. But checking out the whole system...

This is an extremely complex system. So you check out the satellites that detect the boost, that part of it worked. You check out the target vehicle. You're checking out the battle management system. You're checking out the X-band radar link. You're checking out the communication link up to the interceptor booster, and then the final part. The part we didn't get and what we were hoping to get was much more information on the terminal phase.

So the question is whether we have enough information on the terminal phase in order to be able to make an assessment that says we should go ahead and try to build that site at Shemya. That's one that the Secretary and the President are going to have to call, not...

Q: Is there any chance there would be another test before that decision?

Gansler: The next test that's scheduled right now is in the October/November time period. As you remember in the last flight when we had a failure, we spent quite a bit of time trying to analyze and then fix before we go ahead. If this requires major analysis and fix, that even could be delayed. But otherwise it's probably in the October/November time period.

Because of the construction time cycle at Shemya and the fact that we have the engineering work to be done for that site and then the construction to start in the spring, it seems to me that that's trying to push the

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decision pretty far down. We'd like to have a decision made by November rather than a flight by November.

Q: It seems pretty clear that you didn't get the data from this test that you'd hoped to have and that you needed to have in order to provide that recommendation to go ahead.

Gansler: I would say we didn't get the data we had hoped to have. The question of whether it's an absolute need or not is the one that the Secretary and the President will be deciding.

Q: General Kadish, of all the things that could have gone wrong with this flight, was this at the very bottom of your concern list?

Kadish: It wasn't even on my list. We had good confidence in the reliability of this. It's worked very well before. And to have the kill vehicle not separate was not something we worried about.

Q: You had a glazed look in your eye from the pool coverage when you took the phone call saying it didn't work. You seemed fairly shocked. Is that a good description?

Kadish: I was more disappointed than shocked. I'm never surprised by the things that can happen. This was not—again, this is rocket science and things do happen on this stuff that are unexpected. But of all the things we worried about and had risks associated with it, this was not something we thought would happen.

Q: Dr. Gansler, you say that the President and the Secretary will have to make a decision based on whether or not, will have to decide whether or not there's enough data, and yet they are not physicists, they are not scientists, they will have to... It's the scientists and the physicists who will have to decide if there's enough data.

As someone who's been testing for a long time, would it be your recommendation, is it your determination that there is enough data or not enough data? And would you go ahead with a project like this based on the data that you've got?

Gansler: The distinction I was making was the fact that the Secretary and President will be deciding not just on technical feasibility, but on other considerations as well.

In terms of the technical feasibility of it, in terms of is this design likely to work under the conditions that we assessed, I would personally say that I gained a great deal of confidence from that intercept that we had successfully in terms of the interceptor portion of it because it did work and it did actually do some discrimination.

On the rest of the system, which you can't just say is the interceptor technically feasible. What about the rest of the system? The rest of the system now has successfully worked twice, the last two flights, although the interceptor didn't. We didn't get to the interceptor on this one, and the prior one we had a failure on it.

So in a sense we've tested the major elements of this system sufficiently to say that the design is probably the one that's pretty solid. That is the same conclusion, by the way, that the Welch committee came to as well in terms of the technical feasibility.

We have always said, and they said they same thing, that in terms of making the schedule it is a high risk program, and you wouldn't like, if you had the time, you wouldn't like to make a go-ahead decision of any sort on the basis of what we've seen so far, just these three flights.

But because of the fact that we have a significant number of additional flights planned before the '03 decision to build the missiles, one could then decide that it's a low enough risk to go ahead and build the

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radar at Shemya. That's the decision that they're going to be making, not on whether we're ready to release the missiles.

Q: Just a followup. This was a booster that you've used before and you had a high amount of confidence in. The proposed booster, the one that you really want to us is eight months behind schedule already, I believe.

So doesn't that say that as much confidence as you have in a tested booster, you can't certainly have that much confidence at all in a booster that's eight months behind schedule. Doesn't that feed into this decision also?

Gansler: It does. In fact the booster is going to be the gating item for the second decision which is the one in '01, and that's the decision whether you're going to actually deploy and make a commitment to the radars. And you're correct. That is a gating decision and if we don't have some successful booster launches we probably would delay that decision.

The whole schedule is a tight schedule. It has been a tight schedule right from the beginning, and it's been more threat driven in terms... But on the other hand, it's still event driven because if we don't have successful events, then we wouldn't go ahead.

As I said, I wouldn't personally feel, unless we had a successful intercept, that I had a lot of confidence in intercept design. If I didn't have a successful booster test I wouldn't have a lot of confidence in the booster, and so forth.

Q: General Kadish, I'd just like to ask you to respond to the same question. On the basis of the single time that the intercept phase of this system has been exercised, are you confident you have enough data to draw judgment on the feasibility of that part of the system?

Kadish: I don't think we should draw conclusions from any one test that are irrevocable. What we have is a number of tests and legacy tests for all the elements of the system. When added together, it provides us a great body of evidence of the capability of the system.

Certainly on that test that we had the intercept, it gave us all a lot of confidence that the design we have of the kill vehicle, which is the key to the system, worked in a phase that we never had data on. So from that standpoint a key piece of the puzzle was put into place.

But just as we've been saying for a long time, no one test tends to tell you everything you need to know. We have a body of tests even before this one that tells us an awful lot. And we have increasing confidence as a result of that.

Gansler: These flight tests are validations of a lot of the ground and simulation tests. That's a huge body of data that we have. We need more flight tests.

Kadish: We need more flight tests.

Q: Let me put it to you the other way. You've known for some time you would have to make a DRR recommendation on technical feasibility this summer. You now lack data from two tests on the intercept phase.

What does the absence of that data do to your ability to produce this review? And the quality of the review that you're going to produce.

Kadish: I guess the way I would put it is, we will summarize the data and the situation that we face as of the time we need to make that assessment which is in the coming weeks, to the best of our knowledge, and

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that data... The data that we have and the test data that backs it up will be a high quality evaluation of the situation we face today.

Would we like to have more data? Yes. But we are where we are, and this is a natural course of most programs that I'm associated with. If you go back in history to the ICBM development, to the Safeguard development, there were many successes but also many failures early in the program, and programs have to deal with the data that you have at any given time.

So to answer your question, we will do the best assessment we can given where we are today, after we've concluded the analysis of the...

Q: The bottom line is, despite what happened tonight, early this morning, you can still say this is technically feasible in a review, is that right?

…Q: Doesn't this test also show that the schedule of 2005 is really unrealistic based on how things are going? You said at the last briefing that that schedule was based on essentially everything working the way you thought. Over the testing process you've had a setback. It just seems that the booster being behind schedule, with other complications...

Kadish: I think what we need to do now, just like we do after every test, whether a success or failure, is evaluate what we need to do from here on out and the viability of our schedules from that point, and see if there are mitigating factors.

Dr. Gansler pointed out there is another flight test we have available to us. Whether we can gather the data for that to effect the types of decision making we want in the fall timeframe is going to be a problem, and we have to decide what to do with that.

Q: On that next test, there's no way that that test could be moved up, it might actually be later than it is now scheduled, but no way it could be moved up?

Kadish: That's something we're going to have to look at. But again, this is tough work, and we've got to make sure that we don't do a very expensive test just to do the test.

