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Report to Congressional Requesters

June 1986

STRATEGIC DEFENSE INITIATIVE PROGRAM

Status of Airborne Optical Adjunct and Terminal Imaging Radar

130468

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National Security and
International Affairs Division

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June 23, 1986

The Honorable Lawton Chiles
The Honorable J. Bennett Johnston
The Honorable William Proxmire
United States Senate

This report is in response to your request for information on the status of the Strategic Defense Initiative Organization's technology validation experiments on the Airborne Optical Adjunct (AOA) and Terminal Imaging Radar (TIR). These experiments, being managed by the Army's Strategic Defense Command, are designed to demonstrate that technology is available to develop effective sensors for a terminal phase ballistic missile defense system.

The Strategic Defense Initiative is the Department of Defense's (DOD's) program to determine the feasibility of developing a defense against nuclear ballistic missiles. The program envisions a layered defense system, that is, a system capable of destroying a ballistic missile during any phase of its flight--boost, post-boost, midcourse, or terminal.

Information about the two experiments is summarized in this letter. Further details are included in appendix I.

AIRBORNE OPTICAL ADJUNCT

The AOA consists of a Boeing 767 airplane, a long wave infrared sensor with a signal processor, data processor, and other components. The objectives of the experiment are to (1) demonstrate the resolution of critical technology issues associated with the development of airborne optical sensors, (2) establish a technology base from which further airborne optical sensor development can proceed, and (3) reduce the risk of any future full-scale engineering development. The experiment is expected to demonstrate that component technologies can be developed and integrated into a system which can acquire, track, discriminate, and transfer the data (deleted).[1]

The Army Strategic Defense Command awarded the AOA experiment contract to the Boeing Aerospace Company on July 31, 1984. The contract was for a 5-year period of performance and included development of two different

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[1]Classified information has been deleted from this report. A separate classified report has been issued (GAO/C-NSIAD-86-22).

optical sensors and the data processing hardware and software. (See fig. I.3, p. 10.) The total estimated cost of the experiment was $416 million including $289 million for the Boeing contract and $127 million for other support and funding reserves. Boeing subcontracted development of the sensors to Hughes Aircraft Company and Aerojet Electro Systems, and the data processing hardware and software development to Honeywell Incorporated. The development effort is focused on resolving the functional, hardware development, and phenomenology issues associated with an airborne optical sensor.

About 1 year after the contract was awarded, Boeing identified a potential contract cost overrun of about $103 million. As a result, the experiment was significantly restructured by cancelling the development of Aerojet's sensor. The Army decided to continue with only the Hughes sensor because it was less risky. The Aerojet sensor, although more technically advanced, represented more of a technical challenge. Initially, the Army had hoped to continue with both sensors, but the cost increase was too much.

According to the AOA project manager, restructuring the experiment resulted in (1) loss of competition in designing an airborne optical system, (2) loss of demonstrated validation of one technology issue, (3) a smaller industrial base for this technology, and (4) no backup sensor if the other design does not work. However, the project manager is confident that the major objectives of the experiment can still be achieved under the restructured program. The total estimated cost of the experiment was increased to $524 million, an increase of $108 million.

Army officials told us that they had expected a cost overrun, but were surprised by the magnitude of the overrun and how soon it occurred. According to both Boeing and Army officials, the potential overrun occurred because Boeing did not have a good understanding of the technical complexity of the program and because of the pressure to bid low created by the competitive environment under which the contract was awarded.

TERMINAL IMAGING RADAR

The TIR experiment is to demonstrate a ground-based, phased-array, X-band radar that can (1) receive data from the AOA, (2) acquire and track targets, (3) discriminate between threatening and non-threatening objects, (4) provide information to help interceptors find and destroy reentry vehicles, and (5) assess reentry vehicle damage. The objective of the experiment is to demonstrate the capability to correctly identify reentry vehicles in time for interceptors to destroy them before significant damage is done. Although the Army has been conducting ballistic missile defense research and development for years, most of this effort has focused on defending targets such as Minuteman silos which have been hardened to withstand nuclear blast. Defending soft targets such as industrial centers and people will mean intercepting the enemy warheads at much higher altitudes so that ground damage will be limited even if the warheads detonate. This means that the radar will have to discriminate between the threatening and non-threatening objects at the higher altitudes. (Deleted), but the Army now believes that the X-band radar will provide the needed capability.

The TIR experiment contracts were awarded in June 1985 to Westinghouse Electric Corporation and the Raytheon Company for preliminary design work. In December 1985, the Army exercised options under the contracts for detailed design of the radar. Current plans are to select one of the two contractors in December 1986 to build the radar hardware and conduct the experiment at Kwajalein Missile Range.

The TIR experiment was recently restructured because the funding for fiscal year 1986 was reduced from about $49 million to about $29 million. To stay within the reduced budget and to avoid slipping the experiment schedule, (deleted). However, the officials said that the performance requirements eliminated from the experiment will have to be developed during a future development phase. Therefore, reducing the technical performance requirements during the experiment could increase the technical risk of any future engineering development. The current total estimated cost of the TIR experiment is $590 million.

