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REQUIREMENTS FOR THE DEVELOPMENT OF ADVANCED NUCLEAR WEAPON CONCEPTS

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Introduction

In this paper, I will be discussing requirements for the development of advanced nuclear weapon concepts. The agenda for this workshop indicates that my paper will address third generation nuclear weapons, and the advance workshop literature describes third generation nuclear weapons as including earth penetrating warheads (EPWs) and maneuvering reentry vehicles (MARVs), as well as nuclear directed energy weapons (NDEWs). Within the U.S. defense community, we tend to apply the term third generation nuclear weapons only to NDEWs, and accordingly I will distinguish between NDEWs, MARvs, and EPWs in the remarks that follow.

I will begin by presenting a historical context for the evolution of advanced nuclear weapon concepts, discussing the types of advanced concepts and how they differ from conventional nuclear weapons currently in the stockpile. I will discuss the policy context for doing R&D on nuclear directed energy weapons and how this R&D relates to the Strategic Defense Initiative (SDI).

Regarding requirements per se, I will attempt to demonstrate the importance of doing research on advanced concepts, which in the minds of many can be regarded as the most important requirement of all. I will then describe some military requirements for the various advanced concepts and discuss potential missions, indicating the potential advantages and disadvantages of the various applications.

Finally, I will discuss arms control and stability considerations as they relate to the development of advanced concepts and the implications of the rapidly changing political relationships between the U.S. and the Soviets, and between their respective allies. I will close by suggesting an agenda for the future in this very important area.

My comments will be based on my own personal views, rather than the Lawrence Livermore National Laboratory or the University of California, of which I am an employee.

Historical Context

The history of nuclear weapon development has been evolutionary. The first breakthrough in nuclear weapons - the so-called "first generation" - involved fission weapons (the atomic bombs used during World War II were fission weapons). Additional breakthroughs in fission weapon design occured over the years as weapon sizes and weights decreased. In fact, low yield fission weapons in the range of 1 to tens of kilotons have been developed which can be packaged small enough to fit within cannon-launched artillery shells.

The second generation of nuclear weapons involved the development of thermonuclear secondaries. Yields for a given weapon weight increased dramatically. Thermonuclear weapons permit deliverable packages with yields of tens to thousands of kilotons, and thermonuclear weapons with enhanced output such as neutrons are possible.

The idea of directing a relatively small fraction of the output of a nuclear explosion constitutes the third generation. Figure 1 illustrates the concept in schematic form. In fact, it is conceptually possible to direct the energy of any relatively isotropic energy source, whether the source be nuclear, chemical, or electrical, where the directed energy could be in the form of x-rays, visible light, microwaves, particles, etc. Regarding nuclear directed energy weapons (NDEWs), we are still very much involved with the research stages of such weapons and the problems to be solved are primarily physics problems in nature.

Other advanced nuclear weapon concepts, such as MARVs and EPWs, are second generation nuclear weapons that are packaged in their delivery vehicles in special ways. Contrasted with the physics problems that are currently fundamental to NDEW development, the problems to be solved with

EPWs and MARVs are largely engineering in nature.

Types of Advanced Nuclear Weapon Concepts and How they Differ from Conventional Nuclear Weapons

We will be discussing several types of advanced nuclear weapon concepts. For NDEWS, these types include x-ray lasers, microwave weapons, particle beam weapons, pellet (kinetic energy) weapons, and optical lasers. Most of my remarks will deal with X-ray lasers, which we have demonstrated in nuclear tests. For the other types of NDEWS, I can only say that we are doing research on the various concepts and I will describe some possible missions for such weapons. Other advanced nuclear weapon concepts that will be discussed include EPWs and MARVs.

The physical processes that all these advanced concepts would use to cause damage to a target are not really new. What are new are the ways in which the physical processes are powered, the lethal range, or the means of delivery of the weapon to its target. For example, with EPWs, penetration into the ground allows greatly enhanced energy coupling into the target medium and greatly enhanced shock levels for a given yield. With MARVs, there would be an improved probability of the reentry vehicle reaching its target in regions of heavy ballistic missile defense.

NDEWS would create damage through largely the same physical mechanisms - blast, intense heat and light, radiation, electromagnetic pulse - as do conventional nuclear weapons. There are of course different intended missions for NDEWs and conventional nuclear weapons. Conventional nuclear weapons play a deterrent role that is based primarily on the idea of retaliation with offensive forces and can be used against military and civilian targets. By their very nature, NDEWs have a different range of effects, are more discriminate, and consequently are intended primarily to play a defensive role against offensive nuclear weapons. Of course, any weapon can be used in an offensive as well as a defensive role, as will be discussed below.

Policy Context for R&D on NDEWs

The SDI program has been widely described as a program involving conventional (nonnuclear) weaponry. The question is frequently raised as to the role of NDEWs in SDI. NDEWs play a secondary role in the SDI program and the primary reason for R&D on these weapons is to assess the threat they might play as counterdefenses to conventional SDI deployments and to current offensive deterrent forces. Also, given a substantial breakthrough in the R&D program, NDEWs could play a major primary role in defenses, especially if conventional SDI developments fall short of expectations. The policy for research on NDEWs was established in a letter that was jointly written by the U.S. Secretaries of Defense and Energy on February 27, 1985 (Appendix A).