6. Independent US Government Efforts to Assess Risk, Cost, and Benefits: The CBO Report on Budgetary Implications of National Missile Defense

The most detailed report on the risks, costs, and benefits of the NMD program is provided in a report by the Congressional Budget Office (CBO) entitled on Budgetary Implications of National Missile Defense and which was issued in the April 2000.[25]

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

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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.

….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 and 2007. 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— 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.

The CBO report is the only unclassified US government report which explicitly examines the implications of the cost of an NMD program that goes beyond a limited introductory deployment and it is also certainly correct in warning that even the basic system would cost at least $30 billion, rather than the $26 billion the government budgets, and that a more adequate system would cost at least $50 billion. Given past cost escalations at this level of technical risk,

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the life cycle cost of a Capability 3 system might well rise to levels around $100 billion.

The Details of the CBO Cost Estimate

The details of the CBO estimate show that little parametric and regression analysis was applied to its cost estimates, and it is vital to understand that even the Capability 3 system still locates interceptors at only one site, and does not plan to deal with a large or extremely sophisticated threat. [26]

> 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 III.14). 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.)
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> 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 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).

TABLE III.14.

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

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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.

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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.

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 III.15 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

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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 III.15

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

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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	

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	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

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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.

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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).

The CBO Analysis of Technical Risks and Test and Evaluation

The CBO analysis also provides an important supplement to the reporting by the Welch Panel and the Director of Operational Test and Evaluation of the Department of Defense, and it describes what seems to be a relatively high program.[27]

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 III.16). 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 **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

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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.

TABLE III.16

COMPARISON OF TEST PROGRAMS FOR VARIOUS MISSILES

		Number of Test Flights for Research and Development	
Missile Program	Year of Initial Operational Capability	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.

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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.						

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.[28] 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

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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 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,

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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.

7. Technical Risks and Test and Evaluation: The Problem of Countermeasures

Unfortunately, none of the government reports fully the technical risks identified by the Welch Panel and by opponents of NMD. These risks include the argument that countermeasures like submunitions with reentry capability and hiding balloons in warheads will be available to proliferating states by the time even advanced capability versions of an NMD system are deployable.[29]

The Union of Concerned Scientists and MIT Security Studies Program View of Countermeasures

A report by the Union of Concerned Scientists and MIT Security Studies Program makes the following charges:[30]

> There are numerous tactics that an attacker could use to counter the planned NMD system. None of these countermeasures is new; indeed, most of these ideas are as old as ballistic missiles themselves. All countries that have deployed long-range ballistic missiles (Britain, China, France, Russia, and the United States) have developed, produced, and in some cases deployed, countermeasures for their missiles. There is no reason to believe that emerging missile states would behave differently, especially when US missile defense development is front-page news. Many highly effective countermeasures require a lower level of technology than that required to build a long-range ballistic missile (or nuclear weapon). The United States must anticipate that any potentially hostile country developing or acquiring ballistic missiles would have a parallel program to develop or acquire countermeasures to make those missiles effective in the face of US missile defenses. Countermeasure programs could be concealed from US intelligence much more easily than missile programs, and the United States should not assume that a lack of intelligence evidence is evidence that countermeasure programs do not exist. Many countermeasures are based on basic physical principles and well-understood technologies. As a consequence, a vast amount of technical information relevant to building and deploying countermeasures is publicly available. Any country capable of building a long-range ballistic missile would have the scientific and technical expertise, including people who have worked on missiles for many years, to exploit the avail-able technologies. Moreover, a great deal of

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technical information about the planned NMD system and its sensors has been published. A potential attacker could learn from a variety of open sources enough about the planned NMD system to design countermeasures to defeat it.

To determine whether technically simple counter-measures would be effective against the planned NMD system, we examined three potential countermeasures in detail: submunitions with biological or chemical weapons, nuclear warheads with anti-simulation balloon decoys, and nuclear warheads with cooled shrouds. We find that any of these would defeat the planned NMD system. They would either significantly degrade the effectiveness of the defense or make it fail completely. Moreover, these countermeasures would defeat the planned NMD system even if they were anticipated by the United States. And because these countermeasures use readily available materials and straightforward technologies, any emerging missile state could readily construct and employ them.

Submunitions with Biological or Chemical Weapons. To deliver biological or chemical weapons by long-range ballistic missile, an attacker could divide the agent for each missile among a hundred or more small warheads, or submunitions, that would be released shortly after boost phase. These submunitions would be too numerous for a limited defense—such as the planned NMD system—to even attempt to intercept all of them. Our analysis demonstrates that the attacker could readily keep the reentry heating of the submunitions low enough to protect the agents from excessive heat. Moreover, because submunitions would distribute the agent over a large area and disseminate it at low speeds, they would be a more effective means of delivering biological and chemical agents by ballistic missile than would a single large warhead. Thus, an attacker would have a strong incentive to use submunitions, aside from any concerns about missile defenses.

Nuclear Weapons with Anti-simulation Balloon Decoys. Anti-simulation is a powerful tactic in which the attacker disguises the warhead to make it look like a decoy, rather than attempting the more difficult task of making every decoy closely resemble a specific warhead.

To use this tactic, the attacker could place a nuclear warhead in a lightweight balloon made of aluminized mylar and release it along with a large number of similar, but empty balloons. The balloon containing the warhead could be made indistinguishable from the empty ones to all the defense sensors—including the ground-based radars, the satellite-based infrared sensors, and the sensors on the kill vehicle. The defense would therefore need to shoot at all the balloons to pre-vent the warhead from getting through, but the attacker could deploy so many balloons that the defense would run out of interceptors.

Nuclear Weapons with Cooled Shrouds. The attacker could cover a nuclear warhead with a shroud cooled to a low temperature by liquid nitrogen. The cooled shroud would reduce the infrared radiation emitted by the war-head by a factor of at least one million. This would make it nearly impossible for the kill vehicle's heat-seeking infrared sensors to detect the warhead at a great enough distance to have time to maneuver to hit it.

This same report by the Union of Concerned Scientists and MIT Security Studies Program raises other major objections to NMD, many of which are technical. One is that "operational and technical factors make the job of the defense more difficult than that of the attacker."[31] The technology to be used in the NMD system will be known to attackers years in advance, allowing the attacker to respond against a system that cannot easily be upgraded, and greatly complicating the problems in designing hit-to-kill interceptors which allow little margin

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for error, and the problems in ensuring the system can work the first time it is used.

Other charges state that the "planned NMD system would not be effective against an accidental or unauthorized attack from Russia, or an erroneous launch based on false warning of a US attack, because Russia will upgrade its warheads to defeat the US NMD system and an unauthorized Russian attack could easily involve 50 or even 500 warheads, which would saturate and penetrate a limited NMD system. Similar arguments are made about defense against a Chinese attack on the grounds that China has already developed effective countermeasures.[32]

The report puts a reverse spin on the conclusions of the Rumsfeld Commission by stating that the, "Available evidence strongly suggests that the Pentagon has greatly underestimated the ability and motivation of emerging missile states to deploy effective countermeasures. There are strong indications that the Pentagon's Systems Threat Assessment Requirement (STAR) Document and Operational Requirements Document, which describe the type of threat the NMD system must defend against, underestimate the effectiveness of the countermeasures that an emerging missile state could deploy and thus inaccurately describe the actual threat. If the threat assessment and requirements documents do not accurately reflect the real-world threat, then an NMD system designed and built to meet these less demanding requirements will fail in the real world."[33] If this conclusion is correct, the cost to defeat the current NMD architecture would be affordable even to most Third World states.