CONCLUSIONS

Both the AOA and TIR programs have been restructured and their requirements have been reduced. Requirements that were eliminated from these experiments will have to be included in any subsequent development, thereby increasing the technical risk of full-scale development. Past experience has shown that deferring the resolution of technology issues to later development phases can be more costly in both time and money. Restructuring these programs will result in less hardware and test results on which to base the decision in the early 1990s of whether to develop and deploy a system. However, both the Army Strategic Defense Command and the Strategic Defense Initiative Organization believe the experiments will still provide adequate information for the decision.

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As you requested, we did not obtain official comments on this report. We did, however, discuss the report with Army and Strategic Defense Initiative Organization officials and have included their comments where appropriate.

As arranged with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of the report. At that time we will send copies of the report to the Secretary of Defense, the Secretary of the Army, the Director of the Strategic Defense Initiative Organization, and other interested parties.

Frank C. Conahan
Director

Contents

ABBREVIATIONS

AOA	Airborne Optical Adjunct
DOD	Department of Defense
GAO	General Accounting Office
SDI	Strategic Defense Initiative
TIR	Terminal Imaging Radar

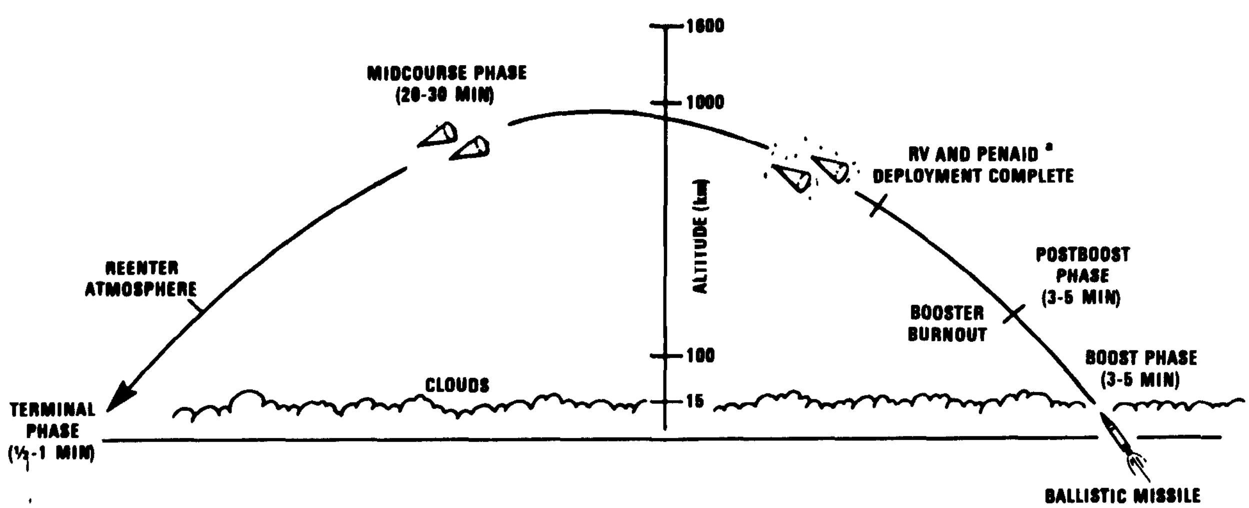
STATUS OF STRATEGIC DEFENSE INITIATIVE

TERMINAL DEFENSE SENSORS EXPERIMENTS

The Strategic Defense Initiative (SDI) is a broad-based research program focused on determining the feasibility of developing and deploying a defense against nuclear ballistic missiles. The initiative was announced by President Reagan in a March 1983 speech to the nation. The Strategic Defense Initiative Organization provides program guidance, oversight, and budgets, but the military services and certain Department of Defense (DOD) agencies execute the program.

The SDI is aimed at demonstrating technologies needed for a layered defense system which could destroy a ballistic missile during any phase of its flight. Generally, a ballistic missile's flight is divided into four phases--boost, post-boost, midcourse, and terminal. (See fig. I.1.)

Figure I.1: Four Phases of an Intercontinental Ballistic Missile Trajectory



[a]Reentry vehicles and penetration aids. Reentry vehicles contain nuclear warheads, and penetration aids are devices such as decoys which are used to confuse defenses.

The boost phase is the time from missile launch until the booster has burned its fuel. It usually lasts from 3 to 5 minutes and during this time the warheads (reentry vehicles) remain attached to the missile.

The post-boost phase begins when the booster has finished firing and also typically lasts about 3 to 5 minutes. During this phase, enemy warheads and penetration aids (such as decoys) are deployed.

The midcourse phase lasts from 20 to 30 minutes during which time warheads and penetration aids travel on a ballistic course above the atmosphere.

The terminal phase begins when the warheads reenter the atmosphere and ends when they detonate at their targets. The terminal phase lasts between 30 seconds and 1 minute.

To be effective, a defense system must find threatening objects and destroy them. The system must be able to detect an attack, discriminate between threatening and non-threatening objects, track the threatening objects, and destroy them. The system must also conduct a "kill" assessment to determine when an object is no longer threatening.

As currently envisioned, each layer of the system will be able to operate autonomously. Each layer is to have (1) sensors for detecting, discriminating, tracking, and guiding interceptors, (2) interceptors, and (3) kill assessment capability. Data obtained by one layer can be passed to and used by succeeding layers.