Another reason for R&D on NDEWs is that such weapons could complement the role that might be played by conventional SDI defenses. A possible mission for such a complementary role is described below.

The Importance of Research on NDEWs

In President Reagan's SDI speech of March 23, 1983, he presented SDI's goal as "...a comprehensive and intensive effort to define a long-term Research and Development Program to begin to achieve our ultimate goal of eliminating the threat posed by strategic nuclear missiles." I believe we should take literally the idea that SDI is a research program rather than a program to deploy defenses.

Research on advanced nuclear weapon concepts is important for a number of reasons. First, even if we do not plan to deploy new weapons, it is important to know what is possible for the other side to accomplish. Second, major breakthroughs are possible that could revolutionize defensive applications and lead to greater stability. Third, developments are possible that could greatly enhance our current defensive retaliatory posture. And finally, the possibility that advanced weapon concepts might be deployed could be an important deterrent in itself.

Regarding finding out what can be accomplished, we should fully expect superpower R&D programs to continue actively into the future, even with the very positive improvements in relations that are now occuring. Verification of research is a serious concern: it is extremely difficult to verify specifically what problems the other side is working on and the status of their research. R&D on "unacceptable" technologies could be masked by R&D on other technologies. While it should be possible to verify the yield or existance of most nuclear tests, it would be extremely difficult to verify the reason for those tests.

Confidence building measures (e.g. open laboratories) could alleviate some concerns. However, we really need a more extensive glasnost on the part of the Soviets and we must see it last. The consequences of failing to identify important research and of being surprised technologically could be very destabilizing and devastating for world peace. Perhaps, as relations continue to improve and we learn more about each other's programs, we may be able to relax our guard and reduce our respective efforts. I personally believe that the evolution of technology is inevitable. What we can hope to accomplish is to avoid deployment of its products.

The possibility that advanced nuclear weapons might be deployed could fulfill an important requirement of deterrence. The possibility of deployment could deter breakout from future treaties and discourage renewed mobilization of strategic forces. For example, suppose we conclude major reductions in offensive missiles in future START agreements. The possibility of effective U.S. defenses against Soviet ICBMs could deter the Soviets from breaking out of a treaty and from building back up their ICBM forces.

With R&D playing such a deterrent role, work on advanced concepts would fall short of actual deployments. Rather, as some of my colleagues describe it, the deployments would be "virtual" - some years away from actuality. Such an approach would place a greater emphasis on the simulation of capabilities. However, we must recognize that simulations could be subject to large uncertainties. Also, we would have to resist pressures for large-scale production - a difficult task in the current product-oriented military-industrial complex. Even an arms control-minded Congress appears to measure success by products in the field. Accordingly, we would need to devlop a new definition of what constitutes a "successful" program.

<u>Potential Military Missions of NDEWs</u>

It is interesting to compare the respective roles that might be played by conventional and nuclear options in SDI (figure 2). Conventional SDI weapons require high aiming accuracy and are expected to work effectively against threats in which the numbers of targets appear at relatively low rates, although the new Brilliant Pebbles concept may be effective at high threat rates. Timely release of conventional SDI defenses is also expected to be more acceptable than release of the authority to use nuclear powered defensive weapons.

On the other hand, NDEWs will probably require less accuracy in aiming, because the beams are expected to be more divergent and more intense. Hence, NDEWs are expected to have larger lethal volumes. Also because nuclear energy is the most intense energy available, NDEWs are expected to be lighter in weight and capable of more survivable basing. NDEWs in the long run may be capable of achieving multiple kills of targets with a single shot.

We can use the x-ray laser to illustrate these concepts. The x-ray laser is conceptually small and lightweight. It is intended to be based in pop-up mode - to be launched from land or submarines and detonated above the atmosphere. Pointing and tracking of x-ray lasers are expected to be less critical than with conventional laser weapons. A number of weapon feasibility issues are being explored for x-ray lasers, including intensity, divergence, and aperture of the beams. Should x-ray lasers meet research goals, they could be capable of destroying targets at roughly a thousand times the distance of an equivalent nuclear explosion (figure 3).

<u>X-ray Lasers and a Defensive Triad</u>

A number of possible roles for x-ray lasers in a defensive architecture have been suggested. In one such architecture, x-ray lasers would form the third leg of a defensive "triad." Much as there is synergism between the three legs of the current offensive triad consisting of ICBMs, SLBMs, and bomber weapons, there would be synergism between the three legs of a defensive triad, which would consist of ground-based, space-based, and sea-based components. The ground-based component could be comprised of ERIS (Exoatmospheric Reentry Interceptor System) interceptors for late mid-course defense, and/or HEDS (High Endo Defense System) interceptors for terminal defense. Nuclear tipped interceptors using Spartan and Sprint technologies would be alternatives to the conventional ERIS and HEDS deployments. The space-based component would be comprised of kinetic energy weapons (KEWs) in the form of small rockets intended for boost-phase intercept. The sea-based component would consist of x-ray lasers based on submarines for pop-up deployment (figure 4) and would complement the KEWs.

