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Before the House Subcommittee on National Security, Veterans Affairs, and International Relations Committee on Government Reform

September 8, 2000

Good morning. Mr. Chairman and Members of the Committee, it is my pleasure to appear before you today to highlight the progress we have made and address challenges we face in our National Missile Defense program. I have said all along that our optimism with respect to this high-risk program must be tempered by realism. The goals we have set are demanding, and this is part of the reason we have not hit the mark in all of the areas where we expected to make progress. Nonetheless, Mr. Chairman, it is also true that, despite the many constraints we face, the progress we have made over the last two years has been remarkable. This morning I would like to describe briefly the NMD program and speak to a few of the more significant challenges we face.

The NMD Program in Historical Context

The charter of the Ballistic Missile Defense Organization (BMDO) is to develop, demonstrate, and deploy when directed a system to defend all fifty states against a limited attack involving intercontinental ballistic missiles (ICBMs) with unsophisticated countermeasures launched by states of concern, such as North Korea, Iran, and Iraq. The most recent National Intelligence Estimate provides no indication that this threat has diminished. In response to Congressional and Administration direction, we are aggressively pursuing the development of the system, and we will achieve operational status as soon as directed to do so.

The NMD program is on an admittedly high-risk schedule. It has been compared with the urgent programs to deploy our nation's first nuclear ICBM force. But the goal of fielding a complex system within a short time frame is not unprecedented.

On average it took 4 3/4 years for the Poseidon, Polaris, Trident I and II SLBM programs and the Minuteman I, II, and III ICBM programs to field a capability–that is from the engineering, manufacturing and development stage to achievement of initial operational capability (IOC). While the proposed NMD system is in some ways more complex than those listed above, each of the programs I cited had its own significant technical and schedule challenges to meet.

In other words, our goal of defending the entire country against an emerging threat by developing an NMD system on an aggressive acquisition schedule does not represent a radical divergence from the way we have procured some major weapon systems critical to national security. Moreover, most development programs have problems associated with them, especially when they are set up in order to pioneer the introduction of a new military capability. As a rule, we expect problems to emerge during developmental testing. It is not unusual for such problems to cause test failures. The Atlas ICBM program experienced 12 failures in its 2 1/2 year flight-testing history. And the Minuteman 1 program suffered 10 failures in a 3 1/2 year testing program.

Our national space programs also have experienced critical problems that have caused many in this country to raise serious concerns about our ability to access space. Indeed, a series of launch mishaps occurred in the 1980s and 1990s involving several of America's operational space launch vehicles. Between 1984 and 1987, catastrophic failures and mission-ending glitches in our Atlas, Titan, Delta, and Space Shuttle launchers destroyed or rendered useless critical satellite payloads for enhancing national communications, intelligence-gathering, and weather-monitoring missions. The tragic loss of the Challenger and its crew in 1986 caused the entire shuttle fleet to be grounded for many months thereafter. Indeed, for much of 1986, as a result of these failures, the United States lost its ability to place heavy objects in orbit.

A similar string of failures in recent years reminded us that launching rockets and missiles remains a challenging and risky business. The years 1998 and 1999 were not good years for the Titan force. A Titan IVA exploded shortly after launch in August 1998, destroying a critical national payload. A malfunction in its upper stage in April 1999 caused a Titan IVB to place a DSP satellite in the wrong orbit. Later that same month, another failure in a Titan IVB upper stage put a Milstar satellite in a useless orbit. The Delta 3, which was attempting its first successful launch, failed twice. This most recent series of space launch mishaps in old and new launch systems destroyed or rendered useless billions of dollars in intelligence, early warning, and communications satellites.

From my point of view, the once-secret Corona program is very instructive in this regard. The managers of one of our earliest space programs had to survive 12 failures and mishaps (and a partially successful mission to recover the first object from space) before they orbited this country's first operational reconnaissance satellite (Discoverer 14). I find some of the parallels between Corona and our NMD program to be particularly striking. Among other things, booster development was in its infancy, and today, although we have come a long way, building reliable boosters for our missile programs continues to be a challenge.

Other engineering and integration challenges in the Corona program included: designing a technologically unproven satellite payload and marrying it with a booster; launching a multistage rocket and separating from the payload in space; achieving an orbit appropriate for the mission; operating and orienting optical sensors for maximum effectiveness over the operational lifetime of the satellite; sending telemetry for the successful capture of the film capsule by the recovery aircraft; and protecting the film capsule from reentry to return undamaged film to Earth for processing and analysis.

Through it all, program support by our national leadership persisted despite frustrations resulting from these technical difficulties, and as a result, this national priority program made profound contributions to our security. In fact, despite difficult technical problems, all of the programs I mentioned worked very aggressive schedules and went on to produce reliable and effective systems, and follow-on systems, that have served the nation well for decades. The point is that birthing a revolutionary system and making it useful is a tough engineering job that requires discipline, patience, and vision, and to expect all development activities to be successful is unrealistic given the history of such endeavors.

