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Report to the Chairman, Subcommittee on Federal Services, Post Office and Civil Service, Committee on Governmental Affairs, U.S. Senate

July 1994

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BALLISTIC MISSILE DEFENSE

Records Indicate Deception Program Did Not Affect 1984 Test Results

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United States
General Accounting Office
Washington, D.C. 20548

National Security and
International Affairs Division

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July 21, 1994

The Honorable David H. Pryor
Chairman, Subcommittee on Federal
Services, Post Office and Civil Service
Committee on Governmental Affairs
United States Senate

Dear Mr. Chairman:

This report responds to your request that we conduct a comprehensive investigation of allegations concerning deception in the U.S. Army's 1984 Homing Overlay Experiment.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after its issue date. At that time, we will send copies to appropriate congressional committees; the Secretaries of Defense and the Army; the Deputy Secretary of Defense; and the Directors, Ballistic Missile Defense Organization and Office of Management and Budget. We will also make copies available to others upon request.

Please contact me on (202) 512-4841 if you or your staff have any questions. Major contributors to this report are listed in appendix II.

Sincerely yours,

Brad Hathaway

Brad Hathaway
Associate Director, Systems
Development and Production Issues

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Executive Summary

Purpose

In June 1984, the Army conducted the fourth in a series of tests to demonstrate that a ballistic missile defense interceptor could find an intercontinental ballistic missile (ICBM) reentry vehicle (RV) in space, guide itself to an intercept, and destroy the target through the force of collision. The tests, part of the Homing Overlay Experiment (HOE), had not produced a successful intercept in the first three tries. After the fourth and final test, called HOE 4, the Army announced a successful intercept. This occurred 2 months after the Strategic Defense Initiative was chartered to expand research in these and other ballistic missile defense technologies.

Senator David Pryor asked GAO to investigate allegations he received in 1993 of deception in HOE 4. He expressed concern that representations about the test might have laid a faulty foundation for the $30-billion investment in the Strategic Defense Initiative. GAO's objectives were to determine (1) the nature of any deception plan for HOE, (2) whether the interceptor and target collided as claimed, (3) whether the interceptor used the claimed infrared homing guidance or an undisclosed guidance subsystem, (4) whether the target and its infrared emissions were appropriate for this demonstration, and (5) whether the Army and the Department of Defense (DOD) accurately represented the performance of HOE 4.

Background

The Army began a technology demonstration program in the mid-1970s to validate emerging technologies to enable nonnuclear, hit-to-kill intercepts of Soviet ballistic missile warheads in space. This program, which became HOE, concluded with four flight tests in 1983 and 1984. Each test involved launching a target from Vandenberg Air Force Base, California, and a HOE interceptor from the Kwajalein Missile Range in the Pacific. Only the fourth test resulted in DOD announcements of a successful intercept.

In September 1993, DOD acknowledged that there was a deception program associated with HOE. The deception program was started in hopes of affecting Soviet perceptions of U.S. ballistic missile defense capabilities, according to records. Deception was seen as a means of impacting arms control negotiations and influencing Soviet spending. The Secretary of Defense said the deception was discontinued prior to the final test, and so it did not impact the test's outcome. The planned deception was to explode the target if the interceptor failed to hit it but passed close enough to support the appearance of a hit.

The deception plan and approval documents indicated that it might become necessary to inform select members of Congress about the plan. DOD said, in September 1993, that Congress was not informed of the plan. No statutory requirement existed in 1984 for DOD to inform Congress about special access program activities. Legislation has since required reporting of such programs, starting in 1988.

Results in Brief

GAO found no evidence that DOD deceived Congress about HOE 4 intercepting the target. Records indicate that the contingency deception plan had been in place for the first two tests but did not affect their outcomes. The plan was dropped prior to HOE 3. Analyses of HOE 4 test data are consistent with the Army's conclusion that the interceptor and target collided.

Records also support the conclusion that the interceptor was guided during its final maneuvers by its onboard infrared sensor. GAO also found that the target was appropriate for this demonstration. However, steps were taken to make it easier for the interceptor's sensor to find the target. DOD's statements in 1984 and 1985 about the success of the test fairly characterize the performance of HOE 4 but do not disclose the enhancements of the target's infrared visibility to increase the probability of detection.

Principal Findings

Plan for Deceptive Explosion Was Dropped Prior to Test

Records of the deception program for HOE show that it was superimposed on the ongoing technical program after the demonstration hardware had been designed and fabricated and that it was discontinued before the third flight. No deceptive explosion occurred on flights 1 and 2 because the interceptor missed the target by too great a distance. While some hardware related to the deception remained onboard the target, it did not affect the outcome of HOE 4. The hardware to implement a deceptive explosion did not interfere with a normal test intercept.

Collision Confirmed by Sensor Data

Both the interceptor and target had sensors that transmitted data to the ground. In addition, test data were gathered by ground-based radars and airborne optical sensors. The data show that the target was destroyed by

collision with the interceptor and not by an explosive charge after a near miss.

Guidance Was Not Rigged

Available evidence supports the conclusion that the interceptor was guided to the target by its onboard infrared sensor. While there were allegations carried in the press that a radar beacon on the target broadcast its location to the interceptor to rig the test, the records of the technical program and deception plan did not suggest alternate means of guidance. In addition, alternate beacon guidance appears implausible because the interceptor guidance hardware required could not be concealed from a test team and would likely have been equal or more costly and risky to develop than the infrared sensor.

Target Selection Was Reasonable

The selection of the target was reasonable. The target had characteristics similar to a modern Soviet ICBM RV, a primary threat to Minuteman silos at the time of HOE. This type of RV remains a threat today of sufficient importance to have been the subject of negotiated reductions in the 1991 Strategic Arms Reduction Talks. The target selected had been developed to support U.S. testing and had been previously used in both radar and infrared sensor tests. Laboratory officials responsible for these targets explained that the RV was designed to behave thermally like a modern ICBM RV, providing a similar long-wave infrared signature.

Enhancement of Target Infrared Visibility Was Reasonable

Late in the program development, the Army decided to enhance the target's infrared visibility due to uncertainties over sensor performance. The enhancements were the result of (1) flying the target in an orientation that presented its side toward the interceptor and (2) heating the target to 100 degrees Fahrenheit prior to launch. These enhancements resulted in an infrared signature closer to the high end of the range of expected threat signatures. While enhancements of the target's infrared signature weakened one part of the demonstration, GAO believes it was a reasonable decision for this early technology demonstration considering the alternatives of (1) risking failure of the entire experiment or (2) investing additional time and money improving the sensor.

Army and DOD Statements Did Not Misrepresent Performance

GAO believes that statements by the Army after the test and by DOD in subsequent budget hearings did not misrepresent HOE's performance. The statements emphasized having demonstrated the ability to locate,

intercept, and destroy a target representative of a Soviet threat and the early, demonstration nature of HOE. However, the statements did not disclose the steps taken to enhance the probability of finding the target.

Recommendations

This report contains no recommendations.

Agency Comments

In its June 27, 1994, letter, DOD concurred with this report.

