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REPORT R-122

STRAT-X

In 20 Volumes

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Volume 16

REACTION--USSR STRATEGY (U)

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INSTITUTE FOR DEFENSE ANALYSES
RESEARCH AND ENGINEERING SUPPORT DIVISION
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FOREWORD TO THE STRAT-X REPORTS

The STRAT-X Study was performed by the Research and Engineering Support Division of IDA in response to ARPA Contract DAHC-15-67-C-0011, Task Order T-56. Many individuals, government agencies and industrial organizations furnished information which was used in the preparation of the STRAT-X reports, but the responsibility for the contents is taken by the individuals shown below.

Gen. Maxwell D. Taylor - President, IDA

Dr. Ali B. Cambel - Director, RESD Division of IDA

Dr. Robert H. Fox - Deputy Director, RESD Division of IDA

Mr. Fred A. Payne - Director, STRAT-X Study

Mr. Dewey Rinehart - Chairman, Design Panel

Mr. Phil De Protine - Active Defense System
Mr. Donald D. Cox - Silo System
Mr. James R. Drake - Land Mobile System
Dr. Willy A. Fiedler - Submarine System
Mr. LeRoy E. Harris - Ship System
Mr. Lloyd E. Munson - Booster Design
Mr. Maurice B. Dunn - Payload Design
Mr. Howard Trudeau - Payload Design
Mr. George Gordon - Guidance & Navigation
Lt. Cdr. Paul Cummins - Design Analysis

Mr. Clifford Cummings - Chairman, Reactions Panel

Dr. David Kahn - Unconventional Reactions
Mr. Kenneth Whitt - Sea-Based Reactions
Dr. J. Christopher Nolen - Active Defense Reactions
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Dr. Irving Yabroff - Chairman, Evaluation Panel

Mr. Jason W. Capps - Deputy Chairman, Evaluation Panel
Dr. Ralph Pennington (Col. USAF) - System Analysis
Mr. Wayne M. Allen - Cost
Mr. Willard W. Perry - Payload Analysis
Dr. Benjamin Sussholz - Nuclear Effects

The STRAT-X reports are submitted in 20 volumes listed below.

Volume	Title
1	The STRAT-X Report
2	Design-Active Defense System
3	Design-Rock Silo System
4	Design-Land Mobile System
5	Design-Ship Based System
6	Design-New Submarine System
7	Design-Boosters
8	Design-Payloads
9	Design-Guidance and Navigation
10	Reaction-Fixed Undefended Systems
11	Reaction-Fixed Defended Systems
12	Reaction-Land Mobile System
13	Reaction-Ship Based System
14	Reaction-New Submarine System
15	Reaction-Unconventional Warfare
16	Reaction-USSR Strategy
17	Systems Analysis
18	Nuclear Effects
19	Costs
20	Payloads Evaluation

FOREWORD TO VOLUME 16

This Volume, "Reaction-USSR Strategy", was prepared under the direction of Mr. C. Cummings. Periodic reviews and report critiques were conducted by an advisory group made up of the following members:

Mr. D'Arcy Brent - Vice President, Baird-Atomic Incorporated

Dr. James Robert Burnett - Director, Minuteman Weapon System, TRW Systems Group, BSD

Mr. Carl Duckett - Central Intelligence Agency

Admiral E.B. Fluckey - OPNAV, The Pentagon

Dr. Richard Latter - RAND Corporation

Professor Samuel B. Treiman - Palmer Physical Laboratory, Princeton University

Mr. T. Walkowitz - Rockefeller Associates

Lt.Colonel Jasper A. Welch - Los Angeles Air Force Station

Colonel Ed Wynn - Defense Intelligence Agency

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PREFACE BY THE UNITED STATES

This report is written as if it were a staff study for the Soviet Minister of Defense in reaction to the STRAT-X staff studies being done for the United States on ballistic missile systems for operational use in the 1975 to 1985 time frame. No attempt is made to say that these are the reactions which the Soviets will have, but it is believed that these reactions are feasible from a strategic, technological, and costing standpoint. Indeed, if some U.S. planners fall into the trap of believing these are the reactions they could be very surprised by some other, equally likely reaction.

To the extent that the text of this report suggests to the reader that the authors are privileged to know the reasoning, logic, or details of Soviet decision-making, the reader is especially cautioned to consider these as only some of the many possibilities that do exist. However, these suppositions have not been incorporated blindly, for a sincere attempt has been made to make them consistent with the many observed facts about the Soviet strategic weapons program.

PREFACE BY THE SOVIET UNION

Within this report there is some technical material which represents direct inputs we have received from our Soviet scientists, laboratories, and intelligence sources; for the several STRAT-X basing concepts they have proposed possible reactions. When the United States makes its STRAT-X basing system choice, we expect to again examine all technical ideas directed against that particular system, even if they were rejected in the preparation of the final report of the STRAT-X study.

Our reaction reports to the STRAT-X study (Vols. 11-15, inclusive) largely reflect the best U.S. technology and application.* We approached the problem in this manner in order to gain additional insight into some of the fundamental differences of approach that exist between the United States and the Soviet Union. This volume attempts to put some of the more striking differences into proper perspective. While we have always realized that it is important to remain cognizant of the claims of the U.S. approach lest a major technical advancement in U.S. capability put us at a disadvantage, it has become increasingly obvious that the United States is making a number of serious mistakes by setting some seemingly impossible goals which are perhaps generated by the computer dream world in which it so delights.

Certain key questions which are discussed in this report are given special emphasis in response to a request by General Andrei Antonovich Grechko, Marshal of the Soviet Union and our new Minister

*In the English translation of this report an attempt has been made to convert from the metric system to British weights and measures at least in areas where it will make direct comparison with the U.S. STRAT-X report results easier.

of Defense. After forty-eight years of military service, including command of the Warsaw Pact Forces since 1960, General Grechko thoroughly appreciates the strong interplay between technology and military strategy. Thus, it is a privilege to prepare this report for one who is so knowledgeable and so keenly interested in our work.

I. HISTORICAL BACKGROUND

A. GENERAL NUCLEAR STRATEGIC HISTORY

The Soviet Union has always sought to bring peace to the world, principally through providing an appropriate environment by which the people of the world could provide for themselves the benefits of world-wide socialism. The imperialist forces, dominated by the United States, have continued to try to hold back the inevitable advances of mankind.

Immediately following World War II, the United States embarked on a program to exploit fears of world destruction through nuclear holocaust. They began developing and making nuclear weapons in very large numbers and outfitting medium-range and long-range bombers with these weapons. It was clear that this nuclear destruction capability was aimed at the Soviet Union, and that this nuclear might was being used as a tool to coerce many nations, weakened by the war or otherwise uncommitted, to align themselves with the United States.

The Soviet Union did not choose to react to this threat from the United States by trying to match them bomber for bomber and nuclear weapon for nuclear weapon. Instead, we chose first to establish adequate defense of our country by building up a large fleet of fighter aircraft and by initiating a surface-to-air missile (SAM) development program to help strengthen the long-term active defense force of the Soviet Union against all forms of enemy aircraft. An additional impetus was given to our SAM development program when our radars detected overflights of the Soviet Union by very high altitude reconnaissance aircraft later identified as the American U-2's. As the world now knows, we shot down one of those airplanes with one of our SAM's in May 1960.

In the United States an extensive SAM development and deployment program was carried out to defend U.S. cities and key strategic installations against a potential bomber force which we of the Soviet Union did not choose to build. Instead, we turned to the development of ballistic missiles at all ranges, from a few hundred miles up to intercontinental ranges, in order to meet our commitment to protect the peoples' republics of Eastern Europe from nuclear blackmail and the threat of aggression from the NATO pact. It must be presumed that the U-2 intelligence activities provided the United States with enough information to serve as a basis for recognizing that we had a major program in ballistic missiles under way. The United States' reaction to this was to initiate a crash development program of intermediate-range and intercontinental-range ballistic missiles and to again place themselves in a maximum offensive position.

In the early days of thermonuclear weapon development there was some degree of uncertainty as to how yield varied with the weight of the weapon. Since it was our desire to demonstrate and to have in being a capability for delivering weapons with multimegaton yield, our initial designs of intercontinental ballistic missiles (ICBM's) were both large and conservative. Both of these features have subsequently proven to be of great benefit to us, as we have used this ICBM as the basic booster in so many of our space programs.

When the United States went into its second generation ballistic missile development programs, it was clear that through the use of hardened silos and POLARIS submarines they were attempting to develop their assured destruction capability. The potential effect of these aggressive steps on the part of the United States upon the thermonuclear balance of power has been to cause us to take some similar steps to protect and enlarge our own assured destruction force.

There are those, both in the United States and in the Soviet Union, who feel that we have been allowing the United States to take all of the development initiative and that we have then been using their strategic, conceptual, and preliminary designs for our weapons systems. It is true that in some situations the U.S. work has been quite directly applicable and that we have chosen to use elements of their ideas. On the other hand, there are many items which are so different that they are still totally foreign to the thinking in the United States. Currently, the debate rages in the United States about our antiballistic missile system (ABM)--its technical details, its purpose, and its ultimate total deployment. They seem to be bewildered about our continuing use of cruise missiles.

Concepts in the United States have involved the use of unduly complicated electronic computers to correct for the many parameters which

B. U.S. REENTRY VEHICLES

Since General Grechko has specifically asked us to consider the relative Soviet-U.S. positions on reentry vehicles, it appears appropriate to include a brief historical sketch of the U.S. reentry vehicle program.

The United States does many things in their ballistic missile programs that do not appear to us to be logical or correct. A few of the more puzzling ones are listed below:

(1) Their extreme interest in small reentry vehicles.

(2) Their goal of a perfect decoy as a penetration-aid (pen-aid).

(3) Their recent infatuation with multiple independent reentry vehicles (MIRV's).

(4) Their belief that we, the Soviets, will suddenly switch to the above three as soon as the United States deploys a defensive ABM system.

In order to better examine the unconventional way in which the Americans appear to be developing ICBM's, we shall give a brief history of their ballistic missile reentry vehicle program as it appears to us.

Up to about 1962 the United States was content to build reasonable reentry vehicles. They were of relatively large yield, ranging from Mt depending on the booster, and of reasonable accuracy--contributing around m to the system circular error of probability (CEP). They were inexpensive and reliable.

However, back in about 1960 the Americans began to act as though they believed that we were deploying an ABM system. The result was sheer panic in the United States. During this panic the warheads designers were pushed into the background and the pen-aids specialists gained control of the reentry vehicle development programs. During the transition to pen-aids the United States was forced to build decoys for its existing reentry vehicles. Decoying was chosen as the means of defeating our ABM's for several reasons:

(1) Their existing reentry vehicles were quite "soft".

(2) Decoys were easy to add to their existing boosters.

(3) Electronic countermeasures (ECM) could not be used because the United States had so little information on our radar systems.

During this period the United States discovered that designing a good decoy was not easy and that deploying decoys from existing boosters produced very large decoy trajectory dispersions. Because of this they are driving toward small reentry vehicles in order to facilitate the development of the perfect decoy.

We thus see that the United States is in a very interesting situation: to make perfect decoys they must have small reentry vehicles, in turn small warheads, and in turn large CEP (as we will show) and soft reentry vehicles (as we will show). For more details see Appendix A.

II. GENERAL STRATEGIC CONSIDERATIONS

Although this study is not a war game study or even an attempt to come up with an analysis of the appropriate Soviet reaction to a total United States force posture, it is appropriate to recognize and examine some strategic factors.

It has been said that World War I was the war of the chemists, World War II the war of the physicists, and a World War III will be the war of the behavorial scientists. The International Socialism movement has made it true that the struggle for power throughout the world is motivated and exploited more and more through the introduction and application of changing ideologies. Our position in the military has always been to provide the material weapons and manpower to support the concepts of international socialism and the accepted strategy of conflict with the forces of imperialism.

