Union of Concerned Scientists
Working Paper

An Assessment of the Intercept Test Program of the Ground-Based Midcourse National Missile Defense System

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30 November 2001

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Contents

Introduction 1

I. The First Four Intercept Tests: A Status Report 3

II. Use of the C-Band Beacon 10

III. A Closer Look at the First Five Intercept Tests: Limits and Artificialities 14

IV. Requirements for More Realistic Testing 19

Executive Summary

In this working paper we examine the first four intercept tests of the ground-based midcourse national missile defense system being developed by the United States, as well as plans for the fifth test. We pay particular attention to the controversial role that the C-band beacon on the warhead played in the recent tests.

The most basic of all the functions that the missile defense system must perform is "hit-to-kill"—the kill vehicle must be able to maneuver to intercept the mock warhead at high closing speeds. But while the past intercept tests have demonstrated hit-to-kill, they have not done so under conditions that are operationally realistic.

We find that the current test program is still in its infancy, and that the United States remains years away from having enough information to make an informed decision on the deployment of even a limited nationwide missile defense system.

Following the previous intercept test in July 2001, which was successful, some missile defense supporters argued that this test demonstrated that the technology was ready to be deployed. It is therefore important to put the current test program in the proper context by describing its limitations and artificialities. While these limitations may be appropriate for a program at this early stage of development, they mean that the tests say little about the ability of the system to operate under realistic conditions.

All four of the previous intercept tests have been essentially repeats of one another, but with additional components included in the later tests. In each case, the trajectories of the target missile and of the interceptor missile were the same, the target complex deployed was the same, the intercept point was the same, and the test took place at the same time of day. The upcoming test will be a repeat of the previous one.

One of the key tasks that a defense system will have to perform is to distinguish the warhead from decoys and other objects. The tests have included a balloon decoy as well as a mock warhead, and the system has been credited with successfully discriminating the warhead. However, the physical appearances of the objects used in the tests have been very different from one another as measured by the various defense sensors. Moreover, in all cases, the defense has been given *a priori* information about the expected appearance of the different objects in advance of the test, an advantage the United States is unlikely to have in a real attack. Thus, the intercept tests reveal very little about the discrimination capabilities of the system.

As a result, it is clear that the tests to date and the upcoming test are mainly focused on the "endgame" of the full intercept process—on whether the kill vehicle can successfully home on a target that it can readily identify (or has been identified for it).

But an examination of the tests shows that even this goal has not been met. Hit-to-kill has been demonstrated, but not under conditions that are operationally relevant.

One of the most relevant parameters for exo-atmospheric hit-to-kill is the closing speed between the kill vehicle and the target. Despite this, the intercepts have all occurred at closing speeds that are much lower—by up to a factor of two—than would be expected for an operational system. This artificiality is compounded by a second one: based on data sent by the C-band beacon or GPS receiver on the mock warhead, the kill vehicles have been launched on a trajectory that is headed essentially straight at the mock warhead. As a result, the kill vehicle does not have to maneuver much to home on the mock warhead and intercept it. In a real attack, the kill vehicle might need to maneuver far more to home on the target, especially if the defense radars had not succeeded in discriminating the warhead from the other objects.

The primary reason for the artificially low closing speeds is that all these tests have used a two-stage surrogate booster in place of the planned three-stage booster for the interceptor. The development of the booster has fallen behind schedule, and is not expected to be ready for use in the intercept tests until at least a year from now. However, it is not clear why BMDO has chosen to use a two-stage surrogate booster rather than a faster three-stage booster. A three-stage booster is used to launch the mock warhead in the tests.

In addition to using a three-stage booster to launch the kill vehicle, the Bush administration should take several other steps to make the test program more realistic and its results more meaningful. These include testing against more realistic decoys and other countermeasures, conducting tests in which the defense does not have full *a priori* knowledge about the test conditions, and testing under a much wider range of conditions. All of these measures can be implemented within the Anti-Ballistic Missile (ABM) Treaty, which permits the ground-based midcourse system to be fully tested.

The report concludes by considering the planned test program, in which 20 more intercept tests are scheduled by the end of 2006, for a total of 24 development tests. Even if this ambitious schedule can be met, operational testing would not begin until 2007. Because initial operational testing would need to be concluded prior to making a well-informed deployment decision, the United States will not be in a position to make a deployment decision about the ground-based midcourse system until 2008 at the earliest.

Introduction

The missile defense system that was being developed by the Clinton administration used ground-based interceptors to deliver a kill vehicle that would operate above the atmosphere, attempting to intercept incoming warheads during the midcourse phase of an attacking missile's flight.

While the Bush administration has talked about developing a considerably more extensive defense system involving several different layers and technologies, the core of the Bush program is a modified version of the Clinton system. This technology, now called the ground-based midcourse segment, is receiving the vast majority of the funding for long-range missile defense and is the system being tested in the current intercept tests. This report therefore focuses on the testing program for this midcourse system.

The individual tests in the testing program are labeled by an IFT number, which stands for Integrated Flight Test. The first two tests, IFT-1A and 2, were "fly-by" tests intended largely to test the sensors on the kill vehicle; these did not involve an attempt to intercept the mock warhead. The intercept tests began with IFT-3. To date, four such intercept tests have taken place, two of which have resulted in intercepts.

The Ballistic Missile Defense Organization (BMDO) has stated that the fifth intercept test, IFT-7, which is currently scheduled for 1 December 2001, will be a repeat of the previous test, which occurred in July. The reason BMDO has given for repeating the test is to increase its confidence in the operation of the system.

However, if the previous test was successful it seems surprising that the upcoming test would not be varied in some way. It is possible that this indicates that despite the successful intercept in the previous test (IFT-6), there were more serious problems with the test than have been acknowledged. Circumstantial support for this position comes from the fact that that the X-band radar is known to have had a software problem and stopped recording track data 64 seconds prior to intercept,[1] and from the fact that BMDO delayed the upcoming test for a month to allow modifications to the kill vehicle.[2]

On the other hand, some missile defense supporters have claimed that the success of the recent intercept test means that the technology is ready to deploy. For example, after the test Senate Minority Leader Trent Lott said, "They hit a bullet with a bullet, and it does work. We can develop that capability." A background paper by the Heritage Foundation stated that the successful intercept in IFT-6 "… provides undeniable evidence that a defense against the present and growing threat of ballistic missiles is technologically possible."[3]

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[1] Press briefing on IFT-6, Maj. Gen. Willie Nance, Program Executive Officer for the Ground-Based Missile Defense Segment, Ballistic Missile Defense Organization, 9 August 2001. The text of the briefing is available at http://www.defenselink.mil/news/Aug2001/t08092001_t809bmdo.html and the briefing slides are available at http://www.defenselink.mil/news/Aug2001/g010809-D-6570C.html

[2] Kerry Gilea, "Raytheon Alters Kill Vehicle for Next NMD Test," *Defense Daily*, 5 October 2001.