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Abbreviations

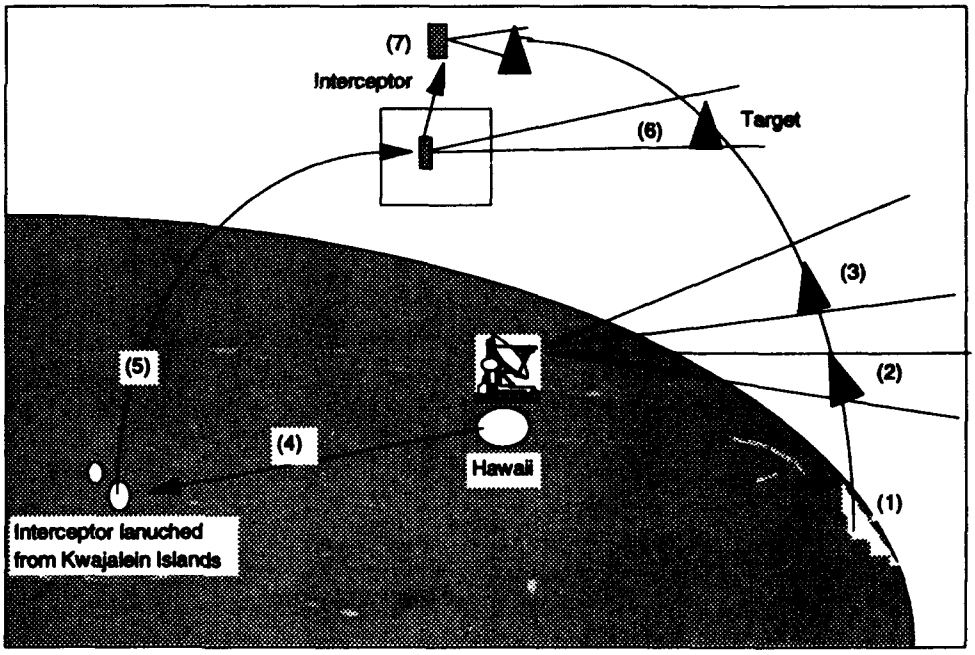
BMDO	Ballistic Missile Defense Organization
DOD	Department of Defense
ERIS	Exoatmospheric Reentry Vehicle Interceptor Subsystem
HOE	Homing Overlay Experiment
ICBM	intercontinental ballistic missile
MIT	Massachusetts Institute of Technology
OTA	Office of Technology Assessment
RV	reentry vehicles
SDIO	Strategic Defense Initiative Organization

Introduction

The Army began researching nonnuclear means to intercept and destroy ballistic missiles during the 1960s. The so-called "hit-to-kill" technologies included infrared homing sensors that would permit an interceptor to guide itself into the path of an incoming warhead and collide with it.

In 1976, the Army began planning the Homing Overlay Experiment (HOE). The purpose was to demonstrate whether an interceptor with an onboard infrared homing sensor could locate and track a target, and then guide itself to a collision with the target representative of Soviet reentry vehicles (RV). Four flight tests were conducted in 1983 and 1984. Each test involved launching a target from Vandenberg Air Force Base, California, and a HOE interceptor from the Kwajalein Missile Range in the Pacific. (See fig. 1.1.)

Figure 1.1: Sequence of HOE Test Events

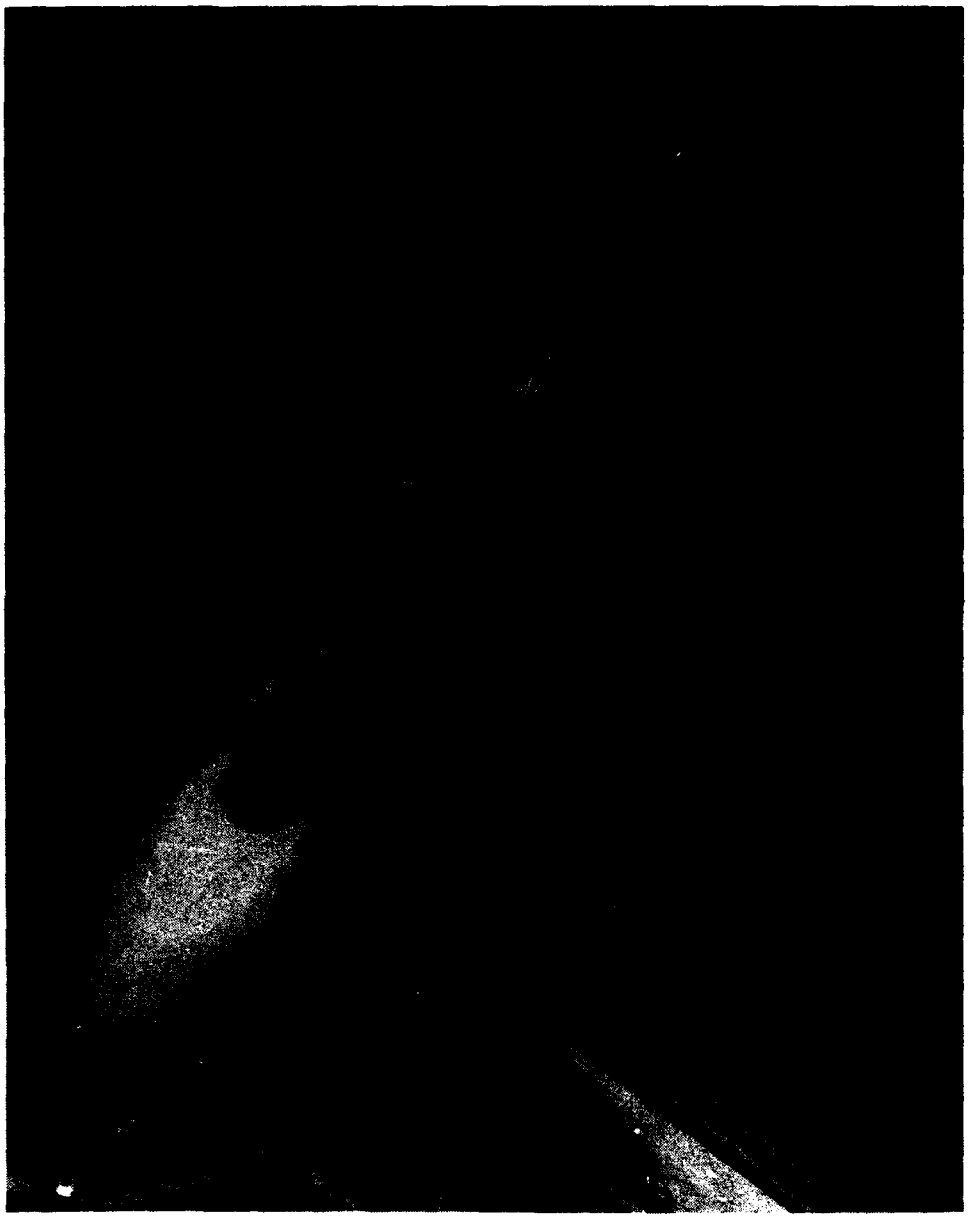


Notes
1. Target launched from Vandenberg Air Force Base on Minuteman I booster.
2. Radar in Hawaii acquires the target after separation from booster.
3. Radar develops prediction of target's track.
4. Target track is provided to interceptor before launch.
5. Interceptor is launched and goes to an area in space based on the radar track data.
6. Interceptor's infrared sensor begins searching for target and acquires it.
7. Based on data from its sensor, interceptor's guidance system directs rocket thrusters to send it into the path of the target where the collision (hit-to-kill) occurs.

HOE Test

The HOE interceptor consisted of surplus Minuteman I launch stages, carrying the "homing and kill" vehicle pictured in figure 1.2. This vehicle included a divert and homing propulsion section, a long-wave infrared sensor, a fixed-fragment-net kill mechanism, data processors, and vehicle control equipment. It also carried equipment to aid test monitoring and measurements. The fixed-fragment net was tested as a means to extend the lethal radius of a HOE-type interceptor. Deployed shortly before intercept, it consisted of 36 aluminum ribs with stainless steel fragments that expanded the interceptor's size to provide greater assurance of hitting the target.