The x-ray lasers could conceivably play a role in the following hypothetical scenario. Let us assume that an all-out attack is successfully conducted against U.S. space-based KEWs. In such a situation, U.S. forces would be immediately alerted to the resulting crisis situation. The submarine-based x-ray lasers could then be launched to pin down and/or extensively damage the ICBMs that would be expected to be launched immediately following the attack on the space-based KEWs. There would be a fairly narrow time window for such a launch before the next constellation of space-based KEWs came into play, and overall timing would be extremely critical. Analysis shows that an affordable number of submarines and missiles would be needed, provided that x-ray laser design goals are met. Other scenarios are, of course, possible, including pin-down of U.S. ICBMs by Soviet x-ray lasers after a first strike against U.S. assets.

Possible Missions for NDEWs

Having discussed a possible mission for x-ray lasers as a complement to space-based KEWs and as a means to pin down ICBM forces, it is important to note that X-ray lasers might also be effectively used as ASAT weapons. Any of the NDEW concepts could indeed serve as an ASAT weapon. Pellet weapons, in which a nuclear explosion could be used to accelerate fragments of material, might also be used to intercept reentry vehicles, and might even provide some effectiveness against MARVs, much as a shotgun can be effective against a darting bird. Possible missions for microwave weapons include soft kill (via burn out of electronic components) of reentry vehicles and space-based defenses, and attack against targets spread out over a large ground area, such as strategic relocatable targets (e.g. mobile missiles) and air defenses. Microwave weapons might have some tactical applications, although conventionally driven microwave sources might also be used for such missions. Nuclear driven optical lasers would have applications similar to conventional optical lasers in SDI.

Of course, as with any weapon, NDEWs could be used in an offensive manner as well as a defensive one. There could be disadvantages as well as advantages to the above missions and roles. Hence, it is important to find out what is possible in the realm of NDEW concepts.

Some Dangers of Deploying Defensive Weapons

The dangers of deploying NDEWs are much the same as with deploying conventional SDI defenses. A global nuclear war could start with these new weapons fighting each other. Computers would have to make many of the command decisions during the battle, and such a complex system would have to work right the first time. And if the new weapons are too expensive, more offensive weapons could be built to overcome them, resulting in an offensive-defensive arms race. An additional danger posed by NDEWs is the possibility of an earlier crossing of the nuclear threshold.

There are many issues regarding an SDI deployment decision. Most important of all, there are the Nitze criteria: it must work, it must be survivable, it must be cost-effective on the margin. There are several additional questions. First, what is "it"? There have been a variety of definitions of SDI ranging from a leak-proof umbrella to Senator Nunn's Accidental Launch Protection System (ALPS). Another important question is whether the deployments would be endurable in an evolutionary sense: would new technologies make existing deployments void and ineffective? A third important question is the cost of SDI. In this regard, we should note that the U.S. Congress has recently made substantial cuts in SDI funding and will probably continue to do so in the future. I believe that the future of SDI is rather tenuous at this time. We might, however, see some Congressional support for an ALPS-like system owing to the fact that such a system could employ existing technologies and would be less expensive than more extensive defensive systems.

Earth Penetrating Warheads (EPWs)

It is important to recognize that there are advantages and disadvantages to EPWs. EPWs could be used to rectify a serious asymmetry that now exists between the U.S. and the U.S.S.R. U.S. leadership is currently quite vulnerable to a strike by Soviet nuclear forces. Our leadership is located fairly close to the coastlines and has virtually no means of protection. They would be quite susceptible to an attack by SLBMS or nuclear SLCMs.

Soviet leadership on the other hand is much less vulnerable. They are further from the coastlines and have extensive underground facilities for their protection. For example, figure 5 (ref. 1) is an aerial photograph of what are believed to be underground facilities at Sharapovo, just south of Moscow. EPWS would hold the Soviet leadership at risk and could be a powerful deterrent against the idea that a strike against the U.S. might succeed with relative impunity.

However, we should note that there are destablizing aspects and other problems with EPWs. EPWs that are used in a decapitation strike could make it difficult to turn off a war once it started. It is important to note that EPWs, and in fact any weapon intended for attack against silo-based missiles, will have limited value against the mobile missile forces that are evolving on each side.

There are indeed alternatives to EPWs in the form of very high yield surface burst warheads and multiple targeting. Such alternatives would also work effectively, but with different collateral damage effects. Two other alternatives would be for the U.S. leadership to build undergound facilties or for the Soviets to give theirs up; however, both these alternatives seem rather unlikely. When I weigh all of the aspects, I conclude that it is extremely important to have serious discussions between the U.S. and the U.S.S.R. on the stabilizing and destabilizing aspects of EPWs.