[3] Jack Spencer, "Moving Forward on Missile Defense," Heritage Foundation Backgrounder No. 1461, 20 July 2001.

Given such claims, it is important to put the current testing program in context.

Below we review the past and upcoming intercept tests, discuss their limitations, and show that the current test series reveals little about whether the technology is ready for deployment. We then discuss the most important steps needed to make the testing more realistic so that the United States will have the information needed to make a sound deployment decision about the ground-based midcourse defense system.

I. The First Four Intercept Tests: A Status Report

We begin with a brief description of how the system components would operate during a real attack. We then describe how the intercept tests have been conducted, and discuss some details of each test. In Section III, we analyze some of the more relevant artificialities of the past and upcoming intercept tests, and discuss their implications for the test program.

The Anatomy of an Intercept Engagement

If a long-range missile were launched at the United States, US early-warning satellites, which use infrared sensors to detect the hot plume of a missile in boost phase, would provide the initial notification of the target launch. Data from the satellites would then be provided to a nearby early-warning radar, which would track the missile after its boost phase.

After boost phase, the missile would release its warhead and any decoys it carried. These objects, along with any debris generated in this process and the deployment bus if one was used, constitute the "target cluster."

The track data collected by the early-warning radar early in the trajectory of the target cluster would be used to predict its future trajectory and calculate an estimate of the location in space where the intercept would occur. In some cases, this information would then be used to formulate the "weapons task plan," which specifies when and where the interceptor(s) should be launched to deliver the kill vehicle to the right point in space at the right time. (If there is an X-band radar in the proper location, track data from this radar might be used to generate the weapons task plan.)

The track information from the early warning radar would also be used to cue the X-band radar, that is, to give the radar an approximate location of the target cluster so that it knows where to search. By concentrating its search in a small region of space, the radar is able to detect the target cluster at much longer distances than would otherwise be possible. Once the radar acquired the target cluster it would begin tracking the objects with high accuracy, refining the estimate of each object's future trajectory. The radar would attempt to determine which object was the warhead.

At the appropriate time, one or more interceptors would be launched. A few minutes after the interceptor was launched, it would release its kill vehicle. The kill vehicle would first perform one or more "star sightings" to allow it to precisely determine its orientation: it would position itself so its visible sensors could observe the stars and then compare its observations to a star map stored in its on-board computer.

While in flight, the kill vehicle would receive updates on its position as well as the target position (called IFTUs, for In-Flight Trajectory Updates) from the X-band radar, via the nearest In-flight Interceptor Communications System (IFICS) ground station. To receive these updates, the kill vehicle is designed so that it must orient itself with its antenna facing toward the IFICS transmitter on the ground; once the kill vehicle orients itself to detect the warhead with its onboard infrared sensors, its cannot receive updates from any ground-based sensors and must operate on its own.

Once it was close enough to the target cluster, the kill vehicle would detect the target cluster with its on-board infrared sensors, attempt to determine which object was the mock warhead, and then maneuver to collide with it.

The Anatomy of an Intercept Test

The only site where the United States currently launches interceptors against long-range target missiles is the Kwajalein Test Range, located on Kwajalein atoll in the Marshall Islands.[4] In addition to an interceptor launch site, this facility includes an X-band radar, which is a one-third-scale prototype of the battle-management Ground-Based Radar (GBR) that is the key sensor to be used in the missile defense system. A prototype battle management center and an IFICS ground station, which is used to communicate between the battle management system and the interceptor, are also located on Kwajalein. In addition, the facility includes numerous sensors and computers that are used to observe and collect information on the tests.

In the four intercept tests of the midcourse system conducted to date, a three-stage target missile carrying a mock warhead was fired toward the Kwajalein test facility from Vandenberg Air Force Base in California, some 7,500 kilometers away. The missile then released the bus, which in turn released the mock warhead and a spherical balloon. These three objects, along with any debris, form the target cluster in the tests.

All four of the previous intercept tests have been essentially repeats of one another, but with additional components of a potential system included in each test. We describe each of these tests in detail below (also see Table 1).

IFT-3

The first intercept test, IFT-3, was originally scheduled for June 1999, but was postponed several times, reportedly due to a series of problems with the prototype exo-atmospheric kill vehicle. The test finally took place on October 2.

This test was only designed to examine the endgame performance of the kill vehicle and did not include the other components that would be part of a defense system. To make up for this lack of radar and sensor data, however, the mock warhead broadcast its location during the first parts of its flight. As BMDO noted in its fact sheet on the test, "Since this was primarily a test to evaluate KV [kill vehicle] technology, it was necessary to ensure the target missile and the target complex were placed into the proper positions in space."[5] Thus, a Global Positioning System (GPS) receiver was placed on the mock warhead along with a backup C-band radar beacon, both of which sent the precise location of the warhead to ground control.

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[4] This site was recently renamed the Ronald Reagan Ballistic Missile Defense Test Site, or Reagan Test Site (RTS) for short.

[5] Available at http://www.acq.osd.mil/bmdo/bmdolink/pdf/jn9910.pdf

Table 1. Intercept Tests

Intercept Test #	IFT#	Date	Intercept?	Weapons task plan generated using info from	Components Tested	Problems during test
1	3	2 Oct 1999	Yes	GPS receiver on warhead	KV	Wrong star map Balloon acted as a beacon rather than decoy
2	4	18 Jan 2000	No	GPS receiver on warhead	KV, GBR-P, BM/C3	IR sensors on KV failed due to blocked cooling line
3	5	8 July 2000	No	C-band beacon on warhead	KV, GBR-P, BM/C3, IFICS	KV failed to separate from booster
4	6	14 July 2001	Yes	C-band beacon on warhead	KV, GBR-P, BM/C3, IFICS	GBR-P computer overwhelmed
5	7	Dec 2001?		C-band beacon on warhead	KV, GBR-P, BM/C3, IFICS	

KV = kill vehicle
GBR-P = prototype ground-based radar
BM/C3 = battle management/command, control, and communications
IFICS = in-flight interceptor communications system

The target flew a pre-programmed flight path. Since the interceptor did not receive target information from the ground-based radars via the command and control center, it also flew to a pre-programmed position, where it received the warhead location information from ground control, downloaded it to a computer in the kill vehicle, and then released the kill vehicle. At that point, the kill vehicle was several hundred miles from the warhead.