Figure 1.2: HOE Interceptor Homing and Kill Vehicle



Source: Department of Defense.

The Army and the Department of Defense (DOD) announced that the interceptor missed the target in the first three tests but successfully intercepted it in the fourth test—HOE 4. The Army reported the success of HOE 4 in a press conference on June 11, 1984, the day after the test. DOD subsequently summarized the accomplishments of HOE 4 in statements to Congress in early 1985. All of these statements presented HOE 4 as a successful demonstration of the interceptor seeing the target, closing on it using an onboard infrared sensor, and destroying it with the energy from the direct collision.

Objectives, Scope, and Methodology

On August 5, 1993, Senator David Pryor requested that we investigate allegations he had received concerning the HOE program. The allegations raised concern that, in attempting to deceive the Soviets, DOD had misled Congress about accomplishments of HOE 4 and about the feasibility of strategic defense technology. On August 18, 1993, Senator Pryor requested the Secretary of Defense to review the charges about the program. The Secretary issued a press release and held a news conference on his findings on September 9, 1993.

The objectives of this report are to determine (1) the nature of any deception plan for HOE, (2) whether the interceptor and target collided as claimed, (3) whether the interceptor used the claimed infrared homing guidance or an undisclosed guidance subsystem, (4) whether the target and its infrared emissions were appropriate to this demonstration, and (5) whether the Army and DOD accurately represented the performance of HOE 4.

The Army had fairly extensive records of the planning and execution of the HOE deception program that revealed the general technical approach to the proposed HOE test deception. The HOE development community did not retain records of the deception activities. Development managers explained that they were instructed to destroy these records shortly after the conclusion of the HOE deception program. Thus, complete documentary records on the hardware implementation of the deception plan were not available.

We reviewed available records of the HOE technical program and of the contingency plan for a deceptive explosion on board the target. We interviewed key participants in the deception program to supplement and corroborate available records. These interviews included participants from both the development community and the Army deception planners.

We had DOD and its agents provide updated analyses on several issues. We employed a professional engineer as a consultant to check the reasonableness of the data and analyses obtained. Specifically, we

- met with the Under Secretary of Defense for Acquisition and staff responsible for special access programs to discuss DOD's investigation and obtain the records supporting their report;
- interviewed (1) two individuals who had related to Senator Pryor the likelihood of some deceptive efforts surrounding the HOE program, (2) the Army deception manager, and (3) key participants in the Army's HOE program, including those who had participated in the deception plan;
- reviewed (1) the HOE 4 flight test report and the final report on the HOE program, (2) formal documents from the Army's deception planners, outlining their plans, approval, and termination, (3) working files from the Army's deception manager, and (4) analyses from the Ballistic Missile Defense Organization (BMDO) on alleged alternate deception schemes;
- retrieved and reviewed relevant records from the Army's Space and Strategic Defense Command's microfilm archives on the HOE program;
- reviewed briefings and documentation from the Massachusetts Institute of Technology (MIT) Lincoln Laboratory on its kill assessment analyses and sensor performance analyses from 1984 and 1985 and subsequent lethality studies that used HOE 4 data;
- reviewed briefings and documentation from the interceptor prime contractor, Lockheed Missiles and Space Company, Inc., on kill assessment and miss distance analyses, including studies done since 1984 using HOE 4 data; and
- reviewed records from working files and from microfilm archives of a national laboratory, the target builder, to understand changes made for the deception plan and for increasing the target's signature.

We conducted our review from September 1993 through May 1994 in accordance with generally accepted government auditing standards. DOD provided formal comments on a draft of this report. (See app. I.)

What Were the Nature and Impact of the Deception Plan?

The HOE deception effort was terminated before the HOE 4 test and therefore did not affect the results. The deception program was started in hopes of affecting Soviet perceptions of U.S. ballistic missile defense capabilities, according to records. This deception was seen as a means of impacting arms control negotiations and influencing Soviet spending.

Initial planning for the HOE deception effort began almost 3 years after the HOE contract had been awarded. The effort was terminated prior to the third flight, according to Army records and the statements of participants we interviewed. Hardware to implement a deceptive explosion was installed so as not to interfere with a normal test intercept. A deceptive explosion was contingent on achieving a near miss and was to occur only after the interceptor had passed the target. The deception effort was terminated after two flights because the failures detracted from the deception plan's goal of showing the Soviets a highly reliable missile defense capability and because of the burden and risks involved in continuing the deception.

What Were the Technical Aspects of the HOE Test Deception?

The plan was to set off an explosion if the interceptor flew by without hitting the target, which was to fool Soviet sensors expected to monitor the test. The target's explosion was to simulate the effect of a strike by the interceptor.

The explosion was set to occur on the target after the point of closest approach of the two vehicles. This timing was to permit HOE test personnel to obtain needed technical performance data before destruction.

The explosion was to be detectable by Soviet sensors, and further, the explosion would destabilize the target upon reentry into the atmosphere, also giving an enhanced optical signature from burning in the friction of the atmosphere.

Chronology of HOE Development Program and Deception Effort

Planning for the HOE program began in 1976, and a contract for the experimental interceptor was awarded in August 1978 to Lockheed. The proposal and contingency plan to use deception evolved in late 1981 and early 1982, after the design and fabrication of experimental hardware had begun. The hardware, procedures, and personnel to implement a deception were in place during the first two HOE flights. However, the interceptor did not pass close enough to the target in either flight to permit the planned deceptive explosion.

Army records indicate that proposals to terminate the deception effort were made by both HOE developers and Army deception managers in the summer of 1983. The Army terminated the deception program in September 1983, prior to the third HOE flight. In October 1983, a development command memorandum lifted the special access data handling procedures that had been required to implement the deception. (See table 2.1.) Test personnel said that the wiring to the explosives was removed for the final two flights, but the explosive material was not removed. Any effect from the explosive material left on the target was masked by the energy of the body-to-body collision, according to test participants.

Table 2.1: Chronology of HOE Development Program and Deception Activities

Date	HOE program	Deception
1976	HOE planning begun	
Aug. 1978	Contract awarded	
Dec. 1980	Critical Design Review	
June 1981		Planning begins
Jan. 1982		Plan presented
Apr. 1982		Modifications funded
Dec. 1982	Flight aborted	
Feb. 1983	First flight	
May 1983	Second flight	
June 1983		HOE program manager requests deception be terminated
Aug. 1983		Deception planners propose termination
Sept. 1983		Army approves termination
Oct. 1983		Special access data restrictions lifted on HOE test
Dec. 1983	Third flight	
June 1984	Fourth flight (HOE 4)	
Dec. 1984	Contract closeout	

Who Was to Be Deceived?

Records indicate that the deception plan was to create perceptions for Soviet decisionmakers that U.S. capabilities for defense against ballistic missiles were more highly developed than was actually the case. This action, it was hoped, could impact arms control negotiations and Soviet spending on related systems.

We found that the deception plan and approval documents indicated that it might become necessary to inform select members of Congress of aspects of the plan. DOD's 1993 review indicated that Congress was not informed of the plan. No statutory requirement existed in 1984 for DOD to inform Congress about special access program activities. Legislation has since required reporting of such programs, starting in 1988.

Why Was the Deception Effort Terminated?

By the summer of 1983, both HOE developers and Army deception planners were reconsidering the continuation of the deception program. Records indicate several factors contributed to the termination.