The Army's Strategic Defense Command is responsible for research and development effort related to ground-based systems for both United States and theater defense. Research and development effort on a terminal defense layer is more advanced than for other layers because the Army had an ongoing ballistic missile defense program at the time SDI was announced. Most of the Army effort under that program was focused on the development of a terminal defense system.

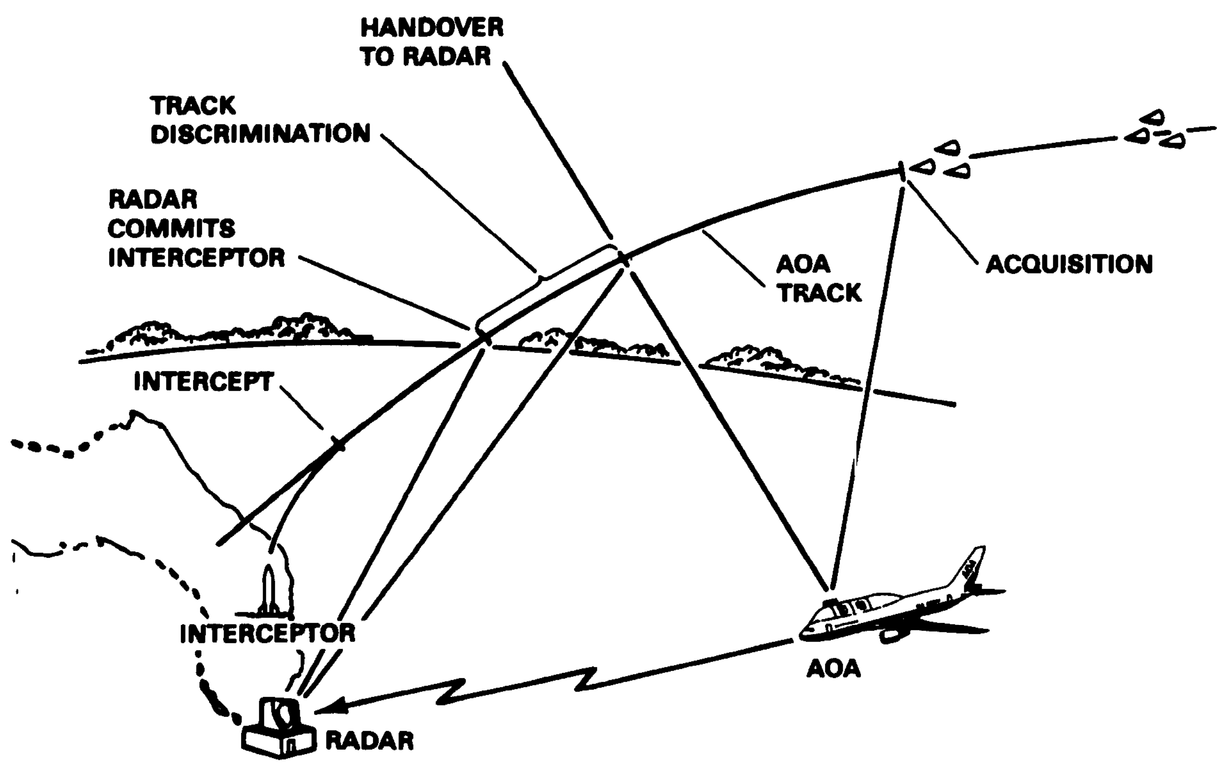
The Army is conducting technology validation experiments to demonstrate the feasibility of developing the sensors and interceptors needed for a terminal defense system. After the individual experiments are completed, an integrated technology validation experiment is planned to demonstrate that the sensors and interceptors can be integrated and properly perform as an effective terminal defense system. The integrated experiment is scheduled for the early 1990s at the Kwajalein Missile Range.

OBJECTIVES, SCOPE, AND METHODOLOGY

We reviewed the Airborne Optical Adjunct (AOA) and Terminal Imaging Radar (TIR) technology validation experiments to determine their cost, schedule, and performance status. The AOA and TIR are the sensors that will be used in the Army's planned integrated technology validation experiment. (See fig. I.2.)

We reviewed the DOD study that identified the need for a terminal ballistic missile defense system and the Army's plans for meeting that need. We reviewed the development plans, acquisition strategies, technical requirements, contracts, and various other documentation related to the AOA and TIR experiments. Our work included visits to contractor plants to obtain their views on the status and progress of the projects. In addition, we discussed various aspects of the projects with the Army Strategic Defense Command and Strategic Defense Initiative Organization officials responsible for managing the AOA and TIR projects. Our work was conducted between August 1985 and February 1986 in accordance with generally accepted government auditing standards.

Figure I.2: Terminal Phase Technology Validation Scenario Concept



STATUS OF AIRBORNE OPTICAL ADJUNCT TECHNOLOGY VALIDATION EXPERIMENT

The purpose of the AOA experiment is to demonstrate that component technologies can be developed and integrated into a system which can acquire, track, discriminate, and hand over the data (deleted). The experiment is expected to:

- --demonstrate the resolution of critical technology issues associated with developing airborne optical sensors,
- --establish a technology base from which further airborne optical sensor development can proceed, and
- --reduce risk of any future full-scale engineering development.