As the Pentagon first acknowledged in January 2000, anomalies in the test led to the kill vehicle initially being unable to find the mock warhead. Because of a malfunctioning Inertial Measurement Unit (IMU) the kill vehicle was unable to orient itself properly and as a result the target cluster was not initially in the field of view of the kill vehicle's infrared sensors. Eventually, the kill vehicle located and began to home on the bright balloon decoy that was included in the test. However, the balloon and warhead were close enough together that the warhead then appeared in the field of view of the kill vehicle, which was then able to home on and intercept the warhead. According to a report by the Pentagon's Director of Operational Testing and Evaluation, the kill vehicle probably would have acquired the deployment bus and subsequently the warhead even if the balloon had not been present.[6]

During this intercept test, the Kwajalein X-band radar and the battle management and command, control, and communications (BM/C3) system participated in a parallel

[6] Director, Operational Test and Evaluation (DOTE), *Report in Support of National Missile Defense Deployment Readiness Review*, 10 August 2000, p. 26, available at http://www.insidedefense.com/secure/defplus/dplus_sam_reader.asp?FN=dpix_4_013.ask&docnum=dplus2001_1908

"shadow" test. US early warning satellites and radars tracked the target and sent data to the command center, but did not provide any information to the interceptor or kill vehicle.

In particular, as part of the shadow test, after target launch the early warning satellites and the early warning radar at Beale AFB, California detected the missile launch, tracked, identified, and designated the mock warhead, and then transmitted the tracking data via the main BM/C3 center in Colorado[7] to the BM/C3 station on Kwajalein. Using this data, the Kwajalein BM/C3 planned the engagement, cued the Kwajalein X-band radar, and sent simulated launch instructions to the interceptor. After the kill vehicle separated from the interceptor booster, the Kwajalein BM/C3 provided simulated target updates to the kill vehicle based on the X-band radar tracking data. The X-band radar also monitored the intercept and provided kill assessment data to the BM/C3.

IFT-4

The second intercept test, IFT-4, took place on January 18, 2000. In design, IFT-4 was identical to IFT-3, including the timing, flight path, velocities, and target set. However, it incorporated more components of the system directly into the test, including the Defense Support Program early warning satellites, the prototype ground-based radar on Kwajalein, and the battle-management system in Colorado. In fact, every system element or a surrogate participated except for the IFICS.[8]

These early tests are designed to provide the kill vehicle information on the position of the mock warhead, and not just of the target cluster. There is currently no radar that can provide such data early enough in the test.[9]

For this reason, in the first four intercept tests (IFT-3 through IFT-6), the track data used to formulate the "weapons task plan," which specifies where and when to launch the interceptor, has instead been simulated. In each case, the warhead has carried a GPS receiver as well as a C-band beacon that allowed a C-band radar on Hawaii to track it. In this test, as in IFT-3, the GPS receiver was the primary source of track data on the warhead.[10]

The track information from the GPS receiver was used to generate the weapons task plan, and to cue the X-band radar on Kwajalein. The interceptor was launched toward a predicted intercept point based on the weapons task plan. After burnout it released the kill vehicle, which then performed a star sighting, as it would during a real attack.

[7] The command center is located at Schriever (formerly Falcon) Air Force Base.
[8] During this test, IFICS operated in a shadow mode since the kill vehicle did not carry a receiver. Despite the lack of IFICS participation, BMDO classified this test as a full system—or end-to-end—test. This is significant because, during the Clinton administration, BMDO established one successful intercept during a full system test as a prerequisite before construction of any system could begin. One successful intercept during *any* system test—which was achieved in IFT-3—was required before a decision to begin construction (as distinct from actual construction) could be made.
[9] DOT&E Report, 10 August 2000, p.17.
[10]BMDO fact sheet on IFT-4 says that the warhead was tracked by the C-band radar, but that the data "did not meet quality requirements" and was not used in the test (this fact sheet is available at: http://www.acq.osd.mil/bmdo/bmdolink/pdf/124.pdf

This time, the star sighting reportedly went smoothly and the kill vehicle oriented itself to detect the mock warhead. However, a failure of the two infrared sensors on the kill vehicle caused it to miss the mock warhead, reportedly by a distance of 100 feet. The miss was attributed to a failure to cool the infrared sensors down to their operating temperatures because of an obstructed cooling line.[11]

IFT-5

In IFT-5, which took place on July 8, 2000, the IFICS ground-based relay station was to be used for the first time to provide target updates to the kill vehicle. However, the test did not progress to the point at which the IFICS could be used.

As in previous tests, the early warning satellites detected the target launch. The bus released the mock warhead and balloon decoy, but the decoy failed to inflate properly.

In this test the C-band beacon—rather than the GPS receiver—served as the primary source of track data.

The C-band beacon is tracked by the FPQ-14 C-band radar located at Kaena Point, Oahu, Hawaii.[12] The beacon on the warhead may be needed since the C-band radar may not have sufficient power to detect and track an object with the radar cross-section of the warhead effectively on its own. It may also have been added with the goal of ensuring that the use of the C-band radar did not violate the Anti-Ballistic Missile (ABM) Treaty. The use of the C-band beacon has been controversial;[13] we discuss this issue in more detail in Section II.

The track information from the C-band radar was used to generate the weapons task plan, and to cue the X-band radar on Kwajalein.

The third intercept test failed when the kill vehicle did not separate from the interceptor booster, dooming the test before it had the chance to attempt an intercept.

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[11] DOTE report, 10 August 2000, p. 27.

[12] Radars are typically classified by the frequency of the radar waves they use. US early-warning radars operate at 420-450 MHz in the "ultra high frequency" (UHF) band and have a corresponding wavelength of roughly 0.7 meters. The FPQ-14 C-band radar on Hawaii is a mechanically steered radar with an antenna diameter of 29 feet, which operates in the range 5.4 to 5.9 GHz, and has a wavelength of roughly 5 centimeters (see L. Parker, J. Watson, J. Stephenson, "Baseline Assessment, Western Space and Missile Center," (RTI/4028/01-02F), July 1989). The X-band radars that are planned to act as the battle-management radars for the missile defense system operate at a frequency of 10 GHz and have a wavelength of roughly 3 centimeters. The smaller the wavelength of the radar waves, the greater the accuracy with which the radar can determine the location of an object, and the better its ability to distinguish details on an object and thus to distinguish between different objects. An X-band radar would have a somewhat higher resolution than a C-band radar, and an early-warning radar would have a considerably lower resolution than either an X-band or C-band radar.

[13] John Donnelly, "In Anti-Missile Test, Target Signaled Its Location," *Defense Week*, 30 July 2001; Joe Conason, "The Rigged Missile Defense Test," Salon. com, 31 July 2001, available at http://www.salon.com/news/col/cona/2001/07/31/test/index.html

IFT-6
After months of delays, the fourth intercept test took place on July 14, 2001 and resulted in a successful intercept of the mock warhead.

As in the previous test, the C-band beacon served as the primary source of track data, which was used to generate the weapons task plan and cue the X-band radar on Kwajalein.

A few minutes after the interceptor was launched, it released the kill vehicle, which successfully performed two star sightings. In this test, for the first time, the kill vehicle received updates on the target position from the X-band radar, via the IFICS ground station on Kwajalein.