- It became increasingly apparent, after two misses by distances too large to have an explosion, that the deception goal of showing the Soviets a highly reliable missile defense capability would not be met.
- The risk of Soviet discovery outweighed remaining benefits.
- The deception was increasingly difficult to conceal due to the large numbers of test personnel requiring access.
- The deception was difficult to manage, according to managers from both the development community and the Army deception planning community. Compartmented data access restrictions made life difficult for development personnel.
- The HOE deception was a drain on manpower.

Did HOE 4 Interceptor Collide With the Target?

Available data from HOE 4 were consistent with an intercept and inconsistent with the deception plan contingency of setting off an explosion in the target after a near miss occurred. As a technology demonstration program, HOE tests were monitored by numerous sensors that provided data for analyses. The Army and its contractors concluded in 1984 that intercept and destruction of the target by the interceptor were confirmed by data from (1) ground-based radars, (2) sensors on board the interceptor and target, and (3) airborne optical sensors.

Since 1984, additional analyses of the HOE 4 intercept data have been performed by MIT Lincoln Laboratory and by Lockheed to support kill assessment studies for current ballistic missile defense programs. Some of these analyses compared HOE 4 data to data from later intercepts that were not available in 1984. For example, on January 28, 1991, the Exoatmospheric Reentry Vehicle Interceptor Subsystem (ERIS) missile intercepted and destroyed a mock RV. These later analyses appear to strengthen the 1984 conclusion.

Ground-Based Radar Data on Fragments

Ground-based radars at Kwajalein Missile Range provided data indicating that a destructive collision had occurred. According to Lincoln, data on fragment sizes, paths, velocities, and dispersal patterns were consistent with a body-to-body impact between the interceptor and target. The data were not consistent with a simple explosion on the target vehicle following a near miss.

Fragment Sizes

Analyses performed by Lincoln in 1984 and more recently, indicated that the small size and number of fragments observed in HOE 4 were consistent with a body-to-body collision. Lincoln's 1984 analysis estimated target fragment sizes ranged up to 10 centimeters, which would not be consistent with the deception plan's explosion scenario.

Change in Fragment Paths and Velocities

The 1984 Lincoln analysis published in the HOE program final report showed that the paths of the interceptor and target fragments were changed by small but measurable amounts from preintercept paths. The velocities of the fragments after impact also changed from the preintercept velocity of the target.

A more recent analysis by Lincoln also considered fragment paths and velocities. The analysis showed the post-impact change in direction and

velocity of the fragments and attributed these changes to momentum transfer that would occur as a result of physical contact between the interceptor and target. If the target had exploded with no collision, the center of the debris cloud would have continued along the original path of the body with no change in velocity.

Fragment Cloud Expansion Speed

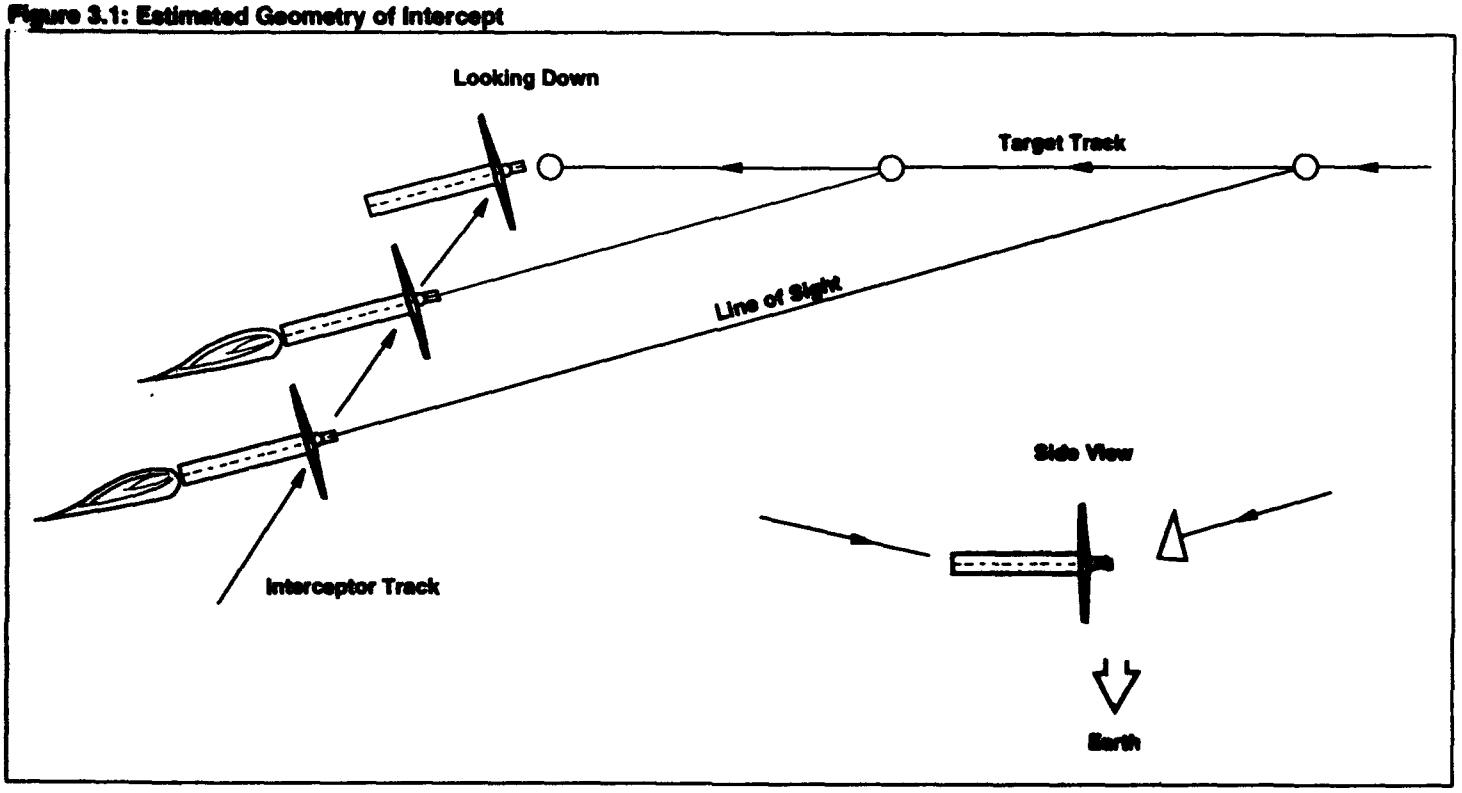
More recently, as part of ongoing lethality studies for theater ballistic missile defense, Lincoln has done additional analyses of HOE 4, comparing the rate of expansion of the debris cloud with that of subsequent intercept tests. These analyses were not done in 1984 because HOE was the first planned exoatmospheric kinetic intercept. According to Lincoln, the rate of expansion of the debris clouds in HOE 4 was consistent with later intercepts. In previously observed missile explosions, the fragment cloud expanded at slower speeds than those observed in HOE 4.

Onboard Sensor Indications of Miss Distance

A 1984 analysis of data from sensors on the interceptor and target showed that the interceptor and target collided. The analysis estimated that the center of the target and the center of the interceptor were probably within 20.6 inches of each other. Given the sizes of the target and interceptor, this "miss distance" would have resulted in a body-to-body collision. The miss distance analysis combined information from the interceptor's radar-frequency miss-distance indicator and infrared sensor and from the target's attitude control system. This information enabled an estimation of where and how the two bodies struck each other.