NMD Development Challenges

Our current plan is to develop an initial system, consisting of 20 interceptors, as soon as possible. This threshold system will be expanded to meet the evolving threat. Within two years of achieving IOC, we plan to expand the system to include 100 ground-based interceptors (GBIs) based in Alaska. We refer to this more capable system as the Expanded Capability 1, or Expanded C1. The initial C1 architecture will incorporate upgrades to the five existing ballistic missile early warning radars and an advanced X-Band Radar (XBR) based in Shemya, Alaska. The NMD system will use the Space Based Infrared System (SBIRS) High, which eventually will replace the existing Defense Support Program satellite constellation to detect initial launch.

The legacy of technologies employed in the NMD system can be traced back at least to the 1980s. Development of our ground-based sensor elements, namely the X-Band Radar (XBR) and the Upgraded Early Warning Radars (UEWRs), in fact may be traced back to the development of the Ballistic Missile Early Warning System (BMEWS) in the 1960s. Non-nuclear ground-based interceptor technologies owe a great deal to the successes we had in the 1984 Homing Overlay Experiment, the Exoatmospheric Reentry Interceptor System (ERIS) program, and the current Patriot Advanced Capability-3 (PAC-3) and Theater High Altitude Area Defense (THAAD) programs. Space-based sensors for early warning have a program history dating back to the Defense Support Program begun in the early 1970s. We also have capitalized on subsequent space-based sensor development programs, so that today we look forward to the deployment of very powerful Space-Based Infrared Systems (High and Low). Similarly, our battle management and advanced information processing and handling capabilities have a legacy running back to the late 1980s.

In other words, we are not awaiting some technological breakthrough in order to proceed with NMD system development. The technologies we are using in our elements–our sensors, interceptors, and BM/C3–are not what make this a high-risk program. Rather, it is our short development schedule that compels us to work with so much risk. High risk means that a significant failure or delay in one element of the system will not allow me to maintain the current schedule. The technical challenge before us has more to do with "system integration" than it does with "technology development." The key development challenge, therefore, is to design and test a system that integrates all of the elements into a reliable system of systems on an aggressive schedule.

NMD Test Program

One of the critical challenges the NMD program faces is ensuring that adequate testing takes place within the schedule in order to provide the data and confidence in technology to support acquisition decisions. Each program milestone must be preceded by key performance milestones, which will be measured in our test and evaluation activities.

The NMD program has a multifaceted and comprehensive element and system test program that extends out through Initial Operational Test and Evaluation. This test program will demonstrate the ability of the elements to operate as an integrated system. It includes numerous integrated flight and ground tests, several risk reduction flights, software and hardware-in-the-loop tests, and many other ground tests and simulation exercises. Most of our testing activities will continue to take place "off center stage," by which I mean that these activities tend to receive much less public attention than our intercept flight tests. Notwithstanding their relatively low profile, these other testing activities provide us with critical development information that gives us confidence that we are proceeding nearly as we had intended in our overall program.

A key component in the final review for initial operational capability will be the assessment of the independent operational test agencies as to the operational effectiveness and suitability of the system. A decision to declare the NMD system operationally capable will not occur without adequate testing and assessment. Naturally, because the testing program is an integral part of our acquisition plans, further significant slips in the testing program would be expected to have an impact on the overall schedule.

This past June, before our last integrated flight test, the NMD Independent Review Team (IRT), chartered by the Secretary of Defense and led by retired Air Force General Larry Welch, finished another thorough review of the NMD development program. The IRT identified a number of challenges associated with it but concluded that, given the adjustments to the schedule that have been made, "the technical capability to develop and field the limited system to meet the defined C1 threat is available." It also expressed concern about the continued high-risk schedule. The team noted with some concern that the flight test restrictions on trajectories, impact areas, and debris in space restrict our ability to test overall system performance limits. I would like to run through a few of the challenges cited by the IRT and a few others that I believe are significant.

While the NMD testing program has experienced delays in development and testing, ground and flight tests to date have demonstrated about 93% of the system's critical engagement functions and shown the ability to integrate the system elements. We had planned to be at about 94% by this stage, so we are very nearly where we expected to be.

We have made good progress. The elements that are the system's "eyes," "nerve network," and "brain" continue to perform at or above expectations. Our major element sensors, or "eyes," which include the existing Defense Support Program satellites (scheduled to be replaced by SBIRS High), provide early warning data and cue the ground-based radars. In all of our tests to date, DSP satellites have provided the necessary alerts to begin the engagement process. The ground-based radars also have performed within design parameters. The EWR has shown repeatedly its ability to acquire and classify the targets, and the prototype XBR (GBR-P) has demonstrated remarkable detection accuracy and sensitivity.