Background

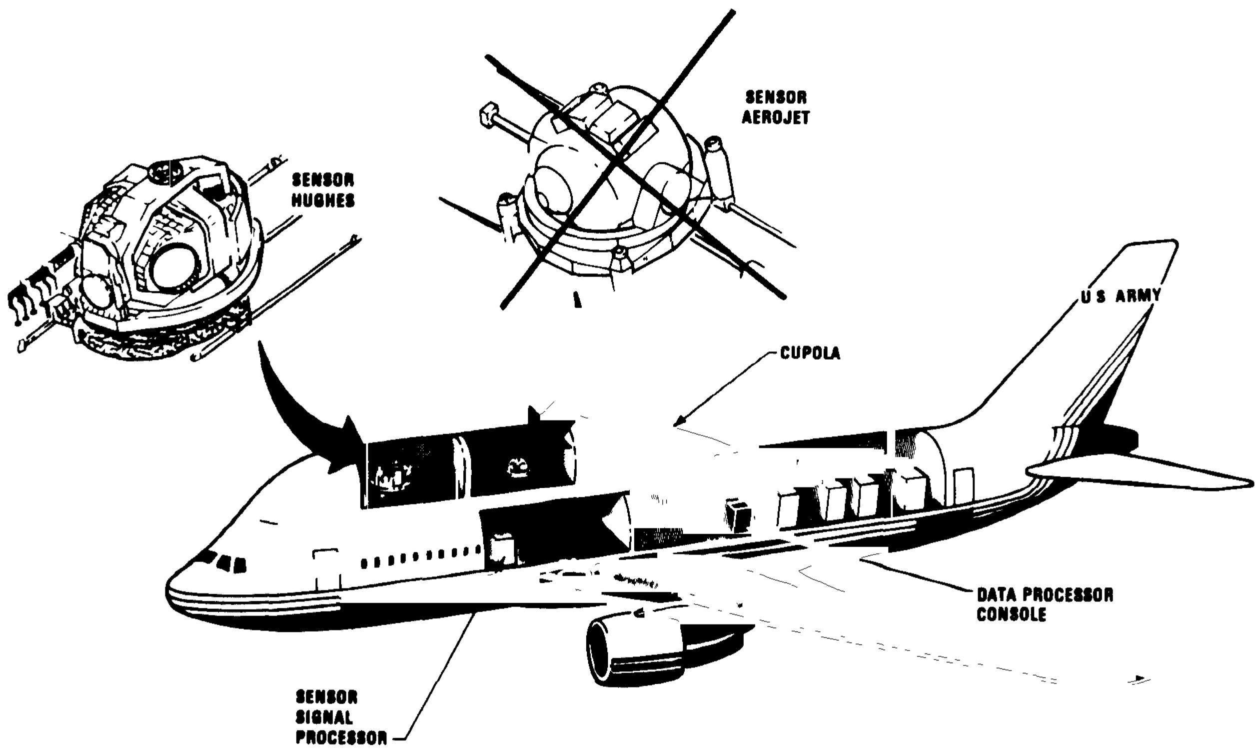
The AOA consists of a Boeing 767 airplane, an optical sensor with a signal processor, data processor, and other components. (See fig. I.3.) The sensor is, in essence, a telescope mounted on the airplane. It detects targets based on the contrast between the heat or infrared energy of an object and that of its surrounding background. The detection process begins when the infrared energy from an object is focused by the telescope on a set of detectors within the sensor. Data from these detectors, or focal plane assembly (see fig. I.4), flow through a signal processor which converts the information to a form which can be used by the data processor. Because the AOA will have only a few seconds to detect and correctly identify a large number of threatening objects, it must process the data from the sensor virtually as soon as it is received.

During a missile attack, enemy nuclear warheads will likely be accompanied by decoys and other penetration aids. To avoid having the defense system shoot at objects which are not a threat, the AOA must distinguish between the warheads and these other objects. This function is performed by discrimination algorithms in the data processing software. These algorithms, which are being developed, will compare what the sensor detects with certain preprogrammed characteristics of Soviet warheads, such as speed and the amount of heat radiated, and decide whether it is a threatening object.

As currently planned, the AOA cannot launch and guide interceptors to destroy threatening objects. Therefore, it must be able to transfer information that it obtains (deleted).

The Army awarded the AOA experiment contract to the Boeing Aerospace Company on July 31, 1984. The contract covered 5-years and required the contractor to provide (1) two separate optical sensors to be installed beside each other in the airplane (see fig. I.3), (2) data processing hardware and software, (3) an airborne platform, and (4) ground and flight tests. Boeing subcontracted the development of the sensors to Hughes Aircraft Company and Aerojet Electro Systems, and the data processing hardware and software development to Honeywell Incorporated. The total AOA experiment, including the prime contract and support from other contractors and the government, is estimated to cost $524 million and is to be completed in late 1989.