Postol and Other Comments About Countermeasures

Somewhat similar objections appeared in the New York Times on June 9, 2000, when Theodore A. Postol of MIT – a long-standing opponent of NMD – claimed that the BMDO test program was rigged to minimize the number and quality of the decoys used in operational testing, and that even relatively unsophisticated countries could easily develop decoys that would defeat the system planned by BMDO. Dr Postol charged that the current kill vehicle could not discriminate between a warhead and a simple decoy and that neither the previous two tests, or any of the future tests, were demanding enough to reveal this critical weakness in the system design.

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Dr. Postol charged that the June 1997 test had also revealed that the infrared profile of the target did not provide enough data for the sensors on the kill vehicle to detect differences between warheads and decoys, and that BMDO had artificially heightened the IR contrast between the warhead and decoys in follow tests to disguise this fact. He released a chart said to come from BMDO that he said showed that all of the 16 tests to be performed between initial testing and deployment in 2005 were "rigged." This included removing all decoys with infrared signatures close to the warhead, such as spherical balloons with stripes to make their infrared signatures vibrate in the same way as cone-shaped warheads, rigid decoys that looked like cones, and cone-shaped balloons. Inflatable balloons are systems that the US has extensibre

The BMDO and Department of Defense Rebuttal

BMDO has strongly denied that countermeasures pose a near-term threat to the current NMD system, and hasclaimed that the charts Postol referred to disguised the fact that the decoys became steadily more sophisticated with time.[34] Lt. Gen. Ronald Kadish, the Director of BMDO, made the following comments to the Year 2000 Multinational BMD Conference on June 5, 2000:[35]

> … Some suggest that we are not testing the NMD system against realistic targets. But they ignore our decades-long practice for testing other complex systems, such as new aircraft. The first test planned for each new aircraft has always been a high-speed taxi test. After all, there is an understandable interest in making sure the basic mechanics, avionics, and computers work as they should before taking the far more risky step of lifting off the ground. This is the evolutionary nature of the testing approach we must use when we develop highly complex machines–we don't test to the maximum every component of the system the first few times.
>
> Two central technological problems confront us. The first is the discrimination problem, or can we find the warhead? The second is the so-called "hit-a-bullet-with-a-bullet" problem, or, once we find the warhead, can we hit it? Historically, solutions to both these problems have eluded us, especially against a massive raid involving hundreds of incoming warheads and countermeasures–decoys, radar chaff, and debris. Up to now, the technological immaturity of our sensors did not allow us to discriminate, or pick out, the countermeasures within a target cluster.
>
> During the past decade, we've made significant advances in our sensor and discrimination technologies, including in the areas of new high-resolution radars, digital radars with sophisticated electronic counter-countermeasures, and infrared seekers. Steady improvements in computer processing power, which has been doubling every 18 months for the last 30 years, has helped us to develop an interceptor that flies out quickly, processes the sensor data faster and with greater accuracy, and destroys the warhead.
>
> We also have shown that we can hit another object in space, something like a five-foot ice cream cone, at closing speeds greater than 15,000 mph. Last October, on our first attempt, we demonstrated the ability of the kill vehicle to travel thousands of miles to a very specific location in space–one ultimately defined by

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inches and microseconds–discriminate among several objects, identify the right target, divert towards it, and collide into it. The kinetic energy created by this high-speed collision of two masses is significant enough to obliterate the target. Today we don't need nuclear weapons to kill warheads in-flight.

We are testing the concept of hit-to-kill rigorously. Last year, our flight tests went a long way to convincing me that we had winning kill vehicle designs. In 1999, we had 6 successful intercepts using hit-to-kill technology, one in our NMD program, and five more in our theater ballistic missile defense programs.

Do we still have work to do? Absolutely, but I'm increasingly optimistic that we will not have to revisit the basic science associated with hit-to-kill.…The critics of NMD tend to magnify the capabilities of states like North Korea, Iran, and Iraq. But just because states can build missiles doesn't mean they can or will develop countermeasures. And then, even if they demonstrate a capability to build them, it is not automatically true that they can use them effectively. These countries can invent on a blackboard almost any kind of countermeasure. But can they be certain that they can make them work effectively? I would argue that they can't.

To be confident that these countermeasures can work effectively, these states also will have to test them. The limited amount of ballistic missile and countermeasure testing done by our adversaries, in other words, amplifies the uncertainties that they must face if they are to use their weapons successfully. This uncertainty will act as a deterrent in some situations

Jasques Gansler provided the following further background on the ability of NMD system to deal with countermeasures in June 2000:[36]

Q: Dr. Gansler, could you … address the core criticism of Professor Postol which I thought provoked the media interest, which in turn has provoked this briefing. I mean, as I understand it, what Professor Postol said, looking at the sensor data from the IFT-1A, and reworking it, what he said is that there is no differentiating signals that come from the warhead as opposed to the decoys; that is that there is no information out there which enables an IR sensor, however good, and enables an algorithm, however good, to differentiate between a tumbling decoy—between a tumbling warhead and the range of possible decoys. You can't discrimination, there isn't enough information specific to the warhead. Could you address that core point?

Mr. Gansler: It is a core point. I should point out, of course, that the 1-A was not the seeker selected, and that was the Boeing-TRW one, not the Raytheon one. But it is important to recognize that we have had lots of independent assessments, including the Welch group continuing to do so.

The types of decoys that are being hypothesized, and not just his criticism but lots of other criticisms, are things that all of us have worked on, and I worked on anti-missile systems—I hate to say it -- 40 years ago, and I've been working on them ever since. And every one of those decoys has been hypothesized and, in fact, most of them have been tried, you know, by the United States and others. So these are not unknown phenomenon they questioned. They're also not as easy as some people hypothesized to make, some of the more difficult ones.

On the other hand, the likelihood of what we will see in the early term period, I think, is very clear, that the experts, all the experts—the physicists and the engineers and so forth—all anticipate the types of decoys being relatively sophisticated as they evolve. And for that, we have looked at how to discriminate those. And there's a large variety—a couple of dozen different things that we'll be using. You know, a tumble rate and sensing mass and using the x-band radar, using infrared, using the infrared detectors on the seeker. As the threat is evolving, we are going to be using a large number of discrimination techniques, not just the simple one that was referred to in that particular report. So the experts—in fact, the people working for us on the contracts and the independent assessors—have all felt that this system has the inherent capability to

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be able to deal with those threats as they come along, and we will, of course, continue to make it more sophisticated as those threats evolve.

Q: Just to follow up on that, if I can. Can you just explain why you've decided in the tests that you've done, the last two tests and in the third intercept test, IFP-5, why you've decided to use a decoy that is a different shape and different size than the warhead? And can you explain in a little more detail the basic science of how you would discriminate between an actual warhead and a decoy that was the same shape and the same size as the warhead?

Mr. Gansler: Well, in fact, we will later be using decoys that are a similar shape and size, because—that's an obvious decoy—and—

Q: So how come you didn't use it in this test?