Communications are managed by a complex Battle Management Command, Control, and Communications (BM/C3) system that updates the engagement plan every 10 seconds. The BM/C3 system, the system's "brain" and the core of a "nerve network" that reaches out to all of the elements, passes data and commands throughout the system and meets our human-in-control requirements. It also has met expectations. An additional element, the In-Flight Interceptor Communications System (IFICS) transmits the target object map to the in-flight Exoatmospheric Kill Vehicle (EKV). During the last integrated flight test, the IFICS sent accurate target updates to the kill vehicle. Given the separation failure in the interceptor, however, we were unable to confirm the EKV's ability to receive and process that data. Our ground tests, however, give us confidence that the IFICS-EKV communications and associated data processing will not pose a significant problem. Finally, based on the successful intercept test last October, we also have confidence that the EKV can discriminate and differentiate the simulated RV from other objects in a simple target cluster and execute internally processed commands to guide itself to the target RV and collide with it. We expect future tests to demonstrate that the EKV is equally effective against more complex target clusters.

IFT-3, a partially integrated intercept test, demonstrated our ability to do hit-to-kill as well as on-board discrimination and target selection. Integrated Flight Tests 4 and 5 were our first integrated system tests, and our second and third hit-to-kill tests. IFT-4, which occurred in January of this year, was partially successful. Although we failed to achieve an intercept, we did test and demonstrate the integrated functionality of the major NMD system elements, the operation and performance of the ground sensors, operation and functionality of the BM/C3 system, and EKV performance up to the last seconds in its flight. The EKV acquired and tracked the RV and decoy but, because of a plumbing failure in the cryogenic cooling system, the infrared sensors lost sight of the target objects. The disabled EKV was unable to intercept the RV.

The most recent intercept test took place on July 7. IFT-5 had the same test objectives and scenario as IFT-4, with one difference. We added the in-flight interceptor communications system element designed to facilitate transmittal of message traffic to the EKV from the battle management system. Following the launch of the target missile from Vandenberg Air Force Base, the EKV, mounted atop a surrogate booster, launched normally out of Kwajalein Missile Range and headed toward the projected intercept area. Because the EKV failed to separate from its booster following second stage burn-out, no interceptor objectives were completed. However, a great deal more data was gathered on the functionality of all of the other elements, including the IFICS, which was able to send information to the boosting EKV.

While the intercept flight tests arguably are the most important tests we can run, mainly because they are most representative of how an operational system would have to perform, they are only one source of the enormous amount of data we have collected. The IFT-4 and 5 test failures that have captured the public eye must be viewed in this context. The important point to take away from these two high-profile failures is that the troubles associated with each were unrelated, meaning that the problems are fixable. The problems we have experienced reflect process problems in basic engineering and fabrication, not underlying flaws in the core NMD technologies or design.

IFT-5 was a disappointment because it did not substantially advance our knowledge of system performance. The test did support what we learned from previous tests and served to validate the integration of the system. For intercept purposes, IFT-5 did not provide us any more information than we would have obtained from any of our risk-reduction flights. Integrated Flight Test 6 will give us the opportunity to do what we had hoped to do this past July. Nevertheless, in the context of our development program, we are one for three in the intercept column. This is not where we expected to be with respect to our flight-tests, but I look at where we are today in this program as a "glass half full," even though the two failed intercept attempts have resulted in disappointment and frustration.

Our Integrated Ground Tests (IGTs) remain critical to our program because they are not subject to flight test restrictions and can run numerous engagement scenarios over the course of a few consecutive weeks. Our ground test capabilities are growing and becoming increasingly representative of NMD production elements as the NMD program matures. The most recent IGTs successfully demonstrated the integration of BM/C3 with the UEWR and XBR and partially succeeded in testing the performance of the C1 architecture against some C1 scenarios.

As I have stated already, this is a high-risk program for the very reason that a significant failure or delay in one element might not allow the program to meet a near-term deployment date. The delays in operational booster production are a cause of some concern and threaten to be that major problem that could significantly impede development progress. While parts of the booster have been used individually in space launchers, they have never been integrated into one system. We are aggressively exploring ways to restructure the NMD program to fix these delays and reduce schedule risk.

As I mentioned earlier, the NMD program executes a series of Risk Reduction Flights in addition to Integrated Flight Tests. These are very significant tests involving all of the elements of the NMD system, except the GBI. Some of these tests are aimed specifically at assessment of the NMD ground-based radars. In these tests, target payloads are launched, and the system elements tested to further prove the design and effectiveness of the system and weed out any problems before we execute the tests involving the EKV. Risk Reduction Flights are essentially rehearsals that strive to stress the sensors in the system well beyond their required capacities for the early intercept tests.

As part of our Risk Reduction Flight program, we also execute what we call Radar Credible Target scenarios, where we use objects that do not have as many data handling devices on them and we place many more objects in the cluster. These flights test the maturity of our X-Band prototype based at Kwajalein as well as the west coast Early Warning Radar. Following the current schedule, we are running on average two to three Risk Reduction Flights per year. Two more such flights are scheduled to take place before the end of FY01.