Figure I.3: AOA Experiment Hardware



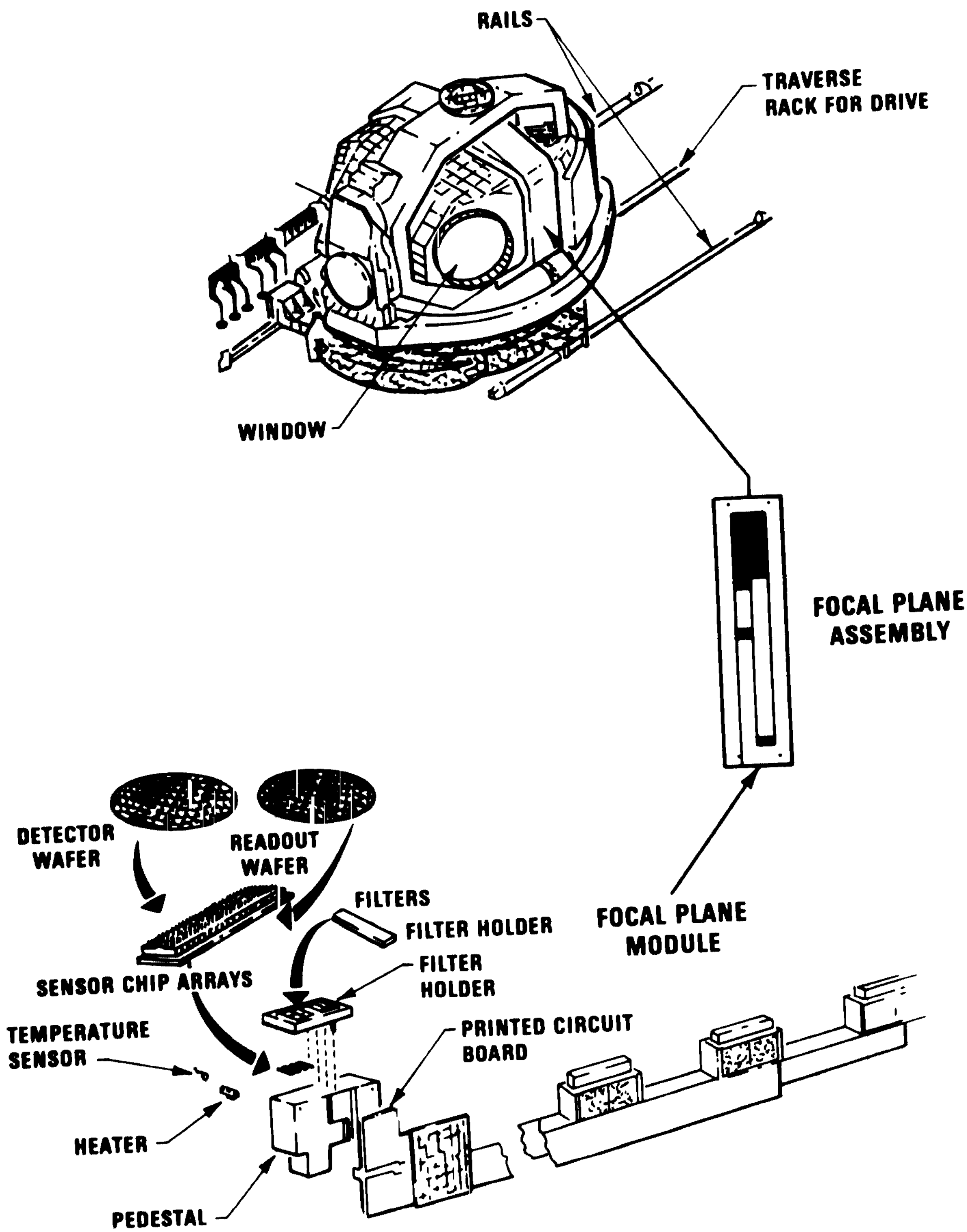
Critical technology issues

One of the major objectives of the AOA experiment is to demonstrate that technology needed to build an airborne optical sensor is available. To be successful, the AOA must demonstrate the capability to acquire, track, correctly identify, and handover information on threatening enemy warheads. The Army has identified the technology issues that must be resolved before the experiment objectives can be achieved. These issues relate to the sensor, data processor, and airborne platform.

The Army conducted a preliminary review of the AOA design in June 1985 and is closely monitoring Boeing's and its subcontractors' efforts to resolve these critical technology

APPENDIX I

Figure I.4: AOA Sensor



issues. The Army is confident that all critical technology issues have been identified and that resolution of them will be demonstrated when system ground and flight tests begin in mid-1988.

Sensor

The Army initially required development of two sensors because it believed that competing sensor designs were important for reducing technical risk and for comparing sensor performance. Competing sensor contractors would also provide a broader technology base in the event a decision is made to develop and deploy a defensive system.

The AOA sensor will require (deleted) detector chips and (deleted) readout chips, plus supporting electronic components, in its focal plane assembly (see fig. I.4) to receive and process information gathered by the sensor. (Deleted.) Therefore, the Army considers this to be a critical technology issue.

The AOA sensor must scan a sector of the sky very rapidly and accurately gather the data needed for detecting and identifying threatening objects. The sensor requires a very accurate pointing and stabilization system to perform this function. One of the major problems is the environment in which the sensor must operate--the vibrations, pitch, and roll of the airplane.

The telescope optics are also a critical element of the sensor. The optics have to be of such quality that they do not degrade the infrared data received from the threatening objects.

