Appendix G

Studies of the High Frontier Global Ballistic Missile Defense I

Deployment Costs

High Frontier[1] asserted that its GBMD I constellation of BMD satellites carrying kinetic-kill vehicles could be built using "off-the-shelf" technology and could be "fully deployed in five or six years at a minimum cost of some $10-$15 billion."[2]

However, the Department of Defense obtained a much higher estimate. Shortly after the High Frontier report was published, Dr. Robert Cooper, director of the Defense Advanced Research Projects Agency, commented on the High Frontier proposal for a subcommittee of the Senate Committee on Armed Services:

> . . . The DOD has worked with the High Frontier analysts throughout the development of their concept and supports the basic Damage-Denial goal. However, as hardware developers of war fighting systems, we do not share their optimism in being able to develop and field such a capability within their timeframe and cost projections. We have conducted several in-house analyses and have experienced some difficulties in ratifying the existence of "off-the-shelf components or technologies" to provide the required surveillance, command and control, and actually perform the intercepts within the orbital and physical conditions described. Our understanding of the systems implications and costs would lead us to project expenditures on the order of $200 to $300 billion in acquisition costs alone for the proposed system.[3]

A year later, John Gardner, Director for Defensive Systems in the Office of the Under Secretary of Defense for Research and Engineering, described some of the DOD analyses before a subcommittee of the Senate Committee on Armed Services:

> We have conducted studies, both in the Army and in the Air Force, on the High Frontier concept as we understand it. Generally, those studies were associated with understanding the concept, identifying the technical issues and risks; doing work to optimize the system and estimating the cost for a deployed system as well as its survivability.
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> While we believe that the technical capabilities of the system are certainly appropriately described by the High Frontier, we do have some reservations about the survivability of a system of the kind that has been described.
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> We have looked at system components in some detail. I would say that of the various elements of the system—the spacecraft, the search and acquisition system, and the interception system–I believe that the judgment is that the highest risk would exist in the interception system and in the command and control that would be required to drive and control the whole system.
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> We have made estimates of the cost of such a system, using the costing techniques that are common to the Department of Defense for both defensive systems, space launches, and satellite systems. It is on the basis of the cost estimates that estimates have been made ranging from $50 to $60 billion, and to numbers considerably in excess of that ...4

R&D Costs

Since the initial High Frontier deployments were assumed not to require much further technical development, High Frontier estimated that research and development of the entire GBMD I system would cost only $1 billions This estimate for developing the entire GBMD I system can be compared with $1.275 billion (in 1982 dollars) that the Air Force plans to have allocated over the 19 fiscal years from 1972 to 1990 to develop the air-launched and infrared-guided Miniature Vehicle

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[1]Daniel O. Graham, *High Frontier, A New National Strategy* (Washington, DC: High Frontier, 1982).

[2]I bid., p. 8. Estimates by High Frontier of the cost of its entire program, including terminal defense, two layers of space-based defense. improved space transportation, a space station, a high performance spaceplane, and a satellite power system, total $24 billion in the first 5 years and $40 billion for the first 8 years. The GBMD I portion along, the first space-based layer, is estimated to cost $10 to $15 billion.

[3]Response to question submitted for the record following Dr. Cooper's Mar. 10, 1982, appearance before the Subcommittee on Strategic and Theater Nuclear Forces of the Senate Committee on Armed Services. Hearings on S. 2248, DOD Authorization for Appropriations for Fiscal Year 1983, Part 7, p. 4635.

[4]Hearings before the Strategic and Theater Nuclear Forces subcommittee of the Senate Committee on Armed Services, Mar. 23, 1983, printed in S. Hrg. 98-49, Part 5, Department of Defense Authorization for Appropriations for Fiscal Year 1984, Senate Committee on Armed Services, p. 2668-9.

[5]Graham, op cit., p. 128.

ASAT weapon.[6] However, the ASAT weapon is roughly equivalent to the GBMD I kill vehicle alone,[7] and its development would not address the other requirements of the GBMD I system: the carrier satellites, the system wide surveillance, acquisition, and kill assessment sensors, overall command and control, battle management software and hardware, on-orbit transportation and logistical support, and system survivability.

Moreover, technology developed for the MV ASAT would most likely not be sufficient even for the GBMD kill vehicle it corresponds to. The ASAT is designed to find satellites against the cold background of space; GBMD kill vehicles must operate looking down against a warm earth. The booster's exhaust plume, of course, is much hotter than either the booster or the earth background, but a booster cannot be killed by attacking its exhaust. Either the kill vehicle will need to track some part of the booster itself, or it will need to know where the booster is relative to the exhaust–both of which are more difficult tasks than locating an isolated satellite with nothing behind it. In many cases, the kill vehicle would not be able to reach the booster before burnout, obviating plume tracking.