We also look for other flight opportunities to test the system elements. For example, in FY99 the U.S. Air Force launched two test rockets from facilities on Kodiak Island in Alaska that released multiple objects on a trajectory that ran along the west coast of the United States. We used these launch opportunities to further test the capability of our west coast EWR. We then took that data and ran an analysis as to how the upgraded early warning radar would have responded. In May 2001, the NMD program will launch its own target complex out of Kodiak as one of its Risk Reduction Flights.

Delays in ground-testing and in our primary modeling and simulation tool, the Lead System Integrator Integrated Distributed Simulation (LIDS), need to be fixed. Although no other system can provide all the integration and functionality of LIDS, numerous test beds, hardware-in-the-loop facilities and NMD simulation and tools are available to support our engineering and integration efforts. We have other model and simulation tools, for example, that address the element-level rather than the system level of operation.

Testing Constraints and Operational Realism

Based on the testing guidelines developed within and approved by the Department in 1999 and a recognition that we are still early in the development testing phase, we have demonstrated substantial progress.

The DoD-directed NMD Independent Review Team concluded that confidence in the assessments of the operational effectiveness of the NMD system is impacted by the variety of real-world, fact-of-life test restrictions concerning missile overflight, impact area, and space debris. The result of these restrictions is that we are permitted to test the system in only a limited part of the required operating envelope. These restrictions do not present a problem in the near-term, but we can increase our confidence in the system as we proceed with the program if they are addressed now.

The testing restrictions that we face and the safety concerns we have are tied to the reality that we must demonstrate the planned NMD system on what, in effect, is a global test range. The boundaries of the range we currently use cover more than 4,000 miles and extend in a southwesterly direction from the west coast of the United States out over the Hawaiian islands and across the Pacific ocean, ending in the vicinity of the Kwajalein Atoll, which is located in the Marshall Islands. Within this range, the trajectories of our target missiles fly well over 100 miles in altitude, reaching out and touching the fringe of outer space. The geographic expanses we must work with are enormous, and the speeds at which our target missile and the ground-based interceptor must travel, which are measured in thousands of miles per hour, mean that the engagements we plan take place within a matter of minutes. You can see the challenge that this presents for the tester, who must be able to use existing launch ranges and sensor assets as well as deploy a far-flung network of element prototypes and surrogates to create stressing testing conditions that approximate as closely as possible real-world engagement scenarios.

Yet even this expansive test range is relatively small when compared to the distances and altitudes involved in missile flights towards the United States from, for example, the Middle East. Assuming ground-based interceptors based in Alaska, a Middle Eastern engagement scenario involving a missile heading towards Florida would take place across a geographic expanse that spans roughly half the globe–from Alaska to the Middle East. An intercept at this range, and at even shorter ranges, would take place in Earth orbits that come close to points in space used by many satellites.

Our current policy to minimize space debris, moreover, restricts our tests to lower altitudes and modified trajectories. The debris that could result from a collision at higher altitudes may produce fragments that could remain in orbit for many years. The higher an object is in orbit, the longer it will take for it to reenter. Test results to date show that, with a direct hit, the target would be shattered into very small pieces. Given the sizes of these pieces, they would easily burn up once they reentered the atmosphere, minimizing to some extent the concern about space debris. But during testing we could not guarantee a hit in the "sweet spot" of the target in every instance, and, as a result, larger fragments may persist in orbit. So the concern about space debris resulting from our tests is one of the reasons we must limit our demonstrations of hit-to-kill to lower altitudes. At these lower elevations, any fragments or parts of the EKV or target RV that survive impact would burn up relatively quickly upon reentry into the Earth’s atmosphere.

Given the truncated flight range from Vandenberg Air Force Base on the west coast to Kwajalein, we must restrain our interceptor velocities in order to stay within the bounds of the Kwajalein Missile Range. Added to this are range safety concerns (that is, the safety of ocean vessels and residents in Hawaii and the Marshall Islands), which restrict us to a limited number of trajectories and intercept altitudes and velocities that are on the low end of how we would like to test.

All of these constraints introduce a degree of artificiality into the NMD testing program. In order to strive for greater operational realism, the NMD program constructed a prototype X-Band Radar (the GBR-P within the KMR test range) and uses an EWR surrogate (the FPQ-14, which is an existing range asset located in Hawaii) in order to watch, track, and discriminate the approaching target. The GBR-P radar capability, and its proximity to the interceptor launch site, does not allow it to provide tracking information as early in the flight test as would an operational XBR (the GBR-P location prevents midcourse tracking because the Earth's curvature blocks its view).