Data processor

The design of a highly reliable data processor with the required speed and capacity and within the size, weight, and power constraints of the AOA is a challenging technological task. In addition, the development of algorithms to perform the discrimination and handover functions is a technology risk. Once the AOA detects an object, it must very quickly and correctly identify the object and hand the information over to another defense system. The ability of an airborne optical sensor to do this with the required speed and accuracy is a critical issue.

Airborne platform

The AOA sensor will be mounted in a cupola on top of a Boeing 767 airplane. (See fig. I.3.) It will gather data by looking through an open port in the cupola. The ability of the sensor to accurately gather data through the turbulence produced by the open port is a technology issue. In addition, the sensor will be looking through the atmosphere. The varying densities of the atmosphere disturb incoming optical signals and will affect the accuracy of the sensor.

Restructured program

In July 1985, about 1 year after the AOA contract was awarded, Boeing informed the Army that its latest cost estimate was about $103 million more than the contract amount. Boeing attributed the increase to higher subcontract costs, higher staffing levels and labor rates, and a better understanding of the complexity of the development work.

After Boeing announced the potential cost overrun, the Army conducted a detailed review which confirmed the higher estimate. According to the AOA Project Manager, the potential cost growth occurred because of the competition and Boeing's failure to fully understand the technical complexity of the required work. He said that in the attempt to win the contract, Boeing reduced its subcontractors' bids, proposed inadequate skills and staffing levels in some areas, and did not provide for a required data processing capability. Boeing also omitted some required items such as certain environmental tests, cooling equipment, hardware spares, and a maintenance tower for access to the sensors when the aircraft is on the ground.

The Army had indications of a potential contract cost overrun before the contract was awarded. According to the AOA Project Manager it was not a question of whether there would be an overrun, but of when the overrun would occur and how much it would be. Boeing's proposed costs for the contract were significantly lower than the government's estimates--15 percent lower than the project office's estimate and 29 percent lower than an independent estimate prepared by the Strategic Defense Command's Cost Analysis Office. The Army considered the risk involved and elected to award the contract in light of the funding reserves programmed in future years.

In addition, the source selection cost evaluation team did not believe they had received an adequate explanation from Boeing on the subcontractors' costs and they questioned the labor rates and pricing factors proposed by Boeing. During its audit of the proposal, the Defense Contract Audit Agency found that certain labor rates and pricing factors proposed by Boeing were significantly lower than those recorded on other military programs of a similar nature and size. However, Boeing maintained that the lower rates and factors could be achieved through intense management of the program.

The Army restructured the AOA program to reduce the impact of the cost overrun. After reviewing Boeing's revised estimate, the Army told Boeing to terminate the sensor being developed under a subcontract with Aerojet. According to the project manager, the only way to significantly reduce the program's cost was to eliminate one of the two sensors. The Army decided to continue with only the Hughes sensor because it was less risky: the Aerojet sensor, although more technically advanced, represented more of a technical challenge.

The initial decision was to permit Aerojet to continue development of an advanced technology detector material and to provide one module constructed from this material which could be tested in the focal plane assembly (see fig. I.4) of the Hughes sensor. The Army wanted to retain the advanced detector module because it (1) (deleted), (2) is likely to be more resistant to the nuclear effects that will be present during a ballistic missile attack, and (3) offered the potential for providing the sensor with a longer detection range than the more conventional materials used by Hughes.

However, Boeing's proposal for the Aerojet advanced detector module was unacceptable to the Army. Aerojet's proposed schedule was incompatible with Hughes' schedule, the cost of the Aerojet module work was considered excessive, and there were significant technical issues that would have to be resolved. Based on these cost, schedule, and technical implications, the Army ordered work on Aerojet's advanced detector module stopped. Although the Army has lost the potential benefits of the advanced detector module development as a part of the AOA program, research on this technology is ongoing in other SDI Army and Air Force research programs.

Two sensors would have allowed for demonstration of sensor-to-sensor correlation. Sensor-to-sensor correlation involves two sensors looking at the same object and knowing that they are looking at the same object. (Deleted.)

According to the AOA Project Manager, restructuring the program resulted in (1) loss of competition in designing optical sensors of the size and type needed for an airborne optical system, (2) loss of demonstrated validation of the sensor-to-sensor correlation technology issue (3) a smaller industrial base for this technology, and (4) no backup sensor if Hughes' design does not work. However, the project manager is confident that the major objectives of the experiment can still be achieved under the restructured program.

The contract modification for the restructured AOA program was finalized in December 1985. The program includes development and fabrication of only one optical sensor, and a 4-month extension of the contract--from 60 months to 64 months--for technical performance. Total cost increased by about $108 million--from $416 million to $524 million. In an effort to avoid further cost overruns on the AOA contract, Boeing has assigned a new program manager and Hughes has realigned its management structure to be more responsive should problems arise.

In addition, the restructured contract provides incentives for Boeing to control contract cost. For example, the original contract was a cost-plus-award-fee type. Under the restructured contract, the fee arrangements were revised to include, in addition to an award fee, incentive fees and a cost-sharing arrangement between Boeing and the government. Under these arrangements, Boeing's fee will be reduced unless it controls contract costs. According to the AOA project manager similar arrangements have also been incorporated in Boeing's subcontract with Hughes.