<u>Maneuvering Reentry Vehicles (MARVs)</u>

As with EPWs, there are potential missions for MARVs which have stabilizing and destabilizing aspects. MARVs could provide an effective response against breakout from the existing ABM Treaty or a future Defense and Space Treaty, by providing an effective way to evade ABM defenses. In this way, MARVs could provide some stability against such future developments. On the other hand, MARVs might also be effective against strategic relocatable targets, such as mobile ICBMs, and they might accomplish such a mission at relatively low yields owing to high accuracies. However, we should recognize the instabilities that could result any time that one side attacks the other's retaliatory forces.

<u>Arms Control and Stability Considerations</u>

I believe that the most important requirement for advanced nuclear weapon concepts is the need to do research to find out what is possible, if only to allow us to devise appropriate counters and defenses against such weapons and thereby maintain stability. While it may be possible to develop NDEWs (and conventional defensive weapons for that matter) that might effectively enhance our deterrent posture, deployment of such weapons should be considered only in the light of proper stability analysis. Such analysis should account for the possibility that as deeper and deeper arms cuts are achieved, there may be a greater potential role for defenses of all kinds. Arms control negotiations should address how we can make a stable transition from today's offense-dominated deterrent to a future deterrent that might be largely based on defenses. And as pointed out earlier, the possibility that advanced weapons might be deployed could serve as a deterrent to breakout from treaties and, therefore, be stabilizing. Arms control discussions should also focus on the stabilizing and destablizing aspects of EPWs, IPWs, and MARVs.

Nuclear test bans and flight test bans have been suggested as ways to limit the development of advanced weapon concepts. While such bans may be effective in providing such limits, we should recognize that they create other problems. Flight testing is essential to ensure the continued reliability of missiles and to certify important changes to missile systems (or new missiles such as Midgetman) that might be required to maintain strategic stability. Nuclear test bans or restrictive nuclear test limits would severely restrict our ability to develop the highly optimized and cost-effective warheads that would be needed for new weapon systems and our ability to maintain reliability in the existing stockpile. I believe that it is far better to concentrate the arms control agenda on reducing the most destabilizing weapons and in limiting deployments of new weapon systems that might decrease stability.

<u>The Significance of Today's Rapidly Improving Political Relationships</u>

We are now experiencing rapid improvement in political relationships between the U.S. and U.S.S.R. and between NATO and the Warsaw Pact. These improvements will likely lead to a change in the role of nuclear deterrence. However, we still have a long way to go before we can eliminate our reliance on nuclear weapons, and we must determine if today's improvements will be lasting ones. As relations continue to improve, we should expect to see increasing pressures within the U.S. to slow down R&D, especially from a budget conscious Congress.

While the need for defenses against superpower nuclear weapons may diminish, we will probably see a growing need for some kind of defenses against third world nuclear capabilities. However, conventional defenses should suffice for this role.

As to the implications of third generation nuclear weapons for Europe, I believe that these implications are currently weak or indirect - a condition likely to continue into the future. The indirect nature of the implications comes from the impact of third generation nuclear weapons on the U.S.-U.S.S.R. strategic relationship.

A Suggested Agenda for the Future

I believe that we should maintain the current arms control momentum toward major reductions in destabilizing weapon systems, including avoiding deployment of new destabilizing weapons. We should continue the U.S.-Soviet dialog in arms control, and should attempt to define, together, the future role of superpower nuclear weapons. We should discuss the role of defenses and how we might make a stable transition from today's offense-dominated world to a future world that might be based on defenses. We should continue to seek ways to build confidence that the activities of one side do not threaten the other side, for example by establishing rules of the road for superpower efforts in R&D and in deployments. Finally, we should continue to reduce existing asymmetries, such as the one existing with respect to the relative vulnerabilities of U.S. and Soviet leadership to a first strike.

References

1. Soviet Military Power, U.S. Department of Defense Document, 1988, pp. 59-62.

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Appendix A

POLICY FOR NUCLEAR RESEARCH IN THE STRATEGIC DEFENSE INITIATIVE

The purpose of this paper is to clarify the role of nuclear research in regard to the Strategic Defense Initiative (SDI). The SDI is a program of vigorous research focused on advanced defensive technologies with the aim of finding ways to provide a better basis for deterring aggression, strengthening stability, and increasing the security of the United States and our allies. As a broad research program, the SDI is not based on any single or preconceived notion of what an effective defense system would look like, but the long term goal of the research program is a truly effective nonnuclear defense.

There are, however, some new concepts which could, if proven feasible, convert nuclear energy in a carefully directed, controlled way so as to destroy attacking missiles, after they are launched, at a great distance. Unlike the thinking of the past, these new concepts would not use the effects close to the explosion of nuclear weapons to destroy the attacking missile, and they would be controlled so that there would be no harmful effects from the nuclear source. There are a variety of reasons for including research on such concepts at this time:

(1) To determine the feasibility and effectiveness of counterdefensive nuclear-driven systems that an adversary may develop for use against future U.S. surveillance and defensive systems.

(2) To understand the technical feasibility and impact that such concepts might have on our deterrent forces if utilized in Soviet defensive systems.

(3) To explore nuclear directed energy options as SDI possibilities if needed.