Our master strategy must continue to be like that of the starfish who wants to open and eat the oyster. First he gets a good grip on both sides of the oyster and gives a firm pull which only slightly opens the oyster shell. The oyster responds by clamping down with its full muscle capability. The starfish waits until he is certain that the oyster has again relaxed. Then the cycle is repeated, time and time again, with very little effort on the part of the starfish and with the oyster becoming more and more desperate with each clamping of his shell until, eventually, he becomes totally exhausted and the starfish easily opens the shell and eats the oyster.

Our policy of encouraging the war in Vietnam has again proven the strategic advantage to us of such action. As the United States becomes more involved with further commitment of men, materiel, and money they are forced to divert some of the best of all three of these from their strategic forces and to delay new strategic developments and deployment. We had hoped to have the Arab-Israeli conflict draw off more U.S. resources. Without a major commitment on our part to fight for the Arabs, our strategic objectives are further fulfilled as we are provided with time to increase our nuclear supremacy over the United States. We must remember that the U.S. policy on strategic forces has changed from insistence on supremacy to allowing us to have parity with them. We will always need to represent our supremacy as parity or else they will feel compelled to escalate their forces to reach that parity. If the Americans continue their current trends in payloads we will have an advantage when we have parity in what they call "equal throw weight".

Over the past two decades, the U.S. position has appeared to us to be one of maintaining overwhelming first strike capability backed up by an assured destruction capability. We have maintained an effective active defense through SAM's and ABM's along with our form of assured destruction capability. We now have an excellent ICBM being deployed in large numbers in hardened sites with a very fine capability of striking back at the soft sites of the United States including its many large cities.

Both the United States and the Soviet Union have an overwhelming capability to overkill each other. However, as our intelligence analysts see it, the United States is following a curious approach to the "improvement" of their MINUTEMAN ICBM force. While increasing the "throw weight" (as they term it) by improving the MINUTEMAN third stage, they then proceed to squander this benefit by adding not more warhead capability, but a myriad of penetration-aids along with a few warheads

The "post boost vehicle", as it is called, must execute these maneuvers with great precision, lest the entire mission be considered a failure. Surely the Americans must have great faith in their ability to develop the required degree of reliability in so complicated a system,

The Americans still seem bent on following aggressor's tendencies however; for, while preaching "deterrence" on one hand, they are desperately trying to develop a "hard target" or "counterforce" capability on the other, as indicated by a growing effort to improve their ICBM accuracy with new reentry vehicle programs such as Mark 17. We, of course, possess a truly deterrent force, as evidenced by the characteristics of our reentry vehicles

In this respect it is also flattering to our reentry vehicle designers that the Americans are seriously considering deployment of a limited or "thin", as they call it, defensive system to protect their MINUTEMAN sites; or perhaps this is an indication that the sites are not nearly as "hard" as they were originally meant to be.

An indication of both our own warhead delivery capability and that of the United States is shown in Fig. 1

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FIGURE 1 Projected Estimates of ICBM Warhead Delivery Capability for the United States and the Soviet Union

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The curious trend shows that the United States, by retiring their TITAN II force and "improving" their MINUTEMAN force, intends to reduce its deliverable yield substantially during the next few years. This is indeed fortunate and shows that the will of the great proletariat shall prevail by a large margin over the bourgeois aggressors. Figure 1 also indicates the great respect with which our defensive systems designers are regarded by the Americans, for it is because of them that the U.S. offensive capability has thus reacted and been severely penalized.

It is interesting to note that the United States has had an ABM system in development for many years now. The political, economic, and strategic impact of deployment of this weapon has been a matter of continuing debate. If it were deployed at the present time or in the near future, it would indeed be effective against our ballistic missile capability. One of the principal technical arguments against its deployment has been that it would be ineffective against a projected Soviet capability in MIRV's. As long as the United States does not deploy this defensive weapon around its relatively soft sites, our assured destruct capability is real. Once they start to deploy it we have plenty of time, in a shorter time cycle, to develop and deploy either maneuvering reentry vehicles (MRV's) or MIRV's for our existing ballistic missiles and thus to perpetuate our assured destruct position.

It is also observed that a large portion of the U.S. population is vulnerable to a bypass or fallout attack which nullifies any advantage of a terminal defense unless accompanied by a large-scale shelter program which they do not appear to be seriously considering. Furthermore, the proposed area defense umbrellas appear to be very susceptible to penetration by low angle or fractional orbit trajectories, a fact which our scientists have demonstrated from an extensive experimentation program. This, coupled to the fact that we currently have this type of penetration ability, allows us a quick response to the initial U.S. deployment of an ABM system. It is only after the ABM system reaches rather high levels of deployment, which would take considerable time, that we would have to field additional weapons beyond the current plans to maintain our assured destruction capability.

The relative numbers and accuracy of the missiles which the United States and the Soviet Union have make it clear that we do not intend at this time to try to knock out their hardened missile sites. At the present time, it becomes necessary for us to keep the number of our hardened missile sites large enough so that even with damage before launch from a U.S. first attack, our assured destruct capability will still be in force. The new basing concepts being considered by the United States place increased emphasis on the possibility that we will attempt to have a first strike or preemptive strike capability adequate to pinpoint the majority of their missile installations and that they must have a capability of surviving during the strike. This is an assumption which can be very expensive to the United States, and therefore we will want to encourage them to continue it even though it is based on the assumption that we will do things as they do.

We do not expect to accomplish our aims by actually going beyond the brink of nuclear war. This would only result in the destruction of our Socialist countries, as well as those we will continue to bring into the Socialist system. Our nuclear capability enables us to utilize our real offensive weapons--our propaganda, volunteer forces (infiltration), and other forms of aid to those countries trying to raise the yoke of capitalism. However, we do need a potent nuclear capability, because we must convince the United States and the world that we are not subject to nuclear coercion of the type that was espoused by John Foster Dulles. We are resolute, strong, and prepared.

Thus, it would appear that we should continue to strive to deter war through multiple techniques which provide us with a high probability of having an assured destruct capability without in actuality having a first strike or preemptive attack capability designed to knock out all U.S. missile sites. Moreover, to the extent that a specialized technique (such as placing a sustained nuclear effects curtain over the entire U.S. ICBM force) is effective we must also be prepared to exploit these techniques. We must always be alert to opportunities.

We must realize the extent of the threat to the Soviet Union which is represented by the new U.S. basing concepts.

The only justifiable reason for planning such large numbers of reentry vehicles and for such small CEP's is to use them in a first strike against Soviet strategic forces (principally our missile sites). It is interesting that the U.S. planners say the Soviets are planning a first strike, do a study ostensibly aimed at deterring us from such action, and end up designing for themselves a first strike capability under the name of an assured destruction force. If they really wanted an assured-destruction-only capability they would not spend any more of their cost-effective dollars on guidance system improvements! As long as they do we must be prepared for them to use their force in a first strike mode.

For the Soviet Union to maintain an assured destruction capability with the threat of the new U.S. MIRV warhead program, it will probably be necessary for us to deploy

We must also give serious consideration in this study to all reasonable ideas including techniques similar to those which the United States is considering in its STRAT-X study.

From the strategic standpoint it is inconceivable that the United States will abandon the NATO countries of Europe as they examine the Soviet targets they visualize striking. It is clear they will want to do everything they can to either negate or blunt our potential striking force against Europe as well as against the United States. Thus, we must expect them to devote more and more effort to methods for striking our mobile medium-range and intermediate-range ballistic missile (MRBM/IRBM) forces. The fact that we are now preparing land mobile ICBM's will probably serve as a further stimulus to the United States in developing surveillance systems with very short intelligence cycle times and very tight coupling to the striking weapons.

During the 1975 to 1985 period, we must recognize that China is potentially as much, if not more, of a threat to our security than the United States. Thus, an assured destruct capability with an active defense system for damage limiting, which is carefully tuned to the threats represented by the United States' new weapons and basing concepts, might conceivably leave us very vulnerable to some other threat. A strategy which we might expect the Chinese to consider very seriously is the unmanned orbital bomb. It is one which they may choose to use in a blackmail and prestige building role. Certainly, if they do deploy this weapon, it would be as a major threat against all their potential enemies. Were we to deploy it ourselves, it could be a very effective diversification of our assured strike capability.

Both sides have chosen to deploy submarine based missiles as an almost certain assured destruction capability. Nevertheless we shall continue to seek methods of positive detection and destruction of each other's submarine based missile forces. The likelihood of being very effective in such an effort appears hopeful during the next decade even though there are many problems.

There has been an interesting and very beneficial aspect of having heavy bombers as a major striking force of each country.

Missiles in hard silos always have the appearance (almost certainly correct) of being ready for action within minutes after any alert or firing instructions are received. With systems of this type it is not possible to observe, in such a force, increases and decreases in tensions of the opposition. If it is the dominant force on either side, then the opposition must operate on a continuous alert and high tension basis. Thus, if the chosen new U.S. basing mode emphasizes a force whose tension level can be measured, and if that basic adjustable characteristic appears to be fundamental to the system, then we should recognize the desirability of having forces on both sides whose tensions are both flexible and observable. Thus, we should seriously consider a comparable basing concept.

III. SPECIFIC STRATEGIC CONSIDERATIONS

It appears the United States has made the following assumptions concerning the Soviet Union for the 1975 to 1985 time period being studied:

In the past, our Soviet Union has had the following nuclear strategy:

We have four basic reactions available to us:

(1) Indifference to nuclear war (no deterrence);

(2) Damage limiting only;

(3) Assured destruction only; and

(4) Assured destruction plus damage limiting.

What we have done provides us with a very adequate force for deployment of missiles. If we are to choose a submarine force as the principal mode of multiplying our assured destruction capability and providing an observable measure of our tensions, then it would appear we would need to put considerable effort into the development of specialized undersea techniques and into the industry which is associated with this technology. We have traditionally been a major land power and have prided ourselves on our love of the land and our capabilities to utilize mobility. We are now recognized as a great power in space. We have the opportunity to also become a great power at sea, but we need not make that choice for we can indeed achieve our objectives through proper deployment of our weapons either on the land or in space.

If the U.S. choice for basing is a Ship Based System or a New Submarine System, we will need to become a stronger sea power if we are to counter their threat and have a damage limiting strike capability against it.

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Both of our countries have realized and exploited the advantage of these

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Table 1. SUMMARY OF POSSIBLE REACTIONS

	Assured-Destruction-Only		Assured Destruction Plus Damage Limiting	
Basing Concept	Preferred Reaction	Alternatives	Preferred Reaction	Alternatives

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techniques

Table 1 summarizes possible reactions to each of the basing concepts (all missiles from each basing concept are assumed to have MIRV warheads with highly accurate guidance for targeting against each of our weapons).

IV. STRATEGIC AND TECHNOLOGICAL INTERACTIONS

Since our capability to react to the next generation of U.S. strategic weapon systems must be operational in 1975, it will be necessary to start to upgrade our concepts and capabilities soon.

Strategic decisions can be based on significant improvements in sensing, analyzing, and communicating data. Improved accuracies, wider bandwidth transmission systems, and lower power requirements will be realistic and available for reaction systems including the espionage and sabotage elements. However, no major breakthrough in weapons can be expected as a reaction means. Thus, no CASABA/HOWITZER, or laser ray gun, or comparable weapon can be assumed in the reaction technology.

A. GUIDELINES FROM STRATEGISTS FOR ANALYSTS AND TECHNICAL DESIGNERS

As guidelines to those preparing the reactions study the following ground rules have been established:

(2) Two natural constraints are to be considered as still valid in this time period:

(a) The current limited access from the Soviet Union to the open seas will continue to exist. (We will not have operational ports in any Warsaw Pact countries.)

(b) Although there may be many nations throughout the world who are friendly toward the Soviet Union, we are not to plan on using any but our own landmass, the open seas, and space for the basing of surveillance equipment and weapons. Any recommended deviation must be fully justified.