STATUS OF TERMINAL IMAGING RADAR TECHNOLOGY VALIDATION EXPERIMENT

The TIR experiment will demonstrate a ground-based, phased-array, X-band radar that can (1) receive handover data from the AOA, (2) acquire and track targets, (3) discriminate between threatening and non-threatening objects, (4) provide information to help interceptors find and destroy reentry vehicles, and (5) assess reentry vehicle damage.

Background

The Army awarded TIR contracts to the Raytheon Company and Westinghouse Electric Corporation in June 1985 for preliminary design. These contracts were for about $5 million each and covered a 6-month period. The contracts each included an option for a 12-month detailed design phase to follow the preliminary design phase. Those options were exercised by the Army in December 1985, but were for reduced amounts due to fiscal year 1986 funding constraints. At the end of the detailed design phase, the Army plans to select one of the two contractors to build the radar. The experiment is to be completed in early 1991.

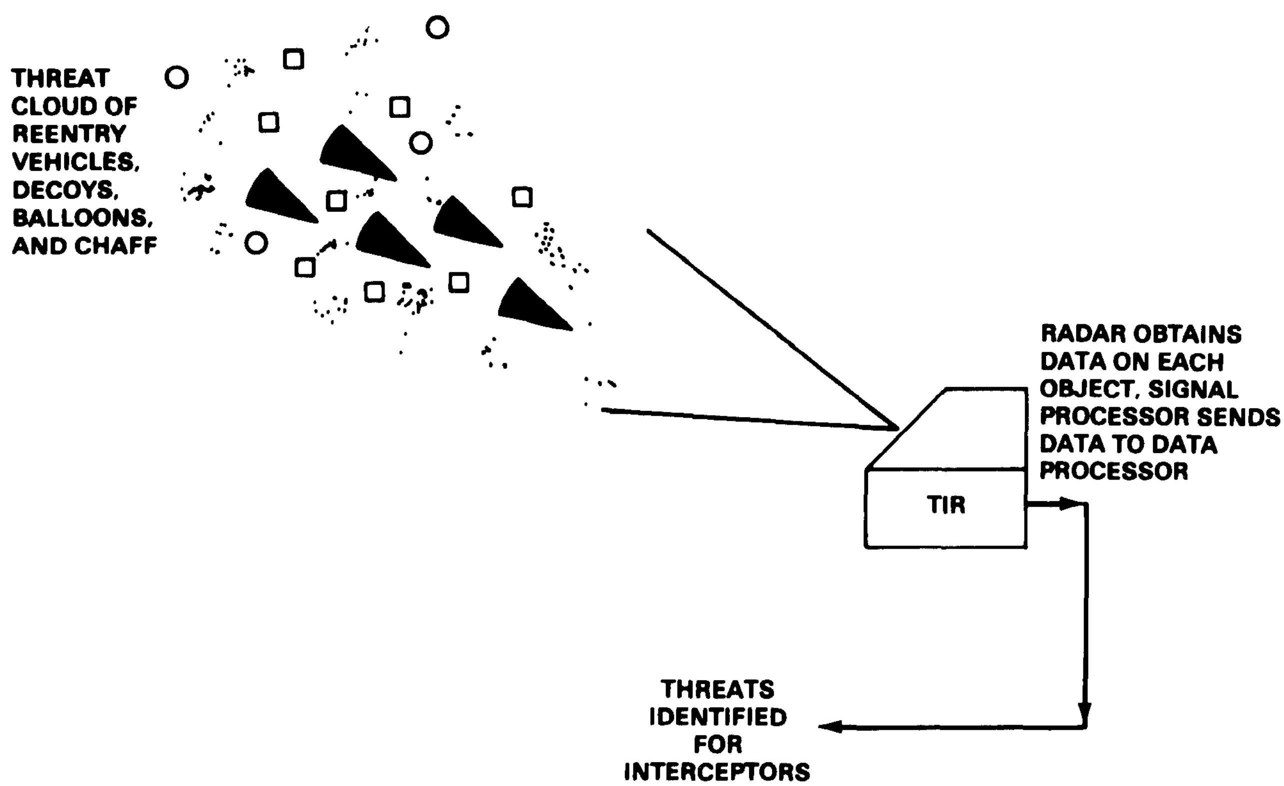
The total estimated cost for the TIR experiment is currently $590 million (fiscal year 1985 dollars). This amount includes the actual costs for the preliminary and detailed design phases and the estimated cost for the hardware development phase as shown below:

	Estimated costs (millions)
Preliminary design phase	$10
Detailed design phase	24
Hardware development phase	556
Total	$590

Critical technology issues

To achieve its objectives, the TIR must detect incoming objects and very rapidly distinguish between threatening and non-threatening objects in the upper atmosphere. (See fig. I.5.) After years of Army ballistic missile defense research and development, an effective discrimination capability at the altitudes that will be required to defend industrial and population centers (deleted). However, the Army now believes that the needed discrimination capability can be developed using an X-band, imaging radar.

Figure I.5: Terminal Imaging Radar



The critical technology issues in the TIR development are (1) building an X-band radar with the power and precision required for discrimination and (2) developing the discriminants to determine whether an object is a reentry vehicle or a decoy.