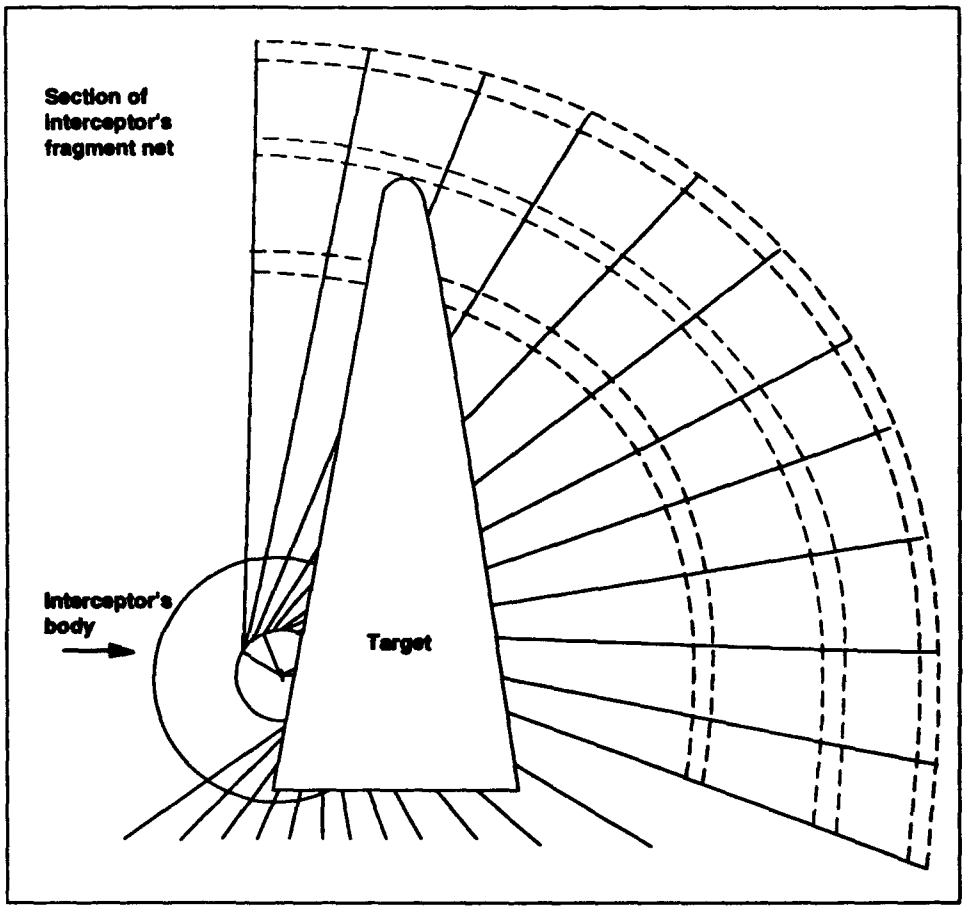
The estimated geometry of the intercept and collision is illustrated in figures 3.1 and 3.2. The interceptor was flown in an orientation that maximized the area its fixed-fragment net presented to the approaching target. The net was a 13-foot diameter, aluminum-ribbed net, laced with steel fragments. The target for this test was flown in a near-broadside orientation to the interceptor's line of sight, as explained in chapter 5.

Figure 3.1: Estimated Geometry of Intercept



Source: DOD.

Figure 3.2: Estimated Geometry at Instant of Collision



Source: DOD.

The interceptor's miss-distance indicator registers when the target passes through each of three preset ranges from the interceptor. The infrared sensor on the interceptor is used to determine the angle at which the interceptor and target are approaching. This angle is determined by estimating the direction the target image moves across the infrared sensor's detectors as the interceptor closes on the target. The attitude control system provides information on the orientation of the target in space.

Lockheed staff working on a subsequent program used an alternative method to calculate the miss distance in HOE 4. Their analysis indicated a

miss distance consistent with a successful intercept of the target. The analysis concluded that miss-distance indicator data alone, without combining the other sensor information used in the 1984 analysis, indicated a miss distance consistent with at least a collision between the interceptor's fixed fragment net and the target.

Airborne Optics

Optical sensors on a high-flying aircraft were used to record the optical signature of the emissions resulting from the impact. Specifically, they recorded the dispersal patterns of target debris during reentry through the lower atmosphere and the intensity of light at specific wavelengths. The number and small size of the fragments limited the analyses that could be performed. However, the intercept flash recorded by the sensors showed that the energy patterns lasted several seconds beyond the collision. The data from the sensors confirmed the intercept and destruction of the target, according to the test report.

A later Lockheed analysis, performed in conjunction with another defense missile program, found that the intensity and duration of the optical flash were much greater than what would be expected from an explosion on the target vehicle. This analysis also compared the observed two-stage flash in HOE with the flash observed in a 1991 intercept test and found they had similar patterns. An initial brief flash is attributed to a body-to-body collision, and the creation of a hot plasma is observed. A second, less intense flash, which persists for 6 seconds, is attributed to a fireball from vaporized portions of the target and interceptor.

Any effect from the explosive material left on the target was masked by the energy of the body-to-body collision, according to test participants.

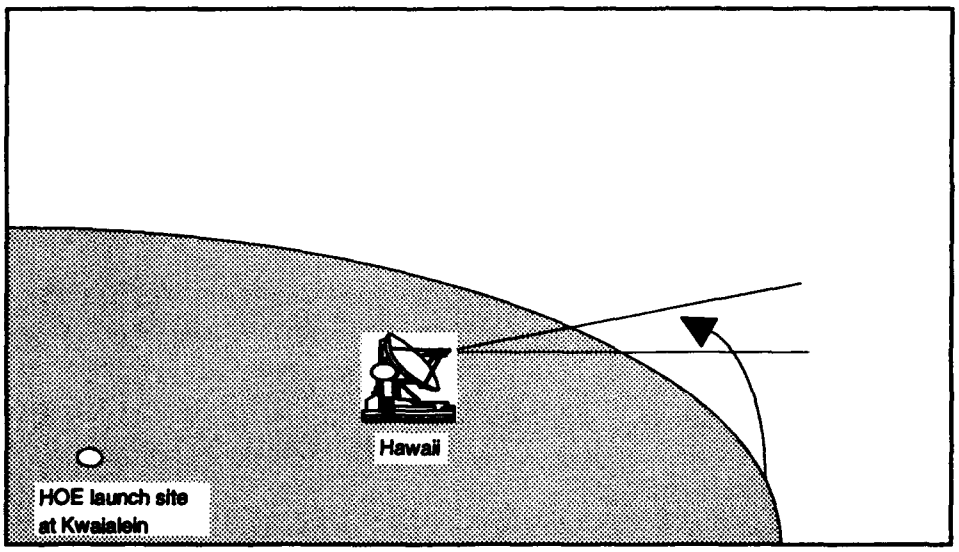
Was Infrared Homing Guidance Used on HOE 4?

Records of the HOE technical program support DOD's statements that HOE 4 was a homing and kill interceptor that was guided during flight by its onboard infrared sensor. Records of the special access program provide further support that the HOE interceptor was guided by an infrared homing sensor. In addition, technology histories show that infrared homing was the technology of choice for exoatmospheric hit-to-kill homing concepts dating back to the 1960s. The records do not support allegations that the interceptor used signals from a beacon that was onboard the target for in-flight guidance.

Ground-Based Radar Used Beacon's Signals to Calculate Target's Track

A ground-based radar in Hawaii used signals from a beacon on the target to calculate a sufficiently accurate estimate of the speed and path of the target after it was launched from Vandenberg Air Force Base in California. A radar track without the beacon would not have provided sufficient accuracy for the HOE flight tests. (See fig. 4.1.)