Area of Coverage

In a background paper done for OTA,[8] Ashton Carter analyzed the High Frontier GBMD I system. He states that, due to the slow speed (1 km/see) of the individual kill vehicles, they would not be able to travel very far during the boost phase of a Soviet ICBM. "[Thousands of satellites would be needed worldwide for continuous coverage of Soviet ICBM fields, " wrote Carter. "The High Frontier concept with only 432 satellites would therefore have meager coverage of Soviet ICBM fields. "[9] He noted that in the only example of boost-phase intercept given in the High Frontier report, '" the kill vehicle would have been launched 53 seconds before its target ICBM was launched, with no explanation of how the defense would know in advance when that launch would occur. Although the High Frontier study also discusses interceptions during the post-boost period, the kill vehicIe sensors postulated for the initial deployment (GBMD I) would not be appropriate for phases following boost phase. Carter's overall conclusion was that

> It would therefore appear that the technical characteristics of the High Frontier scheme result in a defensive system of extremely limited capability for boost phase intercept of present Soviet ICBMs and with no capability against future MX-like Soviet boosters, even with no Soviet effort to overcome the defense.[11]

Overall Capability

On February 21, 1985, 2 years after John Gardner had testified about High Frontier before a Senate Armed Services subcommittee, Strategic Defense Initiative Organization Director James A. Abrahamson appeared before the same subcommittee, Senator Sam Nunn asked Abrahamson about a recent High Frontier claim that **a 95** percent-effective defense could be built using off-the-shelf technology in **5** to 6 years.

Abrahamson did not substantiate that assertion.[12] He stated that the kinetic-kill vehicle concept adopted by High Frontier is considered by SDI to be one of the more mature BMD technologies, and that it could provide part of an initial, partial capability for boost-phase intercept against current ballistic missiles. However, later on in his testimony, Abrahamson indicated that the kinetic-kill vehicles considered by the Strategic Defense Initiative would be solid-propelled rockets traveling five to eight times faster than the High Frontier design. Abrahamson also emphasized that it takes more than a weapons concept to make an overall ballistic missile defense. The full job requires tracking, surveillance, and command and control, and is a more complex issue than was implied by the High Frontier publication that Senator Nunn referred to.

In his testimony, Abrahamson highlighted the basic difference between the High Frontier approach and that being pursued by the SDI. He said

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'From the Dec. 31, 1983 Comprehensive Selected Acquisition Report (SAR) on Space Defense and Operations (A SAT). Figures are corrected from the total given in the SAR (in 1977 dollars) to 1982 dollars using the DOD Air Force RDT&E deflator.

'According to John Gardner's testimony, "the space-based component of [the High Frontier GBMD I defense] does postulate the use of defensive interceptors that take advantage of the technology that is currently being developed as part of the anti-satellite program. "

–Senate Armed Services Committee Hearings, Mar. 23, 1983, p. 2667.

[8]Ashton Carter, *Directed Energy Missile Defense in Space,* background paper prepared under contract for the Office of Technology Assessment, April 1984.

'Ibid., p. 35.

'"Graham, op cit., p. 122.

[11]Carter, op cit., p. 35. According to the Department of Defense, the Soviets are currently developing an ICBM, the SS-X-24, which is similar in many characteristics to the MX. (Soviet *Military Power, 1985.* See pp. 29-30 for data on U.S. and Soviet ICBMs.)

[12]Testimony given below is paraphrased from General Abrahamson's spoken testimony.

that there were two dangerous consequences that could happen should the United States deploy only a partial BMD capability and then stop. First, it might drive the Soviets in precisely the wrong direction, stimulating them to build up offensive forces if they thought that they could overwhelm the defense. Second, if the U.S. system were based on a single concept, the entire system would be vulnerable should the Soviets discover a countermeasure to that concept.

Alluding to the survivability problems mentioned about High Frontier by Gardner 2 years earlier, Abrahamson explained that the SDI did not yet know enough to be confident that a High Frontier-type system could not be countered or easily knocked out. He noted that General Graham did not have the resources available to him to investigate all the countermeasure problems and the command and control difficulties. The High Frontier program could be a good start, Abrahamson said, but he did not know if it would be the best start. At present, he would not recommend that the United States proceed to deploy it.