Mr. Gansler: Well, actually, it was kind of interesting. In this early test, what we were trying to do was to pull it off and so used something that was even larger and much more obvious, and we figured that might pull the interceptor off to the target, and in fact, it did, in the flight. It found this decoy first because it was larger, did have more radiation, and it found it first, and it said, "Oh, there's the target," and started to go for it, because we didn't have the link that General Kadish mentioned before that would point out where it thought the target was. And so it searched and it found that one first, started going for it, and its software said, "That's the wrong target." And then it shifted to the target that had the characteristics it was supposed to have had, in this case purely in terms of the infrared characteristics because that was all that seeker had.

Now the system, the complex system that he just described will have other ways of measuring the characteristics, as I said, a couple of dozen of them. The one thing I don't want to do is to get into the details of which techniques we're using and which ones we're not using, which ones work, which ones don't, which target. That's where the Welch report goes into it in terms of classified information. But in terms of recognizing that you have to have multiple discrimination techniques, not a single one, and in fact recognizing that likely things will have—they'll go to the trouble of making some that have similar characteristics in heat, some that have similar characteristics in radar reflection, some that have similar characteristics in size, some that have similar characteristics in tumble, and so forth. The problem for them is to make things that look alike in all those characteristics. And that's difficult. And it's that combination of characteristics that we're trying to take advantage of with the software.

Gen. Kadish: Let me say one thing. And I don't want to be naive in this answer. But a balloon does not look like an RV to a human. I mean, it's obvious. One is a balloon and the other is cone. But to sensors from a distance, even to the human eye, a balloon and an RV present the same dot if you will, to IR sensors and to radar sensors. And it's just kind of like looking at the difference between a pickup truck and a car at two miles. I mean, they are different in their orientation. So a balloon is a very effective, in certain circumstances, decoy even though it doesn't look like an RV, and is relatively straightforward in terms of its capability to be deployed and potentially proliferate.

So that's why we have, in our early tests, balloons to go after. And there are many other, as Dr. Gansler said, ways of discriminating. But each has a unique signature. So, just because it doesn't look like the RV doesn't mean it can't be a decoy.

Q: You mentioned the phrase, "sensing mass." Can you just explain what you mean by that?

Gen. Kadish: I'm sorry, I missed the question.

Q: He mentioned—Dr. Gansler mentioned the phrase, "sensing mass." I'm just curious what you mean by that, how that works.

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Gen. Kadish: The x-band radar can measure—take measurements that could actually—I'd rather not get into that. (Laughter.)

Mr. Gansler: That's where you get into some of the -

Gen. Kadish: It is not helpful to have a public discussion of this type of activity.

Q: Dr. Gansler, you've spent your whole adult life on this business. Realizing it's not your call, is it your personal opinion that it would be good for the country to deploy missile defense, and what is your rebuttal to those who say it will just provoke an action-reaction phenomenon, including the Russians mining space with mines, and whenever there's a period of tension they just blow one off to blind our detection systems. Address your personal view in the possibility of escalating this into a war in space.

Mr. Gansler: Well, I guess I should say, luckily, I've spent my career on the engineering side, not on the public policy side, so it's really not the kind of issue that I should be addressing and would prefer not to, because it seems to me that it's—the kind of questions that you're raising are the ones that the president's going to be trying to address. My job is to determine whether the system can technically work and whether we've addressed what we think to be the likely threats, whether it can be done in the time period with a reasonable confidence level. Things of that sort, I can answer for you. Whether or not, you know, how it affects arms control, how it affects the arms race, how it affects things of that sort, I can't.

I can tell you, in terms of the threat assessments that we're trying to address that those seem to be quite realistic; that proliferation of this type of weapon, both in terms of delivery and in terms of the kill mechanism vehicles—you know, the weapons of mass destruction—seem to be quite realistic, in my personal opinion.

Secretary of Defense Cohen gave the following response to a question in an interview on National Public Radio on July 7, 2000,[37]

Q: Two critics of the missile defense system from MIT, Theodore Postol and George Lewis, write today in the New York Times that this test has been "dumbed down". Here's what they say. They say instead of the ten objects that confounded the kill vehicle in the first test in '97, today's test, like the two before it, will use a single mock balloon which is nearly ten times brighter than the warhead and the kill vehicle will be programmed to home in on the dimmer of the two objects. Is that true?

Secretary Cohen: It's somewhat ironic that this is a criticism now being leveled at this particular test. We are responding and have responded to an independent review committee or commission headed up by General Welsh, Larry Welsh, who in the past has been critical of the testing program, saying it was a rush to failure. As a result of his initial recommendation we responded to it by restructuring the program so that we would walk before running, and that we would start out incrementally to test this interceptor against a relatively simple type of target missile and decoy with the idea that we will progressively increase the level of complexity as the tests continue. So we are responding and have responded to the independent review saying we should walk before we run. Then to be criticized for doing that it seems to me to be rather ironic.

There is no way to resolve such uncertainties. As has been noted, the June 2000 report of Welch Panel did raise countermeasures as a major issue, and stated: While we believe that the current design requirements will meet the C-1 threat, the NMD program requires critical attention to potential countermeasures challenges to execute the planned evolutionary approach

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to the threat."[38] Furthermore, the US has had considerable success with similar countermeasure programs. These programs include the 2.2 Meter Balloon. Lightweight Replica LREP. Inflatable Exoatmospheric Object (IEO). Firefly, and Multi-Balloon Canister (MBC) tests – although it is far from clear how soon most threat countries could deploy similar technology or how far they would go in defeating the current and growth countermeasure capabilities of the current NMD architecture.[39] At the same time, a US decoy failed to deploy in a test on July 7, 2000, and little about the Iranian, North Korean, and Chinese test programs to date has revealed much sophistication in countermeasure technology.

Other Technical Objections to the Current NMD System

Other arguments are less technical and have already been discussed. They include the following points:

- Long-range missiles would be neither the only nor the optimum means of delivery for an emerging missile state attacking the United States with nuclear, biological, or chemical weapons.

- The planned testing program for the NMD system is inadequate to assess the operational effectiveness of the system.

- The deployment of the NMD system could seriously impair efforts to control the proliferation of long-range ballistic missiles and weapons of mass destruction, and thus ultimately increase the threat to the United States from these weapons.

- Deterrence will continue to be the ultimate line of defense against attacks on the United States by missiles armed with weapons of mass destruction.

The problem with such arguments is not one of technical possibility. The report by the Union of Concerned Scientists and MIT Security Studies Program is 119 pages long plus 54 pages of detailed technical appendices, and includes an analysis of past US tests against countermeasures. The problem is that while such arguments are technically interesting, and are well supported with technical detail, they are structured to support one hypothesis and serve a political purpose. Like

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the technical arguments for NMD, they raise important issues, but it is impossible to properly assess their merit without access to extensive technical expertise and classified data. As such they illustrate the limits to unclassified risk analysis in ways which preclude any final judgment about their merit.

8. Efforts to Assess Risk, Cost, and Benefits: Summary Conclusions

Some of NMD's strongest supporters still believe that the risks in the NMD program can be overcome by political pressure and added funding, while their opponents believe that they will be cumulatively fatal regardless of how the program is managed and scheduled. The progress that BMDO has made since the GAO report was written, however, does not seem to justify either view. The NMD program has continued to slip in ways that are clear warning that politics and money can serve as a "forcing function" that makes technology work. At the same time, nothing about the various slippages in the NMD program as yet indicate that NMD is inherently infeasible and that it cannot be made to work within a relatively few years of its currently planned schedule.