Figure 4.1: Radar in Hawaii Acquires Target and Provides Track Prediction to HOE Interceptor on Launch Pad at Kwajalein



The prediction of the target's track from the ground-based radar was then "handed over" to the interceptor's computer before the interceptor was launched from Kwajalein to intercept the target. The beacon-aided track

was necessary to enable the interceptor to fly to a specific area in space with high confidence that the target would appear in the field of view of the infrared sensor (see fig. 4.2). After the interceptor arrived in the designated area in space and its infrared sensor acquired the target, onboard systems guided the interceptor into the path of the target (see fig. 4.3).

Figure 4.2: Interceptor Launched to Area in Space Based on Data Provided by Ground-Based Radar

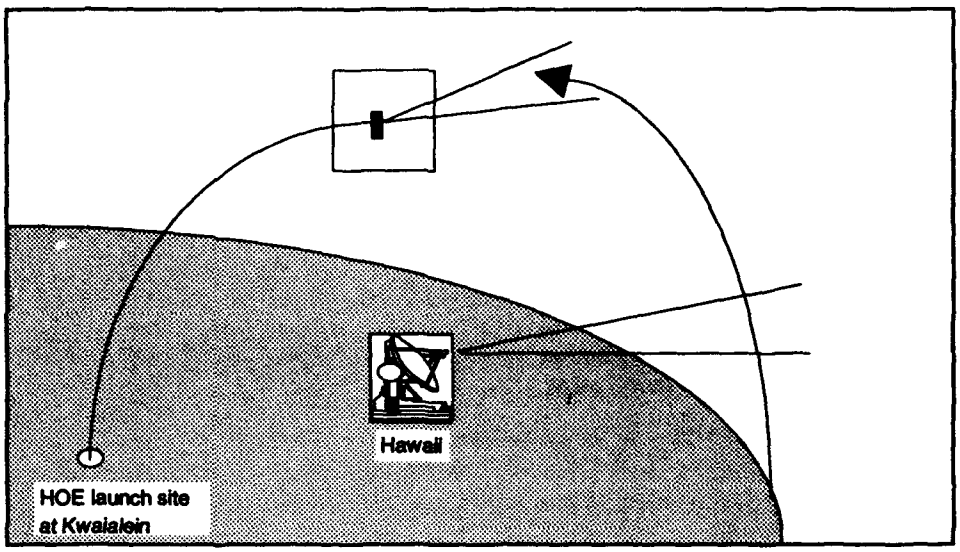
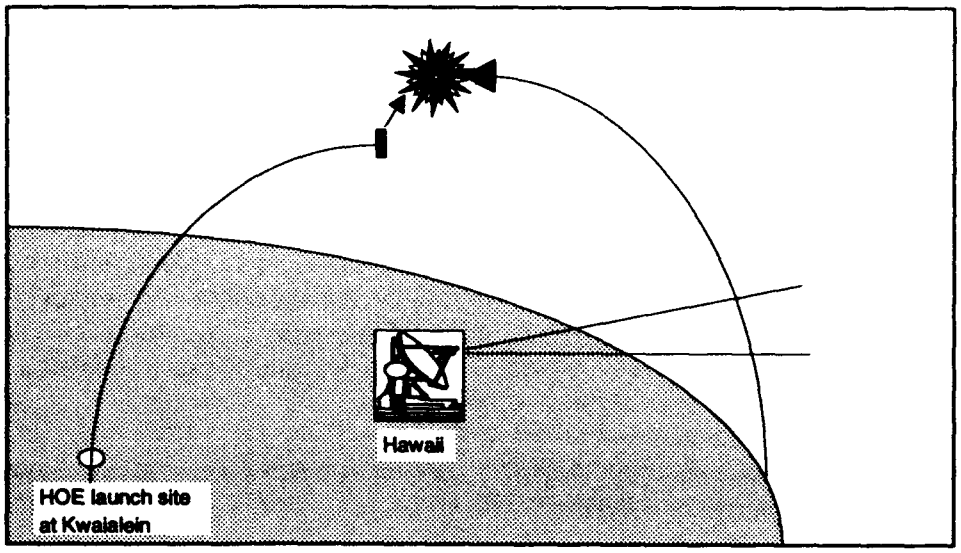


Figure 4.3: Infrared Sensor Locates Target and Guidance System Diverts Interceptor into Path of Target



Originally, the test plan included passing a second target track estimate to the HOE interceptor, after launch. However, program documentation noted that such a link was not used. The test manager explained that, after problems with the link were reviewed, he concluded that the prelaunch data about the target's path and speed should be sufficiently accurate.

Beacon Homing Guidance Was Implausible

It was alleged that the test was rigged by placing a radar-frequency beacon on the target that communicated directly to a receiver on the interceptor, giving the interceptor the target's location. This was allegedly done in lieu of using data collected by the infrared sensor. However, based on its investigation of the HOE program, DOD reported that the interceptor did not have such a receiver.

DOD technical experts concluded that the alleged beacon guidance was not feasible. BMDO, Army, and contractor scientists we spoke with explained that the hardware required for beacon homing was of a size and complexity that made such guidance implausible. Had a parabolic antenna been used to receive beacon signals, it would have been about 27 meters in diameter. An antenna this size would have been technically implausible and difficult to hide on an interceptor that was less than a meter in

diameter. Interferometer[1] reception of beacon signals was judged equally implausible, as the technologies for such a system would be as risky or riskier than the infrared guidance used. In either case, a separate development, calibration, and testing effort would have had to have been funded, staffed, and concealed while the publicized development of infrared homing proceeded.

We believe that a radar homing interceptor would be equally or more complex and expensive to develop and test than was the infrared sensor. Considerable time, resources, and documentation would have had to be devoted to this alternate sensor, and hidden from test personnel, to carry out a deception. We saw no evidence of this, and we do not think this is plausible.

Finally, the Army's decision to enhance the infrared signature of the target (see ch. 5) is consistent with an infrared homing interceptor.

Uplink Not Used

DOD reported that the communications up-link receiver on the interceptor was not used for HOE 4. DOD analysts calculated that guiding the interceptor in the terminal homing phase using the ground radar's beacon tracks communicated to the interceptor via the uplink would not be plausible, as the radar tracks were too inaccurate. The intercept accuracies demanded by this hit-to-kill program were about a hundred times greater than what was available from radars at the test site.

Program records indicate that problems were encountered with the communications uplink and that it was not used for the test. The test manager explained that, after problems with the link were reviewed, he concluded that prelaunch target data should be sufficiently accurate without updating the target's path and speed.

Data provided by DOD and reviewed by our consultant engineer confirmed that the ground radar's beacon tracks were not accurate enough to be a plausible means to guide HOE to an intercept.

[1]A radar frequency interferometer determines the angle to a radiating target by measuring differences in the signal received at multiple, separated antenna elements.

Were HOE Target Selection and Enhancement Reasonable?

The target for HOE was built using the materials and construction expected of certain Soviet RVs. The target's infrared emissions and behavior during collision were to simulate the Soviet threat. We found that the target and its signature were representative of a leading threat that a HOE-type system would be designed to counter.

Late in the HOE program, in response to uncertainties in the interceptor's sensor performance, the Army decided to increase the target's infrared emissions in the direction of the interceptor to ensure that the interceptor would find it. Specifically, the Army decided (1) to fly the target in a broadside orientation to the interceptor and (2) to heat the target. The enhancement of the target still put its "signature" within the range of anticipated threat signatures. We believe that the decision to enhance the target signature was a reasonable program judgment, considering the alternatives of (1) risking failure of the entire experiment if the target was not acquired or (2) investing additional time and money improving the sensor. It did, however, result in demonstrating target acquisition under less stressing conditions than originally planned.

Target Selection Was Reasonable

The target selected was an existing simulation of a Soviet threat. The target was specifically designed to help understand infrared and radar signatures of the Soviet threat.