Terminal imaging radar

The X-band radar will have more power and wider processing bandwidth than previous ballistic missile defense radars. With the additional power and wider bandwidth, the radar can more precisely track and identify enemy warheads. The TIR will be this country's first X-band ballistic missile defense radar.

The ability to generate images of reentry vehicles from radar data has been demonstrated, (deleted).

Originally the Army established some specific technical requirements for the radar. For example, it was required, through simulation, to process information on objects entering the field-of-view (deleted). However, these requirements were changed as part of the restructured program.

Discrimination

Correctly identifying threatening enemy warheads is essential for an effective terminal defense system. The TIR will have an extremely limited amount of time for discrimination. (Deleted.) To achieve a real time operational capability, the TIR will require highly accurate methods for identifying and classifying enemy warheads, and very fast data processing hardware that has a very large memory capacity.

Restructured Program

The TIR experiment was restructured because the Strategic Defense Initiative Organization reduced the Army's funding for fiscal year 1986. The Army requested about $49 million for fiscal year 1986 but received about $29 million. According to officials of the Strategic Defense Initiative Organization, funding for TIR as well as other planned efforts were reduced to implement the lump-sum reduction by the Congress to SDIO's budget request for 1986. SDIO selected the programs to be reduced and the amount of the reductions.

The Strategic Defense Initiative Organization directed the Army not to slip the TIR schedule because such a slip would impact the planned early 1990s decision on whether to develop and deploy a ballistic missile defense system. To stay within the reduced budget and avoid slipping the experiment schedule, the Army (1) reduced the planned work for the detailed design phase and (2) (deleted).

Detailed design phase changes

The Army had originally planned to provide about $24 million to each contractor for the detailed design of each radar. However, because of the reduced funding, it provided $12 million to each contractor. As a result, the scope of work during the detailed design phase had to be reduced. (Deleted.) A number of other reports were also eliminated.

Technical performance requirements reduced

The Army reduced or dropped some of the technical performance requirements of the radar. (Deleted.)

The TIR deputy project manager told us that an objective in restructuring the program was to assure that the experiment's technical objectives could still be achieved. He believes that the objectives are achievable under the restructured program even though the radar will be smaller and less complex than originally planned. However, he said that the technology eliminated from the experiment will have to be developed during a future development phase.

GLOSSARY

Algorithm	A procedure for solving a problem.
Antenna scan angle	The area in elevation and azimuth that a radar antenna is capable of observing to detect targets.
Bandwidth	The range of radio frequencies within a radar signal.
Boost phase	The first phase of an intercontinental ballistic missile's flight. It begins when the missile is launched and ends when the booster rocket has burned its fuel and separates from the missile. Typically, the boost phase lasts from 3 to 5 minutes.
Cupola	A domed structure atop the AOA airplane that houses the sensor.
Data processor	The computer which takes the data or information provided by the sensor and follows a very strictly defined set of procedures and instructions.
Detector	A device that reacts to the energy impacting on its surface.
Discrimination	The ability of a sensor to distinguish between non-threatening objects and warheads.
Focal plane assembly	A group of detectors on which the image of objects viewed by the telescope is focused.
Field-of-view	The area that can be viewed by a sensor.
Handover	Passing information from one device to another.
Layered defense system	The use of multiple layers of a ballistic missile defense at different phases of a missile's trajectory. Each layer is designed to be as independent as possible of the others, and each will probably use its own distinctive set of missile defense technologies.
Long wave infrared	An invisible electromagnetic radiation wave from 0.8 to 1000 microns in length. A micron is equal to one millionth of a meter.

Midcourse phase	The third phase of an intercontinental ballistic missile's trajectory. During this phase, reentry vehicles travel through space on a ballistic course toward their intended targets. This phase lasts from 20 to 30 minutes.
Penetration aid	A device deployed along with reentry vehicles that is used to confuse defenses. The device may be a decoy or anything else that makes it more difficult for the defense to detect and destroy reentrv vehicles.
Phased array	A radar antenna with stationary elements, but with an electronicallv steerable beam that can switch rapidlv from one target to another. This type radar antenna is needed for tracking many targets at the same time.
Pointing and stabilization	The aiming of sensors with the accuracy required to detect and track targets.
Post-boost phase	The second phase of an intercontinental ballistic missile's trajectory. During this phase, reentry vehicles and penetration aids are deployed on ballistic courses toward their intended targets. This phase usually lasts from 3 to 5 minutes.
Radar imaging	An ability of a radar to electronically generate representations of the physical likeness of an object. Imaging may be used to measure and characterize those target attributes that can be used to discriminate between lethal targets and decoys.
Readout chip	A silicon chip that interprets information from the detectors in the focal plane assembly.
Real time	The ability of a sensor to process information on a target without any significant delay.
Reentry vehicle	A container that carries the nuclear warheads.
Sensor-to-sensor correlation	Involves more than one sensor looking at the same target and being able to determine that they are looking at the same target.

Signal processor	The electronic components and software that extracts information from radar or optical sensor's signal.
Telescope optics	The lenses and mirrors of the AOA sensor.
Terminal phase	The final phase of a ballistic missile's trajectory. It begins when the reentry vehicle reenters the atmosphere and ends when the warhead detonates. It usually lasts one minute or less.
Upper atmosphere	The area within the atmosphere above 200,000 feet altitude.

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