(3) Assume the primary U.S. strategy is to strike first against our strategic forces and that their secondary consideration is assured destruction (taking a first strike from us).

(4) There will not be any technological surprise in the U.S. weapons designs. Where the Soviet Union does not yet possess a present or projected technology which the United States will use at that time, we assume the Soviet Union will obtain that information.

(5) It is to be expected that we will be able to obtain all of the design, force structure, and methods of operation details we need for any U.S. basing concept. However, we cannot expect to have, at all times, detailed daily operations plans.

(6) Costing of Soviet Union reactions are to be in terms of U.S. dollars. To the extent possible, the description of the reaction systems should be in sufficient detail to point out methods used in the Soviet Union which are different from those used in the United States so that our systems will not be costed as if they were designed and fabricated in the United States.

(7) The sunk costs of the Soviet Union reactions are assumed to be those which will have been spent on preparing the Soviet Union reaction to current U.S. weapons.

B. THE IMPACT OF TECHNOLOGY ON STRATEGY AND SYSTEMS DESIGN

For each of the U.S. basing concepts there are a number of technologies which need to be considered in terms of their potential contributions to counter the U.S. systems. Many of the required technologies are sufficiently well in hand so that we could start to cut hardware immediately. In each of the basing concepts we find that the potential reaction will invariably involve the combined use of multiple technologies, and in some cases a noticeable improvement in one or two of these could make the Soviet reaction far more effective than it would otherwise be. We have every reason to be proud of the fact that over the years we in the Soviet Union have not only recognized but demonstrated that it is not necessary to make all elements of a new system be new themselves. Rather we have had very fine success by using specific components and concepts in several different systems.

For the next generation of weapons, the United States expects to have significant improvements in warhead technology, guidance systems accuracy and surveillance system sensors, and readout devices and data transmission subsystem technology. We expect to have the same technological advances available to us but in some cases

V. SYSTEMS REACTIONS

The material in this section provides for each of the U.S. basing concepts (1) a description of some of the system options available to us for our reaction force planning, (2) a brief discussion of the presently preferred reaction force(s), (3) the current Soviet situation concerning the required technology, and (4) the areas and extent of required technical effort we must have to make our preferred system technically satisfactory and operationally effective.

Where we list the technologies which are available it must be remembered that both known Soviet technology and known U.S. technology are available for our use. With a few exceptions, no specific identification as to which is which is made when each of these technologies are referred to.

By the time this whole study is completed we will have narrowed the list of potential reactions even more than we have to date. In all cases it must be remembered that the Soviet Union will not be required to carry through with a reaction to all of the basing concepts. When we know which concept the United States finally chooses, we will then be able to focus our attention on the specific reactions necessary to counter that specific basing system.

As our study has progressed we have been examining the costs. On some of the reactions we find that as we have been filling in the details the costs appear to rise quite considerably. However, the largest element in costing a given system usually turns out to be the ground rule relative to the operational cycles. It is abundantly clear that massive reaction systems which are carefully tuned to the threat from the United States need not and should not be maintained on a fully operational basis for a 10-year period of time if their role is to provide for our first strike capability. Some systems [redacted] only require minor enlargement from our current status to provide us with the continuous and total capability which we should have anyway, whether or not the United States comes up with a new basing system or we decide on any specific reaction. In addition, it must be clearly emphasized to our decision-makers that the ability to choose our own time for launching a first strike could lead to considerable improvement in the overall effectiveness of a counterforce attack. This is based upon the normal fluctuations in both maintenance and surveillance effectiveness.

Reaction system costs have gone down drastically when we have found more effective and at the same time less elaborate ideas. In particular, some systems which are only practical in a surge mode look very good from a cost standpoint and of course, in general, do not tip off the enemy ahead of time as to our intended mode of reaction.

One element of our reaction which is common to all the U.S. basing concepts is our ABM systems. While U.S. planners have been calculating and debating the value of ABM systems, we have developed and deployed hardware which gives us a usable area and local defense which we can extend to other locations and to which we can add new developments as they become available to us. We have carried out an extensive testing program in the ABM field at our Sary Shagan test range. Due to necessary security precautions we have not had the advantage of an extended range ABM facility such as the United States has on Kwajalein. We fully understand the capabilities of our ABM systems.*

With the potentiality that the United States will go to MIRV's, there becomes an even greater premium and interest on our part to

*U.S. Editor's Note: This sentence best illustrates a rather perplexing observation that confronts the U.S. analyst reading this document and other Soviet writings, i.e., the problem of what is the real level of communication between Soviet officials and Soviet scientists.

perfect exoatmospheric kills. The very large lethal radius of nuclear weapons outside the atmosphere against post boost vehicles and relatively unhardened warheads of the type the United States is apparently planning to use can make our area kill ABM's quite effective. The mere existence of our ABM capability has induced the United States to try to disperse their reentry vehicles by using busses. It is also interesting to note that the United States does not appear to have any capability of countering large VHF radars from an electronic standpoint and thus will have to depend upon direct strikes against our radars. We, of course, know that the United States is working hard on the development of techniques for reducing the radar cross section of its reentry vehicles. Fundamentally, this is not an easy thing to do, and it is certainly more difficult at the lower frequencies which we use as contrasted to the higher frequencies which the United States uses.

A. DEFENDED, FIXED AND DISPERSED BASING CONCEPTS

For those systems with active defense, the first step is to defeat the defense and then follow by striking the appropriate aim points. In the active defense the key point for attack is the radar because it is the softest point and controls the interceptors.

We have a great deal of experience in developing and building active defense systems against both aircraft and ballistic missiles. For all of these systems we have done considerable analytical work and established key design guidelines. The current experience in Vietnam shows the wisdom of some of these design features.

Thus, the precautionary measures which we took

1. <u>System Options for Reaction Forces</u>

Our experience puts us in the position of being able to recognize potential weaknesses in the active defense systems which the United States is designing and may deploy to defend their new weapons system.

[redacted]

The proper mix of [redacted] will be very much dependent on the final U.S. defense system choices. It is clear that preferential defense of silos and radars can be very costly to us in trying to draw down the U.S. force. Certainly we must plan to destroy the radars first and then the silos. If we use a pure reentry vehicle attack, first on the radars and then on the silos, we will kill [redacted] percent of the U.S. force at a cost to us of about [redacted] If we add [redacted] the cost comes down to about [redacted] The cost for a system which [redacted] the radars, then kills them and the silos, is also [redacted] billion.

3. <u>Currently Available Soviet Technology</u>

[redacted]

Our new Minister of Defense, General Andrei A. Grechko, has appropriately asked us to review again our Soviet position on penetration-aids and to explain to him the basis for the U.S. position on them.

[redacted] The United States has committed a great deal of their strategic concept and of their money, based on this viewpoint. They are in for a rude awakening when their test programs reveal this is not the case and their analysts eventually show that the vehicle dependent effects, which are part of the real facts of life and which cannot be eliminated, make the behavior of [redacted] vehicles very much dependent on other factors [redacted] The United States has gone so far in this concept that even their [redacted] warheads are going to be placed in reentry vehicles whose dispersion is going to turn out to be very large compared to the fantastically small CEP's which they think they are going to achieve.

[redacted]

4. <u>Areas and Extent of Required Technical Effort</u>

[redacted]

[redacted]

In general, we would probably not depend on the special nature of [redacted] as methods for negating U.S. forces, but we will certainly consider them as potentially valuable adjuncts to our prime reaction systems.

B. UNDEFENDED, FIXED AND DISPERSED BASING CONCEPTS

Once the defense for a defended system has been defeated then it appears as an undefended system with the particular set of aim points which are determined by the original defended system concept. From a conceptual standpoint, then, those aim points and the aim points for any other undefended system can be examined. For any fixed aim point the key question is the hardness of that aim point and the appropriate combination of weapon yield and CEP which we must use to defeat it. Another key point is to understand what the weak points of these particular installations are and to consider whether or not that point of vulnerability should be attacked as a prime basis for defeating this system or as an additional insurance to assure the defeat.

1. System Options for Reaction Force

The number of system options against multiple, fixed aim points is really not very great. Although the use of [redacted] could prove effective in a preemptive strike mode against most of the fixed and dispersed basing designs it appears that dependence on ballistic attack is more practical. The use of [redacted] is an additional option for use against fixed and dispersed systems. [redacted]

2. <u>Presently Preferred Reaction Force</u>

Our proposed primary response to fixed and dispersed systems, with or without deception, is the delivery of a ballistic attack on each aim point. In order to make the CEP low, a radio midcourse guidance system and a terminal phase internal sensing system are used.

3. <u>Currently Available Soviet Technology</u>

4. <u>Areas and Extent of Required Technical Effort</u>

In order to go from the present proven capability to about will require considerable effort which will doubtless be worthwhile if we do decide we want a devastating first strike capability against the U.S. weapons. Such an improvement in CEP for the system would provide us with a very effective MINUTEMAN killer and on that basis alone should be pushed. This CEP improvement can apparently be achieved by

We will probably need to increase

C. LAND MOBILE

As avowed enthusiasts for mobility most people would expect us to think a comparable basing system in the United States would be a good idea for them. Not so, because of the asymmetries which work against them. Some of these are: (1) their total available landmass (in the western United States) is less than 230,000 sq km; (2) all their land is available for undisputed free access by anyone in the United States (five million people a year, including foreign tourists, travel through these regions); (3) United States land management and conservationists will force them to operate on "township roads" (laid out on a grid of roads two mi apart), and (4) the chosen desert region is all visible optically a very high percentage of the time.

Our objective is to find a method of getting all of the moving transporter-launchers simultaneously located with sufficient accuracy and soon enough before the arrival of appropriate kill mechanisms so the latter can be directed to the proper kill areas. The potentiality of such a threat has already forced the United States to running speeds of 55 km/hr with a missile about the size of our SS-9.

1. <u>System Options for Reaction Force</u>

The most obvious kill mechanism is a ballistic delivered reentry vehicle for each transporter-launcher. The use of aircraft (currently there aren't any plans to defend this area of the United States against bombers) appears reasonable. The attractiveness of big targets on open land also makes a special clandestine/sabotage effort using simple hand-held weapons look very attractive.

4. <u>Areas and Extent of Required Technical Effort</u>

In this system there is very little which we don't have as basic technology. However, this job represents a very large engineering, development, and deployment effort.

D. SURFACE LONG-RANGE MISSILE SHIP

Currently, everyone on our staff "feels" the Ship Based System will be relatively easy to draw down in the real world. The proponents for the Ship Based System seem to take the view that when they are trapped by one method they will find one more operational tactic or call up some special U.S. Navy help and spring free. This just seems to emphasize how much attention these ships really will get at sea and therefore how relatively easy it will be to keep track of them. They have an unrealistic view that the Soviet threat will be fully known and time will be on their side to work out counteraction. Actually, we will decide what reaction to the U.S. system and what operating modes we want to have and when and how we will employ that reaction!

The U.S. designers suggest that they will counter our reactions by drastic action such as harrassment and driving our tracking ships off, . etc. An accidental loss of one of their ballistic missile ships at sea is likely to be blamed on us and could precipitate a U.S.-initiated war at sea. We do not believe the U.S. system planners will actually implement any basing system which, for its survival, requires the United States to take such irrational, brinksmanship action.