Relevant Threat Was Simulated

The target had characteristics similar to a modern Soviet intercontinental ballistic missile (ICBM) RV, a primary threat to Minuteman silos at the time of HOE. This type of RV remains a threat today of sufficient importance to have been the subject of negotiated reductions in the 1991 Strategic Arms Reduction Talks.

The target selected had been developed to support U.S. testing and had been previously used in both radar and infrared sensor tests. Laboratory officials responsible for these targets explained that the RV was designed to behave thermally like a modern Soviet ICBM RV, providing a similar long-wave infrared signature.

Due to constraints of the Minuteman launch booster, the target was smaller than the modern Soviet ICBM RV. Viewed broadside, it presented an area about 88 percent the size of the real target. Thus, the long-wave infrared signature would be proportionally less than that of the real target under similar conditions.

Based on information DOD supplied, the Office of Technology Assessment (OTA) noted in a classified 1987 and unclassified 1988 report that the target "radiated about 10 times more IR [infrared] energy than that expected from today's Soviet RV [reentry vehicle]...." DOD explained that the target was emulating larger Soviet silo-busting RVs, not the small RVs used in OTA's comparison.

HOE Was Not a System Test Against "Reactive" Threats

OTA also noted in 1988 that while HOE demonstrated the technical feasibility of detecting targets against a space background, the United States was not ready to deploy operational exoatmospheric interceptors. OTA noted that threat signatures could be reduced by various techniques.

The laboratory target developers also noted that the HOE target was reasonable for a first demonstration of infrared homing and kill in space. The target did not incorporate all the signature reduction measures that one could reasonably attribute to the Soviets in estimating how they might modify their weapons in reaction to U.S. ballistic missile defenses. Such "reactive" threat measures would need to be accommodated in any formal acquisition program.

At the time of HOE 4, Strategic Defense Initiative planning anticipated 6 or more years of continued research and technology development. Thus, it would be several more years before the United States would decide whether the technology existed to engineer a system to perform HOE functions against reactive threats. Only after this time would the more stringent requirements for operational test realism be imposed.

Decision to Enhance Target Signature Was Reasonable

The HOE test was primarily labeled a demonstration of the homing and kill subsystem (i.e., interceptor) of an overlay defense system. The sequence of critical functions to be demonstrated depended on the interceptor's sensor first successfully finding the target. After finding the target, the interceptor was to demonstrate tracking of the target, homing on the target in two successive data processing modes, and destroying the target. The final function—kill assessment—was to be done using several sensors.

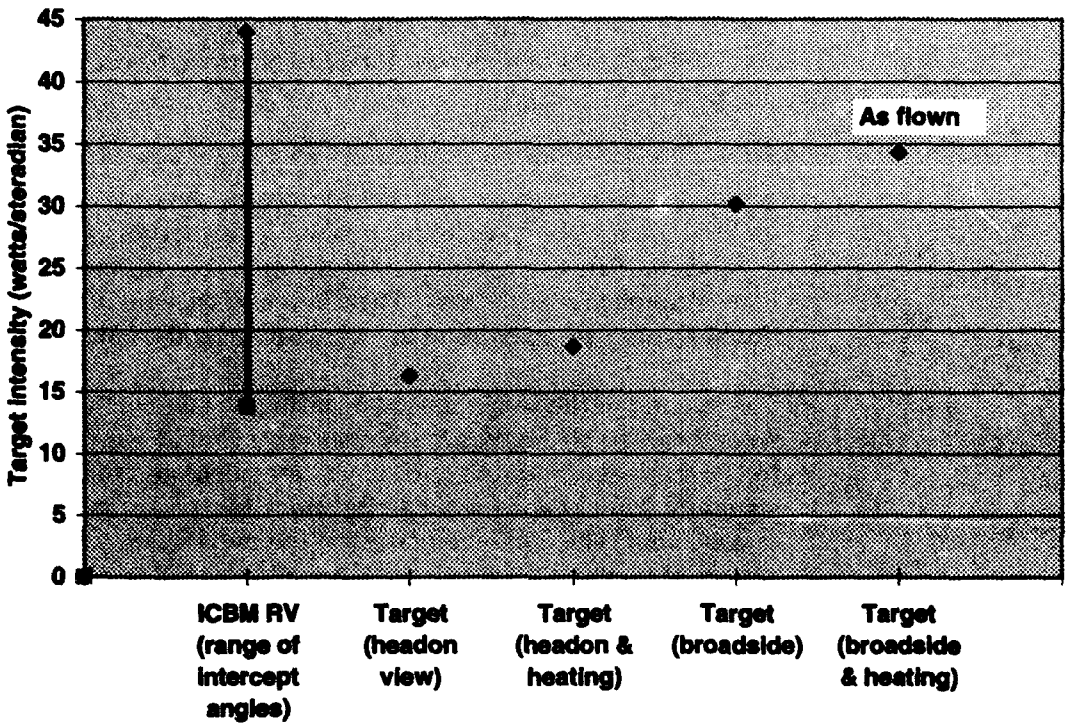
Beginning in 1980, HOE developers were facing problems in fabricating and calibrating the infrared homing sensor for the HOE interceptor. The program manager explained that several months prior to the scheduled first flight, when a worst-case analysis showed sensor performance might

prove marginal, he decided to enhance the target's signature. The enhancements involved (1) flying the target in a nearly broadside orientation to the interceptor at the time of acquisition and (2) heating the target. The enhancements doubled the target's infrared signature, raising it from the low end of expected threat signatures, toward the high end (see fig. 5.1).

The target was flown at a near-broadside angle, which exposed the greatest surface area toward the interceptor's sensor. The infrared energy emitted toward the interceptor is directly proportional to the target's exposed surface area presented to the interceptor's sensor, according to conventional physics theory. This alone increased the target's signature about 85 percent, according to calculations by the laboratory.

The heating of the target involved raising its planned launch temperature from the 70 to 80 degrees Fahrenheit expected at the Vandenberg facility to 100 degrees at launch. The laboratory calculated the increase in target signature from heating alone to be about 14 percent at the time of engagement. The combined effect of the two enhancements raised the signature to about 2.1 times the initial plan, yielding a total increase of 110 percent. Figure 5.1 compares HOE 4 target emissivity with and without enhancements to estimated infrared intensities expected from the modern Soviet ICBM RV.

Figure 5.1: Emissivity of HOE Target and Modern Soviet ICBM RV



Source: A National Laboratory.

The national laboratory provided estimates of modern Soviet ICBM RV infrared intensities over the range of plausible intercept angles and temperature conditions. These ranged from about 14 to 44 watts per steradian,[1] in engagement angles from 15 to 50 degrees. The HOE 4 target's infrared intensity, calculated using flight records of temperature and orientation and using standard optical signature codes, was about 34 watts per steradian in the HOE sensor wave-band. The unenhanced target would

[1]If an emitter in the center of a sphere is emitting in all directions, this is expressed by giving the area of the sphere. In order to measure the intensity of the radiation, the sphere's radius is taken into account. Thus, a steradian is the solid angle (cone) from the center of a sphere taking in about 1/12th of the sphere's surface.

have emitted about 16 watts per steradian toward the interceptor's sensor, according to the laboratory's calculations.

The target signature enhancements removed the opportunity to demonstrate sensor abilities against more stressing targets. As a result, the final program report said that the goal of demonstrating the ability of the interceptor's sensor to pick out a minimum operational target was only partially fulfilled, since the minimum target was not flown.