Since production-representative hardware is not now available, the NMD program used surrogates and prototypes to support early developmental testing to provide a basis for system functionality assessments. As the elements mature, the prototypes will be upgraded to reflect the production configuration and in some cases, be replaced by the maturing element. The GBR-P will serve as the XBR prototype, receiving software upgrades, and will be replaced by the XBR at Shemya, in the initial system. The BM/C3 is involved in testing today and will continue to receive software up-grades throughout program development. The Ground Based Interceptor is represented today by the Exo-atmospheric Kill Vehicle and Payload Launch Vehicle, but will be replaced by the Ground Based Interceptor in FY02. The DSP satellites represent the SBIRS element, and will continue to do so until SBIRS-High is deployed. The Early Warning Radar and FPQ-14 radar represent the UEWR in testing and the FPQ-14 radar, which is also required for range safety, serves as a source of midcourse target information for Weapon Task Plan formulation.

The use of prototypes and surrogates is common practice during flight tests for most weapon systems and play an important role in early developmental testing. The use of surrogates, however, should not be confused with the need to employ systems that help us to meet range safety requirements. The use of the systems like the FPQ-14 and GPS satellites, in other words, should not be construed to imply that the tests are rigged. In reality, the GPS is used for truth data and as a back-up should ground based radars fail to provide adequate information for Weapons Task Plan development. GPS will continue to be used in this manner as an essential backup system to allow a test to continue should a radar problem occur during a test. As it turned out, we did not need GPS to track the target during IFT-4 and IFT-5--our radars did all of that work.

The FPQ-14 radar is also used for range safety (we do not want to launch a RV without knowing where it is at all times) and post-test analysis as well as a source of mid-course target tracking (i.e., as a UEWR surrogate). We are exploring alternatives to the use of FPQ-14 as a surrogate for an NMD system element. The FPQ-14 radar, however, would remain a necessary part of the range safety architecture.

Other surrogates we must use at this phase in our scheduled tests are the DSP satellites (which will be replaced by the SBIRS-High constellation) and the

Minuteman-derived Payload Launch Vehicle, which will serve our purpose until we bring the production booster on line.

Test range limitations and the use of surrogates are constantly under scrutiny to determine how to maximize our return on the existing investment while leveraging them to meet future operational test requirements. Some testing artificialities will be minimized as the system matures and we introduce production representative elements. It is our goal to incorporate more realistic scenarios, including long-range intercepts and intercepts with greater closing velocities, and we are currently assessing ways to do so. A significant investment in test range infrastructure will be required to achieve tactically representative flight test scenarios. We also are currently developing launch infrastructure at the Kodiak launch facilities in Alaska, which will allow us to fly the target missile towards KMR, which will add additional engagement geometries.

Yet other restrictions on operational realism will never go away. For obvious safety reasons, we do not want to test our system capabilities by launchinig an ICBM towards the United States, nor do we want to test our ability to counter a live nuclear warhead. The fact that we have testing assets out in the Pacific also will mean that we can only launch target missiles in one direction–westward. Our present inability to launch target missiles in the opposite direction restricts our ability to assess the impact the Earth’s rotation might have on the flights of the target missile and GBI.

We also have been criticized for not making our intercept flight tests more realistic with the addition of realistic decoys. But as I will outline below, the NMD test program will become increasingly operationally realistic by 2004. In general terms, our testing approach is to test individual system components, one by one, and then gradually link them for partially-integrated and, later, fully-integrated flight testing. The tests also will become progressively more stressful, involving, among other things, greater discrimination challenges, longer ranges, higher closing speeds, and day and nighttime shots. The results from each test are fed into subsequent tests and models, so that incremental improvements may be made to the elements and the system.

The NMD flight test program is structured to provide targets of increasing threat realism as testing progresses through development testing to operational testing, within range, safety and test asset limitations. The flight test program began with seeker characterization flights. In IFT 1A and 2 we sought to identify the different capabilities of two competing suites of EKV sensors. The Boeing sensor suite flew on IFT-1A and the Raytheon sensor suite, the one we chose to go into our operational system, flew on IFT-2. The testing objectives for these first two flight tests were different from and, in some ways, much simpler than the testing objectives of the integrated flight tests that followed because they tested only how well the two competing sensor suites could see the dummy warhead and countermeasures. Hit-to-kill was not attempted in these first two tests. The NMD team evaluated EKV performance on the basis of their ability to collect target data to validate our discrimination capability.

The target clusters released in space for the first two flight tests contained the reentry vehicle, nine decoys, and the target deployment bus. This significant countermeasures package contained more objects than the countermeasures packages we employed during IFTs-3, 4, and 5 because we wanted to see how well the EKV sensors could discriminate within the target complex and identify the warhead.

We have been criticized for using only a single large balloon in subsequent integrated flight tests. Consistent with our early flight test objectives, we dramatically reduced the number of objects in the target complex because our testing objective in IFTs-3, 4, and 5 changed from one of simply seeing and discriminating among the objects to one of maneuvering at very high speeds and ramming into the warhead's "sweet spot" as well as seeing the objects, discriminating among them, evaluating them, and selecting the warhead instead of the decoy or rocket stage. In other words, we were testing our ability to do hit-to-kill in the last three intercept flight-tests. These tests were not set up to evaluate the ability of the system to discriminate real world countermeasures. The goals in these tests were very different and the challenge (because we were attempting to hit the target RV) was much greater than in the first two tests.