Once it was close enough to the target cluster, the kill vehicle reportedly detected the target cluster with its on-board infrared sensors, determined which object was the mock warhead, and then maneuvered to collide with it.

A detailed timeline of the sequence of events that took place during the fourth intercept test (IFT-6), and will take place in the fifth intercept test (IFT-7) if it proceeds as planned, is given in Table 2.

One "anomaly," as the Pentagon describes it, did occur in the test. The ground-based X-band radar on Kwajalein stopped storing data in the last stages of the test. According to the Pentagon, the last objective for the radar was to switch its track from the mock warhead to the kill vehicle and report if it hit, and so test the radar's ability to perform kill assessment. According to the Pentagon, about 64 seconds before intercept a software problem locked up a database in the object track file for the radar. That lock-up prevented the radar from following any more tracks, and thus from tracking the kill vehicle.[14] The radar apparently became overwhelmed with data when it switched to track the kill vehicle.[15] Prior to that point, however, the radar had reportedly detected the objects in the target complex, discriminated the mock warhead, and transmitted that information to the kill vehicle via the IFICS.

[14] Nance press briefing, 9 August 2001.
[15] Peter Pae, "Crucial Radar Failed Missile Defense Test," *Los Angeles Times*, 18 July 2001; James Dao, "Missile Interception Test Was Hit-and-Miss, Pentagon Reports," *New York* Times, 19 July 2001.

Table 2. The sequence of events that took place during intercept test #4 (IFT-6)
(Source: Nance press briefing, 9 August 2001)

Time (Minutes: Seconds)	Event
0	Launch of target missile from Vandenberg
< 0:35	Missile booster detected by US early warning satellite
0:59	Missile detected by early warning radar in Beale, CA
1:49	Early warning satellite sends a quick alert message based on tracking the booster, and predicting its future trajectory.
3:00	Booster of target missile burns out
4:46	"Human in Control" gives authority to intercept missile; after this time the defense system operates autonomously
7:30	Target complex fully deployed (balloon decoy and mock warhead, accompanied by deployment bus)
11:38	FPQ-14 radar on Hawaii sends target information to battle management system on Kwajalein
16:53	X-band radar on Kwajalein detects target complex
18:28	X-band radar on Kwajalein detects mock warhead
21:34	Interceptor booster launched based on data from the FPQ-14 radar on Hawaii
24:11	Kill vehicle separates from booster
24:19	Kill vehicle performs 1st star sighting to orient itself
25:03	Kill vehicle receives 1st in-flight target update (IFTU) via IFICS
26:49	Kill vehicle performs 2nd star sighting to orient itself
27:30	Kill vehicle receives 2nd in-flight target update (IFTU) via IFICS
28:08	Kill vehicle acquires target complex
29:11	Kill vehicle discriminates mock warhead and maneuvers to impact target
29:42	Kill vehicle intercepts target

II. Use of the C-Band Beacon

As described in Section I, in the previous two intercept tests (IFT-5 and IFT-6), the C-band beacon attached to the mock warhead was the defense system's primary source of track data on the warhead early in its flight. This data was used to generate a weapons task plan and to calculate an approximate intercept point in space, and then to launch the interceptor toward the estimated intercept point. The beacon will also be the primary source of this track data in the upcoming intercept test, IFT-7, and is expected to be used in this way over the next year, until the battle-management software is upgraded to allow the defense to use track data from the early warning radar at Beale, CA.

In an operational system, track data on the trajectory of the warhead and target suite relatively early in flight would be provided by one of the sensors of the system—an early warning radar or an X-band radar if it was deployed far enough forward to get early track data. BMDO has argued that the beacon is a necessary artificiality at this point in the testing program to compensate for the lack of an X-band radar in the proper location in the current tests.[16]

In IFT-6, the beacon apparently provided the defense with very high quality tracking information on the warhead. (Note that since the beacon is attached to the mock warhead, it provides the location of the warhead itself rather than just the location of a basket containing the target cluster.)

In particular, the distance between the actual intercept point in IFT-6 and the estimated intercept point the defense calculated based on the beacon data and used to launch the interceptor, was apparently only 400 meters.[17]

The fact that the beacon data allowed the battle management system to predict the intercept point (which is the future location of the warhead) to within 400 meters means the defense knew the location of the warhead with an uncertainty that is considerably smaller than the separation distance between the warhead and the other objects in the target cluster.[18] This allowed the defense to launch the interceptor on a trajectory that was aimed essentially directly at the warhead, rather than toward a larger basket that included the full target cluster.

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[16] In addition, BMDO officials have stated that the information from the beacon is important as a backup so that the test can proceed even if the radars fail, and is needed for monitoring the test and providing accurate "truth data"—that is, providing accurate information about the actual trajectory of the warhead—that can be used to assess the performance of the system afterwards (Nance briefing, 9 August 2001).

[17] Private communication, October 2001.

[18] A BMDO briefing slide on IFT-6 shows that 30 seconds before intercept the warhead was separated from the balloon decoy and bus by 5.6 and 1.8 kilometers, respectively, and that the distance between the balloon and the bus was 7.2 kilometers (Nance press briefing, 9 August 2001). Since these distances would have increased linearly with time after deployment, one can estimate the separation at earlier times in the flight. A second briefing slide also included an image of the target cluster from the kill vehicle's sensor. Based on the actual separation of the objects at 30 seconds before intercept, one can calculate by what distances the objects were separated in the plane of observation of the kill vehicle's sensor, which is the apparent separation distance observed by the kill vehicle. The separation distances, as seen by the kill vehicle, are roughly 0.9 to 1.1 kilometers (Ted Postol, personal communication, October 2001).

The test thus assumed that the defense knew the location of the warhead within the target cluster before it launched the interceptor. This situation is relevant to the case in which the X-band radar has discriminated the warhead before the kill vehicle is launched. While BMDO clearly hopes to discriminate the warhead as early as possible, this may or may not be the case in an operational situation.

There are several ways in which the defense might need to operate, depending on the track data available on the target cluster and the warhead. Accordingly, the defense system is apparently being designed with several potential scenarios in mind. Among these are scenarios in which the weapons task plan is developed (and therefore the interceptor is launched) using (1) track data on the warhead, which assumes the X-band radar has discriminated the warhead, (2) track data on the target cluster but not the individual warhead, which assumes the X-band radar has not succeeded in discriminating the warhead, and (3) track data on the missile booster from the early warning satellites, which assumes that track data from the early warning and X-band radars is not available.[19]

The previous intercept test, IFT-6, thus falls into the first scenario. Apparently so will the intercept tests for the next year, as we discuss below.

However, the timeline for IFT-6 (see Table 2 in Section I) raises a question about the use of the beacon: why was the interceptor launched based on tracking information from the beacon, rather than from the ground-based X-band radar on Kwajalein?