1. <u>System Options for Reaction Forces</u>

For the process of keeping track of the missile ships there are many sensors available. Indeed, it is considered desirable to plan on using most of them in order to keep the confidence level high that all of the missile ships are being kept track of at all times. When they are in any port, they will be identified and thus located; when they leave port, they will be designated by our port watchers. Once out of the port, they may be tracked by the radar on a waiting ship designated to trail them. If necessary, a trail ship may dispatch its helicopters to get higher altitude views with more sensors and to distinguish between some unknown ships and the real one. The advantage of a trail ship is its capability for performing instant kill at the start of hostilities. A trailing ship force [redacted] would have a ten-year cost of about [redacted] It also could carry a high speed interceptor to knock down the first missiles from the ship. Whether or not there is a trail ship immediately available to trail the missile ship out of port, it will be added to the [redacted] If the missile ship is not placed under active trail by a ship with its own helicopter, then it will be overflown for positive identification every few days by aircraft. The deployment by the United States of this system could easily become a very strong incentive for us to base these barrier aircraft in Cuba. [redacted]

It is clear that there are many ways to observe the missile ships; many of them are available at very little cost. Thus the multiple overlay of collection systems will start to build statistical assurance of ship tracking. The magnitude and cost of the total required system can be calculated as soon as some of the uncertainties now associated with surface ships are reduced to numbers (shipping densities, percent transmitting location each day, weather, etc.).

2. Presently Preferred Reaction Force

A multivariate surveillance system is preferred. Tracking will be initiated at port departure and the missile ships will be placed in a radar blip catalog developed from an overhead satellite and ground computer system. COMINT and HF/DF will be used on all transmitting vessels to keep them off our target list. On a daily basis, positive identification of some ships can be made by specific aircraft overflights. When the time for kill arrives, these same aircraft will deliver the weapon to kill the ship. An alternative would be to use our current submarine missiles, deployed in an area coverage mode, launched on the basis of real time radar blip transmissions from the overhead satellites. As the situation demands, more and more sensors will be added at an ever-increasing pace, if need be, to maintain constant track of the missile ships.

3. Currently Available Soviet Technology

4. <u>Area and Extent of Required Technical Effort</u>

E. NEW SUBMARINE SYSTEM

We must assume that the United States will deploy its New Submarines out of U.S. ports and into the proper operating areas in the same way which we have found to be so successful. Presumably they will arrange to have a good steady flow of noisy surface ships which leave the ports containing their submarines, and occasionally they will place one of their exiting submarines underneath it, have it travel well out to sea and then drop off on station.

Detection, location, and identification of very quiet, slowly moving submersibles is indeed a difficult problem. It is accomplished most easily when the ranges from the sensors to the vessel are relatively short . For area search this implies the rapid use of many sensors.

1. System Options for Soviet Reaction Forces

and launching a fast interceptor to kill the first missiles if the United States tries to shoot under such a trail condition.

Although not available as a preemptive mode, another system for drawing down submarine forces is to kill the missiles during their boost phase. The POLARIS/POSEIDON is restricted to operation in about sq km. A proposed system would use in this entire area. Part of the will carry interceptor missiles with very large yield warheads to knock out the missiles with exoatmospheric bursts. During the boost phase the missile is very susceptible to interceptors utilizing fairly crude homing devices, thereby minimizing the requirements on the accompanying radar systems.

The costing of this surge reaction can have large variations depending on costing ground rules and technical performance assumed. Certainly ten-year costs have no meaning in this type of reaction. If we modify existing (in 1975) to our costs will range from about to about to kill off the assuming the most pessimistic number for total deployment area and depending on optimistic or pessimistic assumptions about the performance. If we must buy the that could add Against the New Submarine if we make the pessimistic assumption that we have no knowledge of where to look in the entire sq mi deployment area, and we assume that we must pay and that will be spaced the total cost still amounts to only

3. <u>Currently Available Soviet Technology</u>

Although relatively new, the technology of building very deep submarines is now in being. The USS Dolphin is nearly ready to go to sea and the NR-1, the nuclear powered equivalent, is in construction. This will give the United States a man-rated submarine capable of operation at

4. <u>Areas and Extent of Required Technical Effort</u>

In the past, we have placed a great deal of emphasis on our Naval problems./

APPENDIX A

Many months ago our new Minister of Defense, General Andrei A. Grechko, asked us to examine the U.S. approach to reentry vehicles

FIG. A-1

The prime penetration technique considered by the Americans is that of exhausting defense interceptors and leak-through. They seem to believe that this is the only way to defeat our ABM system. This in turn means that the weight of each object (for a fixed total payload weight) must be low. We must agree that small reentry vehicles are easier to decoy than large ones. However, their present decoys are still not very effective. To obtain many objects, the United States must sacrifice warhead yield. To make up for this they must decrease CEP. This they believe requires high-beta vehicles.

The above is a reasonable philosophy if one is willing to live with the consequences.

This penetration philosophy couples the design of their pen-aids to their estimate of our ABM system. This has created the "threat-of-the-month" as the United States calls it. Every time they imagine something new about our ABM system they must modify their pen-aids designs. This makes the U.S. pen-aids program very costly and time consuming.

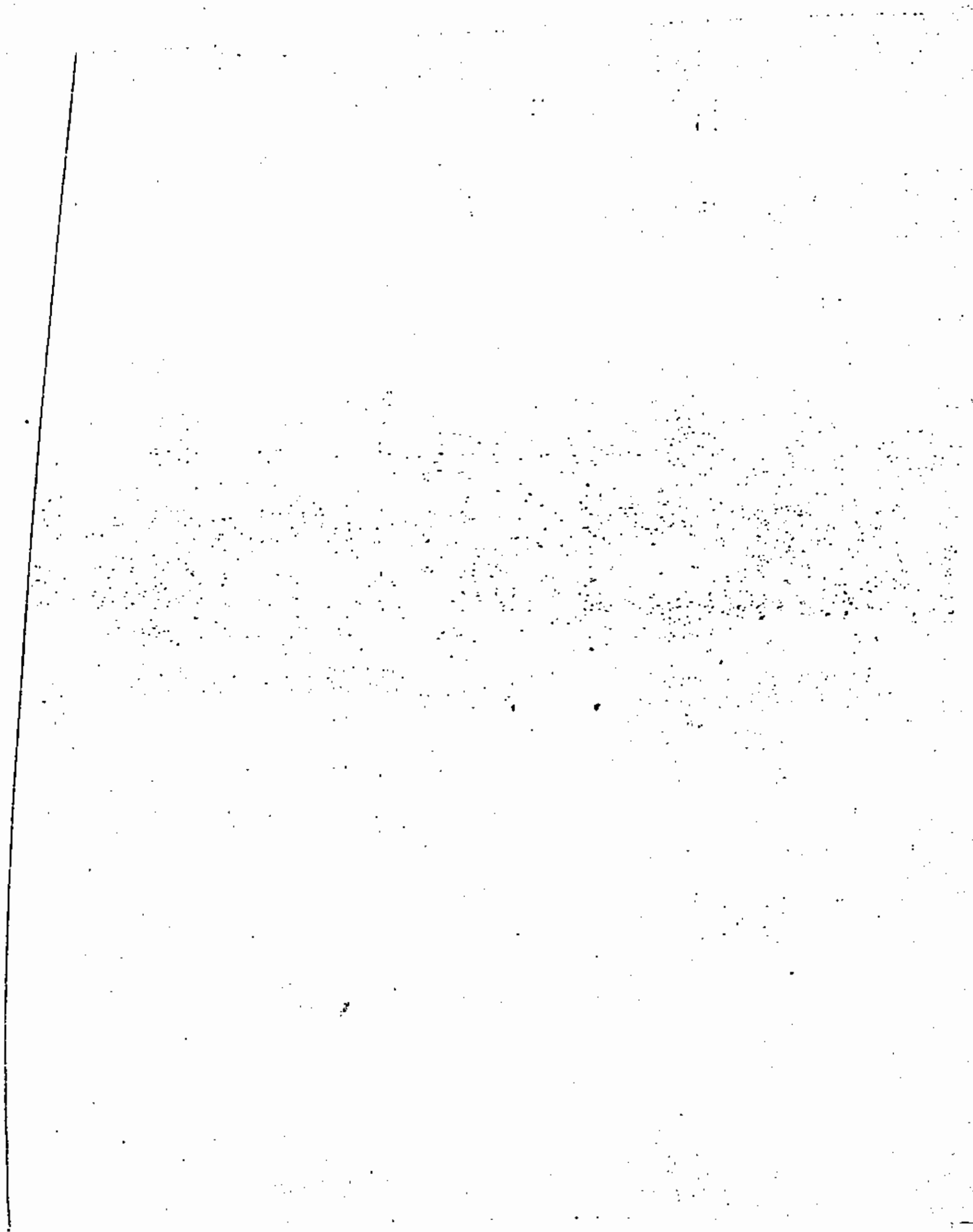


FIGURE A-2 Advantages of Low-β and High-β Reentry Vehicles

One of the most mysterious obsessions which U.S. weapons systems designers seem to possess is their insistence to quote a reentry vehicle accuracy solely as a function of its ballistic coefficient. Moreover, this paranoia is further extended to imply the same about reentry vehicle effectiveness. Therefore, it is held that if we desire to create a counterforce capability,/

Similarly, in the Americans' desire to create such a capability, we observe them attempting the development of high-beta vehicles, thereby substantiating their own conclusions and closing the "logic-loop".

It is certainly true that theoretical calculations indicate a lesser dispersion due to atmospheric uncertainties as the ballistic coefficient of a vehicle is increased. The effect of atmospheric uncertainties which dominate the dispersion of low-beta vehicles, however, is replaced by vehicle dependent uncertainties that come into being as vehicle geometry is made slimmer to achieve high beta and the reentry aerodynamic environment becomes more severe. These uncertainties include asymmetric ablation, center of gravity offset, drag coefficient uncertainty, angle-of-attack effects, etc. In certain cases, these effects can combine (e.g., roll resonance) to give very large target miss, although the miss due to atmospheric effects is negligible.

The Americans have not been able to amass sufficient data to isolate atmospheric errors with confidence due to range instrumentation limitations inherent in an island-supported water impact area and their insistence to launch only in good weather to obtain optical data. They must therefore compute these errors theoretically, and the method they use appears to be quite conservative, i.e., overestimating the atmospheric effects.

They use the following technique to compute atmospheric dispersion:

A typical result is the "atmospheric dispersion" curve shown in Fig. A-3. We have analyzed this method and found that it results in dispersion estimates that are too large. Further, that by taking weather samples from actual target areas, one can reduce the dispersion even more.

The above illustrates how the United States decided that low-beta vehicles are not accurate.

Atmospheric dispersion is only one source of reentry miss distance. Following is an examination of other contributions to reentry errors.