CASPAR W. WEINBERGER
SECRETARY OF DEFENSE

DATE: 21 FEB 1985

JOHN S. HERRINGTON
SECRETARY OF ENERGY

DATE: February 27, 1985

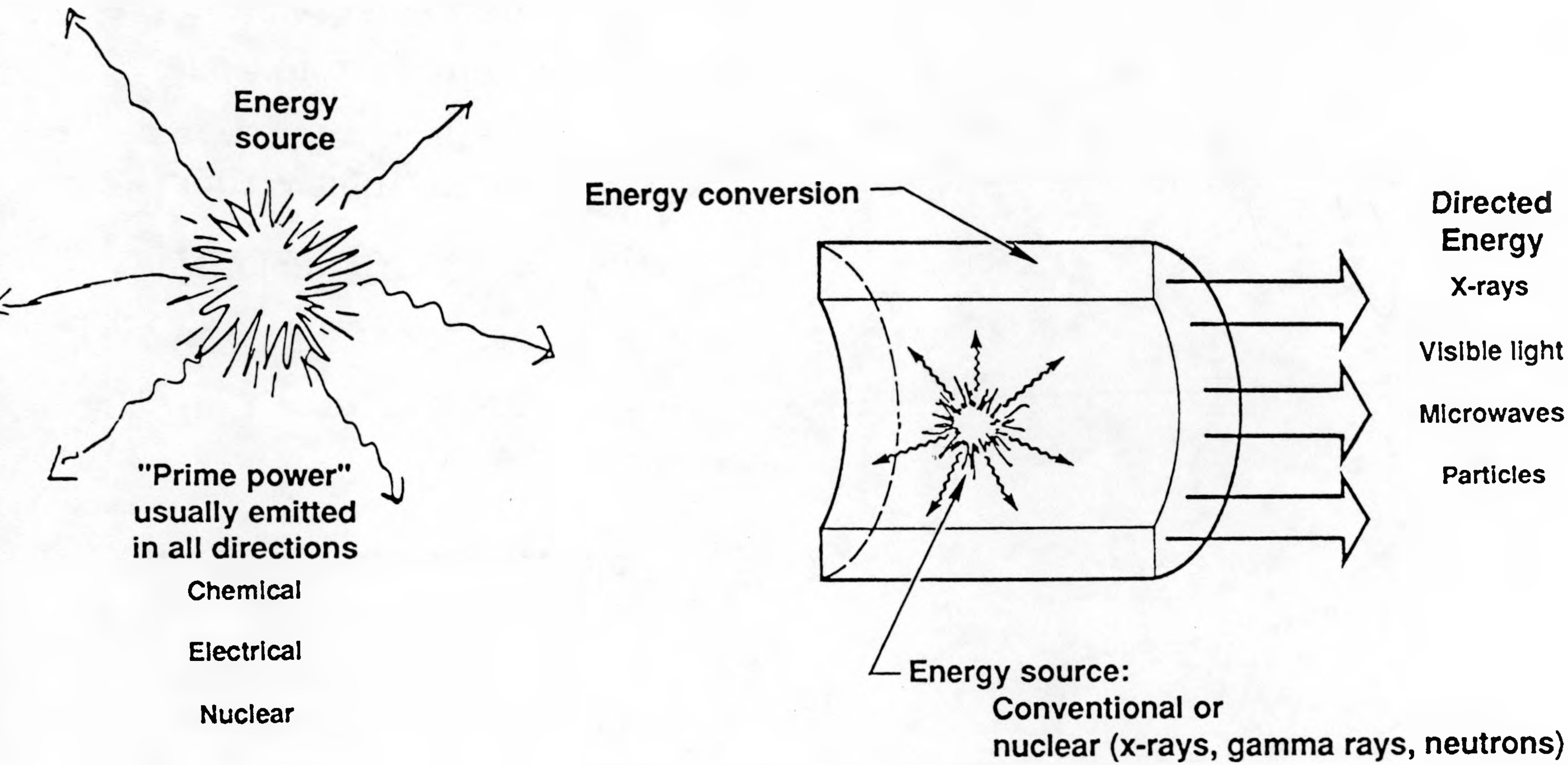

Figure 1. Comparison of isotropic versus directed energy weapons.