With respect to defeating future likely countermeasures, General Welch's independent panel concluded that, while there is extensive potential with the designed system to grow greater discrimination capabilities, the NMD program needed to test beyond the C1 design discrimination capabilities. We agree and plan a number of tests that go beyond the C1 requirement.

NMD Counter-Countermeasures Capability

Aside from the technical and schedule challenges I have just mentioned, one major area of controversy concerns the NMD system's susceptibility to countermeasures. So I would like to take some time this morning to address the countermeasures problem. Before I begin, though, I would like to emphasize the fact that many of the discrimination technologies and techniques the proposed NMD system relies on cannot be discussed in an open forum. There are legitimate national security concerns about divulging our counter-countermeasure capabilities, so that our objective must continue to be one of preventing access to information by potential adversaries concerning the design specifications of our counter-countermeasures system.

Countermeasures are part of the natural evolution of any military capability. Every weapon system we have today is susceptible to a countermeasure. All weapon systems will be scrutinized by potential adversaries and probed for weaknesses. The NMD program itself represents our attempt to reduce the advantage held by potential foes armed with long-range offensive weapons and is a "countermeasure." So, given that we can expect this kind of interaction today and in the future, we will face countermeasures that will try to confuse the system about the real threatening target. The question is: what do we do about it?

Discrimination, or our ability to find the target in the presence of countermeasures, is a major technical challenge. The ability to discriminate between decoys and RVs has always been a part of our design criteria. Our initial capability will be able to handle simple countermeasures, with significant capability inherent for more sophisticated countermeasures as they present themselves.

We are designing a system that allows each element to gather and share data throughout the engagement in order to enhance discrimination and improve kill probability. We have designed a system of systems that uses more than the kill vehicle to discriminate among countermeasures. Major advances in focal plane array technology and computer processing allow us to deploy extremely sensitive "eyes" in space and on the ground. Space-based infrared sensors would detect and project a tracking path and monitor such things as booster burnout, which might help identify the type of missile. Information from Defense Support Program satellites, and later Space Based Infrared System "High" satellites, will be handed over to the ground-based radars. EWRs would acquire and classify the target complex. The discrimination capability of EWRs would be refined over the length of time that it viewed the target cluster, helping to distinguish and do initial characterization of objects.

The cluster is then tracked and information handed over to the XBR or the in-flight EKV. The XBR would discriminate using a variety of techniques to determine, in some cases very precisely, the number, characteristics, and movements of objects in the cluster. By way of illustrating a portion of its capability, the XBR will be powerful enough to distinguish a golf ball 2,400 miles away, or the distance between Washington, D.C. and Seattle.

Using increasingly fast, small, and powerful computers, the NMD battle-management system processes large volumes of data in order to integrate operations, sort through and prioritize tracking and cueing information, and control multiple intercepts. Using refined data fed to it by ground sensors and the command center, the EKV acquires the target cluster, and further discriminates and characterizes the objects using IR and optical sensors. Once the EKV's internal processing unit identifies the target, it uses this information to set up a collision course with the target object. Using its sensors and other advanced hit-to-kill technologies (including advanced thrusters), the EKV refines its path to the target and rams into the RV, destroying both itself and the target.

What this means is that the baseline NMD discrimination toolbox can do precise measurements using multi-frequency, multi-aspect composite discrimination. With the addition of the SBIRS-Low satellite constellation, a capability to view payload deployment would be added, providing dual-phenomenology, multi-aspect SBIRS-radar composite discrimination, for an even greater advantage against states of concern. It is important to understand the countermeasures released in the midcourse part of the trajectory will not just instantaneously appear to confront the on-coming EKV. The NMD system of sensors is capable of "watching" a missile and the deployment of its payload, including countermeasures, from the early stages of flight through the terminal phase.

I am confident that countermeasures initially deployed by states of concern will not be sophisticated enough to fool all of the discrimination capabilities employed by the planned NMD system. Each of the elements contributes uniquely to the discrimination mission using various measures and extrapolating additional information derived from physical principles (e.g., launch trajectories), which can then be processed on the ground and by the EKV. What might fool a XBR might not, for example, fool the planned UEWRs, SBIRS-Low, or the EKV. The system is redundant and synergistic, so that the total capability is greater than the sum of the parts. This synergy among the elements should be expected to improve as the system evolves by upgrading software and hardware, increasing the number of existing elements, and augmenting the system using additional platforms in other geographic environments.