A. DESCRIPTION OF ERROR SOURCES

Consider in more detail some of the factors which cause impact point inaccuracies of a reentry vehicle. Figure A-5 summarizes these

FIG A-3

Fig A-4

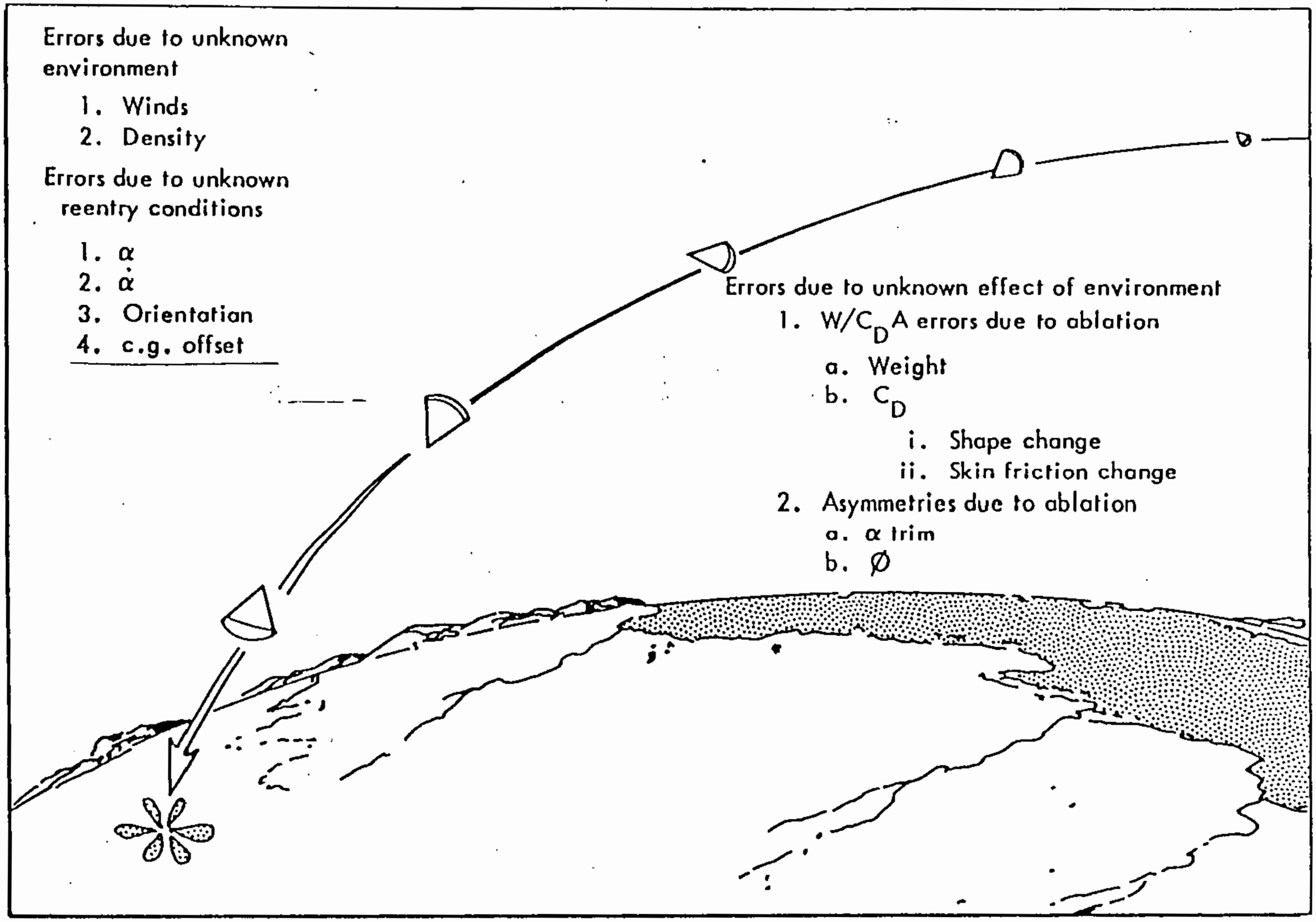


FIGURE A-5 Description of Reentry Error Contributors factors pictorially, showing that the miss distance contributing uncertainties can be grouped into three general categories: uncertainties in initial conditions, the environment, and the effects of the environment.

The initial condition uncertainties include uncertainties in the angle-of-attack of the vehicle, its angular rate, and its inertial attitude or orientation. There are also vehicle dependent uncertainties which can be considered as initial condition uncertainties. These are its mass and shape asymmetries. Furthermore, manufacturing tolerances and quality control errors exist that are inescapable when constructing a reentry vehicle. It is not feasible to construct vehicles without some mass asymmetries and center of gravity offsets.

Next, the interaction of the vehicle with the atmosphere creates additional uncertainties largely due to heat shield ablation. The "effective" ballistic coefficient history throughout reentry is a very complicated function, particularly for sharp vehicles. Understanding of the shape changes due to ablation is important. Also, the asymmetries due to uneven ablation on one side of the vehicle compared to the other can introduce body fixed-trim angles which give rise to phenomena known as roll resonance and roll reversal.

Finally, in addition to the uncertainties which develop during passage through a "nominal" atmosphere, there are additional effects due to uncertainties in the environment itself. The primary uncertainties in the atmospheric environment lie in the density and wind profiles. This is the one error source that becomes insignificant as ballistic coefficient goes up. The wind and density errors are the major portion of the dispersion of low-beta vehicles; this is one reason for the desire to go to higher-beta vehicles. Examples of many of these effects considered individually will be given in the material that follows, without regard to the extremely complicated and multi-faceted nature of their interaction in "real life" when the additional uncertainties due to coupling of these effects is encountered.

B. ANGLE-OF-ATTACK UNCERTAINTY

Figure A-6 shows the effect that an unknown angle-of-attack at reentry might have on impact point error. The plot is shown for vehicles with ballistic coefficients of [redacted], for cases where the vehicles are spinning and not spinning.

The vehicle mass characteristics used for these computations are summarized in Table A-1 and correspond roughly to the [redacted] and [redacted] designs.

Table A-1. CHARACTERISTICS OF REENTRY VEHICLES USED IN ACCURACY STUDY

[redacted]

The aerodynamic characteristics of each vehicle are also used. It should be emphasized here that the [redacted] is used for comparison in these studies only because it represents a vehicle for which relevant data exists. It is not suggested that the results illustrate differences that are solely due to differences in [redacted] of the vehicles to the exclusion of other properties, particularly [redacted]

An unknown angle-of-attack will exist if the vehicle has no attitude control system. The angle-of-attack at reentry of a slowly tumbling vehicle is unknown, the most probable angle-of-attack being 90 deg. However, even with an attitude control system one might still have an unknown angle at reentry due to either its malfunction or perhaps due to a possible perturbation when attacking a defended target introduced by the defense burst. Figure A-6 shows that even for a moderate angle-of-attack, less than 90 deg, there is substantial loss in impact point accuracy due to this effect. It should be noted that the spinning vehicle has a larger impact error than the nonspinning vehicle. This is because gyroscopic forces of the spinning vehicle tend to inhibit the angle-of-attack convergence by aerodynamic forces, and this will result in a greater range degradation due to integrated drag effects than for the nonspinning vehicle.

Our decision is based on the calculations shown in Fig. A-6 and related test results.

One of the primary purposes of rolling a reentry vehicle after separation from the booster is, supposedly, to alleviate subsequent impact point errors due to a vehicle center of gravity offset. As discussed in the roll dynamics section, this is not always successful, but in general it is probably effective for larger vehicles.

C. VEHICLE AXIS ORIENTATION UNCERTAINTIES

Not only does an uncertainty in the total angle-of-attack (relative to the velocity vector) introduce an impact uncertainty, so also does the angular orientation of the vehicle axis with respect to the local horizontal. Figure A-7 shows this effect for the

The band of ΔR, for a given total angle-of-attack, represents the extremes of the miss distance, as the reentry vehicle orientation at reentry is varied from "nose high" to "nose low". Consequently, although the total angle-of-attack remains the same, the orientation with respect to inertial space can lead to an error which may be significant in the context of a hard target threat. Within this context the lines on the previous curve (Fig. A-6) should

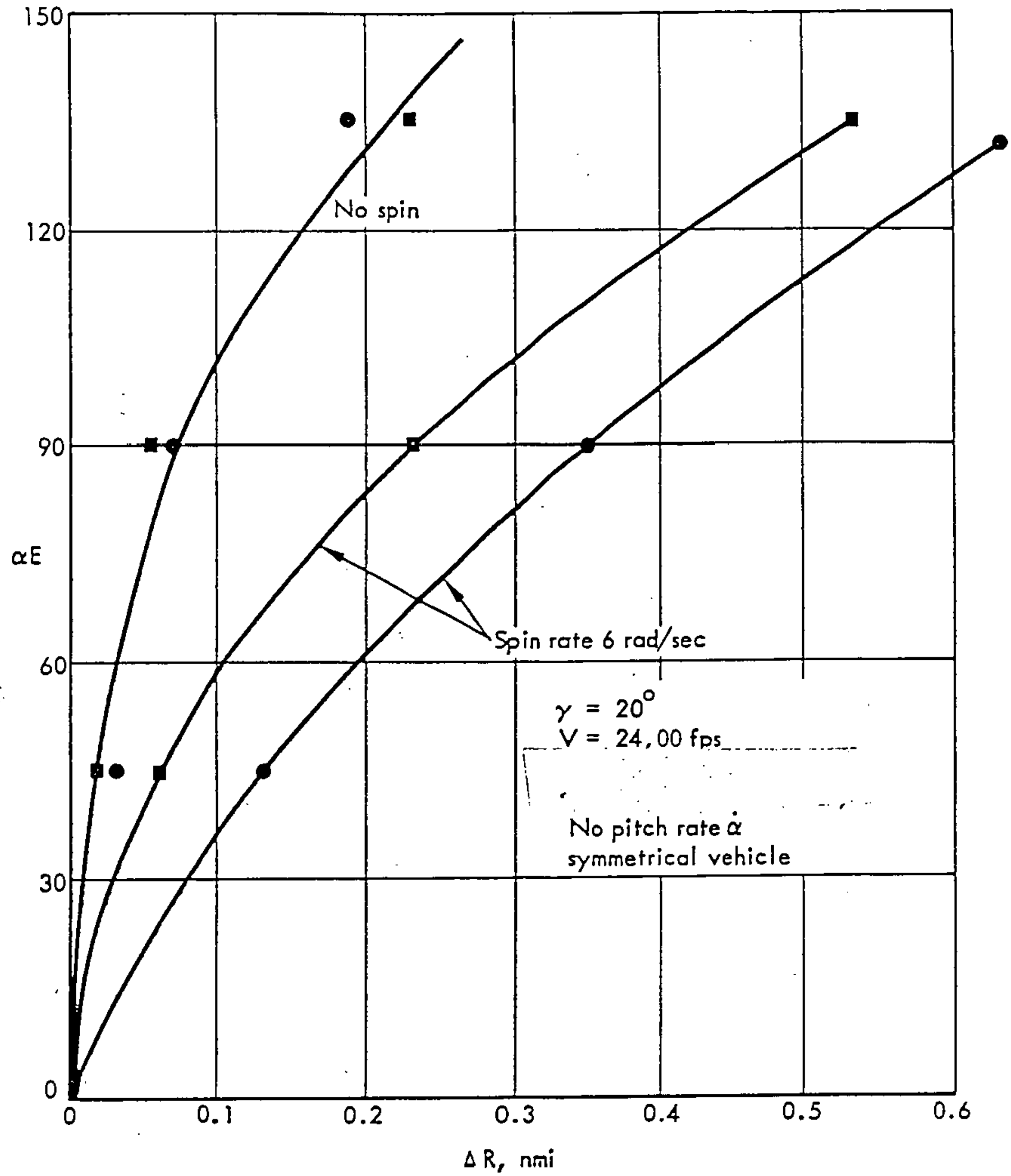


FIGURE A-6 Effect of Initial Angle-Of-Attack on Impact Point Error

FIG A-7

TABLE A-2

also be considered as bands. A feel for typical attitude angles at reentry may be obtained by inspection of Table A-2, which shows the results of some [redacted] The "nominal" cases (1, 2, and 3) had no abnormal separation features, yet an angle-of-attack of about [redacted] was observed. The targeting drag model corrects for the nominal angle-of-attack at reentry; however, as seen from Fig. A-7, the band of uncertainty due to vector orientation gives an impact error of over [redacted]. From the other cases in Table A-2, it is seen that an attitude control system malfunction or nonnominal separation error can result in much higher angles-of-attack, hence quite large impact errors.

D. INDUCED PITCH RATE EFFECTS

Now consider a possible mechanism which would provide an unknown angle-of-attack and tumble rate at reentry. When firing against a defended site some nuclear bursts can be nonlethal but affect the accuracy of the reentry vehicle. Figure A-8 shows the pitch rate due [redacted] This can result in a substantial degradation in accuracy as shown in Fig. A-9. Figure A-9 corresponds to an intercept altitude of 400,000 ft where the angle-of-attack before intercept is zero deg. A pitch rate of a few tenths of a rad/sec can result in a relatively large miss distance at the target, simply due to unexpected drag coefficient modulation. Of course, spinning helps to reduce this effect because of "gyroscopic resistance" to the X-ray impulse torque. The range degradation for a low ballistic coefficient vehicle is also shown for comparison purposes. Note that its error is not as bad as that of the high-beta vehicle, although, again, substantially affected. The reason the low-beta vehicle is not affected as much is because its drag coefficient is not as sensitive to angle-of-attack as in the case of the slender shape.