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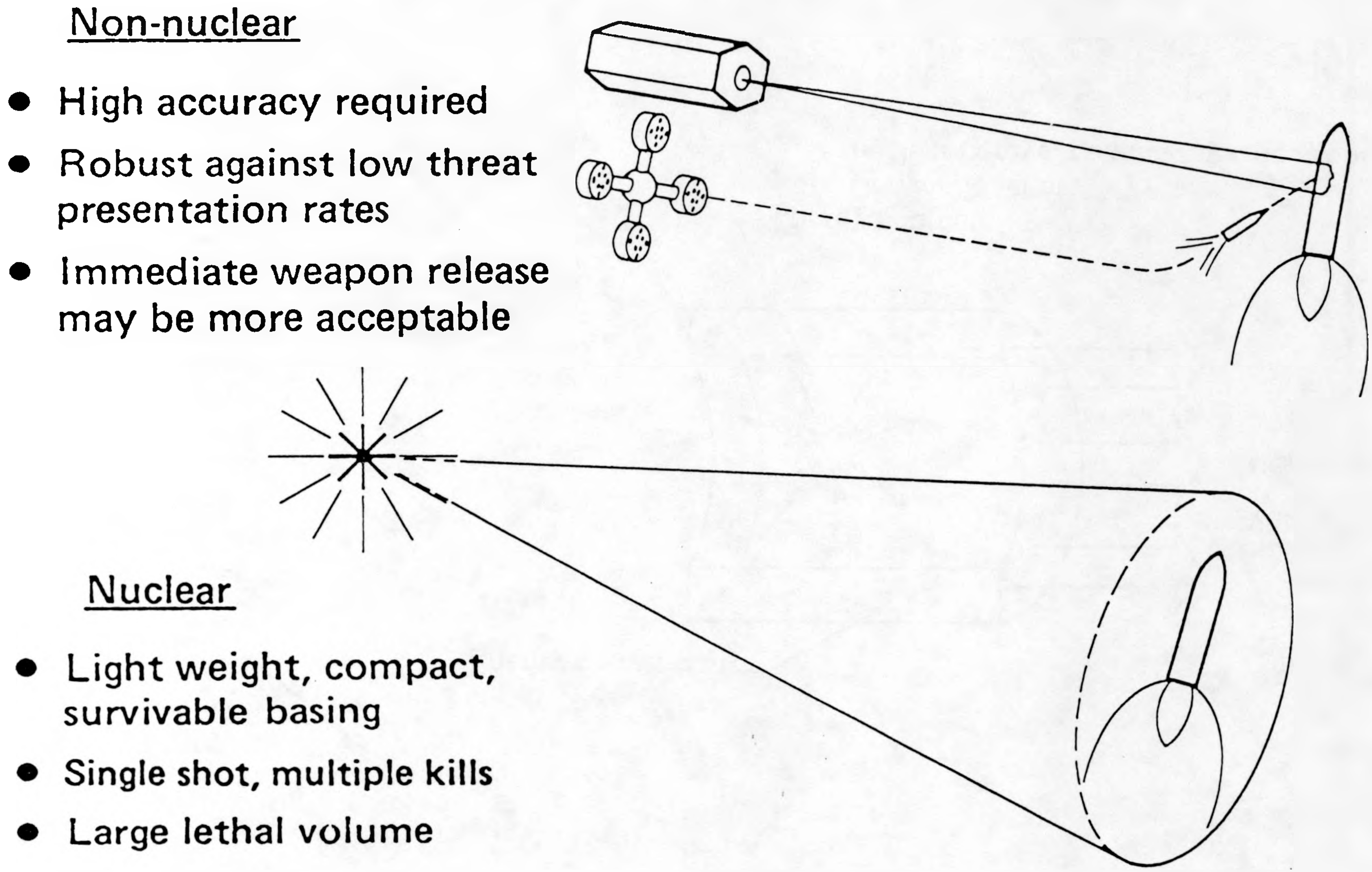

Figure 2. Comparison of nuclear and non-nuclear options in SDI.

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X-ray laser weapons could destroy multiple targets at 1000 times the distance of an equivalent nuclear explosion