At the time the interceptor was launched (at 21 minutes and 34 seconds into the test), the Kwajalein radar had been tracking the objects in the target cluster for more than four and a half minutes and had been tracking the mock warhead itself for over three minutes. Why, then, was the interceptor launched using information from a surrogate component (the C-band radar) when detailed track information should have been available from the prototype GBR?

The fact that the interceptor launch was not based on GBR data may indicate that the weapons task plan must be produced more than three minutes before it can be used to launch the interceptor, which would have been before the GBR had discriminated the warhead. One question is why the weapons task plan would have to be issued this long prior to the launch of the interceptor.[20]

Alternately, the use of the beacon data may indicate a problem with the GBR, or lack of trust in the GBR data. It would be interesting to understand this issue, and whether BMDO plans to continue to launch the interceptor using beacon data as long as the beacon is being used in the tests, or to plans to begin using data from the X-band radar to construct the weapons task plan.

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[19] DOTE report, 10 August 2000, p. 17.

[20] This appears to be consistent with the timeline for the early intercept tests given in the 10 August 2000 DOTE report, which seems to indicate that the weapons task plan was issued about three and a half minutes prior to interceptor launch (p. 18, Figure IV-1).

Using high quality beacon data to launch the interceptor may be appropriate at this stage in the testing program, but it has several implications for what can be learned about the endgame from these tests.

First, the test conditions that have been used so far represent the least stressing case for the defense. Since the kill vehicle was apparently launched on a trajectory that headed it essentially straight toward the target, the kill vehicle needed only minor, if any, course updates from the ground-based radar, and the total maneuvering required of the kill vehicle to hit the target was small compared to what might be expected in an operational scenario. In particular, in cases in which defense had not discriminated the warhead from the target cluster by the time the interceptor was launched, the kill vehicle would be launched toward a basket containing the full target cluster, which could easily be tens of kilometers in size, and homing would require a considerably greater level of maneuvering than is demonstrated in the current tests.

Even if the test assumes that the X-band radar successfully discriminates the warhead, it still matters how accurate the beacon data is and when that information is made available to the kill vehicle. It is not publicly known how the quality of the tracking data supplied by the beacon compares to tracking data that would be expected from the X-band radar in an operational situation, nor when in the engagement the tracking data would be expected to be available to the kill vehicle. If highly accurate data was supplied at interceptor launch—as it was in IFT-6—rather than at the final in-flight update, the kill vehicle would be required to do much less maneuvering.[21]

A second implication is that the warhead location data provided prior to interceptor launch was accurate enough that the kill vehicle would have known where to point its sensors to place the warhead in the sensor's field-of-view when it turned them on, even without any in-flight updates from the X-band radar.[22] In IFT-6, the kill vehicle reportedly began acquiring the target at a distance of 700 kilometers; at this range, the field-of-view of the kill vehicle's sensors would have been about 12 kilometers across (assuming a one degree field-of-view), which is considerably larger than the roughly 400 meter uncertainty to which the kill vehicle apparently knew the warhead's position.

We again note that this artificiality may be justified at this early stage in the development process if the tests are intended to test the homing process under conditions that do not stress the system. However, such tests should not be construed as demonstrating the capability of the system under operational conditions, which could be considerably more demanding.

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[21] In IFT-6, interceptor launch occurred eight minutes before intercept, while the final IFTU occurred only two minutes before intercept.

[22] This assumes that the kill vehicle knew its own orientation in space, which it was apparently able to determine successfully using the star sightings. In IFT-3, while the interceptor was launched on high quality GPS data, the warhead did not initially appear in the kill vehicle's field-of-view. But this is because the malfunctioning IMU in that case resulted in the kill vehicle not knowing its own orientation.

It appears that the beacon will be used in intercept tests for another year. BMDO officials have stated that an additional reason the beacon is required at this point in the testing program is that the current version of the battle-management software can only use data on single objects, not cluster data on the full target cluster.[23] Apparently the Beale radar can only provide cluster data; as discussed above, it is unclear why such object data is not available from the X-band radar. The beacon is therefore needed to supply object data to the battle-management software.

BMDO has stated that within about a year, when its software has been improved to handle cluster tracks, the C-band beacon will no longer be used, and the system will instead use cluster track data provided by the Beale early warning radar in California. Once this change is made, then the cluster track of the full target cluster will be used to form the weapons task plan that is used to launch the interceptor toward the cluster.[24] Since the target cluster could be many kilometers across, this would require a considerably greater level of maneuverability by the kill vehicle than has been demonstrated in tests so far, and than apparently will be demonstrated for the next year.

[23] Nance briefing, 9 August 2001.
[24] Nance briefing, 9 August 2001.

III. A Closer Look at the First Five Intercept Tests: Limits and Artificialities

In this section we consider the current tests in some detail to understand what they reveal about the state of the technology of the missile defense system that is being developed. As with any development program at an early stage, these tests are necessarily scripted and somewhat artificial. It is necessary to examine these artificialities to evaluate what has actually been demonstrated in the tests so far, and to assess what measures should be taken to make future tests more realistic.

As we discuss in more detail below, the artificialities fall into three general categories. First, there has been essentially no variation in the engagement conditions or target complex in these tests. Second, the scenario that is being used in these tests does not allow for realistic testing of the discrimination capabilities of the defense. Third, while these tests remain basically tests of the kill vehicle performance in the end game, even the endgame is not conducted under operationally-realistic conditions.

Lack of Variation in Tests

As described in the previous section, the past intercept tests have essentially been repeats of one another, with additional components added as the test proceeded. The upcoming test (IFT-7) will be identical to the most recent one (IFT-6). There are several ways in which the tests are identical:

<u>Identical Test Geometries</u>

The same test geometry has been used in all of the past intercept tests, and will be used again in IFT-7. The trajectories of the target and interceptor missiles, as well as the planned intercept point have been identical, and will again be the same for the upcoming test. In each test, a target missile carrying a mock warhead was fired from Vandenberg Air Force Base in California toward the Kwajalein test facility in the Marshall Islands, 7,500 kilometers away. Some 20 minutes later, the interceptor was launched from the Kwajalein atoll and released the kill vehicle, which traveled north to an intercept point roughly 700 kilometers from Kwajalein and at an altitude of 230 kilometers.

The intercept altitude of 230 kilometers has reportedly been chosen to minimize the spread of debris on the ground and in space. However, to intercept warheads in their midcourse, an operational system must be able to intercept at altitudes above 1000 kilometers, and BMDO has stated that its goal is to eventually intercept at altitudes as low as 130 kilometers.

<u>Same Objects in Target Cluster</u>

The objects released by the target missile have been the same in each test. They consist of a mock warhead, which is conical in shape, and a "decoy" balloon, which is spherical.[25]

[25] The mock reentry vehicle is roughly 1.8 meters in height and has a based diameter of roughly 0.75 meters. The balloon in the first three intercept tests had a diameter of 2.2 meters; the fourth test used a new balloon with a diameter of 1.7 meters. The change in balloon diameter is not significant.