FIG A-8

FIG A-9

FIG A-10

Figure A-9 considers only the impact error due to pitch rate induced by a nuclear blast. There is also a vehicle translation impulse, of course, which adds a ΔV error. The X-ray impulse calculations were made assuming a Newtonian center of pressure, [redacted] and side aspect burst.

E. ROLL EFFECTS

Now consider another phenomenon which applies more specifically to slender shapes and can result in highly significant impact errors under certain circumstances. The dynamic interaction between the rolling and pitching motions of a reentry vehicle can create a type of motion which is quite significant when exaggerated by the effect of offset center-of-gravity and ablation asymmetries. The phenomenon known as roll resonance occurs when a reentry vehicle rolls at the same frequency as its natural pitching frequency during reentry. Consider the motion of a vehicle as shown in Fig. A-10. The roll rate is nominally [redacted] through midcourse. During reentry it begins to develop a roll torque that is dependent upon the center of gravity offset and the particular orientation of ablation asymmetries. This roll torque can act either to increase the existing roll rate or to decrease it, depending on the orientation of the asymmetry and the center of gravity offset (Δy). If the roll rate is decreased to a negative roll rate it must roll through zero rate. This rolling through zero rate will produce a miss distance because small roll rates (near zero) will not average out the effect of the rotating lift vector. The faster one rolls through zero the smaller the miss distance. The other critical case is when the roll rate becomes equal to the frequency shown on the chart by the dotted line called P_{CR}, p critical. The critical roll rate is defined as the rate at which resonance or lock-in is possible. A resonant or lock-in motion will present a single face of the vehicle to the wind during the resonant motion resulting in more severe ablation asymmetries. The so-called lunar motion which takes place in this stable roll resonance condition can persist to lower altitudes and indeed all the way to impact and

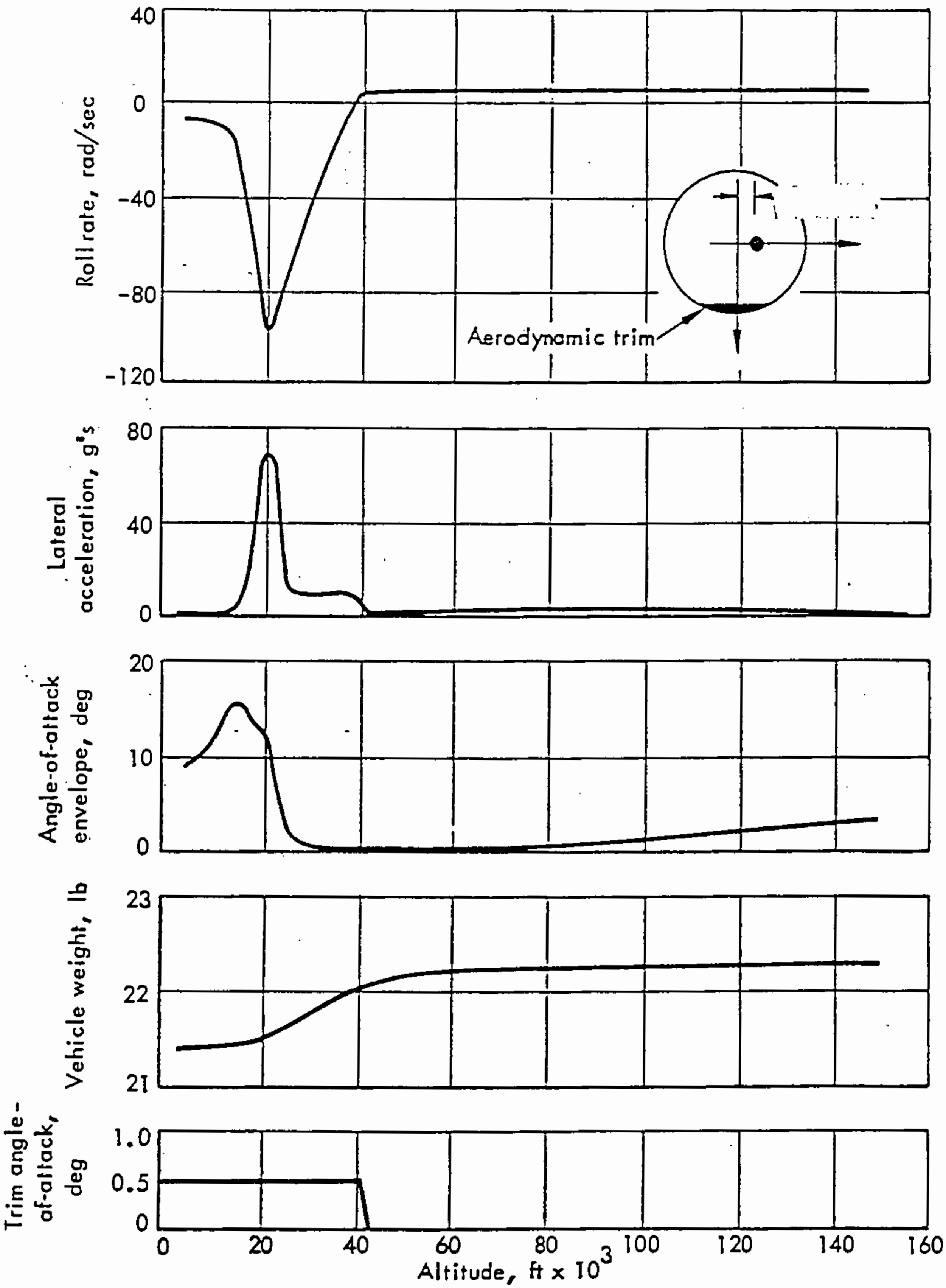


FIGURE A-11 Effects of Trim Angle-Of-Attack and Offset Center of Gravity result in very large miss distances. The occurrence of roll reversal and roll resonance is a phenomenon which depends on the orientation and magnitude of the trim angle-of-attack, the center of gravity offset position, the rolling moment coefficient, and damping in roll.

Figure A-11 illustrates the dynamics of the particular situation. An aerodynamic trim is induced by virtue of asymmetric ablation and cannot be adequately predicted before a flight. The relationship between the trim angle thus induced and the center of gravity as shown creates a roll torque. This roll torque then increases the roll rate until it reaches the critical frequency. The roll coupling phenomenon may then occur. For the calculations shown in Fig. A-11 the body was assumed to be reentering with a constant roll rate as shown on the top portion of the figure. At an altitude of where approximately percent of the total heat shield ablation has occurred, a trim angle of deg was assumed and inserted into the computation. The result of this asymmetric trim created a roll torque which as seen decreases the roll rate through zero and then rapidly increases it in the negative direction to approximately deg/sec at which point it becomes equal to the critical frequency. At this resonant point the total angle-of-attack also increases. This amplification of the angle-of-attack (by a factor of 30 to 40) results in a large lateral acceleration of around As the critical frequency decreases with attitude, the roll rate also decreases, as does the angle-of-attack and the lateral acceleration. It is the lateral acceleration created by the significantly higher drag due to angle-of-attack that creates the impact error. The amount of miss that one might expect for various values of the parameters that characterize roll resonance are shown in Fig. A-12.

The plot shows the degradation in accuracy as a function of the angle between the trim asymmetries and the line through the center of gravity offset as shown on the picture. For example, if the trim angle induced by the asymmetric ablation occurs 90 deg around from the line of center of gravity offset, you

would find that the miss distance can be over [redacted] mi for the case where the trim angle is [redacted] deg and the offset center of gravity is 0.05 in.

[redacted]

Now let us consider the case of roll reversal which was discussed briefly previously. Figure A-13 [redacted] and shows the miss distance that one might get if the vehicle rolls down through zero roll rate. The ellipses shown here are for a [redacted] trim angle-of-attack. This is not a particularly unlikely error in terms of the vehicle uncertainties which could occur. Notice that the rate at which the vehicle passes through zero, that is, the rate of change of roll rate with altitude, is an important parameter in evaluating the miss distance due to this effect. The interior ellipse is where the roll rate change with altitude was high in comparison to the outer ellipse.

FIG A-13

TABLE A-3

FIG A-14

FIG A-5

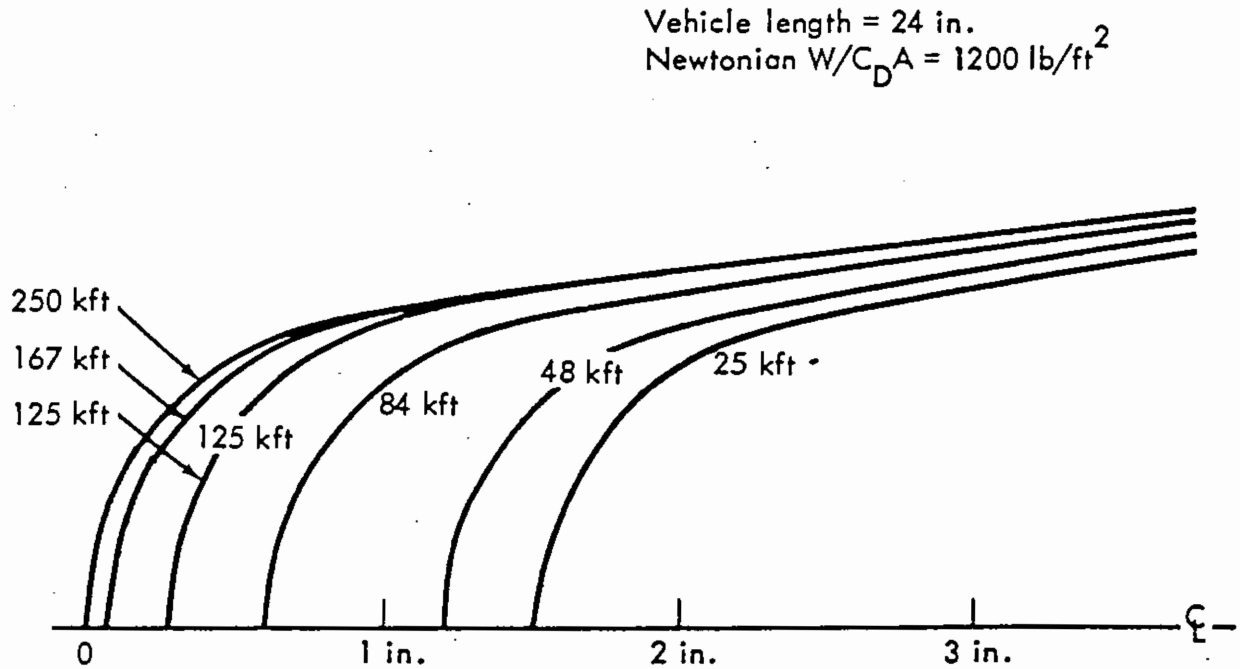
While data on center of gravity offsets and trim angles-of-attack are relatively meager, an attempt has been made to justify the [redacted]