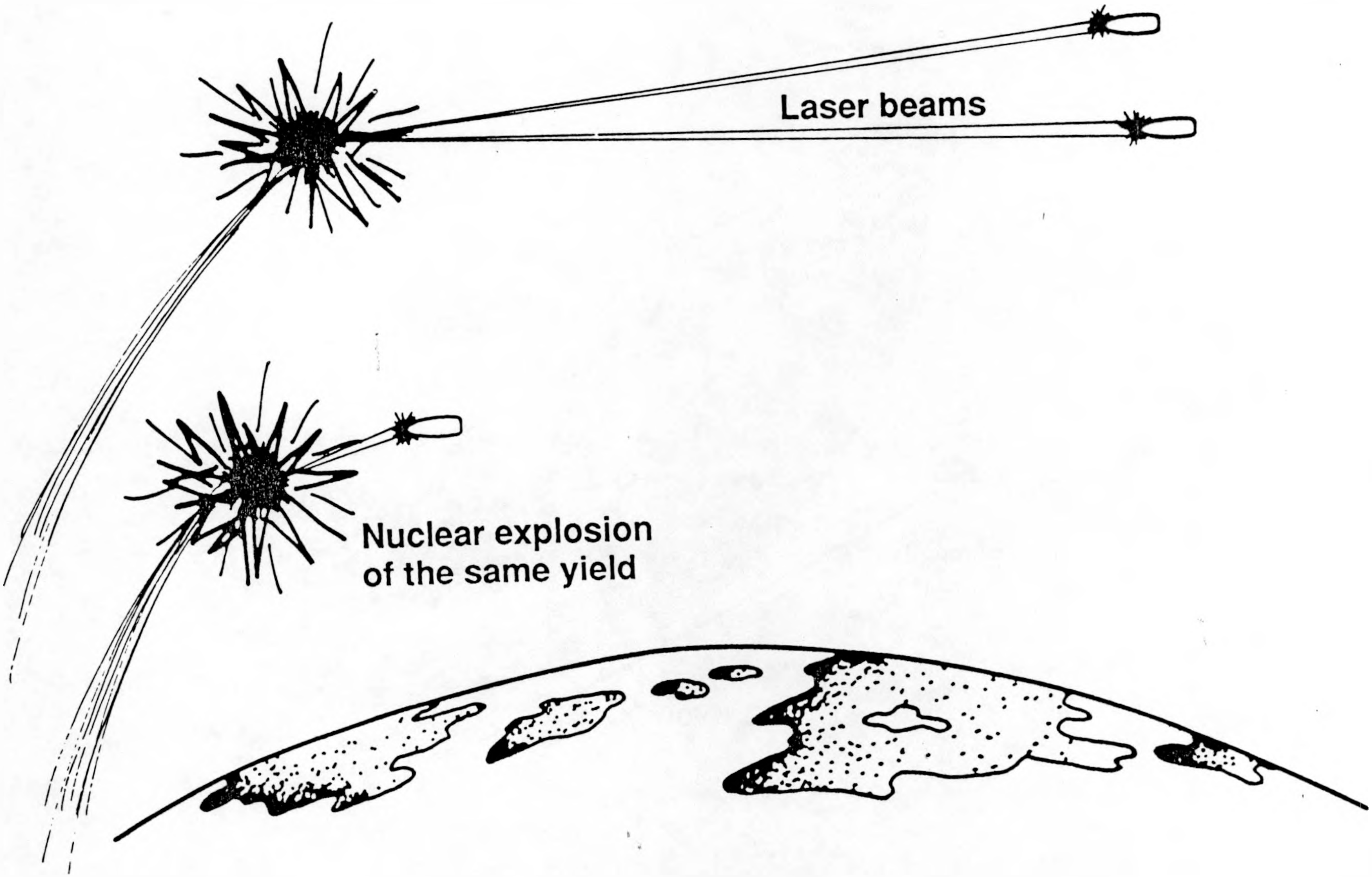

Figure 3. X-ray laser weapons could destroy targets at roughly 1000 times the distance of an equivalent nuclear explosion.

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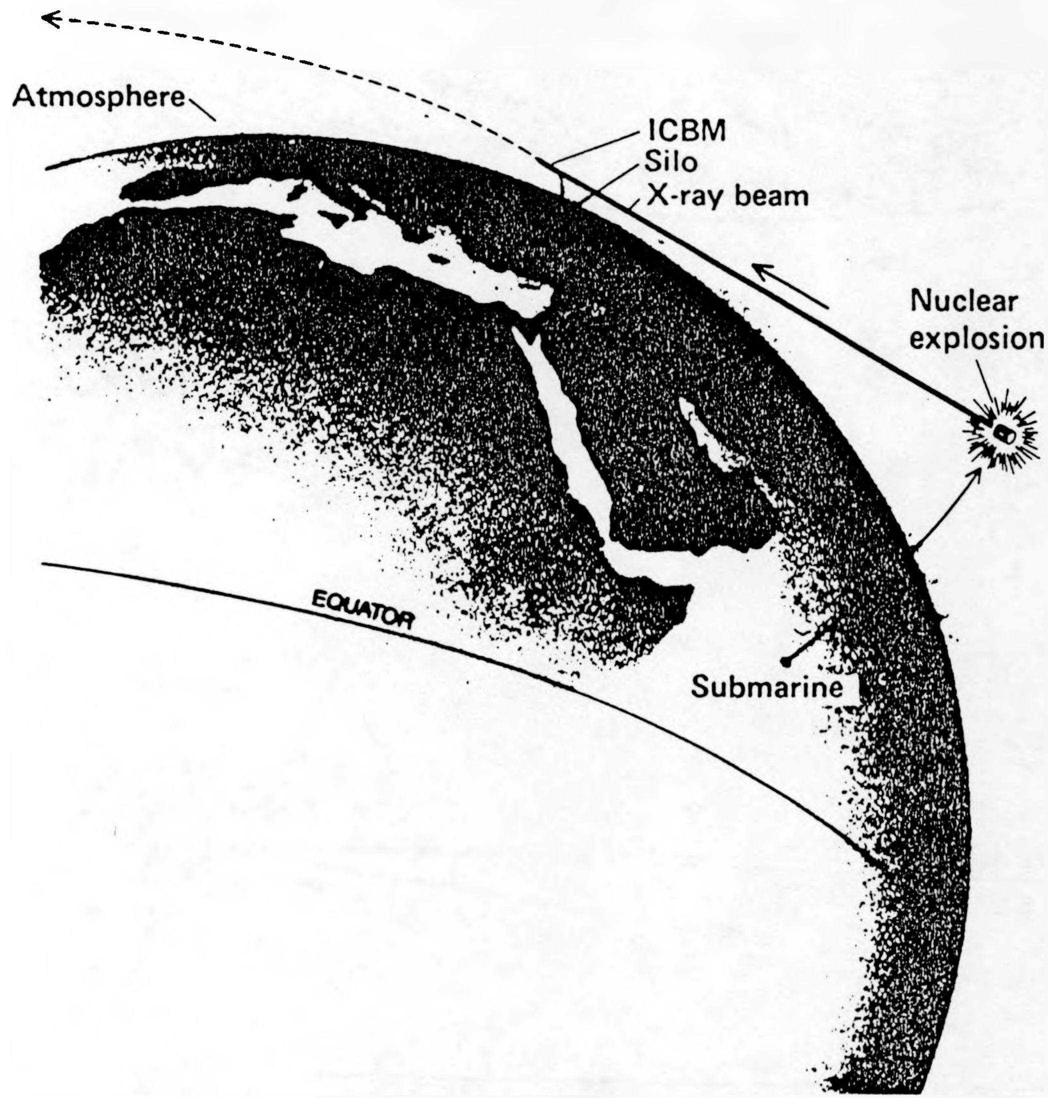