There are insufficient data to estimate the true nature of the potential escalation in life cycle costs which could still easily reach 50% to 100% above the currently program estimates. It seems likely that the program will slip by at least one or two years in spite of the past delays in its estimated date of completion, and the GAO's reservations about the test and evaluation program may, if anything, be optimistic. The point it raises about the limited scale of the present BMDO program is a critical one and goes beyond the simple issue of the number of tests.

The results of reviews like the Welch Panel raise critical doubts about whether developmental simulation and testing can be a substitute for the deployment of a full test-bed system. The present BMDO program can at best establish that the components of the proposed NMD system can work. It is far too limited in scale to establish system reliability and lethality even if all of the tests are successful. It also assumes that a complex system involving massive amounts of complex command and control and sensor systems can be tested through a

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combination of simulations and limited technical testing before deployment.

No nation in the world has ever been remotely successful in deploying a combat ready weapons system of similar complexity in this fashion. NORAD and NADGE took nearly half a decade to transform into limited success after their initial deployment dates. The same was true of the original Hawk, Patriot, and AEGIS interceptors. All of these much less complex systems were eventually made to work once deployed, but none came close to being reliable combat-ready systems at their initial date of deployment.

E. The Deployment Schedule for the Current NMD Architecture

The present NMD architecture is not static and some aspects of the presently contemplated system and deployment schedule will probably change during the coming years. At present, however, President Clinton is schedule to take a deployment decision in September 2000,

Much will depend, however, on progress in development testing before and after the President's decision, negotiations with Russia, and changes in the threat assessment Even when an initial NMD system is deployed, it is certain to remain highly developmental in some ways. It must respond to both changes in the threat and arms control environment, progress in applied technology, and the success of the systems integration required to reliably ensure that all components of such a complex system work. These uncertainties dictate the evolutionary nature of the NMD system.

1. The Deployment Readiness Decision

Any comments on President Clinton's decision regarding deployment readiness must be highly tentative at this time. As is noted in the following section, there are good reasons why such a decision should be delayed, and why more testing is needed. A number of political analysts believe that both Vice President Gore and Governor Bush would prefer to make the decision when one assumes the Presidency in 2001, and other believe that President Clinton does

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not want to force a decision with major implications in terms of arms control and in the face of Russian, European, and Chinese opposition. They also cite the delays and problems in the test program and the risk that the US may not complete key tests in time.

Nevertheless, it is important to note that the Congress has mandated that the US “shall deploy” the system “as soon as it is technically feasible. US Defense officials have also raised a number of arguments why the decision should be made in 2000. Lt. Gen. Ronald Kadish, the Director of BMDO, made the following case for such timing in a speech on June 5, 2000:[40]

> …."Headline": The United States should delay its NMD deployment readiness decision. I’m frequently asked: why has the DRR been scheduled for this summer? The answer is that the threat is emerging faster than we thought it would just five years ago. For this reason, it is essential that we protect an option for a presidential decision to deploy a system as soon as possible. In order to preserve that option, we need to undertake a technological readiness review soon.
>
> To put the DRR in proper context, you should understand first what it is not. This summer’s internal Defense Department review is not a decision to deploy the system. The decision to proceed with deploying missile defenses lies squarely on the desk of the President, in consultation with the Congress. But before the President can formulate informed answers to the questions of whether to deploy by 2005, he must have before him some critical pieces of information concerning four primary criteria: the threat, the technological readiness of the system, the cost of that system, and our national security and arms control objectives. The DRR is actually an on-going internal Secretary of Defense evaluation that focuses only on two of the criteria–technological readiness and the cost of the system.
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> If the President decides that we need an operational capability by 2005, and you back up all of the activities that we need to do to meet that commitment, it turns out that building the X-band radar must occur early in the process. If this radar needs to be built in Alaska, work must begin next spring because of the short construction season. If work is to begin roughly a year from now, we have to let construction contracts this fall. If we wait another year to begin building that radar, I would not be able to assure the country that we can have the initial system up and running by 2005.
>
> "Headline": We don’t have enough test data to make a deployment decision, and we’re not doing adequate testing. An important part of understanding the error in this headline is understanding the way we have developed and acquired weapon systems in the past, and how we have changed our approach to meet an urgent schedule. The standard approach to weapon-system acquisition has been simply too risk-averse to allow us to develop new system concepts rapidly, especially when the threat drives the urgency for development. With average cycle times for major acquisition programs over the past decades averaging 8 to 9 years, and that’s 8 to 9 years from the time the decision is made to build, it is clear that the traditional way of doing business in defense procurement will not handle many of our future demands.
>
> The NMD program is on a compressed, high-risk schedule to deploy a system by 2005 for one reason and one reason only–the threat. Because we are moving on that fast track, the program we are executing is high-risk, which means that a significant setback in any one element can delay the entire program. Taking such risks is inconsistent with today’s acquisition culture. For this reason, we are being accused by some of "rushing," or of pushing a system forward that, once fielded, will not be operationally effective.
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> But high-risk does not mean reckless. There is a difference between rushing and moving as fast as is prudent. We have every incentive to get a capability into the field as quickly as possible. We also have

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every incentive to get it right.

A prudent testing program, therefore, will address first the basics of the system. We've scheduled four tests to get two demonstrations of hit-to-kill. The first was successful. The second was partially successful. The next is planned for later this month.

2. The Impact of Risk on the Deployment Decision

It is important to note, however, that BMDO has made it repeatedly clear that any such decision involves substantial risk and is driven by political factors, legislative requirements, and threat assessments that may be unrealistic. Lt. Gen. Ronald Kadish made this clear in a speech on March 30, 2000:[41]

> But I do not wish to minimize the immense difficulties before us. In the months ahead, there are several more tests scheduled in our national and theater missile defense programs that will involve increasing levels of complexity and integration. We still have lots of hard work ahead of us.
>
> We are striving to deploy an initial NMD capability, or C-1, in fiscal '05. This will consist of 20 interceptors designed to counter a handful of missiles with simple countermeasures. Because the threat is dynamic and we expect some dangerous states to be able to launch more missiles in that timeframe, we will move to an "expanded-capability-one" architecture, or Expanded C-1, in fiscal '07. By 2007, in other words, we plan to deploy a total of 100 interceptors. We have requested from the Congress an additional $1.9 billion in funds through the Future Years Defense Program to execute this program, or 43% of our $4.5 billion BMDO budget for next year. In context, this represents less than two-thirds of one percent of the fiscal '01 Defense budget.
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> Given that we are scheduled to deploy in 2005, and we only started to work this in earnest about a year and a half ago, we are forced to work with a high-risk program. As most of our critics have noted, the program is high-risk, primarily because, as I stated earlier, we are driven today to accelerate the NMD program to field an effective limited defensive system by 2005 in order to meet the threat. We are moving on as many concurrent tracks as we think prudent. High risk means that the schedule is so compressed that a significant setback in one element can delay the entire program. We cannot work this program as we would a normal development program, where we develop and test sequentially. We must do these steps concurrently. To date, we have been able to meet our commitments, but the program will require continued aggressive management if we are to succeed.
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> Although I continue to be optimistic about the system's eventual capabilities, we should guard against being either overly optimistic or unduly pessimistic about the deployment readiness of the NMD system. Rather, I am realistic. The NMD program is still a high-risk program. But I believe a successful test program and the timely execution of system-element schedules will provide us the information we need to assess reliably the progress in our NMD program.
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> Which brings me to a very important event in our program schedule. We put a "stake in the sand" this coming summer. This July we are preparing to conduct an NMD Deployment Readiness Review, or DRR. There seems to be some confusion about what this review really entails, so I'd like to spend a few moments describing this process for you.
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> To put the DRR in proper context, you should understand first what it is not. This summer's review will not result, for example, in a decision to deploy the system. The decision to deploy missile defenses to protect all fifty United States against a limited attack by a dangerous state lies squarely and entirely on the

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desk of the President, who will decide in consultation with Congress. But before the President can formulate informed answers to the questions of whether, when, and where to deploy, he must have before him some very critical pieces of information concerning four primary factors: the threat, our national arms control objectives, the technological readiness of the system, and the cost of that system. The DRR is a process that focuses only on the last two criteria - technology readiness and cost.