The bus that releases the warhead and balloon is also part of the target cluster. The same three objects will be used in the upcoming test.

Same Time of Day

All of the previous tests have been conducted at essentially the same time of day—with the planned intercept occurring 2 to 4 hours before local sunset at Kwajalein. This means that the sun is in a similar location for each test, and illuminates the mock warhead and other objects from behind the kill vehicle. As a result, the illumination of the objects is very similar in each test and the kill vehicle is approaching the objects with the sun to its back. The upcoming test is also scheduled to occur at this time of day.

The time of day at which the test occurs is relevant in part because the infrared signature of an object in space depends strongly on the whether the object is in sunlight or the earth's shadow (at night), and for how long it is in sunlight.

At this early stage of the testing process, repeating tests under the same test conditions may well be justified since it is important to be sure all the components are working as intended before moving on to test under different conditions. However, the fact that the upcoming test (IFT-7) will be a repeat of the previous test underscores the fact that the system is still in the very early stages of development testing.

Moreover, since these early tests are being conducted under identical conditions, it is important to understand exactly what is being tested in this one configuration. Are the different components of the system being used in realistic ways? Are the different tasks the system will need to perform being realistically tested? We examine these issues next.

Ability to Discriminate Not Realistically Tested

One of the key functions the defense system would need to perform in a real attack is to discriminate the warhead from other objects—including decoys, and debris from the bus or final stage of the booster that may be inadvertently or deliberately created during deployment of the warhead and decoys. There are several aspects of the discrimination function that need to be tested and demonstrated. These include: the ability of the defense sensors to measure various characteristics of the objects in the target cluster (e.g., radar cross section, physical shape, and infrared signature); the ability of the battle management system to use the radar measurements to discriminate the warhead from the other objects under different conditions (both when the battle management system has advance intelligence information about the appearance of the objects, and when it does not); and the ability of the kill vehicle to discriminate the warhead from the other objects under different conditions (when the kill vehicle receives discrimination information from the radars and when it does not, and when the defense does and does not have advance information about the appearance of the objects).

As we discuss below, many of these aspects have not been tested in the intercept tests.

Mock Warhead and Decoy Have Very Different Characteristics

The Pentagon has stated that the mock warhead and balloon decoy look very different from one another to the missile defense sensors. In particular, it has stated that the balloon appears much brighter (i.e., it has a stronger infrared signature) to the kill vehicle than does the warhead. Moreover, the X-band radar should have little difficulty in distinguishing the different shapes and radar cross sections of these two objects.

In contrast, a real attack should be expected to involve decoys that more closely resemble a warhead, or warheads whose appearance has been disguised and decoys that appear similar to the disguised warhead. BMDO apparently assumes that certain signatures will correspond to either a warhead or a decoy. According to BMDO's Nance, the defense will "…use physics-based information about objects…" and "…will recognize that there are certain features that are associated with certain objects…"[26] In fact, there is no reason to assume that either the warhead or decoys will have certain unique characteristics that can be determined by the sensors.[27]

Detailed *A Priori* Information

Not only has the appearance of the warhead been significantly different from the other objects in these tests, but the defense system has been told what to look for. The defense is given detailed information in advance on the anticipated appearance (i.e., the radar and infrared signatures) of the warhead and other objects. The defense then matches the measured signatures to the expected signatures. As a result, these tests do not assess the ability of the defense to discriminate the warhead from other objects under conditions in which it does not have this *a priori* information.

The importance of this *a priori* information to the performance of the defense during these intercept tests is underscored by the reaction of BMDO Director Kadish during IFT-5. When he was told that the balloon decoy did not deploy properly, he responded "The decoy is not going to look exactly like what we expected. This presents a problem for the system that we didn't expect."[28] The test was later aborted when the kill vehicle failed to separate from its booster, so the test was not able to provide information on the extent to which this posed a problem for the defense.

There is no reason to assume that such *a priori* information will be available to the defense before an attack. Because emerging missile states will not extensively flight-test their ballistic missiles, the United States is unlikely to have much information about the appearance of its warheads or decoys.

These artificialities mean that the intercept tests reveal very little about the discrimination capabilities of the defense system. Indeed, BMDO's Nance stated, "I will tell you that these are not stressing discrimination tests. We don't intend that. These tests are principally focused on demonstrating we could do hit-to-kill."[29]

[26] Nance briefing, 9 August 2001.
[27] For a detailed discussion of how an attacker could use "anti-simulation" to make a warhead appear like a decoy, see chapter 8 of *Countermeasures: A Technical Evaluation of the Operational Effectiveness of the Planned US National Missile Defense System*, Andrew Sessler, et al, (Cambridge, MA: Union of Concerned Scientists and MIT Security Studies Program) April 2000. Available at http://www.ucsusa.org/security/CM_exec.html
[28] *60 Minutes II*, 31 October 2000.
[29] Nance briefing, 9 August 2001.

If that is the goal of these intercept tests, it is important to understand how realistic the endgame of these tests has been and to what extent they have demonstrated hit-to-kill under operational conditions. As we discuss next, the endgame parts of these tests have also included significant artificialities.

Unrealistic Endgame Conditions

Although two of the intercept tests resulted in successful intercepts, all the intercept attempts were made under endgame conditions that were—in several ways—unrealistic for a defense against long-range missiles.

Low Closing Speed

One of the most important parameters for any exoatmospheric hit-to-kill missile defense system is the closing speed at which it will have to make its intercept. The task that BMDO faces is not to demonstrate hit-to-kill, which has been done, but to do so under realistic conditions and at realistic closing speeds.

In the tests, the closing speed has been 7.4 kilometers per second, while the operational system must be able to function at closing speeds nearly twice that large. This is important, since the time available for homing depends on the distance at which the kill vehicle can detect the target, and on the closing speed. Doubling the closing speed would halve the time available for homing, for a given detection range.

The primary reason for the artificially low closing speeds is that all these tests have used a two-stage surrogate booster in place of the planned three-stage booster for the interceptor. As a result, the speed of the kill vehicle has been much lower than would be expected in the operational system; currently the interceptor has a top speed of about 2.2 kilometers per second, compared to a planned speed of 7 to 8 kilometers per second for the operational interceptor.

As discussed in Section IV, the interceptor booster being developed for the operational system is now a year and half behind schedule, and is not expected to be ready to be used in tests until a year from now. However, it is not clear why BMDO has chosen to use a two-stage surrogate booster rather than a faster three-stage booster. A three-stage booster is used to launch the target complex from Vandenberg.