FIG A-16

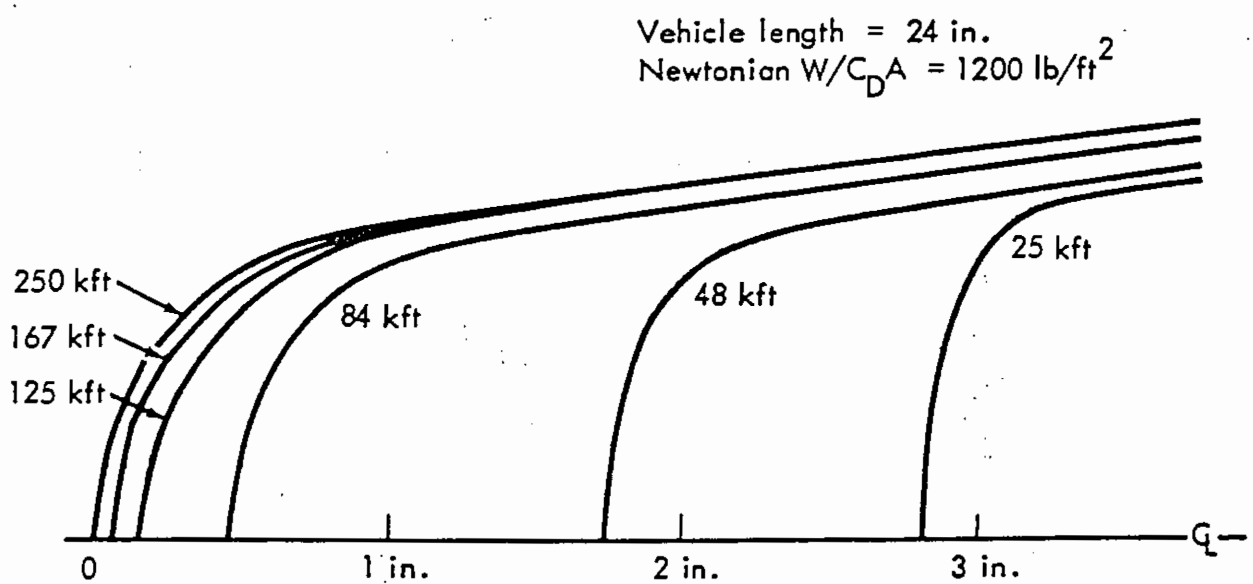
FIG A-17

FIG A-18

The amount of actual flight test data which exists to illustrate the uncertainty in nose tip ablation changes is quite small, and a great deal of effort is involved in attempting to derive theoretical models which will adequately take into account these effects. These theoretical models as yet do not predict asymmetries, and they are



Preflight minimum ablation blunting model



Preflight extreme ablation blunting model

Range difference = 1.49 nmi

FIGURE A-19 Preflight HAPDEC Ablation Predictions

FIG A-20

FIG A-21

FIG A-22

FIG A-23

[redacted]
Considering error contributors such as roll resonance, not only must the magnitude of the ablation asymmetry be predictable but also its location on the vehicle's surface. [redacted]

While in general it appears that small vehicles are more likely to encounter roll coupling there is no reason to a[redacted]er [redacted]

G. NUCLEAR BLAST EFFECTS

Let us assume that the United States is willing to sacrifice weight in order to help solve some of these vehicle dependent problems and that by some miracle they are able to penetrate our defense. Remember, with their small yield, they must target several reentry vehicles to each hard target to be assured of destroying it. The first reentry vehicle will produce a nuclear cloud filled with dirt, rocks, water, etc. The next reentry vehicle must penetrate this cloud. Referring to Fig. A-23, the cloud form for a 4-Mt burst at sea level after 60 sec is presented (this is the smallest yield cloud that we had available). As can be seen, the high-beta reentry vehicle enters the cloud at very high velocities and will probably be destroyed by hypervelocity particle impact unless the reentry vehicles are spaced several minutes apart. This will require that each following reentry vehicle come from a different booster. If [redacted] reentry vehicles are required to destroy a target and they must wait [redacted] min between reentry vehicles, then their attack is spread out over [redacted] min giving us time to alter our defensive and offensive tactics.

Thus, we see that the United States probably does not have the highly accurate weapon that it touts, nor is their "quick reaction" of much use to them. Let us now consider their philosophy of "penetration".

II. HARDNESS

As discussed previously, present U.S. reentry technology appears to be based upon the premise that pen-aids, especially in the form of multiple target objects, are effective as an offensive threat and their penetration techniques will require us to employ multiple interceptors for each actual reentering warhead. The Americans have convinced themselves that by having more reentry objects than we have interceptors they will be able to penetrate our defenses. The fallacies of the U.S. concept of penetration are:

(1 [redacted]

[redacted]

(2) The United States assumes that it takes one interceptor to kill each reentry object and that we will shoot at every object that will reenter. [redacted]

This poses another paradox in the present U.S. technology; i.e., they are intrigued with increased penetration capability, yet their method of achieving penetration is making them more susceptible to damage from our large exoatmospheric bursts. By putting payload weight into decoys (the effectiveness of which is yet to be proven) rather than into nuclear hardness, and by going to low-weight reentry vehicles, our studies show a very large weight penalty if one tries to harden these designs to nuclear effects. It would seem that the U.S. technologists are following a course which is 180 deg to our penetration approach. The United States is forecasted to have, in the future, more weight in decoys and small yield reentry vehicles, all of which are supposed to "soak up" interceptors; [redacted]

We have considered the various exoatmospheric intercept phenomena (Table A-4) and our solution to the problems are as follows (the atmospheric intercept is discussed later).

[redacted]

TABLE A-4

FIG A-24

FIG A-25

[redacted]

The most important kill mechanisms in the atmosphere are neutrons, blast effects, debris, and transient electronic effects. By hardening vehicles to exoatmospheric X-ray effects, we find that the atmospheric blast and X-ray induced transient electronic effects are essentially nonexistent. [redacted]

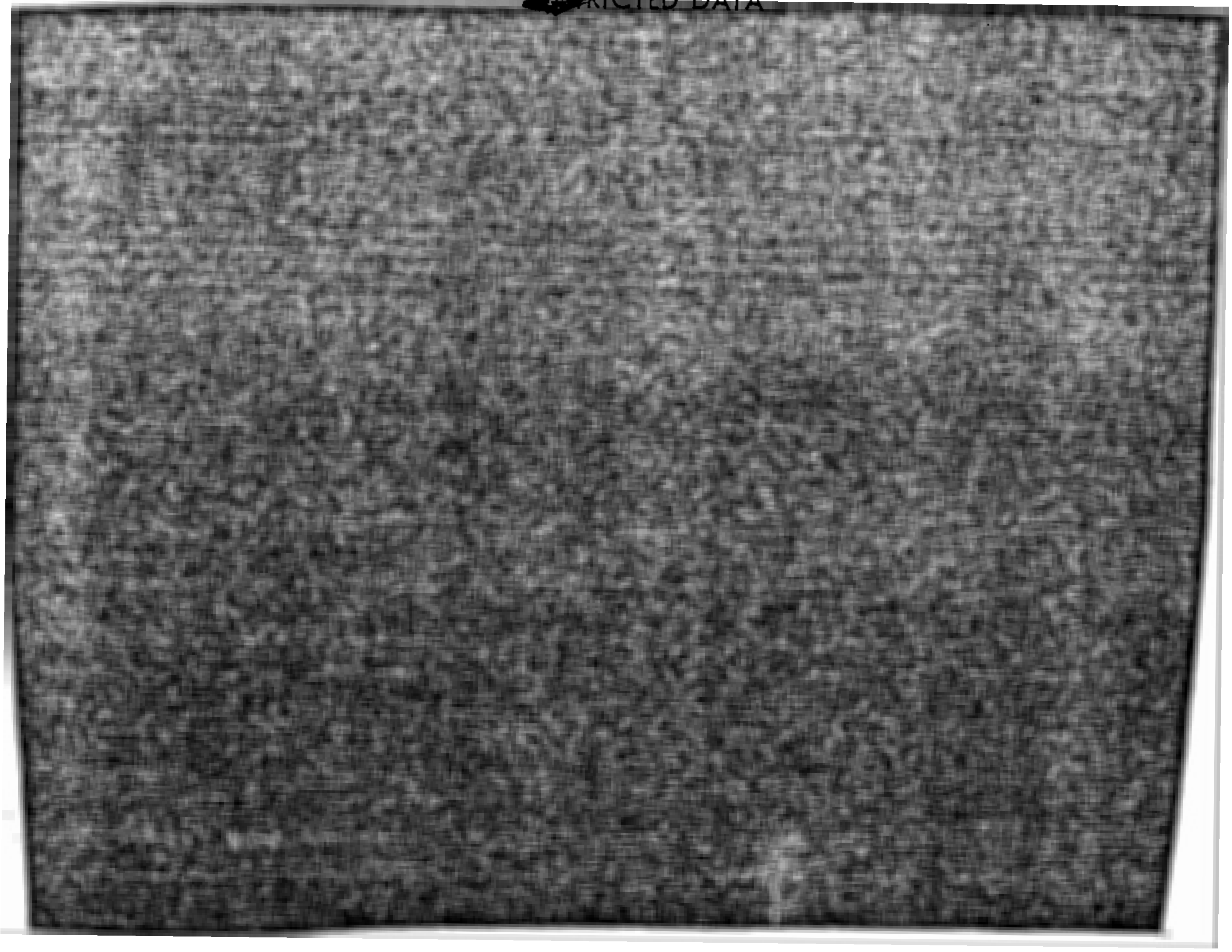
FIG A-26

in a tactical situation wherein nuclear bursts with dust clouds and various wind and density profiles may be prevalent in the target area.

It is important to note that we have given a great deal of consideration to the environment our vehicles will see in the tactical situation. Figure A-23 shows a typical example of a nuclear environment which may exist in the target area. Note that the low-beta vehicle enters the disturbed area with a much lower velocity, hence, has a greater chance for survival. [redacted]

Neutrons, the postulated primary atmospheric kill mechanism, are causing our warhead designers considerable problems. A certain degree of protection against neutrons can be achieved by shielding the warhead with such neutron moderating materials as [redacted] or [redacted] To harden our warheads against neutrons, however, involves considerable penalties both in [redacted] and in [redacted]. This is especially true in the cases of small reentry vehicles [redacted] With large blunt warheads [redacted] the percentage weight penalty

TABLES A-5 & A-6



A. EFFECTIVENESS CALCULATIONS

Lethal radius curves against U.S. 1-Mt exoatmospheric bursts are shown for various hardness in Figs. A-27 through A-29. The effectiveness of exoatmospheric hardening is best illustrated by Fig. A-30 taken from [redacted] design study. This curve shows the number of reentry vehicles required to destroy a defended hard target as a function of reentry vehicle hardness. As the reentry vehicle hardness increases, the accuracy of the interceptor becomes quite important. As the lethal radius of the interceptor approaches its CEP, more interceptors are required to kill the reentry vehicle. If we assume that each target is protected by 10 interceptors, then five successfully launched [redacted] will destroy the target. The American "numbers" method of analysis could result in requiring a minimum of three MINUTEMAN boosters with two Mark 12's each to