Understanding that we are talking about system "readiness," not system "deployment," is the key to properly characterizing the review that will take place this July. Led by the Under Secretary of Defense for Acquisition, Technology, and Logistics, Dr. Gansler, the Deployment Readiness Review that I am currently preparing for will concentrate on the technological progress we are making in the development of NMD technologies and system elements. As part of this analysis we also will review overall system operational effectiveness and, as I mentioned earlier, program life-cycle cost and the adequacy of projected funding.

As part of the DRR process, we will be examining the design to see if we have adequately demonstrated that the NMD elements not only work well, but that they work well together. There also are key performance parameters we have to meet and take a hard look at, one of the most important being the ability of the planned system to defend all fifty states. Judgments will have to be made about the maturity of the system and its readiness for deployment by the projected deployment date of 2005. We will also have to immerse ourselves in the evaluation of minutia more directly related to the production and physical construction of the elements, including manufacturing production readiness, our ability to field the system on schedule, and our ability to sustain the system once it is deployed.

The DRR is a process as well as an event.

No one involved in the DRR is going into this process cold. The DRR, while it is the beginning of the deployment decision-making process, is really a later stage of a multi-year developmental program. The people that will be focused on this one major review in July will already have been engaged for months and even years in a series of tiered process reviews within the Department involving all interested parties, from the action officer level up through the senior appointed officials, in what we call integrated product team reviews. This is an established and proven process for handling the development of all complex acquisition systems. In short, the DRR is a point further down an already well-trodden path. No spin up of the principals will be necessary.

The DRR is an important initial step in a lengthy and involved deployment decision process that includes at least three major acquisition decision milestones in the program over the next five years to determine the system's technological status. These decision milestones are steps we must take in the acquisition life of the NMD system. These acquisition decisions will be made in addition to major policy decisions throughout the life of the program made at the levels of the Secretary of Defense and the President. Each acquisition decision made over the course of the next five years will be based on an assessment of the program's progress at that time and will give authority to proceed on further key activities. The July DRR, a part of that acquisition decision process, just happens to be the decision milestone nearest to us in time - and hence, it is receiving a lot of attention.

One of the key criteria we will use when conducting this technology status review will be a determination of success in our testing program. There are literally hundreds of different criteria we are watching, ranging from software development to construction specifications for this highly complex system. We have used an internal short-hand measure of two intercepts in our integrated flight test program to demonstrate our readiness. We believe this will serve as a good benchmark, though it is not the only benchmark, and that it will help us to understand when we will be in a position to undertake the Deployment Readiness Review. We have one intercept already under our belt and confidence that our basic interceptor design works. As we look forward to achieving our second intercept in integrated flight test number 5, we are increasingly confident that we will be able to get our second intercept.

That said, and I will reiterate this point again later because I believe it is fundamentally important to

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understand, we were able to achieve a number of successes during the IFT-4 test, even though we failed to get our second intercept. We successfully proved in that test that many of the technologies and systems we will require to detect, acquire, and track the target missiles and reentry vehicles will work. We demonstrated the efficient processing of commands and effective control over critical system elements. From this perspective, IFT-4 was a major success. This is important information that also will be taken into account as we assess the technological status of the program. Our testing program is rigorous, highly complicated and involved. I have full confidence in our testing regime, that once we have completed it, we will have sufficient data and analysis to know with a high degree of certainty whether the system we are planning to deploy will work as designed.

The internal DoD review process we call DRR, therefore, will attempt to assess many, many aspects of this program, to include testing successes and lessons learned, other technical aspects of the program, construction timelines and deadlines, and even such practical matters as construction contracts. The intercepts we are striving to achieve are only the most visible criteria that we will have to take into account when we decide from a technological standpoint whether or not it is prudent to proceed with the production of the system.

If a decision is made in 2000 to deploy, a decision that also will include a commitment to a specific site, we will conduct a Defense Acquisition Board review in fiscal '01 and another in fiscal '03 to assess the acquisition status of the program. The Defense Acquisition Board is a senior level forum that meets as required to advise the Department's top acquisition executive - Dr. Gansler - on critical decisions concerning major defense acquisition programs. As a major acquisition program, the NMD system necessarily falls under the purview of this board. Based on program performance at each point in time, we would seek approval to start implementing the longer lead-time items first, such as construction work on the X-band radar, the missile field, and the upgrading of our Early Warning Radars. This first DAB review is also required before we continue with the integration of our BM/C3 system.

We won't seek approval to procure and deploy the ground-based interceptors and necessary spares until fiscal '03. What this means is that we can continue to test and refine the elements of our system until their individual decision dates are due, as driven by the ultimate deployment date. We are phasing our deployment based on the technological progress of the various system elements, progress that will be reviewed by the Defense Acquisition Board during the five years leading up to the deployment of the initial 20 interceptors in 2005.

This brings me to another important question I frequently get about the DRR, that is, why has it been scheduled for this summer? Why not next summer? The answer is that there is general agreement across the government that we need to deploy a system to meet a threat in 2005. Construction activities will be limited by short construction seasons, especially if a decision is made to deploy in Alaska. A decision to build an X-Band Radar in Alaska, for example, will mean that site construction must begin in the spring of 2001 if we are to attain our goal of having an operational capability in 2005. Because these activities have long lead-times, construction contracts need to be awarded this fall. But before we can even get to this step, will we need a presidential decision and congressional budget authorization to proceed. If we do not have a deployment decision by this fall, our entire deployment schedule will be jeopardized.

After receiving the results of the Deployment Readiness Review, now scheduled for July, and after making his own judgments about the system and related policy issues, the Secretary of Defense will forward a recommendation to the President. That, ladies and gentlemen, is the phased deployment decision process, and as you can see, the July DRR is only an initiating part of that process.

Now, what about our NMD test program? We have had a very encouraging start in this multiyear series of tests that continue through eventual deployment. Initially, we had two fly-by tests to demonstrate the sensor performance of two different kill-vehicles. These were followed by two integrated flight tests to support the DRR decision process.

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Last October's test, Integrated Flight Test Three, demonstrated the ability of the kill vehicle to travel thousands of miles to a very specific location in space - one ultimately defined by inches and microseconds - discriminate among several objects, identify the right target, divert towards it, and collide into it at a closing velocity of over 15,000 miles an hour. We did that very well. We did not do it "by accident." The flash of light captured by our infrared sensors punctuated the technical complexity of this achievement. In spite of what some critics might say, we accomplished all of our test objectives in that flight, which aimed entirely at demonstrating the EKV technology. We now know our interceptor concept works - it worked the very first time we tried - a fact that has helped to build our confidence that we can maintain our aggressive schedule.