In April of this year, critics from the Union of Concerned Scientists released a widely publicized and frequently cited report on the susceptibility of the NMD system to even the simplest countermeasures. I have read the report carefully and I am impressed with the scientific effort put forth. But as in any scientific analysis, you must look very carefully at the underlying assumptions. I believe the report's conclusions are based on assumptions that tilt in favor of the offense and against the defensive system we are developing. I do not believe the report gives proper credit to the capabilities of the proposed NMD system, nor does it take into account that our discrimination and lethality capabilities will evolve as the threat matures.

Indeed, the report's conclusions are based on assumptions that would indicate more 'knowledge' than anyone--even I--have regarding the capability of the more far-term "C3" NMD system, a system for which we do not yet have finalized plans. Moreover, I also believe these critics base their conclusion on erroneous assumptions about the threat, that they grossly overestimate the countermeasure capabilities of countries like North Korea, Iran, and Iraq yet minimize our ability to respond. Nevertheless, we have been and are continue to solve the countermeasures challenge, both in terms of gaining a better understanding of what potential adversaries would actually be able to do and evaluating our system's ability to handle them.

The technical and operational challenges facing potential adversaries are several. If an attacker were to have any confidence in the operational effectiveness of his countermeasure package, that attacker would have to have access to NMD technology and understand the concept of operations. The critical defense functions that need to be overcome include: detection; track and aimpoint prediction; discrimination; acquisition; homing; intercept; and kill assessments. The attacker, after all, has the difficult task of assessing and responding to BMD systems designed specifically to counter his threat.

Unless they purchase more sophisticated ICBMs, states of concern will have to go through an evolution in the development of their missile systems. There are significant challenges in designing and building the booster, integrating guidance, navigation, and control, and engineering the RV. All of these elements then have to be integrated into the whole system. The development of warheads is especially difficult, mainly because of the challenges posed by atmospheric reentry and the requirement to use technologies not commercially available.

Add to this the challenge of employing effective countermeasures. Countermeasures, unless purchased, must be engineered and built. They must be deployed and positioned among the missile forces to be effective. They must be configured to work properly in space or the atmosphere depending on the missile's range. Developing an effective, reliable countermeasure requires a great deal of time and testing, not only to ensure robust performance, but to verify that the countermeasure has not inadvertently degraded the performance of the missile, the deployment process of the reentry vehicle, or other countermeasures. But most countries do not have test ranges, not to mention a network of sensors to measure results. If the attacker desires to reach some level of perfection in the construction and use of his countermeasures, he would not be capable of testing the chosen countermeasures without revealing telltale characteristics to the NMD system. And even if states of concern get past the development and deployment steps, it is not automatically true that they can use them and use them effectively.

Different phases of development will accommodate the introduction of different types of countermeasures. In the earliest phases of missile development, a state would have limited spacing on its warhead bus to accommodate the payload and the countermeasures. The added payload weight of countermeasures would reduce the missile's range capabilities. Thus, a potential adversary would face a difficult decision as to whether to accept the additional technical risk and give up a portion of the missile's throw-weight to add countermeasures with unknown effectiveness, side effects, and reliability. The absence of a capability to put several warheads or constructed decoys on a bus would mean that it might not be possible for the state of concern to launch much more than small lightweight decoys, such as balloons, together with the payload.

The chemical weapon early release submunitions highlighted in the Union of Concerned Scientists' report are expected to present the NMD system with more targets than it could handle. But even free-flying submunitions pose engineering, dispersal, and lethality hurdles that we must not assume states of concern will overcome with ease. The weights of the reentry heat shields, fusing, and dispersal mechanism may be expected to severely restrict the available volume and weight for chemical agents. The agents in early release submunitions also will have to survive atmospheric reentry.

For submunitions carrying chemical agent to be effective, however, they must have a sufficiently dense distribution within the impact area. To accomplish this, they need to be released from the missile at a relatively low altitude above the target. In that case, a mid-course defense could kill the incoming RV prior to the release of submunitions. However, if released early in the missile's trajectory, in the ascent phase, for example, the submunitions would disperse over a wide area and might not achieve the lethal concentration levels required near the target. Therefore an aggressor employing submunitions would be faced with the choice of delaying release and leaving the missile vulnerable to intercept or employing early release submunitions that would have reduced effectiveness. If our defense forced a state of concern to adopt submunitions, we would have succeeded in preventing that state from using nuclear weapons, which cannot be deployed in this way.

If the attacker is going to succeed using erected or inflated decoys, there are other engineering considerations. Once they are released and erected or inflated in space (bearing in mind that emerging missile states do not yet have a capability to launch multiple RVs on a single bus), these decoys must maintain their RV-like characteristics throughout their mid-course flight so that they would look the same to the many sensors employed by the NMD system.

Conversely, the adversary could attempt to hide RV-like characteristics by enveloping the warhead in a balloon (to mask or simulate a false target), but he must hide those characteristics reliably and throughout the duration of flight. The complexity of surrounding an RV with a balloon and having it mimic decoy balloons is a technically challenging operation. The adversary also would have the challenge of having the decoy balloons mimic the balloon carrying the RV.