Objects in Target Cluster Simultaneously in Kill Vehicle Field-of-View

From the BMDO briefing on IFT-6, it appears that the test was designed so that the warhead, decoy, and bus would all remain simultaneously in the kill vehicle's field-of-view until very late in homing process. This was likely the case for the previous tests as well.

To achieve this, the bus appears to be programmed to release the warhead and balloon in a carefully planned way so that these three objects are all roughly lined up along the direction of sight of kill vehicle's sensors.[30] As a consequence, although the warhead and

[30] Ted Postol, personal communication, October 2001.

decoy are separated by five and a half kilometers shortly before intercept, to the kill vehicle they appear separated by less than a kilometer; similarly, the bus appears within about a kilometer of the other objects even though its actual spatial separation is greater.

Lining the objects up in this way allows the kill vehicle to collect data on them simultaneously. Otherwise, it would have maneuver to rotate its sensors' field-of-view from one object to another. Assuming the kill vehicle infrared sensors have a field-of-view of one degree, then two objects separated by five and a half kilometers could not be seen simultaneously when the kill vehicle was closer than about 300 kilometers. If the objects were separated by one kilometer, they could be seen simultaneously until they were within 60 kilometers of the kill vehicle.

This arrangement therefore simplifies the job of the kill vehicle and allows it to collect data on the objects for a longer time. This situation could obviously not be expected in general. Indeed, in an actual attack, one might expect that the attacker would consciously try to separate some of the objects in the target cluster far enough to make observing them more difficult for the kill vehicle. Moreover, this problem becomes more severe at the higher closing speeds appropriate to an operational system, since the kill vehicle would then have less time to collect data on the objects in the target cluster. Since the closing speed using the operational booster could be twice as large as that in current tests, this could cut in half the time available for the kill vehicle to view the objects.

Kill Vehicle Provided with Very Accurate Tracking Data

As discussed in Section II, the C-band beacon on the mock warhead appears to have provided the defense with very high quality tracking information on the location of the warhead. This allowed it to launch the interceptor on a trajectory that was aimed essentially directly at the warhead, rather than toward a larger basket that included the full target cluster. Consequently, the kill vehicle did not need to maneuver very much to hit the target.

This test situation is only relevant to the case where the radars have already discriminated the warhead prior to the launch of the interceptor booster. In the other situation, the kill vehicle itself must discriminate. In this case the kill vehicle would be launched toward a basket containing the full target cluster, which could easily be tens of kilometers in size, and homing would require a considerably greater level of maneuvering than is demonstrated in the current tests.

We do not believe that these endgame artificialities are justified even at this early stage in the development process since they preclude demonstrating hit-to-kill under operationally realistic conditions. In any event, such tests should not be construed as demonstrating the capability of the system under operational conditions, which could be considerably more demanding.

IV. Requirements for More Realistic Testing

As discussed in Section III, the current testing program has a number of important limitations and artificialities. To assess the capability of the defense system, testing must take place under realistic conditions and with enough variations to demonstrate the operation of the system under the range of conditions it might face in an actual attack. Without extensive testing under realistic conditions, the United States would have little meaningful information about the effectiveness of the defense against a real attack. While it is not surprising that such extensive and realistic testing has not been completed at this point in the test program, it is essential that such testing be completed prior to making a decision to deploy the system.

What needs to be done to make the current test program more realistic?

Here we discuss three sets of measures that BMDO should take to address some of the issues raised in Section III. Some of these measures were suggested by the Pentagon's Director of Operational Testing and Evaluation (DOT&E), Philip Coyle, in his August 2000 evaluation of the program.[31] While Coyle's evaluation was of the Clinton testing plan, it remains relevant to the Bush testing plan for the ground-based midcourse system.

(1) Make the endgame more realistic.
A key step to making the endgame more realistic would be to increase significantly the closing speed during the test by using a faster booster for the interceptor. The prototype interceptor booster under development will be considerably faster than the surrogate booster that is currently used; however, it will not be ready for use until at least a year from now. Until it is ready, BMDO should use a different surrogate booster, perhaps similar to the booster being used to launch the target cluster. This booster reaches 6.5 kilometers per second rather than 2.2 kilometers per second of the current interceptor booster.

In the near term, the intercept tests should also include target clusters that are large enough that the kill vehicle cannot track all the objects simultaneously. At the same time, the kill vehicle should not be given high quality data on the location of the warhead, so that it would be required to do considerably more maneuvering to home on its target.

(2) Test the system's discrimination capabilities under more realistic conditions.
The two main steps required to test the system's discrimination capabilities are to incorporate more realistic countermeasures than have been used or appear to be planned, and to include tests in which the defense has limited *a priori* knowledge of the target complex. While it is appropriate that this has not yet occurred during the intercept tests, these measures should be incorporated into the tests soon.

Demonstrating the ability to discriminate under realistic conditions is crucial to the operation of the defense. The midcourse system being developed is vulnerable to a range of countermeasures of the kind that must be assumed would accompany a missile

[31] DOT&E report, 10 August 2000.

attack.[32] While the current tests include a spherical balloon as a so-called "decoy," this is not a credible countermeasure since its appearance to the missile defense sensors is very different from that of the mock warhead. Moreover, the defense has precise information about how the balloon and warhead will appear to the sensors, so the sensors know exactly what to look for. This would not be true in a real scenario. The United States is unlikely to have such detailed information about an attacker's warhead and countermeasures, which that country would certainly take great pains to hide. Even if the United States did have such information, an attacker could readily take steps to disguise the warhead to change its appearance in order to confuse the defense sensors.

While both the Clinton and Bush administrations have said that the testing program will eventually include more demanding countermeasures, it was reported in June 2000 that the set of decoys planned as part of the testing program had been modified to remove decoys that might have a signature too similar to that of the mock warhead.[33] There is no public indication that these plans have been changed, nor any indication when tests against more stressing countermeasures are planned.

(3) Vary the test conditions.

Even aside from the shortcomings listed above, the current tests provide little confidence in the ability of the system to work under conditions other than those used in tests so far. Even if the system worked well under a particular set of test conditions, complex technical systems often exhibit unexpected behavior when subjected to different sets of conditions. Until the system is tested under the range of conditions it could be expected to face in an actual attack, the United States will have inadequate information about its effectiveness.

In Section III we discussed some of the important parameters that will affect the operation of the system and must be varied in the test program. A more complete list includes: [34]

- the intercept geometry
- the time of day
- the weather conditions (by testing in heavy rain and dense clouds)
- the interceptor flyout range
- the altitude of intercept

In addition, Coyle has noted the importance of conducting tests that involve multiple interceptors launched against multiple targets, which complicates the operation of the system and can confuse the ground-based radars. Facilities to launch multiple missiles from both Vandenberg and Kwajalein are apparently planned, as are apparently two tests that involve multiple kill vehicles (see below).

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[32] *Countermeasures*, April 2000.