Much attention has been given to last January's Integrated Flight Test Four. IFT-4, just our second test, showed that, despite the success in IFT-3, that success won't always happen. But remember, IFT-4 was one in a long-line of increasingly demanding testing events we have planned through 2005. While many have called that flight test a failure, this is not an accurate characterization.

Viewed in a mission context, we failed in IFT-4 to hit the target - we missed the RV. However, in the context of testing, IFT-4 was a successful developmental test that proved we could integrate our separate major elements and make them work together as one system. The major elements of the architecture we tested were: the early warning satellite constellation and tracking radar system, the X-band radar prototype, and the battle management system. Together, they brought the kill vehicle within striking distance of its intended target - the EKV deployed, conducted its navigational star shots, acquired and diverted for the target cluster.

In the final six seconds, we had a malfunction in our interceptor sensor system that prevented us from colliding with the target. We've since learned that we had an obstruction in the EKV's krypton cooling system. We've taken the necessary corrective actions, both on the equipment and in our processes, to mitigate against a recurrence in our next and all subsequent tests. Everything we did in IFT-4, except the intercept part, we did perfectly. And because we did it near perfectly, we actually had to do very little else in the integration and command and control part of our test in order to prepare for IFT-5. As a result of the fixes we have had to make, we postponed by two months the next integrated flight test, IFT-5, to June 26. There are two key points to take away from this. First, our accelerated NMD schedule does not mean we are "rushing." If we were rushing, I would have stuck to our original test date. Second, everything that failed on IFT-4 worked on IFT-3. We believe we have a solid EKV design, and that we will not have to go back and review the fundamental science of our hit-to-kill vehicle.

As I said earlier, the NMD system is one of the most complex systems our country has ever attempted to develop and produce. The interception phase of the NMD mission is clearly the most visible phase and it is key to our success. Yet we must not lose sight of the fact that the successful integration of the highly interdependent system elements is no less critical. The integration and support aspects of our testing events are transparent to most people, but I assure you that we could not do the job without them. Our tests are designed to weed out flaws. While we strive for success on every test, we do not expect that we will always have it. We learn from our successes and failures - and, often, we learn more from the failures.

The country has accepted the higher level of risk associated with the compressed NMD development and deployment schedules in order to complete the program on time. As someone who has had a lot of acquisition experience, it would be nice to move ahead with a program that allowed me to do development testing and production sequentially, rather than concurrently. But I assure, we do not have that luxury with this program.

Now, I will have failed in my discussion with you this morning if I have not driven home the following point concerning the NMD program - that is that the program is driving the decision-making process - and not the other way around. I have the very challenging job of balancing the technical requirements of this program with other requirements, including the requirement to deploy a system to meet the projected threat

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to our homeland.

So we are compelled to work the NMD program concurrently. We are making good progress against the schedule we must work, which is geared to deploy an initial capability by 2005. The DRR will start the process of committing to the NMD system, but there are many things to be evaluated along the way. Our test program is good. And we can always use more data. I believe we are where we want to be. Thank you.

3. Will the Deployment Decision be a Deployment Decision?

The complex mix of political and technical uncertainties surrounding a deployment decision may explain why President Clinton may not take a firm decision regarding the deployment of the NMD system in September 2000, or will at least avoid any decision that would lead to an immediate crisis over the ABM Treaty. According to a number of sources, the Administration is looking a legal options for moving ahead in some aspects of deployment without taking the kind of decision that will fully commit the US to a long-term program.

It may also explain why Dr. Jacques Gansler explained in some detail that a deployment decision might note be a deployment decision in a briefing on June 20, 2000:[42]

There are basically four major decisions that will be made. The last one is the easiest one; that simply says the system is ready. That's the one in which you say, "I have 20 interceptors. I'm ready to go." It's these three that are the major decision points in the development process, the first of which, the so-called Deployment Readiness Review, is the one that is scheduled this year. That one is the one that—the secretary of Defense will then make a recommendation to the president as to whether or not we have done the technical demonstration adequate to show that in fact you could, if you decide to do so, make a fiscal-year '05 impact.

Between the time the secretary makes his recommendation and the president makes his decision, in the fall of this year, there is some time period there for the decision-making process. I'll come back in a minute and tell you exactly what this commits us to, in terms of that radar on Shemya that I mentioned earlier. But the primary things that have to be done at this time, if you want to make a 2005 schedule, is you have to select the site, authorize site construction for the radar in Shemya, start to do the design and then the build of it. And I'll show you the schedule of that in a minute. And there are a few early long-lead parts that we might want to order at that point.

The second key point in terms of the decision process is next year, when again to make the 2005 schedule, you have to actually start the building of the radars and the communications. They become the second long-lead item. And you will authorize some long-lead parts then for the interceptors, which are the third major decision. This is the decision at which you actually commit the interceptors. And in terms of the typical program, this is when you say, "I am going to build my weapons." This is the decision that actually gets made in 2003. That's the real decision, in terms of commitment, to building weapons.

So here you commit to construction of the radar at Shemya, the X-band radar. Here you commit to the other radar upgrades and the communication systems and the building of the radar or the X-band radar. And here you commit to the actual interceptor builds. And then, as I said earlier, to the IOC.

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> Now, there are a series of flight tests that are planned all the way through this program. These are the two that I told you about—this 1 and 1(a) -- and two that I told you about for the seeker calibration against the sophisticated targets. This is the one where we hit the target. This is the one where we tested the rest of the system and—the last five seconds didn't work—and then this is the one that's coming up right now. These will give you the indication of the technical feasibility for this decision point.
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> Then there are a series of additional flights. This Flight No. 8 is critical because it is the place in which we are going to first be testing that next-generation booster that I mentioned, the booster that we have planned for the production. So it's important that that booster be tested before you have this next decision. It's a milestone point.
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> And then the third one here is the point at which you actually make your decision to release for the interceptors. And here you'd like to be using the production design interceptor. Now, the interceptor functionally is the same for the ones we're testing right now as for the one that will be built in production. But as you know, when you go from engineering to production, you do a lot of quality changes, process changes, and you want to make sure that the production—the interceptor, in this case the kill vehicle, is the final proven design. And so that will determine this. This "DAB," by the way, is Defense Acquisition Board. This is the review board that I chair that makes the recommendations to the secretary what we do next.
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> So as you can see, then we—during this process, we are adding increasing sophistication to the decoys and to the system to counter those decoys as the system evolves.
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> There's also a series of test flights that we have that are not intercept flights but are actually putting up additional decoys and additional demonstrations on the target side just to try to check out the radars, check out a lot of the rest of the system. These are risk-reduction flights…. There's a whole series of those, in fact, that have been going on and that will continue. We had one not long ago where we had actually 22 different objects in space to test out the radar for its discrimination capabilities. That's the sort of thing that I was thinking of in terms of improving our discrimination capability.

As is often the case, the broad polarized rhetoric of the NMD debate often conceals more than it reveals and is filled with artificial deadlines. It does not take much reading between the lines to see that the Department may do what it has to do to adjust the deployment schedule to make NMD work in spite of artificial deadlines and Congressional mandates.