The enhancement of the target still put its "signature" within the range of anticipated threat signatures. We believe that the decision to enhance the target signature was a reasonable program judgment, considering the alternatives of (1) risking failure of the entire experiment if the target was not acquired or (2) investing additional time and money improving the sensor. It did, however, result in demonstrating target acquisition under less stressing conditions than originally planned.

What Did DOD Say in 1984 and 1985 About HOE 4?

Statements by the Army at its press conference in 1984 following the test and by DOD before congressional committees in 1985 presented HOE 4 as a successful demonstration of the interceptor seeing the target, guiding itself using an onboard infrared sensor, and destroying it with the energy from the direct collision. Both the Army and DOD were careful to indicate that it was an "experiment," or early demonstration, to distinguish it from a formal acquisition program in late stages of development or operational testing. These statements fairly characterize the test's accomplishments, although enhancing the target's signature to increase the probability of locating the target was not mentioned.

Statements at Press Conference After HOE 4

At the press conference on June 11, 1984, the day after the test, the Army stated that it had demonstrated that a nonnuclear interceptor could acquire and track a representative threat RV using the interceptor's infrared sensor and could intercept and kill the vehicle. The Army emphasized the "experimental" nature of HOE. We believe the following excerpts characterize how the Army represented HOE during the press conference.

"What we were trying to do was investigate the capability of intercepting . . . outside the atmosphere close enough so that we could use a non-nuclear kill mechanism in the future. In this case we hit it . . . ."

"[HOE 4] proved that . . . we could see with this seeker at great distances . . . with enough precision to pick up the RV . . . to do the final homing and bring the . . . homing and kill part, directly on line and intercept the reentry vehicle . . . ."

"We have proven . . . with the kind of ICBM [intercontinental ballistic missile] reentry vehicle that we would have to address in the next decade or two, we do know we can pick them up and we can hit them . . . ."

"The HOE program was designed to validate the optical homing technology needed to develop a near-term, non -nuclear capability for destroying an attacker's strategic nuclear missiles outside the atmosphere . . . ."

"[HOE] . . . will fold into . . . the ERIS missile program . . . which is presently in concept definition . . . ."

"This is an experiment. It's clearly an experiment to test to see what we could get from this seeker that we built . . . ."

"[HOE is an] advanced development, technology effort . . . . It's a technology effort, clearly . . . ."

" . . . this is a test bed experiment . . . . We were doing technology . . . we have put together for the experiment . . . piece parts that we [had] in our arsenal . . . without having to invent new machinery beyond . . . the crucial piece, the optical sensor and the mechanism that controlled that sensor in the air . . . . What we were working on is a technology test bed experiment . . . ."

Statements to Congress in 1985

During testimony before various committees of Congress in 1985, the Secretary of Defense, the Army Chief of Staff, and the Director of the Strategic Defense Initiative Organization (SDIO) made statements that were similar to those made in the 1984 press conference. That is, HOE 4 demonstrated that a nonnuclear interceptor could acquire and track a representative threat RV using its infrared sensor and could intercept and kill the vehicle. We believe the following excerpts characterize how DOD represented HOE to the committees.

February 5 statement by the Army Chief of Staff before the Senate Committee on Armed Services:

" . . . we have been conducting some experiments . . . called the Homing Overlay Experiment where we intercept an incoming warhead and destroy it with nonnuclear capability outside the atmosphere. That illustrates that the technology is well advanced."

February 21 statement by the Director, SDIO, before the Senate Committee on Armed Services:

"The HOE technology and the significance of that particular intercept, the first and foremost significance was that we were able to intercept head-on-head, meaning on a warhead coming in at full intercontinental ballistic missile speed, with another nonnuclear warhead that just destroyed by hitting that particular system . . . ."

"We were able to intercept that, and that was the real proof. And what we demonstrated then was the idea that you could use a surveillance system that could move as quickly as one needed and intercept it."

March 15 statement by the Director, SDIO, before the Senate Committee on Armed Services:

"I think a much more accurate interpretation of our technological demonstration was that we demonstrated that we could intercept a warhead coming in at nearly 15,000 miles [per

hour] closing velocity, that is an incredible rate, and that meant that our guidance system had to be a [high performance] guidance system, and it demonstrated that we had the technology to be able to see that warhead on the way by using infrared techniques."

March 18 statement by the Director, SDIO, before the Senate Committee on Armed Services:

". . . the Army Homing Overlay Experiment demonstrated the capability of a non-nuclear missile to intercept and destroy an incoming warhead outside the earth's atmosphere."

". . . the Homing Overlay Experiment (HOE), successfully demonstrated the feasibility of nonnuclear kill of reentry vehicles. This experiment formed the basis for the ERIS demonstration program."

March 19 statement by the Director, SDIO, before the House Committee on Armed Services:

". . . last June, the Army Homing Overlay Experiment demonstrated the capability of a nonnuclear missile to intercept and destroy an incoming warhead outside the earth's atmosphere."

April 2 statement by the Director, SDIO, before the Subcommittee on Defense, Senate Committee on Appropriations:

". . . I would like to start by talking about a demonstration that gives us confidence in a mature technology, this was that flight of the Army Homing Overlay Experiment last June where we successfully "hit a bullet with a bullet" for the first time."

"I know you are familiar with this. This was an experiment that was built on technology and investment that was started a long time ago. It was certainly not weaponized."

"What happened in space and here is what we really demonstrated: The ability to accurately strike with a non-nuclear warhead."

"It was good enough, and here is the first thing we demonstrated, to see a warhead, not a rocket—it didn't have to have a rocket exhaust, but a warhead with its inherent heat even before it struck the atmosphere, against the blackness of space. That was the first thing . . . ."

"The second thing is that we could maneuver in such a way that we could strike this thing right on the nose. Now, we did have this device which came out [and] had little balls on it and had it even hit out here on the edge, it would have destroyed it, but we hit it right square on the nose."

"Now, you see the very active maneuvering so that it can hit square. That is the next difficult job that we demonstrated, that kind of effective guidance system—you can't stay with it very well—and then the intercept."

"What we showed is that we can intercept in space with non-nuclear means."

May 7 statement by the Director, SDIO, before the Subcommittee on Defense, House Committee on Appropriations:

"Last June we hit a bullet with a bullet. We did that with an experimental apparatus. We fired a missile out of Vandenberg Air Force Base and then we fired an interceptor missile out of Kwajalein —."

"To give you a feel for that, nobody tried to productionize it and we are not trying to productionize."

"We were concerned with keeping it at low cost, but still had to accomplish that technical challenge. That is yesterday's technology."

June 25 statement by the Secretary of Defense before the Subcommittee on Defense, Senate Committee on Appropriations:

"As you know, we have destroyed one missile by firing another missile at it."

Statements by the Army at its press conference in 1984 following the test and by DOD before congressional committees in 1985 fairly characterize the accomplishments of HOE 4. These statements presented HOE 4 as a successful demonstration of the interceptor seeing the target, guiding itself using an onboard infrared sensor, and destroying it with the energy from the direct collision. However, the statements do not mention the steps taken to enhance the target's signature to increase the probability of locating the target.

Comments From the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE

WASHINGTON, D. C. 20301-2000

POLICY

JUN 27 1994

Mr. Frank C. Conahan
Assistant Comptroller General
National Security and
International Affairs Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Conahan:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, entitled--"Ballistic Missile Defense: Records Indicate Deception Program Did Not Affect 1984 HOE Test Results," dated June 13, 1994 (GAO Code 707036), OSD Case 9673.

The DoD has reviewed the draft report and concurs without further comment. The DoD appreciates the opportunity to comment on the draft report.

Sincerely,

Linton Wells II
Deputy to the USD(P)
for Policy Support

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