[33] William Broad, "Antimissile Testing is Rigged to Hide a Flaw, Critics Say," *New York Times*, 9 June 2000, p. A1.

[34] For a more detailed analysis, see "The Alaska Test Bed Fallacy: Missile Defense Deployment Goes Stealth, Lisbeth Gronlund and David Wright, *Arms Control Today*, September 2001, available at: http://www.armscontrol.org/act/2001_09/gronlundwrightsept01.asp

The three points discussed above make clear that success of the current tests in no way implies that the technology is ready for deployment. Moreover, all of these improvements to the test program can be done within the terms of the Anti-Ballistic Missile (ABM) Treaty. All of them can be done using the test facilities at Kwajalein atoll, with the addition of second launch silos at Kwajalein and Vandenberg, and possibly a launch site for interceptors on Kodiak Island in Alaska. Adding such a test facility is allowed under the ABM Treaty.[35]

The Proposed Alaska "Test Facilities"

The Bush administration has recently announced plans to build new missile defense facilities in Alaska, which it claims are necessary to make the testing program more realistic. The most controversial of these facilities is at Fort Greely, where the Pentagon plans to build a battle-management center and five interceptor silos, and to deploy interceptor missiles in those silos. However, since interceptors cannot be test launched from the Fort Greely site for safety reasons, building the silos cannot be justified on testing grounds. Moreover, even if interceptors *could* be test-launched from Fort Greely, doing so is neither necessary nor useful to increase the realism of the testing program.[36]

The Planned Test Schedule

While it is important that the tests be conducted under realistic conditions, it is also essential that enough tests be conducted to provide meaningful information about the system performance.

Under President Clinton, the BMDO scheduled a total of 19 intercept tests (out of 21 flight tests) of the ground-based midcourse system, which were to be completed by 2005 when the first phase of the system would be deployed. These tests included 16 Research, Development, Test & Evaluation (RDT&E) tests. RDT&E tests are part of the development process and can include both prototype and surrogate components; it is anticipated that these tests may result in modifications to the design of the system.

However, RDT&E tests are not used to assess the effectiveness of the system being considered for deployment. Such an assessment is made using Initial Operational Test & Evaluation (IOT&E) tests, which are conducted when significant changes are no longer being made to the system components. Operational tests are conducted using actual soldiers to operate the system rather than employees of defense contractors, using production or near-production components, and under conditions when the defense is not told in advance exactly when the test will take place or what the mock attack will entail. Under current US law, a decision to begin procurement of a weapons system may only be taken after the initial operational tests have taken place.[37]

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[35] For a more detailed discussion of the utility of these test facilities, see Gronlund and Wright, "The Alaska Test Bed Fallacy."

[36] For a detailed analysis of the proposed facilities at Fort Greely, see Gronlund and Wright, "The Alaska Test Bed Fallacy."

[37] See US Code, Title 10, Sec. 2399, available at http://www4.law.cornell.edu/uscode/10/

The Clinton plan included only three Operational Test & Evaluation (IOT&E) tests—almost certainly too few to provide adequate information about the expected operational capabilities of the system. Moreover, Clinton scheduled his deployment decision to take place after only three development tests—and years before any operational tests—were conducted.

The Bush administration recently stated that it now plans a total of 24 intercept tests (including the four that have already taken place) for the midcourse system through FY06.[38] All of these tests will be RDT&E tests. The Bush plan thus includes eight more RDT&E tests than did the Clinton plan. However, the current test plan also includes some repeats of tests that were not in the Clinton plan (e.g., the fourth intercept test (IFT-6) was a repeat of the previous test (IFT-5), which failed, and the upcoming test (IFT-7) will be a repeat of IFT-6). Moreover, some of these tests will apparently include the launch of two kill vehicles, and will therefore be considered as two separate intercept tests (this will apparently be the case for IFT-18 and 19, and for IFT-23 and 24).[39] Thus, the new test schedule reflects a real, but modest, increase in the number of RDT&E intercept tests.

Operational testing of the ground-based midcourse system is not planned to begin until 2007. Six initial operational tests are scheduled to take place through the end of 2008, with an additional eight long-range operational tests scheduled through the end of 2010.[40] It makes no sense to make a deployment decision before initial operational testing has been completed; under a reasonable yet best-case scenario, deployment of the ground-based midcourse system would not take place until some time after 2008.[41]

However, even this potential deployment date is likely optimistic. BMDO has said it plans a very aggressive test schedule, with four tests per year for the next five years, finishing in the fall of 2006. This rate corresponds to a test every three months. This may be optimistic since the first five intercept tests will have taken place with an average of six and a half months between them, assuming the upcoming test takes place in early December of this year. The testing program so far has seen significant delays. For example, the upcoming intercept test (IFT-7) was initially scheduled for January 2001 when the program was restructured in January 1999.

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[38] Nance briefing, 9 August 2001.
[39] Lt. Col. Rick Lerner of BMDO, private communication, 26 November 2001.
[40] Rick Lerner, private communication, 29 November 2001.
[41] While the Bush administration has discussed fielding prototypes of the technology by 2004 that could be used as "emergency defenses," these systems would have very limited utility for several reasons. The limited testing that would have occurred by that time would give the United States very little basis to have confidence in their performance. Moreover, even if the interceptor and kill vehicle technology worked perfectly by that time, the system would be severely limited by its sensors. BMDO has stated that the X-band radar is a key sensor needed to discriminate the warhead from other objects, including debris or simple decoys, but there would be no such radar that could see trajectories from North Korea fired toward the United States. According to testimony by Deputy Secretary of Defense Paul Wolfowitz before the Senate Armed Services Committee on 17 July 2001, an upgraded version of the Cobra Dane radar on Shemya Island in Alaska "will provide enhanced early warning and may have some ABM radar capability." But, Wolfowitz noted, "In any operational system, we anticipate that the X-band radar at Shemya would be required to provide needed discrimination, even with all possible upgrades to Cobra Dane."

Moreover, the prototype booster intended for the operational interceptor is well behind schedule. The first flight test of the booster took place on August 31 of this year—18 months behind schedule—and it is unclear when a version will be ready to integrate into intercept tests. Despite relying on off-the-shelf technology and being billed as one of the more straightforward parts of the system, tests of the booster have been delayed by a number of difficulties, and the August flight test reportedly was not entirely successful.[42] IFT-7 was intended to be the first test to use the prototype booster; it now appears that tests will continue to use the two-stage surrogate booster for at least another year.

In addition, the development of crucial software needed for testing the system has been reported to be many months behind schedule.[43] This software is intended to allow testers to run simulations that check the operation of the defense under a wide range of conditions, and is a necessary complement to field-testing. There are reports that even the latest version of the software has significant limitations.

[42] Bruce Smith, "Anti-Missile Concepts Jockey for Position," *Aviation Week and Space Technology*, 10 September 2001, p. 38.