Similarly, the "cooled shroud," posited by the Union of Concerned Scientists to be a "simple" countermeasure, would present daunting engineering and integration challenges. The concept behind this countermeasure is that it would circulate a cryogenic fluid around the RV within a hollow shroud so that the RV could escape detection by infrared sensors. Yet even if the technical hurdles associated with designing and employing this rather sophisticated countermeasure could be overcome, it would be ineffective against NMD radar and optical sensors, which are designed to gather and refine information on the target throughout the course of its flight and pass information on the target's characteristics and location through the IFICS to the EKV up until just moments before impact.

Many ground and flight tests and numerous modeling and simulation exercises have been conducted by the United States and its allies to learn about the effectiveness of the full range of penetration aids, a practice that has helped us to understand the current counter-countermeasures challenge. In the 1970s and 1980s, the United Kingdom took more than ten years and spent around $2 billion to modify their submarine-launched strategic missile system to include countermeasures, and they had to use U.S. ranges to test it. The British were able to do a lot of ground testing of countermeasures, but in fact there was no alternative to testing their system on U.S. ranges. The flight- and ground-testing and experimentation accomplished over several years has filled in many knowledge gaps and provided the designers of BMD systems some level of confidence in the effectiveness of their systems, including the sensors that gather the information, the software algorithms that categorize and prioritize it, and to the computational power required to make required comparisons in near-real-time.

The experience of the United States with BMD countermeasures, including balloon-encased RVs, submunitions, and cooled shrouds, is extensive and several decades old. Extensive experience tells us that these things, purposefully altering characteristics in space so as to fool different sensor types, are not easily done by states like North Korea, Iran, and Iraq. U.S. flight-testing has uncovered weaknesses in many simple and more sophisticated countermeasures. Many objects designed to be countermeasures cannot be relied on to act as RVs would act, even in the near vacuum of space. At a more basic level, just because a countermeasure is "simple" does not mean it is simple to engineer or employ.

Moreover, it is also important to observe that ICBM forces among states of concern likely will not likely grow to be very large over the next ten years. Emerging missile states, therefore, will lack the missile inventory that is needed to saturate or suppress our proposed 100-interceptor NMD system, which could launch salvoes of interceptors to engage attacking missiles and any unresolved target objects.

Of course, many robust countermeasures to the NMD system may be possible (and still many more can be imagined on a blackboard), but estimates are that, if they were available, they probably would not be used effectively by states of concern within the timeframes under consideration. Advances in sophistication in missile development, and therefore in countermeasures capability, require experience in applied science, engineering and implementation as well as access to testing ranges and the necessary sensors, computers, and software.

In my view, credible, sophisticated countermeasures are costly and difficult to develop and make effective against this design, whereas simple, cheap attempts can be readily countered by the NMD system. Given our extensive toolbox and the forty years of experience the United States has with offensive and defensive weapon systems, we know how to play the countermeasure/counter-countermeasure game. And we know how to win.

Summary

To summarize, Mr. Chairman, it is important to understand the entire context of our development and testing programs in assessing the progress in NMD technology development and the impact of the test failures we have experienced on our program schedule. We will continue to test our NMD system based upon the disciplined, proven, and scientific methods learned over more than four decades of missile development, deployment, and operations. There is no technical reason at this point, validated by independent review teams, indicating that we could not develop an effective NMD system.

We have a tough engineering job before us, but we do not believe we need technological inventions to make it work. The technologies we require are in hand. Our critics still think that we are dabbling in science and they cannot let go of the unfounded idea that what we are attempting to engineer is a "Star Wars" missile defense system to take on the major nuclear powers of this world. But, in fact, this is a real but limited program with a firm grounding in science and engineering. We can develop and eventually deploy a real capability, a capability we do not presently have, against a very real and growing ballistic missile threat.

Some critics also have challenged the integrity of this program, implying that we will cheat in our testing program. Yet the NMD program is unique for the amount of attention and intense scrutiny it receives daily. The very scrutiny that the program has received, still receives, and will continue to receive, may be its surest way to ensure we are doing the right things. Daily attention from the American people, the Executive and Legislative branches of government, U.S. industry, and independent analysts, together with the sheer numbers of good, honest, and hard-working people inside the program representing various and independent public and private entities, help ensure the integrity of the information we use to affirm our system engineering approach.

The fact is, Mr. Chairman, many people, thousands of people, have worked diligently on this program and remain dedicated to developing this country’s first operational national missile defense system. To be sure, the failures we have had in our flight-test program to date have been a bitter disappointment to us all. We all would have hoped for more at this stage. Yet we should not lightly dismiss the significant progress we have made. I believe that we can all be confident in the prospect that the hard work and diligence that has brought us this far, together with the engineering ingenuity and scientific know-how displayed time and time again by the people of this country, will enable us to achieve this historic goal.

Thank you, Mr. Chairman. I would be happy to answer any questions you and the members of the committee might have.