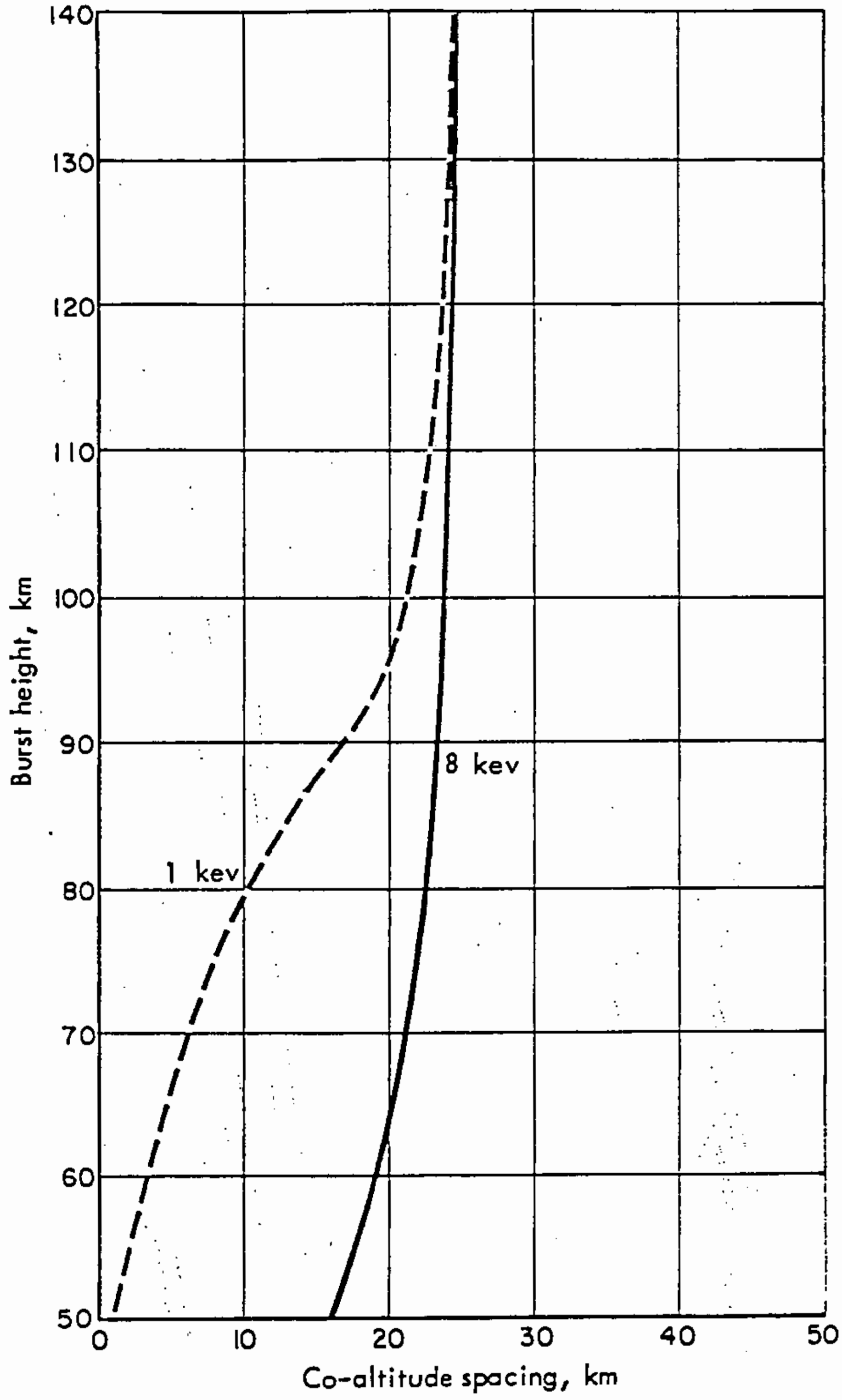


FIGURE A-27 Distance from 10-Mt Burst to 100 cal/cm^2

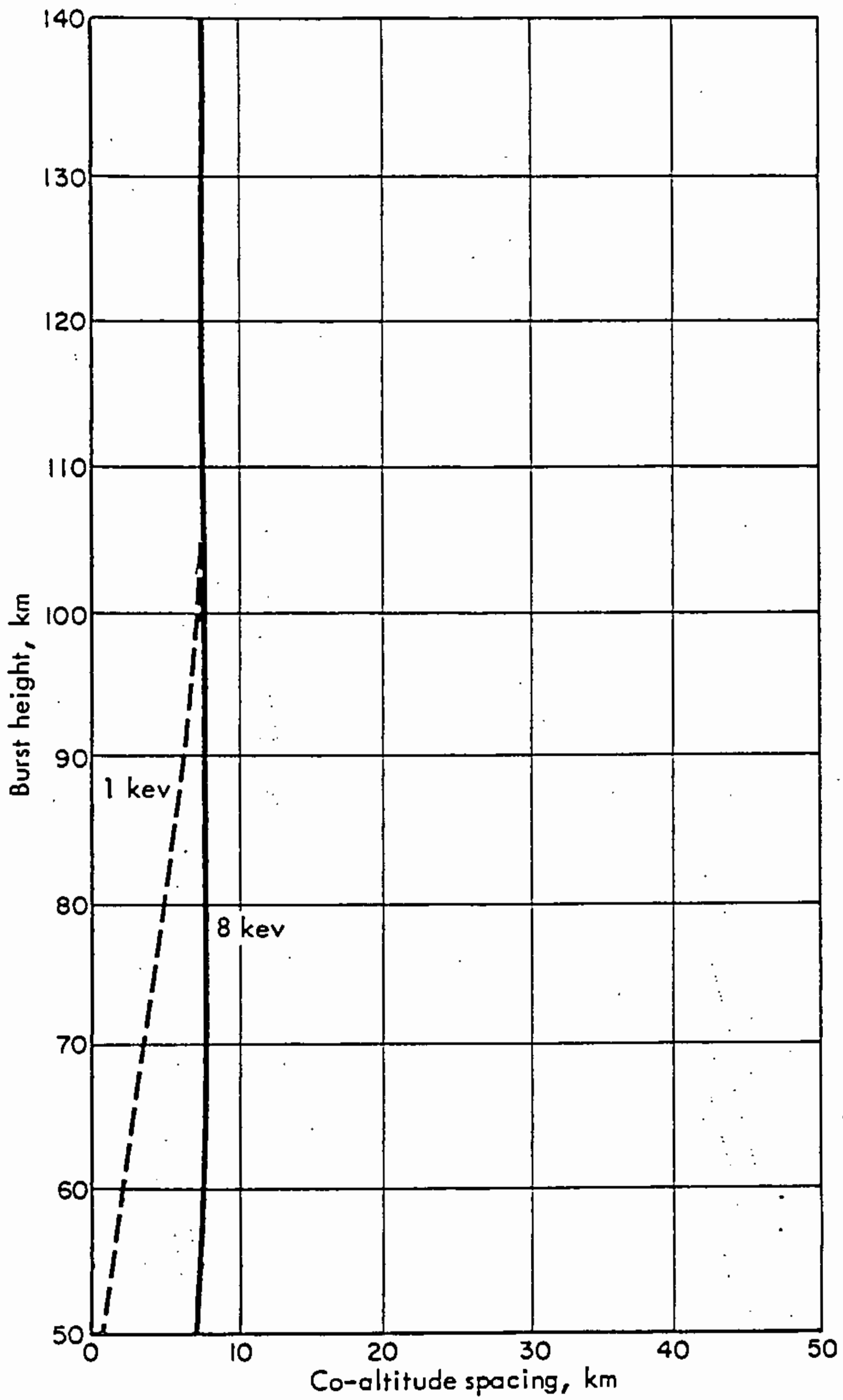


FIGURE A-28 Distance from 10-Mt Burst to 1000 cal/cm^2

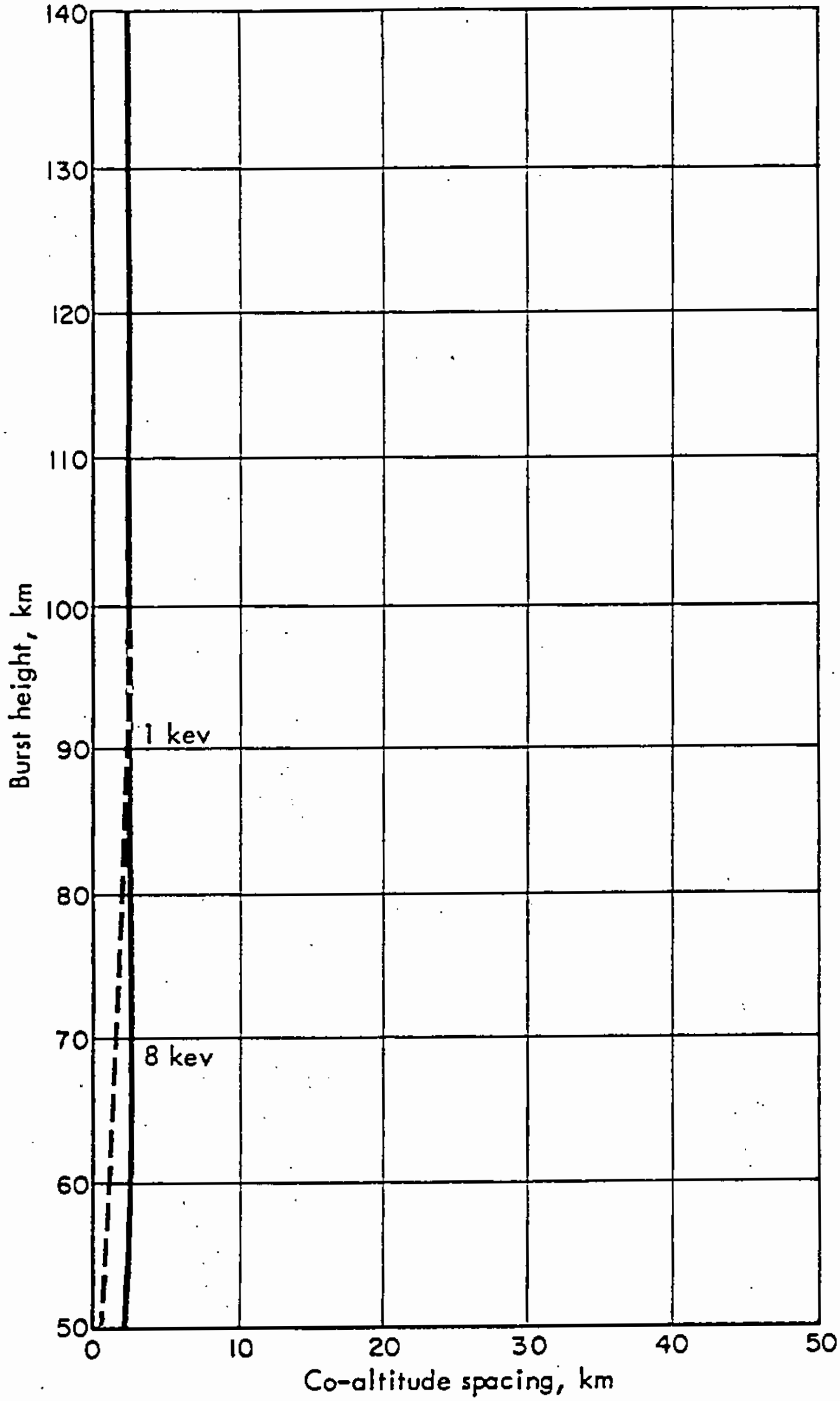


FIGURE A-29 Distance from 10-Mt Burst to 10,000 cal/cm^2

FIG A-30

exhaust our 10 interceptors (one interceptor to clear the chaff, then one interceptor for each reentry vehicle). They must then still fire [redacted] more successful boosters to destroy the undefended target if their CEP is [redacted] and must space them at least [redacted] apart to prevent fratricide. Hence, a total time of [redacted] and [redacted] successful boosters are required to destroy one target. Vehicle hardening clearly pays off.

For the United States to kill a hard target with only five MINUTEMEN, the required MINUTEMAN CEP is 0.25 nmi; then only two additional boosters must be used to insure target destruction following interceptor exhaustion. [redacted] The probability that the Mark 12 reentry vehicle will achieve a CEP of 0.25 nmi is about the same as that of the Ice Cap mysteriously melting from the frozen tundra of Novaya Zemlya.

B. FUTURE REENTRY SYSTEM CONCEPTS

For the time period about 1975, our reentry technology will consist of several new approaches to penetration. [redacted]

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13. ABSTRACT

The Soviet Union strategy with respect to the STRAT-X basing concept study is presented. The Soviet reactions are presented as being feasible but not necessarily as being authentic. The report discusses general nuclear strategic history, U.S. reentry vehicles, and both general and specific strategic considerations. Also considered are the effects imposed by strategists upon the analyst and designer and the impact of technology upon strategy and system design. Reactions to the four candidate STRAT-X basing concepts and to an active defense system are also briefly discussed. (U)

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