Figure 4. Pop-up defensive system for x-ray lasers.

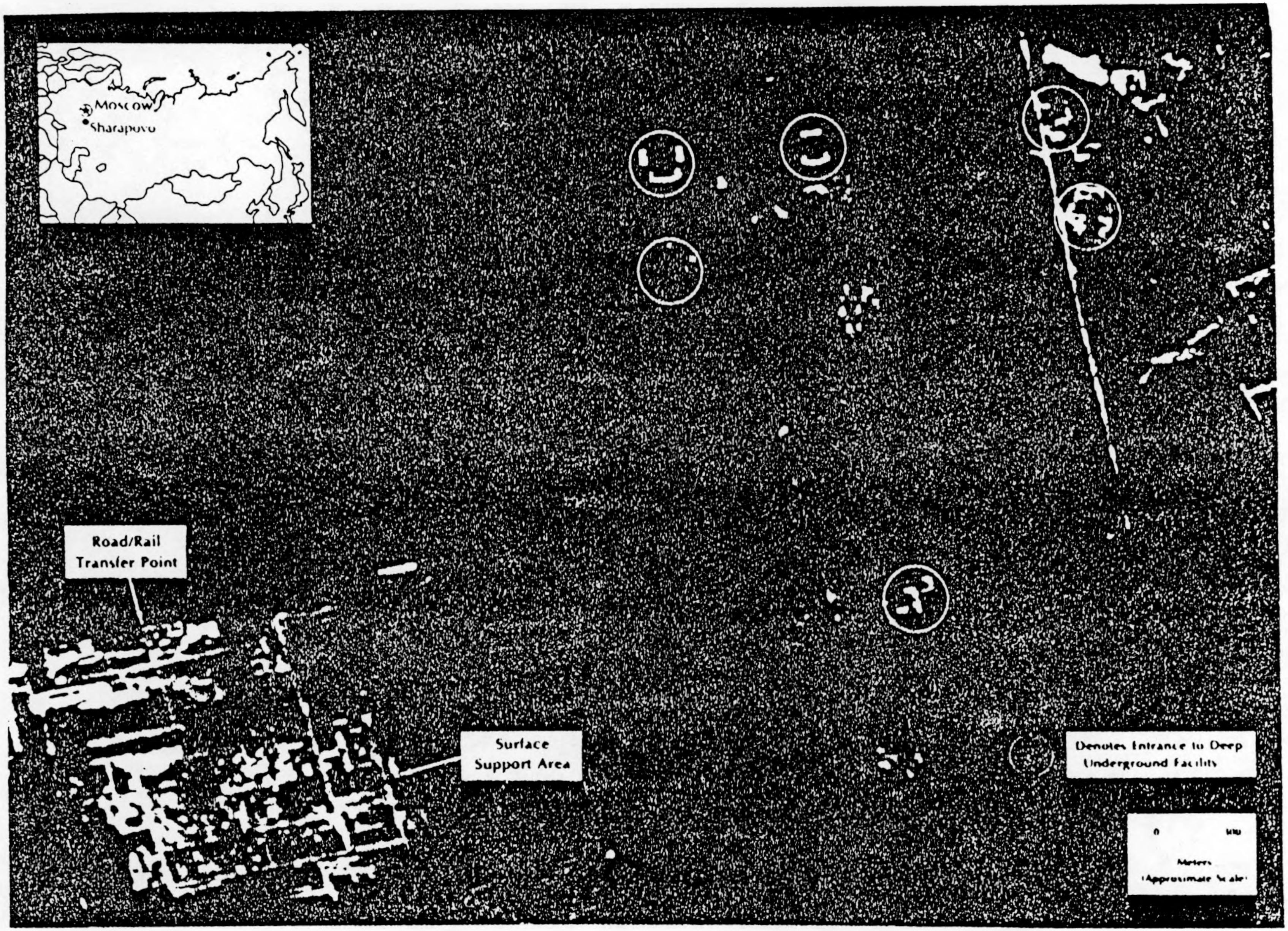

Figure 5. Some underground facilities designed to protect the Soviet leadership are relatively shallow and can accommodate thousands of people. This deep underground facility is a wartime relocation for the Soviet National Command Authority.

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