As a result, politically-driven arguments that exaggerate the pace of the threat, and demand that the US either rush a deployment decision, or rush the development program,, may well serious damage or block US efforts to develop and deploy an effective NMD system It is clear from the US government reports that there are critical questions about the value of a deployment review that is supposed to take place as early as July 2000 and whether a valid Presidential decision to deploy could possibly be made as early as October 2000. Such a decision would have to "bet on the come," regardless of the success of any tests during 2000. It would also potentially force the NMD program into a deployment schedule that would be unrealistic in

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terms of technical risks, systems integration, cost, and scheduling.

In contrast, deferring a deployment schedule until the next President takes office, stepping up the test and evaluation program, recasting the deployment effort to suit technical progress rather than the calendar, and accepting the need to use some form of at least limited deployment to develop a mature system offers a much higher chance of success.

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[1] DoD News Briefing, Dr. Jacques Gansler, Undersecretary for Acquisition, Technology & Logistics and Lieutenant General Ronald Kadish, Director, BMDO, "Special Briefing Regarding the National Missile Defense Program," June 20, 2000

[2] New York Times, June 30, 2000, p. A-10.

[3] General Accounting Office, "National Missile Defense: Even With Increased Funding Technical and Schedule Risks are High," GAO/NSIAD-98-153, June 1998. Also see National Missile Defense: Schedule and Technical Risks Represent Significant Development Challenges (GAO/NSIAD-98-28, December 12, 1997.

[4] Institute for Defense Analyses, Report of the Panel on Reducing Risk in Ballistic Missile Defense Flight Test Programs, February 27, 1998.

[5] The quotes are taken from "Report of the Panel on Reducing Risk in Ballistic Missile Defense Flight Test Programs, Final Report, February 27, 1998, www.fas.org/spp/starwars/program/welch/welch-1.htm. The data on updates are taken from The Washington Post, June 18, 2000, p. A-1, and New York Times, June 21, 2000, p. A-10.

[6] Taken from "Report of the Panel on Reducing Risk in Ballistic Missile Defense Flight Test Programs, Final Report, February 27, 1998, www.fas.org/spp/starwars/program/welch/welch-1.htm.

[7] Washington Post, July 7, 2000, p. A-1; New York Times, July 8, 2000, p. A-1.

[8] See William J. Broad, "Missile Contractor Doctored Tests, Ex-Employee Charges," New York Times, March 7, 2000, pp. A-1 and A-19.

[9] Based on the Department of Defense release of the executive summary of the report on June 20, 2000.

[10] The Washington Post, June 18, 2000, p. A-1, and New York Times, June 21, 2000, p. A-10.

[11] DoD News Briefing, Dr. Jacques Gansler, Undersecretary for Acquisition, Technology & Logistics and Lieutenant General Ronald Kadish, Director, BMDO, "Special Briefing Regarding the National Missile Defense Program," Tuesday, June 20, 2000.

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[13] "Proliferation News," January 20, 2000; ABC News, January 20, 2000; New York Times, January 19, 2000, January 20, 2000; Washington Post, January 17, 2000, January 20, 2000, February 8, 2000; News Briefing by the Office of the Assistant Secretary of Defense, Public Affairs, January `9, 2000, 15:34 PM.

[14] News Briefing by the Office of the Assistant Secretary of Defense, Public Affairs, January `9, 2000, 15:34 PM; Washington Post, January 17, 2000, January 20, 2000, February 8, 2000.

[15] New York Times. February 15, 2000, p. A-23 and Washington Post, February 15, 2000. P. A-4

[16] Phillp E. Coyle III, Director of Operational Test and Evaluation, Department of Defense, Annual Report for FY1999, Section VI, February 2000.

[17] Washington Post, March 21, 2000, p. A-8.

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[19] Statement of Lieutenant General Ronald T. Kadish, USAF, Director, Ballistic Missile Defense Organization, to the Senate Appropriations Committee, Defense Subcommittee,, April 12, 2000

[20] DoD News Briefing, Dr. Jacques Gansler, Undersecretary for Acquisition, Technology & Logistics and Lieutenant General Ronald Kadish, Director, BMDO, "Special Briefing Regarding the National Missile Defense Program," June 20, 2000.

[21] Reuters, July 7, 2000,

[22] DoD News Briefing, July 7, 2000

[23] DoD press release, Number 393-00, July 8, 2000.

[24] DoD News Briefing , July 8, 2000 - 1:37 a.m. EDT.

[25] Congressional Budget Office (CBO), "Budgetary Implications of National Missile Defense," April 2000, pp. 6-10.

[26] Congressional Budget Office (CBO), "Budgetary Implications of National Missile Defense," April 2000, pp. 15-22.

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

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[29] See Andrew M. Sessler and others, "Countermeasures: A Technical Evaluation of the Operational Effectiveness of the Planned US National Missile Defense System, Union of Concerned Scientists/MIT Security Studies Program, April 2000; and Stephen W. Young, "Pushing the Limits: The Decision on National Missile Defense," Coalition to Reduce Nuclear Dangers/Council for a Livable World Education Fund, April 2000.
[30] See Andrew M. Sessler and others, "Countermeasures: A Technical Evaluation of the Operational Effectiveness of the Planned US National Missile Defense System, Union of Concerned Scientists/MIT Security Studies Program, pp. xxii.
[31] See Andrew M. Sessler and others, "Countermeasures: A Technical Evaluation of the Operational Effectiveness of the Planned US National Missile Defense System, Union of Concerned Scientists/MIT Security Studies Program, pp. xxi-xxii.
[32] See Andrew M. Sessler and others, "Countermeasures: A Technical Evaluation of the Operational Effectiveness of the Planned US National Missile Defense System, Union of Concerned Scientists/MIT Security Studies Program, pp. xxii.
[33] See Andrew M. Sessler and others, "Countermeasures: A Technical Evaluation of the Operational Effectiveness of the Planned US National Missile Defense System, Union of Concerned Scientists/MIT Security Studies Program, pp. xxiii.
[34] New York Times, June 9, 2000, pp. A-1 and A-22.
[35],Lt Gen Ronald Kadish, USAF, Director, Ballistic Missile Defense Organization, "U.S. National Missile Defense, Looking Past the Headlines," address to the Year 2000 Multinational BMD Conference, Philadelphia, PA, June 5, 2000.
[36] DoD News Briefing, Dr. Jacques Gansler, Undersecretary for Acquisition, Technology & Logistics and Lieutenant General Ronald Kadish, Director, BMDO, "Special Briefing Regarding the National Missile Defense Program," June 20, 2000.
[37] DoD News Briefing, July 7, 2000
[38] Based on the Department of Defense release of the executive summary of the report on June 20, 2000.
[39] See the Federation of American Scientists web site discussion of "Targets and Decoy," www.fas.org.
[40] Lt Gen Ronald Kadish, USAF, Director, Ballistic Missile Defense Organization, "U.S. National Missile Defense, Looking Past the Headlines," address to the Year 2000 Multinational BMD Conference, Philadelphia, PA, June 5, 2000.
[41] Lt Gen Ronald Kadish, USAF, Director, Ballistic Missile Defense Organization, Address to the Congressional Breakfast Series, sponsored byNational Defense University/National Defense Industrial Association March 30, 2000, Capitol Hill Club
[42] DoD News Briefing, Dr. Jacques Gansler, Undersecretary for Acquisition, Technology & Logistics and Lieutenant General Ronald Kadish, Director, BMDO, "Special Briefing Regarding the National Missile Defense Program," June 20, 2000.

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